Psychometric Analyses of the 2006 MCAS High School Introductory Physics Test[1,2]

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[2] **Center for Educational Assessment Research Report No. 647**. Amherst, MA: University of Massachusetts, Center for Educational Assessment.

1. Goal of the Psychometric Analyses

The primary goal of our work has been to provide readers with a number of worthwhile psychometric analyses of the 2006 MCAS high school Introductory Physics Test. These analyses provide more details on the Introductory Physics Test than it was possible to provide in the summary report prepared by Hambleton, Zhao, Smith, Lam, and Deng (2008). These analyses include (1) an item analysis, (2) descriptive statistics on the test scores including break-outs for several subgroups of students, (3) classical reliability analyses for the test scores organized by item format, and for the total test, (4) two investigations of test dimensionality, (5) item response theory (IRT) item calibrations obtained from fitting the three-parameter logistic model to binary-scored items and the graded response model to polytomously-scored items, (6) various item and test level model fit findings, (7) test information and conditional standard errors, and (8) the identification of differentially functioning test items.

2. Description of the Introductory Physics Test

The MCAS 2006 Grade 9/10 Introductory Physics Test consists of 45 items assessing six standards (sometimes called "curriculum strands"): Motion and Forces, Conservation of Energy and Momentum, Heat and Heat Transfer, Waves, Electromagnetism, and Electromagnetic Radiation, based on learning standards in the Physics content strand of the Massachusetts Science and Technology/Engineering Curriculum Framework (2006). The test was administered in a 2-day session in May of 2006, the first session consisted of the first 26 items on the test; and the second session consisted of the remaining 19 items. Each session included multiple-choice and open-response questions. More information about the curriculum and the test items can be found at **www.doe.mass.edu**.

Table 2.1 presents the number of items, by item type, and the total number of items and score points for the MCAS 2006 Grade 9/10 Introductory Physics Test. There are 40 multiple choice items (each with four choices) and five polytomously-scored performance items (or sometimes called "constructed response items"). Multiple choice items were scored dichotomously; a score of 1 for a correct answer, 0 otherwise. Performance items were scored polytomously, with possible scores ranging from 0 to 4.

Table 2.1 Number of Items by Item Type on the Introductory Physics Test

Item Type	Points	Number of Items
Multiple Choice	1 or 0	40
Performance	0 to 4	5
Total	60	45

3. Item Analyses

In total, 16,619 students were administered the Physics Test. However, an exclusion criterion was implemented so as to reduce the distortion of findings due to the use of student responses that would introduce systematic errors into the data analyses. Students who had a total test score of 0 were excluded. Clearly, these students had not taken the test seriously, or perhaps were not even present for the test administration. After applying the exclusion rule, there were 15,762 students left in the dataset. Therefore, about 5% of the examinee data were excluded. These students served no useful purpose for our psychometric analyses of the items and the test and so they were deleted.

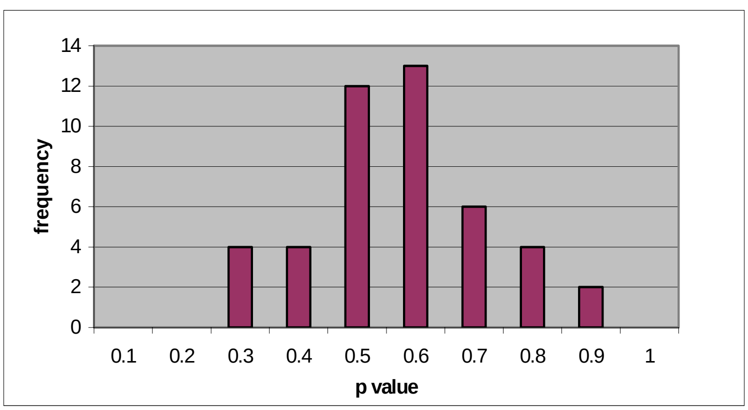
Item Difficulty

Difficulty indices (correct proportion for binary-scored data or item means for polytomously-scored data) were measured by averaging the proportion of points for correct answers received by all the students who answered the test items. As a result, for students who were absent for the test or who showed up with none of the items answered, their responses were not included in these analyses. Multiple choice questions (MC) were scored dichotomously (0 and 1). For these items, difficulty indices were simply the proportion of students who got the correct answers. Performance items were scored from 0 to 4. For those items, difficulty indices were obtained by dividing the average proportions by 4, so that all the difficulty indices were on the same scale and within the range from 0 to 1, regardless of item type. Indices of larger values indicate easier items. For example, an index of 1 means everyone got the correct answer, while an index of 0 means no one received the point. Summary statistics and histogram of item difficulty index distribution are provided in Table 3.1 and Figure 3.1.

Table 3.1 Summary of Classical Item Difficulty Indices

Number of Item	Mean	SD	Range	Minimum	Maximum
45	0.53	0.15	0.62	0.25	0.87

Figure 3.1 Histogram Showing the Distribution of Classical Item Difficulty Indices



The figure showing that difficulty indices have a wide range: From about the level of chance (.25) to about 0.9, with the mean around 0.5.

Item-Test Correlations

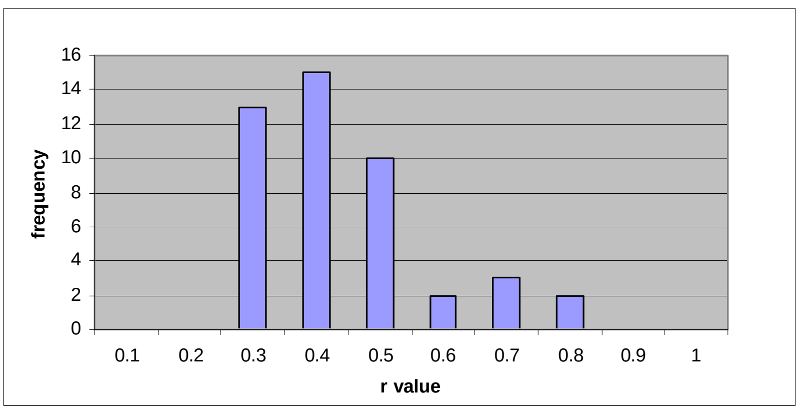
Item-test correlations are called item discrimination indices. They indicate the degree to which test items distinguish between the performance of higher proficient and lower proficient students. The discrimination index was calculated using Pearson correlations and the range is within -1.0 to 1.0. The typical range of discrimination indices for operational multiple-choice items is from 0.2 to 0.6. Summary statistics and histogram of discrimination indices distribution are provided in Table 3.2 and Figure 3.2.

Table 3.2 Summary of the Classical Item Discrimination Indices

Number of Item	Mean	S.D.	Range	Minimum	Maximum
45	0.40	0.14	0.56	0.23	0.79

Figure 3.2 Histogram Showing the Distribution of

Classical Item Discrimination Indices



A comparison of difficulty and discrimination indices between multiple choice items and performance items are displayed in Table 3.3.

Table 3.3 Average Item Difficulty and Discrimination Indices across Item Types

Average Statistics	Item Type		
	All	**MCQ**	**Performance Items (PI)**
Difficulty (p)	0.527	0.539	0.427
Discrimination (r)	0.399	0.359	0.718
Number of Items	45	40	5

Because multiple choice items can be answered correctly by guessing, they generally have higher difficulty indices (i.e., are easier items) than many performance items. Besides, for the similar reason, their discrimination indices are usually lower than the performance items since the multiple choice questions could have chance scores and therefore decrease the possible score range and introduce error. In addition, candidates spend much more time in completing the performance items. Therefore the information provided by performance items is more reliable and more information is coming in. Hence their r values are higher. The indices of the 45 items are provided in Table 3.4.

Table 3.4 Classical Item Statistics

Item	Item Type	Difficulty	Discrimination
1	MC	0.847	0.253
2	MC	0.434	0.371
3	MC	0.532	0.43
4	MC	0.719	0.397
5	MC	0.733	0.418
6	MC	0.776	0.328
7	MC	0.389	0.297
8	MC	0.493	0.341
9	MC	0.758	0.4
10	MC	0.501	0.337
11	PI	0.660	0.681
12	MC	0.545	0.355
13	MC	0.598	0.231
14	MC	0.470	0.375
15	MC	0.700	0.444
16	MC	0.571	0.278
17	MC	0.501	0.282
18	MC	0.483	0.293
19	MC	0.582	0.337
20	MC	0.459	0.318
21	MC	0.520	0.274
22	MC	0.367	0.304
23	MC	0.593	0.368
24	MC	0.543	0.387
25	PI	0.435	0.787
26	PI	0.428	0.781
27	MC	0.874	0.415
28	MC	0.477	0.322
29	MC	0.646	0.467
30	MC	0.637	0.535
31	MC	0.611	0.478
32	PI	0.345	0.663
33	MC	0.378	0.256
34	MC	0.555	0.431
35	MC	0.485	0.362
36	MC	0.251	0.277
37	MC	0.278	0.235
38	MC	0.486	0.455
39	PI	0.268	0.677
40	MC	0.426	0.284
41	MC	0.428	0.357
42	MC	0.527	0.449
43	MC	0.628	0.505
44	MC	0.259	0.261
45	MC	0.511	0.465

Distracter Analysis

The proportions of students choosing each option of the multiple choice items were calculated by **Test Analysis Program** (TAP), a software program coming from Ohio University. The detailed results for each item are provided in Appendix A.

In Appendix A, the frequencies and percentages of students who chose each of the four choices are displayed for each item. Besides, the statistics and the differences were calculated for high and low groups (respectively top and low 27% of total scores). The correct answer should have a distinct positive difference (more of the high group than of the low group), and negative differences should be displayed across all the other incorrect answers. The results show that all the correct answers of 40 multiple choice items have positive differences between the high and low groups, and they enjoy satisfactory large proportions in the high group. Besides, most of the incorrect answers show negative differences, except for two options, option 3 of item 33 and option 3 of item 44, with difference indices of 3% and 10% respectively. The indices indicate that the two incorrect options attracted more students in high group than in low group and may need some improvement, however, the differences are not significant. Overall, most incorrect answers, called distracters, functioned well in distracting the students from the low group with an average percentage of around 20%.

In sum, the item statistics are highly supportive of an excellent test. Of special importance for tests like the MCAS tests, are items with high discriminating powers, and a range of p values to support consistent and accurate performance classifications at three widely spaced performance standards along the proficiency scale.

4. Basic Test Score Descriptive Statistics and Reliability Analyses

Basic Test Score Descriptive Statistics

There were 16,619 students in total enrolled in the 2006 Introductory Physics Test. The distributions of attendance, gender and ethnicity are displayed in Table 4.1.

Table 4.1 Demographic Statistics

	Subgroup	Number	Percentage (%)
Attendance	Valid	15,762	94.8
	Absent	622	3.7
	Scored “0”	235	1.4
Gender	Male	8,219	49.5
	Female	7,925	47.7
	Unspecified	475	2.9
Ethnicity	White	10,939	65.8
	Black	2,141	12.9
	Hispanic	1,997	12.0
	Asian	1,007	6.1
	Native	50	0.3
	Unspecified	485	2.9
Enrolled in Total		16,619	100

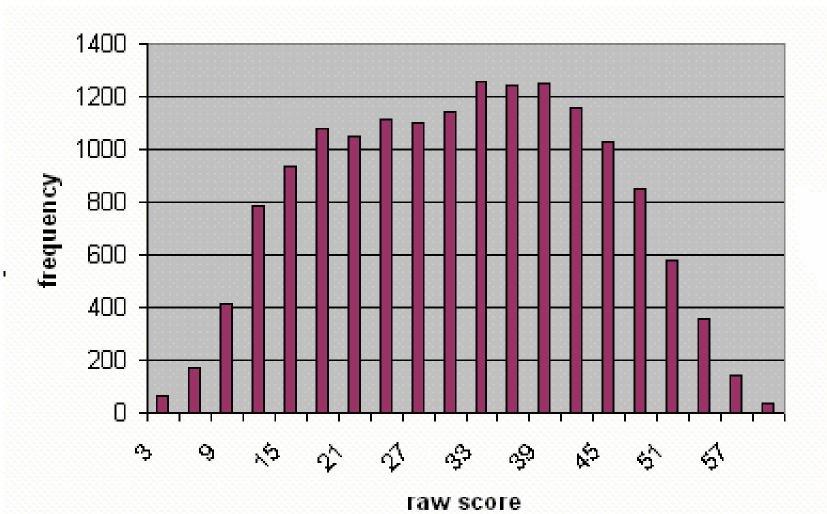
There are 15,762 valid total scores out of the enrolled students. The summary statistics of the valid total scores are shown in Table 4.2, and its histogram of distribution is shown in Figure 4.1. The distribution might be described as platykurtic.

Table 4.2 Descriptive Statistics of Total Scores

Mean	SD	Median	Mode	Minimum	Maximum	Number of Students *
30.12	12.55	31	35	1	60	15762

* For the purpose of test analysis only, the number of students excludes the number of absent students and students who showed up with zero scores.

Figure 4.1   Histogram Showing the Distribution of Total Scores



Reliability

Internal consistency reliability was estimated using *coefficient alpha*, which measures the degree to which all of the items measure a common characteristic of the person and it depends on the consistency of the individual's performance from item to item. The reliability statistics of all items, the multiple-choice questions and the performance items are shown in Table 4.3.

Table 4.3 Test Score Reliability Statistics

Statistic	All Items	MCQ	Performance Items
Coefficient Alpha	0.901	0.874	0.83

In addition, the correlation coefficients between MCQ scores, performance item scores and total scores are displayed in Table 4.5.

Table 4.5 Correlations Among MCQ Scores, Performance Scores, and Total Scores

Score	MCQ Score	Performance Item Score
Performance Items Score	0.801	
Total Score	0.967	0.927

5. Test Dimensionality

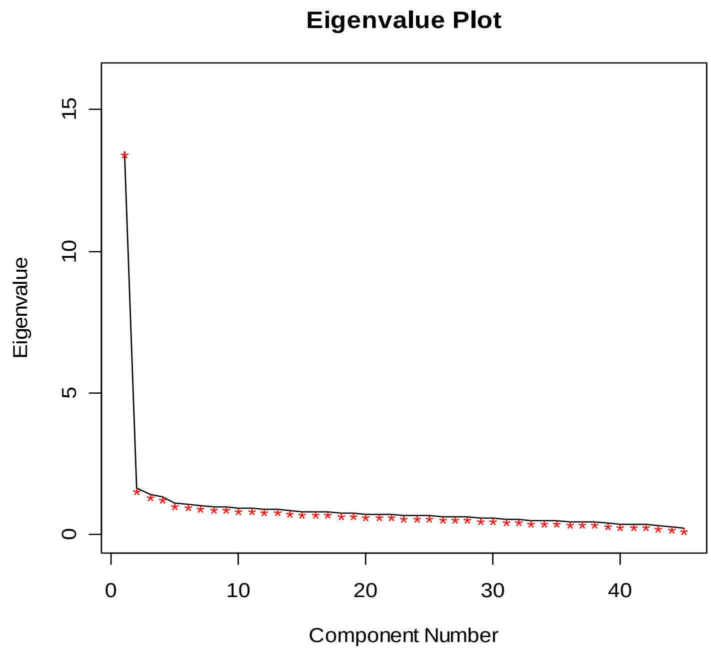
Before any IRT-related analyses, one important assumption to be confirmed is unidimensionality. The assumption of unidimensionality means that all the items are measuring a single dominant trait; in this case it refers to physics proficiency. Good model fit requires a reasonable good approximation of the unidimensionality assumption. Even the data in Table 4.5 provides an initial estimate of unidimensionality since the MCQ scores and performance item scores are very highly correlated (0.80) without any adjustments for the unreliability of each score. If any multidimensionality in the data were to be present, it might be expected to show up in items assessed by different formats and measuring different learning standards, and then the correlation would be expected to be considerably lower than .80.

Table 5.1 shows the eigenvalues of the 45x45 correlation matrix. Figure 5.1 shows the scree plot. The largest engenvalue accounted for about 30% of the total variance. Also, the first eigenvalue is over 7 times larger than the second eigenvalue. Based on the conventional standards, that is, the first dominant factor accounts for at least 20% of the total variance and is four or five times larger than the second factor, it demonstrates that the test is strongly unidimensional.

Table 5.1 Eigenvalues and Variances Explained

Component	Eigenvalue	Percentage of Variance Explained (%)	Cumulative Percentage of Variance Explained (%)
1	13.5	30.05	30
2	1.65	3.67	34
3	1.41	3.14	37
4	1.32	2.94	40
5	1.10	2.44	42
6	1.07	2.38	45
7	1.01	2.24	47
8	0.99	2.21	49
9	0.97	2.16	51
10	0.93	2.06	53
11	0.92	2.05	55
12	0.90	2.00	57
13	0.87	1.94	59
14	0.83	1.84	61
15	0.81	1.80	63
16	0.80	1.78	65
17	0.79	1.76	66
18	0.77	1.72	68
19	0.76	1.69	70
20	0.73	1.62	71
21	0.72	1.59	73
22	0.70	1.56	75
23	0.69	1.54	76
24	0.69	1.53	78
25	0.67	1.49	79
26	0.63	1.41	81
27	0.61	1.36	82
28	0.61	1.35	83
29	0.59	1.31	85
30	0.58	1.28	86
31	0.56	1.24	87
32	0.54	1.20	88
33	0.52	1.15	89
34	0.51	1.13	91
35	0.50	1.11	92
36	0.47	1.04	93
37	0.45	1.01	94
38	0.44	0.99	95
39	0.43	0.95	96
40	0.38	0.85	97
41	0.37	0.83	97
42	0.35	0.77	98
43	0.30	0.68	99
44	0.27	0.59	99
45	0.25	0.55	100

Figure 5.1 Plot of the 45 Eigenvalues



The students' responses to the 45 items were further analyzed using Confirmatory Factor Analysis (CFA) with Structural Equation Modeling (SEM) by the software package LISREL. Table 5.2 shows the factor loadings of a 1-factor model on the 45 items (variables).

Table 5.2 Estimated Factor Loadings in a One-Factor Solution

Item	Factor Loading
1	.40
2	.56
3	.66
4	.64
5	.64
6	.51
7	.43
8	.52
9	.62
10	.57
11	.74
12	.54
13	.35
14	.55
15	.65
16	.43
17	.43
18	.49
19	.53
20	.49
21	.43
22	.47
23	.56
24	.61
25	.83
26	.83
27	.71
28	.46
29	.67
30	.80
31	.71
32	.73
33	.36
34	.70
35	.61
36	.47
37	.37
38	.66
39	.75
40	.44
41	.54
42	.70
43	.81
44	.44
45	.69

All of the loadings are high, and so these results combined with the other analyses we carried out are strongly supportive of a strong first factor, a perquisite for a good fitting unidimensional IRT model.

6. Item Calibrations and Model Fit

Forty dichotomous items and five polytomous items were calibrated using Parscale, with the 3P logistic model fitted to dichotomous items, and the Graded Response Model (GRM) fitted to the polytomous items. The estimated discrimination (slope), difficulty (location), and guessing parameter estimates of the 45 items and their summary statistics are shown in Table 6.1 and Table 6.2. Figure 6.1 shows the score category curves for all the items.

