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Supplement material for

Short-Scale Construction Using Meta-Analytic Ant Colony Optimization: A Demonstration With the Need For Cognition Scale

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Table E1

Items of the Risk of Bias Scale

	Items	Response scale
1.	Was the sampling frame largely representative of the studied population?	0 = Yes, they are identical or the sampling frame is representative to a great extent (e.g., telephone directory) 1 = No, the sampling frame represents a much more specific group than the studied population or not reported or no population specified.
2.	Were appropriate methods utilized for participant recruitment?	0 = Yes, with relatively low sampling bias (e.g., random selection) 1 = No, high potential for sampling bias (e.g., convenience sample) or not reported.
3.	Is the exclusion rate of participants acceptable and falls below 10%?	0 = Yes, equal or below 10%. 1 = No, more than 10% or not reported.
4.	Is the final sample size sufficient (i.e., at least 250 for correlations or 500 for factor loadings) for the research design?	0 = Yes, equal or above the criterion. 1 = No, less than the criterion or not reported.
5.	Are the characteristics of the sample reported (demographic variables)?	0 = Yes, both age and gender are reported. 1 = No, one or both of them are not reported.
6.	Are adequate effect sizes (i.e., correlations) available?	0 = Raw data or correlations are available. 1 = Factor loadings are available.
7.	Was the study conducted in a controlled setting?	0 = Controlled environment (e.g., laboratory, interviewer-led) 1 = Uncontrolled environment (e.g., online) or not reported
8.	Are data cleaning and management procedures reported?	0 = Yes, reporting of either missing data, outliers, or invalid responses. 1 = No, all unreported.

Note. The quality of each study was rated with an adapted version of the risk of bias scale by Nudelman and Otto (2020). In comparison to the original assessment, we made two changes to adapt it to the specific conditions of the present meta-analysis (see also Gnambs & Schroeders, 2023, for a similar procedure): (a) For Item #4, we chose thresholds of 250 and 500 participants as sufficient sample sizes for correlations and factor loadings, respectively, because previous research showed that correlations and loadings tend to stabilize at these values (Hirschfeld et al., 2014; Schoenbrodt & Perugini, 2013). (b) For item #6, we decided to refer to the available data type (i.e., raw data or correlations versus factor loadings patterns) instead of the reported reliability of the measure.

Table E2

Pooled Correlations With Standard Errors and Random Effects of All Studies

	I01	I02	I03[#]	I04[#]	I05[#]	I06	I07[#]	I08[#]	I09[#]	I10	I11	I12[#]	I13	I14	I15	I16[#]	I17[#]	I18
Pooled correlations																		
I01	1.00																	
I02	.550	1.00																
I03[#]	.287	.331	1.00															
I04[#]	.334	.357	.507	1.00														
I05[#]	.269	.305	.463	.539	1.00													
I06	.421	.450	.268	.273	.228	1.00												
I07[#]	.223	.237	.374	.413	.400	.214	1.00											
I08[#]	.208	.227	.309	.370	.337	.192	.327	1.00										
I09[#]	.287	.279	.353	.465	.392	.229	.372	.383	1.00									
I10	.377	.449	.286	.293	.254	.375	.194	.175	.201	1.00								
I11	.440	.505	.304	.334	.296	.394	.215	.212	.268	.466	1.00							
I12[#]	.247	.280	.437	.439	.411	.238	.336	.290	.329	.270	.328	1.00						
I13	.447	.446	.239	.267	.207	.408	.185	.161	.235	.368	.428	.217	1.00					
I14	.368	.388	.268	.263	.243	.364	.207	.170	.209	.385	.417	.274	.408	1.00				
I15	.429	.444	.248	.289	.237	.367	.193	.171	.238	.394	.418	.231	.410	.372	1.00			
I16[#]	.203	.207	.309	.359	.337	.184	.289	.279	.323	.173	.191	.303	.159	.143	.152	1.00		
I17[#]	.227	.238	.350	.402	.374	.199	.355	.305	.347	.209	.263	.380	.176	.195	.200	.336	1.00	
I18	.226	.256	.147	.141	.127	.293	.137	.076	.097	.275	.263	.136	.246	.282	.243	.064	.115	1.00

