



# The structural validity of the Inductive Reasoning Developmental Test for the Measurement of Developmental Stages

Hudson F. Golino, B. Psy, Msc (Dev. Psy)  
Cristiano Mauro Assis Gomes, Ph.D

Laboratório de Investigação da  
Arquitetura Cognitiva  
Universidade Federal de Minas Gerais

---

# Constructing items

- Constructing calibrated tests for developmental stage identification requires a specific design that is defined by Commons and colleagues (Commons & Pekker, 2008; Commons newest axiom paper ).

# Constructing items

## Strategy 1

- 1) grouping items with same hierarchical complexity [ $h(i_1) = h(i_2) = h(i_3) = \dots h(i_n)$ ] within stages

## Why?

- It deals with item or task equivalence, important in order to avoid the elaboration of an anomalous scale that confuses its analysis (Fischer & Rose, 1999)

# Constructing items

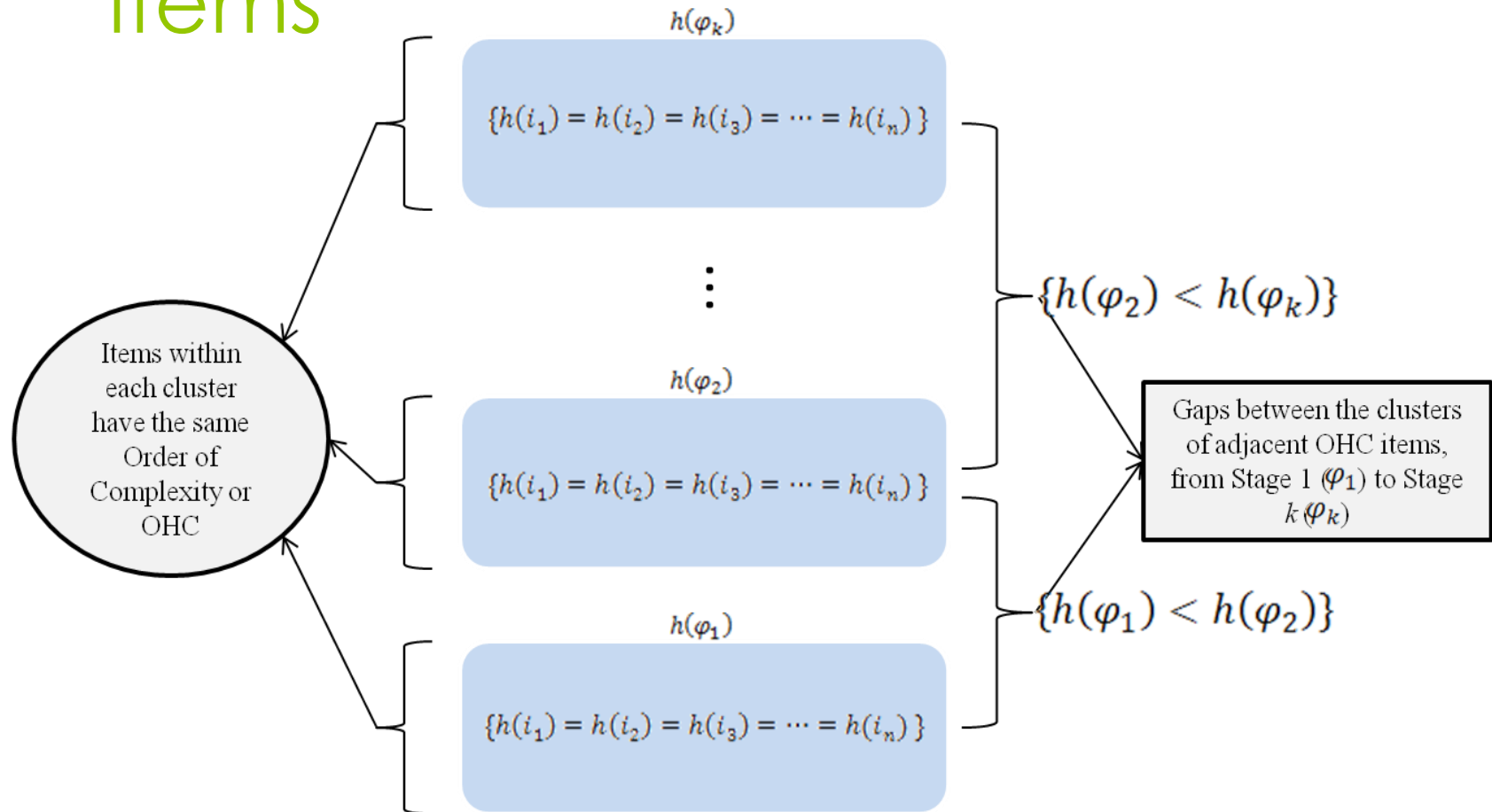
## Strategy 2

- Using items with increasing hierarchical complexity [ $h(\text{Stage } 1) < h(\text{Stage } 2) < h(\text{Stage } 3) < \dots < h(\text{Stage } k)$ ] between stages.

## Why?

- It makes possible the identification of discontinuous, stage-like development, with gaps between different orders.

# The expected structure of items



# Study

- Inductive Reasoning Developmental Test (IRDT) 3th edition is a pencil and paper instrument based on the MHC, constructed to identify 7 stages, from Pre-operational to Metassystematic.
- The IRTD was administered to a convenience sample composed by 1,193 Brazilian people (53% women, 47% men) aged between 6 to 86 years ( $M = 15.02$ ,  $SD = 12.30$ ). The sample was intentionally broad, and had a distribution of 34.20% from 6 to 11 years, 53.50% from 12 to 18 years, 6.40% from 19 to 49 years, and 5.90% from 50 to 86 years. All the participants were from the city of Belo Horizonte, state of Minas Gerais, Brazil.

# Data analysis

- In the first part of the data analysis the dichotomous Rasch Model is used, using the software Winsteps 3.70.1 (Linacre, 2012). It produces linear measures, gives estimates of precision, allows the detection of lack of fit or misfit, enables the parameters' separation of the object being measured and of the measurement instrument (Panayides, Robinson & Tymms, 2010) and enables the verification of hierarchical sequences of both item and person, being especially relevant to developmental stage identification (Dawson, Xie & Wilson, 2003). After verifying the fit to the dichotomous Rasch Model, the structure of the items' difficulties is visually verified through the Wright (variable) map. It is expected that items constructed to identify a particular stage form a well-defined cluster. Each cluster of items should be separated by a gap. The clusters visually verified can be checked analytically through hidden markov model, using the depmixS4 package of the R software.

