

Measurement Invariance of the Dirty Dozen: Student and Working Adult Samples

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Abstract

One or two sentences providing a **basic introduction** to the field, comprehensible to a scientist in any discipline.

Two to three sentences of **more detailed background**, comprehensible to scientists in related disciplines.

One sentence clearly stating the **general problem** being addressed by this particular study.

One sentence summarizing the main result (with the words “**here we show**” or their equivalent).

Two or three sentences explaining what the **main result** reveals in direct comparison to what was thought to be the case previously, or how the main result adds to previous knowledge.

One or two sentences to put the results into a more **general context**.

Two or three sentences to provide a **broader perspective**, readily comprehensible to a scientist in any discipline.

Keywords: keywords

Word count: X

Measurement Invariance of the Dirty Dozen: Student and Working Adult Samples

Some groups may be expected to exhibit different item-construct associations due to shifting motivational forces.

Methods

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study.

Participants

In total 1106 individuals responded to the Dirty Dozen (as well as additional scales not the focus of the current presentation). This total was comprised of 208 working adults low-stakes, 527 working adults high-stakes, and 371 students low-stakes individuals. After screening for undifferentiated responses via the R package **careless** (Yentes & Wilhelm, 2021), we retained 1054 respondents who had no more than 6 sequentially identical responses across the 12 total items.

Material

Procedure

Decrease in $\Delta\chi^2$ across models indicates a lack of invariance (typically not considered a “good thing”). Multiple indices are consulted across models, including $\Delta\chi^2$, RMSEA, CFI, TLI, BIC, and AIC.

Data analysis

We used R [Version 4.0.5; R Core Team (2021)] and the R-packages *careless* [Version 1.2.1; Yentes and Wilhelm (2021)], *foreign* [Version 0.8.81; R Core Team (2020)], *lavaan* [Version 0.6.8; Rosseel (2012)], *papaja* [Version 0.1.0.9997; Aust and Barth (2020)], and

50 *semTools* [Version 0.5.5; Jorgensen, Pornprasertmanit, Schoemann, and Rosseel (2021)] for
 51 all our analyses.

52 Results

```

53 ##
54 ## Measurement invariance models:
55 ##
56 ## Model 1 : fit.configural
57 ## Model 2 : fit.loadings
58 ## Model 3 : fit.intercepts
59 ## Model 4 : fit.means
60 ##
61 ## Chi-Squared Difference Test
62 ##
63 ##           Df    AIC    BIC   Chisq Chisq diff Df diff
64 ## fit.configural 153 37059 37640 1407.7
65 ## fit.loadings   171 37135 37626 1518.9      111.25     18
66 ## fit.intercepts 189 37230 37632 1650.5      131.54     18
67 ## fit.means      195 37344 37716 1775.9      125.40      6
68 ##           Pr(>Chisq)
69 ## fit.configural
70 ## fit.loadings    1.837e-15 ***
71 ## fit.intercepts  < 2.2e-16 ***
72 ## fit.means       < 2.2e-16 ***
73 ## ---
74 ## Signif. codes:
75 ## 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

76 ##
77 ##
78 ## Fit measures:
79 ##
80 ##          cfi rmsea cfi.delta rmsea.delta
81 ## fit.configural 0.641 0.153      NA      NA
82 ## fit.loadings   0.615 0.150    0.027    0.003
83 ## fit.intercepts 0.582 0.148    0.032    0.001
84 ## fit.means      0.548 0.152    0.034    0.004

85 ## lavaan 0.6-8 ended normally after 108 iterations
86 ##
87 ##   Estimator                      ML
88 ##   Optimization method          NLMINB
89 ##   Number of model parameters    117
90 ##
91 ##   Number of observations per group:
92 ##     working adults low-stakes    191
93 ##     working adults high-stakes   510
94 ##     students low-stakes          351
95 ##
96 ## Model Test User Model:
97 ##
98 ##   Test statistic                  1407.674
99 ##   Degrees of freedom              153
100 ##   P-value (Chi-square)           0.000
101 ##   Test statistic for each group:
102 ##     working adults low-stakes    182.467

