Supplement to Graham, Haidt, and Nosek (in press) – Confirmatory Factor Analysis Model Comparisons

The following supplemental materials provide evidence that the moral foundations measures conform to a five-factor structure as specified in Graham, Haidt, and Nosek (in press). These structural equation models form the basis of a second manuscript focused on factor structure and scale properties (Graham, Haidt, Nosek, Iyer, Koleva, & Ditto, in prep). They are provided as a supplement to this manuscript as some readers may wish to review the evidence for the five-factor structure. The tables describe exercises in comparative model fitting with the first three numerical columns providing fit statistics for the individual models, and the last two columns providing the comparative fits with the previous model. In the first step, we compare nested first-order models. Our hypothesis is that model 4 (five correlated factors: Harm, Fairness, Ingroup, Authority, and Purity) would provide a better overall model fit than a single morality factor model (1), two-factor model (2: Individualizing and Binding), and three-factor model (3: corresponding to Shweder's ethics of Autonomy, Community, and Divinity). All available datasets confirmed these predictions; the overall best model (weighing fit and parsimony) was the five-factor model in every case. In the second step, we tested whether the five factors could be more parsimoniously modeled with two correlated superordinate factors representing our theoretical distinction of "individualizing" and "binding" foundations. For two of the five datasets the hierarchical model was as good a fit as the model with five intercorrelated factors. Both of these models provide support for a five-factor conceptualization of foundational moral concerns.

Step 1 – Comparison of first-order models

Supplemental Table 1. Goodness-of-fit indices for structural models representing confirmatory factor analyses of Study 1 data (N=1548)

Model – Relevance items	$\chi2$	*df*	ε_a	$\Delta\chi2/\Delta df$	95%CI $\varepsilon_a\Delta$
[1] Single factor (H-F-I-A-P)	1547.7	90	.102		
[2] Two correlated factors (H-F and I-A-P)	703.0	89	.067	844.7/1	0.689-0.789
[3] Three correlated factors (H-F, I-A and P)	595.0	87	.061	108.0/2	0.151-0.221
[4] Five correlated factors (H, F, I, A, and P)	480.98	80	.057	114.02/7	0.081-0.119

Note. ε_a = root-mean-square error of approximation (RMSEA) for the model. $\Delta\chi2/\Delta df$ = change in χ^2 and degrees of freedom relative to the previous model. 95%CI $\varepsilon_a\Delta$ = confidence interval around RMSEA of the change in fit between models; if .050 falls within the CI, then model fits are not considered significantly different. Model in bold is the best-fitting model according to these comparisons.

Supplemental Table 2. Goodness-of-fit indices for structural models representing confirmatory factor analyses of Study 2 data (N=2135)

Model – Relevance items	$\chi2$	*df*	ε_a	$\Delta\chi2/\Delta df$	95%CI $\varepsilon_a\Delta$
[1] Single factor	3751.0	230	.085		
[2] Two correlated factors	2149.8	229	.063	1601.2/1	0.824-0.909
[3] Three correlated factors	1844.8	227	.058	305.0/2	0.237-0.297
[4] Five correlated factors	1641.7	220	.055	203.1/7	0.099-0.131
Model – Judgments items	$\chi2$	*df*	ε_a	$\Delta\chi2/\Delta df$	95%CI $\varepsilon_a\Delta$
[1] Single factor	1859.7	170	.068		
[2] Two correlated factors	1397.3	169	.058	462.4/1	0.423-0.508
[3] Three correlated factors	1299.4	167	.056	97.9/2	0.121-0.181
[4] Five correlated factors	1178.5	160	.055	120.9/7	0.071-0.104
Model – All items	$\chi2$	*df*	ε_a	$\Delta\chi2/\Delta df$	95%CI $\varepsilon_a\Delta$
[1] Single factor	8134.7	860	.063		
[2] Two correlated factors	5499.2	859	.050	2635.5/1	1.069-1.154
[3] Three correlated factors	5087.8	857	.048	411.4/2	0.280-0.340
[4] Five correlated factors	4708.0	850	.046	379.8/7	0.142-0.174

Note. ε_a = root-mean-square error of approximation (RMSEA) for the model. $\Delta\chi2/\Delta df$ = change in χ^2 and degrees of freedom relative to the previous model. 95%CI $\varepsilon_a\Delta$ = confidence interval around RMSEA of the change in fit between models; if .050 falls within the CI, then model fits are not considered significantly different. Model in bold is the best-fitting model according to these comparisons.

Supplemental Table 3. Goodness-of-fit indices for structural models representing confirmatory factor analyses of Study 3 data (N=8193)

Model – Taboo trade-off items	$\chi2$	*df*	ε_a	$\Delta\chi2/\Delta df$	95%CI $\varepsilon_a\Delta$
[1] Single factor	15312.2	299	.078		
[2] Two correlated factors	9673.0	298	.060	5639.2/1	0.808-0.851
[3] Three correlated factors	9085.8	296	.060	587.2/2	0.174-0.204
[4] Five correlated factors	8772.3	289	.060	313.5/7	0.065-0.081

Note. ε_a = root-mean-square error of approximation (RMSEA) for the model. $\Delta\chi2/\Delta df$ = change in χ^2 and degrees of freedom relative to the previous model. 95%CI $\varepsilon_a\Delta$ = confidence interval around RMSEA of the change in fit between models; if .050 falls within the CI, then model fits are not considered significantly different. Model in bold is the best-fitting model according to these comparisons.

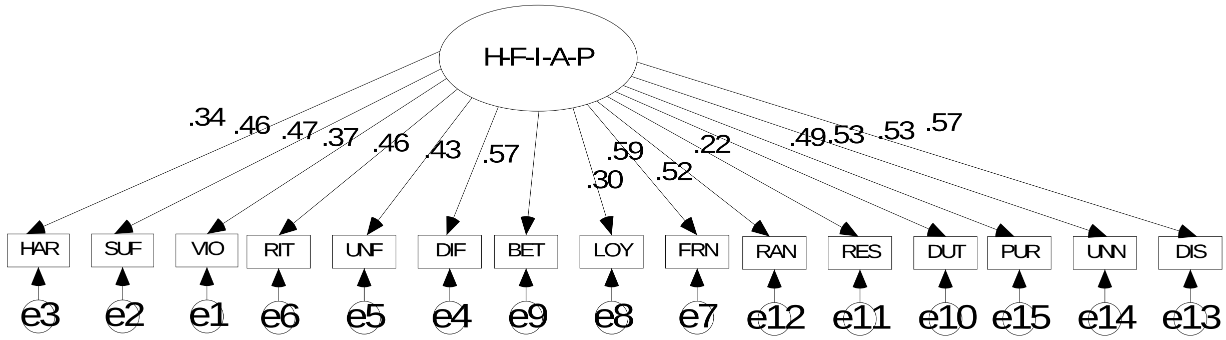
Step 2 – Comparison of five-factor models

Supplemental Table 4. Goodness-of-fit indices for structural models representing confirmatory factor analyses for Studies 1, 2, and 3, comparing the optimal first-order models (five intercorrelated factors) to hierarchical models containing two superordinate factors

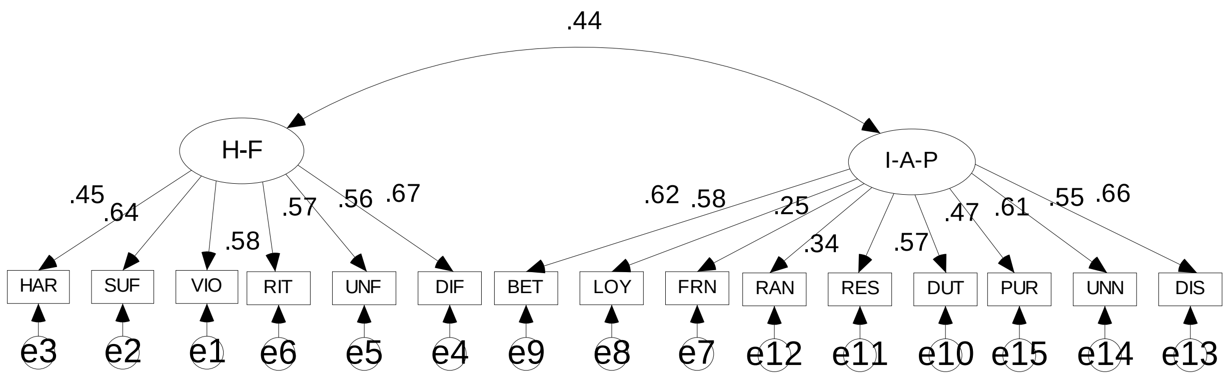
Study 1 – Relevance items	$\chi2$	*df*	ε_a	$\Delta\chi2/\Delta df$	95%CI $\varepsilon_a\Delta$
[1] Hierarchical model	508.9	85	.057		
[2] Five correlated factors	480.98	80	.057	27.92/5	0.032-0.079
Study 2 – Relevance items	$\chi2$	*df*	ε_a	$\Delta\chi2/\Delta df$	95%CI $\varepsilon_a\Delta$
[1] Hierarchical model	1688.0	225	.055		
[2] Five correlated factors	1641.7	220	.055	46.3/5	0.043-0.082
Study 2 – Judgment items	$\chi2$	*df*	ε_a	$\Delta\chi2/\Delta df$	95%CI $\varepsilon_a\Delta$
[1] Hierarchical model	1293.1	165	.057		
[2] Five correlated factors	1178.5	160	.055	114.6/5	0.083-0.121
Study 2 – All items	$\chi2$	*df*	ε_a	$\Delta\chi2/\Delta df$	95%CI $\varepsilon_a\Delta$
[1] Hierarchical model	4808.5	855	.047		
[2] Five correlated factors	4708.0	850	.046	100.5/5	0.076-0.114
Study 3 – Taboo trade-off items	$\chi2$	*df*	ε_a	$\Delta\chi2/\Delta df$	95%CI $\varepsilon_a\Delta$
[1] Hierarchical model	9146.6	294	.061		
[2] Five correlated factors	8772.3	289	.060	374.3/5	0.085-0.105

Note. ε_a = root-mean-square error of approximation (RMSEA) for the model. $\Delta\chi2/\Delta df$ = change in χ^2 and degrees of freedom relative to the previous model. 95%CI $\varepsilon_a\Delta$ = confidence interval around RMSEA of the change in fit between models; if .050 falls within the CI, then model fits are not considered significantly different. Model in bold is the optimal model (weighing both fit and parsimony) according to these comparisons; if no significant difference was found between the models, then the hierarchical model was considered better because it requires estimation of fewer parameters.