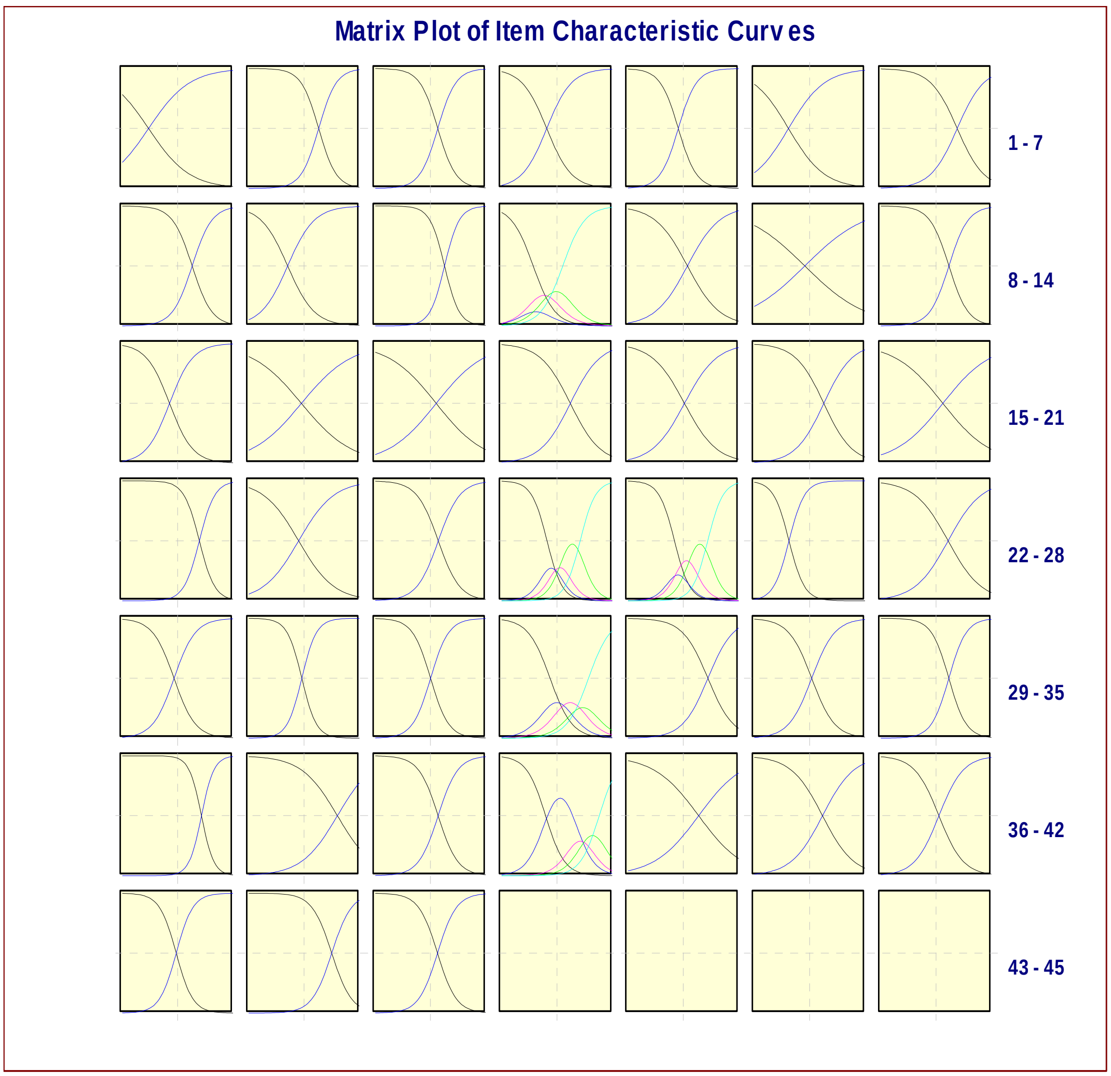
Table 6.1 Item Parameter Estimates

Item	Slope(a)	SE of a	Location(b)	SE of b	Guessing(c)	SE of c
1	0.53	0.04	-1.58	0.29	0.32	0.09
2	1.23	0.08	0.80	0.03	0.22	0.01
3	1.20	0.07	0.40	0.04	0.23	0.02
4	0.87	0.05	-0.55	0.08	0.20	0.03
5	1.19	0.07	-0.27	0.06	0.34	0.02
6	0.60	0.04	-1.15	0.15	0.17	0.06
7	0.81	0.07	1.15	0.05	0.21	0.02
8	1.10	0.08	0.79	0.04	0.30	0.02
9	0.81	0.04	-0.89	0.09	0.15	0.04
10	1.47	0.10	0.77	0.03	0.31	0.01
11	0.98	0.02	-0.59	0.02	0.00	0.00
12	0.67	0.05	0.22	0.08	0.17	0.03
13	0.35	0.03	-0.27	0.22	0.13	0.05
14	1.13	0.07	0.70	0.04	0.23	0.01
15	0.93	0.05	-0.44	0.07	0.20	0.03
16	0.43	0.03	-0.14	0.13	0.09	0.04
17	0.45	0.03	0.31	0.11	0.09	0.03
18	0.72	0.06	0.73	0.07	0.23	0.02
19	0.67	0.05	0.06	0.09	0.19	0.03
20	0.76	0.06	0.77	0.06	0.21	0.02
21	0.45	0.04	0.37	0.14	0.13	0.04
22	1.40	0.11	1.18	0.03	0.24	0.01
23	0.61	0.03	-0.29	0.07	0.07	0.02
24	1.00	0.06	0.43	0.05	0.26	0.02
25	1.41	0.02	0.27	0.01	0.00	0.00
26	1.41	0.02	0.30	0.01	0.00	0.00
27	1.39	0.08	-1.12	0.07	0.31	0.04
28	0.65	0.05	0.65	0.08	0.19	0.03
29	1.01	0.05	-0.20	0.05	0.19	0.02
30	1.47	0.07	-0.12	0.03	0.18	0.02
31	1.19	0.06	0.01	0.04	0.20	0.02
32	0.98	0.02	0.70	0.02	0.00	0.00
33	0.85	0.08	1.34	0.06	0.23	0.02
34	0.94	0.05	0.11	0.05	0.15	0.02
35	1.24	0.08	0.69	0.04	0.28	0.01
36	1.75	0.12	1.30	0.03	0.15	0.01
37	0.60	0.07	1.81	0.09	0.12	0.02
38	1.10	0.06	0.42	0.03	0.15	0.01
39	1.14	0.02	1.06	0.01	0.00	0.00
40	0.48	0.04	0.84	0.10	0.11	0.03
41	0.69	0.05	0.70	0.06	0.13	0.02
42	0.89	0.05	0.15	0.05	0.12	0.02
43	1.29	0.06	-0.08	0.04	0.19	0.02
44	1.09	0.09	1.51	0.05	0.15	0.01
45	1.14	0.06	0.38	0.04	0.19	0.02

Table 6.2 Summary Statistics of Item Parameter Estimates

Parameter	Mean	SD	Number
Slope	0.958	0.336	45
Location	0.294	0.727	45
Guessing	0.193	0.067	40

Figure 6.1 Item Score Category Function



Model Fit

Item response theory possesses many advantages over classical test theory in analyzing the measurement data of latent traits. However, the advantages will be greatly undermined if the model used to analyze does not fit the observed data. Therefore the assessment of model fit should always be carried out as an integrated part of IRT analyses.

Most IRT calibration programs offer the fit statistics at the item level. Table 6.3 provides the Chi-square item fit statistics and probabilities from Parscale, though there is not much confidence in these statistics because they are very dependent on sample size. With very big samples as we used in this study, it will appear that none or only a few items will actually fit the data. This is a common finding and it is little value.

Table 6.3 Item Fit Statistics

Item	Chi-square	D.F.	Probability
1	49.77	28	0.007
2	33.59	30	0.297
3	43.78	30	0.050
4	40.93	27	0.042
5	21.89	26	0.695
6	53.29	30	0.006
7	22.17	30	0.848
8	25.42	30	0.705
9	62.76	27	0.000
10	36.86	30	0.181
11	239.08	99	0.000
12	51.12	30	0.010
13	66.30	30	0.000
14	26.31	30	0.660
15	38.93	27	0.064
16	49.52	30	0.014
17	58.99	30	0.001
18	21.59	30	0.869
19	32.07	30	0.364
20	27.16	30	0.615
21	40.91	30	0.088
22	41.22	30	0.083
23	68.07	30	0.000
24	59.43	30	0.001
25	137.45	90	0.001
26	126.98	90	0.006
27	30.89	20	0.057
28	35.44	30	0.227
29	24.90	28	0.634
30	25.76	26	0.477
31	33.20	27	0.190
32	376.24	97	0.000
33	26.01	30	0.675
34	62.83	30	0.000
35	63.55	30	0.000
36	39.26	30	0.120
37	34.48	30	0.262
38	37.44	30	0.164
39	108.53	88	0.068
40	53.02	30	0.006
41	28.14	30	0.563
42	26.33	30	0.658
43	33.88	27	0.169
44	60.36	30	0.001
45	40.95	30	0.088
Total	2616.83	1627	0.000

In addition to fit statistics, standardized residuals (SR) were calculated for each item using the FIT output file produced by Parscale. This type of analysis is much more insightful. Figure 6.2 shows the distribution of SR across all items. Table 6.4 displays the percentage of SR in each interval. The results suggest large proportions of SRs around the value of zero and suggest excellent model fit.

Figure 6.2 Distribution of Standardized Residuals (SR)

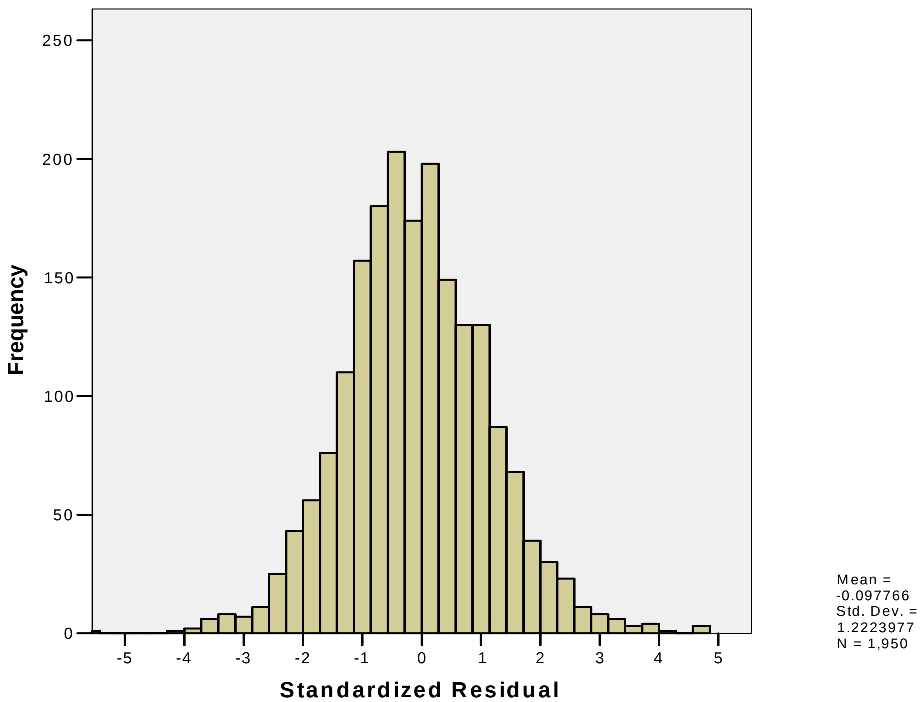


Table 6.4 Percentage of Standardized Residuals (SR), Organized in Intervals along the Proficiency Continuum

SR Interval	Percentage
< -3	1%
(-3, -2)	4%
(-2, -1)	17%
(-1, 1)	61%
(1, 2)	13%
(2, 3)	4%
>3	1%

An item would show good fit with the model if its SR falls into the range (-2, 2), suggesting a 95% confidence when the model predicts the proportion of candidates who answer the item correctly. Table 6.4 shows that, out of a total of 1950 SRs (30 theta intervals for each dichotomous item, 150 for each polytomous item), there are 90% falling into the interval (-2, 2), and 98% falling into (-3, 3). As a result, the model shows very good fit for nearly all of the test items. More information of SR can be found in Appendix C.

As it is widely recognized that fit statistics are easily affected by sample size, residual plots for the 45 items are provided in Appendix B to help illustrate the fit between model and data. There is one plot for each dichotomous item, which shows the correct response category. And five plots for each polytomous item, which show the response categories from 0 to 4. Small and random deviations off the curves are good indicators of model fit. Again, the fit seems excellent.

Assessment of model fit can not only be checked at item level, but also at the test level. Comparison between observed and expected total score distributions provide another view of model fit. Figure 6.3 compares the distribution of observed total scores with the distribution of averaged predicted scores from 100 simulations, given the estimated item and ability parameters. The corresponding comparison of cumulative distributions is provided in Figure 6.4. Both figures show close approximations of the predicted score distribution to the observed distribution.

Figure 6.3 Comparison of Total Score and Predicted Test Score Distributions

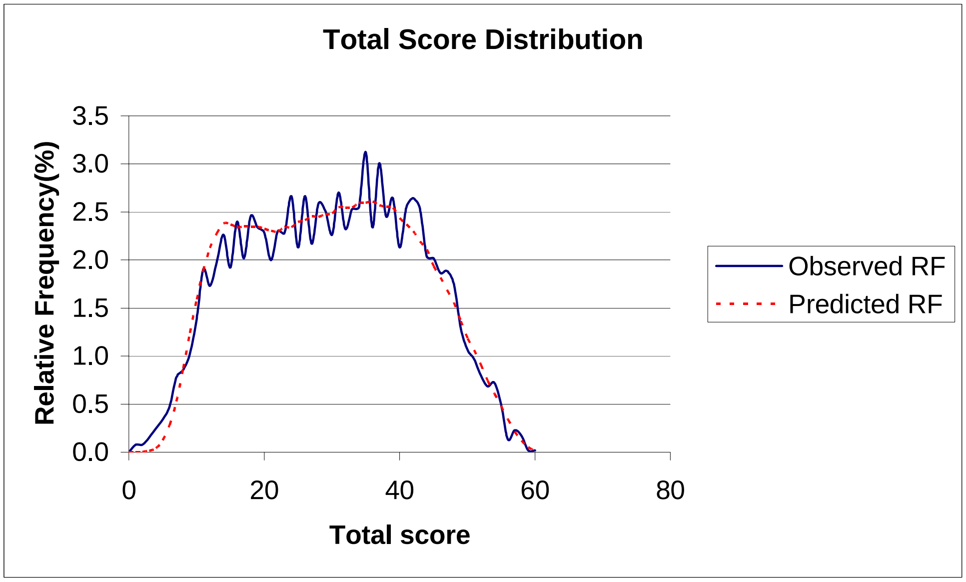
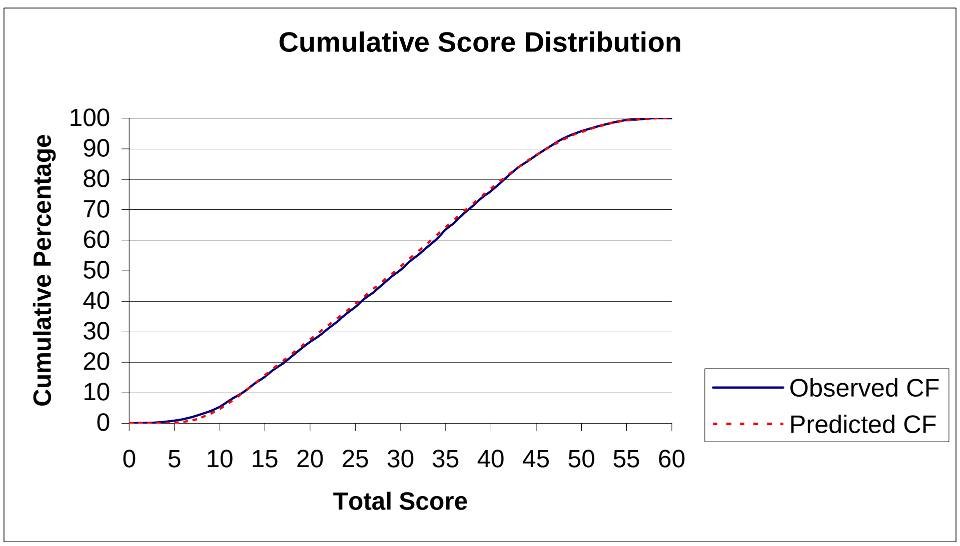


Figure 6.4 Comparison of Cumulative Score Distributions



In summary, these analyses are highly reflective of model fit to the data.

7. Test Information and Conditional Standard Errors

Test information and conditional standard errors are shown in Figure 7.1 and Figure 7.2. The test information is high from the middle through the higher end along the proficiency continuum. As a rough rule of thumb, information above 10 is highly desirable and this is the case for proficiency scores between -1.0 and 2.0. The average student on the test is located around a scaled score of 0.0. Here the test information is high suggesting an above level of precision than is usually observed with achievement tests. This is excellent news and may suggest in the future that the addition of a few additional easy questions, could strengthen precision for lower performing candidates without taking anything significant away from proficiency estimation in the middle range of scores.

Figure 7.1 Test Information Function

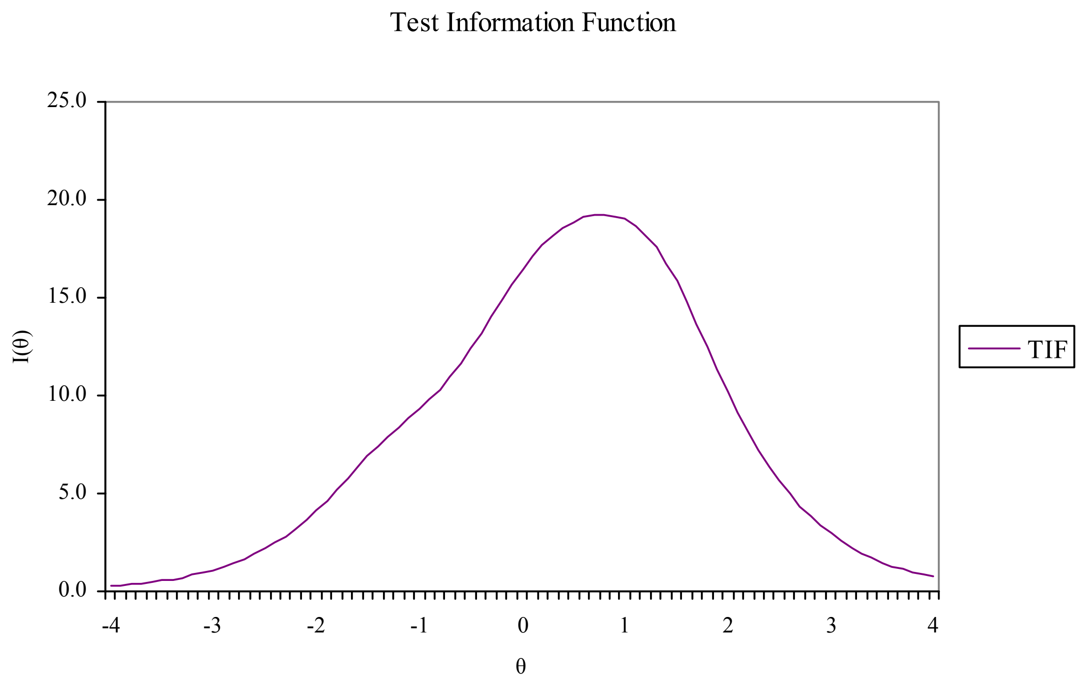


Figure 7.2 Conditional Standard Errors

8. Identification of Differentially Functioning Items

Differential item functioning (DIF) analyses becomes a routine part in the analyses of large-scale assessments as an effort to enhance test fairness. DIF exists if individuals with the same ability, but from different subgroups, have different probabilities in answering the item correctly. DIF is different from bias in that more evidence needs to be collected to spot the sources of DIF. The sources of DIF could be the construct intended to measure, or could be construct-irrelevant factors. The latter one is often considered as bias.

It is important to check the means and standard deviations of test scores across different subgroups before completing DIF analyses. Table 8.1 shows the summary statistics of the scores for the subgroups.

Table 8.1 Descriptive Statistics of the Test Scores

	Group	Number	Minimum	Maximum	Mean	Std. Deviation
Gender	Female	7559	1	60	30.56	11.97
	Male	7762	1	60	30.33	12.89
Ethnicity	White	10568	1	60	33.34	11.41
	Hispanic	1780	1	56	20.74	10.02
	Black	1939	1	56	21.34	10.65
	Asian	981	4	60	34.90	12.56
	Native	44	8	55	28.73	12.60

In addition to score distributions, item parameters calibrated from different subgroups were plotted. Figure 8.3 to Figure 8.5 show the difficulty parameter (b) scatter plots between the groups, male/female, white/Black, and white/Hispanic.

Figure 8.3 b-plot from Male and Female Samples

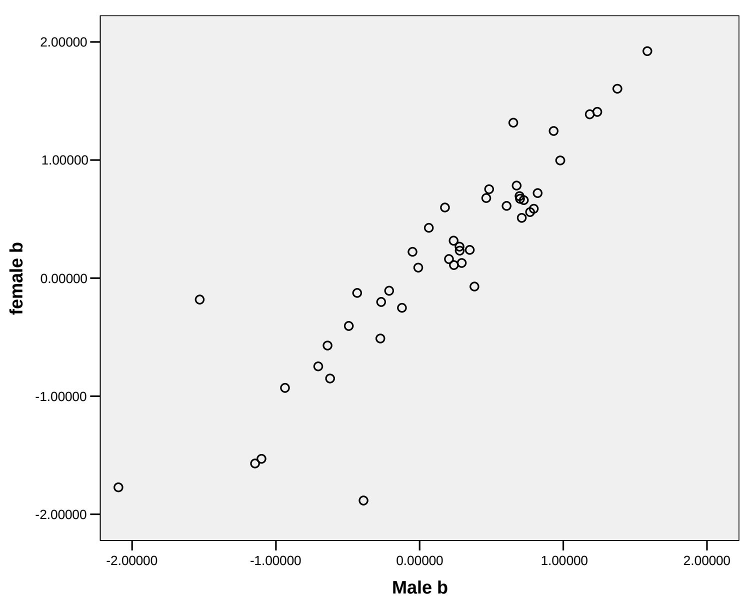


Figure 8.4 b-plot from White and Black Samples

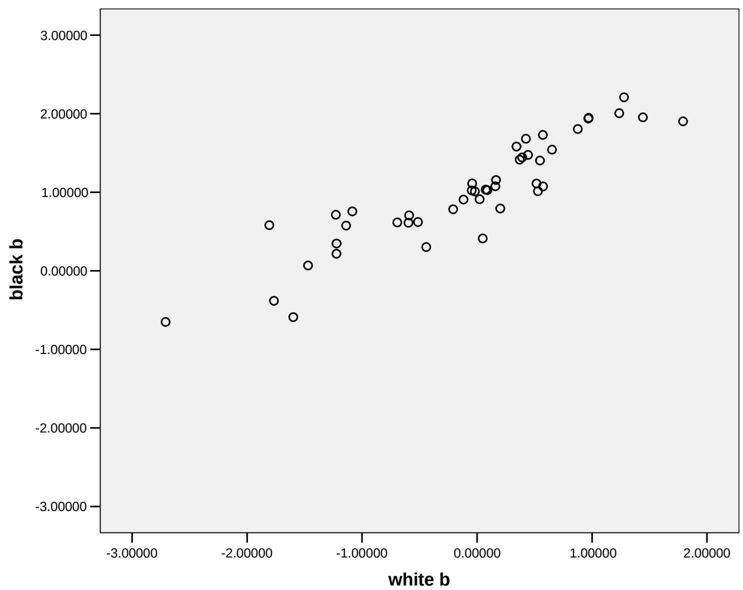
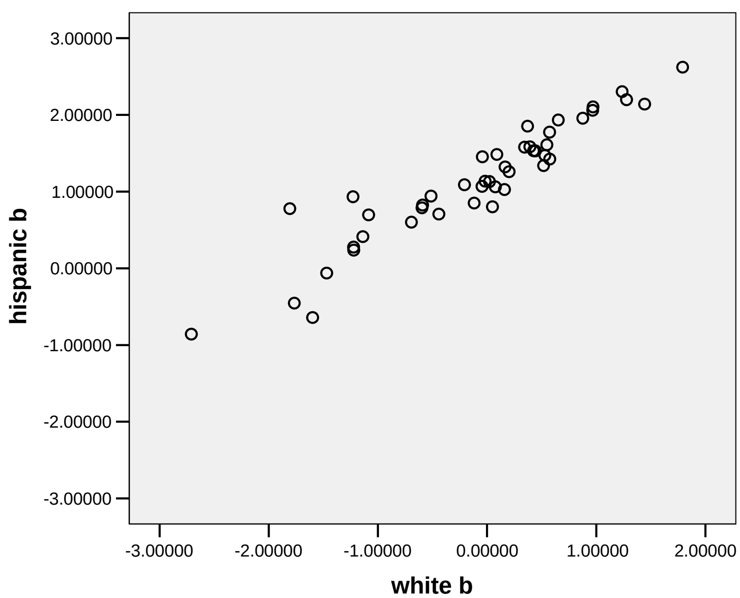


Figure 8.5 b-plot from White and Hispanic Samples



The statistics show that for gender groups, males and females achieve comparable scores, while for ethnicity groups, whites perform better than Blacks and Hispanics. In addition, item difficulty parameter plots show good linear relationship between the scores of subgroups suggesting a minimum amount of DIF. Clearly then we were not surprised by the results that follow using more traditional DIF procedures.