```

103	##	working adults high-stakes	523.812
104	##	students low-stakes	701.395
105	##		
106	##	Model Test Baseline Model:	
107	##		
108	##	Test statistic	3696.466
109	##	Degrees of freedom	198
110	##	P-value	0.000
111	##		
112	##	User Model versus Baseline Model:	
113	##		
114	##	Comparative Fit Index (CFI)	0.641
115	##	Tucker-Lewis Index (TLI)	0.536
116	##		
117	##	Loglikelihood and Information Criteria:	
118	##		
119	##	Loglikelihood user model (H0)	-18412.727
120	##	Loglikelihood unrestricted model (H1)	-17708.890
121	##		
122	##	Akaike (AIC)	37059.454
123	##	Bayesian (BIC)	37639.593
124	##	Sample-size adjusted Bayesian (BIC)	37267.983
125	##		
126	##	Root Mean Square Error of Approximation:	
127	##		
128	##	RMSEA	0.153
129	##	90 Percent confidence interval - lower	0.146

```

130 ##    90 Percent confidence interval - upper          0.160
131 ##    P-value RMSEA <= 0.05                          0.000
132 ##
133 ## Standardized Root Mean Square Residual:
134 ##
135 ##    SRMR                                              0.110
136 ##
137 ## Parameter Estimates:
138 ##
139 ##    Standard errors                                Standard
140 ##    Information                                    Expected
141 ##    Information saturated (h1) model              Structured
142 ##
143 ##
144 ## Group 1 [working adults low-stakes]:
145 ##
146 ## Latent Variables:
147 ##              Estimate  Std.Err  z-value  P(>|z|)
148 ##    mach =~
149 ##      A30              1.000
150 ##      A31              0.392    0.095    4.111    0.000
151 ##      A32              0.224    0.096    2.332    0.020
152 ##      A33              0.538    0.063    8.507    0.000
153 ##    narc =~
154 ##      A34              1.000
155 ##      A35              0.262    0.263    0.996    0.319
156 ##      A36              1.982    0.367    5.394    0.000

```

```

157 ##      A37              1.752    0.332    5.277    0.000
158 ##    psyc =~
159 ##      A38              1.000
160 ##      A39              1.328    0.240    5.541    0.000
161 ##      A40              0.820    0.195    4.196    0.000
162 ##      A41              0.814    0.205    3.969    0.000
163 ##
164 ## Covariances:
165 ##              Estimate Std.Err  z-value  P(>|z|)
166 ##    mach ~~
167 ##      narc              0.311    0.066    4.691    0.000
168 ##      psyc              0.700    0.144    4.859    0.000
169 ##    narc ~~
170 ##      psyc              0.251    0.065    3.863    0.000
171 ##
172 ## Intercepts:
173 ##              Estimate Std.Err  z-value  P(>|z|)
174 ##    .A30              1.948    0.089   21.789    0.000
175 ##    .A31              1.901    0.083   22.999    0.000
176 ##    .A32              4.607    0.083   55.484    0.000
177 ##    .A33              1.340    0.056   24.095    0.000
178 ##    .A34              1.393    0.061   22.680    0.000
179 ##    .A35              4.267    0.091   46.791    0.000
180 ##    .A36              1.890    0.083   22.892    0.000
181 ##    .A37              1.508    0.078   19.429    0.000
182 ##    .A38              2.984    0.122   24.507    0.000
183 ##    .A39              1.759    0.087   20.119    0.000

