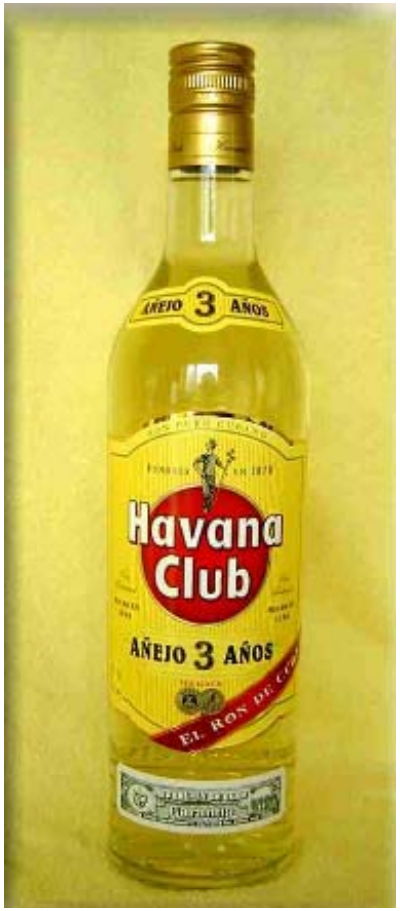


R. Hatzinger and P. Mair's
Psychometric Methods

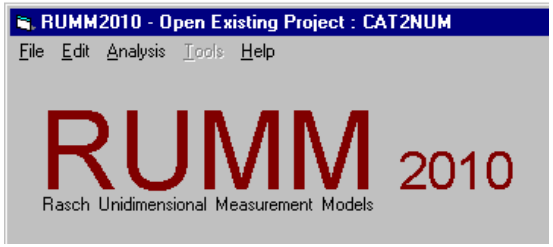
RUMM – Rasch Unidimensional Measurement Models

Thomas Salzberger

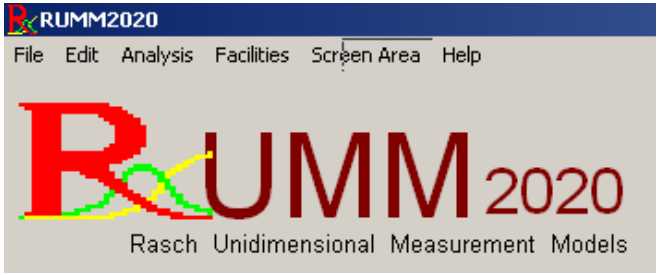
WU WIRTSCHAFTS UNIVERSITÄT WIEN VIENNA UNIVERSITY OF ECONOMICS AND BUSINESS

History, Developers

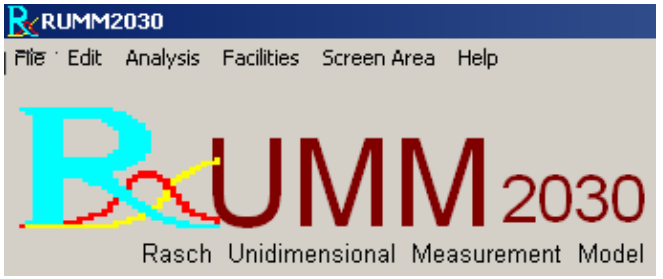
- 1997: RUMM 2.7q
  by Sheridan, B., Andrich, D., and Luo, G. (1997),
  Perth, WA: RUMM Laboratory.
- 2000: RUMM 2010
  Andrich, Sheridan, Luo



- 2005: RUMM 2020
  Andrich, Sheridan, Luo



- 2010: RUMM 2030
  Andrich, Sheridan, Luo



RUMM

- Unidimensional Rasch measurement models
- User-friendly design
- Exportable graphics ready to print
- Data/Models:
  - Dichotomous responses
  - Multiple choice data (MC)
  - Polytomous responses (max. 101 categories)
    - Rating scale model
    - Partial credit model
    - Subtests (item bundles, testlets, super-items)
  - Multi-faceted data
    - Extension to the basic item structure: 1st factor = items, up to two more factors (facets)
  - Person factors (sample characteristics) (up to 9)
  - Combination of dichotomous, polytomous and MC data

RUMM

- What is not covered by RUMM
  - LLTM
  - Any model that implies different slopes of the ICCs (general IRT models, i.e. non-Rasch models, OPLM, frame-of-reference-Rasch model)
  - Non-cumulative models (unfolding models)

Data Input

- Raw data file: fixed asci file

Person id	person factors	item responses
1	131...	24341 76...

- Definition of the data within RUMM
  - Coding/recoding can be done in RUMM (e.g., 1 to 7 is mapped to 0 to 6)
  - Template files
- SPSS/PASW files cannot be read in directly

- Project file:
  - Contains the data and all analyses
- *Template files:*
  - *.itm* *data format*
  - *.spc* *item specifications (number of categories, labels)*

Template Files

	A	B	C	D	E	F	G	H	I	J
1	blockID	segmentID	Comments	blockStart	blockWdth	testType	respType	itemLength	itemSubNuml	missSymb
2	1	1	personid	1	4	0	0	0	0	bsp
3	2	2	card	5	1	0	0	0	0	bsp
4	3	21	no atm card	1	0	0	0	0	0	0
5	4	21	atm card	1	1	0	0	0	0	0
6	5	2	gender	6	1	0	0	0	0	bsp
7	6	22	male	3	1	0	0	0	0	0
8	7	22	female	3	2	0	0	0	0	0
9	8	3	ItemBlock1	8	29	1	1	1	29	9

	A	B	C	D	E	F	G	H
1	itemSeq	testType	itemCode	itemState	respType	respNumb	scKey	respSeq
2	1	E	I0001	feel anxiety	N	5		1
3	2	E	I0002	prefer people	N	5		1
4	3	E	I0003	atms are fun	N	5	R	1
5	4	E	I0004	feel comfortable	N	5	R	1
6	5	E	I0005	want to learn more	N	5	R	1
7	6	E	I0105	dont go after hours	N	5		1
8	7	E	I0006	worry making mista	N	5		1
9	8	E	I0007	time consuming	N	5		1
10	9	E	I0008	atms agitate me	N	5		1
11	10	E	I0009	takes a long time	N	5		1