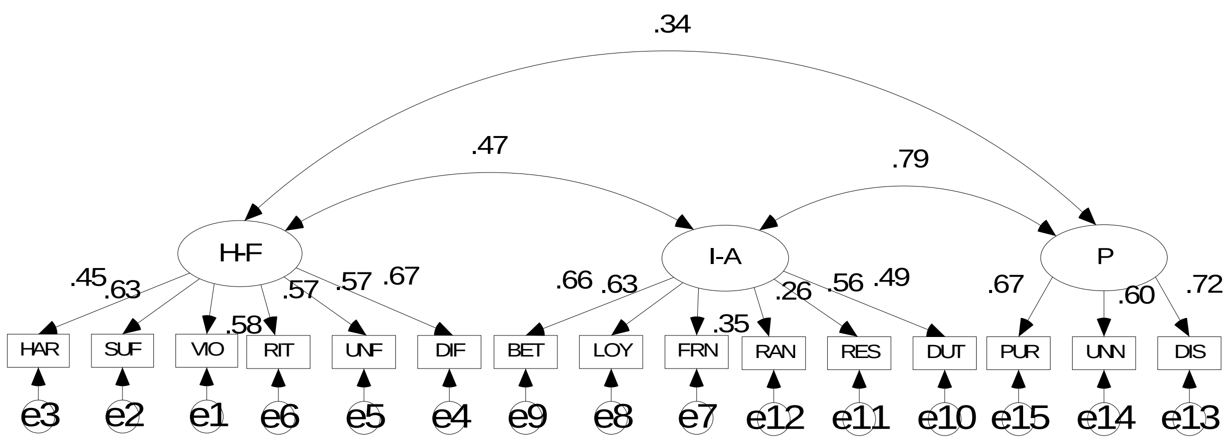
GHN Study 1: 15 Relevance items



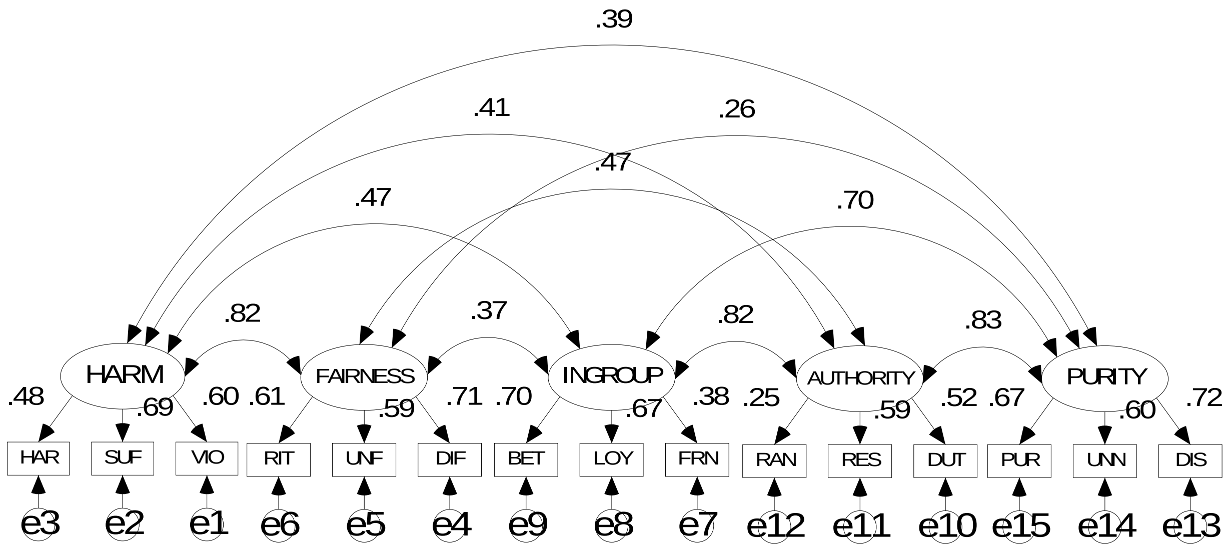
GHN Study 1, one factor. N=1548, $\chi2$=1547.7, df=90, para. est.=45, ε_a=.102;



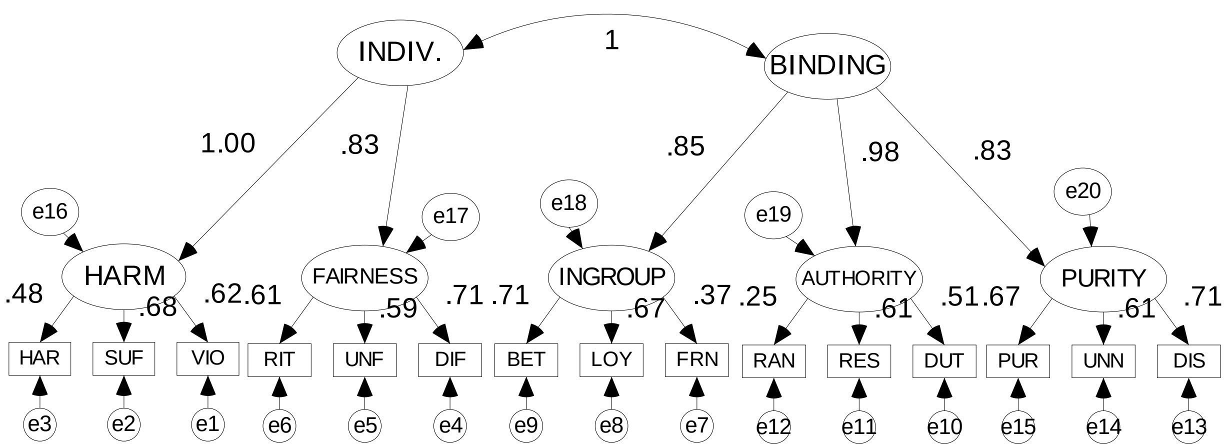
GHN Study 1, two factors. N=1548, $\chi2$=703.0, df=89, para. est.=46, ε_a=.067;
$\Delta\chi2$=844.7(1df), 95%CI $\varepsilon_a\Delta$ = (0.689 ; 0.789)



GHN Study 1, three factors. N=1548, $\chi2$=595.0, df=87, para. est.=48, ε_a=.061;
$\Delta\chi2$=108(2df), 95%CI $\varepsilon_a\Delta$ = (0.151 ; 0.221)

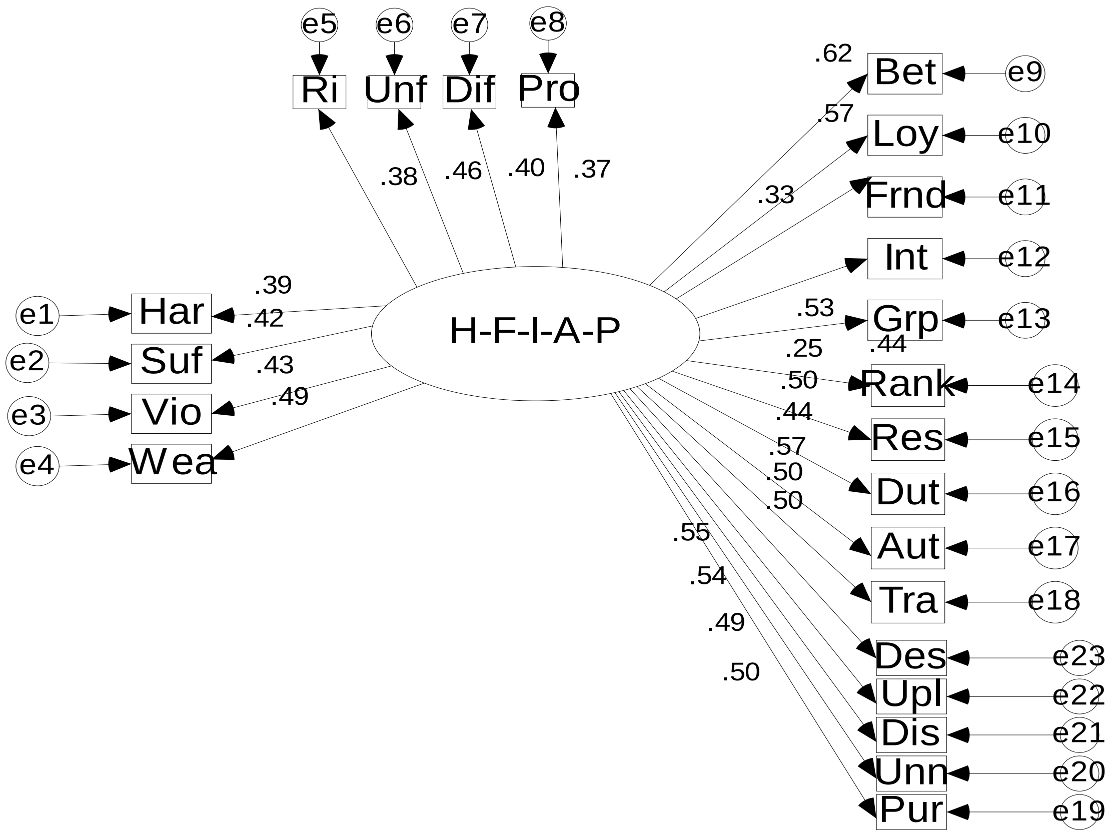


GHN Study 1, five factors. N=1548, $\chi 2$=480.98, df=80, para. est.=55, ε_a =.057;
(vs.3)$\Delta\chi 2$=114.021(7df), 95%CI $\varepsilon_a\Delta$ = (0.081 ; 0.119)
(vs.H.) $\Delta\chi 2$=27.92(5df), 95%CI $\varepsilon_a\Delta$ =(0.032 ; 0.079)