```


184	##	.A40	2.031	0.100	20.231	0.000
185	##	.A41	3.288	0.109	30.174	0.000
186	##	mach	0.000			
187	##	narc	0.000			
188	##	psyc	0.000			
189	##					
190	##	Variances:				
191	##		Estimate	Std.Err	z-value	P(> z)
192	##	.A30	0.678	0.099	6.865	0.000
193	##	.A31	1.174	0.122	9.608	0.000
194	##	.A32	1.274	0.131	9.725	0.000
195	##	.A33	0.345	0.041	8.401	0.000
196	##	.A34	0.562	0.063	8.951	0.000
197	##	.A35	1.578	0.162	9.753	0.000
198	##	.A36	0.682	0.099	6.890	0.000
199	##	.A37	0.666	0.088	7.523	0.000
200	##	.A38	2.350	0.247	9.509	0.000
201	##	.A39	0.610	0.098	6.251	0.000
202	##	.A40	1.601	0.168	9.514	0.000
203	##	.A41	1.948	0.204	9.572	0.000
204	##	mach	0.848	0.157	5.419	0.000
205	##	narc	0.158	0.052	3.008	0.003
206	##	psyc	0.482	0.172	2.812	0.005
207	##					
208	##					
209	##	Group 2 [working adults high-stakes]:				
210	##					

211 ## Latent Variables:

212 ## Estimate Std.Err z-value P(>|z|)

213 ## mach =~

214 ## A30 1.000

215 ## A31 0.495 0.059 8.361 0.000

216 ## A32 0.152 0.060 2.537 0.011

217 ## A33 0.398 0.031 12.716 0.000

218 ## narc =~

219 ## A34 1.000

220 ## A35 0.377 0.148 2.544 0.011

221 ## A36 1.683 0.188 8.946 0.000

222 ## A37 0.622 0.098 6.323 0.000

223 ## psyc =~

224 ## A38 1.000

225 ## A39 1.148 0.139 8.287 0.000

226 ## A40 0.408 0.087 4.692 0.000

227 ## A41 0.864 0.142 6.100 0.000

228 ##

229 ## Covariances:

230 ## Estimate Std.Err z-value P(>|z|)

231 ## mach ~~

232 ## narc 0.336 0.038 8.881 0.000

233 ## psyc 0.579 0.079 7.293 0.000

234 ## narc ~~

235 ## psyc 0.251 0.039 6.388 0.000

236 ##

237 ## Intercepts:

238	##		Estimate	Std.Err	z-value	P(> z)
239	##	.A30	1.761	0.050	34.986	0.000
240	##	.A31	1.727	0.047	36.930	0.000
241	##	.A32	4.788	0.047	101.300	0.000
242	##	.A33	1.204	0.025	48.421	0.000
243	##	.A34	1.224	0.033	36.737	0.000
244	##	.A35	4.422	0.050	87.885	0.000
245	##	.A36	1.825	0.050	36.532	0.000
246	##	.A37	1.198	0.030	39.522	0.000
247	##	.A38	3.076	0.075	40.922	0.000
248	##	.A39	1.539	0.044	35.365	0.000
249	##	.A40	1.557	0.048	32.693	0.000
250	##	.A41	2.800	0.069	40.364	0.000
251	##	mach	0.000			
252	##	narc	0.000			
253	##	psyc	0.000			
254	##					
255	##	Variances:				
256	##		Estimate	Std.Err	z-value	P(> z)
257	##	.A30	0.564	0.053	10.564	0.000
258	##	.A31	0.938	0.061	15.403	0.000
259	##	.A32	1.123	0.070	15.926	0.000
260	##	.A33	0.200	0.014	14.029	0.000
261	##	.A34	0.434	0.030	14.306	0.000
262	##	.A35	1.272	0.080	15.941	0.000
263	##	.A36	0.902	0.068	13.291	0.000
264	##	.A37	0.418	0.027	15.564	0.000

```

265 ##      .A38              2.415    0.158    15.304    0.000
266 ##      .A39              0.350    0.048     7.324    0.000
267 ##      .A40              1.079    0.069    15.726    0.000
268 ##      .A41              2.105    0.137    15.401    0.000
269 ##      mach              0.728    0.083     8.767    0.000
270 ##      narc              0.131    0.026     4.974    0.000
271 ##      psyc              0.468    0.108     4.315    0.000
272 ##
273 ##
274 ## Group 3 [students low-stakes]:
275 ##
276 ## Latent Variables:
277 ##              Estimate  Std.Err  z-value  P(>|z|)
278 ##      mach =~
279 ##      A30              1.000
280 ##      A31              0.322    0.076     4.220    0.000
281 ##      A32              0.424    0.063     6.764    0.000
282 ##      A33              0.854    0.078    10.963    0.000
283 ##      narc =~
284 ##      A34              1.000
285 ##      A35              1.286    0.240     5.359    0.000
286 ##      A36              1.756    0.300     5.853    0.000
287 ##      A37              1.486    0.276     5.387    0.000
288 ##      psyc =~
289 ##      A38              1.000
290 ##      A39              1.430    0.150     9.551    0.000
291 ##      A40              0.785    0.119     6.627    0.000