DIF analyses were carried out for three pairs of subgroups, male/female, white/Black, and white/Hispanic. The sample sizes of Asian and Native groups were not large enough to do the DIF analyses. The weighted two-stage conditional p-value comparison procedure was used to calculate the DIF index by STDIF, a DOS-based program written by Frederic Robin (2001). The procedure consists of two stages. In Stage 1, for students in the focal and reference groups with the same total scores, the difference in proportion-correct at each score point were calculated and summed up. A statistic of unsigned DIF indices (UDIF) (all differences are treated as positive and contribute to DIF) was obtained for each item. The items with absolute values of UDIF larger than 0.075 were flagged as potential DIF items and were excluded from the total score in Stage2. In Stage 2, the comparisons were repeated based on the newly adjusted total scores. Items with absolute values of UDIF equal to or larger than 0.1 were flagged and identified as DIF items .Table 8.2 shows the UDIF indices of the items for the three pair wise groups in Stage 1 and Stage 2.

Table 8.2. UDIF Indices in Stage 1 and Stage 2*

Item	UDIF(G) Stage 1	UDIF(G) Stage 2	UDIF(B) Stage 1	UDIF(B) Stage 2	UDIF(H) Stage 1	UDIF(H) Stage 2
1	0.062	0.063	0.079**	0.059	0.062	0.040
2	0.045	0.053	0.061	0.056	0.061	0.056
3	0.051	0.053	0.057	0.058	0.069	-0.078
4	0.031	0.029	0.072	0.063	0.061	-0.063
5	0.035	0.041	0.086**	0.075	0.075	0.078
6	-0.043	-0.042	-0.064	-0.064	-0.049	-0.063
7	0.127 **	0.127 **	0.068	0.063	0.057	-0.056
8	-0.050	-0.046	-0.130**	-0.104**	-0.100**	-0.074
9	0.044	0.040	-0.077**	0.081	0.063	-0.064
10	-0.052	-0.055	-0.126**	-0.099	-0.098**	-0.084
11	-0.029	-0.028	0.042	0.042	0.047	0.037
12	0.037	0.051	-0.075	-0.067	-0.081**	-0.056
13	-0.052	-0.044	-0.060	-0.066	-0.058	-0.063
14	0.048	0.050	0.072	0.066	0.066	-0.052
15	0.031	0.031	0.076**	0.081	0.058	0.071
16	0.052	0.049	0.064	0.068	0.061	0.055
17	-0.037	-0.043	-0.061	-0.055	0.052	0.062
18	-0.038	-0.038	-0.059	-0.049	-0.077**	0.063
19	0.050	0.051	-0.071	-0.064	-0.069	-0.060
20	-0.059	-0.053	-0.103**	-0.085	-0.084**	-0.075
21	-0.046	-0.046	-0.075	-0.066	-0.061	-0.061
22	0.066	0.064	-0.062	-0.044	-0.061	-0.058
23	0.062	0.066	0.055	-0.055	0.079**	0.073
24	0.065	0.069	-0.072	-0.073	-0.048	-0.047
25	-0.030	-0.026	-0.024	-0.023	0.030	-0.025
26	-0.042	-0.037	-0.029	-0.033	0.029	-0.024
27	0.022	0.017	0.048	-0.044	-0.056	-0.057
28	0.068	0.068	0.063	-0.059	0.058	0.073
29	0.082 **	0.086	0.075	0.050	-0.066	-0.066
30	0.051	0.053	0.070	0.066	0.072	0.060
31	0.046	0.043	0.060	-0.050	-0.068	-0.043
32	-0.042	-0.041	0.064	0.052	0.046	0.041
33	0.045	0.047	0.059	-0.062	-0.061	-0.049
34	-0.090 **	-0.089	-0.104**	-0.086	-0.083**	-0.081
35	-0.059	-0.057	-0.091**	-0.065	-0.099**	-0.080
36	0.038	0.034	0.056	0.057	0.062	0.050
37	0.044	0.044	0.051	0.051	0.049	0.048
38	-0.039	-0.044	-0.057	-0.071	0.061	0.051
39	-0.017	-0.014	0.031	0.022	0.024	0.019
40	-0.052	-0.053	0.071	0.053	0.062	-0.052
41	0.054	0.048	0.059	0.042	-0.064	-0.065
42	0.048	0.040	-0.061	-0.056	0.070	0.056
43	-0.050	-0.050	-0.088**	-0.076	-0.089**	-0.072
44	0.049	0.049	0.056	0.046	-0.040	-0.056
45	0.041	0.036	0.053	-0.039	-0.059	-0.072

* G = Groups of Male/Female, B = Groups of White/Black, H = Groups of White/Hispanic.
** Flagged items where |UDIF| > 0.075 at Stage 1, and |UDIF| ≥ 0.1 at Stage 2.

Table 8.3 displays the distributions of UDIF indices at Stage 2. For gender groups, one item was flagged with UDIF larger than 0.1 favoring males over females. For the White/Black group comparison, one item was flagged with UDIF smaller than -0.1 favoring Blacks over whites. For the White/Hispanic group comparison, there was no item flagged showing high DIF.

Table 8.3 Distribution of UDIF Indices in Stage 2

	UDIF ≤ -.1	-.1<UDIF <–.075	-.075≤UDIF≤.075	.075<UDIF<.1	UDIF≥.1
	High DIF	Low DIF	Non-DIF	Low DIF	High DIF
Gender	0	1(2.2%)	42(93.3%)	1(2.2%)	1(2.2%)
W/B	1(2.2%)	4(8.9%)	38(84.4%)	2(4.4%)	0
W/H	0	4(8.9%)	40(88.9%)	1(2.2%)	0

Note: UDIF < 0 favoring focal groups (Female, Black or Hispanic). UDIF > 0 favoring reference groups (Male or White)

Figure 8.9 to Figure 8.11 illustrate the magnitudes and directions of UDIF indices across the 45 items.

Figure 8.9 Plot of Male/Female UDIF Indices

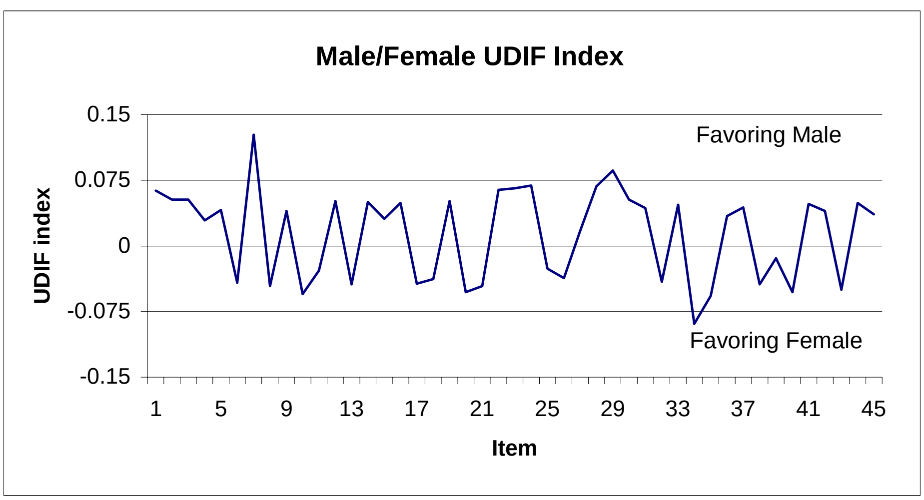


Figure 8.10 Plot of White/Black UDIF Indices

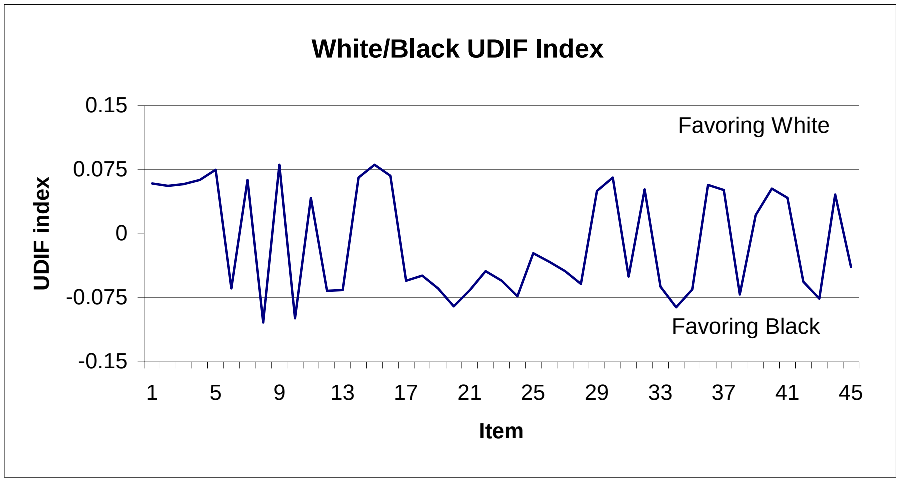
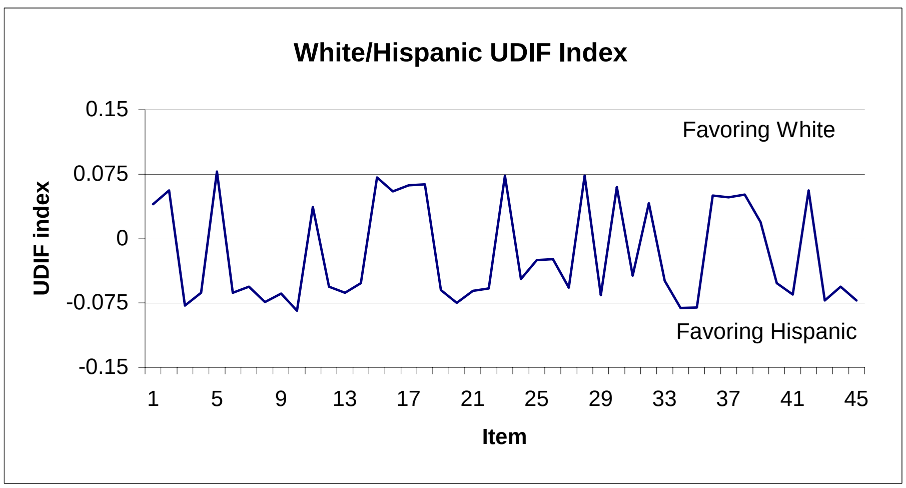


Figure 8.11 Plot of White/Hispanic UDIF Indices



The figures below are p-value plots conditional on adjusted total score and only two items were flagged from the analyses. The plots for these potentially problematic items allow for a closer look at whether the DIF is uniform (consistent in direction), whether the magnitude is the same across test scores, or whether there is any interaction between the DIF and proficiency level (as evidenced by intersecting displays of data), etc.

Figure 8.12 The Conditional p-value Plot of Flagged Item in the Gender Group

(UDIF = 0.127)

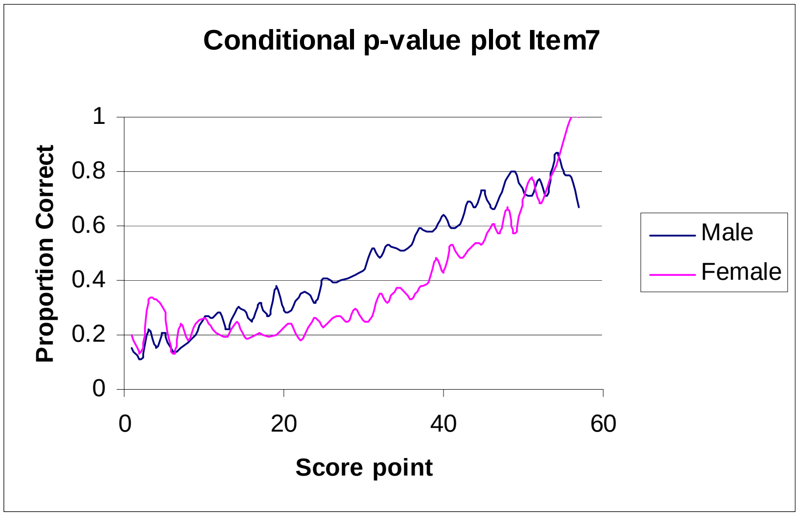
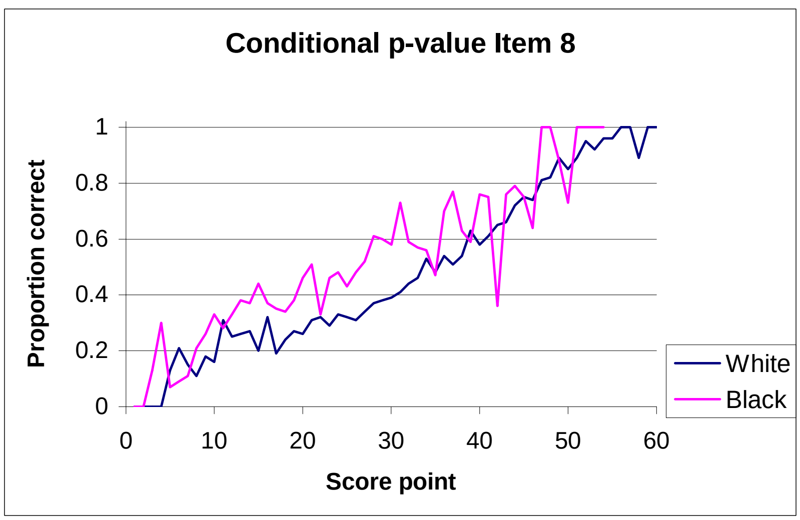


Figure 8.13 The Conditional p-value Plot of Flagged Item in White/Black Group

(UDIF= -0.104)



Both plots show more or less uniform conditional differences. Also, the plot of ethnicity group comparisons showed more fluctuation than that of the gender group comparison. This is probably because of the smaller sample size at each score point in the ethnicity groups. In fact, the group sizes in the ethnicity groups are less than 20 at test scores above 40. A further check of the item type shows that both items are multiple-choice items and the flagged item in the gender group comparison includes reference components. However, further studies are required in determining the causes of DIF, and whether the items are really biased or not. The detection of two problematic items in three DIF comparisons of 45 items each does not suggest anything approaching a problem with bias in the Introductory Physics Test.

9. Conclusions

In summary, the various analyses in this report suggest that the 2006 MCAS Grade 9/10 Introductory Physics Test is psychometrically sound—in fact, we would describe the statistical analyses as reflecting an excellent test. In classical item analyses, the items are of appropriate difficulty levels, properly discriminate between high and low performers, and the test scores are satisfactorily reliable for the multiple-choice items, performance items, and the total scores. From the item response theory (IRT) analyses, all of the indicators suggest a strong first factor. Also, the fits of the model to the data were excellent. The fit between model and data was checked in different ways using graphical procedures. The results show excellent model fit at both the item and test levels. In addition, the test information function shows that measurement precision is excellent across the scale. The differential item functioning (DIF) analyses show very little evidence of DIF. Only two items were identified, one from the male/female group comparison (favoring males), and the other from the white/Black group comparison (favoring Blacks). These two items suggest potential bias and need further checking. But the identification of only two items is not above the level that might be expected by chance. In summary, we believe our analyses have revealed that the Introductory Physics Test in 2006 is excellent in every statistical respect. We noticed that a slight shift in the test information function could be helpful, and our DIF analyses revealed that two items might be checked further, not because of their small to trivial impact on the test scores in 2006 but because something might be learned to eliminate these small problems from future tests.

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Appendix A. A Detailed Distracter Analysis with Frequencies and Percentages

* is keyed answer, # is option that discriminates better than keyed answer

Item	Group	A	B	C	D
1	TOTAL	4437*(0.844)	89 (0.017)	627 (0.119)	83 (0.016)
	High	1648 (0.946)	4 (0.002)	81 (0.046)	8 (0.005)
	Low	1054 (0.700)	71 (0.047)	306 (0.203)	59 (0.039)
	Diff	594 (0.246)	-67(-0.045)	-225(-0.157)	-51(-0.035)
2	TOTAL	891 (0.170)	2285*(0.435)	1072 (0.204)	966 (0.184)
	High	202 (0.116)	1221 (0.701)	161 (0.092)	155 (0.089)
	Low	313 (0.208)	337 (0.224)	493 (0.328)	335 (0.223)
	Diff	-111(-0.092)	884 (0.477)	-332(-0.235)	-180(-0.134)
3	TOTAL	2765*(0.526)	1307 (0.249)	656 (0.125)	485 (0.092)
	High	1426 (0.819)	132 (0.076)	111 (0.064)	68 (0.039)
	Low	374 (0.249)	644 (0.428)	269 (0.179)	192 (0.128)
	Diff	1052 (0.570)	-512(-0.352)	-158(-0.115)	-124(-0.089)
4	TOTAL	458 (0.087)	3756*(0.715)	670 (0.128)	338 (0.064)
	High	16 (0.009)	1621 (0.931)	96 (0.055)	9 (0.005)
	Low	285 (0.189)	655 (0.435)	286 (0.190)	251 (0.167)
	Diff	-269(-0.180)	966 (0.495)	-190(-0.135)	-242(-0.162)
5	TOTAL	537 (0.102)	390 (0.074)	3841*(0.731)	444 (0.085)
	High	31 (0.018)	18 (0.010)	1658 (0.952)	32 (0.018)
	Low	308 (0.205)	252 (0.167)	651 (0.433)	259 (0.172)
	Diff	-277(-0.187)	-234(-0.157)	1007 (0.519)	-227(-0.154)
6	TOTAL	385 (0.073)	332 (0.063)	447 (0.085)	4057*(0.772)
	High	31 (0.018)	20 (0.011)	89 (0.051)	1601 (0.919)
	Low	237 (0.157)	196 (0.130)	206 (0.137)	837 (0.556)
	Diff	-206(-0.140)	-176(-0.119)	-117(-0.086)	764 (0.363)
7	TOTAL	2626 (0.500)	207 (0.039)	303 (0.058)	2078*(0.396)
	High	626 (0.359)	14 (0.008)	34 (0.020)	1065 (0.611)
	Low	856 (0.569)	135 (0.090)	153 (0.102)	328 (0.218)
	Diff	-230(-0.209)	-121(-0.082)	-119(-0.082)	737 (0.393)
8	TOTAL	2607*(0.496)	1074 (0.204)	972 (0.185)	538 (0.102)
	High	1275 (0.732)	217 (0.125)	144 (0.083)	97 (0.056)
	Low	432 (0.287)	396 (0.263)	406 (0.270)	227 (0.151)
	Diff	843 (0.445)	-179(-0.139)	-262(-0.187)	-130(-0.095)
9	TOTAL	361 (0.069)	652 (0.124)	225 (0.043)	3976*(0.757)
	High	22 (0.013)	54 (0.031)	15 (0.009)	1650 (0.947)
	Low	225 (0.150)	362 (0.241)	159 (0.106)	721 (0.479)

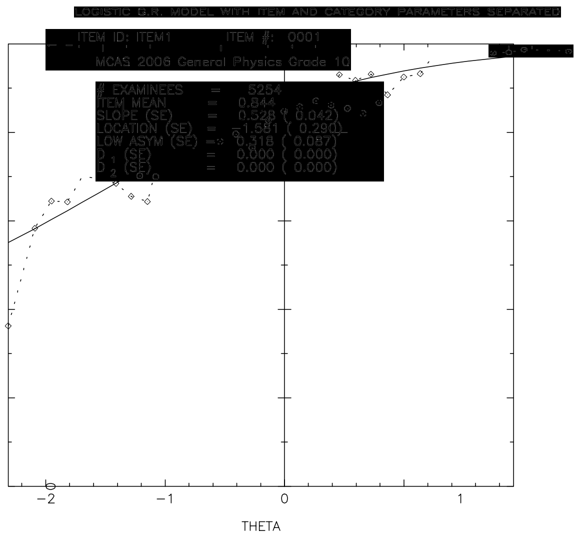
	Diff	-203(-0.137)	-308(-0.210)	-144(-0.097)	929 (0.468)
10	TOTAL	2605*(0.496)	1333 (0.254)	865 (0.165)	393 (0.075)
	High	1317 (0.756)	291 (0.167)	99 (0.057)	31 (0.018)
	Low	445 (0.296)	399 (0.265)	407 (0.270)	213 (0.142)
	Diff	872 (0.460)	-108(-0.098)	-308(-0.214)	-182(-0.124)
12	TOTAL	663 (0.126)	493 (0.094)	1168 (0.222)	2873*(0.547)
	High	83 (0.048)	47 (0.027)	255 (0.146)	1356 (0.778)
	Low	314 (0.209)	278 (0.185)	400 (0.266)	462 (0.307)
	Diff	-231(-0.161)	-231(-0.158)	-145(-0.119)	894 (0.471)
13	TOTAL	3143*(0.598)	1288 (0.245)	412 (0.078)	356 (0.068)
	High	1277 (0.733)	358 (0.206)	55 (0.032)	50 (0.029)
	Low	622 (0.413)	439 (0.292)	216 (0.144)	178 (0.118)
	Diff	655 (0.320)	-81(-0.086)	-161(-0.112)	-128(-0.090)
14	TOTAL	472 (0.090)	2451*(0.467)	1329 (0.253)	946 (0.180)
	High	63 (0.036)	1277 (0.733)	234 (0.134)	166 (0.095)
	Low	257 (0.171)	366 (0.243)	462 (0.307)	370 (0.246)
	Diff	-194(-0.135)	911 (0.490)	-228(-0.173)	-204(-0.151)
15	TOTAL	523 (0.100)	3667*(0.698)	646 (0.123)	359 (0.068)
	High	48 (0.028)	1611 (0.925)	54 (0.031)	27 (0.015)
	Low	310 (0.206)	583 (0.387)	339 (0.225)	220 (0.146)
	Diff	-262(-0.178)	1028 (0.537)	-285(-0.194)	-193(-0.131)
16	TOTAL	2979*(0.567)	274 (0.052)	384 (0.073)	1552 (0.295)
	High	1290 (0.741)	10 (0.006)	11 (0.006)	430 (0.247)
	Low	512 (0.340)	214 (0.142)	276 (0.183)	445 (0.296)
	Diff	778 (0.400)	-204(-0.136)	-265(-0.177)	-15(-0.049)
17	TOTAL	667 (0.127)	823 (0.157)	1073 (0.204)	2616*(0.498)
	High	139 (0.080)	213 (0.122)	212 (0.122)	1175 (0.675)
	Low	280 (0.186)	279 (0.185)	454 (0.302)	426 (0.283)
	Diff	-141(-0.106)	-66(-0.063)	-242(-0.180)	749 (0.391)
18	TOTAL	642 (0.122)	1604 (0.305)	2550*(0.485)	390 (0.074)
	High	106 (0.061)	379 (0.218)	1210 (0.695)	45 (0.026)
	Low	299 (0.199)	515 (0.342)	425 (0.282)	206 (0.137)
	Diff	-193(-0.138)	-136(-0.125)	785 (0.412)	-161(-0.111)
19	TOTAL	995 (0.189)	565 (0.108)	3079*(0.586)	539 (0.103)
	High	210 (0.121)	37 (0.021)	1405 (0.807)	87 (0.050)
	Low	337 (0.224)	352 (0.234)	503 (0.334)	244 (0.162)
	Diff	-127(-0.103)	-315(-0.213)	902 (0.472)	-157(-0.112)
20	TOTAL	1112 (0.212)	2438*(0.464)	658 (0.125)	966 (0.184)