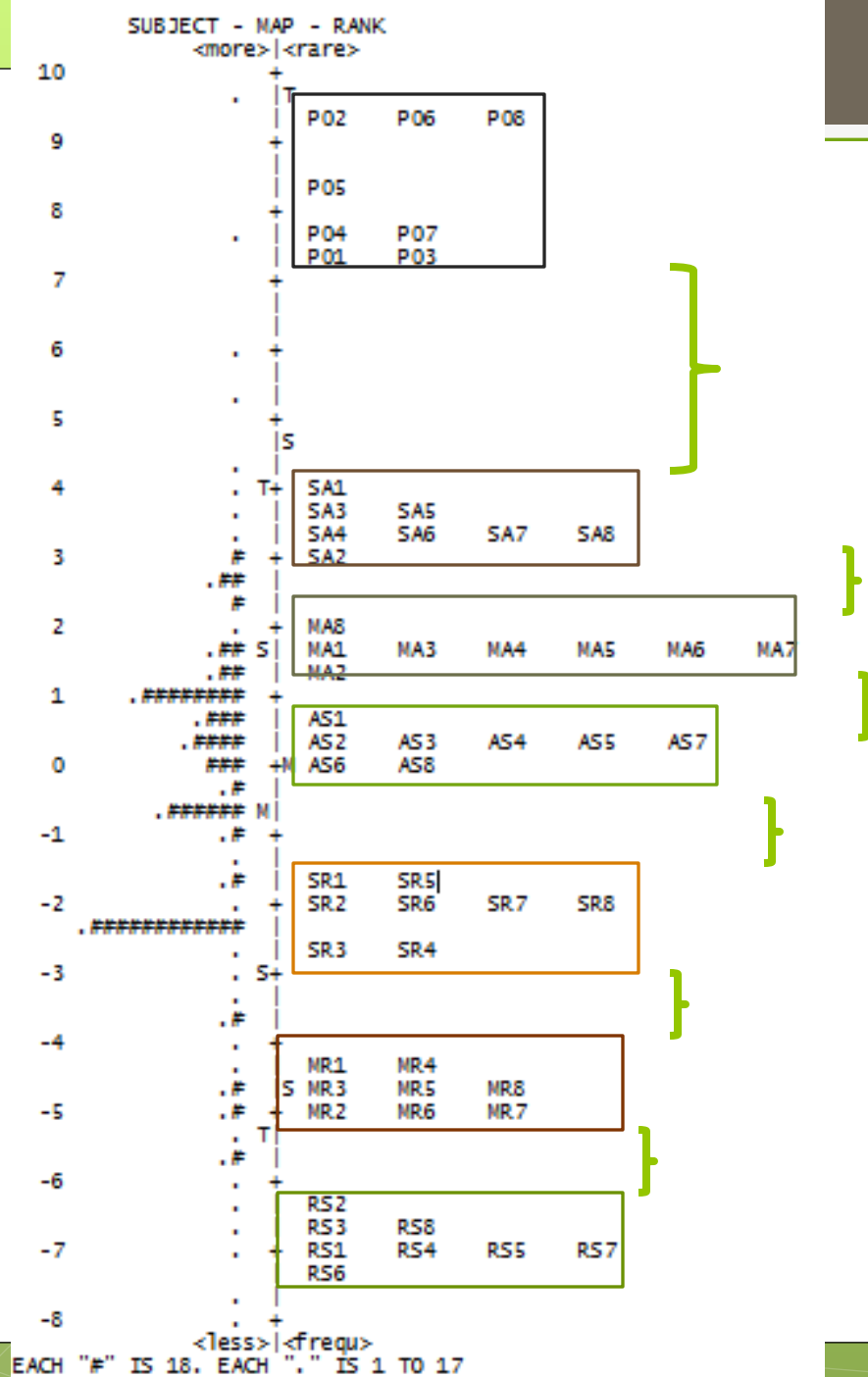
# Results

SUBJECT	1193	INPUT	1193	MEASURED		INFIT		OUTFIT	
	TOTAL	COUNT		MEASURE	ERROR	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	15.7	32.9		-.73	.93	1.01	-.3	1.38	.1
S.D.	10.4	18.4		2.39	.50	1.04	1.7	2.54	1.7
REAL RMSE	1.06	TRUE SD	2.15	SEPARATION	2.03	SUBJEC	RELIABILITY	.80	

RANK	56	INPUT	56	MEASURED		INFIT		OUTFIT	
	TOTAL	COUNT		MEASURE	ERROR	IMNSQ	ZSTD	OMNSQ	ZSTD
MEAN	335.1	699.9		.00	.29	.90	-.9	2.09	1.4
S.D.	307.4	227.7		4.76	.28	.23	2.1	2.34	5.0
REAL RMSE	.40	TRUE SD	4.75	SEPARATION	11.83	RANK	RELIABILITY	.99	