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	I01	I02	I03#	I04#	I05#	I06	I07#	I08#	I09#	I10	I11	I12#	I13	I14	I15	I16#	I17#	I18
Standard errors (lower off-diagonal) and random effects (SD; upper off-diagonal)																		
I01		.089	.048	.049	.046	.091	.040	.035	.038	.074	.060	.046	.073	.067	.067	.033	.037	.048
I02	.010		.062	.049	.051	.084	.053	.031	.037	.076	.077	.048	.069	.078	.067	.031	.032	.051
I03#	.007	.008		.073	.073	.059	.095	.054	.051	.064	.061	.091	.048	.053	.058	.050	.066	.026
I04#	.007	.007	.009		.074	.049	.090	.062	.056	.042	.055	.071	.038	.026	.042	.049	.064	000
I05#	.007	.007	.009	.009		.055	.088	.062	.05	.048	.046	.076	.031	.030	.036	.044	.066	.019
I06	.011	.010	.008	.007	.008		.062	.044	.037	.080	.068	.037	.085	.081	.078	.040	.028	.085
I07#	.006	.008	.011	.011	.011	.008		.079	.071	.073	.056	.086	.039	.048	.052	.078	.092	.066
I08#	.006	.006	.008	.008	.008	.007	.010		.074	.032	.037	.068	.028	.035	.018	.054	.059	.048
I09#	.006	.006	.007	.007	.007	.006	.009	.009		.052	.051	.058	.030	.028	.036	.053	.053	.021
I10	.009	.009	.009	.007	.007	.010	.009	.006	.007		.108	.058	.068	.072	.068	.051	.04	.077
I11	.008	.009	.008	.007	.007	.009	.008	.006	.007	.012		.095	.070	.065	.066	.049	.051	.072
I12#	.007	.007	.011	.009	.009	.006	.011	.009	.008	.008	.011		.038	.051	.037	.050	.071	.022
I13	.009	.009	.007	.006	.006	.010	.006	.006	.006	.009	.009	.006		.095	.062	.041	.030	.063
I14	.009	.010	.007	.005	.006	.010	.007	.006	.005	.009	.008	.007	.011		.075	.016	.021	.065
I15	.009	.009	.008	.006	.006	.010	.007	.005	.006	.009	.008	.006	.008	.009		.044	.036	.055
I16#	.006	.006	.007	.007	.007	.007	.010	.008	.007	.007	.007	.007	.007	.005	.007		.056	.047
I17#	.006	.006	.009	.008	.009	.006	.011	.008	.007	.007	.007	.009	.006	.005	.006	.008		.035
I18	.007	.007	.005	.003	.005	.011	.009	.007	.005	.010	.009	.005	.008	.009	.008	.007	.006	