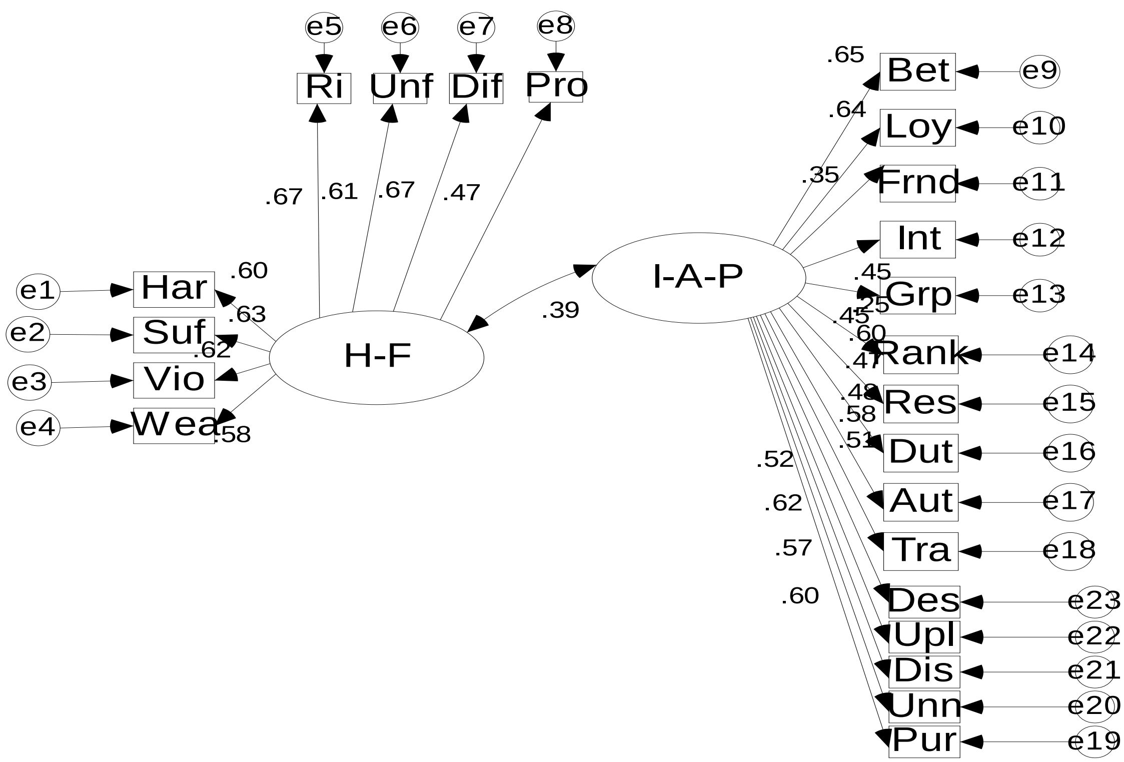


GHN Study 1, hierarchical model. $\chi 2$=508.9, df=85, para. est=50, ε_a =.057
Note. This model estimates a correlation of 1 for the two second-order factors, suggesting that they could be collapsed into a single factor. However, this correlation was not replicated in any of the four other hierarchical models, and did not correspond with any prespecified structural hypotheses. We therefore refrain from data-driven (and atheoretical) model modification likely to capitalize on idiosyncrasies of specific samples.

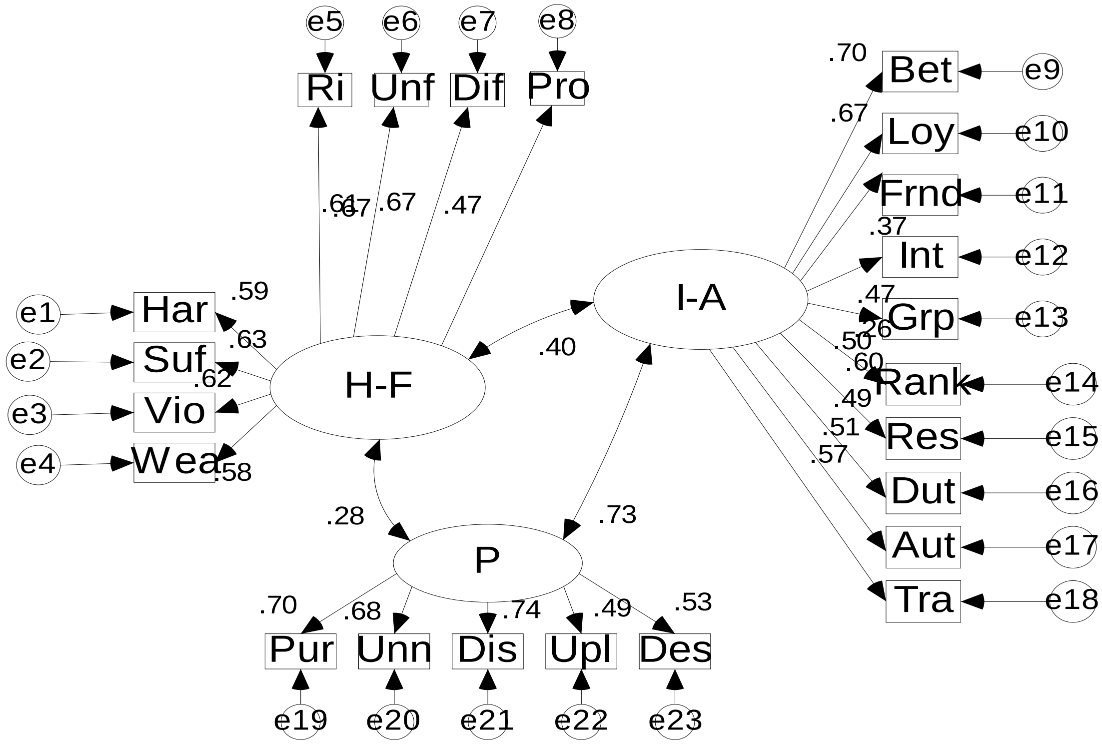
GHN Study 2: Relevance items



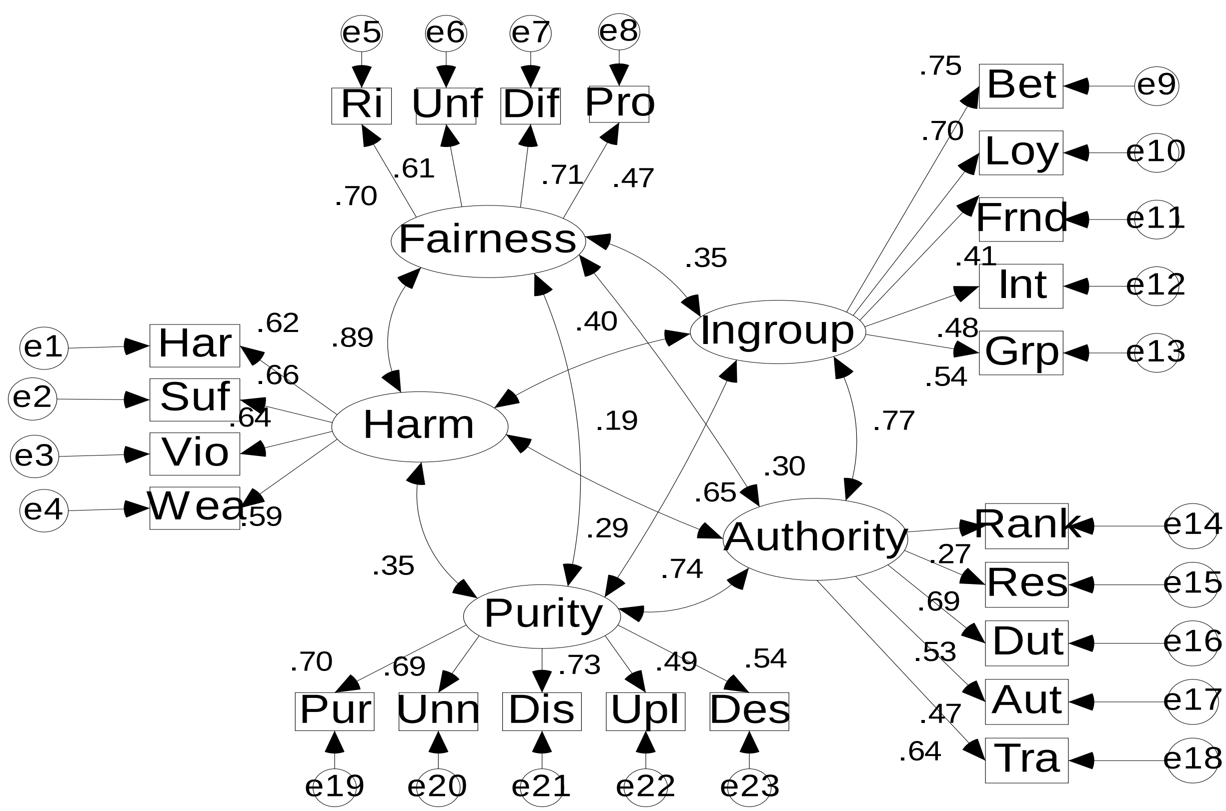
GHN Study 2 Rel, one factor. N=2135, $\chi2$=3751.0, df=230, para. est.=69, ε_a =.085