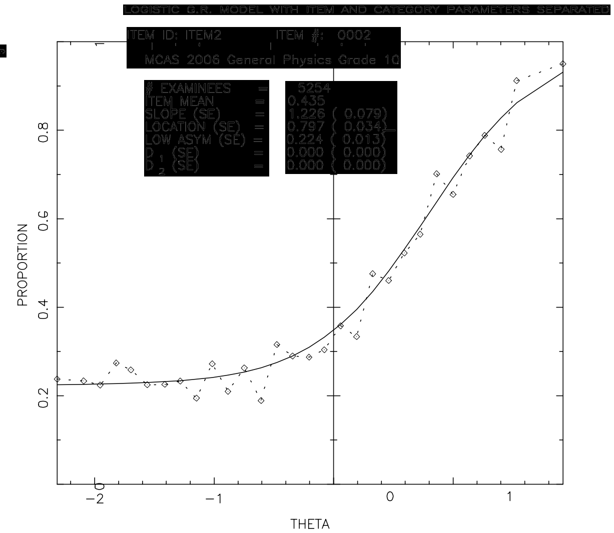
	High	369 (0.212)	1200 (0.689)	53 (0.030)	118 (0.068)
	Low	323 (0.215)	379 (0.252)	341 (0.227)	391 (0.260)
	Diff	46(-0.003)	821 (0.437)	-288(-0.196)	-273(-0.192)
21	TOTAL	2694*(0.513)	978 (0.186)	1113 (0.212)	370 (0.070)
	High	1187 (0.681)	207 (0.119)	299 (0.172)	43 (0.025)
	Low	463 (0.308)	384 (0.255)	355 (0.236)	219 (0.146)
	Diff	724 (0.374)	-177(-0.136)	-56(-0.064)	-176(-0.121)
22	TOTAL	1266 (0.241)	1043 (0.199)	1912*(0.364)	941 (0.179)
	High	383 (0.220)	188 (0.108)	1010 (0.580)	160 (0.092)
	Low	382 (0.254)	365 (0.243)	325 (0.216)	347 (0.231)
	Diff	1(-0.034)	-177(-0.135)	685 (0.364)	-187(-0.139)
23	TOTAL	433 (0.082)	572 (0.109)	1051 (0.200)	3108*(0.592)
	High	17 (0.010)	50 (0.029)	268 (0.154)	1404 (0.806)
	Low	260 (0.173)	326 (0.217)	371 (0.247)	469 (0.312)
	Diff	-243(-0.163)	-276(-0.188)	-103(-0.093)	935 (0.494)
24	TOTAL	436 (0.083)	1169 (0.222)	688 (0.131)	2861*(0.545)
	High	73 (0.042)	166 (0.095)	89 (0.051)	1407 (0.808)
	Low	218 (0.145)	450 (0.299)	331 (0.220)	421 (0.280)
	Diff	-145(-0.103)	-284(-0.204)	-242(-0.169)	986 (0.528)
27	TOTAL	4585*(0.873)	210 (0.040)	156 (0.030)	164 (0.031)
	High	1727 (0.991)	6 (0.003)	1 (0.001)	8 (0.005)
	Low	953 (0.633)	164 (0.109)	139 (0.092)	116 (0.077)
	Diff	774 (0.358)	-158(-0.106)	-138(-0.092)	-108(-0.072)
28	TOTAL	1175 (0.224)	581 (0.111)	2533*(0.482)	809 (0.154)
	High	303 (0.174)	74 (0.042)	1193 (0.685)	168 (0.096)
	Low	348 (0.231)	325 (0.216)	388 (0.258)	299 (0.199)
	Diff	-45(-0.057)	-251(-0.173)	805 (0.427)	-131(-0.102)
29	TOTAL	3387*(0.645)	730 (0.139)	682 (0.130)	299 (0.057)
	High	1577 (0.905)	92 (0.053)	60 (0.034)	13 (0.007)
	Low	466 (0.310)	348 (0.231)	340 (0.226)	204 (0.136)
	Diff	1111 (0.596)	-256(-0.178)	-280(-0.191)	-191(-0.128)
30	TOTAL	433 (0.082)	644 (0.123)	685 (0.130)	3320*(0.632)
	High	25 (0.014)	38 (0.022)	39 (0.022)	1639 (0.941)
	Low	245 (0.163)	347 (0.231)	385 (0.256)	370 (0.246)
	Diff	-220(-0.148)	-309(-0.209)	-346(-0.233)	1269 (0.695)
31	TOTAL	751 (0.143)	619 (0.118)	3177*(0.605)	545 (0.104)
	High	91 (0.052)	42 (0.024)	1571 (0.902)	37 (0.021)
	Low	328 (0.218)	327 (0.217)	405 (0.269)	294 (0.195)
	Diff	-237(-0.166)	-285(-0.193)	1166 (0.633)	-257(-0.174)

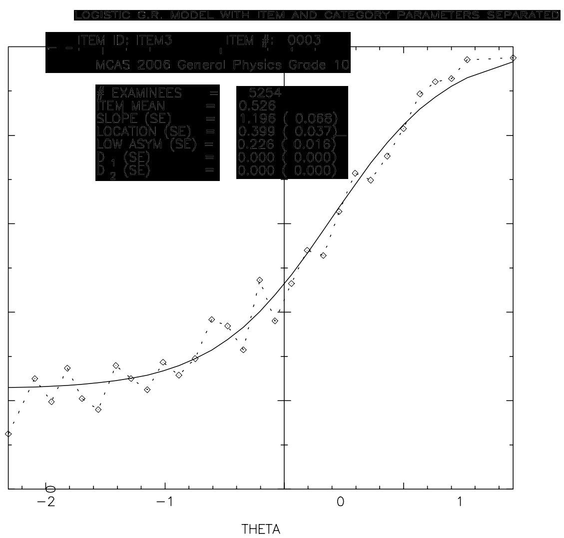
33	TOTAL	838 (0.159)	1987*(0.378)	1567 (0.298)	642 (0.122)
	High	175 (0.100)	964 (0.553)	513 (0.294)	90 (0.052)
	Low	329 (0.219)	351 (0.233)	397 (0.264)	235 (0.156)
	Diff	-154(-0.118)	613 (0.320)	116 (0.031)	-145(-0.104)
34	TOTAL	468 (0.089)	1176 (0.224)	473 (0.090)	2907*(0.553)
	High	95 (0.055)	174 (0.100)	26 (0.015)	1447 (0.831)
	Low	206 (0.137)	414 (0.275)	302 (0.201)	381 (0.253)
	Diff	-111(-0.082)	-240(-0.175)	-276(-0.186)	1066 (0.577)
35	TOTAL	332 (0.063)	2593*(0.494)	1589 (0.302)	505 (0.096)
	High	24 (0.014)	1326 (0.761)	337 (0.193)	54 (0.031)
	Low	212 (0.141)	404 (0.268)	448 (0.298)	238 (0.158)
	Diff	-188(-0.127)	922 (0.493)	-111(-0.104)	-184(-0.127)
36	TOTAL	1988 (0.378)	764 (0.145)	904 (0.172)	1334*(0.254)
	High	542 (0.311)	128 (0.073)	272 (0.156)	789 (0.453)
	Low	513 (0.341)	294 (0.195)	266 (0.177)	223 (0.148)
	Diff	29(-0.030)	-166(-0.122)	6(-0.021)	566 (0.305)
37	TOTAL	974 (0.185)	1812 (0.345)	816 (0.155)	1406*(0.268)
	High	296 (0.170)	483 (0.277)	238 (0.137)	721 (0.414)
	Low	274 (0.182)	535 (0.355)	276 (0.183)	217 (0.144)
	Diff	22(-0.012)	-52(-0.078)	-38(-0.047)	504 (0.270)
38	TOTAL	847 (0.161)	2519*(0.479)	835 (0.159)	800 (0.152)
	High	135 (0.077)	1361 (0.781)	142 (0.082)	98 (0.056)
	Low	318 (0.211)	300 (0.199)	326 (0.217)	354 (0.235)
	Diff	-183(-0.134)	1061 (0.582)	-184(-0.135)	-256(-0.179)
40	TOTAL	965 (0.184)	737 (0.140)	2227*(0.424)	751 (0.143)
	High	325 (0.187)	139 (0.080)	1037 (0.595)	195 (0.112)
	Low	269 (0.179)	284 (0.189)	336 (0.223)	243 (0.161)
	Diff	56 (0.008)	-145(-0.109)	701 (0.372)	-48(-0.050)
41	TOTAL	665 (0.127)	2243*(0.427)	817 (0.156)	988 (0.188)
	High	132 (0.076)	1159 (0.665)	206 (0.118)	202 (0.116)
	Low	252 (0.167)	299 (0.199)	283 (0.188)	316 (0.210)
	Diff	-120(-0.092)	860 (0.467)	-77(-0.070)	-114(-0.094)
42	TOTAL	2776*(0.528)	761 (0.145)	822 (0.156)	331 (0.063)
	High	1414 (0.812)	68 (0.039)	191 (0.110)	21 (0.012)
	Low	312 (0.207)	361 (0.240)	278 (0.185)	193 (0.128)
	Diff	1102 (0.604)	-293(-0.201)	-87(-0.075)	-172(-0.116)
43	TOTAL	419 (0.080)	596 (0.113)	3271*(0.623)	412 (0.078)

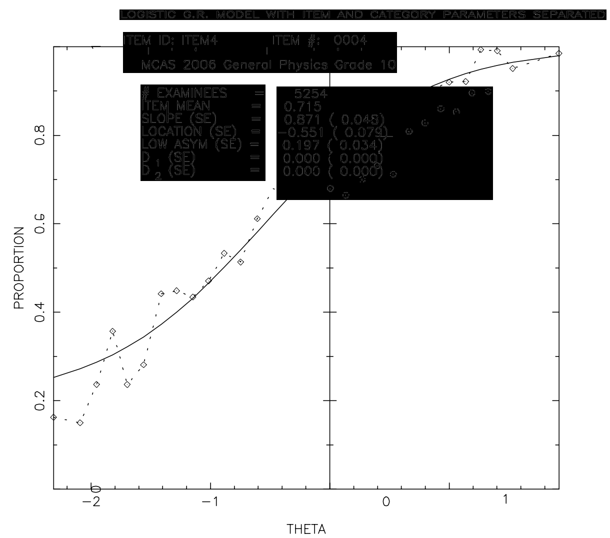
	High	28 (0.016)	39 (0.022)	1604 (0.921)	26 (0.015)
	Low	222 (0.148)	286 (0.190)	412 (0.274)	219 (0.146)
	Diff	-194(-0.131)	-247(-0.168)	1192 (0.647)	-193(-0.131)
44	TOTAL	843 (0.160)	954 (0.182)	1515 (0.288)	1388*(0.264)
	High	188 (0.108)	167 (0.096)	569 (0.327)	773 (0.444)
	Low	271 (0.180)	331 (0.220)	327 (0.217)	216 (0.144)
	Diff	-83(-0.072)	-164(-0.124)	242 (0.109)	557 (0.300)
45	TOTAL	990 (0.188)	565 (0.108)	2678*(0.510)	474 (0.090)
	High	172 (0.099)	47 (0.027)	1421 (0.816)	55 (0.032)
	Low	362 (0.241)	262 (0.174)	328 (0.218)	201 (0.134)
	Diff	-190(-0.142)	-215(-0.147)	1093 (0.598)	-146(-0.102)

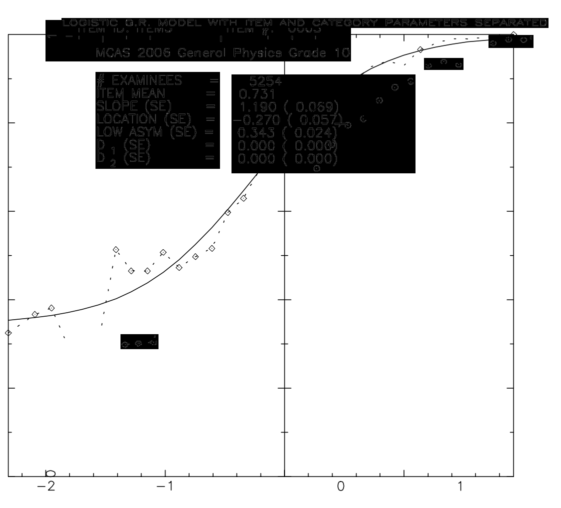
Appendix B   Item Residual Plots

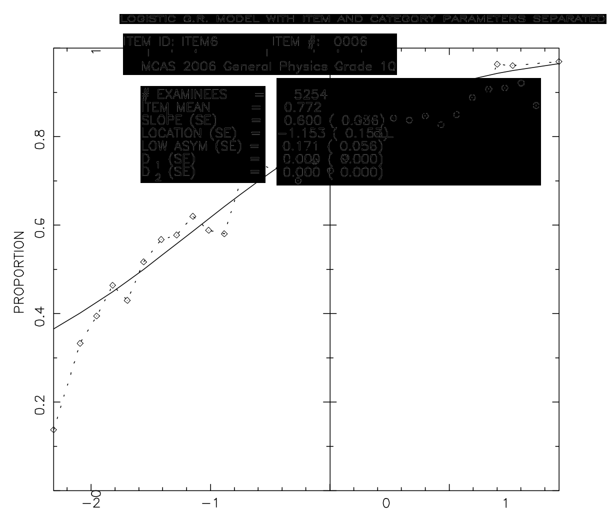


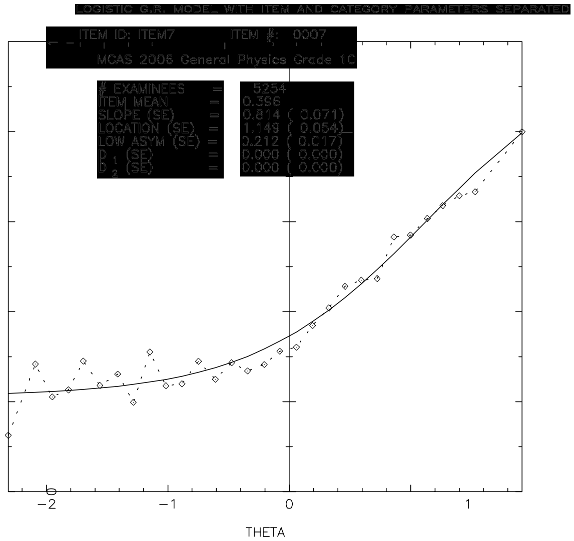








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ITEM ID: ITEM7 ITEM #: 0007
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.396
SLOPE (SE) = 0.814 (0.071)
LOCATION (SE) = 1.149 (0.054)
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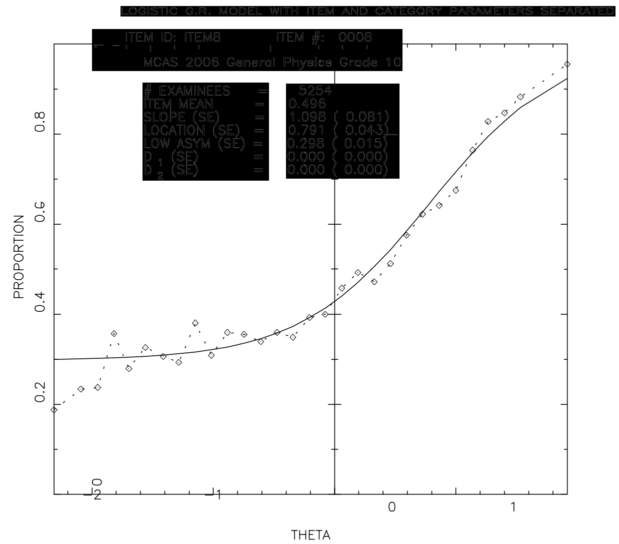
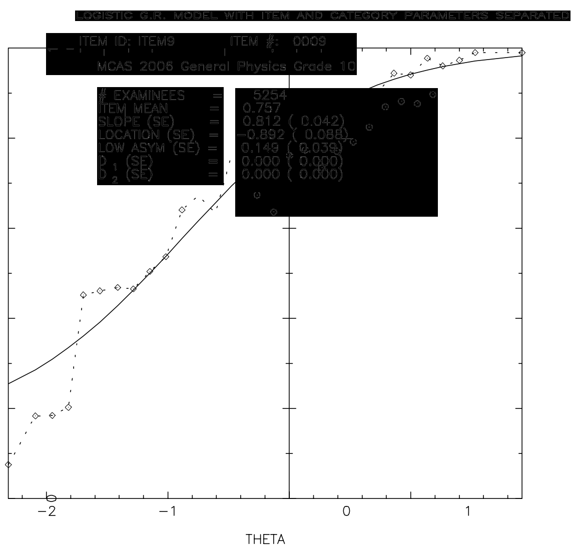
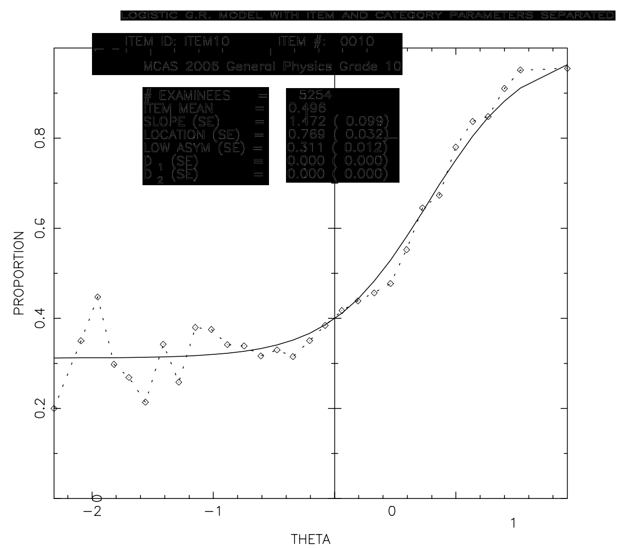
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM8 ITEM #: 0008
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.496
SLOPE (SE) = 1.098 (0.081)
LOCATION (SE) = 0.791 (0.043)
LOW ASYM (SE) = 0.298 (0.015)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM9 ITEM #: 0009
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.757
SLOPE (SE) = 0.812 (0.042)
LOCATION (SE) = −0.892 (0.088)
LOW ASYM (SE) = 0.149 (0.039)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
THETA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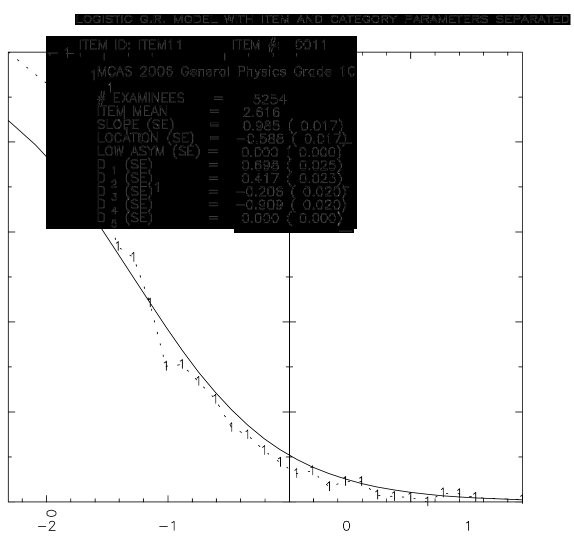
ITEM ID: ITEM10 ITEM #: 0010
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.496
SLOPE (SE) = 1.472 (0.099)
LOCATION (SE) = 0.769 (0.032)
LOW ASYM (SE) = 0.311 (0.012)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
THETA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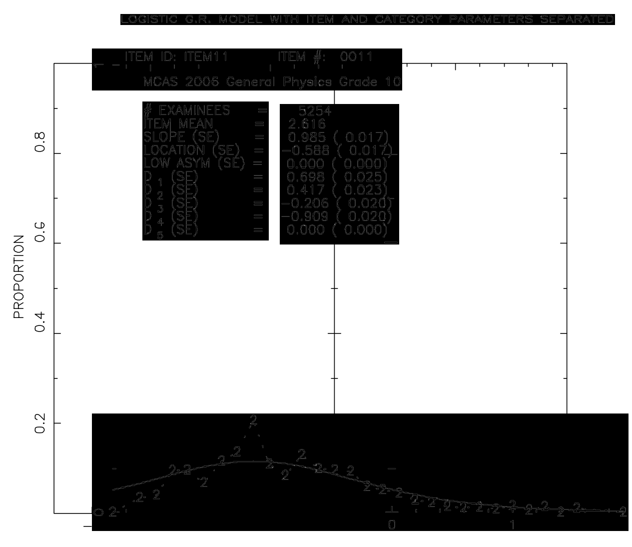
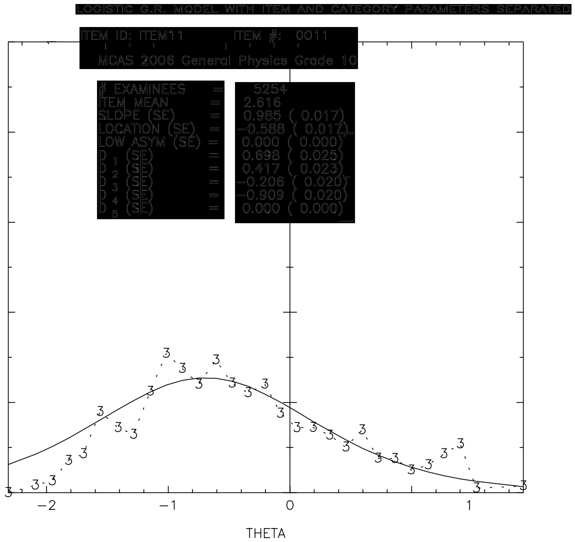
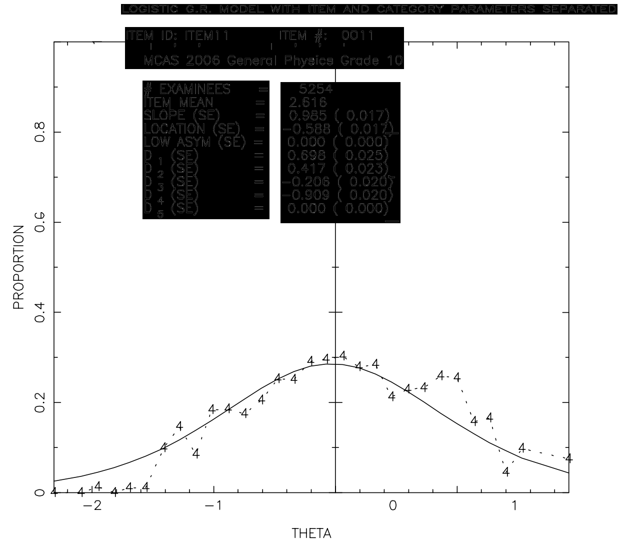
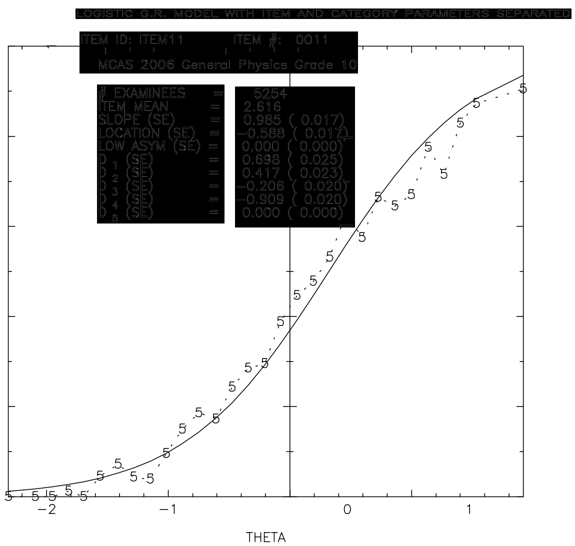
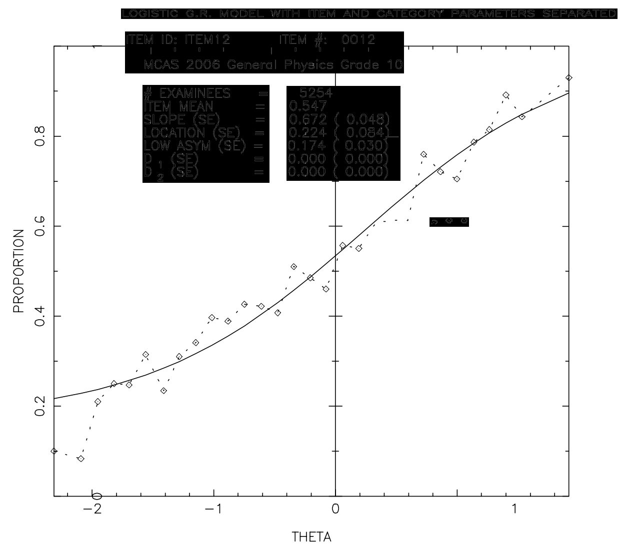
ITEM ID: ITEM11 ITEM #: 0011
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 2.616
SLOPE (SE) = 0.985 (0.017)
LOCATION (SE) = −0.588 (0.017)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.698 (0.025)
D 2 (SE) = 0.417 (0.023)
D 3 (SE) = −0.206 (0.020)
D 4 (SE) = −0.909 (0.020)
D 5 (SE) = 0.000 (0.000)
THETA