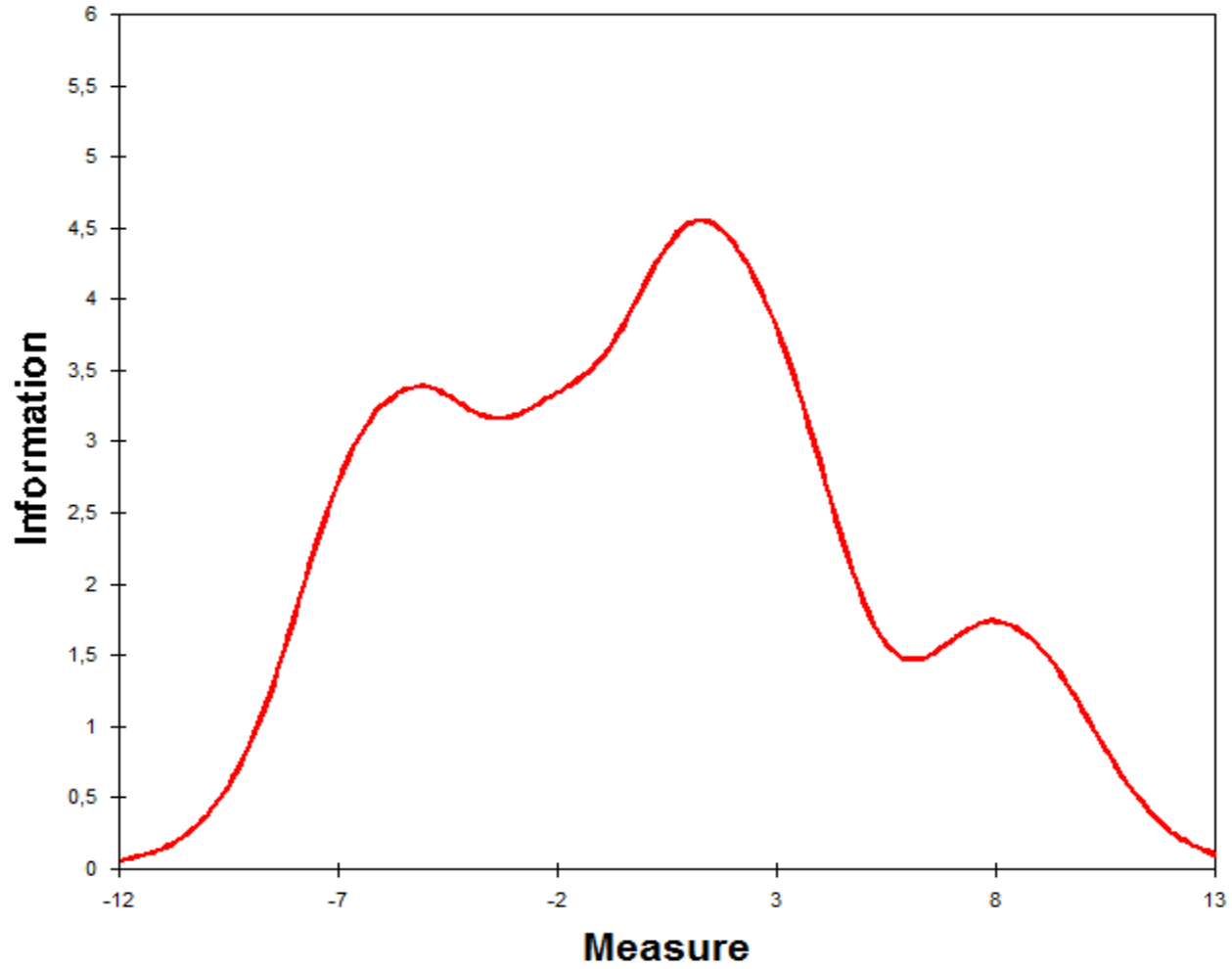


# Results

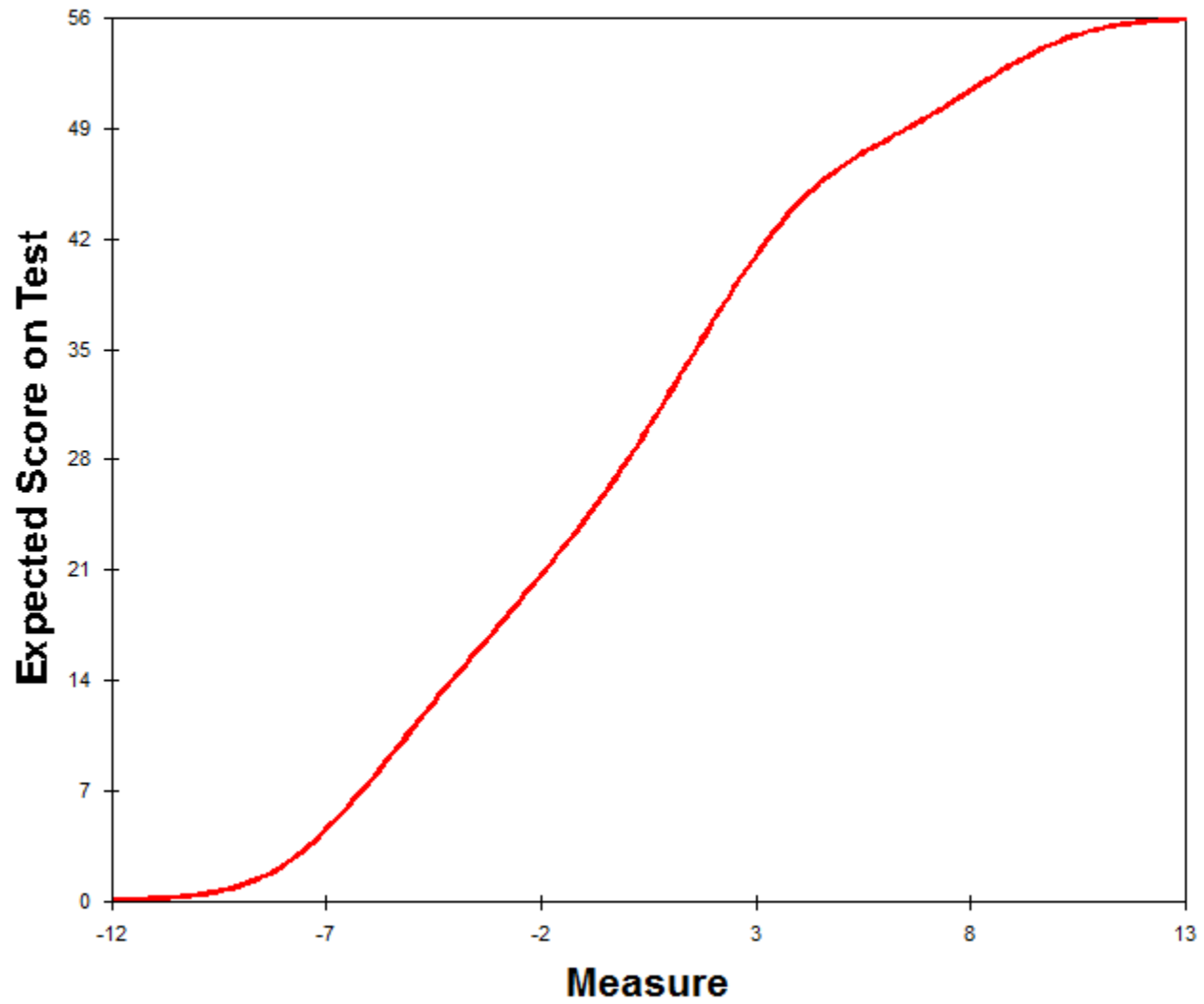


# Results

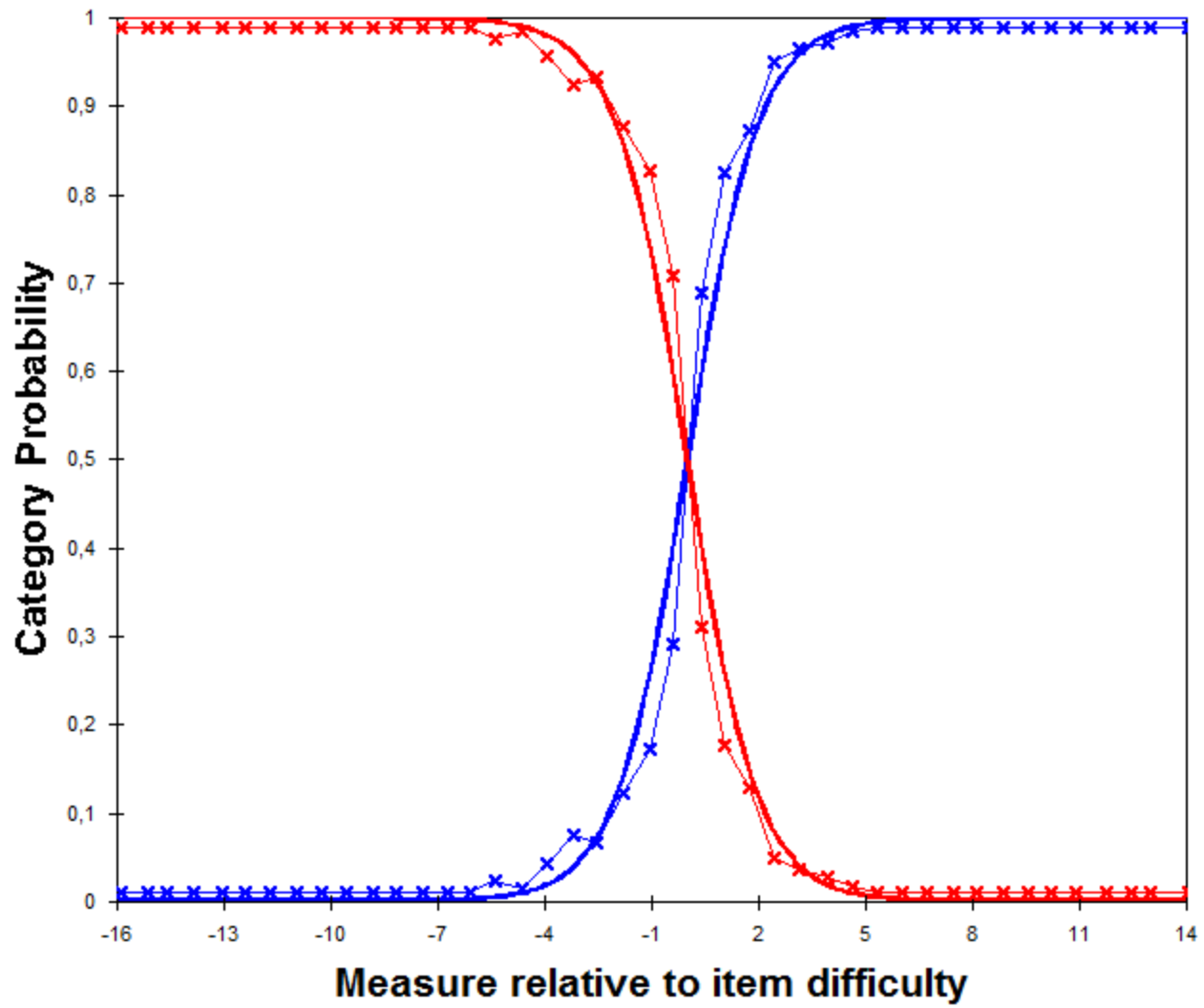
Test Information Function