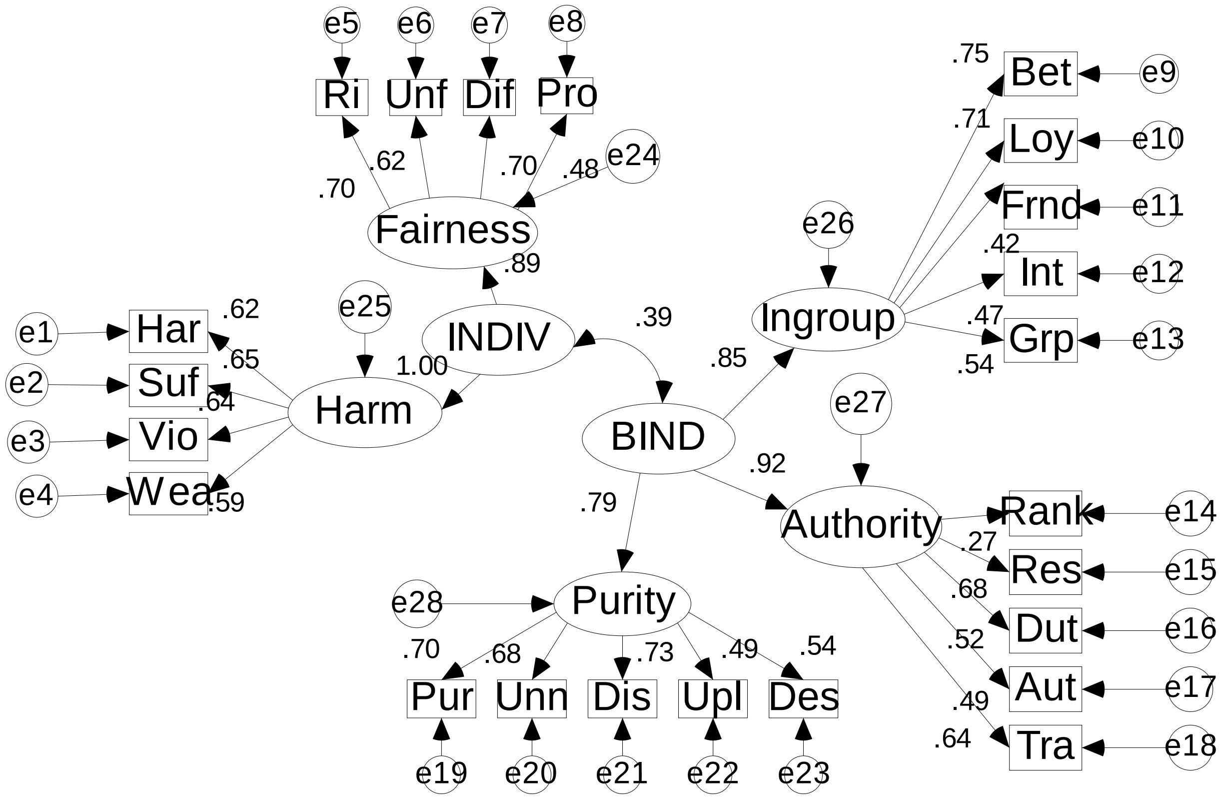
GHN Study 2 rel, two factors. $\chi2$=2149.8, df=229, para. est.=70, ε_a =.063;
$\Delta\chi2$=1601.2(1df), 95%CI $\varepsilon_a\Delta$ = (0.824 ; 0.909)



GHN Study 2 rel, three factors. $\chi 2$=1844.8, df=227, para. est.=72, ε_a =.058;
$\Delta\chi 2$=305.0(2df), 95%CI $\varepsilon_a\Delta$ = (0.237 ; 0.297)

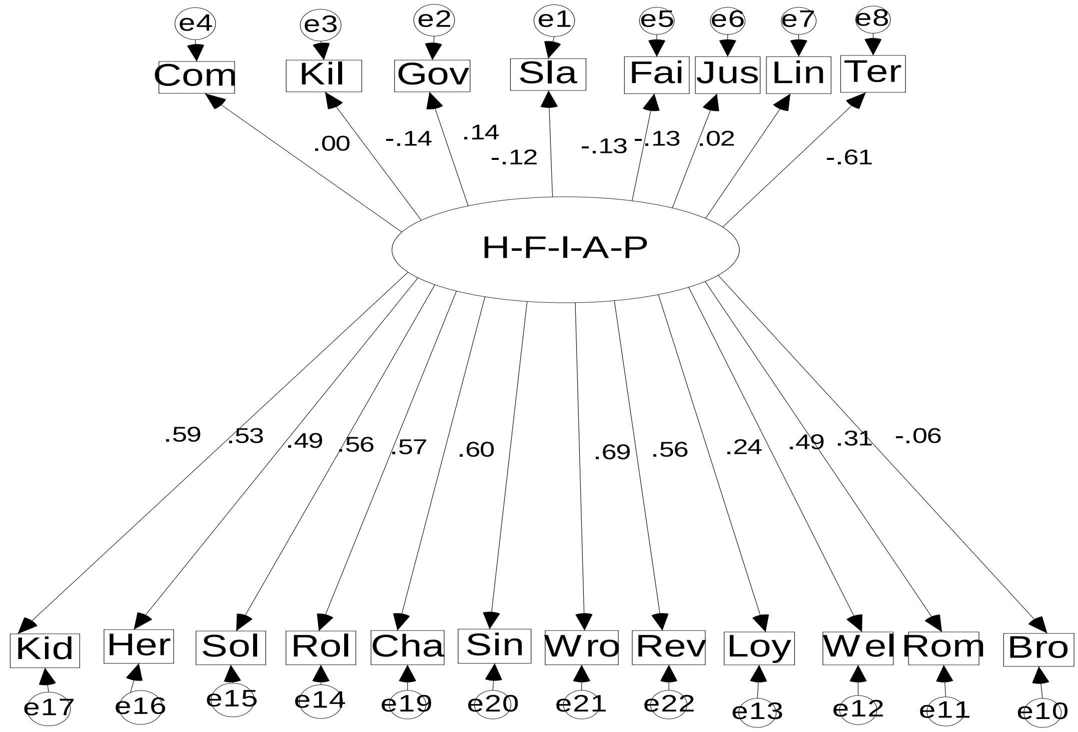


GHN Study 2 rel, five factors. $\chi 2$=1641.7, df=220, para. est.=79, ε_a =.055;
(vs.3)$\Delta\chi 2$=203.1(7df), 95%CI $\varepsilon_a\Delta$ = (0.099 ; 0.131)
(vs.H)$\Delta\chi 2$=46.3 (5df), 95%CI $\varepsilon_a\Delta$ = (0.043 ; 0.082)

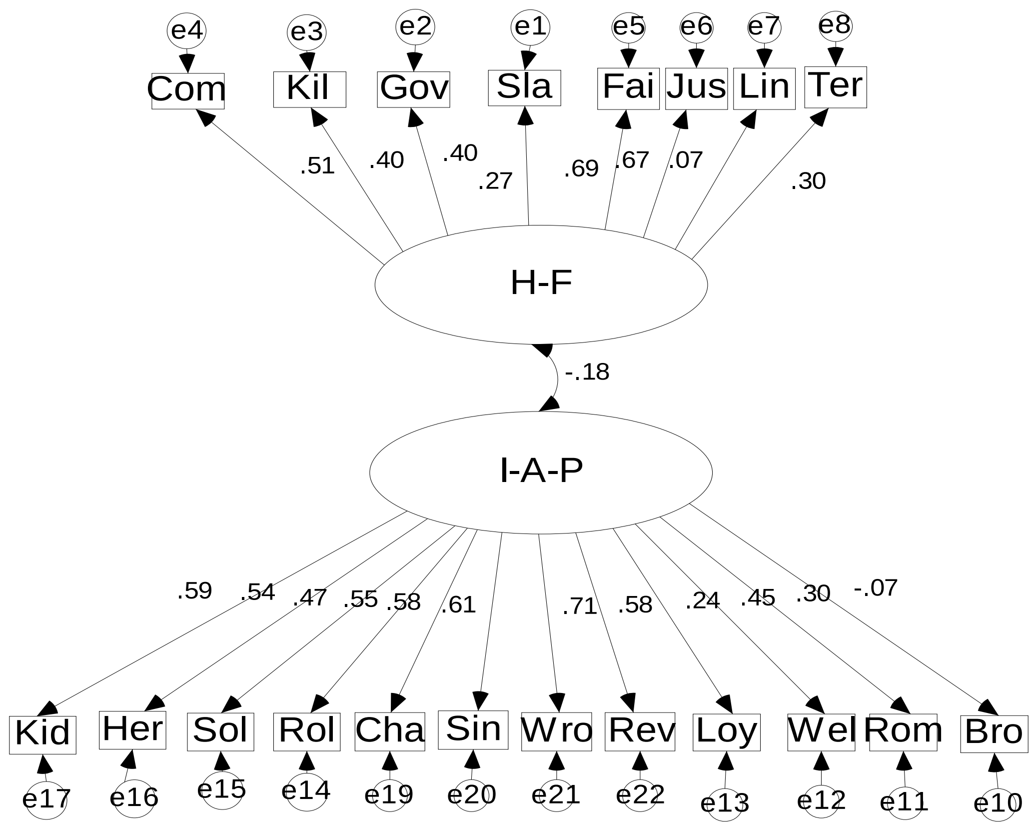


GHN Study 2 rel, hierarchical model. $\chi 2$=1688.0, df=225, para. est.=74, ε_a =.055