Estimation

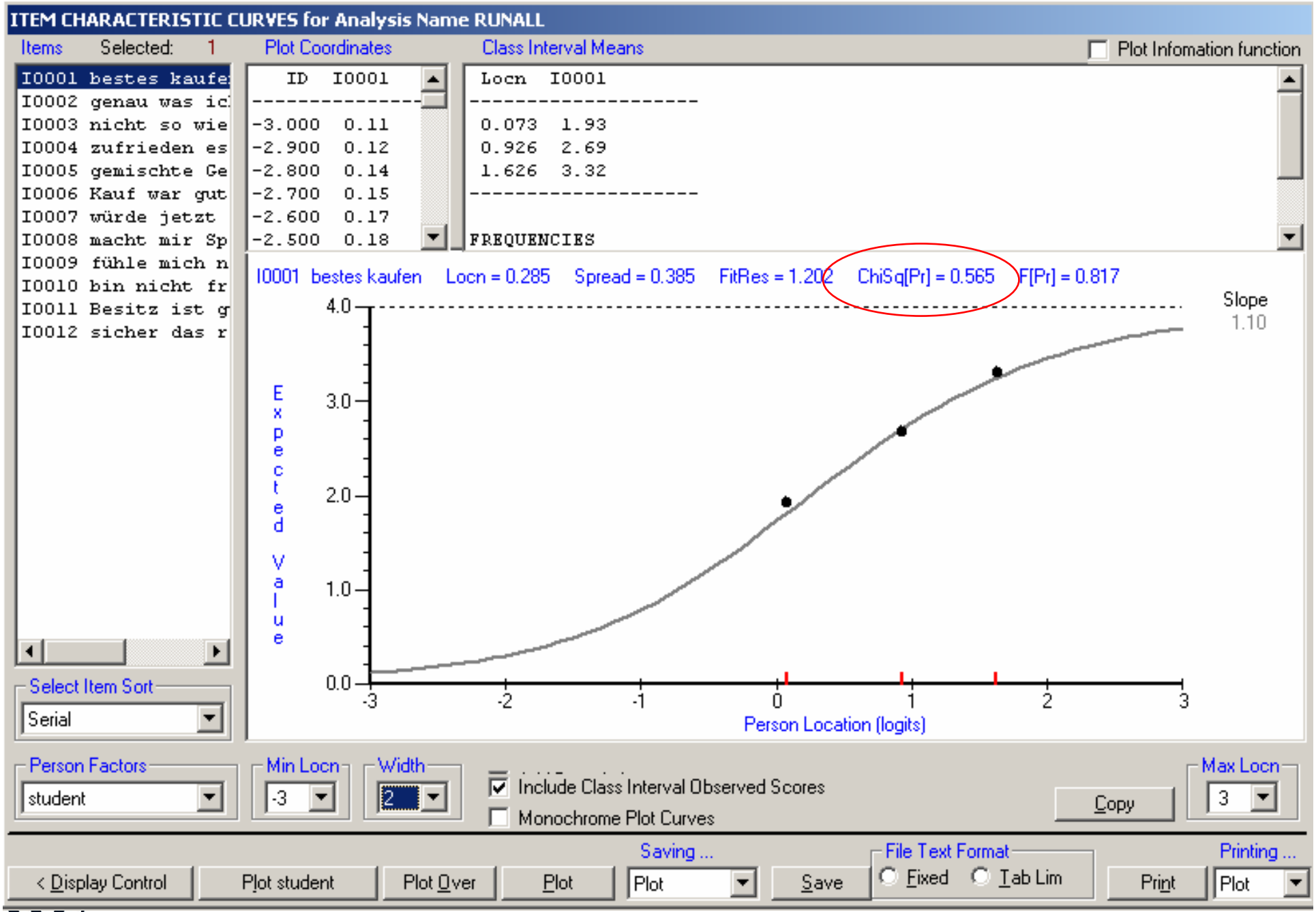
- Pairwise estimation procedure (Andrich and Luo, 2003; Zwindermann, 1995)
- Equivalent to conditional maximum likelihood (CML)
    - Zwindermann, A. H. (1995), 'Pairwise Parameter Estimation in Rasch Models', Applied Psychological Measurement, 19, 369-375.
    - Andrich, D. and G. Luo (2003), 'Conditional Pairwise Estimation in the Rasch Model for Ordered Response Categories using Principal Components', Journal of Applied Measurement, 4 (3), 205-221.

Fit Assessment

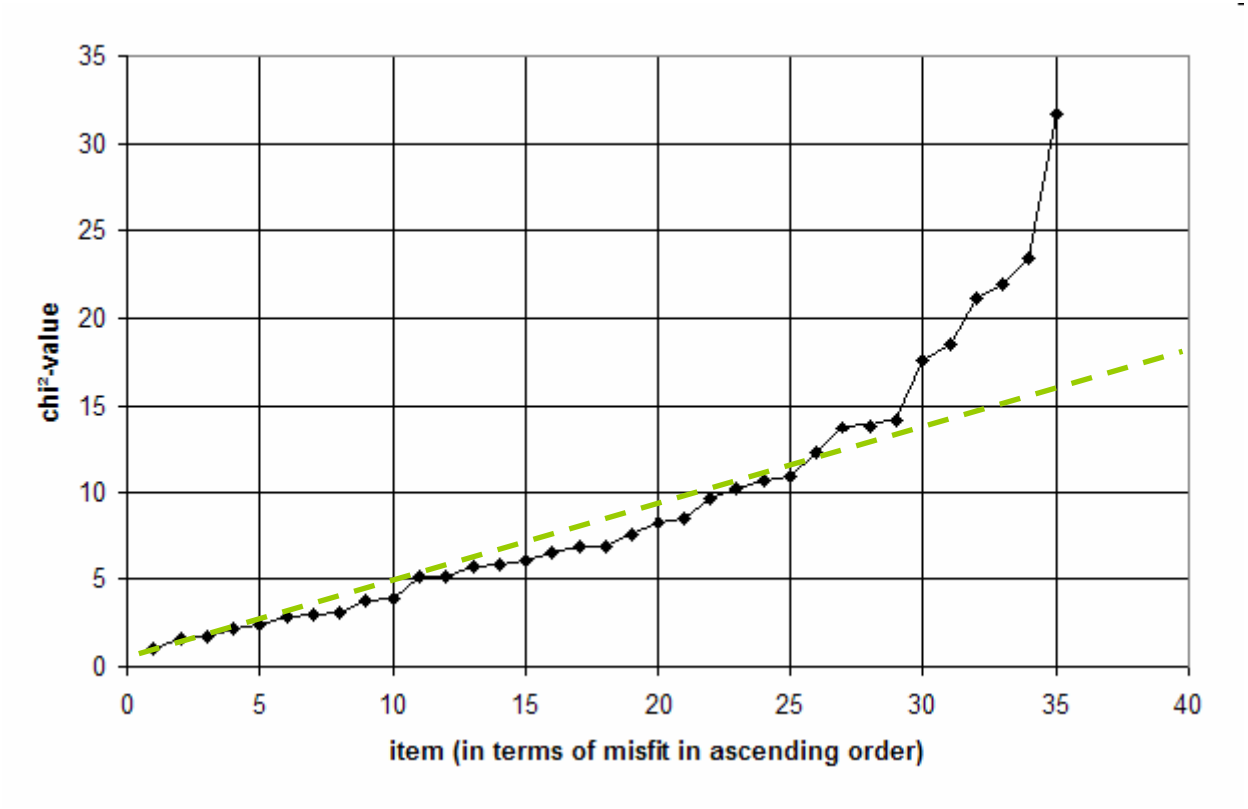
- Overall fit
- Item fit
- Differential item functioning (DIF)
- Multidimensionality
- Local dependence
- Person fit

Fit Assessment

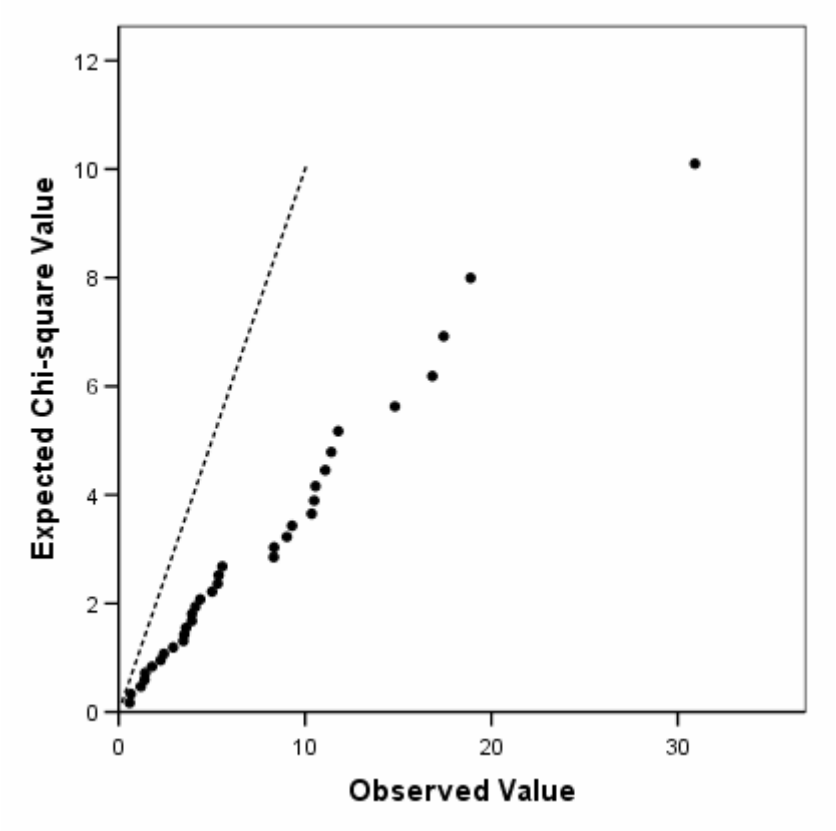
- Item fit
  - χ^2-test of fit: observed (proportion) - expected (probability)
    respondents are grouped into up to 10 class intervals
    can be added up to yield test fit statistic
  - F-test: one-way Anova with class interval as factor
    better accounts for individual residuals