Note. N = 90,215 from 87 samples. # negatively keyed item

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Table E3

Meta-Analytic Exploratory Factor Loading Pattern for the NCS-18

		Single factor model		*Oblique two-factor model*		
	Item	Factor 1	h^2	Factor 1	Factor 2	h^2
I01	I would prefer complex to simple problems.	**.64**	.41	**.65**	.03	.45
I02	I like to have the responsibility of handling a situation that requires a lot of thinking.	**.69**	.47	**.70**	.04	.52
I03[#]	Thinking is not my idea of fun.	**.63**	.40	.07	**.60**	.42
I04[#]	I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.	**.68**	.46	.04	**.71**	.54
I05[#]	I try to anticipate and avoid situations where there is likely chance I will have to think in depth about something.	**.60**	.36	-.01	**.69**	.46
I06	I find satisfaction in deliberating hard and for long hours.	**.60**	.36	**.62**	.00	.38
I07[#]	I only think as hard as I have to.	**.55**	.30	-.04	**.61**	.34
I08[#]	I prefer to think about small, daily projects to long-term ones.	**.46**	.21	-.04	**.56**	.28
I09[#]	I like tasks that require little thought once I've learned them.	**.56**	.31	.01	**.61**	.37
I10	The idea of relying on thought to make my way to the top appeals to me.	**.58**	.34	**.62**	.01	.39
I11	I really enjoy a task that involves coming up with new solutions to problems.	**.66**	.44	**.65**	.06	.47
I12[#]	Learning new ways to think doesn't excite me very much.	**.60**	.36	.06	**.57**	.37
I13	I prefer my life to be filled with puzzles that I must solve.	**.55**	.30	**.68**	-.06	.41
I14	The notion of thinking abstractly is appealing to me.	**.56**	.32	**.60**	.00	.36
I15	I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.	**.56**	.31	**.63**	-.02	.39
I16[#]	I feel relief rather than satisfaction after completing a task that required a lot of mental effort.	**.42**	.17	-.06	**.55**	.27
I17[#]	It's enough for me that something gets the job done; I don't care how or why it works.	**.52**	.27	-.03	**.60**	.34
I18	I usually end up deliberating about issues even when they do not affect me personally.	.33	.11	**.46**	-.09	.17

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Eigenvalue	5.89	3.55	3.39
Proportion of variance	33%	20%	19%
Proportion of explained variance	100%	51%	49%

Note. N = 90,215 from 87 samples. # negatively keyed item; h^2 = Communality. Exploratory weighted least square factor analysis with direct oblimin rotation based on the pooled correlation matrix. The factor correlation for the oblique model was r = .59. All items were recoded in such a way that higher values indicate a higher need for cognition. Salient factor loadings with absolute values greater than .40 are in bold.

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Table E4

Parameter Estimates of Competing Measurement Models for the NCS-18

	Model 1		Model 2			Model 3				
Factor(s)	NFC		NFC_{pos}	NFC_{neg}		NFC				
λ_1	.62	λ_1	.68		λ_1	.68	$\theta_{3,4}$	.31	$\theta_{7,12}$	.21
λ_2	.66	λ_2	.74		λ_2	.74	$\theta_{3,5}$	.29	$\theta_{8,12}$	.18
λ_3	.62	λ_3		.66	λ_3	.43	$\theta_{4,5}$	.36	$\theta_{9,12}$	.18
λ_4	.67	λ_4		.75	λ_4	.46	$\theta_{3,7}$	.24	$\theta_{12,16}$	.20
λ_5	.60	λ_5		.67	λ_5	.39	$\theta_{4,7}$	.27	$\theta_{3,16}$	.19
λ_6	.53	λ_6	.62		λ_6	.62	$\theta_{5,7}$	.27	$\theta_{4,16}$	.23
λ_7	.49	λ_7		.57	λ_7	.32	$\theta_{3,8}$	.18	$\theta_{5,16}$	.23
λ_8	.45	λ_8		.51	λ_8	.29	$\theta_{4,8}$	.24	$\theta_{7,16}$	.20
λ_9	.56	λ_9		.61	λ_9	.38	$\theta_{5,8}$	.22	$\theta_{8,16}$	.20
λ_{10}	.56	λ_{10}	.63		λ_{10}	.63	$\theta_{7,8}$	.23	$\theta_{9,16}$	.22
λ_{11}	.65	λ_{11}	.70		λ_{11}	.70	$\theta_{3,9}$	.19	$\theta_{12,17}$	.25
λ_{12}	.56	λ_{12}		.62	λ_{12}	.39	$\theta_{4,9}$	.29	$\theta_{16,17}$	.25
λ_{13}	.54	λ_{13}	.61		λ_{13}	.61	$\theta_{5,9}$	.24	$\theta_{3,17}$	.21
λ_{14}	.52	λ_{14}	.60		λ_{14}	.60	$\theta_{7,9}$	.25	$\theta_{4,17}$	.25
λ_{15}	.55	λ_{15}	.62		λ_{15}	.62	$\theta_{8,9}$	.27	$\theta_{5,17}$	.24
λ_{16}	.44	λ_{16}		.49	λ_{16}	.27	$\theta_{3,12}$	.27	$\theta_{7,17}$	.25
λ_{17}	.50	λ_{17}		.57	λ_{17}	.33	$\theta_{4,12}$	.26	$\theta_{8,17}$	.21
λ_{18}	.29	λ_{18}	.36		λ_{18}	.36	$\theta_{5,12}$	.26	$\theta_{9,17}$	.22
		$r_{\text{pos, neg}}$	.60							
ω	.89		.85	.84		.85				
Model fit										
χ^2	9,515.5	χ^2	1,486.0		χ^2	927.7				
df	135	*df*	134		*df*	99				
NNFI	.805	NNFI	.972		NNFI	.977				
CFI	.828	CFI	.975		CFI	.985				
RMSEA	.028	RMSEA	.011		RMSEA	.009				
SRMR	.081	SRMR	.056		SRMR	.019				