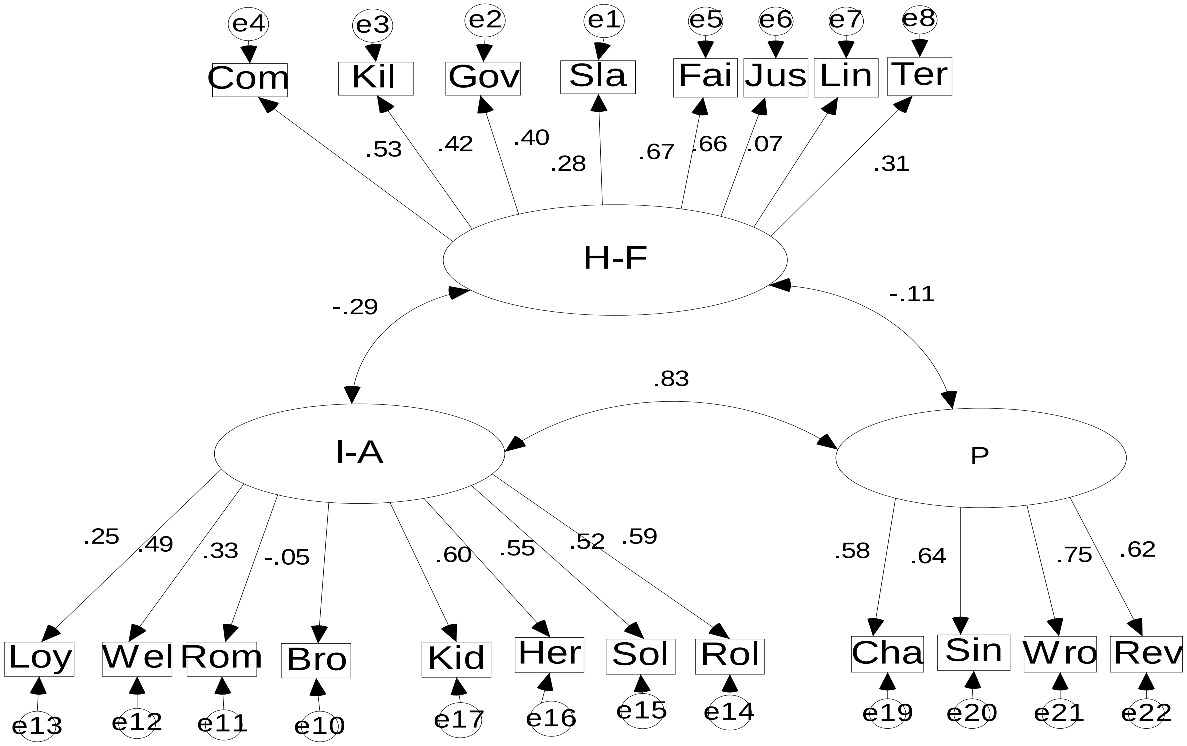
GHN Study 2: Judgment items



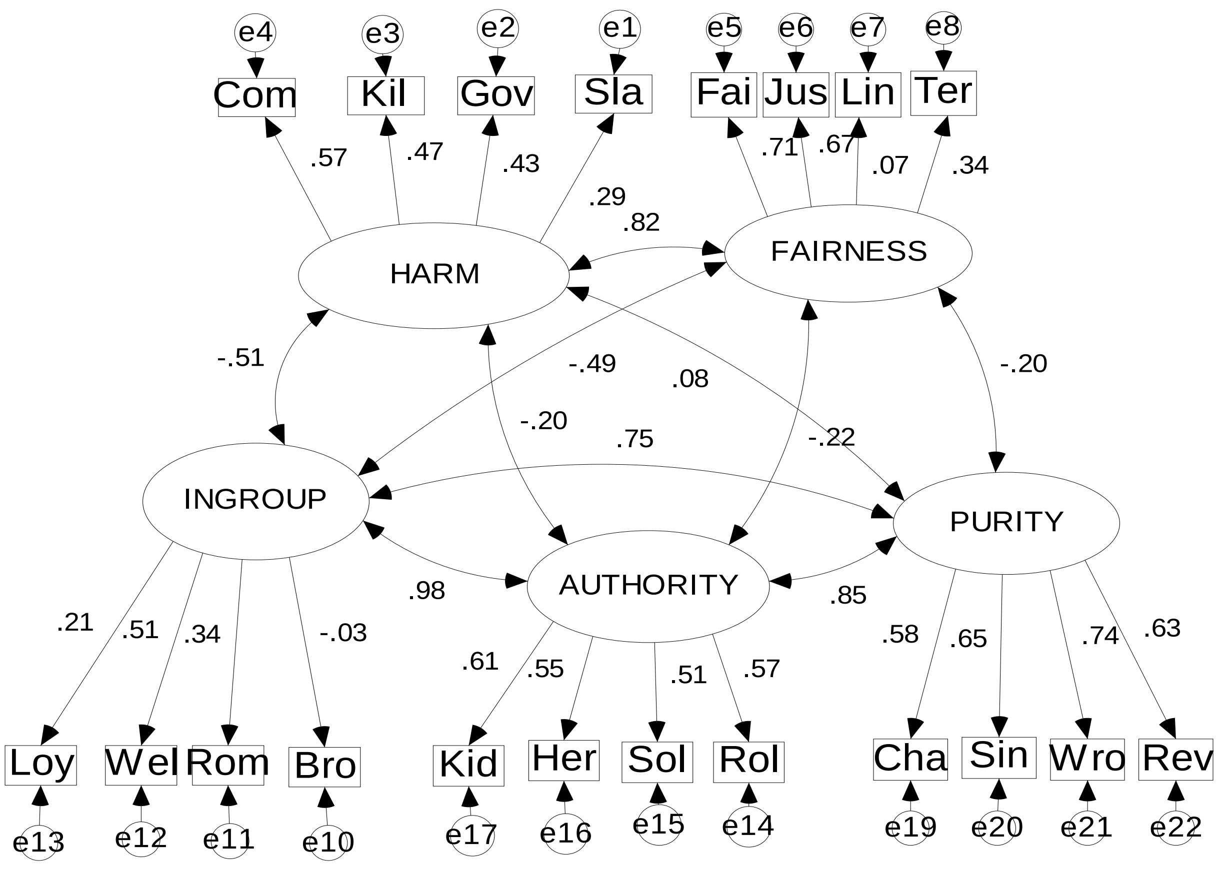
GHN Study 2 judgments, one factor. χ2=1859.7, df=170, para. est.=60, ε_a =.068



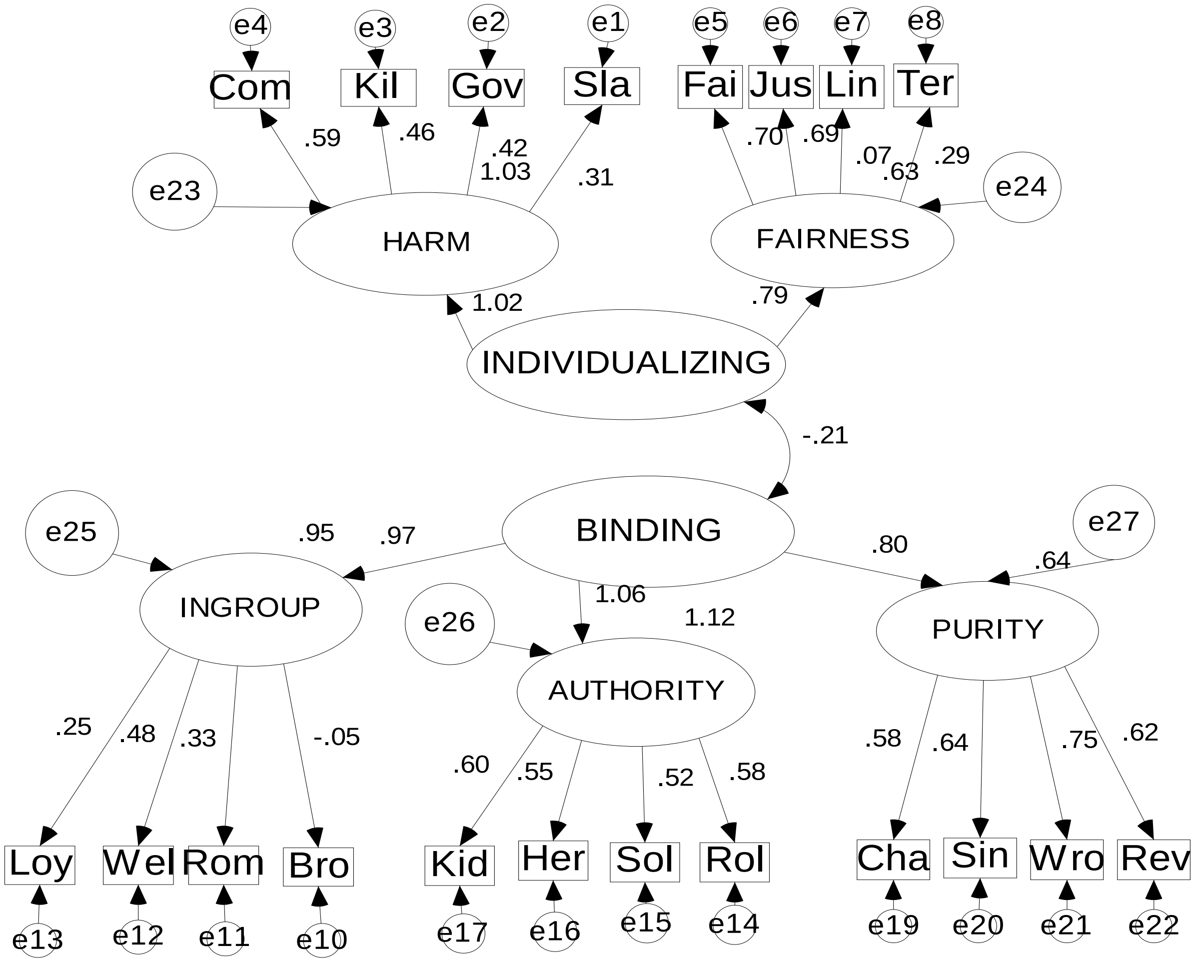
GHN Study 2 judgments, two factors. χ2=1397.3, df=169, para. est.=61, ε_a =.058; Δχ2=462.4(1df), 95%CI $\varepsilon_a\Delta$ = (0.423 ; 0.508)