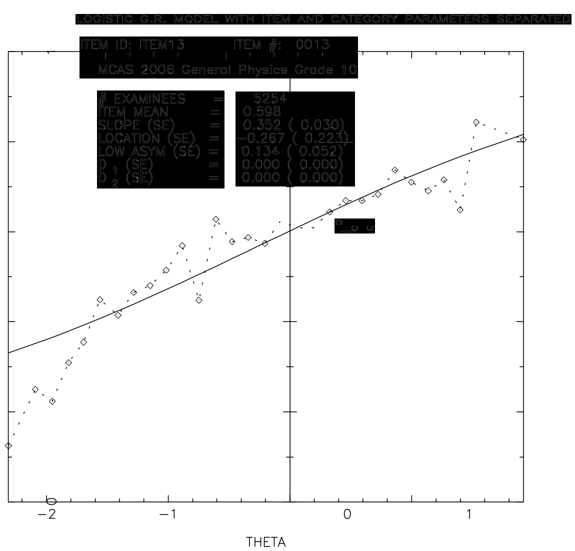

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM11 ITEM #: 0011
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 2.616
SLOPE (SE) = 0.985 (0.017)
LOCATION (SE) = −0.588 (0.017)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.698 (0.025)
D 2 (SE) = 0.417 (0.023)
D 3 (SE) = −0.206 (0.020)
D 4 (SE) = −0.909 (0.020)
D 5 (SE) = 0.000 (0.000)
PROPORTION
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM11 ITEM #: 0011
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 2.616
SLOPE (SE) = 0.985 (0.017)
LOCATION (SE) = -0.588 (0.017)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.698 (0.025)
D 2 (SE) = 0.417 (0.023)
D 3 (SE) = -0.206 (0.020)
D 4 (SE) = -0.909 (0.020)
D 5 (SE) = 0.000 (0.000)
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM11 ITEM #: 0011
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 2.616
SLOPE (SE) = 0.985 (0.017)
LOCATION (SE) = -0.588 (0.017)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.698 (0.025)
D 2 (SE) = 0.417 (0.023)
D 3 (SE) = -0.206 (0.020)
D 4 (SE) = -0.909 (0.020)
D 5 (SE) = 0.000 (0.000)
PROPORTION
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM11 ITEM #: 0011
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 2.616
SLOPE (SE) = 0.985 (0.017)
LOCATION (SE) = -0.588 (0.017)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.698 (0.025)
D 2 (SE) = 0.417 (0.023)
D 3 (SE) = -0.206 (0.020)
D 4 (SE) = -0.909 (0.020)
D 5 (SE) = 0.000 (0.000)
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM12 ITEM #: 0012
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.547
SLOPE (SE) = 0.672 (0.048)
LOCATION (SE) = 0.224 (0.064)
LOW ASYM (SE) = 0.174 (0.030)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM13 ITEM #: 0013
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.598
SLOPE (SE) = 0.352 (0.030)
LOCATION (SE) = -0.267 (0.223)
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D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
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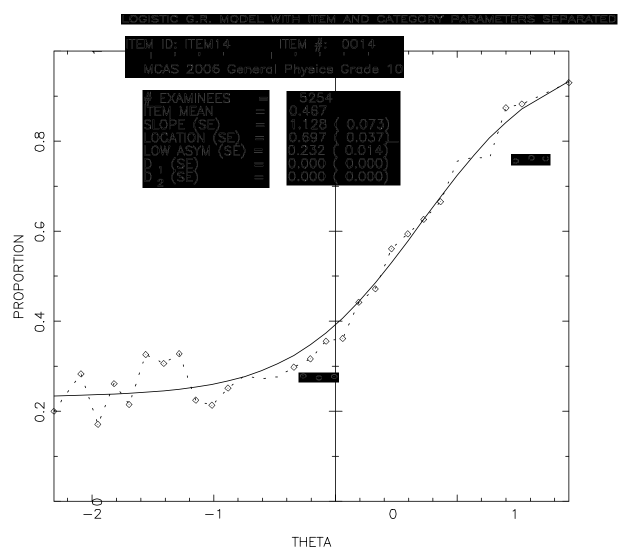
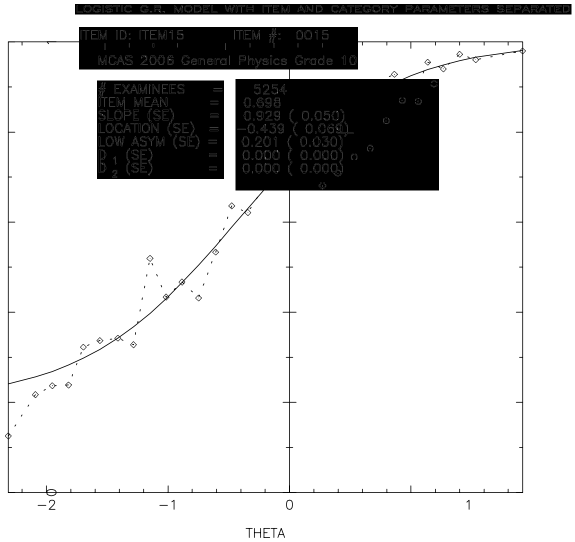

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM14 ITEM #: 0014
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.467
SLOPE (SE) = 1.128 (0.073)
LOCATION (SE) = 0.697 (0.037)
LOW ASYM (SE) = 0.232 (0.014)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM15 ITEM #: 0015
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.698
SLOPE (SE) = 0.929 (0.050)
LOCATION (SE) = −0.439 (0.069)
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D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
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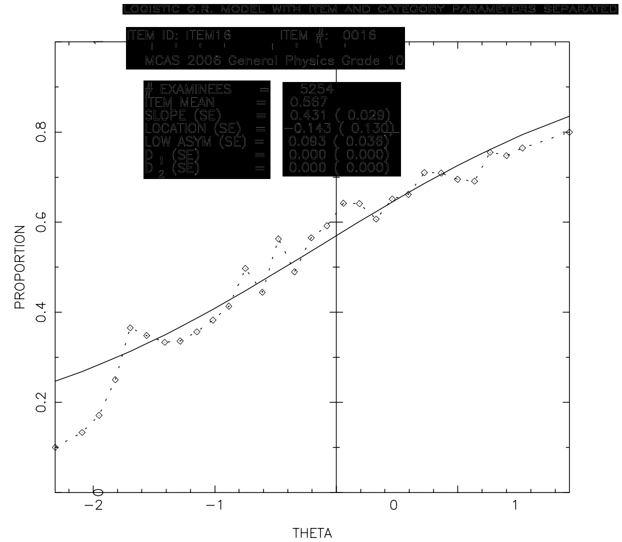
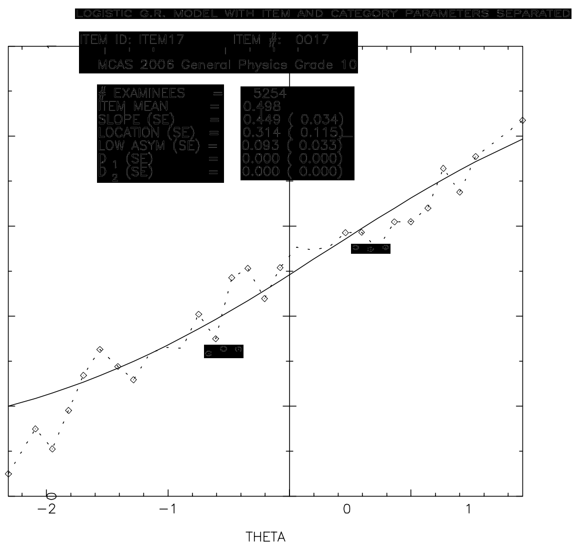

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM16 ITEM #: 0016
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.567
SLOPE (SE) = 0.431 (0.029)
LOCATION (SE) = −0.143 (0.130)
LOW ASYM (SE) = 0.093 (0.038)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM17 ITEM #: 0017
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.498
SLOPE (SE) = 0.449 (0.034)
LOCATION (SE) = 0.314 (0.115)
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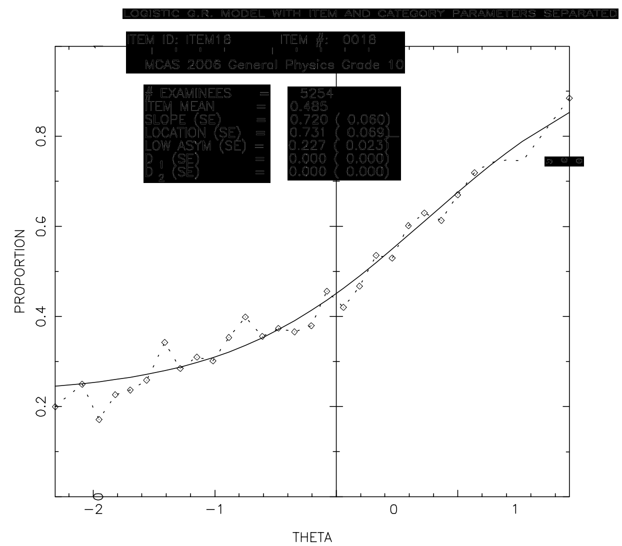
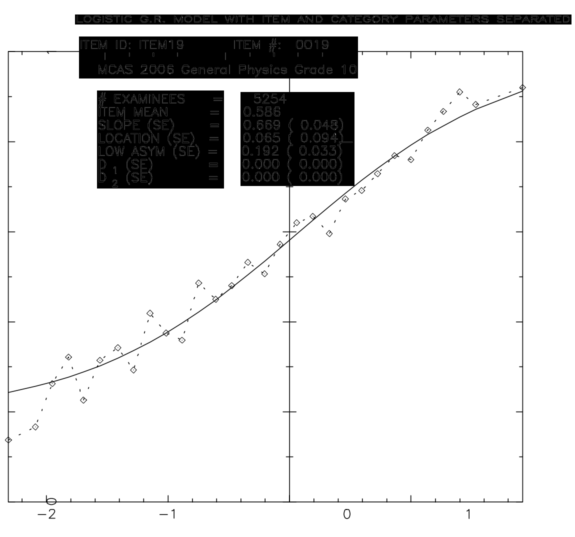
D 2 (SE) = 0.000 (0.000)
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM18 ITEM #: 0018
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.485
SLOPE (SE) = 0.720 (0.060)
LOCATION (SE) = 0.731 (0.069)
LOW ASYM (SE) = 0.227 (0.023)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM19 ITEM #: 0019
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.586
SLOPE (SE) = 0.669 (0.048)
LOCATION (SE) = 0.065 (0.094)
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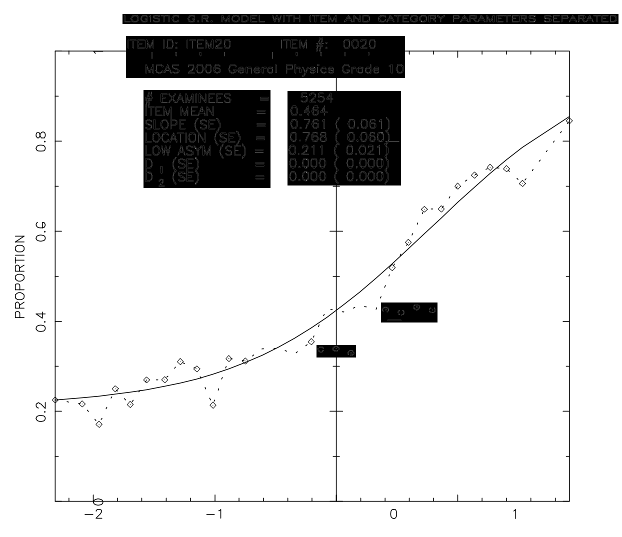
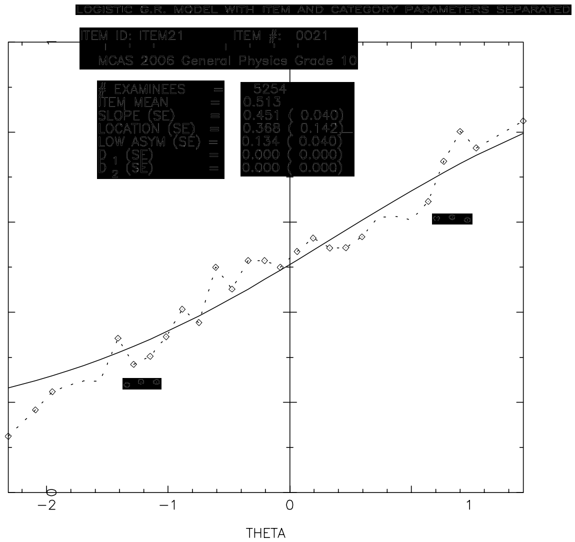
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM20 ITEM #: 0020
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.464
SLOPE (SE) = 0.761 (0.061)
LOCATION (SE) = 0.766 (0.060)
LOW ASYM (SE) = 0.211 (0.021)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
THETA



LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM21 ITEM #: 0021
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.513
SLOPE (SE) = 0.451 (0.040)
LOCATION (SE) = 0.368 (0.142)
LOW ASYM (SE) = 0.134 (0.040)
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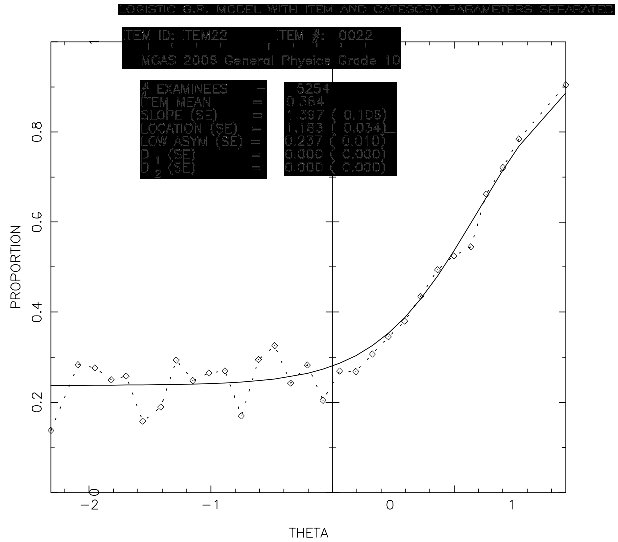
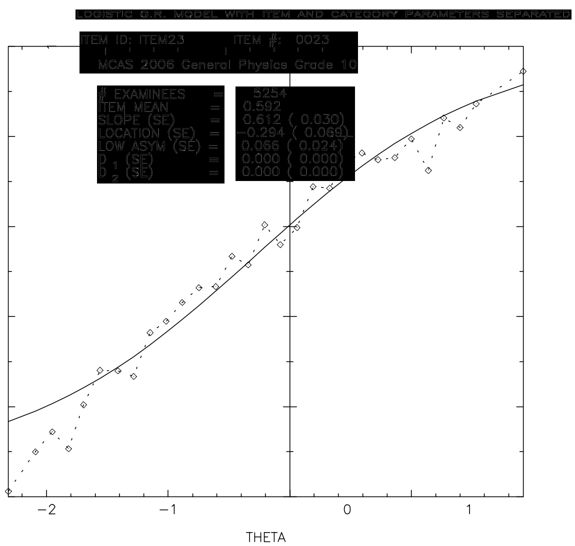
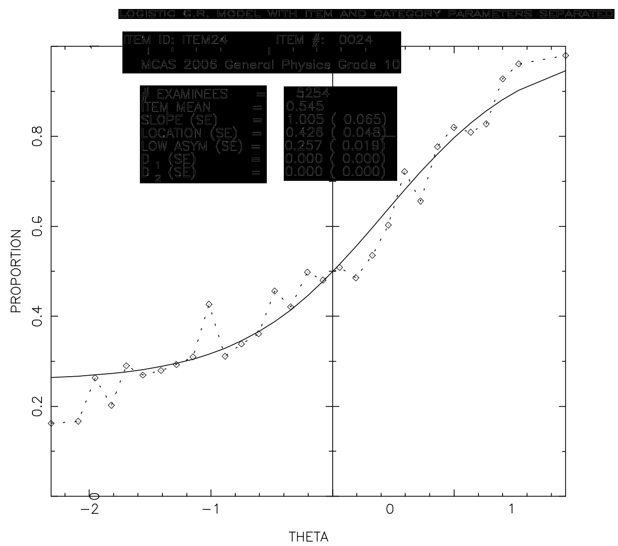
D 2 (SE) = 0.000 (0.000)
−2 −1 0 1
THETA



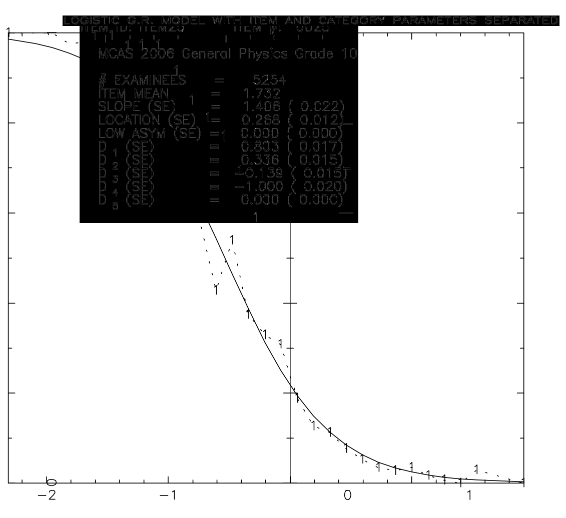
LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM22 ITEM #: 0022
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.364
SLOPE (SE) = 1.397 (0.106)
LOCATION (SE) = 1.183 (0.034)
LOW ASYM (SE) = 0.237 (0.010)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
0.2 0.4 0.6 0.8
−2 −1 0 1
THETA