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Factor(s)	Model 4 NFC	Model 4 NFC_{pos}	Model 4 NFC_{neg}		Model 5 NFC	Model 5 NFC_{neg}		Model 6 NFC	Model 6 Acqui.
λ_1	.43	.51		λ_1	.68		λ_1	.62	-.28
λ_2	.47	.55		λ_2	.74		λ_2	.66	-.28
λ_3	.70		-.09	λ_3	.43	.47	λ_3	.60	.28
λ_4	.75		.09	λ_4	.46	.59	λ_4	.67	.28
λ_5	.66		.11	λ_5	.39	.55	λ_5	.59	.28
λ_6	.38	.49		λ_6	.62		λ_6	.56	-.28
λ_7	.54		.24	λ_7	.32	.50	λ_7	.50	.28
λ_8	.47		.30	λ_8	.29	.43	λ_8	.46	.28
λ_9	.58		.29	λ_9	.38	.48	λ_9	.55	.28
λ_{10}	.39	.48		λ_{10}	.63		λ_{10}	.56	-.28
λ_{11}	.45	.51		λ_{11}	.70		λ_{11}	.63	-.28
λ_{12}	.63		-.01	λ_{12}	.40	.45	λ_{12}	.56	.28
λ_{13}	.35	.54		λ_{13}	.61		λ_{13}	.54	-.28
λ_{14}	.37	.48		λ_{14}	.60		λ_{14}	.54	-.28
λ_{15}	.37	.50		λ_{15}	.62		λ_{15}	.55	-.28
λ_{16}	.46		.24	λ_{16}	.27	.43	λ_{16}	.44	.28
λ_{17}	.54		.21	λ_{17}	.33	.48	λ_{17}	.51	.28
λ_{18}	.19	.35		λ_{18}	.36		λ_{18}	.33	-.28
ω	.85	.74	.18		.85	.74		.89	
Model fit									
χ^2	895.2			χ^2	1,243.5		χ^2	1,242.0	
df	117			*df*	126		*df*	134	
NNFI	.981			NNFI	.975		NNFI	.977	
CFI	.986			CFI	.980		CFI	.980	
RMSEA	.009			RMSEA	.010		RMSEA	.010	
SRMR	.019			SRMR	.023		SRMR	.023	

Note. N = 90,215 from 87 samples., λ = factor loadings; θ = residual correlations, ω = reliability index. CFI = comparative fit index; NNFI = non-normed fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean residual; Acqui. = Acquiescence.

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Table E5

Short Versions Derived With MASEM ACO

Number of Items	Selected Items																	
	I1	I2	I3[#]	I4[#]	I5[#]	I6	I7[#]	I8[#]	I9[#]	I10	I11	I12[#]	I13	I14	I15	I16[#]	I17[#]	I18
4	x	x		x	x													
5	x	x	x	x							x							
6	x	x	x	x	x						x							
7	x	x	x	x	x						x				x			
8		x	x	x	x					x	x	x			x			
9	x	x	x	x	x		x			x	x				x			
10		x	x	x	x		x			x	x	x	x		x			
11		x	x	x	x	x	x			x	x			x	x		x	
12		x	x	x	x	x	x			x	x	x	x		x		x	
13	x	x	x	x	x	x	x			x	x	x	x		x		x	
14	x	x		x	x	x	x	x	x	x	x			x	x	x	x	
15	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	

Note. [#] negatively keyed item. The underlying model was an acquiescence model.

