Binary IFA-IRT Models in Mplus v. 8.4

Example data: 635 older adults (age 80–100) self-reporting on 7 items assessing the Instrumental Activities of Daily Living (IADL) as follows:

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1. Housework (cleaning and laundry): 1=64%
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2. Bedmaking: 1=84%

3. Cooking: 1=77%

4. Everyday shopping: 1=66%

5. Getting to places outside of walking distance: 1=65%

6. Handling banking and other business: 1=73%

7. Using the telephone 1=94%

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Two versions of a response format were available:
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Binary \rightarrow 0 = needs help, 1 = does not need help

Categorical \rightarrow 0 = can't do it, 1 = big problems, 2 = some problems, 3 = no problems

Higher scores indicate greater function. We will look at each response format in turn.

Binary 2-PL Model Syntax (left) and 1-PL Model Syntax (right) using ML and a logit link:

```
Assess binary IADL items using 2PL under full-info ML
                                                                       TITLE:
                                                                               Assess binary IADL items using 1PL under full-info ML
DATA:
       FILE = Example5.csv; ! Don't need path if in same folder
                                                                       DATA:
                                                                               FILE = Example5.csv; ! Don't need path if in same directory
        FORMAT = free;
                               ! Default
                                                                               FORMAT = free:
                                                                                                     ! Default
        TYPE = INDIVIDUAL:
                               ! Default
                                                                               TYPE = INDIVIDUAL:
                                                                                                     ! Default
VARTABLE:
           NAMES = case dial-dia7 cial-cia7; ! All vars in data
                                                                       VARTABLE:
                                                                                   NAMES = case dial-dia7 cial-cia7; ! All vars in data
            USEVARIABLES = dia1-dia7;
                                              ! All vars in model
                                                                                   USEVARIABLES = dia1-dia7:
                                                                                                                      ! All vars in model
            CATEGORICAL = dia1-dia7;
                                              ! All ordinal outcomes
                                                                                   CATEGORICAL = dia1-dia7;
                                                                                                                      ! All ordinal outcomes
            MISSING = ALL (99999);
                                              ! Missing value code
                                                                                   MISSING = ALL (99999);
                                                                                                                     ! Missing value code
            IDVARIABLE = case:
                                              ! Person ID variable
                                                                                   IDVARIABLE = case;
                                                                                                                      ! Person ID variable
ANALYSIS:
           TYPE = GENERAL;
                                           ! Default
                                                                       ANALYSIS: TYPE = GENERAL;
                                                                                                                   ! Default
            ESTIMATOR = ML; LINK = LOGIT; ! Full-info ML in logits
                                                                                   ESTIMATOR = ML; LINK = LOGIT; ! Full-info ML in logits
            CONVERGENCE = 0.0000001;
                                           ! For OS comparability
                                                                                   CONVERGENCE = 0.0000001;
                                                                                                                   ! For OS comparability
MODEL:
                                                                       MODEL:
! Factor loadings all estimated in 2PL
                                                                       ! Factor loadings all held equal in 1PL
                                                                           IADL BY dia1-dia7* (loading);
    IADL BY dia1-dia7*;
! Item thresholds all estimated
                                                                       ! Item thresholds all estimated
    [dia1$1-dia7$1*];
                                                                           [dia1$1-dia7$1*];
! Factor mean=0 and variance=1 for identification
                                                                       ! Factor mean=0 and variance=1 for identification
    [IADL@0]; IADL@1;
                                                                           [IADL@01; IADL@1;
OUTPUT:
            STDYX:
                                ! Standardized solution
                                                                       OUTPUT:
                                                                                   STDYX:
                                                                                                        ! Standardized solution
            RESIDUAL TECH10;
                                ! Local fit info
                                                                                   RESIDUAL TECH10;
                                                                                                        ! Local fit info
SAVEDATA:
                                                                       SAVEDATA:
            SAVE = FSCORES:
                                       ! Save factor scores (thetas)
                                                                                   SAVE = FSCORES;
                                                                                                              ! Save factor scores (thetas)
            FILE = IADL 2PLThetas.dat; ! File factor scores saved to
                                                                                   FILE = IADL 1PLThetas.dat; ! File factor scores saved to
            MISSFLAG = 99999;
                                                                                   MISSFLAG = 999999;
                                      ! Missing data value in file
                                                                                                              ! Missing data value in file
PLOT:
       TYPE = PLOT1:
                         ! PLOT1 gets you sample descriptives
                                                                       PLOT: TYPE = PLOT1;
                                                                                                ! PLOT1 gets you sample descriptives
                         ! PLOT2 gets you the IRT-relevant curves
                                                                               TYPE = PLOT2:
                                                                                                ! PLOT2 gets you the IRT-relevant curves
        TYPE = PLOT2:
        TYPE = PLOT3:
                        ! PLOT3 gets you descriptives for theta
                                                                               TYPE = PLOT3:
                                                                                                ! PLOT3 gets you descriptives for theta
```

This error message indicates that these 2 sets of chi-squares for the

on the same data. So we can't compare the chi-squares to test the

difference in model fit, but we can still compare LL values.

2-PL and 1-PL are not on the same scale because they are not based

Binary 2-PL Model Fit (left) and 1-PL Model Fit (right) using ML logit:

	FIT INFORMATION - 2PL		MODEL FIT INFORMATION - 1 PL				
Number	of Free Parameters	14	Number of Free Parameters	8			
Loglike	elihood		Loglikelihood				
	H0 Value	-1454.634	HO Value	-1464.457			
Informa	ation Criteria		Information Criteria				
	Akaike (AIC)	2937.268	Akaike (AIC)	2944.915			
	Bayesian (BIC)	2999.619	Bayesian (BIC)	2980.544			
	Sample-Size Adjusted BIC $(n^* = (n + 2) / 24)$	2955.170	Sample-Size Adjusted BI (n* = (n + 2) / 24)	C 2955.144			
_	uare Test of Model Fit for the E al) Outcomes	Binary and Ordered Categorical	Chi-Square Test of Model Fit for (Ordinal) Outcomes**	the Binary and Ordered Categorical			
	Pearson Chi-Square		Pearson Chi-Square				
	Value	340.829	Value	296.199			
	Degrees of Freedom	113	Degrees of Freedom	118			
	P-Value	0.0000	P-Value	0.0000			
	Likelihood Ratio Chi-Square		Likelihood Ratio Chi-Square				
		120.273	Value	126.354			
	Value	120.273					
	Value Degrees of Freedom	113	Degrees of Freedom	118			

should not be used to assess model fit.