ITEM CHARACTERISTIC CURVES for Analysis Name RUNALL
Items Selected: 1
Plot Coordinates
Class Interval Means
Plot Infomation function
I0001 bestes kaufe
I0002 genau was ic
I0003 nicht so wie
I0004 zufrieden es
I0005 gemischte Ge
I0006 Kauf war gut
I0007 würde jetzt
I0008 macht mir Sp
I0009 fühle mich n
I0010 bin nicht fr
I0011 Besitz ist g
I0012 sicher das r
ID I0001
-3.000 0.11
-2.900 0.12
-2.800 0.14
-2.700 0.15
-2.600 0.17
-2.500 0.18
Locn I0001
0.073 1.93
0.926 2.69
1.626 3.32
FREQUENCIES
I0001 bestes kaufen Locn = 0.285 Spread = 0.385 FitRes = 1.202 ChiSq[Pr] = 0.565 F[Pr] = 0.817
Slope
1.10
Expected Value
4.0
3.0
2.0
1.0
0.0
-3
-2
-1
0
1
2
3
Person Location (logits)
Select Item Sort
Serial
Person Factors
student
Min Locn
-3
Width
2
Include Class Interval Observed Scores
Monochrome Plot Curves
Copy
Max Locn
3
Saving ...
File Text Format
Fixed
Tab Lim
Printing ...
< Display Control
Plot student
Plot Over
Plot
Plot
Save
Print
Plot

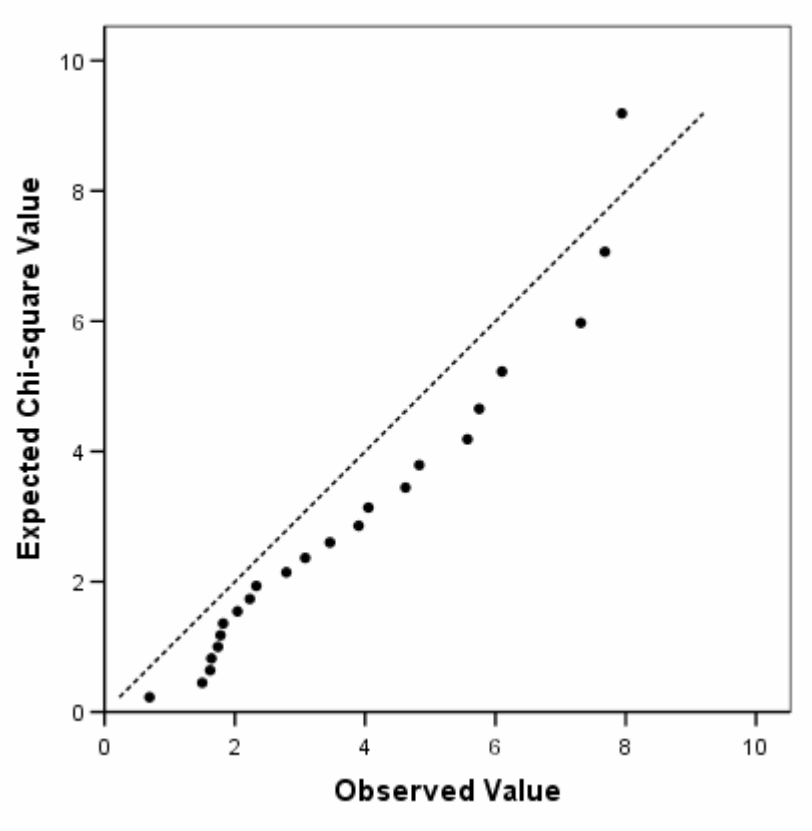
“Scree-plot” of Item χ^2s



Q-Q Plot of Item χ^2s



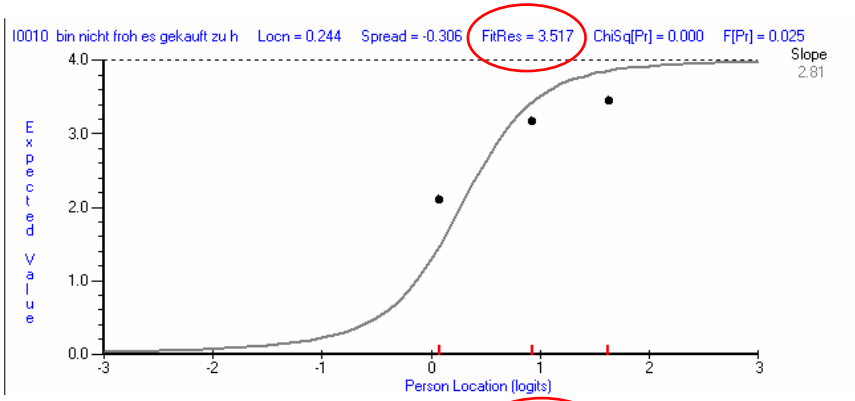
Before purification



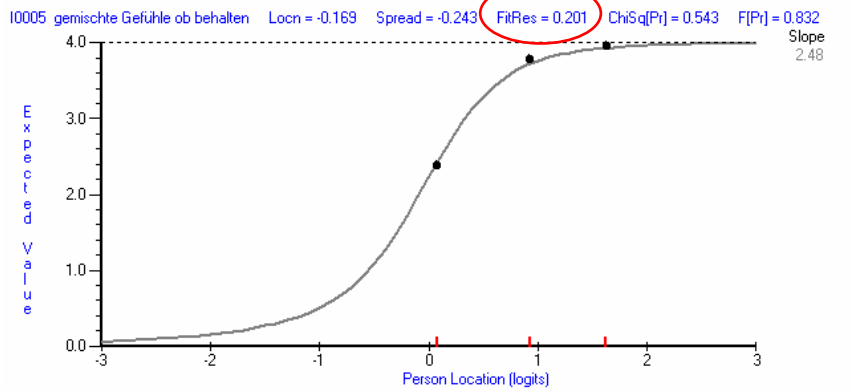
After purification

Fit Assessment

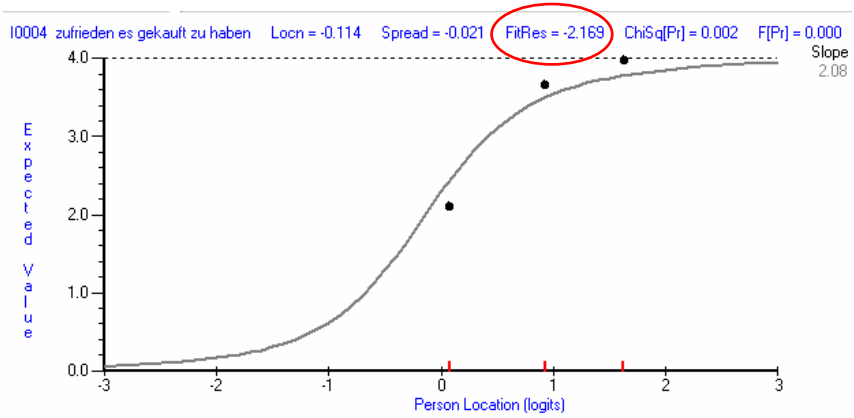
- Item fit residual
  - Fit residual statistic: approximately z-distributed
  - Captures discrimination
  - Expected value = 0
  - Values < -2.5 indicate overdiscrimination
  - Values > 2.5 indicate underdiscrimination
  - Equivalent to Winsteps' outfit statistic