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Table E6

Pooled Correlations of Three Large Studies vs. all Other Studies

	I01	I02	I03[#]	I04[#]	I05[#]	I06	I07[#]	I08[#]	I09[#]	I10	I11	I12[#]	I13	I14	I15	I16[#]	I17[#]	I18
I01		.631	.226	.355	.310	.402	.202	.251	.311	.366	.460	.270	.410	.399	.379	.192	.247	.211
I02	.539		.245	.370	.310	.439	.196	.259	.309	.429	.530	.270	.411	.388	.398	.178	.237	.235
I03[#]	.308	.412		.443	.431	.211	.242	.294	.297	.172	.234	.320	.132	.186	.147	.251	.265	.100
I04[#]	.356	.449	.224		.593	.299	.286	.376	.463	.258	.365	.361	.216	.254	.239	.301	.343	.135
I05[#]	.333	.428	.390	.332		.275	.302	.377	.413	.215	.327	.354	.176	.233	.194	.303	.346	.123
I06	.358	.213	.370	.292	.294		.215	.247	.266	.368	.411	.251	.406	.384	.291	.151	.211	.291
I07[#]	.526	.195	.381	.398	.336	.370		.323	.324	.146	.182	.251	.164	.172	.118	.225	.249	.120
I08[#]	.263	.216	.455	.223	.292	.430	.392		.463	.181	.249	.288	.163	.221	.160	.259	.294	.109
I09[#]	.305	.316	.319	.202	.336	.234	.417	.174		.187	.290	.322	.214	.226	.216	.308	.338	.082
I10	.475	.369	.308	.266	.455	.362	.288	.250	.378		.528	.197	.378	.359	.366	.088	.157	.236
I11	.535	.332	.268	.460	.454	.389	.394	.403	.350	.184		.322	.439	.421	.397	.173	.271	.265
I12[#]	.428	.178	.384	.247	.272	.295	.439	.425	.196	.156	.199		.176	.231	.165	.276	.321	.129
I13	.458	.334	.208	.286	.285	.272	.454	.256	.314	.185	.384	.186		.508	.361	.089	.156	.243
I14	.285	.282	.175	.467	.220	.249	.282	.422	.286	.225	.309	.200	.167		.358	.131	.192	.270
I15	.272	.274	.210	.461	.417	.367	.309	.380	.332	.241	.352	.219	.151	.072		.049	.145	.211
I16[#]	.221	.372	.437	.428	.192	.215	.254	.213	.199	.375	.227	.346	.134	.106	.144		.313	.002
I17[#]	.231	.469	.502	.239	.161	.156	.388	.220	.204	.418	.264	.230	.300	.283	.247	.250		.093
I18	.246	.391	.328	.364	.244	.208	.214	.329	.315	.384	.395	.262	.141	.265	.285	.086	.126	

Note. *N*(large studies) = 54,138, *N*(other studies) = 36,077. [#] negatively keyed item. Above the diagonal the correlations of the three large studies are depicted (i.e., study IDs `barcelo2023`, `LISS-Wave1` to `LISS-Wave10`, `hussey2020`).