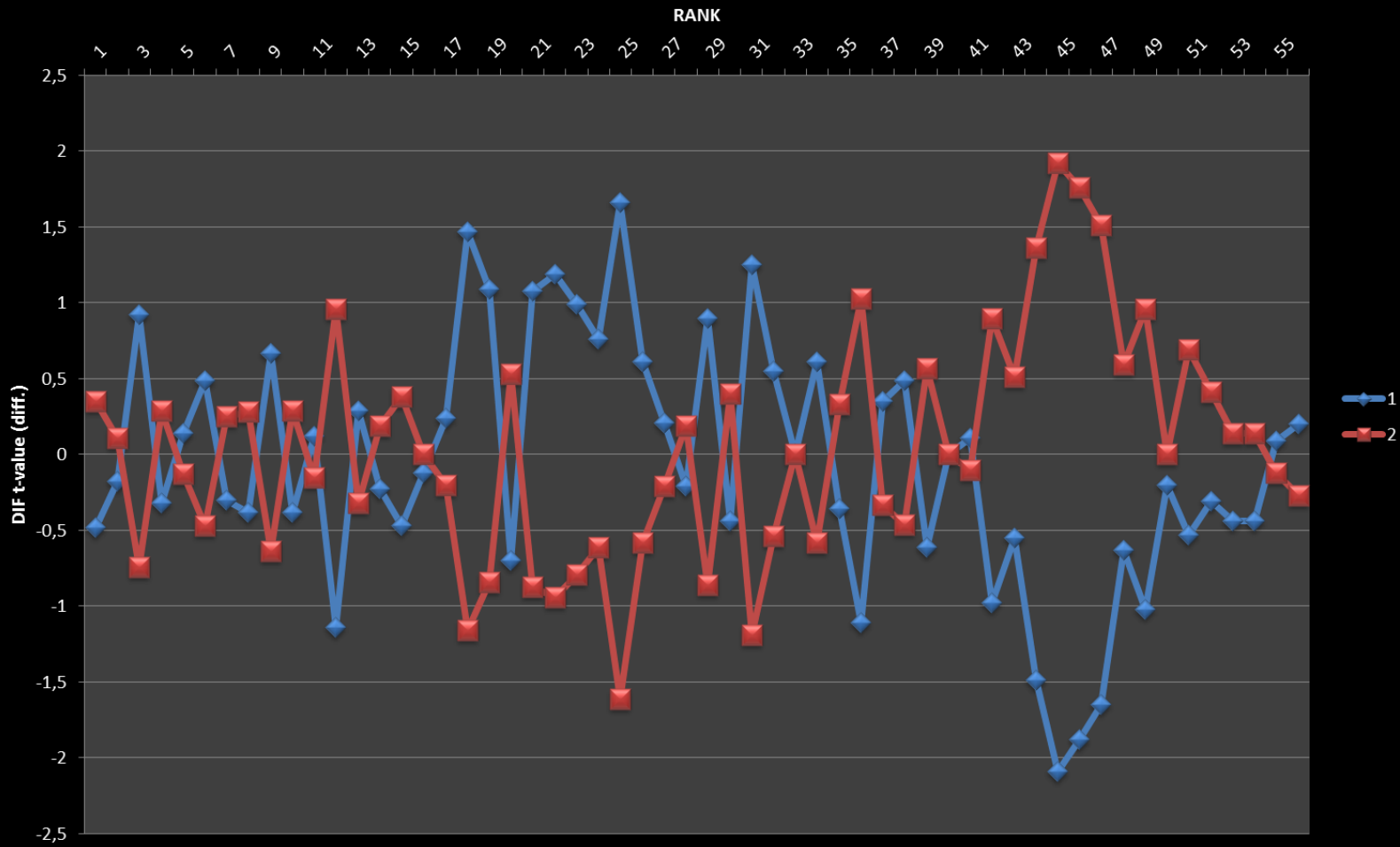
Test Characteristic Curve



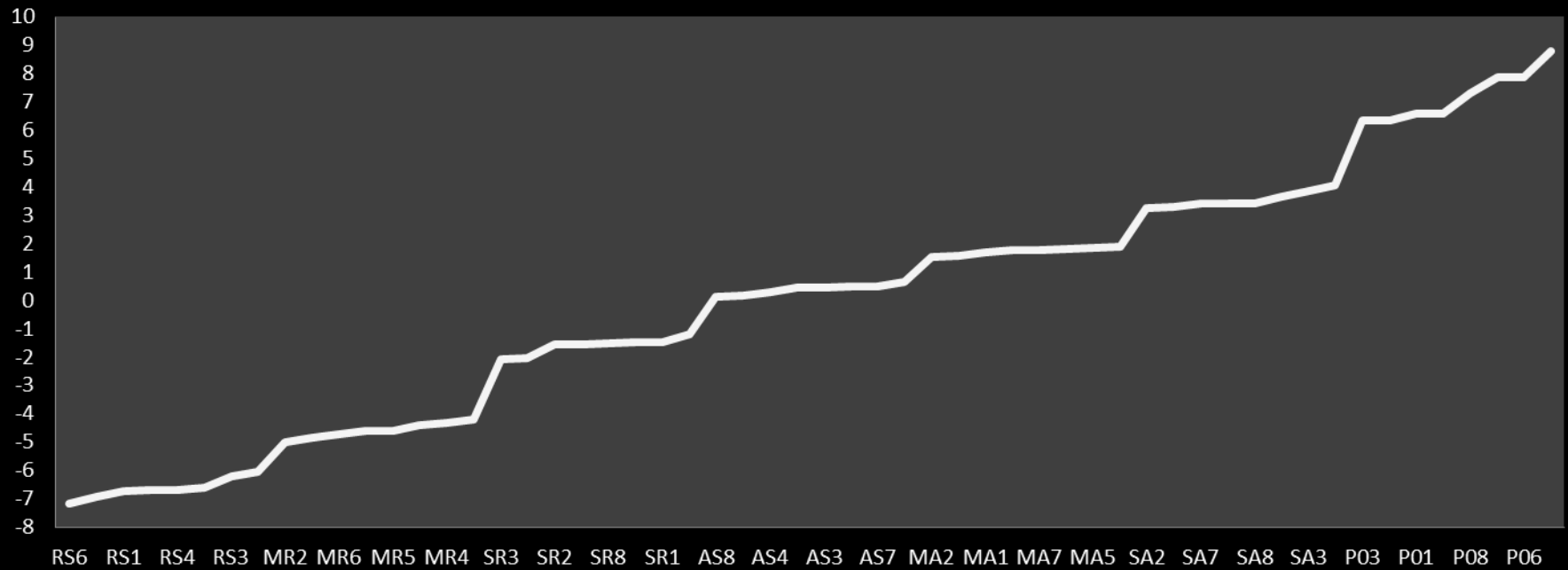
TDRI2012



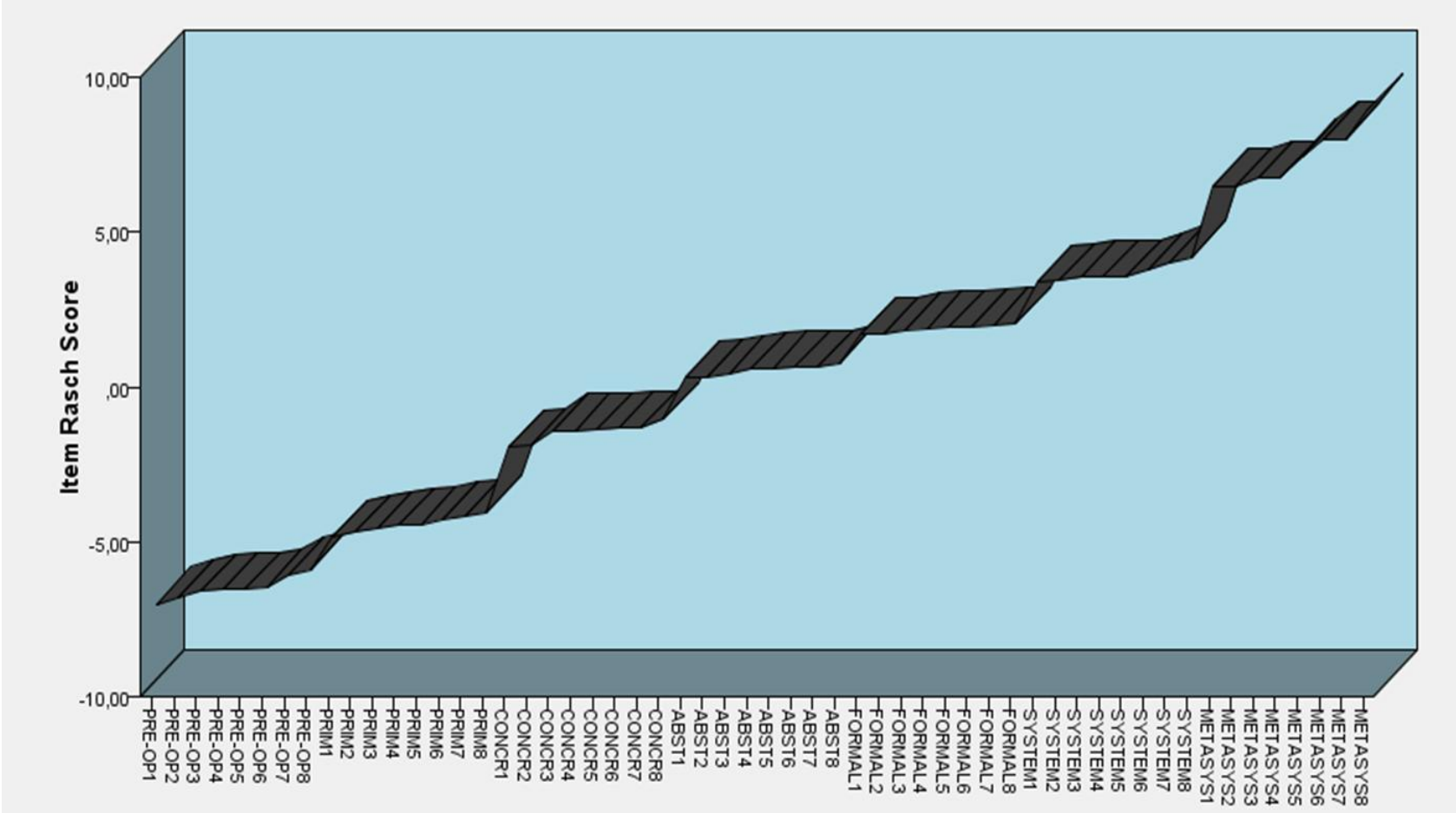
# SUBJECT DIF plot (DIF=SEX)