Value > 2.5 indicates overdiscrimination



Value of 0.201 indicates discrimination as expected



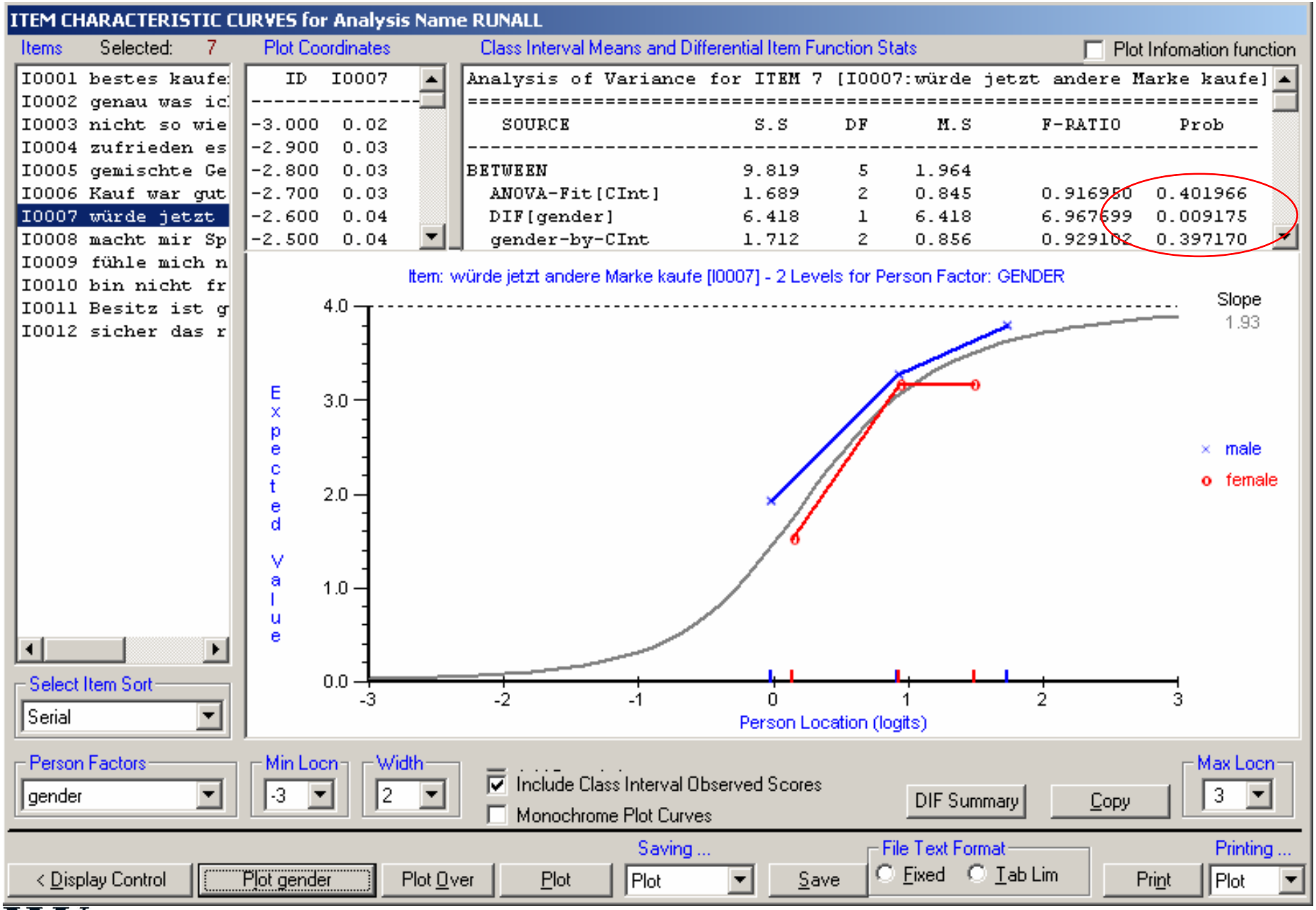
Value < -2.5 indicates overdiscrimination

Differential Item Functioning (Item bias)

- Item works differently for different groups of respondents
- Implies violation of specific objectivity

- Uniform DIF: different item location but equal slope (quantitative difference)
- Non-uniform DIF: different slopes (qualitative difference)

- Two-way anova:
  - Factor 1: class interval; main effect indicates general misfit
  - Factor 2: person factor (DIF factor); main effect indicates uniform DIF
  - Interaction: indicates non-uniform DIF


ITEM CHARACTERISTIC CURVES for Analysis Name RUNALL
Items Selected: 7
Plot Coordinates
Class Interval Means and Differential Item Function Stats
Plot Infomation function
I0001 bestes kaufe
I0002 genau was ic
I0003 nicht so wie
I0004 zufrieden es
I0005 gemischte Ge
I0006 Kauf war gut
I0007 würde jetzt
I0008 macht mir Sp
I0009 fühle mich n
I0010 bin nicht fr
I0011 Besitz ist g
I0012 sicher das r
ID I0007
-3.000 0.02
-2.900 0.03
-2.800 0.03
-2.700 0.03
-2.600 0.04
-2.500 0.04
Analysis of Variance for ITEM 7 [I0007:würde jetzt andere Marke kaufe]
SOURCE S.S DF M.S F-RATIO Prob
BETWEEN 9.819 5 1.964
ANOVA-Fit[CInt] 1.689 2 0.845 0.916950 0.401966
DIF[gender] 6.418 1 6.418 6.967699 0.009175
gender-by-CInt 1.712 2 0.856 0.929102 0.397170
Item: würde jetzt andere Marke kaufe [I0007] - 2 Levels for Person Factor: GENDER
Slope
1.93
male
female
Expected Value
4.0
3.0
2.0
1.0
0.0
-3
-2
-1
0
1
2
3
Person Location (logits)
Select Item Sort
Serial
Person Factors
gender
Min Locn
-3
Width
2
Include Class Interval Observed Scores
Monochrome Plot Curves
DIF Summary
Copy
Max Locn
3
Saving ...
File Text Format
Fixed
Tab Lim
Printing ...
< Display Control
Plot gender
Plot Over
Plot
Plot
Save
Print
Plot

Multidimensionality

- Multidimensionality = more than one latent variable, i.e. at least two variables govern the response process
- Pragmatic considerations
- “Thickness” of a variable, multiple strands of a rope, fractal dimensionality

- General fit statistics (χ^2) do not necessarily indicate multidimensionality
- Depends on correlation of dimensions and number of items per dimension
- Large number of items of dimension 1 and small number of items of dimension 2 -> latent variable in the model dominated by dimension 1, items of dimension 2 will misfit, in particular when dimensions are weakly correlated
- Equal number of items -> latent variable in the model is a composite of two variables and general fit statistics will not detect multidimensionality

Multidimensionality

- Principal components analysis of the residuals (exploratory analysis)
- If residuals are poorly random, then there should be no structure in the residuals and a PCA should yield random components.

Principal Component Summary

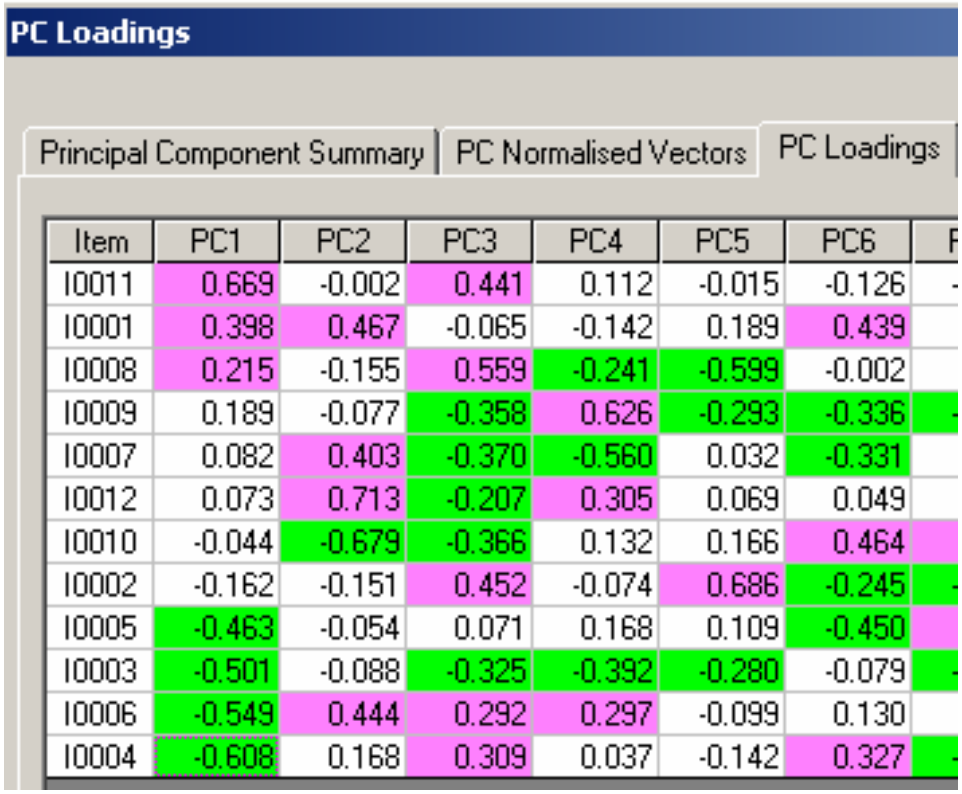
Principal Component Summary | PC Normalised Vectors | PC Loadings | Vari