Further, the possible total df for the χ^2 is calculated based on # possible response patterns. Here, for 7 binary items:

2PL model: $2^7 = 128$ possible - 7 loadings - 7 thresholds - 1 = 113 1PL model: $2^7 = 128$ possible - 1 loading - 7 thresholds - 1 = 119

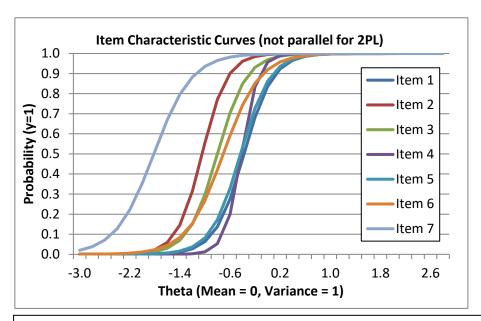
However, the 1PL only has df=118 because of the deleted cell.

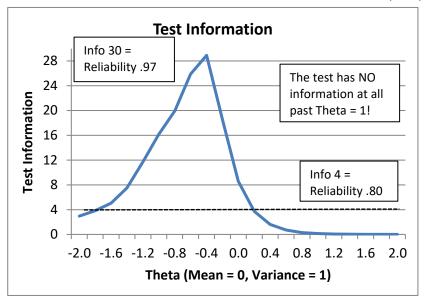
Does the 2-PL fit better than the 1-PL?

 $-1454.634^*-2 = 2909.258$ -2LL difference = 19.946, df = 6, p = .0032 AIC (but not BIC) is smaller for 2PL, too

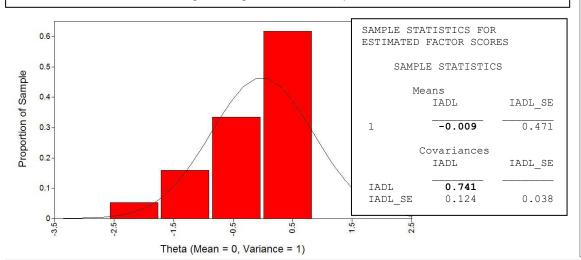
3 differently scaled 2-PL solutions from ML logit provided by Mplus – all provide the exact same model predictions!