GHN Study 2 judgments, three factors. χ2=1299.4, df=167, para. est.=63, ε_a =.056;
Δχ2=97.9(2df), 95%CI $\varepsilon_a\Delta$ = (0.121 ; 0.181)



GHN Study 2 judgments, five factors. χ2=1178.5, df=160, para. est.=70, ε_a =.055;
(vs.3)Δχ2=120.9(7df), 95%CI $\varepsilon_a\Delta$ = (0.071 ; 0.104)
(vs.H)Δχ2=114.6(5df), 95%CI $\varepsilon_a\Delta$ = (0.083 ; 0.121)



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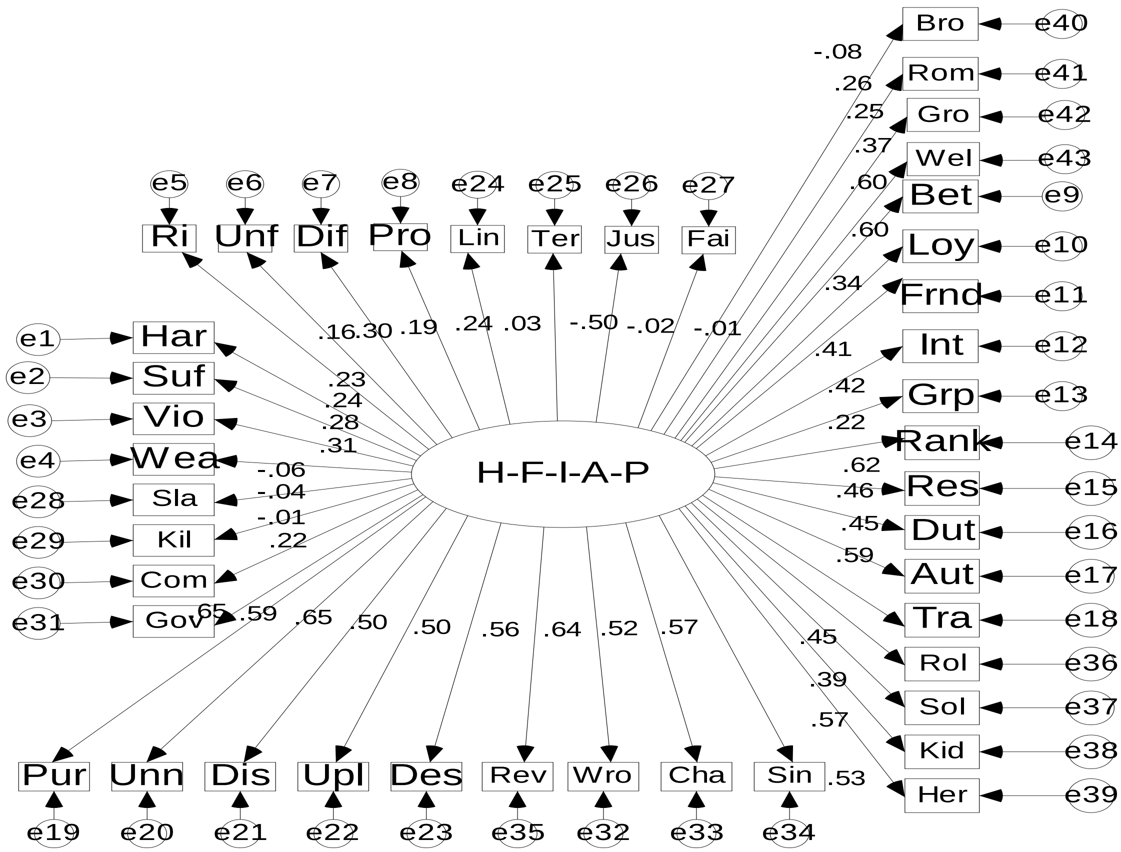
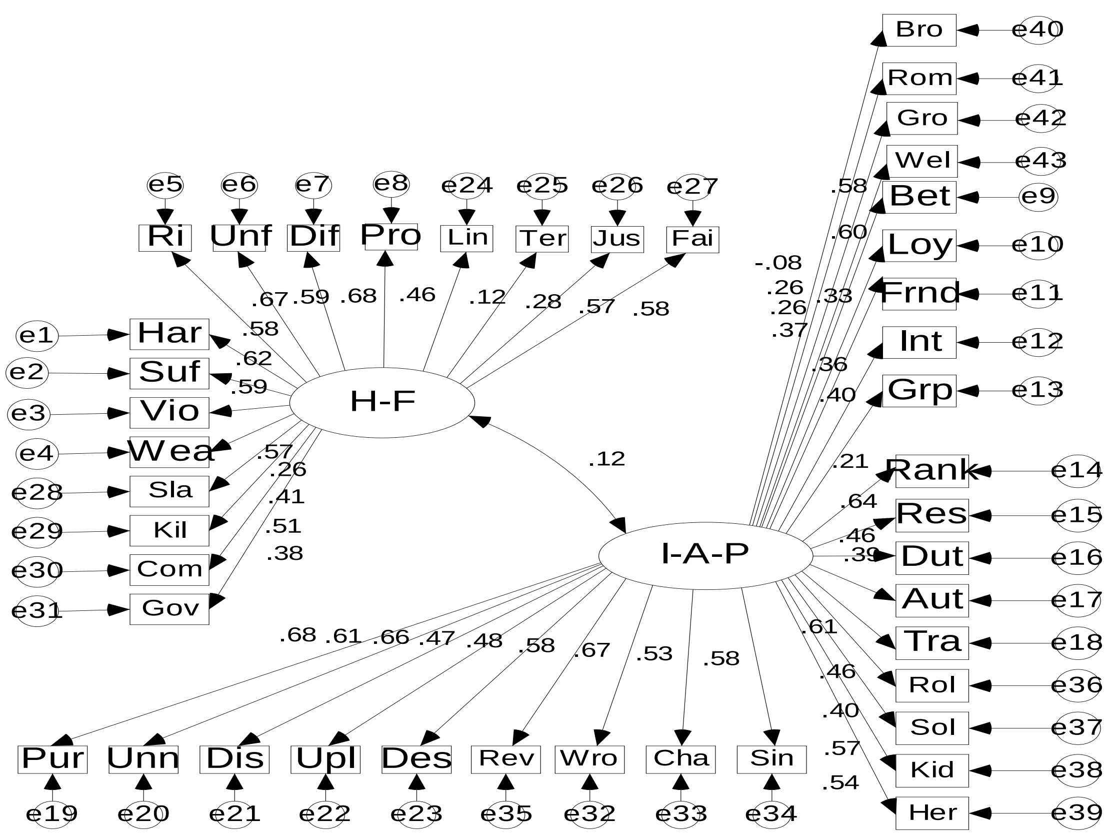
HN Study 2 judgments, hierarchical. $\chi 2$=1293.1, df=165, para. est.=65, ε_a =.057

Note. Although point estimates for two parameters in this model are greater than 1, they should not be considered evidence for model misspecification or statistical violation as they are very close to 1 and the confidence intervals of these estimates contain 1.