PC	Eigen	Percent	CPercent	StdErr
PC001	1.864	15.53%	15.53%	0.248
PC002	1.638	13.65%	29.19%	0.211
PC003	1.449	12.07%	41.26%	0.194
PC004	1.183	9.86%	51.12%	0.150
PC005	1.105	9.21%	60.33%	0.132
PC006	1.043	8.69%	69.02%	0.137
PC007	0.989	8.24%	77.26%	0.127
PC008	0.845	7.05%	84.30%	0.108
PC009	0.715	5.96%	90.26%	0.096
PC010	0.635	5.29%	95.56%	0.087
PC011	0.507	4.22%	99.78%	0.076
PC012	0.026	0.22%	100.00%	0.052

Eigenvalue #	Random Eigenvalue	Standard Dev
1	1.4715	.0697
2	1.3417	.0529
3	1.2454	.0410
4	1.1611	.0365
5	1.0822	.0292
6	1.0153	.0328
7	0.9466	.0298
8	0.8854	.0297
9	0.8136	.0339
10	0.7482	.0342
11	0.6823	.0338
12	0.6069	.0431

Multidimensionality

- Principal components analysis of the residuals
- Loadings on the first component


PC Loadings

Principal Component Summary | PC Normalised Vectors | PC Loadings

Item	PC1	PC2	PC3	PC4	PC5	PC6
I0011	0.669	-0.002	0.441	0.112	-0.015	-0.126
I0001	0.398	0.467	-0.065	-0.142	0.189	0.439
I0008	0.215	-0.155	0.559	-0.241	-0.599	-0.002
I0009	0.189	-0.077	-0.358	0.626	-0.293	-0.336
I0007	0.082	0.403	-0.370	-0.560	0.032	-0.331
I0012	0.073	0.713	-0.207	0.305	0.069	0.049
I0010	-0.044	-0.679	-0.366	0.132	0.166	0.464
I0002	-0.162	-0.151	0.452	-0.074	0.686	-0.245
I0005	-0.463	-0.054	0.071	0.168	0.109	-0.450
I0003	-0.501	-0.088	-0.325	-0.392	-0.280	-0.079
I0006	-0.549	0.444	0.292	0.297	-0.099	0.130
I0004	-0.608	0.168	0.309	0.037	-0.142	0.327

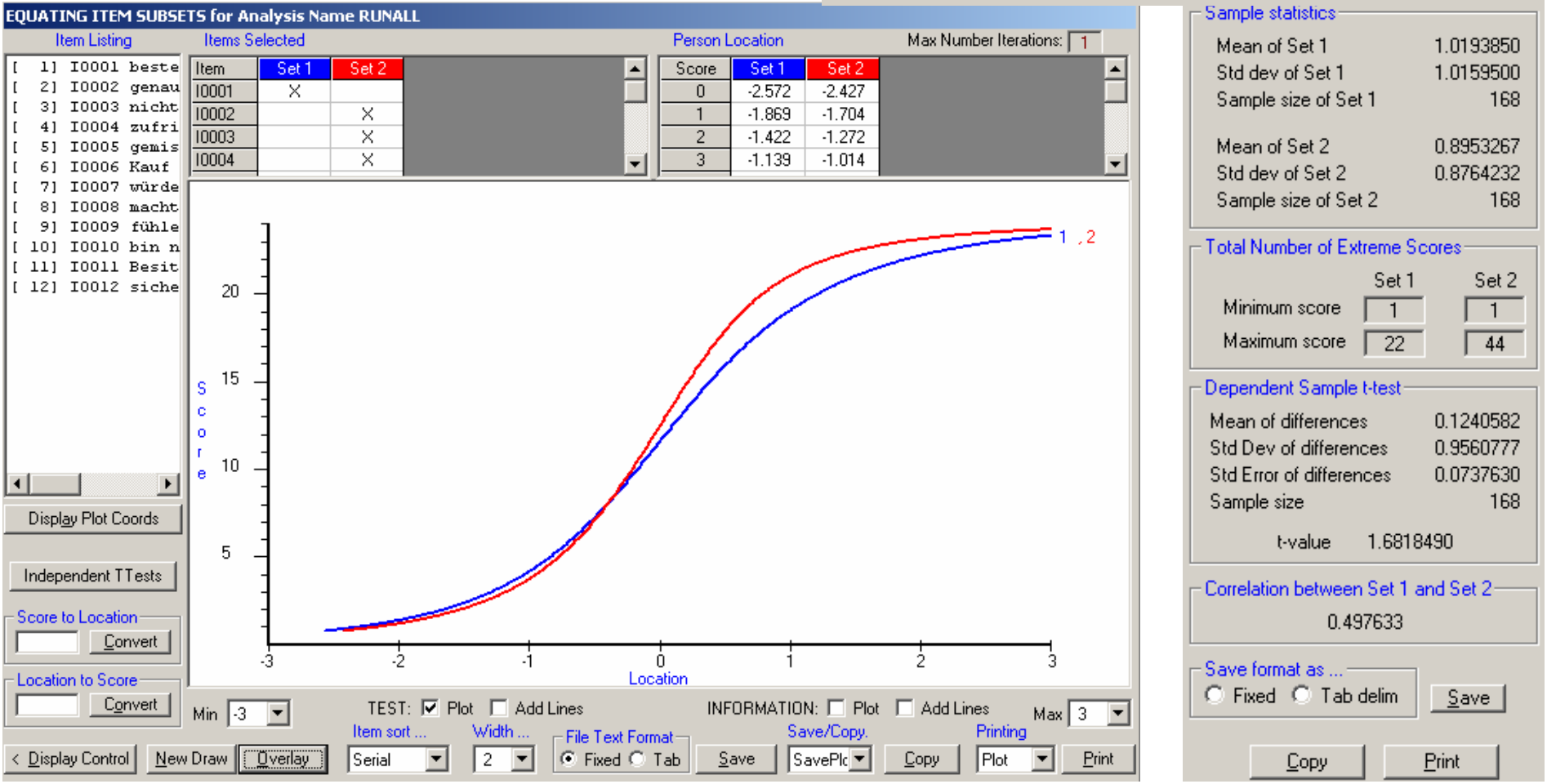
Multidimensionality

- t-Test procedure: in case of unidimensionality, estimates based on different sets of items should be equal up to random variation.

CI: 0.0595 +- 0.37

Summary Table of t-test analyses for this Subtest pair

Test	Subset Pair	No. < 5%	No. < 1%	PerC < 5%	PerC < 1%	Total
1	Set 1; Set 2	10	2	5.95%	1.19%	168



Local Dependence

- Extra dependence of item responses (response dependency), may but need not be due to multidimensionality
- Item residual correlations
- Values < -0.30 or > 0.20 should be considered problematic