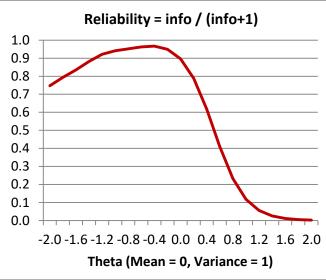
	ED MODEL RESU	LTS (IFA		•	(output from	same model c	continued	d)		
				wo-Tailed						
	Estimate	S.E.	Est./S.E.	P-Value	IRT PARAMETER	-	-			_
FACTOR LOADINGS	= CHANGE IN LOG	IT(Y=1) PE	R UNIT CHANG	GE IN THETA	WHERE THE LOC	GIT IS DISCRI	MINATION	I* (THETA -	DIFFICU	LTY)
IADL BY										
DIA1	4.328	0.560	7.725	0.000	Item Discrimina	ations = SLOPE O	F ICC AT P	- .50		
DIA2	4.978	0.808	6.159	0.000	IADL BY					
DIA3	4.323	0.570	7.579	0.000	DIA1	4.328	0.560	7.725	0.000	
DIA4	7.511	1.696	4.429	0.000	DIA2	4.978	0.808	6.159	0.000	
DIA5	4.248	0.527	8.062	0.000	DIA3	4.323	0.570	7.579	0.000	
DIA6	3.451	0.401	8.600	0.000	DIA4	7.511	1.696	4.429	0.000	
DIA7	3.283	0.601	5.467	0.000	DIA5	4.248	0.527	8.062	0.000	
					DIA6	3.451	0.401	8.600	0.000	
HRESHOLDS = EX	PECTED LOGIT (Y=0) WHEN THE	TA IS 0		DIA7	3.283	0.601	5.467	0.000	
DIA1\$1	-1.629	0.295	-5.516	0.000						
DIA2\$1	-5.202	0.770	-6.754	0.000	Item Difficulti	ies = LOCATION O	F ITEM ON	LATENT TRAIT	at P=.50,	LOGIT=0
DIA3\$1	-3.462	0.441	-7.842	0.000	DIA1\$1	-0.376	0.052	-7.298	0.000	
DIA4\$1	-3.120	0.744	-4.193	0.000	DIA2\$1	-1.045	0.065	-15.978	0.000	
DIA5\$1	-1.833	0.298	-6.158	0.000	DIA3\$1	-0.801	0.059	-13.562	0.000	
DIA6\$1	-2.442	0.292	-8.368	0.000	DIA4\$1	-0.415	0.047	-8.849	0.000	
DIA7\$1	-5.962	0.858	-6.951	0.000	DIA5\$1	-0.432	0.052	-8.296	0.000	
DIMIYI	3.302	0.030	0.551	0.000	DIA6\$1	-0.708	0.060	-11.889	0.000	
MDVV MODET	RESULTS (STAN		TEN MODE	T COTIMTON	DIA7\$1	-1.816	0.126	-14.454	0.000	
IDIX MODEL	KESULIS (SIAN	DAKDIZEL		•	D1111 V 1	1.010	0.120	11.101	0.000	
	Bak Smake	0 F		wo-Tailed						
	Estimate	S.E.	Est./S.E.	P-Value	USING RESULTS	EDOM TEX MO	NET /TEE	יו דישואכו וחיי		
	T11 6 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	VEED TO	1 1: +05 /	The Let (OD (T)	USING RESULTS	5 FROM IFA MC	DET (TEE	: PANEL):		
	IN STANDARDIZED	METRIC =	Togaing*SD(:	rneta)/SD(Y)						
ADL BY					TTD		4 . 1 4	/m1 t - \		
	0.000	0.010	E1 710	0.000	IFA model: Logit				m1	
DIA1	0.922	0.018	51.712	0.000	Threshold = expe	ected logit of (y=0) for s	omeone with		
DIA1 DIA2	0.940	0.018	52.557	0.000		ected logit of (y=0) for s	omeone with		instead
DIA1 DIA2 DIA3	0.940 0.922	0.018 0.018	52.557 50.622	0.000	Threshold = expe When *-1, thresh	ected logit of (nold becomes int	y=0) for s ercept: ex	omeone with pected logit		instead
DIA1 DIA2 DIA3 DIA4	0.940 0.922 0.972	0.018 0.018 0.012	52.557 50.622 80.380	0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres	ected logit of (nold becomes int ssion of item lo	y=0) for sercept: executed the sercept of the server is a server in the server in the server is a server in the server in the server is a server in the se	comeone with pected logit	for (y=1)	instead
DIA1 DIA2 DIA3 DIA4 DIA5	0.940 0.922 0.972 0.920	0.018 0.018 0.012 0.018	52.557 50.622 80.380 52.291	0.000 0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres	ected logit of (nold becomes int	y=0) for sercept: executed the sercept of the server is a server in the server in the server is a server in the server in the server is a server in the se	comeone with pected logit	for (y=1)	instead
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6	0.940 0.922 0.972 0.920 0.885	0.018 0.018 0.012 0.018 0.022	52.557 50.622 80.380 52.291 39.729	0.000 0.000 0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres	ected logit of (nold becomes int ssion of item lo	y=0) for sercept: executed the sercept of the server is a server in the server in the server is a server in the server in the server is a server in the se	comeone with pected logit	for (y=1)	instead
DIA1 DIA2 DIA3 DIA4 DIA5	0.940 0.922 0.972 0.920	0.018 0.018 0.012 0.018	52.557 50.622 80.380 52.291	0.000 0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres = change	ected logit of (nold becomes int ssion of item lo	y=0) for sercept: executed the sercept of the server is a server in the server in the server is a server in the server in the server is a server in the se	comeone with pected logit	for (y=1)	instead
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7	0.940 0.922 0.972 0.920 0.885 0.875	0.018 0.018 0.012 0.018 0.022 0.037	52.557 50.622 80.380 52.291 39.729 23.380	0.000 0.000 0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres = change	ected logit of (nold becomes int ssion of item lo in logit(y) fo	y=0) for s ercept: ex git on The r a one-un	omeone with pected logiteta it change in	t for (y=1)	
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7	0.940 0.922 0.972 0.920 0.885 0.875	0.018 0.018 0.012 0.018 0.022 0.037	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y)	0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres	ected logit of (nold becomes int ssion of item lo in logit(y) fo = 1.629 + 4.328(y=0) for s ercept: ex git on The er a one-un Theta) →	omeone with pected logit ta it change in if Theta=0,	t for (y=1) Theta prob(y=1):	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 CHRESHOLDS IN SE	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303	0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres = change	ected logit of (nold becomes int ssion of item lo in logit(y) fo = 1.629 + 4.328(y=0) for s ercept: ex git on The er a one-un Theta) →	omeone with pected logit ta it change in if Theta=0,	t for (y=1) Theta prob(y=1):	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 CHRESHOLDS IN SEDIA1\$1 DIA2\$1	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303 -17.409	0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres	ected logit of (nold becomes int ssion of item lo in logit(y) fo = 1.629 + 4.328(y=0) for s ercept: ex git on The er a one-un Theta) →	omeone with pected logit ta it change in if Theta=0,	t for (y=1) Theta prob(y=1):	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 CHRESHOLDS IN S' DIA1\$1 DIA2\$1 DIA3\$1	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303 -17.409 -14.373	0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres	ected logit of (nold becomes int ssion of item lo in logit(y) fo = 1.629 + 4.328(y=0) for s ercept: ex git on The er a one-un Theta) →	omeone with pected logit ta it change in if Theta=0,	t for (y=1) Theta prob(y=1):	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 CHRESHOLDS IN S' DIA1\$1 DIA2\$1 DIA3\$1 DIA4\$1	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739 -0.404	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051 0.045	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303 -17.409 -14.373 -8.928	0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres	ected logit of (nold becomes int ssion of item lo in logit(y) fo = 1.629 + 4.328(y=0) for s ercept: ex git on The er a one-un Theta) →	omeone with pected logit ta it change in if Theta=0,	t for (y=1) Theta prob(y=1):	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 CHRESHOLDS IN S' DIA1\$1 DIA2\$1 DIA3\$1	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739 -0.404 -0.397	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051 0.045 0.048	52.557 50.622 80.380 52.291 39.729 23.380 hold/sD(Y) -7.303 -17.409 -14.373 -8.928 -8.348	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres	ected logit of (nold becomes int ssion of item log in logit(y) fo = 1.629 + 4.328(= 5.962 + 3.283(y=0) for sercept: exercept: exercept: exercept: exercept on The rain and the rain	if Theta=0,	Theta prob(y=1): prob(y=1):	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 CHRESHOLDS IN S' DIA1\$1 DIA2\$1 DIA3\$1 DIA4\$1	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739 -0.404	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051 0.045	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303 -17.409 -14.373 -8.928	0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres	ected logit of (nold becomes int ssion of item log in logit(y) fo = 1.629 + 4.328(= 5.962 + 3.283(y=0) for sercept: exercept: exercept: exercept: exercept on The rain and the rain	if Theta=0,	Theta prob(y=1): prob(y=1):	