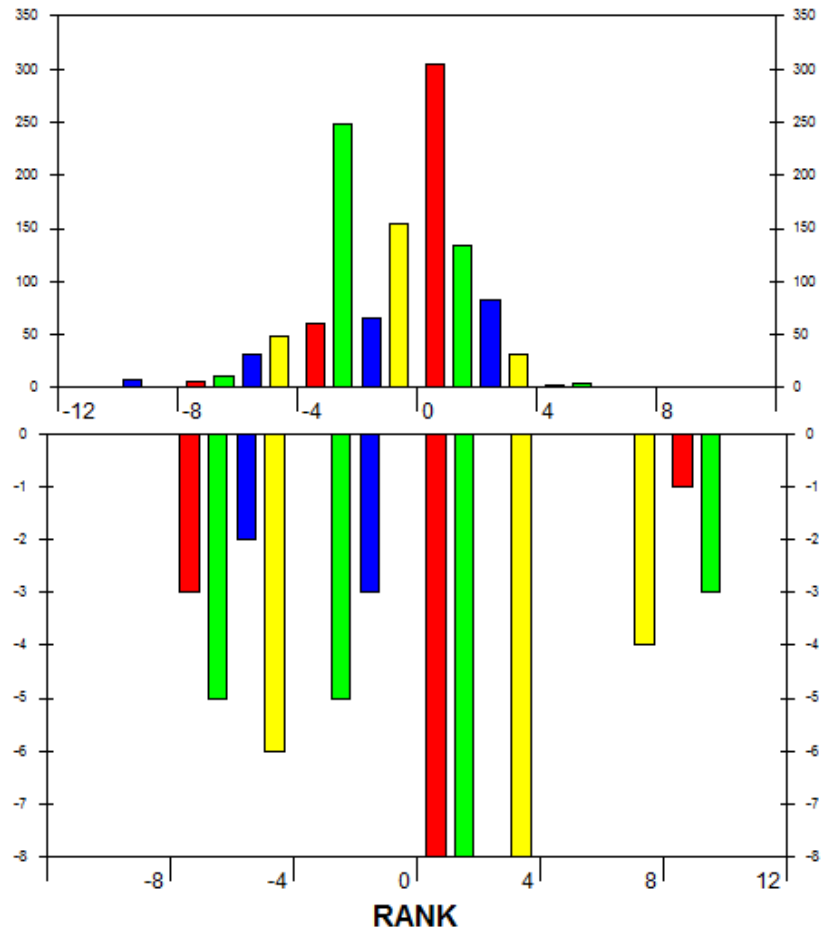
## Distribution of Items according to difficulty



# Distribution of Items according to difficulty



# SUBJECT





# Results

Table of STANDARDIZED RESIDUAL variance (in Eigenvalue units)

		-- Empirical --		Modeled
Total raw variance in observations	=	225.8	100.0%	100.0%
Raw variance explained by measures	=	169.8	75.2%	73.2%
Raw variance explained by persons	=	64.2	28.4%	27.7%
Raw Variance explained by items	=	105.6	46.8%	45.6%
Raw unexplained variance (total)	=	56.0	24.8%	26.8%
Unexplned variance in 1st contrast	=	3.9	1.7%	6.9%
Unexplned variance in 2nd contrast	=	2.6	1.1%	4.6%
Unexplned variance in 3rd contrast	=	2.5	1.1%	4.4%
Unexplned variance in 4th contrast	=	2.3	1.0%	4.2%
Unexplned variance in 5th contrast	=	2.2	1.0%	3.9%

TABLE OF SAMPLE NORMS (500/100) AND FREQUENCIES CORRESPONDING TO COMPLETE TEST

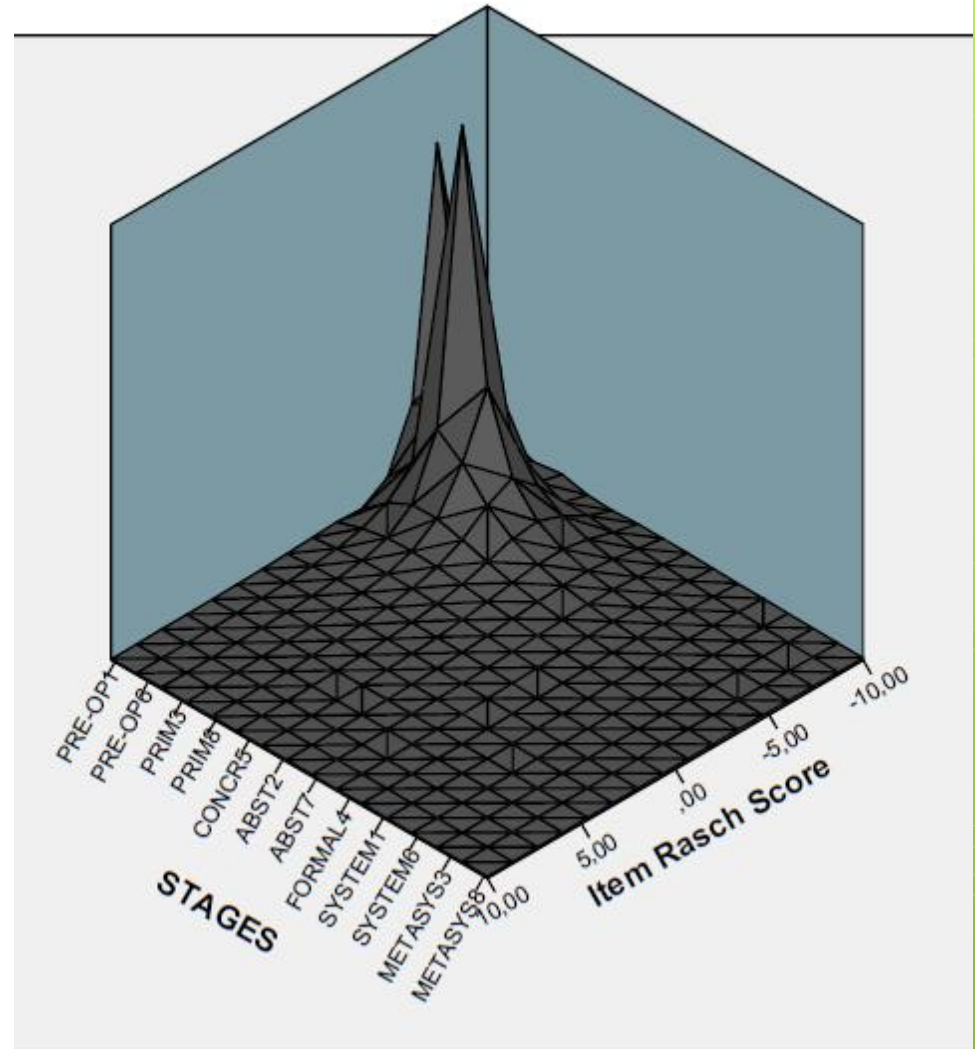
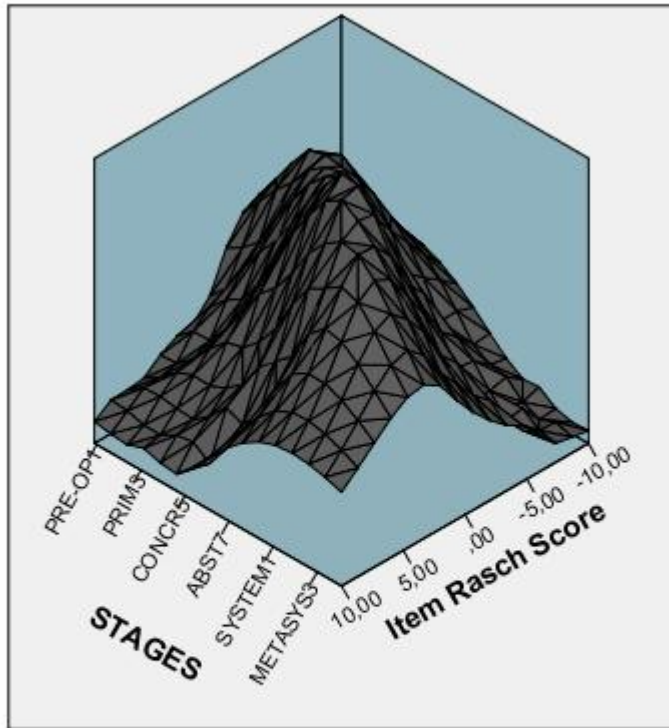
SCORE	MEASURE	S.E.	NORMED	S.E.	FREQUENCY	%	CUM. FREQ.	%	PERCENTILE
0	-10.26E	1.886	101	77	0	0	0	0	0
1	-9.98	1.886	155	44	0	0	0	0	1
2	-8.17		189	33	0	0	0	0	1
3	-7.53		211	28	0	0	1	1	1
4	-6.21		229	26	0	0	1	1	1
5	-5.04		244	24	0	0	1	1	1
6	-4.00		259	23	0	0	2	2	1
7	-3.08		272	23	0	0	2	2	1
8	-2.27		285	23	1	1	3	3	1
9	-1.57		299	23	1	1	4	4	1
10	-0.97		312	20	1	1	5	5	1
11	-0.47		322	20	1	1	6	6	1
12	0.03		335	20	1	1	7	7	1
13	0.53		347	20	1	1	8	8	1
14	1.03		360	20	1	1	9	9	1
15	1.53		373	20	1	1	10	10	1
16	2.03		386	20	1	1	11	11	1
17	2.53		400	20	1	1	12	12	1
18	3.03		415	20	1	1	13	13	1
19	3.53		429	20	1	1	14	14	1
20	4.03		444	20	1	1	15	15	1
21	4.53		459	20	2	2	17	17	1
22	5.03		474	20	3	3	20	20	1
23	5.53		489	20	4	4	24	24	1
24	6.03		504	20	5	5	29	29	1
25	6.53		519	20	6	6	35	35	1
26	7.03		534	20	8	8	43	43	1
27	7.53		549	20	10	10	53	53	1
28	8.03		564	20	13	13	66	66	1
29	8.53		579	20	17	17	83	83	1
30	9.03		594	20	22	22	105	105	1
31	9.53		609	20	28	28	133	133	1
32	10.03		624	20	35	35	168	168	1
33	10.53		639	20	43	43	211	211	1
34	11.03		654	20	52	52	263	263	1
35	11.53		669	20	62	62	325	325	1
36	12.03		684	20	73	73	398	398	1
37	12.53		699	20	85	85	483	483	1
38	13.03		714	20	98	98	581	581	1
39	13.53		726	20	112	112	693	693	1
40	14.03		748	20	127	127	820	820	1
41	14.53		766	20	144	144	964	964	1
42	15.03		784	20	162	162	1126	1126	1
43	15.53		802	20	181	181	1307	1307	1
44	16.03		820	20	201	201	1508	1508	1
45	16.53		838	20	221	221	1729	1729	1
46	17.03		856	20	242	242	1971	1971	1
47	17.53		874	20	264	264	2235	2235	1
48	18.03		892	20	287	287	2522	2522	1
49	18.53		910	20	311	311	2833	2833	1
50	19.03		928	20	336	336	3169	3169	1
51	19.53		946	20	362	362	3531	3531	1
52	20.03		964	20	389	389	3920	3920	1
53	20.53		982	20	417	417	4337	4337	1
54	21.03		1000	20	446	446	4783	4783	1
55	21.53		1018	20	476	476	5259	5259	1
56	22.03		1036	20	507	507	5766	5766	1
57	22.53		1054	20	539	539	6305	6305	1
58	23.03		1072	20	572	572	6877	6877	1
59	23.53		1090	20	606	606	7483	7483	1
60	24.03		1108	20	641	641	8124	8124	1
61	24.53		1126	20	677	677	8801	8801	1
62	25.03		1144	20	714	714	9515	9515	1
63	25.53		1162	20	752	752	10267	10267	1
64	26.03		1180	20	791	791	11058	11058	1
65	26.53		1198	20	831	831	11889	11889	1
66	27.03		1216	20	872	872	12761	12761	1
67	27.53		1234	20	914	914	13675	13675	1
68	28.03		1252	20	957	957	14632	14632	1
69	28.53		1270	20	1001	1001	15633	15633	1
70	29.03		1288	20	1046	1046	16679	16679	1
71	29.53		1306	20	1092	1092	17771	17771	1
72	30.03		1324	20	1139	1139	18910	18910	1
73	30.53		1342	20	1187	1187	20097	20097	1
74	31.03		1360	20	1236	1236	21333	21333	1
75	31.53		1378	20	1286	1286	22619	22619	1
76	32.03		1396	20	1337	1337	23956	23956	1
77	32.53		1414	20	1389	1389	25345	25345	1
78	33.03		1432	20	1442	1442	26787	26787	1
79	33.53		1450	20	1496	1496	28283	28283	1
80	34.03		1468	20	1551	1551	29834	29834	1
81	34.53		1486	20	1607	1607	31441	31441	1
82	35.03		1504	20	1664	1664	33105	33105	1
83	35.53		1522	20	1722	1722	34827	34827	1
84	36.03		1540	20	1781	1781	36608	36608	1
85	36.53		1558	20	1841	1841	38449	38449	1
86	37.03		1576	20	1902	1902	40351	40351	1
87	37.53		1594	20	1964	1964	42315	42315	1
88	38.03		1612	20	2027	2027	44342	44342	1
89	38.53		1630	20	2091	2091	46433	46433	1
90	39.03		1648	20	2156	2156	48589	48589	1
91	39.53		1666	20	2222	2222	50811	50811	1
92	40.03		1684	20	2289	2289	53100	53100	1
93	40.53		1702	20	2357	2357	55457	55457	1
94	41.03		1720	20	2426	2426	57883	57883	1
95	41.53		1738	20	2496	2496	60379	60379	1
96	42.03		1756	20	2567	2567	62946	62946	1
97	42.53		1774	20	2639	2639	65585	65585	1
98	43.03		1792	20	2712	2712	68297	68297	1
99	43.53		1810	20	2786	2786	71083	71083	1
100	44.03		1828	20	2861	2861	73944	73944	1