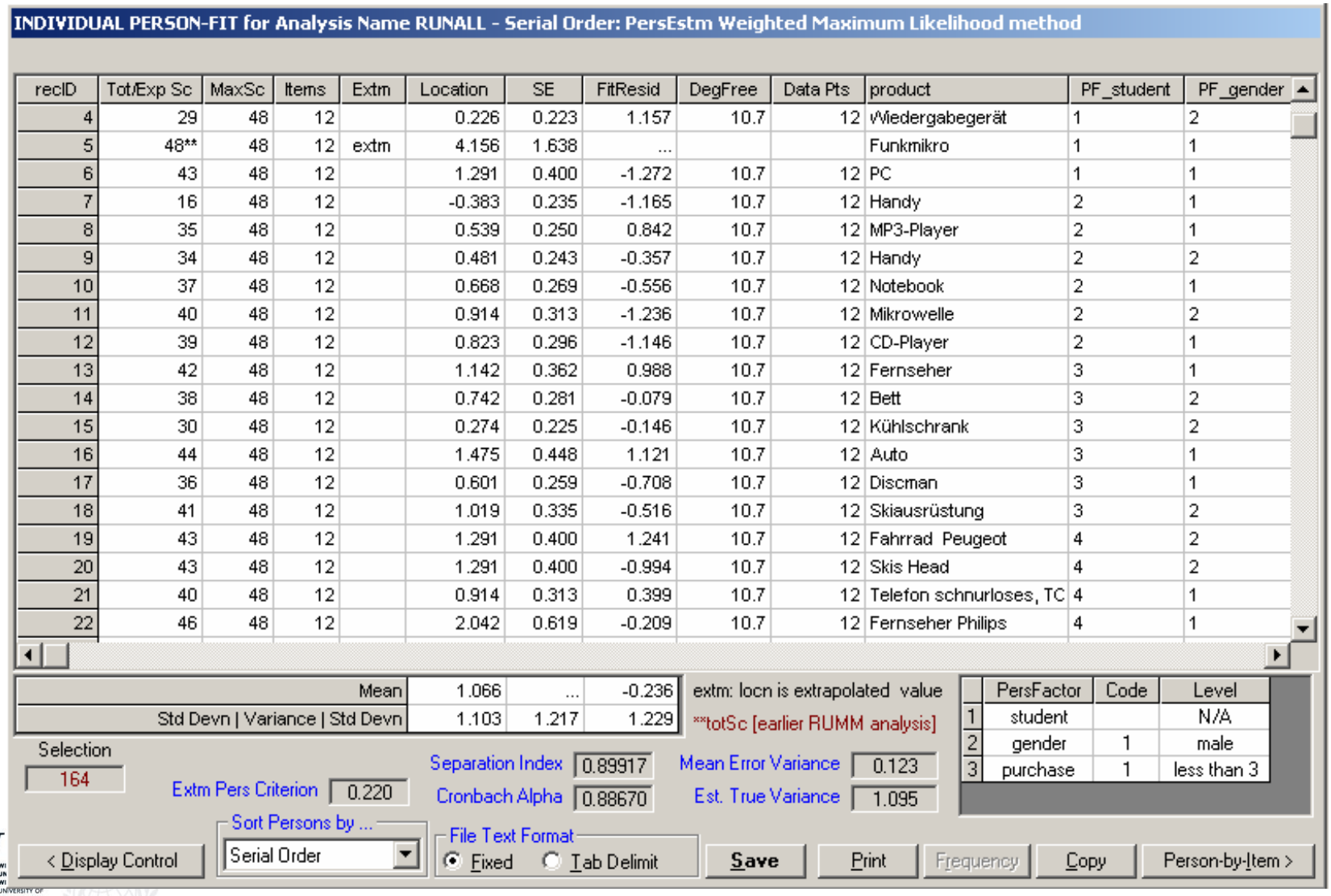
Person-Item Residual Correlation Matrix

Principal Component Summary | PC Normalised Vectors | PC Loadings | Varimax Rotation Loadings | Residual Correlation Matrix

Item	I0001	I0002	I0003	I0004	I0005	I0006	I0007	I0008	I0009	I0010	I0011	I0012
I0001	1.000											
I0002	-0.136	1.000										
I0003	-0.187	-0.090	1.000									
I0004	-0.131	0.056	0.132	1.000								
I0005	-0.206	0.030	0.027	0.023	1.000							
I0006	-0.088	0.000	-0.017	0.354	0.174	1.000						
I0007	0.022	-0.152	0.010	-0.134	-0.085	-0.084	1.000					
I0008	-0.077	-0.106	-0.123	-0.036	-0.080	-0.031	-0.130	1.000				
I0009	-0.121	-0.183	-0.077	-0.153	-0.084	-0.118	-0.134	-0.143	1.000			
I0010	-0.230	-0.147	-0.077	-0.135	-0.066	-0.212	-0.241	-0.177	-0.075	1.000		
I0011	0.029	-0.011	-0.366	-0.222	-0.222	-0.210	-0.134	0.162	-0.027	-0.221	1.000	
I0012	0.175	-0.165	-0.109	-0.032	-0.060	0.208	0.120	-0.214	0.039	-0.250	-0.004	1.000

Person Fit

- Fit residual statistic



INDIVIDUAL PERSON-FIT for Analysis Name RUNALL - Serial Order: PersEstm Weighted Maximum Likelihood method

recID	Tot/Exp Sc	MaxSc	Items	Extm	Location	SE	FitResid	DegFree	Data Pts	product	PF_student	PF_gender
4	29	48	12		0.226	0.223	1.157	10.7	12	Wiedergabegerät	1	2
5	48**	48	12	extm	4.156	1.638	...			Funkmikro	1	1
6	43	48	12		1.291	0.400	-1.272	10.7	12	PC	1	1
7	16	48	12		-0.383	0.235	-1.165	10.7	12	Handy	2	1
8	35	48	12		0.539	0.250	0.842	10.7	12	MP3-Player	2	1
9	34	48	12		0.481	0.243	-0.357	10.7	12	Handy	2	2
10	37	48	12		0.668	0.269	-0.556	10.7	12	Notebook	2	1
11	40	48	12		0.914	0.313	-1.236	10.7	12	Mikrowelle	2	2
12	39	48	12		0.823	0.296	-1.146	10.7	12	CD-Player	2	1
13	42	48	12		1.142	0.362	0.988	10.7	12	Fernseher	3	1
14	38	48	12		0.742	0.281	-0.079	10.7	12	Bett	3	2
15	30	48	12		0.274	0.225	-0.146	10.7	12	Kühlschrank	3	2
16	44	48	12		1.475	0.448	1.121	10.7	12	Auto	3	1
17	36	48	12		0.601	0.259	-0.708	10.7	12	Discman	3	1
18	41	48	12		1.019	0.335	-0.516	10.7	12	Skiausrüstung	3	2
19	43	48	12		1.291	0.400	1.241	10.7	12	Fahrrad Peugeot	4	2
20	43	48	12		1.291	0.400	-0.994	10.7	12	Skis Head	4	2
21	40	48	12		0.914	0.313	0.399	10.7	12	Telefon schnurloses, TC	4	1
22	46	48	12		2.042	0.619	-0.209	10.7	12	Fernseher Philips	4	1