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Table E7

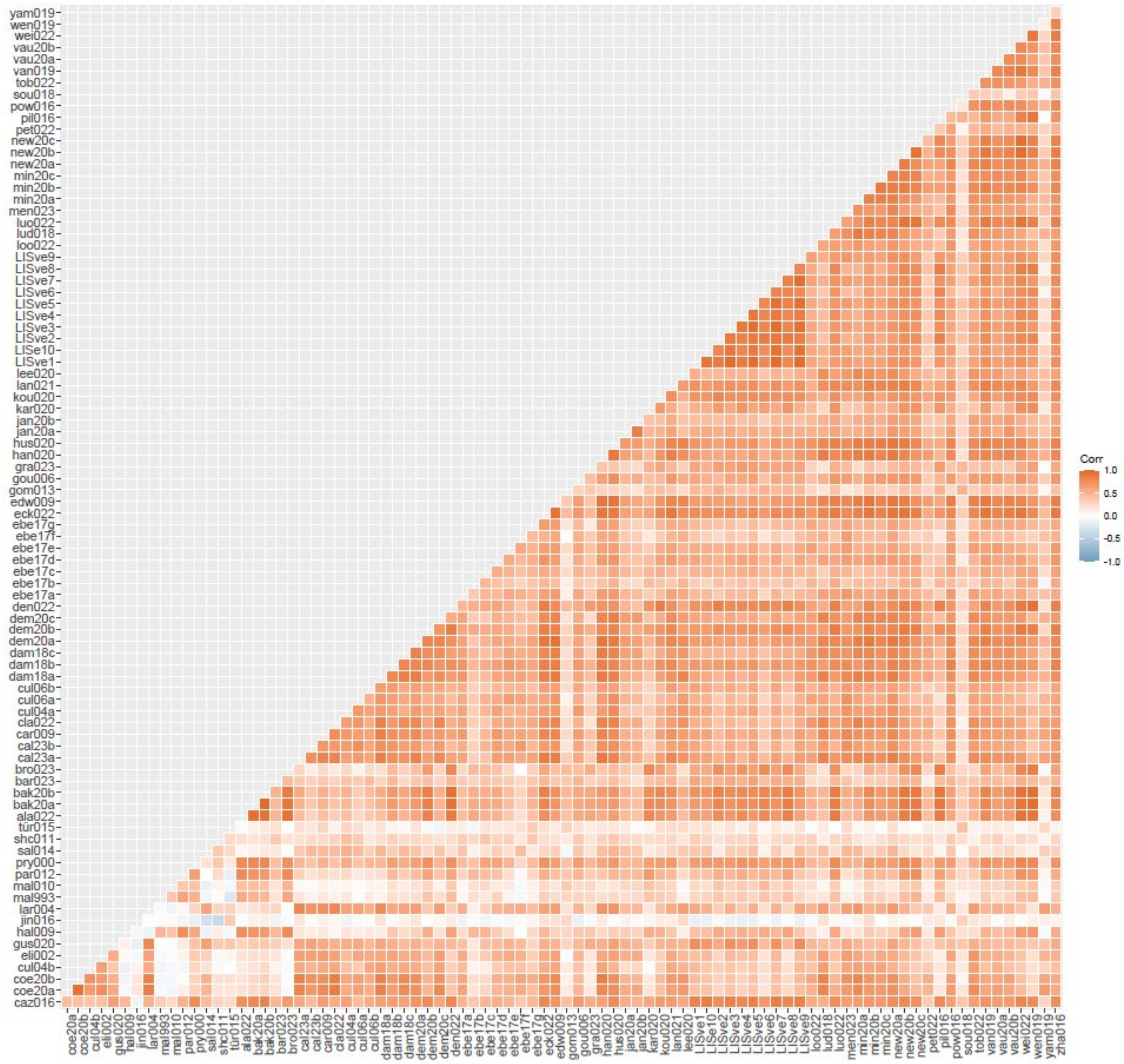
Measurement Models for the NCS-18 of Three Large Studies vs. all Other Studies