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 PHRESHOLDS IN S' DIA1\$1 DIA2\$1 DIA3\$1 DIA4\$1 DIA5\$1	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739 -0.404 -0.397	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051 0.045 0.048	52.557 50.622 80.380 52.291 39.729 23.380 hold/sD(Y) -7.303 -17.409 -14.373 -8.928 -8.348	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expe When *-1, thresh Loading = regres	ected logit of (hold becomes into ssion of item login logit (y) for = 1.629 + 4.328(= 5.962 + 3.283(y=0) for sercept: exercept: exercept	if Theta=0, if Theta=0,	Theta prob(y=1): prob(y=1):	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 PHRESHOLDS IN S: DIA1\$1 DIA2\$1 DIA3\$1 DIA4\$1 DIA4\$1 DIA5\$1 DIA6\$1	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739 -0.404 -0.397 -0.626	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051 0.045 0.048 0.050	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303 -17.409 -14.373 -8.928 -8.348 -12.558	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expense when *-1, threshold = regress = change IFA Models: Logit (DIA1=1) = Logit (DIA7=1) = USING RESULTS	ected logit of (hold becomes into a sion of item logit (y) for a single	y=0) for sercept: exercept: exercept	if Theta=0, if Theta=0, if Theta=1, if Theta=1,	Theta prob(y=1): prob(y=1):	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 CHRESHOLDS IN S: DIA1\$1 DIA2\$1 DIA3\$1 DIA4\$1 DIA5\$1 DIA5\$1 DIA5\$1 DIA5\$1	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739 -0.404 -0.397 -0.626 -1.590 dardized loading	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051 0.045 0.048 0.050 0.080	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303 -17.409 -14.373 -8.928 -8.348 -12.558 -19.949	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expense when *-1, threshold = regres = change IFA Models: Logit (DIA1=1) = Logit (DIA7=1) = USING RESULTS IRT model: Logit a = discriminati	ected logit of (hold becomes into the single of item logit (y) for the single of item logit (y) for the single of	y=0) for sercept: exercept: exercept	if Theta=0, if Theta=0, if Theta=1, if Theta=1,	<pre>prob(y=1): prob(y=1): prob(y=1):</pre>	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 CHRESHOLDS IN S: DIA1\$1 DIA2\$1 DIA3\$1 DIA4\$1 DIA5\$1 DIA5\$1 DIA5\$1 DIA5\$1	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739 -0.404 -0.397 -0.626 -1.590	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051 0.045 0.048 0.050 0.080	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303 -17.409 -14.373 -8.928 -8.348 -12.558	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expense when *-1, threshold = regress = change IFA Models: Logit (DIA1=1) = Logit (DIA7=1) = USING RESULTS	ected logit of (hold becomes into the single of item logit (y) for the single of item logit (y) for the single of	y=0) for sercept: exercept: exercept	if Theta=0, if Theta=0, if Theta=1, if Theta=1,	<pre>prob(y=1): prob(y=1): prob(y=1):</pre>	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 **HRESHOLDS IN S: DIA1\$1 DIA2\$1 DIA2\$1 DIA3\$1 DIA4\$1 DIA5\$1 DIA5\$1 DIA5\$1 DIA5\$1 DIA5\$1 DIA5\$1 DIA5\$1 DIA6\$1 DIA6\$1 DIA7\$1	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739 -0.404 -0.397 -0.626 -1.590 dardized loading	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051 0.045 0.048 0.050 0.080	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303 -17.409 -14.373 -8.928 -8.348 -12.558 -19.949	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expense when *-1, threshold = regres = change IFA Models: Logit (DIA1=1) = Logit (DIA7=1) = USING RESULTS IRT model: Logit a = discriminati	ected logit of (hold becomes into the single of item logit (y) for the single of item logit (y) for the single of	y=0) for sercept: exercept: exercept	if Theta=0, if Theta=0, if Theta=1, if Theta=1,	<pre>prob(y=1): prob(y=1): prob(y=1):</pre>	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 **HRESHOLDS IN S** DIA1\$1 DIA2\$1 DIA3\$1 DIA3\$1 DIA4\$1 DIA5\$1 DIA5\$1 DIA5\$1 DIA5\$1 DIA5\$1 DIA5\$1 CHAS\$1 DIA5\$1 DIA5\$1 DIA6\$1 DIA7\$1	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739 -0.404 -0.397 -0.626 -1.590 dardized loading 0.851	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051 0.045 0.048 0.050 0.080	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303 -17.409 -14.373 -8.928 -8.348 -12.558 -19.949	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expense when *-1, threshold = regres = change IFA Models: Logit (DIA1=1) = Logit (DIA7=1) = USING RESULTS IRT model: Logit a = discriminati b = difficulty (ected logit of (hold becomes into the single of item logit (y) for the single of item logit (y) for the single of	y=0) for sercept: exercept: exercept	if Theta=0, if Theta=0, if Theta=1, if Theta=1,	<pre>prob(y=1): prob(y=1): prob(y=1):</pre>	= .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 **HRESHOLDS IN S** DIA1\$1 DIA2\$1 DIA3\$1 DIA4\$1 DIA5\$1 DIA5\$1 DIA5\$1 DIA6\$1 DIA7\$1 **L-SQUARE = stand DIA1 DIA2 DIA3	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739 -0.404 -0.397 -0.626 -1.590 dardized loading 0.851 0.883 0.850	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051 0.045 0.048 0.050 0.080 2 0.033 0.034 0.034	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303 -17.409 -14.373 -8.928 -8.348 -12.558 -19.949 25.856 26.278 25.311	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expension when *-1, threshold = regres = change IFA Models: Logit (DIA1=1) = Logit (DIA7=1) = USING RESULTS IRT model: Logit a = discriminati b = difficulty (DIA7 = 1) IRT Models:	ected logit of (nold becomes into sion of item logit (y) for single for singl	y=0) for secrept: exercipe on The range of t	if Theta=0, if Theta=0, if Theta=1) itty) ding/1.7 if threshol	Theta prob(y=1): prob(y=1): prob(y=1):	= .836 = .997
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 CHRESHOLDS IN S' DIA1\$1 DIA2\$1 DIA3\$1 DIA4\$1 DIA5\$1 DIA5\$1 DIA6\$1 DIA7\$1 C-SQUARE = stance DIA1 DIA2 DIA3 DIA4	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739 -0.404 -0.397 -0.626 -1.590 dardized loading 0.851 0.851 0.850 0.945	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051 0.045 0.048 0.050 0.080 2 0.033 0.034 0.034 0.034 0.024	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303 -17.409 -14.373 -8.928 -8.348 -12.558 -19.949 25.856 26.278 25.311 40.190	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expension when *-1, threshold = regress = change IFA Models: Logit (DIAI=1) = Logit (DIA7=1) = USING RESULTS IRT model: Logit a = discriminati b = difficulty (DIAI=1) = IRT Models: Logit (DIAI=1) = IRT Models: Logit (DIAI=1) = IRT Models:	ected logit of (nold becomes into sion of item logit (y) for sin l	y=0) for sercept: exercept: exercept	if Theta=0, GHT PANEL) Lity) ding/1.7 e) = threshol if Theta=0,	<pre>prob(y=1): prob(y=1): d/loading prob(y=1):</pre>	= .836 = .997 = .836
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7 CHRESHOLDS IN S' DIA1\$1 DIA2\$1 DIA3\$1 DIA4\$1 DIA5\$1 DIA5\$1 DIA5\$1 DIA6\$1 DIA7\$1 R-SQUARE = stance DIA1 DIA2 DIA3	0.940 0.922 0.972 0.920 0.885 0.875 TANDARDIZED METR -0.347 -0.982 -0.739 -0.404 -0.397 -0.626 -1.590 dardized loading 0.851 0.883 0.850	0.018 0.018 0.012 0.018 0.022 0.037 IC = thres 0.048 0.056 0.051 0.045 0.048 0.050 0.080 2 0.033 0.034 0.034	52.557 50.622 80.380 52.291 39.729 23.380 hold/SD(Y) -7.303 -17.409 -14.373 -8.928 -8.348 -12.558 -19.949 25.856 26.278 25.311	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expension when *-1, threshold = regres = change IFA Models: Logit (DIA1=1) = Logit (DIA7=1) = USING RESULTS IRT model: Logit a = discriminati b = difficulty (DIA7 = 1) IRT Models:	ected logit of (nold becomes into sion of item logit (y) for sin l	y=0) for sercept: exercept: exercept	if Theta=0, GHT PANEL) Lity) ding/1.7 e) = threshol if Theta=0,	<pre>prob(y=1): prob(y=1): d/loading prob(y=1):</pre>	= .836 = .997 = .836