Mean	1.066	...	-0.236
Std Devn | Variance | Std Devn	1.103	1.217	1.229

extm: locn is extrapolated value

**totSc [earlier RUMM analysis]

	PersFactor	Code	Level
1	student		N/A
2	gender	1	male
3	purchase	1	less than 3

Selection: 164

Extm Pers Criterion: 0.220

Separation Index: 0.89917

Cronbach Alpha: 0.88670

Mean Error Variance: 0.123

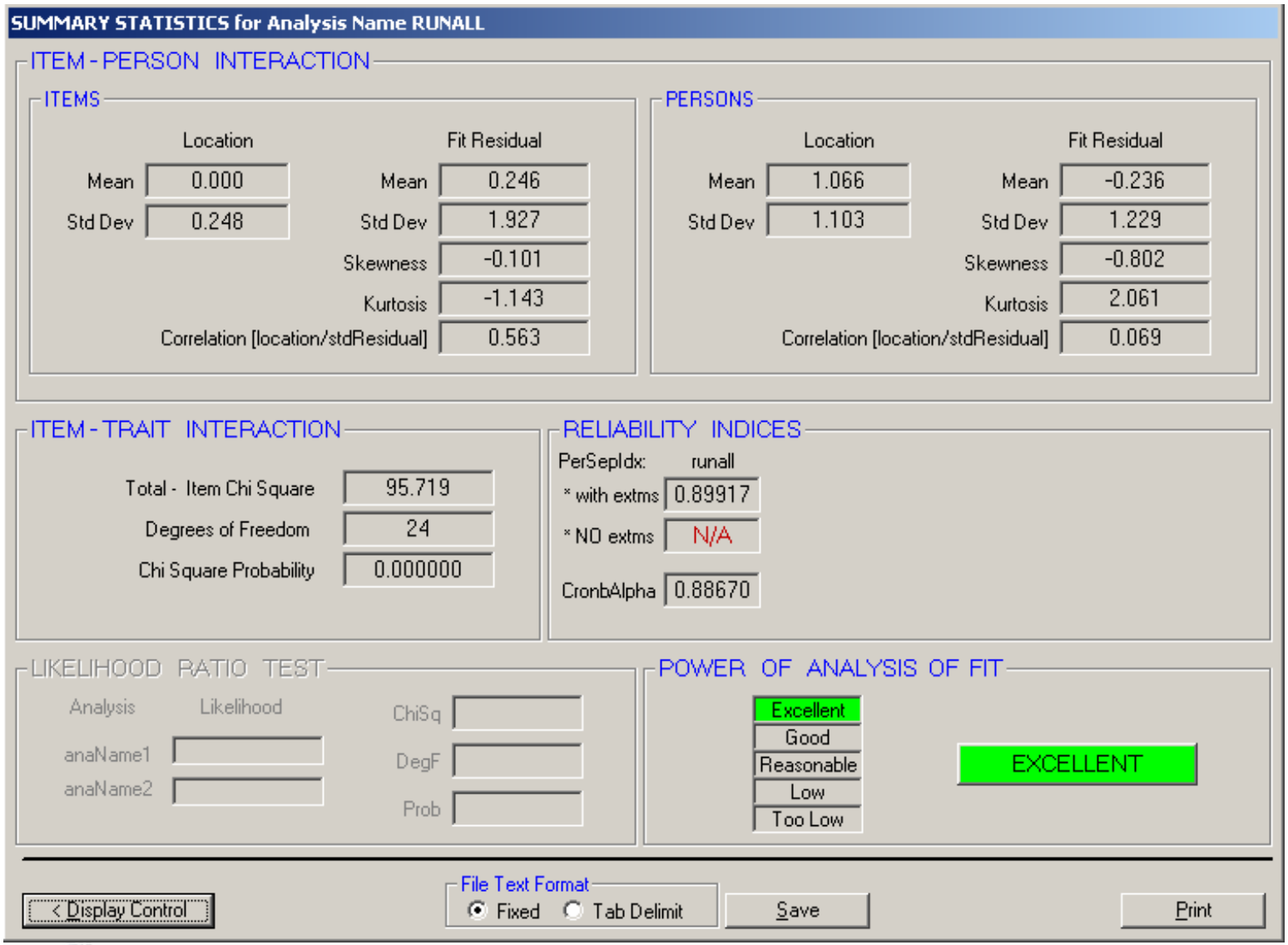
Est. True Variance: 1.095

Sort Persons by ... : Serial Order

File Text Format: Fixed / Tab Delimit

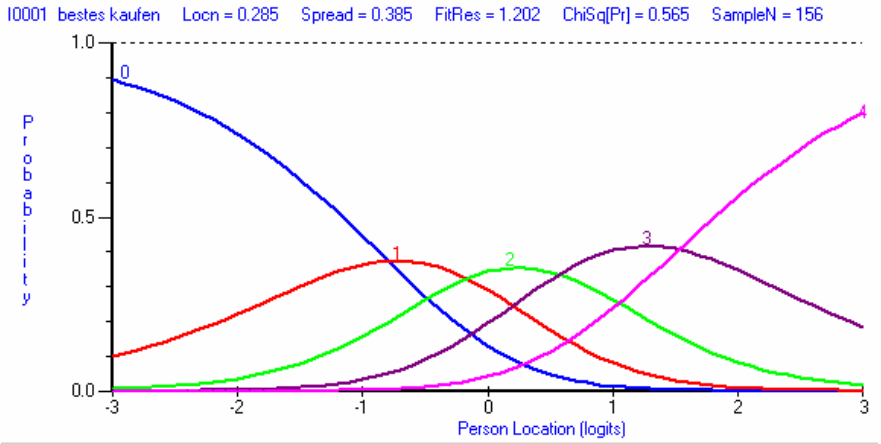
< Display Control | Save | Print | Frequency | Copy | Person-by-Item >