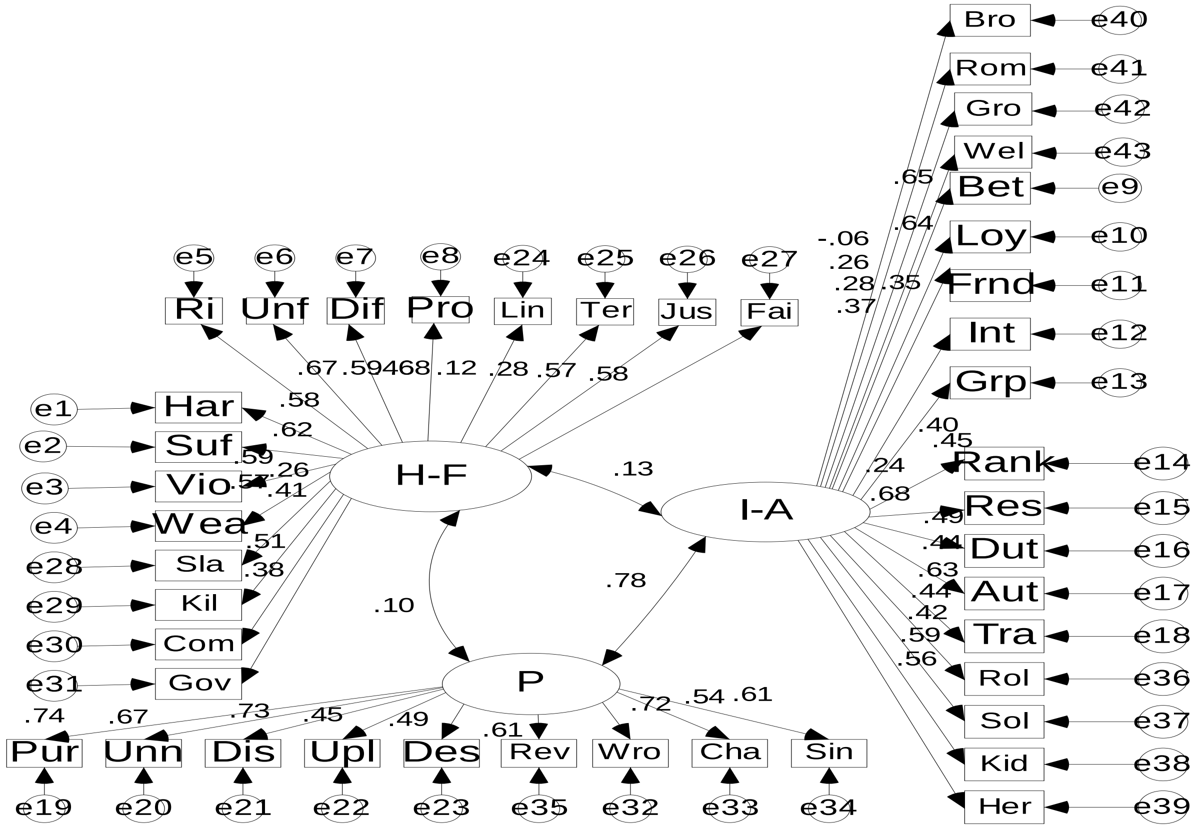
GHN Study 2: Full Scale (Relevance plus Judgments)



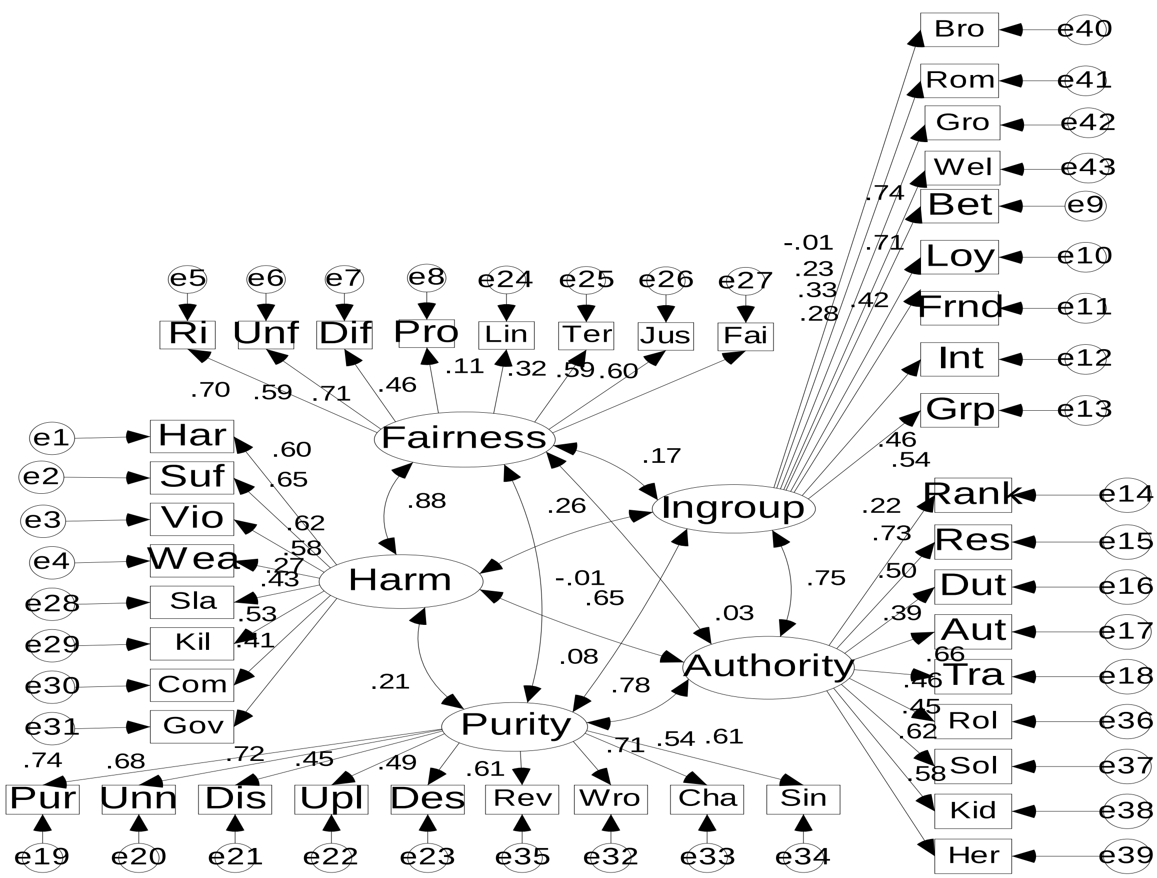
GHN Study 2 full scale, one factor. χ2=8134.7, df=860, para. est.=129, ε_a =.063



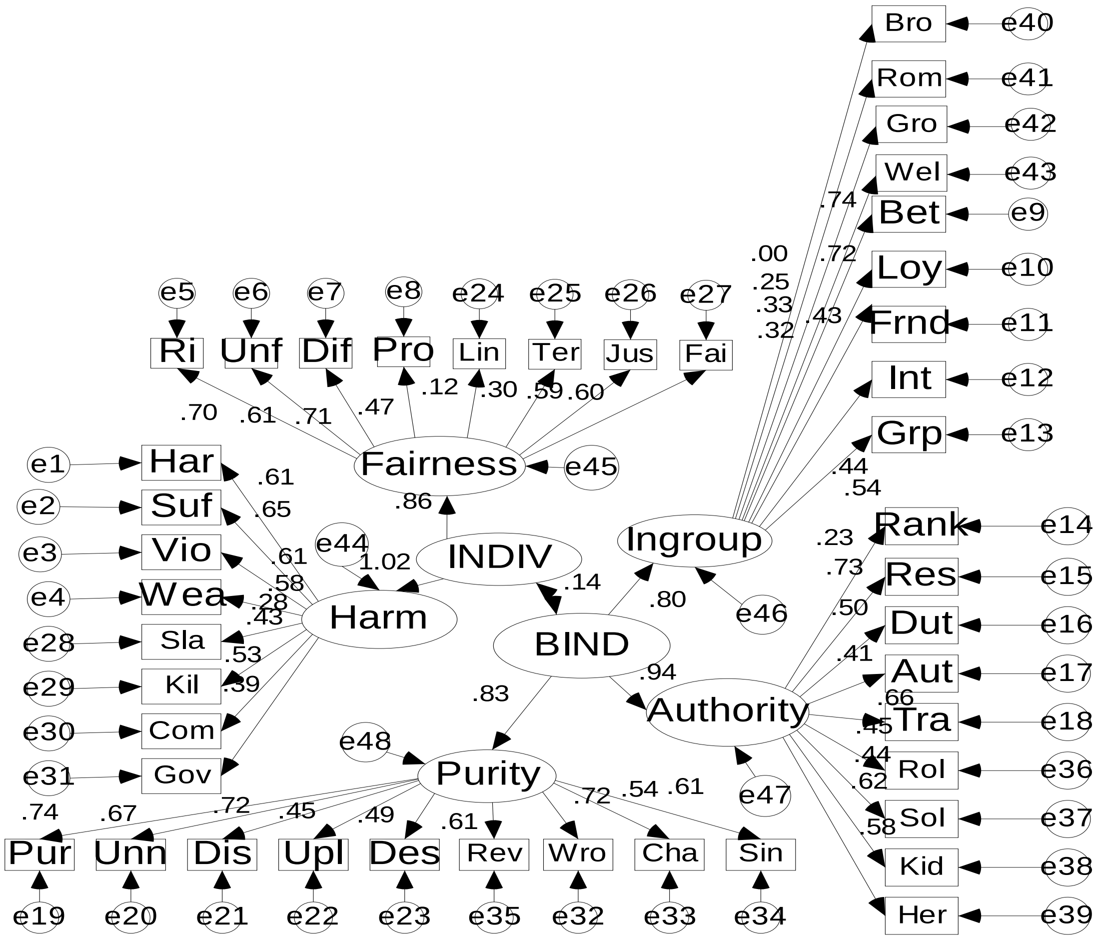
GHN Study 2 full scale, two factors. χ2=5499.2, df=859, para. est.=130, ε_a =.05;
Δχ2=2635.5(1df), 95%CI $\varepsilon_a\Delta$ = (1.069 ; 1.154)



GHN Study 2 full scale, three factors. $\chi2$=5087.8, df=857, para. est.=132, ε_a =.048;
$\Delta\chi2$=411.4(2df), 95%CI $\varepsilon_a\Delta$ = (0.280 ; 0.340)