THE NORMED SCALE IS EQUIVALENT TO U<sub>I</sub>MEAN= 530.4352 U<sub>I</sub>SCALE= 41.7664

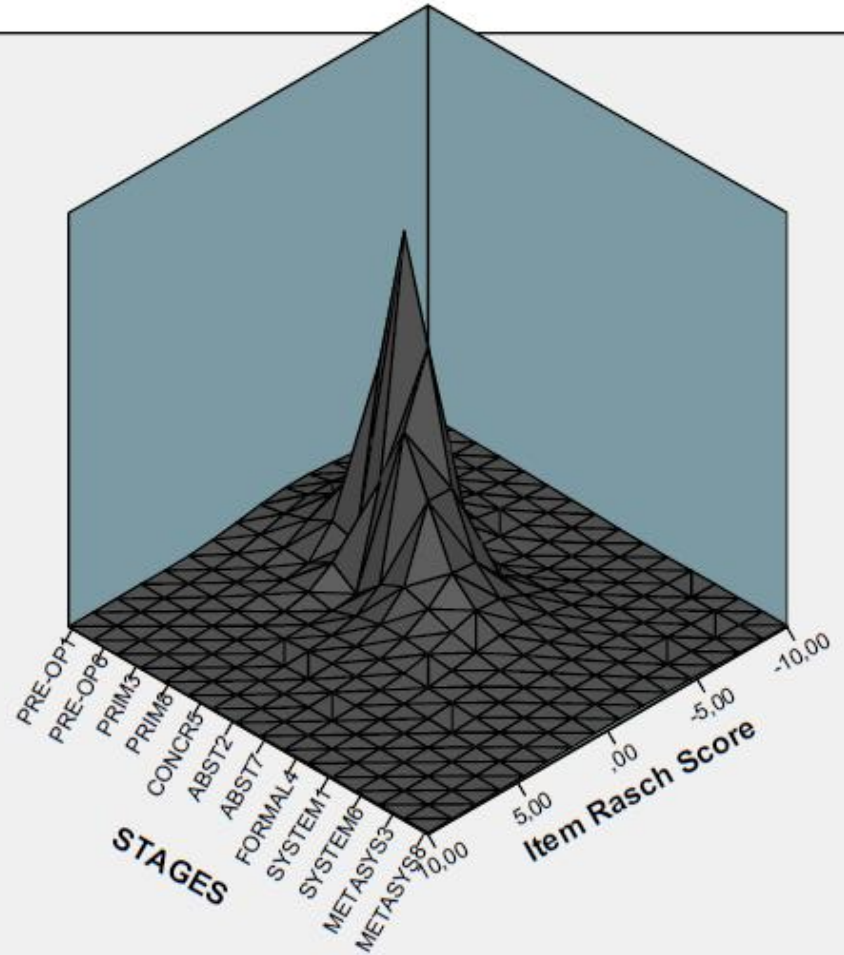
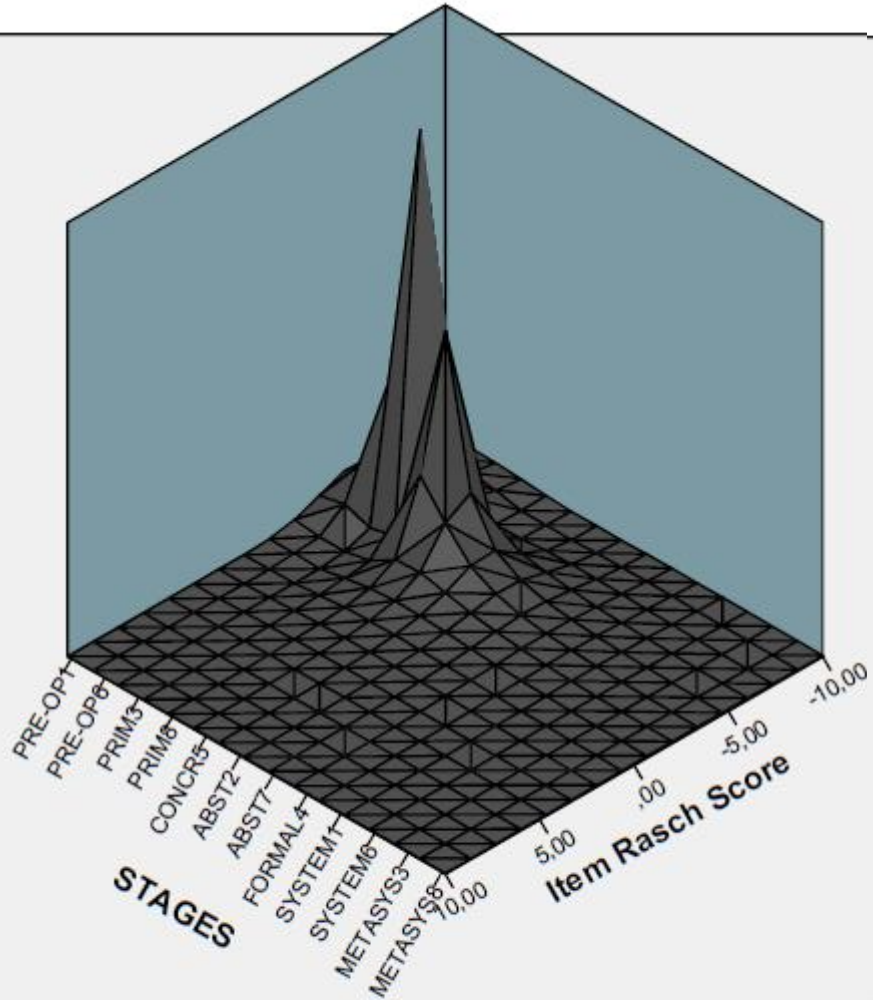
# Hidden Markov Model