```

```

292 ##      A41              1.130    0.140    8.083    0.000
293 ##
294 ## Covariances:
295 ##              Estimate Std.Err  z-value  P(>|z|)
296 ##  mach ~~
297 ##      narc              0.433    0.076    5.678    0.000
298 ##      psyc              0.794    0.105    7.585    0.000
299 ##  narc ~~
300 ##      psyc              0.326    0.060    5.403    0.000
301 ##
302 ## Intercepts:
303 ##              Estimate Std.Err  z-value  P(>|z|)
304 ##      .A30              2.627    0.082   31.924    0.000
305 ##      .A31              2.316    0.072   32.342    0.000
306 ##      .A32              4.826    0.057   84.238    0.000
307 ##      .A33              1.801    0.066   27.348    0.000
308 ##      .A34              1.638    0.063   26.055    0.000
309 ##      .A35              4.490    0.063   70.785    0.000
310 ##      .A36              2.083    0.067   30.984    0.000
311 ##      .A37              1.892    0.072   26.127    0.000
312 ##      .A38              3.903    0.073   53.138    0.000
313 ##      .A39              2.205    0.074   29.698    0.000
314 ##      .A40              1.829    0.072   25.382    0.000
315 ##      .A41              3.903    0.078   49.869    0.000
316 ##      mach              0.000
317 ##      narc              0.000
318 ##      psyc              0.000

```

319 ##

320 ## Variances:

321 ##		Estimate	Std.Err	z-value	P(> z)
322 ##	.A30	1.474	0.124	11.919	0.000
323 ##	.A31	1.707	0.129	13.240	0.000
324 ##	.A32	0.990	0.075	13.148	0.000
325 ##	.A33	0.863	0.076	11.335	0.000
326 ##	.A34	1.276	0.095	13.396	0.000
327 ##	.A35	1.227	0.093	13.238	0.000
328 ##	.A36	1.241	0.099	12.522	0.000
329 ##	.A37	1.593	0.120	13.220	0.000
330 ##	.A38	1.407	0.109	12.936	0.000
331 ##	.A39	0.938	0.085	11.028	0.000
332 ##	.A40	1.522	0.116	13.139	0.000
333 ##	.A41	1.528	0.119	12.827	0.000
334 ##	mach	0.903	0.151	5.989	0.000
335 ##	narc	0.112	0.039	2.896	0.004
336 ##	psyc	0.487	0.099	4.944	0.000

337 We looked at structural invariance as well as latent means (Meredith, 1993; Steinmetz,
 338 Schmidt, Tina-Booh, Wieczorek, & Schwartz, 2009).

339 **Discussion**

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	Constrained parameters	Free parameters	comparison model
configural	FMean (=0)	fl+inter+res+var	
Weak/loading invariance	fl+Fmean (=0)	inter+res+var	configural
Strong/scalar invariance	fl+inter	res+var+Fmean*	Weak/loading invariance
strict invariance	fl+inter+res	Fmean*+var	Strong/scalar invariance

Note. fl= factor loadings, inter = item intercepts, res = item residual variances, Fmean = mean of latent variable, var = variance of latent variable

*Fmean is fixed to 0 in group 1 and estimated in the other group(s)

Figure 1. Steps for measurement invariance (taken from Xu, 2012).