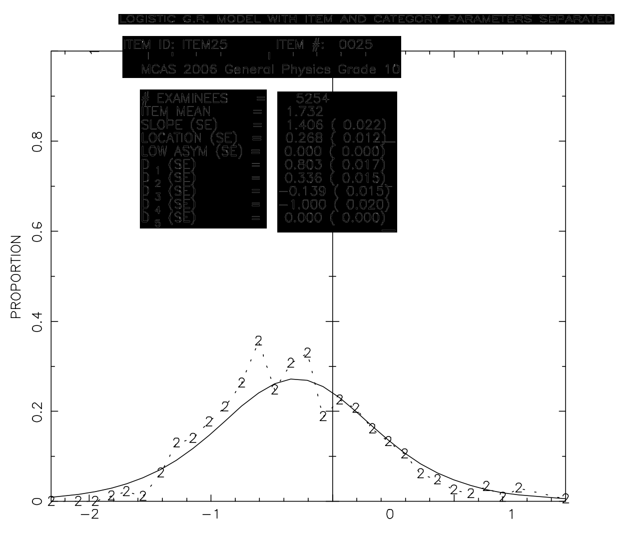
LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM23 ITEM #: 0023
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.592
SLOPE (SE) = 0.612 (0.030)
LOCATION (SE) = −0.294 (0.069)
LOW ASYM (SE) = 0.066 (0.024)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
−2 −1 0 1
THETA



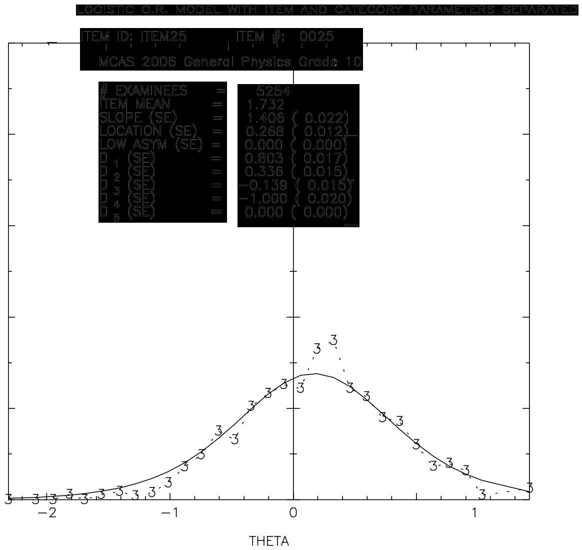
LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM24 ITEM #: 0024
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.545
SLOPE (SE) = 1.005 (0.065)
LOCATION (SE) = 0.426 (0.048)
LOW ASYM (SE) = 0.257 (0.019)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
0.2 0.4 0.6 0.8
−2 −1 0 1
THETA



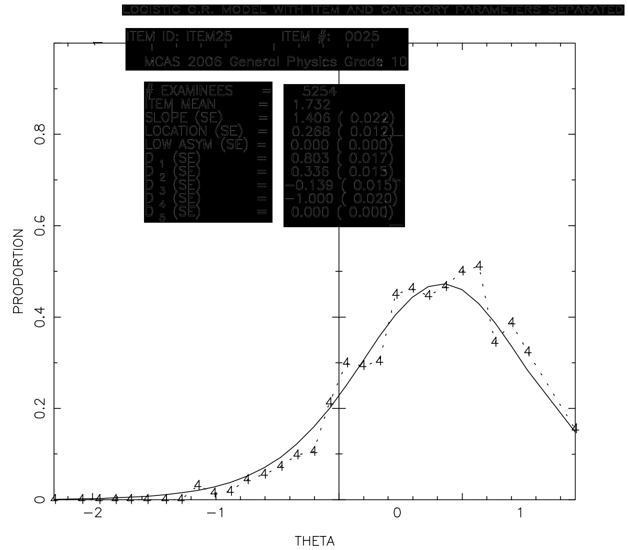
LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.732
SLOPE (SE) = 1.406 (0.022)
LOCATION (SE) = 0.268 (0.012)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.803 (0.017)
D 2 (SE) = 0.336 (0.015)
D 3 (SE) = −0.139 (0.015)
D 4 (SE) = −1.000 (0.020)
D 5 (SE) = 0.000 (0.000)
−2 −1 0 1
THETA



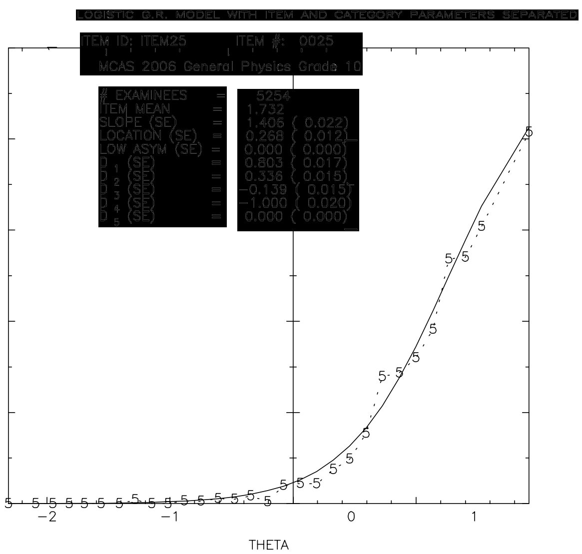
LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM25 ITEM #: 0025
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.732
SLOPE (SE) = 1.406 (0.022)
LOCATION (SE) = 0.268 (0.012)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.803 (0.017)
D 2 (SE) = 0.336 (0.015)
D 3 (SE) = −0.139 (0.015)
D 4 (SE) = −1.000 (0.020)
D 5 (SE) = 0.000 (0.000)
PROPORTION
0 0.2 0.4 0.6 0.8
−2 −1 0 1
THETA



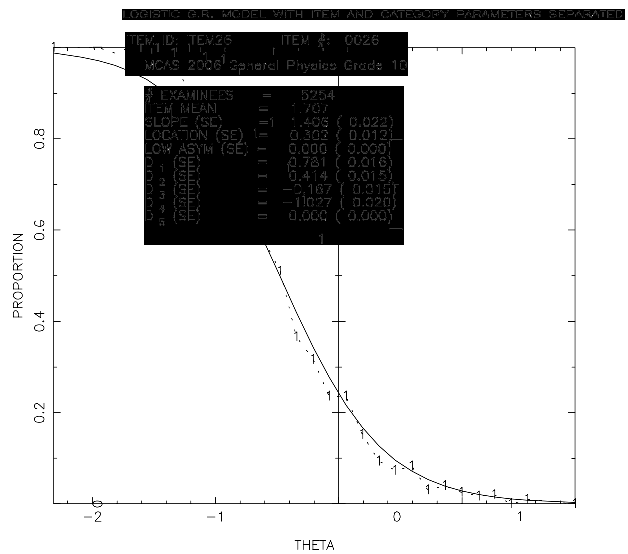
LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM25 ITEM #: 0025
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.732
SLOPE (SE) = 1.406 (0.022)
LOCATION (SE) = 0.268 (0.012)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.803 (0.017)
D 2 (SE) = 0.336 (0.015)
D 3 (SE) = −0.139 (0.015)
D 4 (SE) = −1.000 (0.020)
D 5 (SE) = 0.000 (0.000)
THETA



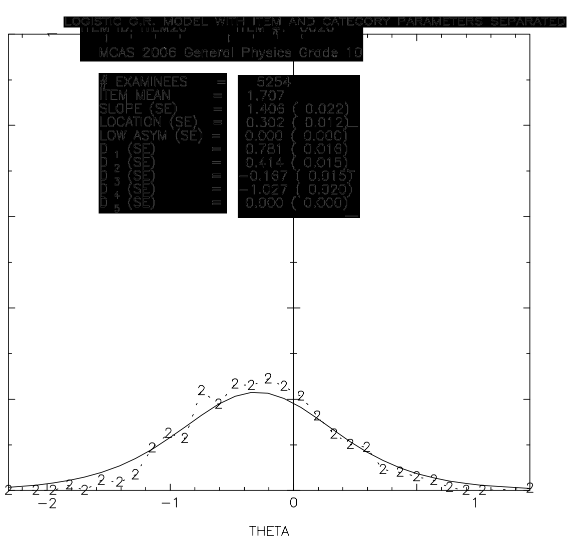
LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM25 ITEM #: 0025
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.732
SLOPE (SE) = 1.406 (0.022)
LOCATION (SE) = 0.268 (0.012)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.803 (0.017)
D 2 (SE) = 0.336 (0.015)
D 3 (SE) = −0.139 (0.015)
D 4 (SE) = −1.000 (0.020)
D 5 (SE) = 0.000 (0.000)
PROPORTION
THETA



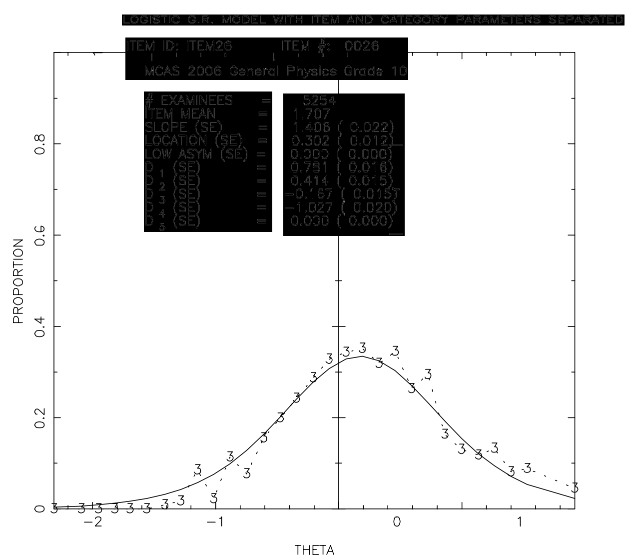
LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM25 ITEM #: 0025
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.732
SLOPE (SE) = 1.406 (0.022)
LOCATION (SE) = 0.268 (0.012)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.803 (0.017)
D 2 (SE) = 0.336 (0.015)
D 3 (SE) = −0.139 (0.015)
D 4 (SE) = −1.000 (0.020)
D 5 (SE) = 0.000 (0.000)
THETA



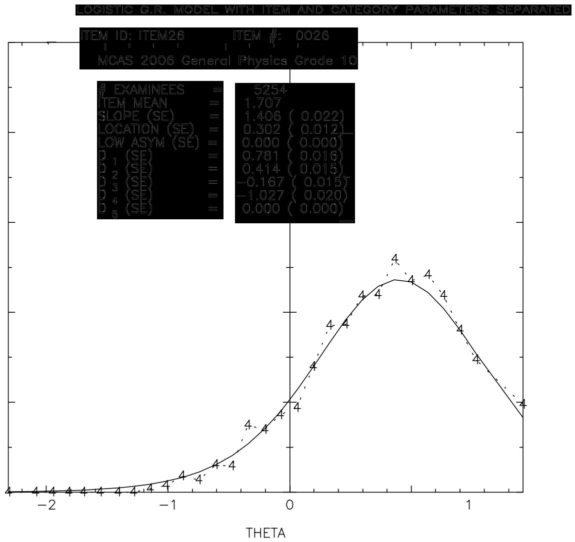
LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM26 ITEM #: 0026
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.707
SLOPE (SE) = 1.406 (0.022)
LOCATION (SE) = 0.302 (0.012)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.781 (0.016)
D 2 (SE) = 0.414 (0.015)
D 3 (SE) = −0.167 (0.015)
D 4 (SE) = −1.027 (0.020)
D 5 (SE) = 0.000 (0.000)
PROPORTION
THETA

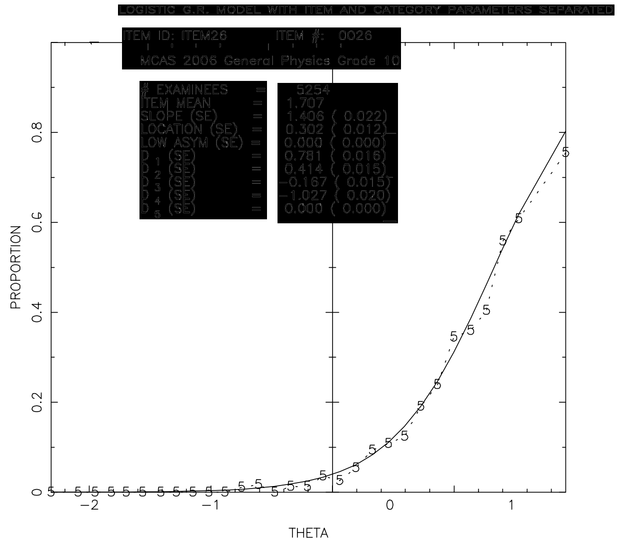


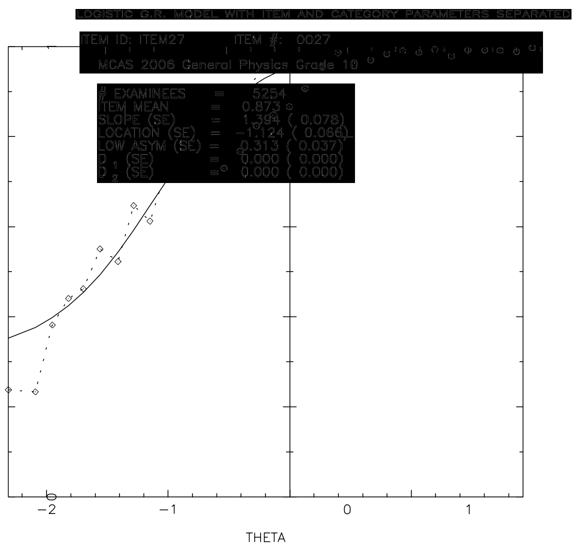
LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.707
SLOPE (SE) = 1.406 (0.022)
LOCATION (SE) = 0.302 (0.012)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.781 (0.016)
D 2 (SE) = 0.414 (0.015)
D 3 (SE) = −0.167 (0.015)
D 4 (SE) = −1.027 (0.020)
D 5 (SE) = 0.000 (0.000)
THETA

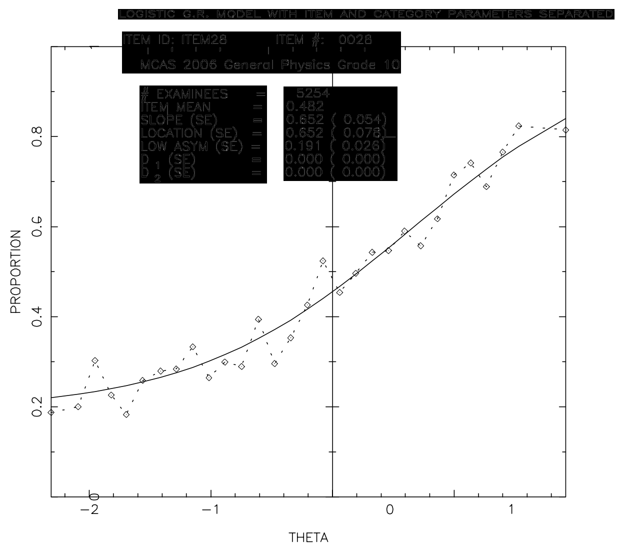


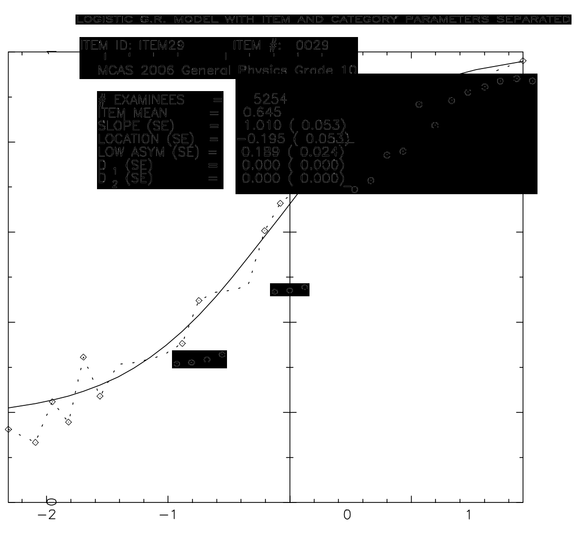
LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM26 ITEM #: 0026
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.707
SLOPE (SE) = 1.406 (0.022)
LOCATION (SE) = 0.302 (0.012)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.781 (0.016)
D 2 (SE) = 0.414 (0.015)
D 3 (SE) = −0.167 (0.015)
D 4 (SE) = −1.027 (0.020)
D 5 (SE) = 0.000 (0.000)
PROPORTION
THETA

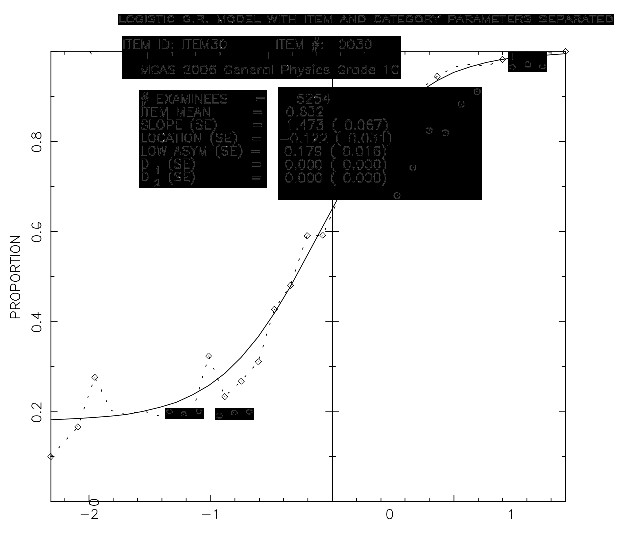

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM26 ITEM #: 0026
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.707
SLOPE (SE) = 1.406 (0.022)
LOCATION (SE) = 0.302 (0.012)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.781 (0.016)
D 2 (SE) = 0.414 (0.015)
D 3 (SE) = −0.167 (0.015)
D 4 (SE) = −1.027 (0.020)
D 5 (SE) = 0.000 (0.000)
THETA

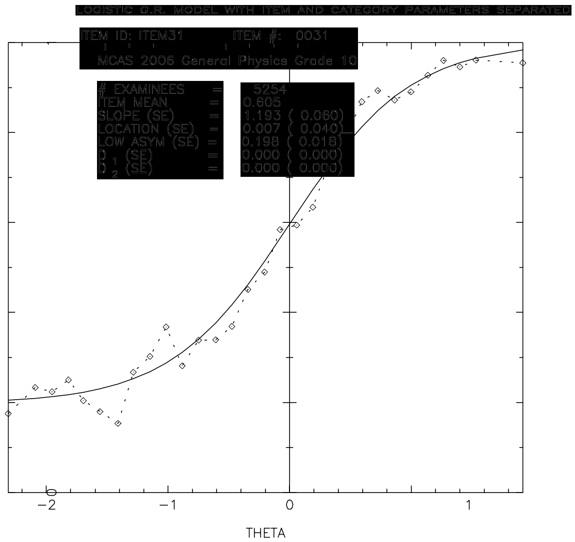

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM26 ITEM #: 0026
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.707
SLOPE (SE) = 1.406 (0.022)
LOCATION (SE) = 0.302 (0.012)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 0.781 (0.016)
D 2 (SE) = 0.414 (0.015)
D 3 (SE) = −0.167 (0.015)
D 4 (SE) = −1.027 (0.020)
D 5 (SE) = 0.000 (0.000)
PROPORTION
THETA

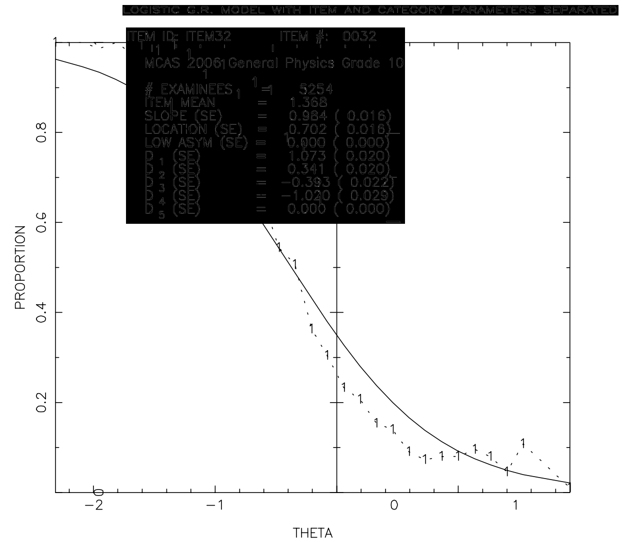

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM27 ITEM #: 0027
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.873
SLOPE (SE) = 1.394 (0.078)
LOCATION (SE) = −1.124 (0.066)
LOW ASYM (SE) = 0.313 (0.037)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
THETA

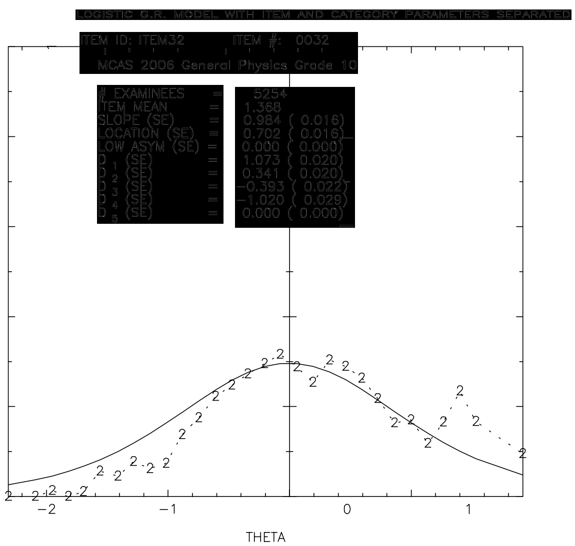

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM28 ITEM #: 0028
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.482
SLOPE (SE) = 0.652 (0.054)
LOCATION (SE) = 0.652 (0.078)
LOW ASYM (SE) = 0.191 (0.025)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
THETA