- The items' difficulties presented 7 clusters with gaps between them, as visually verified by the Wright map. The clusters were confirmed by the hidden markov model, which presented a solution with 7 classes (log Lik.= -26.28, df=62, AIC: 176.57, BIC: 302.14).

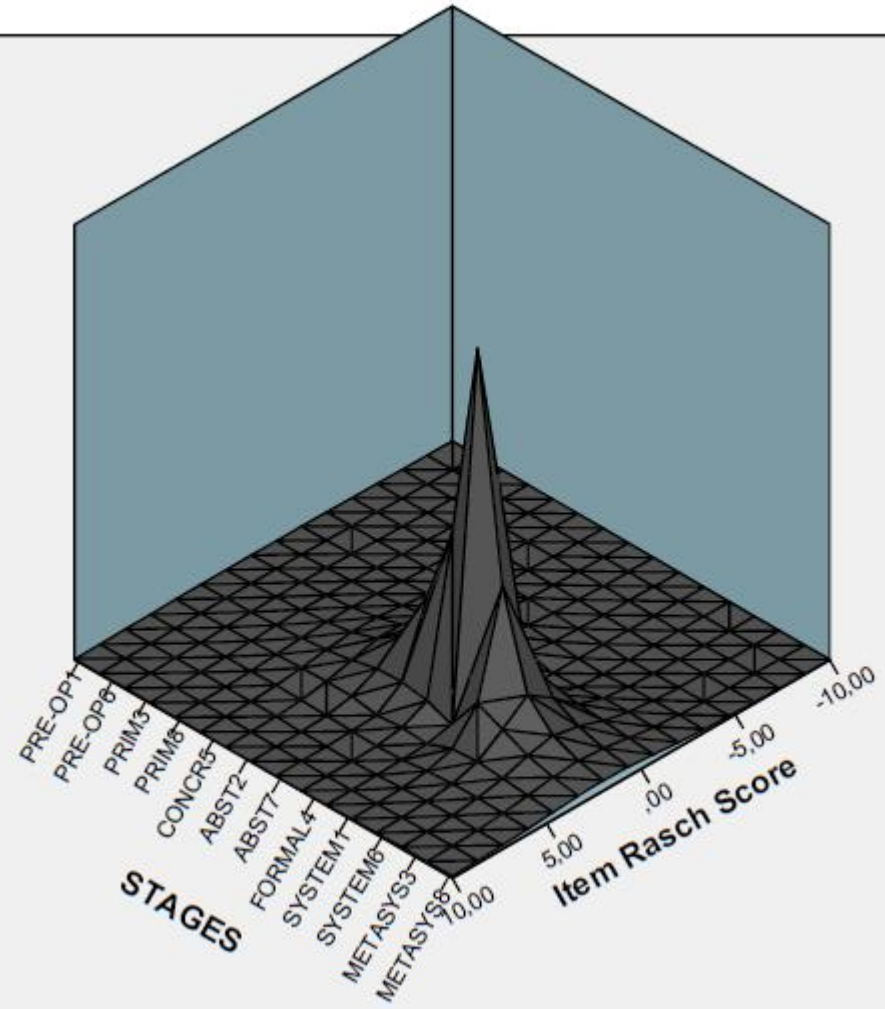
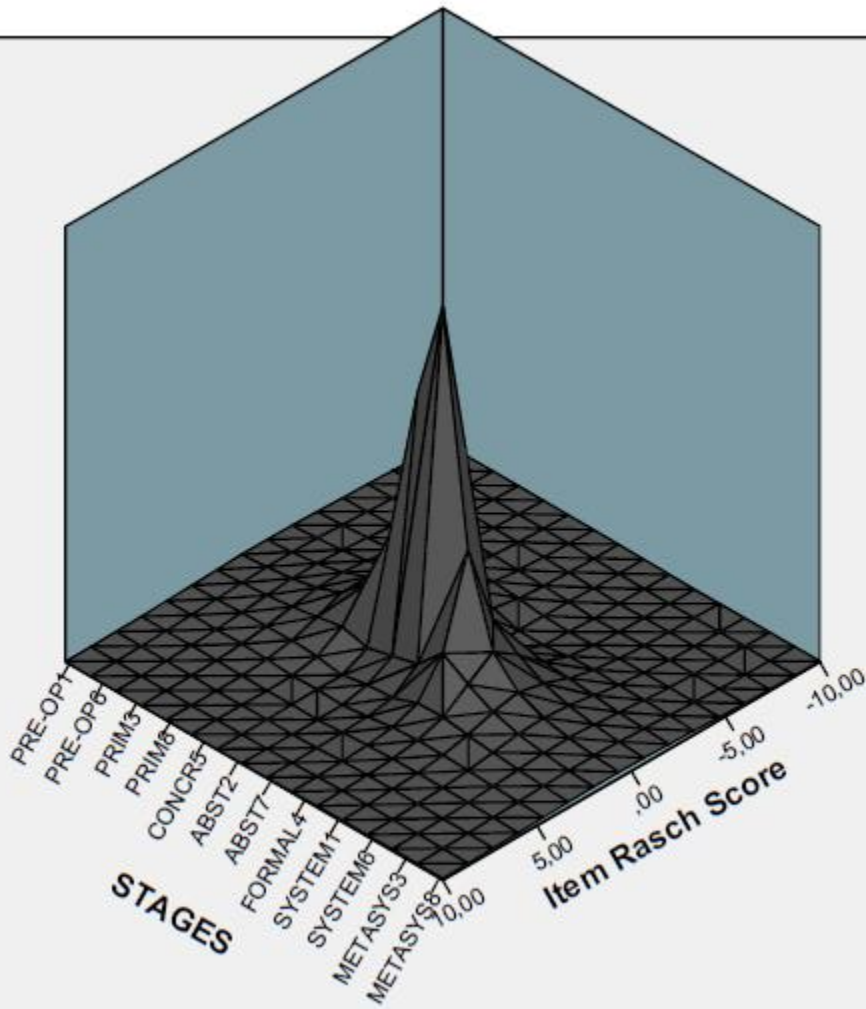
# Density distribution of Items