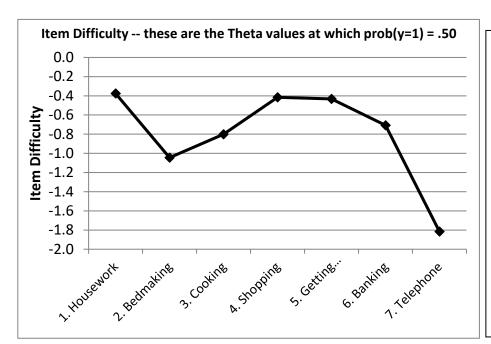


Distribution of Theta under 2 PL (made in Mplus): Although reliability is > .80 from −1.5 to 0.3 or so, we see a huge ceiling effect: most respondents can do all the tasks.





The estimated theta scores are supposed to have a mean of 0 and a variance of 1, but this table shows that they have a variance of only .741 instead. Such shrinkage is why it can be problematic to use these estimated theta scores as observed variables in other analyses.



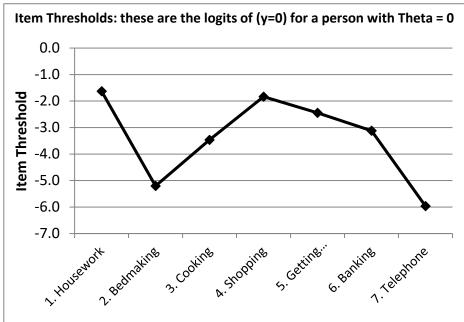
Plots of item parameters and predicted probabilities of item responses (made in excel):

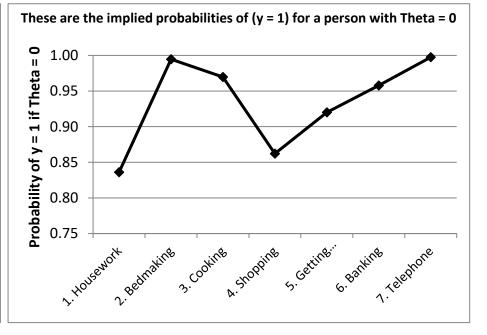
Top Left: Note that no items are available to measure above-average abilities well! The item difficulty for most items covers values of Theta between -1.0 to -0.5.

Bottom Left: These are the thresholds for each item, or the logit of (y=0) if Theta=0. These are hard to interpret as is....