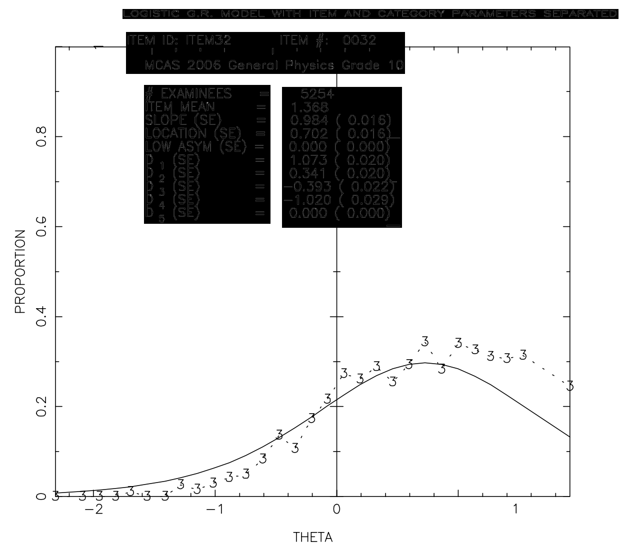

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM29 ITEM #: 0029
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.645
SLOPE (SE) = 1.010 (0.053)
LOCATION (SE) = −0.195 (0.053)
LOW ASYM (SE) = 0.189 (0.024)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
THETA

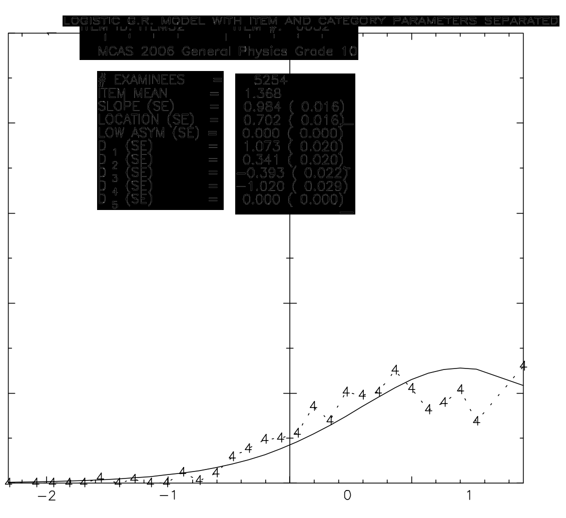

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM30 ITEM #: 0030
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.632
SLOPE (SE) = 1.473 (0.067)
LOCATION (SE) = −0.122 (0.031)
LOW ASYM (SE) = 0.179 (0.016)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
THETA

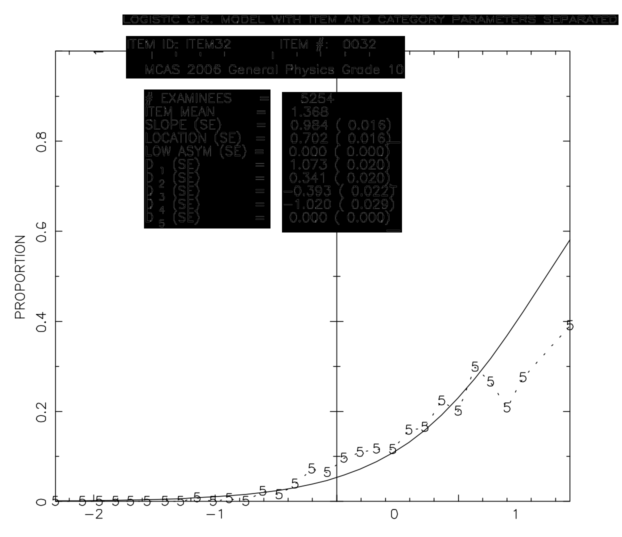

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM31 ITEM #: 0031
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.605
SLOPE (SE) = 1.193 (0.060)
LOCATION (SE) = 0.007 (0.040)
LOW ASYM (SE) = 0.198 (0.016)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
−2 −1 0 1
THETA

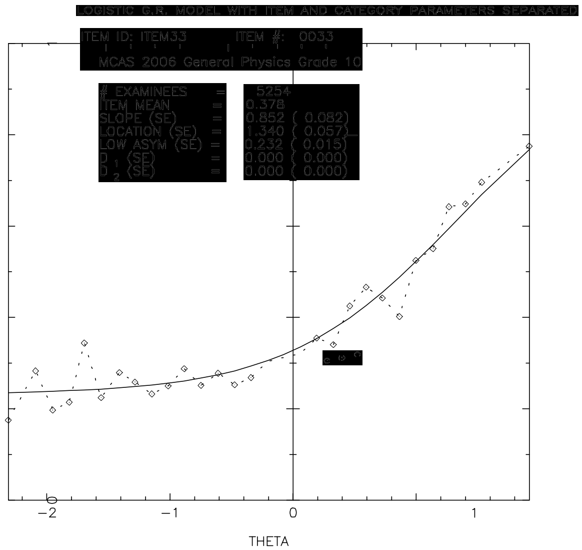

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM32 ITEM #: 0032
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.368
SLOPE (SE) = 0.984 (0.016)
LOCATION (SE) = 0.702 (0.016)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 1.073 (0.020)
D 2 (SE) = 0.341 (0.020)
D 3 (SE) = −0.393 (0.022)
D 4 (SE) = −1.020 (0.029)
D 5 (SE) = 0.000 (0.000)
PROPORTION
0.2 0.4 0.6 0.8
−2 −1 0 1
THETA

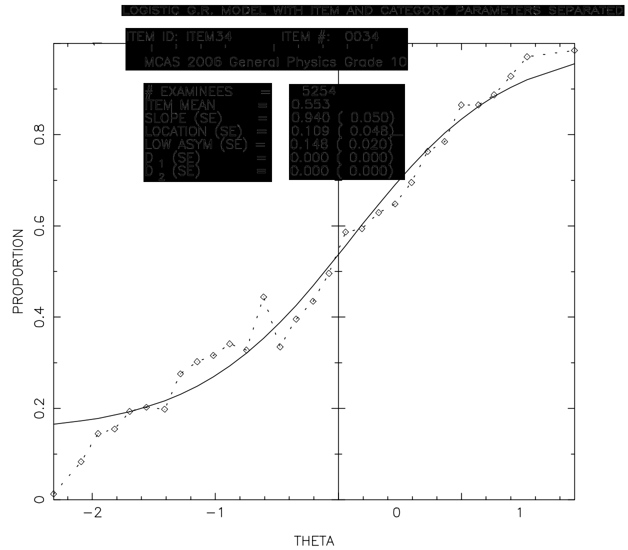

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM32 ITEM #: 0032
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.368
SLOPE (SE) = 0.984 (0.016)
LOCATION (SE) = 0.702 (0.016)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 1.073 (0.020)
D 2 (SE) = 0.341 (0.020)
D 3 (SE) = −0.393 (0.022)
D 4 (SE) = −1.020 (0.029)
D 5 (SE) = 0.000 (0.000)
−2 −1 0 1
THETA

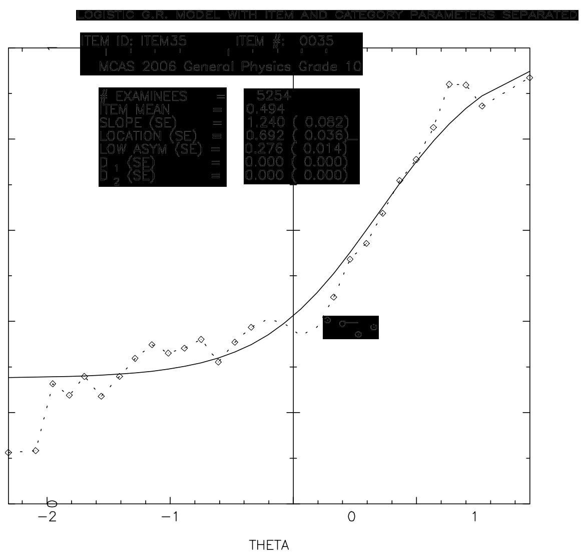

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM32 ITEM #: 0032
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.368
SLOPE (SE) = 0.984 (0.016)
LOCATION (SE) = 0.702 (0.016)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 1.073 (0.020)
D 2 (SE) = 0.341 (0.020)
D 3 (SE) = −0.393 (0.022)
D 4 (SE) = −1.020 (0.029)
D 5 (SE) = 0.000 (0.000)
PROPORTION
0 0.2 0.4 0.6 0.8
−2 −1 0 1
THETA

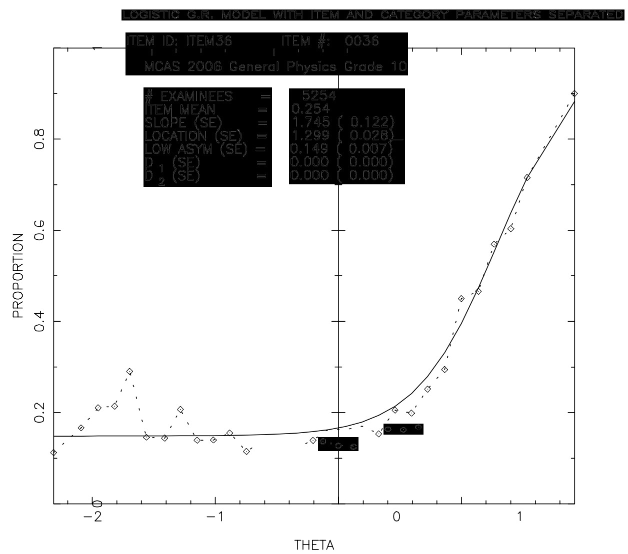

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.368
SLOPE (SE) = 0.984 (0.016)
LOCATION (SE) = 0.702 (0.016)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 1.073 (0.020)
D 2 (SE) = 0.341 (0.020)
D 3 (SE) = −0.393 (0.022)
D 4 (SE) = −1.020 (0.029)
D 5 (SE) = 0.000 (0.000)
−2 −1 0 1
THETA

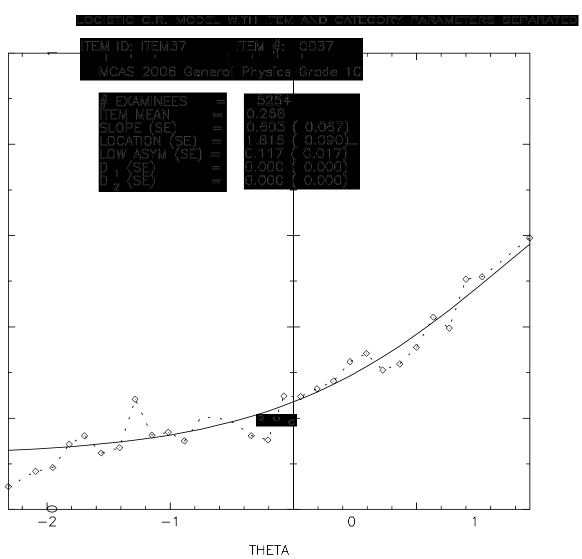

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM32 ITEM #: 0032
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 1.368
SLOPE (SE) = 0.984 (0.016)
LOCATION (SE) = 0.702 (0.016)
LOW ASYM (SE) = 0.000 (0.000)
D 1 (SE) = 1.073 (0.020)
D 2 (SE) = 0.341 (0.020)
D 3 (SE) = −0.393 (0.022)
D 4 (SE) = −1.020 (0.029)
D 5 (SE) = 0.000 (0.000)
PROPORTION
0 0.2 0.4 0.6 0.8
−2 −1 0 1
THETA

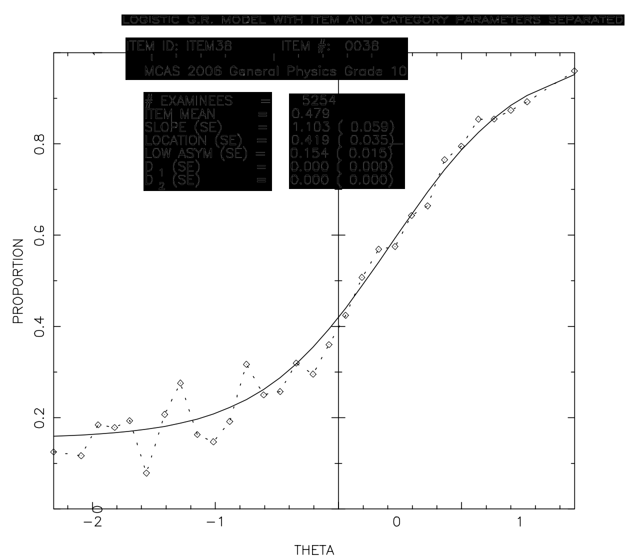

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM33 ITEM #: 0033
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.378
SLOPE (SE) = 0.852 (0.082)
LOCATION (SE) = 1.340 (0.057)
LOW ASYM (SE) = 0.232 (0.015)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
THETA

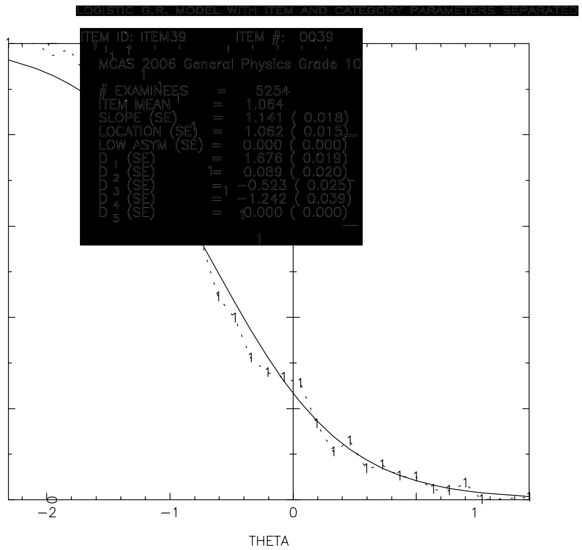

LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM34 ITEM #: 0034
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.553
SLOPE (SE) = 0.940 (0.050)
LOCATION (SE) = 0.109 (0.048)
LOW ASYM (SE) = 0.148 (0.020)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM35 ITEM #: 0035
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.494
SLOPE (SE) = 1.240 (0.082)
LOCATION (SE) = 0.692 (0.036)
LOW ASYM (SE) = 0.276 (0.014)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM36 ITEM #: 0036
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.254
SLOPE (SE) = 1.745 (0.122)
LOCATION (SE) = 1.299 (0.028)
LOW ASYM (SE) = 0.149 (0.007)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM37 ITEM #: 0037
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.268
SLOPE (SE) = 0.603 (0.057)
LOCATION (SE) = 1.815 (0.090)
LOW ASYM (SE) = 0.117 (0.017)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
THETA


LOGISTIC G.R. MODEL WITH ITEM AND CATEGORY PARAMETERS SEPARATED
ITEM ID: ITEM38 ITEM #: 0038
MCAS 2006 General Physics Grade 10
EXAMINEES = 5254
ITEM MEAN = 0.479
SLOPE (SE) = 1.103 (0.059)
LOCATION (SE) = 0.419 (0.035)
LOW ASYM (SE) = 0.154 (0.015)
D 1 (SE) = 0.000 (0.000)
D 2 (SE) = 0.000 (0.000)
PROPORTION
THETA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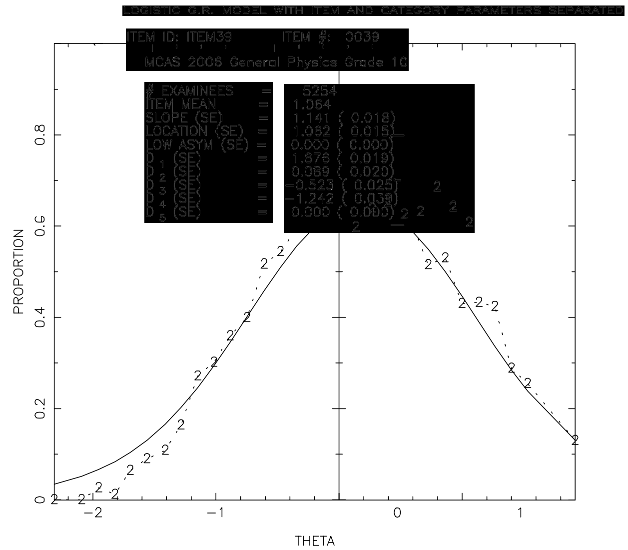
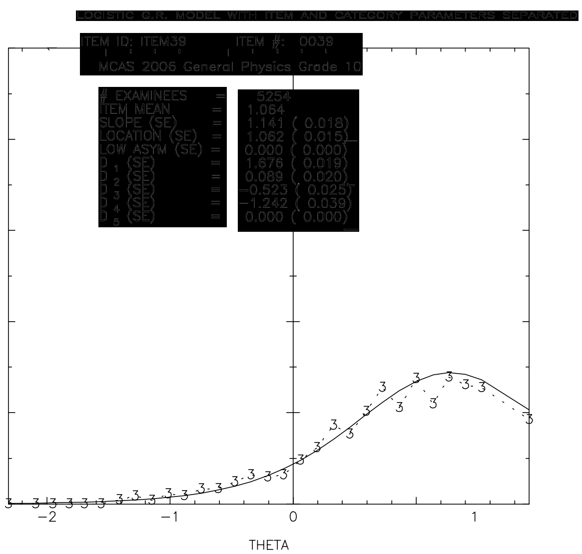

PROPORTION
THETA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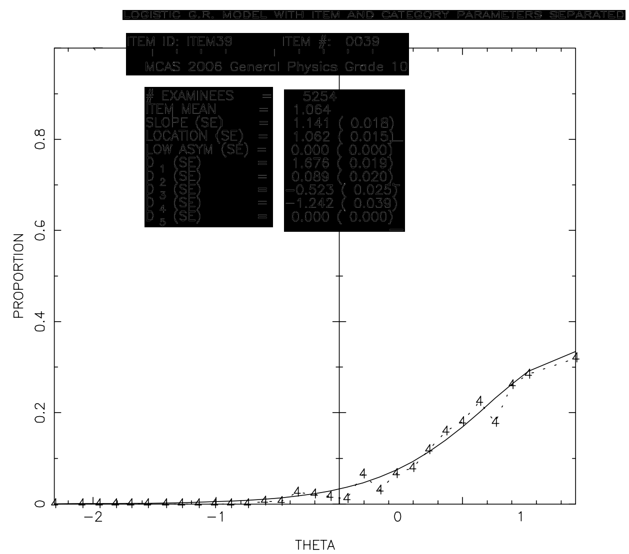
PROPORTION
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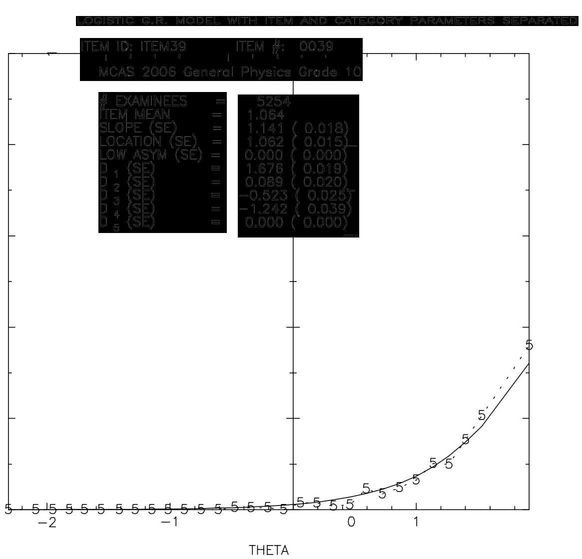
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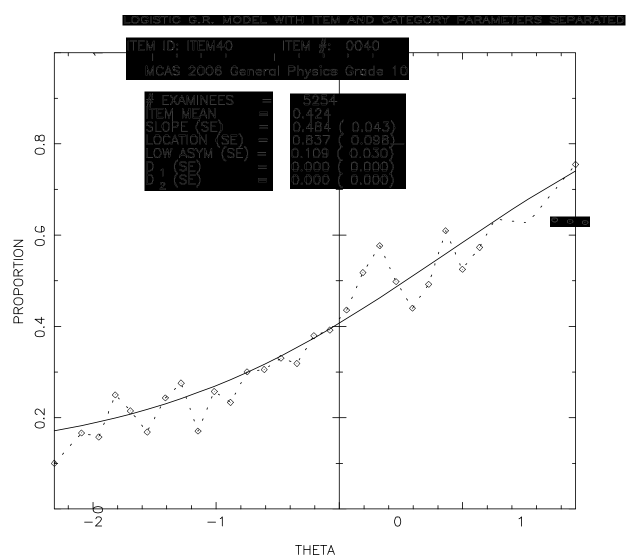
PROPORTION
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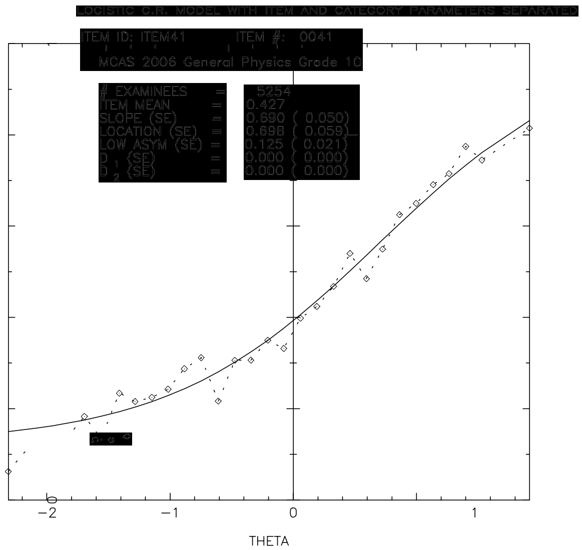
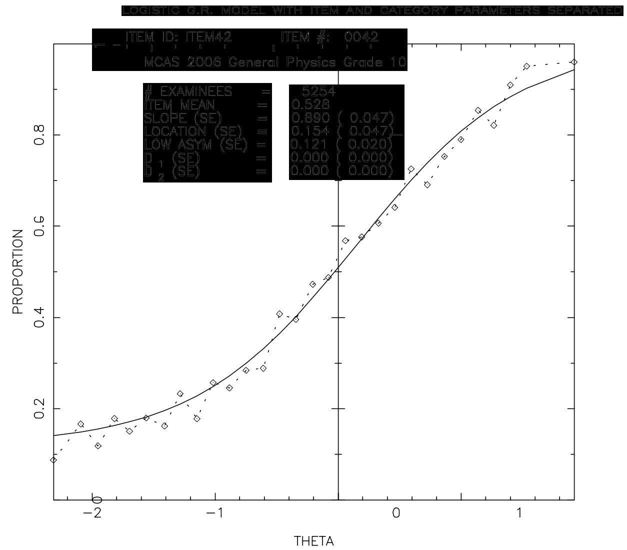
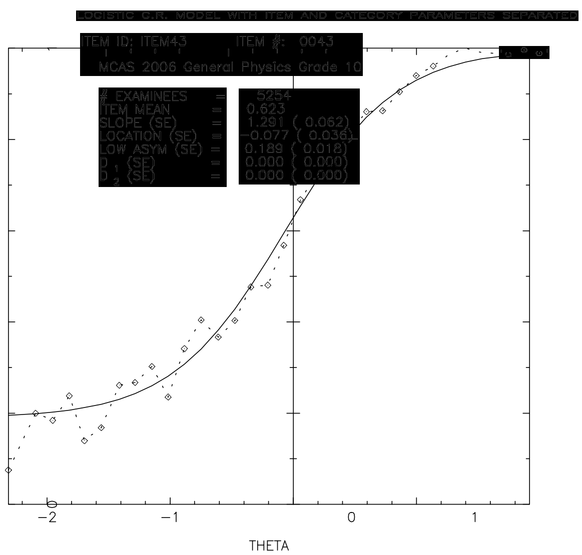