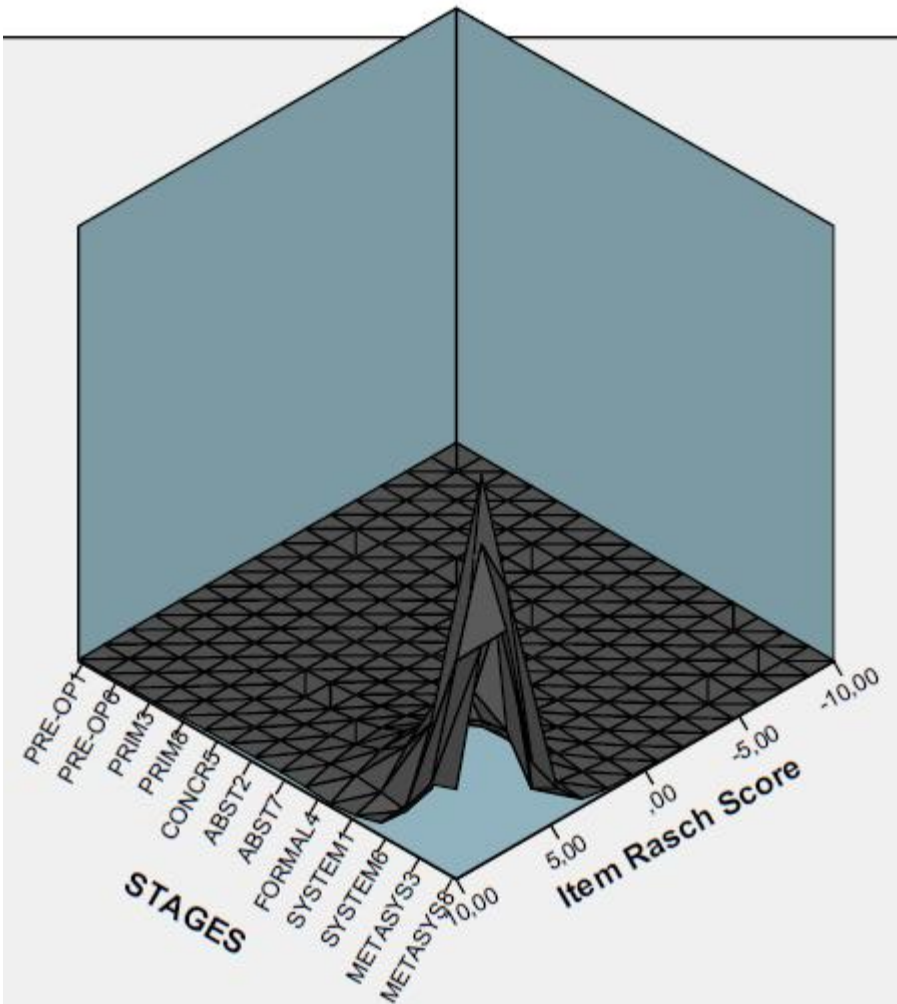
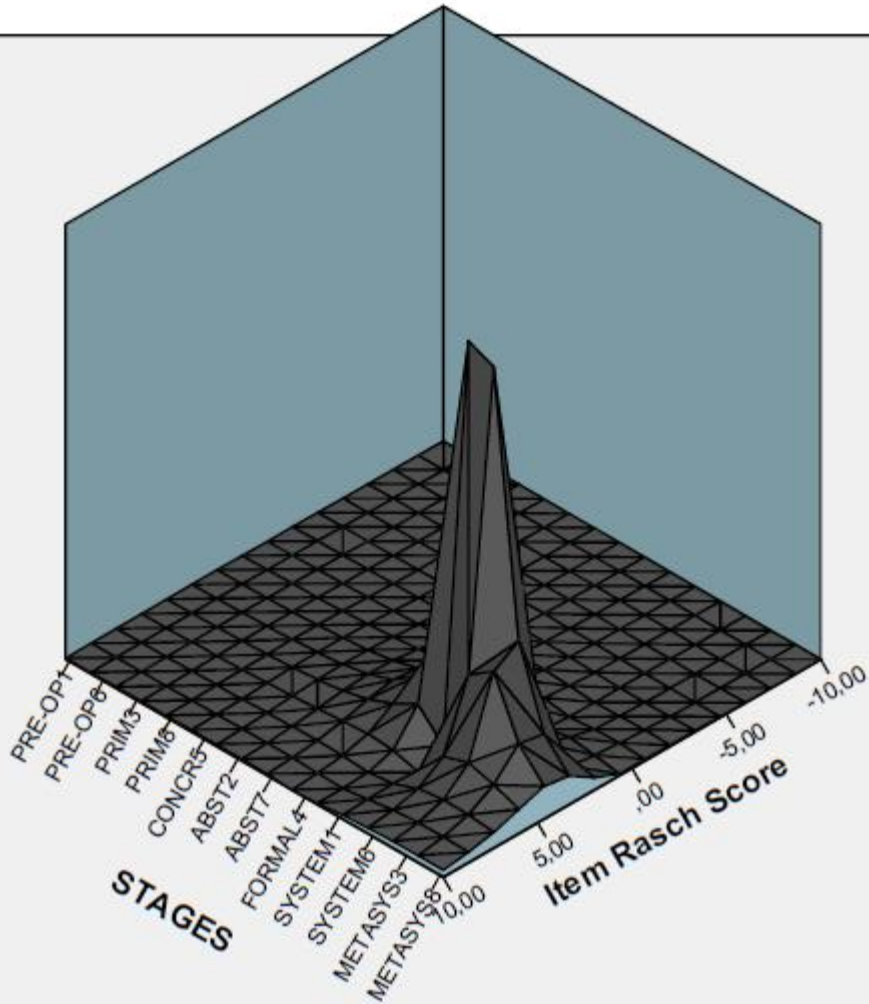
# Density distribution of Items



# Density distribution of Items

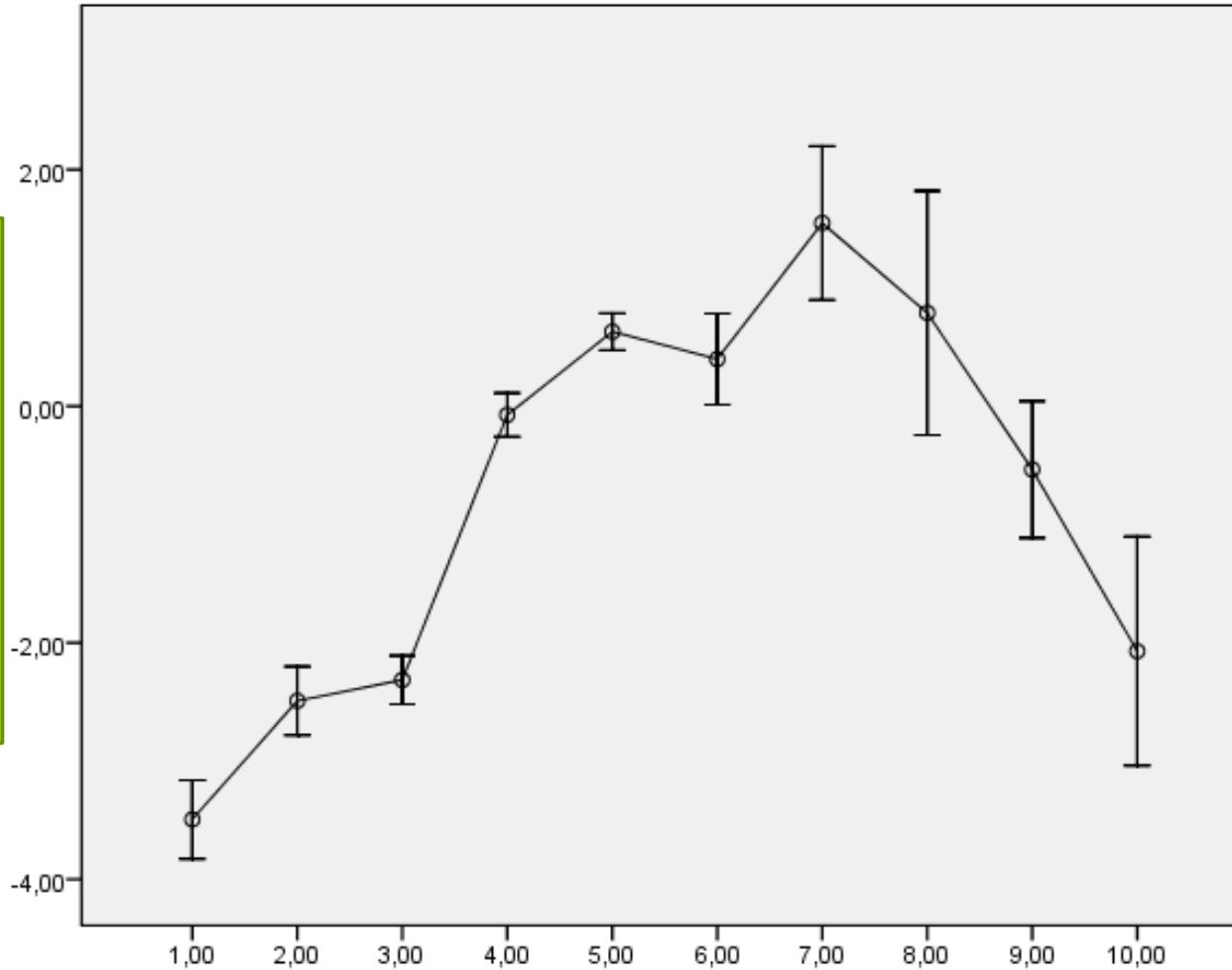


# Density distribution of Items



# Mean Rasch Scores by age group

IRDT Rasch Scores



Age Groups

Age groups

1 = 6 - 8

2 = 9 - 11

3 = 12 - 14

4 = 15 - 17

5 = 18 - 29

6 = 30 - 39

7 = 40 - 49

8 = 50 - 59

9 = 60 - 69

10 = > 70





**LaiCo**

Thank you!

Contact:

[hfgolino@gmail.com](mailto:hfgolino@gmail.com)