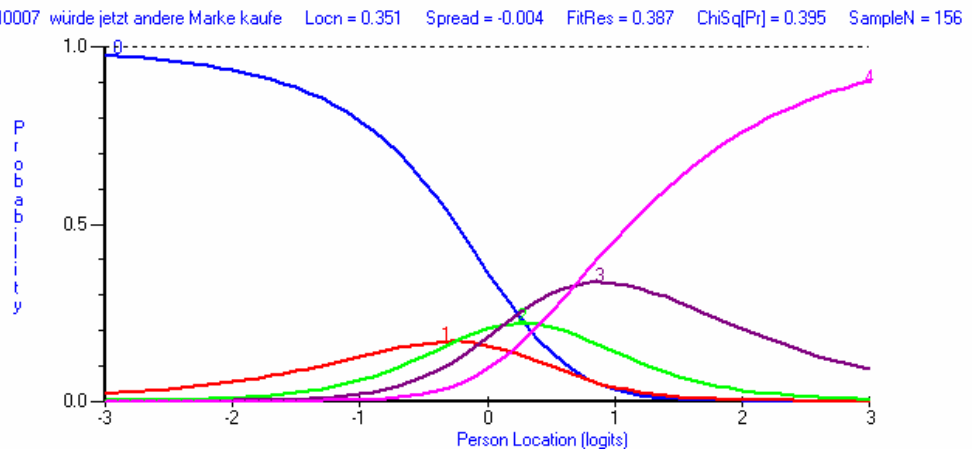
Summary Statistics

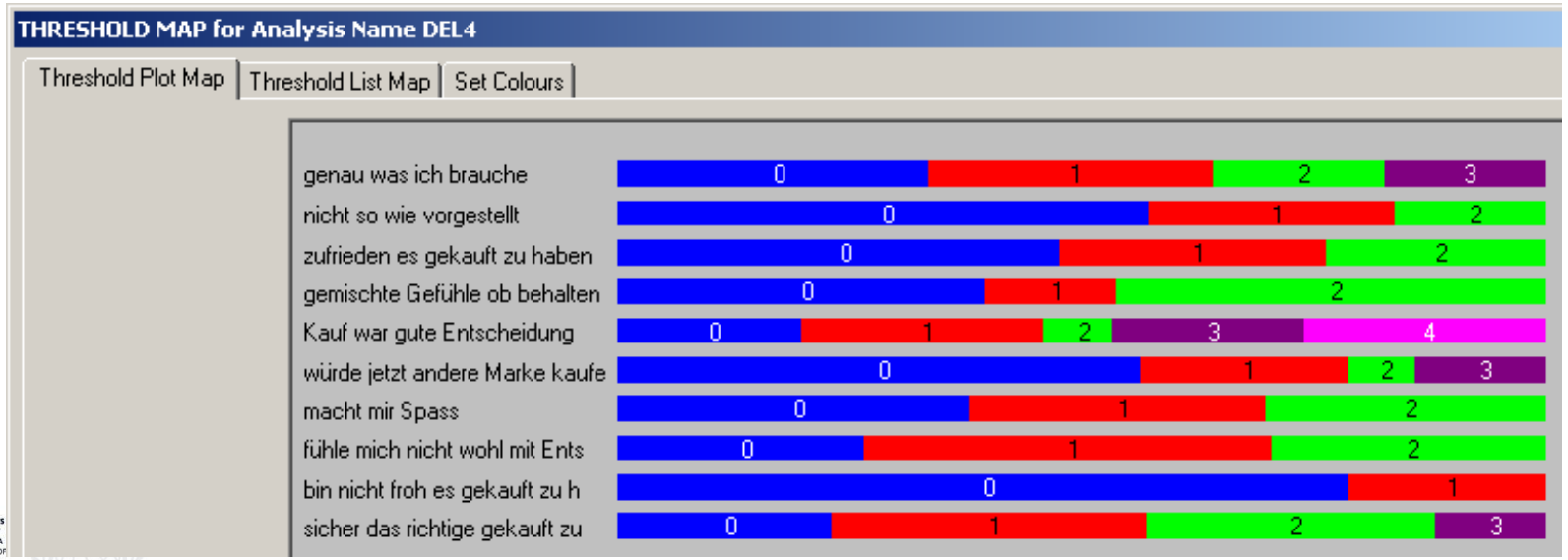


Threshold order

- Order of thresholds between adjacent categories

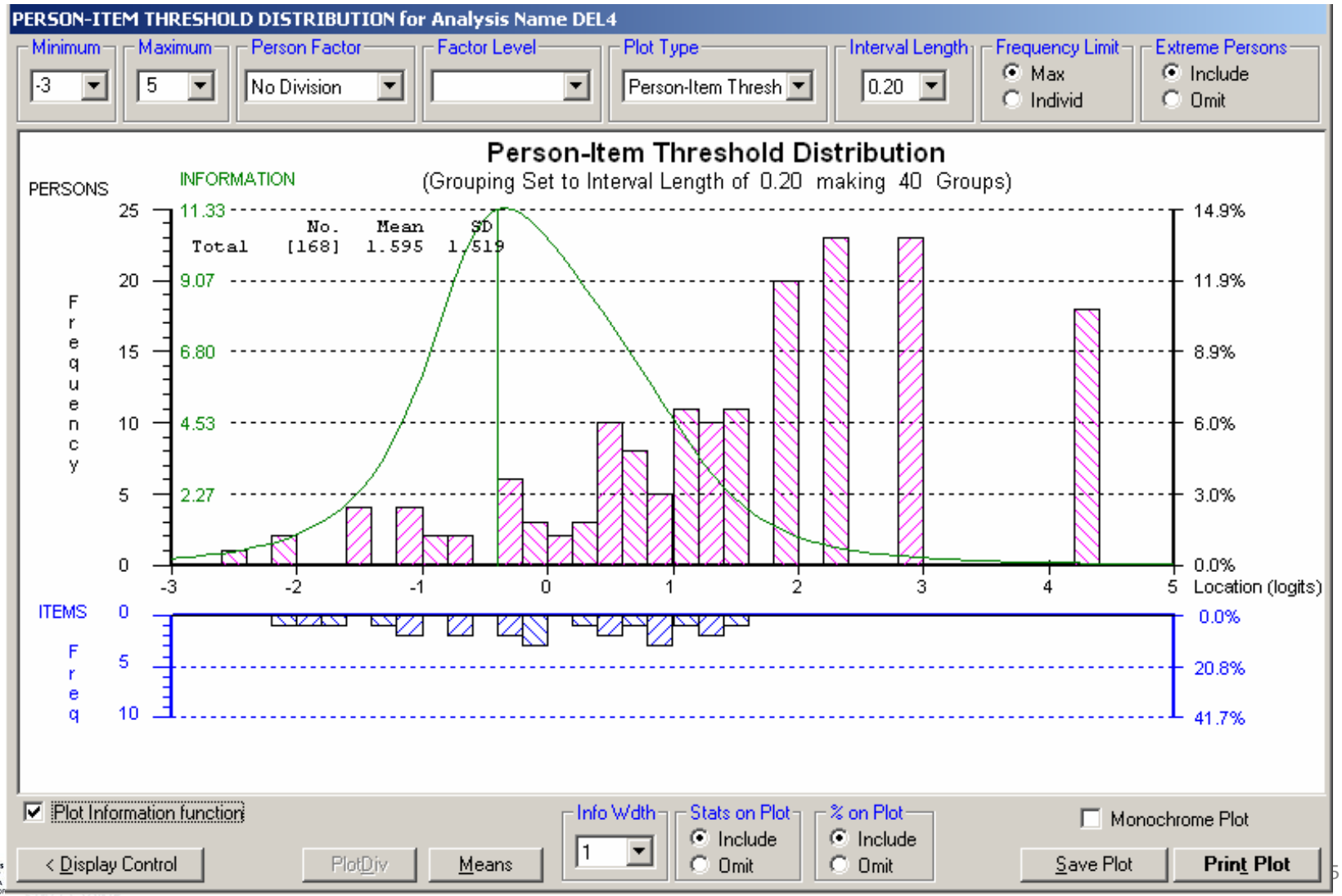






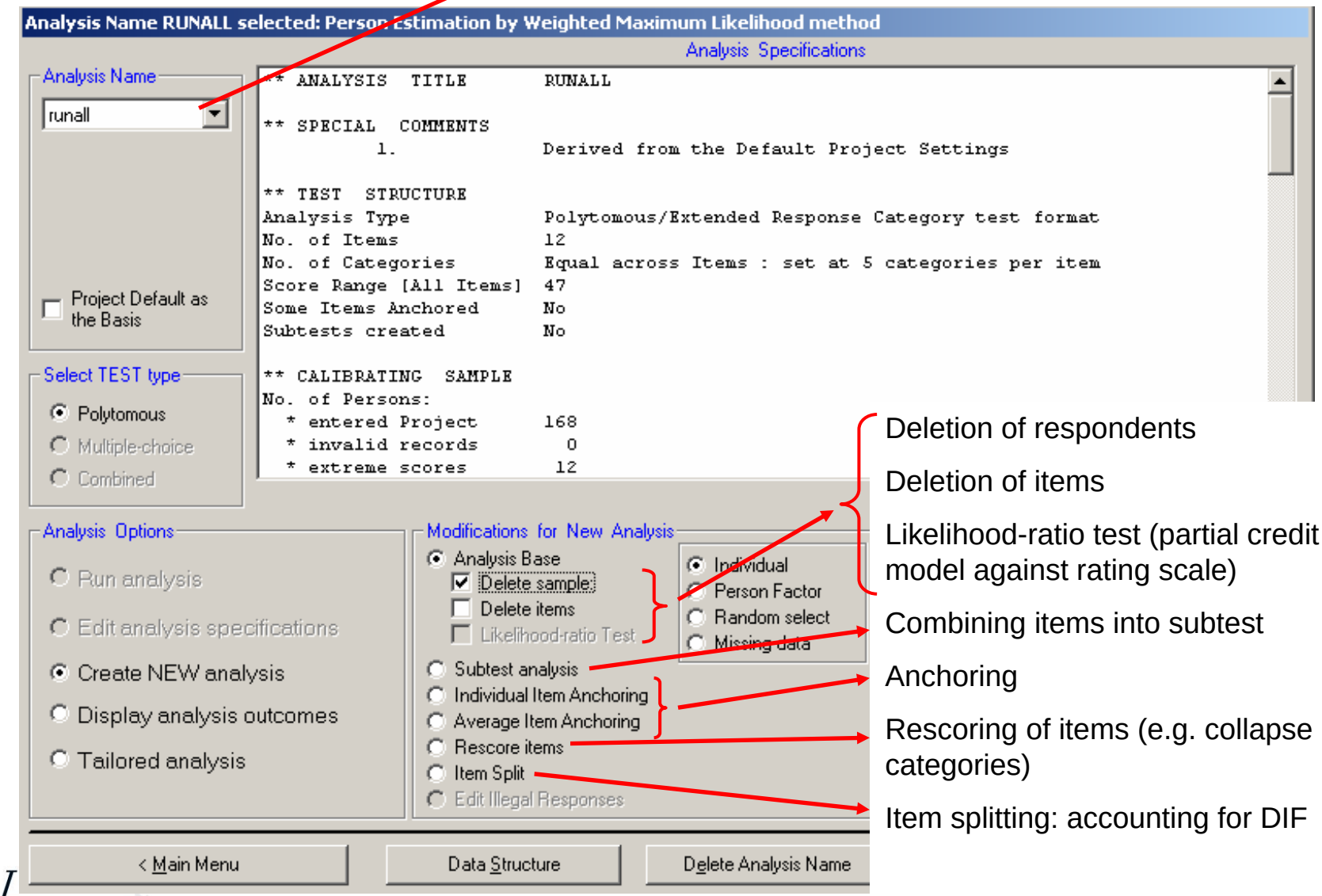
Targeting

- Person-Item location/threshold Distribution



Amended Analyses

New analysis inherits amendments of this analysis



Deletion of respondents

Deletion of items

Likelihood-ratio test (partial credit model against rating scale)

Combining items into subtest

Anchoring

Rescoring of items (e.g. collapse categories)

Item splitting: accounting for DIF