Bottom Right: These are the probability of y=1 if Theta=0, as given by 1 - [exp(threshold) / (1+(exp(threshold))]

See excel workbook for calculations and plots





Here is another estimation approach: a 2PL vs. a 1PL for Binary Responses using WLSMV Probit model

```
TITLE: 2PL Binary Model under limited-info WLSMV
                                                                       TITLE: 1PL Binary Model under limited-info WLSMV
DATA: FILE = Example5.csv; ! Don't need path if in same folder
                                                                       DATA: FILE = Example5.csv; ! Don't need path if in same folder
VARIABLE: NAMES = case dia1-dia7 cia1-cia7;
                                                                                  NAMES = case dial-dia7 cial-cia7:
            USEVARIABLES = dia1-dia7;
                                               ! All wars in data
                                                                                   USEVARIABLES = dia1-dia7;
                                                                                                                      ! All vars in data
            CATEGORICAL = dia1-dia7;
                                               ! All vars in model
                                                                                   CATEGORICAL = dia1-dia7;
                                                                                                                      ! All vars in model
            MISSING = ALL (99999);
                                               ! Missing value code
                                                                                   MISSING = ALL (99999);
                                                                                                                      ! Missing value code
            IDVARIABLE = case;
                                               ! Person ID variable
                                                                                   IDVARIABLE = case;
                                                                                                                      ! Person ID variable
                                         ! Limited-info in probits
                                                                       ANALYSIS:
                                                                                  ESTIMATOR = WLSMV;
                                                                                                                ! Limited-info in probits
ANALYSIS:
           ESTIMATOR = WLSMV;
            PARAMETERIZATION = THETA;
                                        ! Error vars=1 scaling
                                                                                   PARAMETERIZATION = THETA;
                                                                                                               ! Error vars=1 scaling
                                         ! For OS comparability
                                                                                                               ! For OS comparability
            CONVERGENCE = 0.0000001;
                                                                                   CONVERGENCE = 0.0000001;
                                                                                   DIFFTEST=2PL.dat: ! Use saved info from bigger model
MODEL:
                                                                       MODEL:
! Factor loadings all estimated in 2PL
                                                                       ! Factor loadings all equal in 1PL
    IADL BY dia1-dia7*;
                                                                           IADL BY dia1-dia7* (loading);
! Item thresholds all estimated
                                                                       ! Item thresholds all estimated
    [dia1$1-dia7$1*];
                                                                           [dia1$1-dia7$1*];
! Factor mean=0 and variance=1 for identification
                                                                       ! Factor mean=0 and variance=1 for identification
    [IADL@01; IADL@1;
                                                                           [IADL@01; IADL@1;
OUTPUT:
            STDYX RESIDUAL:
                               ! Standardized solution, local fit
                                                                       OUTPUT:
                                                                                                      ! Standardized solution, local fit
                                                                                   STDYX RESIDUAL:
SAVEDATA:
           DIFFTEST=2PL.dat: ! Save info from bigger model
                                                                       SAVEDATA:
            SAVE = FSCORES:
                                       ! Save factor scores (thetas)
                                                                                   SAVE = FSCORES:
                                                                                                              ! Save factor scores (thetas)
            FILE = IADL 2PLThetas.dat; ! File thetas saved to
                                                                                   FILE = IADL 1PLThetas.dat; ! File thetas saved to
            MISSFLAG = \overline{99999};
                                       ! Missing data value in file
                                                                                   MISSFLAG = \overline{99999};
                                                                                                              ! Missing data value in file
                                                                                                              ! Get all IRT plots
       TYPE IS PLOT1 PLOT2 PLOT3;
                                       ! Get all IRT plots
                                                                              TYPE IS PLOT1 PLOT2 PLOT3;
PLOT:
MODEL FIT INFORMATION
                                                                       MODEL FIT INFORMATION
                                                                       Number of Free Parameters
Number of Free Parameters
                                                1 4
Chi-Square Test of Model Fit
                                                                       Chi-Square Test of Model Fit
                                                                                                                   64.889*
          Value
                                            54.820*
                                                                                 Value
          Degrees of Freedom
                                                14
                                                                                 Degrees of Freedom
                                                                                                                       20
          P-Value
                                            0.0000
                                                                                 P-Value
                                                                                                                   0.0000
* The chi-square value for MLM, MLMV, MLR, ULSMV, WLSM and WLSMV
cannot be used for chi-square difference testing in the regular
                                                                       Chi-Square Test for Difference Testing
way. MLM, MLR and WLSM chi-square difference testing is described
                                                                                                                   17.874
on the Mplus website. MLMV, WLSMV, and ULSMV difference testing is
                                                                                 Degrees of Freedom
done using the DIFFTEST option.
                                                                                 P-Value
                                                                                                                   0.0066
RMSEA (Root Mean Square Error Of Approximation)
                                                                       RMSEA (Root Mean Square Error Of Approximation)
          Estimate
                                             0.068
                                                                                 Estimate
                                                                                                                    0.059
          90 Percent C.I.
                                             0.049 0.087
                                                                                 90 Percent C.I.
                                                                                                                    0.044 0.076
          Probability RMSEA <= .05
                                             0.055
                                                                                 Probability RMSEA <= .05
                                                                                                                    0.154
CFT/TLT
                                                                       CFT/TLT
          CFT
                                             0.997
                                                                                 CFT
                                                                                                                    0.996
          TIT
                                             0.995
                                                                                 TLI
                                                                                                                    0.996
Chi-Square Test of Model Fit for the Baseline Model
                                                                       SRMR (Standardized Root Mean Square Residual)
                                         12351.798
          Degrees of Freedom
                                                                       The Chi-Square for Difference Testing tells us directly that the
          P-Value
                                            0.0000
                                                                       2PL version of the binary model fits significantly better
SRMR (Standardized Root Mean Square Residual)
                                                                       (now under WLSMV, same as it did under ML).
                                             0.037
```

Here are the parameter estimates under WLSMV Theta Parameterization (Probit) for the 2PL version of binary items