No	Model	χ^2	*df*	CFI	NNFI	RMSEA	SRMR	AIC	BIC
Large studies									
1	Uni-dimensional model	4,441.6	135	.837	.816	.024 [.024; .025]	.085	4,171.6	2,970.2
2	Two-dimensional model	1,046.2	134	.966	.961	.011 [.011; .012]	.040	778.2	-414.3
3	Correlated uniqueness model	672.2	99	.978	.967	.010 [.010; .011]	.032	474.2	-406.8
4	Bifactor model with two method factors	560.4	117	.983	.978	.008 [.008; .009]	.030	326.4	-714.8
5	Bifactor (S–1) model for the neg. keyed items	907.5	126	.971	.964	.011 [.010; .011]	.037	655.5	-465.8
6	Acquiescence model	766.1	134	.976	.973	.009 [.009; .010]	.036	498.1	-694.4
Remaining studies									
1	Uni-dimensional model	6,466.9	135	.843	.822	.036 [.035; .037]	.086	6,196.9	5,050.3
2	Two-dimensional model	1,273.6	134	.972	.968	.015 [.015; .016]	.025	1,005.6	-132.5
3	Correlated uniqueness model	740.6	99	.984	.975	.013 [.013; .014]	.018	542.6	-298.2
4	Bifactor model with two method factors	794.2	117	.983	.978	.013 [.012; .014]	.018	560.2	-433.6
5	Bifactor (S–1) model for the neg. keyed items	982.8	126	.979	.974	.014 [.013; .015]	.022	730.8	-339.4
6	Acquiescence model	1,129.2	134	.975	.972	.014 [.014; .015]	.024	861.2	-276.9

Note. *N*(large studies) = 54,138, *N*(other studies) = 36,077. [#] negatively keyed item. CFI = comparative fit Index; NNFI = non-normed fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean residual; AIC = Akaike information criterion; BIC = Bayesian information criterion. Large studies had the following study IDs `barcelo2023`, `LISS-Wave1` to `LISS-Wave10`, `hussey2020`.

Figure E1

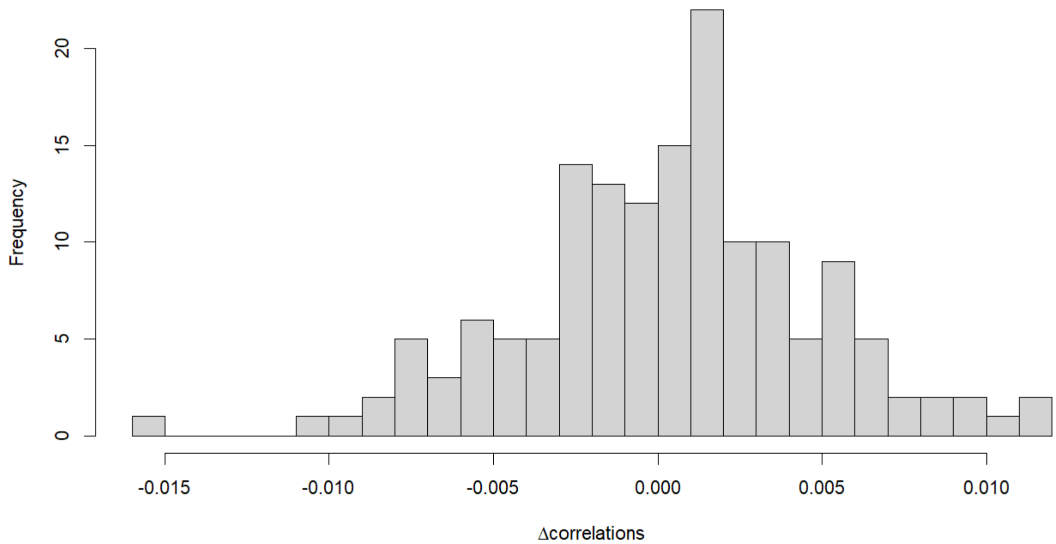
Correlation Matrix of All Correlation Matrices



https://doi.org/10.1027/1015-5759/a000818

Figure E2

Differences in Correlations With and Without Outliers



Note. Studies with the following study ID (sid) were considered outliers because they correlated on average below .30 with all other studies (see Figure E1): `jin2016`, `maldonado1993`, `malmberg2010`, `salama-younes2014`, `shchebetenko2011`, `türker2015`, and `sousa2018`.