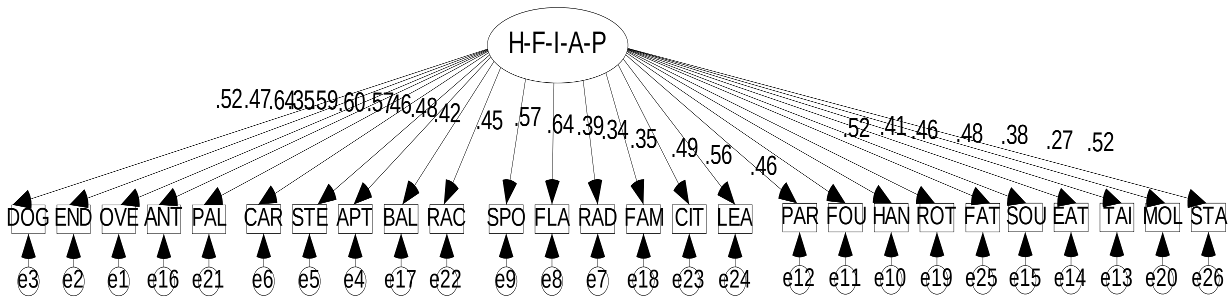
GHN Study 2 full scale, five factors. $\chi2$=4708.0, df=850, para. est.=139, ε_a =.046;
(vs.3)$\Delta\chi2$=379.8(7df), 95%CI $\varepsilon_a\Delta$ = (0.142 ; 0.174)
(vs.H) $\Delta\chi2$=100.5(5df), 95%CI $\varepsilon_a\Delta$ = (0.076 ; 0.114)



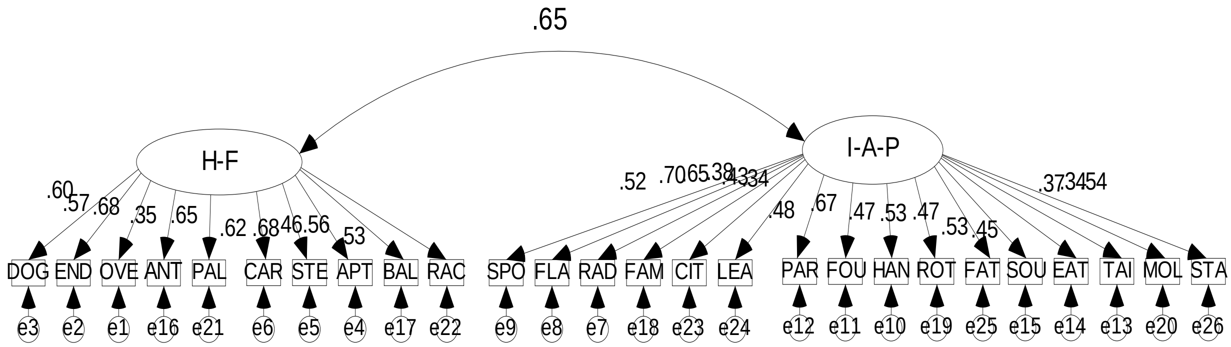
GHN Study 2 full scale, hierarch. $\chi 2$=4808.5, df=855, para. est.=134, ε_a =.047

Note. Although the point estimate for one parameter in this model is greater than 1, it should not be considered evidence for model misspecification or statistical violation as it is very close to 1 and the confidence interval of this estimate contains 1.

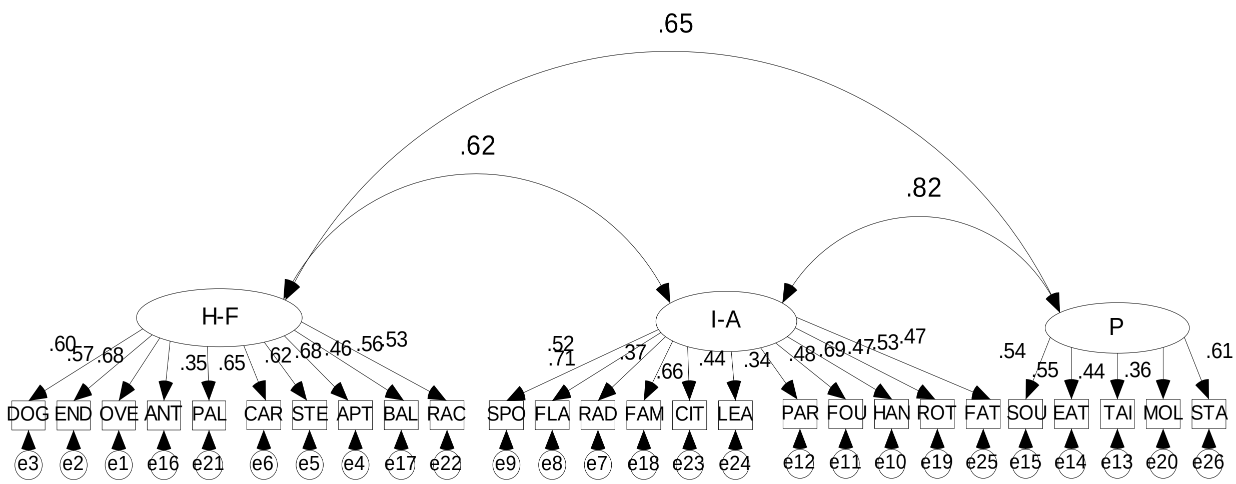
Study 3 – Taboo Trade-off Items (N=8193)



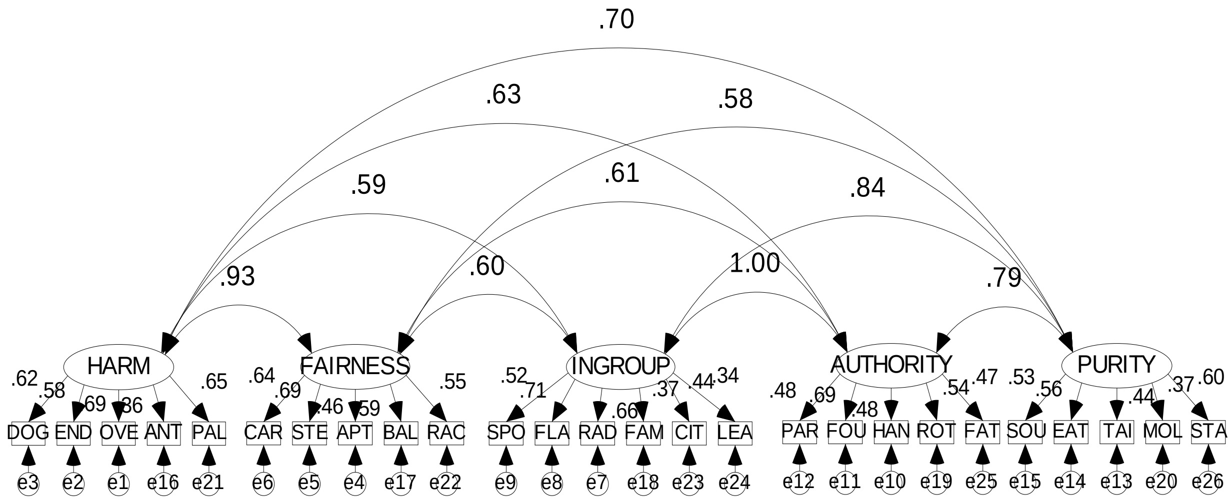
GHN Study 3, one factor. $\chi 2$=15312.2, df=299, para. est.=78, ε_a =.078



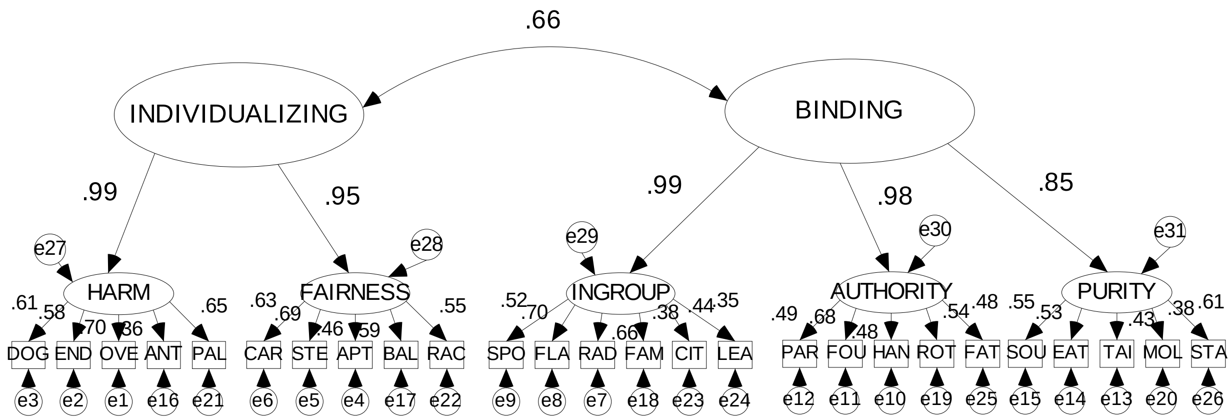
GHN Study 3, two factors. $\chi 2$=9673.0, df=298, para. est.=79, ε_a =.062;
$\Delta\chi 2$=5639.2(1df), 95%CI $\varepsilon_a\Delta$ = (0.808 ; 0.851)



GHN Study 3, three factors. $\chi 2$=9085.8, df=296, para. est.=81, ε_a =.060;
$\Delta\chi 2$=587.2(2df), 95%CI $\varepsilon_a\Delta$ = (0.174 ; 0.204)



GHN Study 3, five factors. $\chi2=8772.3$, df=289, para. est.=88, ε_a =.060;
(vs.3) $\Delta\chi2=313.5$(7df), 95%CI $\varepsilon_a\Delta$ = (0.065 ; 0.081)
(vs.H)$\Delta\chi2=374.3$(5df), 95%CI $\varepsilon_a\Delta$= (0.085 ; 0.105)



GHN Study 3, hierarchical model. $\chi2=9146.6$, df=294, para. est.=83, ε_a =.061