	ED MODEL RESUL.	TS (IF	A MODEL S	•	(output from s	same model c	continue	d)	
	Datimata	0 11		Two-Tailed					
	Estimate	S.E.	Est./S.E.	P-Value	IRT PARAMETER	IZATION IN T	WO-PARAI	METER PRO	BIT METRIC
FACTOR LOADINGS	= CHANGE IN PROBI	T(Y=1)	PER UNIT CH	ANGE IN THETA	WHERE THE PROP	BIT IS DISCR	ITANIMI	ON* (THETA	A - DIFFICULTY
IADL BY		•							
DIA1	2.686	0.317	8.461	0.000	Item Discriminati	ons.			
DIA2	2.941	0.493	5.966	0.000	IADL BY				
DIA3	2.803	0.384	7.290	0.000	DIA1	2.686	0.317	8.461	0.000
DIA4	3.654	0.575	6.356	0.000	DIA2	2.941	0.493	5.966	0.000
DIA5	2.486	0.294	8.449	0.000	DIA3	2.803	0.384	7.290	0.000
DIA5	1.991	0.223	8.940	0.000	DIA4	3.654	0.575	6.356	0.000
					DIA5	2.486	0.294	8.449	0.000
DIA7	1.571	0.299	5.246	0.000	DIA6	1.991	0.223	8.940	0.000
					DIA6 DIA7	1.571	0.223	5.246	0.000
	PECTED PROBIT (Y=0)						0.299	3.246	0.000
DIA1\$1	-1.004	0.179	-5.607	0.000	Item Difficulties		0 055	6 540	0.000
DIA2\$1	-3.097	0.481	-6.444	0.000	DIA1\$1	-0.374	0.055	-6.743	0.000
DIA3\$1	-2.221	0.307	-7.240	0.000	DIA2\$1	-1.053	0.069	-15.360	0.000
DIA4\$1	-1.581	0.298	-5.312	0.000	DIA3\$1	-0.792	0.062	-12.863	0.000
DIA5\$1	-1.057	0.174	-6.071	0.000	DIA4\$1	-0.433	0.054	-7.982	0.000
DIA6\$1	-1.391	0.166	-8.359	0.000	DIA5\$1	-0.425	0.056	-7.607	0.000
DIA7\$1	-2.946	0.398	-7.401	0.000	DIA6\$1	-0.699	0.063	-11.084	0.000
DTW I ST	-2.940	0.390	- / . 401	0.000	DIA7\$1	-1.875	0.154	-12.191	0.000
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	Logit = 1.7*probi	t, or Probit =	Logit/1.7	7	
					TTT	14	14 . 14	· · · · · /ml· · · · · ·	
FACTOR LOADINGS	IN STANDARDIZED M	ETRIC =	loading*SD		IFA model: PROBIT				+b
FACTOR LOADINGS	IN STANDARDIZED M	ETRIC =	loading*SD		Threshold = expec	ted probit of	(y=0) for	someone wi	
	IN STANDARDIZED M	METRIC = 0.013	loading*SD		Threshold = expec When *-1, thresho	eted probit of old > intercept	(y=0) for t: expecte	someone wi	
IADL BY			_	(Theta)/SD(Y)	Threshold = expec	eted probit of old > intercept	(y=0) for t: expecte	someone wi	
IADL BY DIA1 DIA2	0.937 0.947	0.013 0.016	69.487 57.551	(Theta)/SD(Y) 0.000 0.000	Threshold = expec When *-1, thresho	eted probit of old > intercept	(y=0) for t: expecte	someone wi	
IADL BY DIA1 DIA2 DIA3	0.937 0.947 0.942	0.013 0.016 0.015	69.487 57.551 64.551	(Theta)/SD(Y) 0.000 0.000 0.000	Threshold = expec When *-1, thresho Loading = regress	eted probit of old > interception of item pr	(y=0) for t: expecte obit on Th	someone wi d probit foneta	
IADL BY DIA1 DIA2 DIA3 DIA4	0.937 0.947 0.942 0.965	0.013 0.016 0.015 0.011	69.487 57.551 64.551 91.196	(Theta)/SD(Y) 0.000 0.000 0.000 0.000	Threshold = expec When *-1, thresho Loading = regress IRT model: Probit	tted probit of old → interception of item pr c(y=1) = a(thet	<pre>(y=0) for t: expecte obit on Th a - diffice</pre>	someone wind probit foneta	
IADL BY DIA1 DIA2 DIA3 DIA4 DIA5	0.937 0.947 0.942 0.965 0.928	0.013 0.016 0.015 0.011 0.015	69.487 57.551 64.551 91.196 60.671	(Theta)/SD(Y) 0.000 0.000 0.000 0.000 0.000	Threshold = expec When *-1, thresho Loading = regress IRT model: Probit a = discriminatio	tted probit of old → interception of item protection of item protection (y=1) = a(theten (rescaled sl	<pre>(y=0) for t: expecte obit on Th a - diffic ope) = loa</pre>	someone wind probit for the control of the control	or (y=1) instead
DIA1 DIA2 DIA3 DIA4 DIA5 DIA6	0.937 0.947 0.942 0.965 0.928 0.894	0.013 0.016 0.015 0.011 0.015 0.020	69.487 57.551 64.551 91.196 60.671 44.371	(Theta)/SD(Y) 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expec When *-1, thresho Loading = regress IRT model: Probit	tted probit of old → interception of item protection of item protection (y=1) = a(theten (rescaled sl	<pre>(y=0) for t: expecte obit on Th a - diffic ope) = loa</pre>	someone wind probit for the control of the control	or (y=1) instead
IADL BY DIA1 DIA2 DIA3 DIA4 DIA5	0.937 0.947 0.942 0.965 0.928	0.013 0.016 0.015 0.011 0.015	69.487 57.551 64.551 91.196 60.671	(Theta)/SD(Y) 0.000 0.000 0.000 0.000 0.000	Threshold = expec When *-1, thresho Loading = regress IRT model: Probit a = discriminatio	tted probit of old → interception of item protection of item protection (y=1) = a(theten (rescaled sl	<pre>(y=0) for t: expecte obit on Th a - diffic ope) = loa</pre>	someone wind probit for the control of the control	or (y=1) instead
IADL BY DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7	0.937 0.947 0.942 0.965 0.928 0.894	0.013 0.016 0.015 0.011 0.015 0.020 0.046	69.487 57.551 64.551 91.196 60.671 44.371 18.195	(Theta)/SD(Y) 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expec When *-1, thresho Loading = regress IRT model: Probit a = discriminatio	tted probit of old → interception of item protection of item protection (y=1) = a(theten (rescaled sl	<pre>(y=0) for t: expecte obit on Th a - diffic ope) = loa</pre>	someone wind probit for the control of the control	or (y=1) instead
IADL BY DIA1 DIA2 DIA3 DIA4 DIA5 DIA6 DIA7	0.937 0.947 0.942 0.965 0.928 0.894 0.844	0.013 0.016 0.015 0.011 0.015 0.020 0.046	69.487 57.551 64.551 91.196 60.671 44.371 18.195	(Theta)/SD(Y) 0.000 0.000 0.000 0.000 0.000 0.000 0.000	Threshold = expec When *-1, thresho Loading = regress IRT model: Probit a = discriminatio b = difficulty (1	eted probit of old interception of item problem problem problem problem problem (y=1) = a(thet on (rescaled slocation on lat	(y=0) for t: expecte obit on Th a - diffic ope) = los ent metric	someone wind probit for the country adding of the country because	or (y=1) instead
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Extensive Results Section (in which model fit via WLSMV is reported first, followed by full-information MML as "better" version of model parameters). Note this is *way* more text than one would typically write, but I provide it here for completeness:

Psychometric assessment for the extent to which a single latent trait could predict that associations among the 7 binary items measuring physical capacity was conducted using Item Factor Analysis (IFA) in Mplus v 8.4 (Muthén and Muthén, 1998–2017). These models use a link function (i.e., logit or probit) and a conditional Bernoulli response distribution to predict the conditional probability of a response = 1 (instead of 0) from a linear model as $Link(y_{is} = 1) = -\tau_i + \lambda_i F_s$. In this item model, $-\tau_i$ is the item-specific threshold, which when multiplied by -1 becomes an intercept that gives the link-transformed probability of response $y_{is} = 1$ (for item i and subject s) at a latent trait score F for subject s of 0, and t is an item-specific factor loading for the expected change in the link-transformed response for a one-unit change in F_s . No separate item-specific residual variances can be estimated given these items' binary response options.

The current gold standard of estimation for IFA models is marginal maximum likelihood (MML), in which the term marginal refers to the full-information process of allowing all possible trait values for each person in the analysis using adaptive Gaussian quadrature with 15 points per latent trait. Accordingly, measures of model fit when using MML involve the contingency table of all possible responses to all items. In our 7 items, the full contingency table generates up to $2^7 = 128$ possible cells. Consequently, no measures of absolute fit would be valid for the current sample of 635 respondents (which would need a minimum expected count of 5 respondents within each possible cell). Instead, we conducted assessment of model fit via a limited-information diagonally weighted least squares estimator using a mean- and variance-corrected x2 (i.e., WLSMV in Mplus with the THETA parameterization and a probit link function). In the WLSMV estimator, the item responses are first summarized into an estimated tetrachoric correlation matrix using the cross-tabulation of responses for each possible pair of items. The IFA models are then fitted to the estimated tetrachoric correlation matrix, such that traditional measures of global and local absolute fit (i.e., traditional in confirmatory factor analyses of continuous responses) can be computed by comparing the model-predicted and data-estimated tetrachoric correlation matrices. In addition to χ^2 tests of absolute fit, it also provides the Comparative Fit Index (CFI), the Standardized Root Mean Square Residual (SRMR), and the Root Mean Square Error of Approximation (RMSEA). The CFI indexes the fit of the specified model relative to a null model (of no tetrachoric correlations across items), in which CFI values ≥ .95 traditionally indicate excellent fit, Conversely, the SRMR and RMSEA index the fit of the specified model relative to a saturated model (i.e., the data-estimated tetrachoric correlations), in which SRMR and RMSEA values ≤ .06 traditionally indicate excellent fit. RMSEA also offers a 90% confidence interval and a significance test of "close fit" with a null hypothesis of .05. Local misfit can be diagnosed by examining the specific sources of discrepancy between the model-predicted and data-estimated tetrachoric correlations (i.e., as available using the RESIDUAL option in Mplus). Finally, the fit of nested models can be compared using the DIFFTEST procedure in Mplus.

A single-trait model was first fit for the 7 binary items using WLSMV, in which the latent trait mean and variance were fixed for identification to 0 and 1, respectively, and separate thresholds and factor loadings were estimated for each item. This model exhibited acceptable fit by every measure except the χ^2 test of absolute fit, χ^2 (14) = 54.820, p < .001, CFI = .997, SRMR = .037, RMSEA = .068 [CI = .049–.087, p = .055]. Examination of local misfit revealed all discrepancies between the model-predicted and data-estimated tetrachoric correlations were less than .113 in absolute value, indicating no practically significant bivariate item misfit. A reduced model in which all loadings were constrained equal across items fit significantly worse, DIFFTEST(6) = 17.874, p = .007, indicating differences in item discrimination (i.e., the extent to which each item was related to the latent trait). Thus, the original model was retained for further examination using full-information marginal maximum likelihood (MML) estimation instead (given the presence of missing item-level responses).

Model parameters obtained using MML and a logit link are shown in Table 1, which includes the IFA item parameters (thresholds and loadings), as well as their Item Response Theory (IRT) analogous parameter of item difficulty, computed as $b_i = \tau_i/\lambda_i$; IRT discrimination a_i is the same as the loading λ_i in this case. The net result of these item parameters can be described more succinctly by examining the overall reliability with which the latent trait has been measured. In IFA or IRT models—as in any kind of psychometric model with a nonlinear relationship between the item response and the latent trait—reliability is trait-specific, most often characterized by a quantity known as *test information*. For ease of interpretation, the test information function created by the items was converted to a traditional measure of reliability that ranges from 0 to 1 as reliability = information / (information +1). Figure 1 shows that test reliability is \geq .80 only from \sim 1.8 SD below the mean to 0.20 SD above the mean, after which point reliability drops off precipitously due to a lack of items with difficulty levels above 0.

(See Example 5 spreadsheet for Table 1 and Figure 1)

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