THETA


PROPORTION
THETA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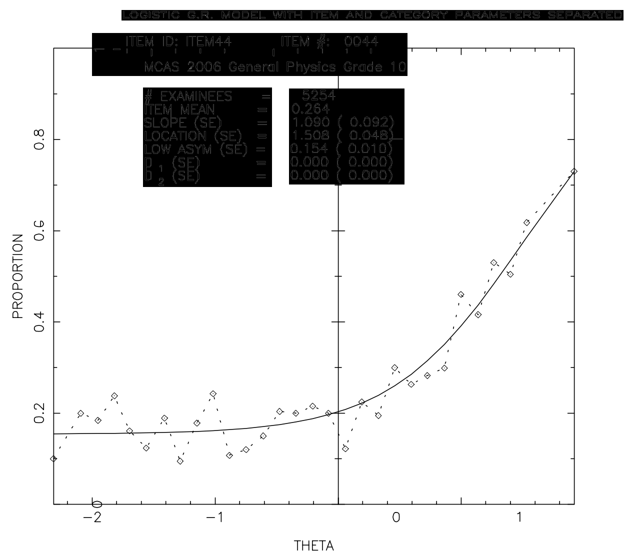
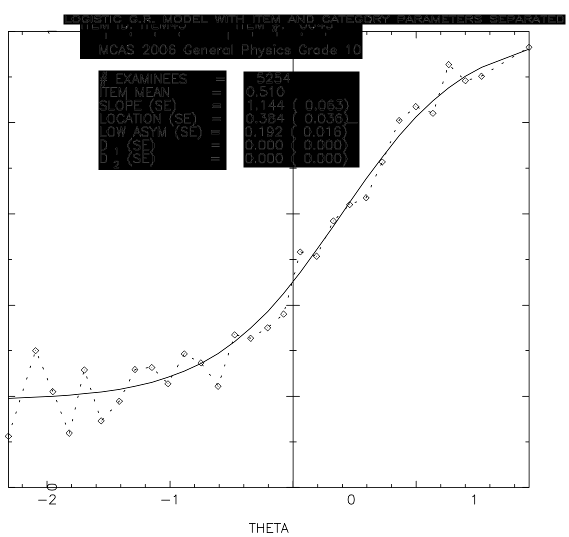
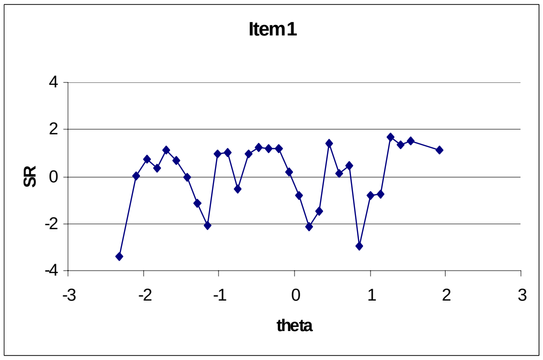
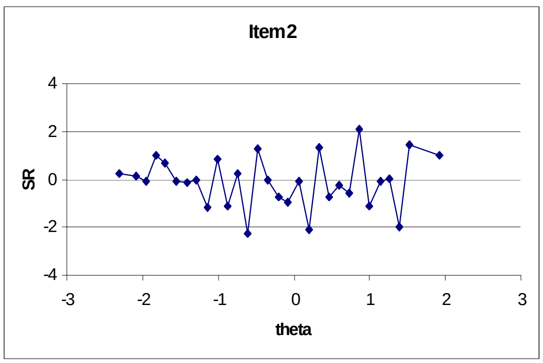

PROPORTION
THETA

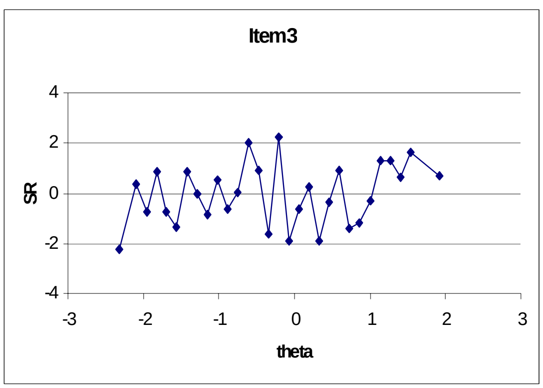

THETA

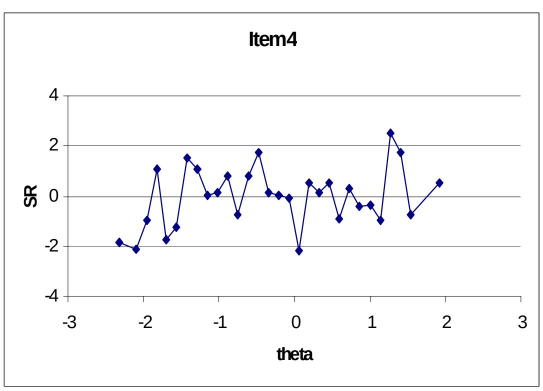
Appendix C. Standardized Residual (SR) Plots

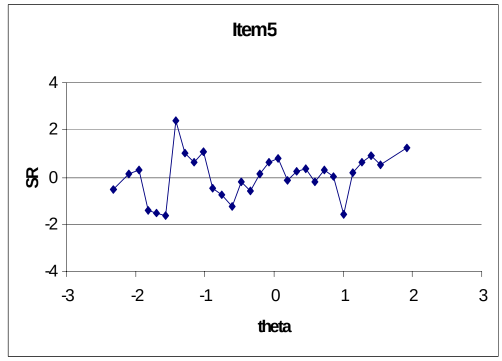
Part I: Standardized Residual (SR) Plots for Dichotomous Items

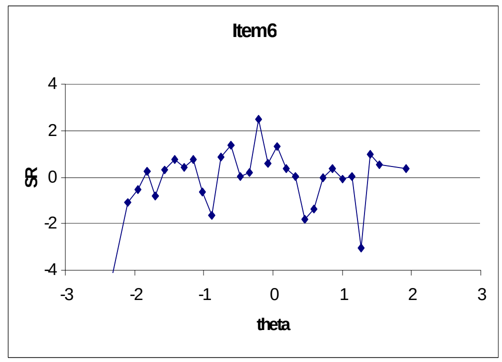


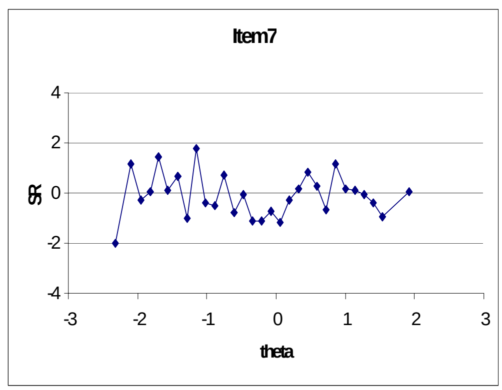


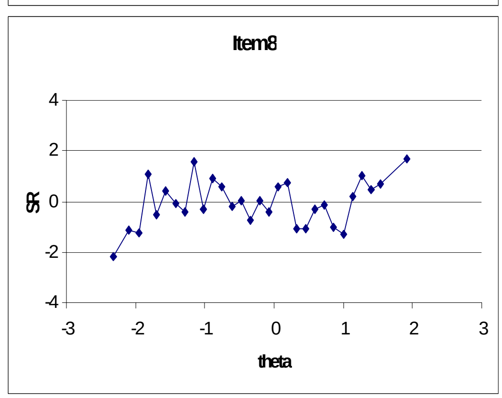


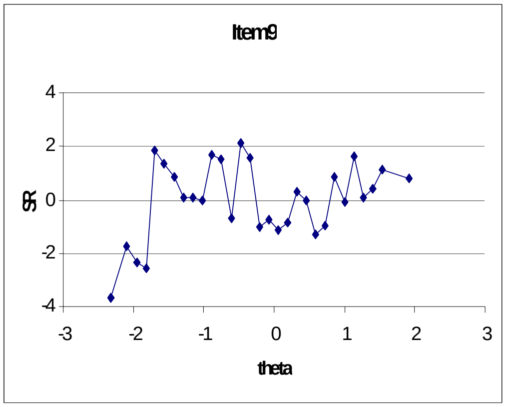


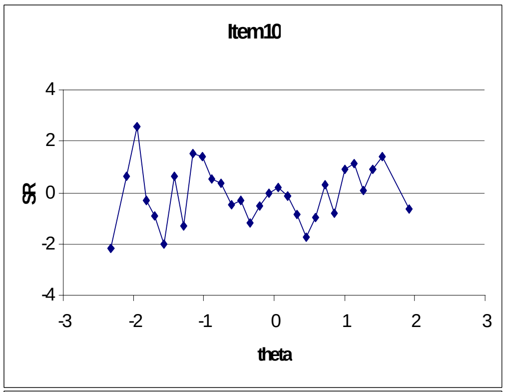


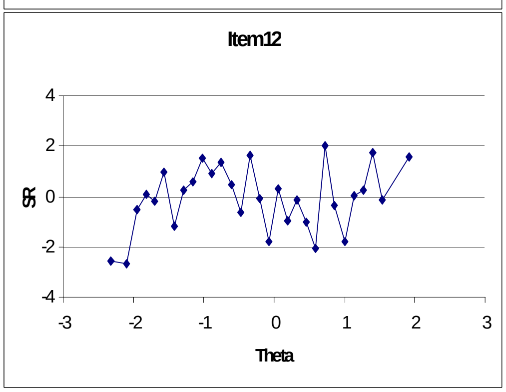


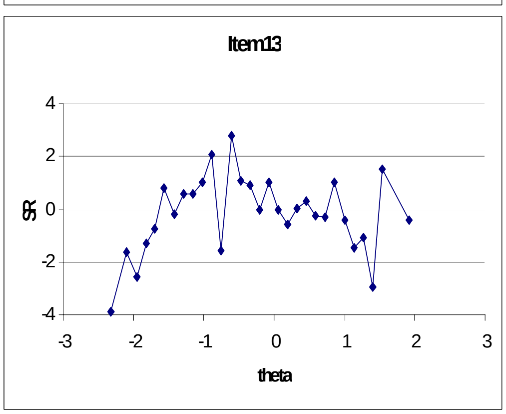


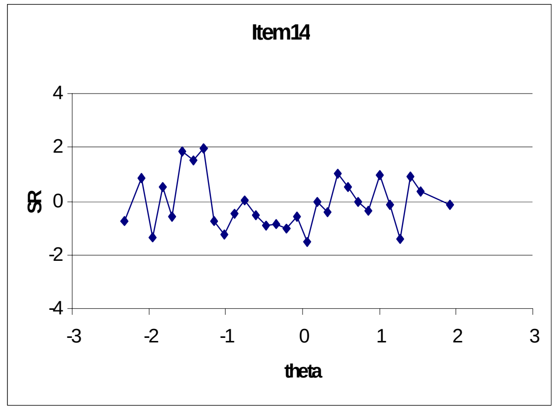


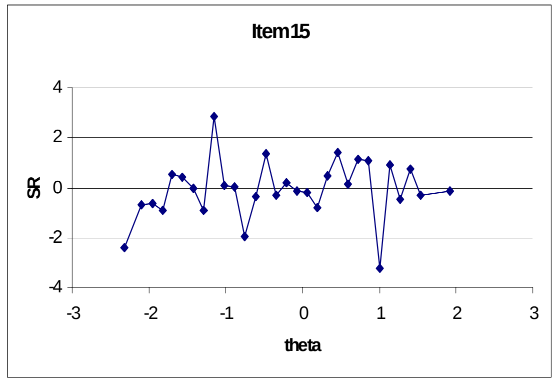

Item9
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
theta

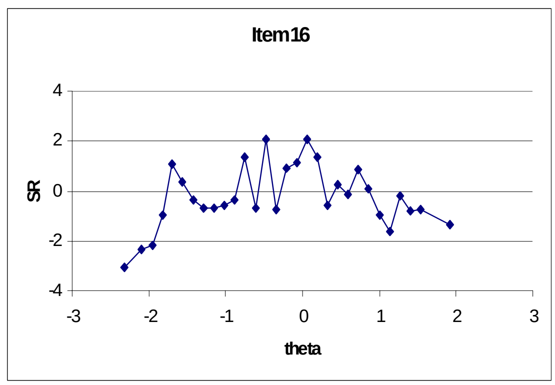

Item10
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
theta

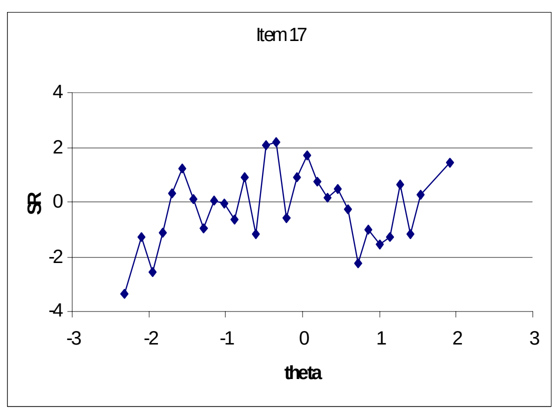

Item12
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
Theta

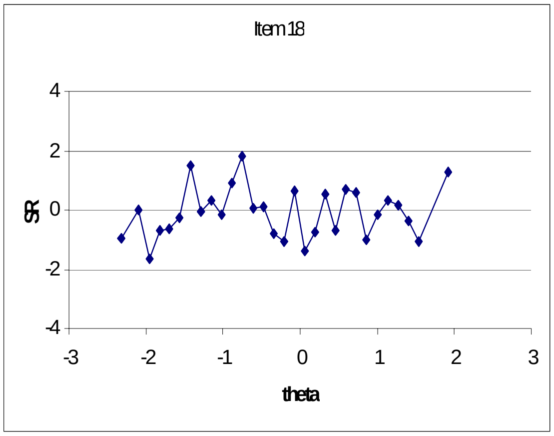

Item13
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
theta

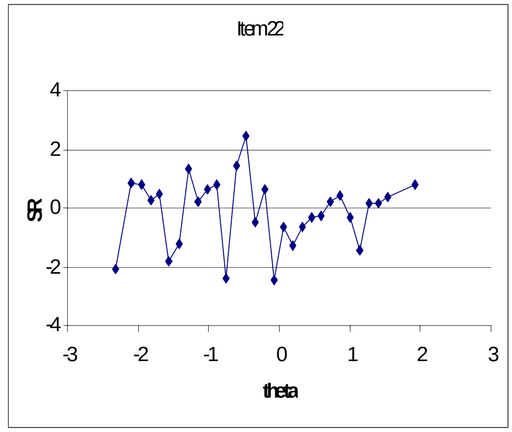

Item14
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
theta

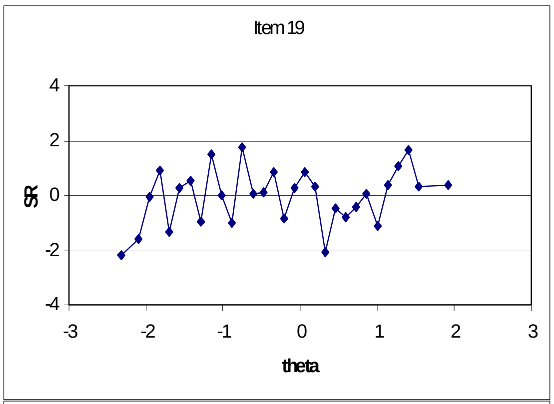

Item15
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
theta

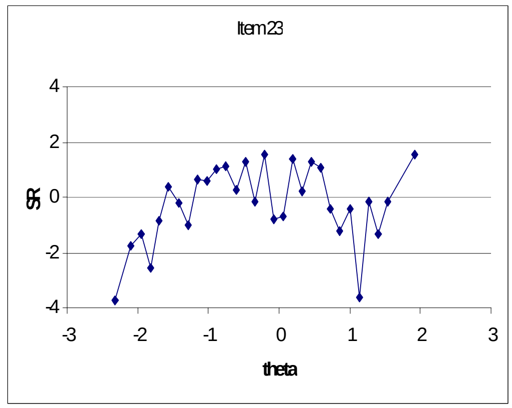

Item16
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
theta

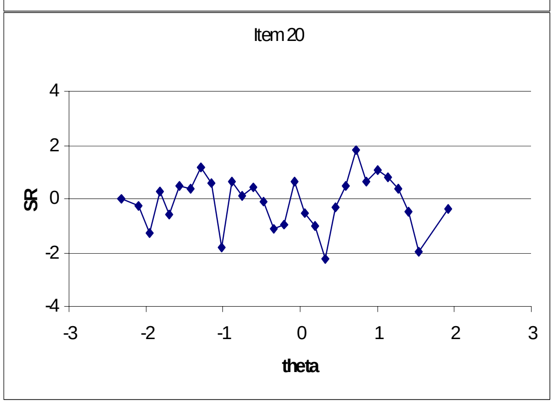

Item 17
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
theta

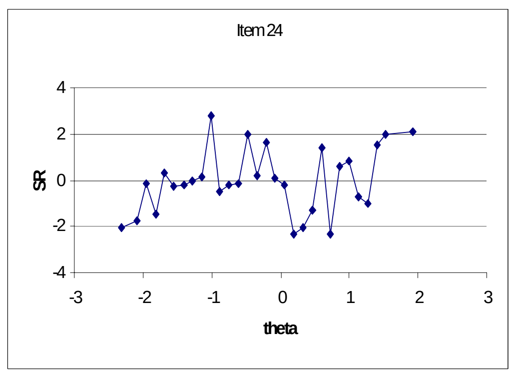

Item18
SR
4
2
0
-2
-4
-3 -2 -1 0 1 2 3
theta

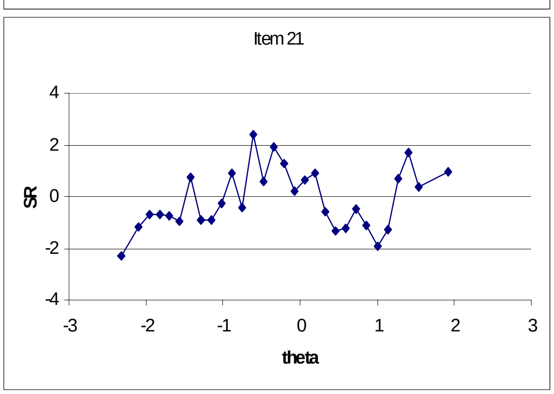

Item22
SR
4
2
0
-2
-4
-3 -2 -1 0 1 2 3
theta

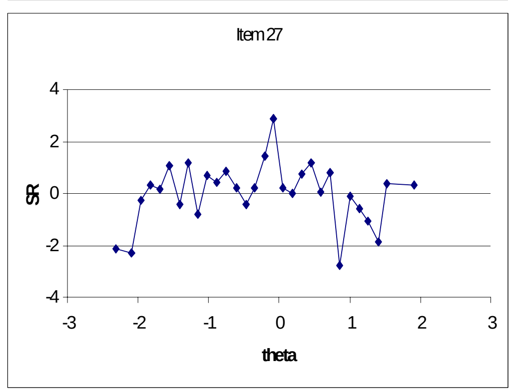

Item19
SR
4
2
0
-2
-4
-3 -2 -1 0 1 2 3
theta

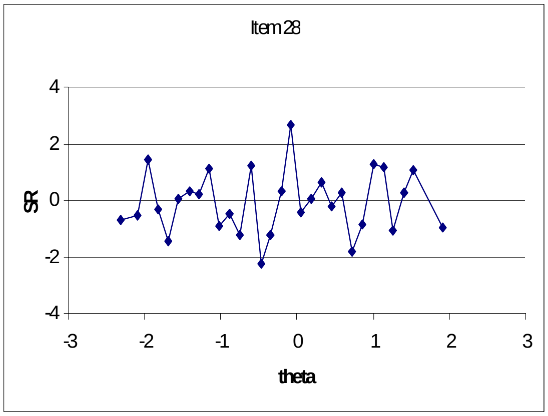

Item23
SR
4
2
0
-2
-4
-3 -2 -1 0 1 2 3
theta

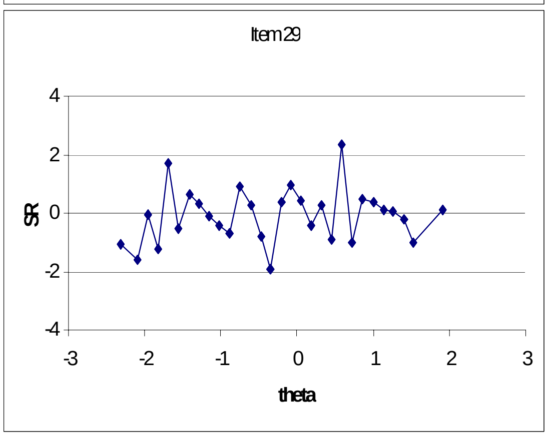

Item 20
SR
4
2
0
-2
-4
-3 -2 -1 0 1 2 3
theta

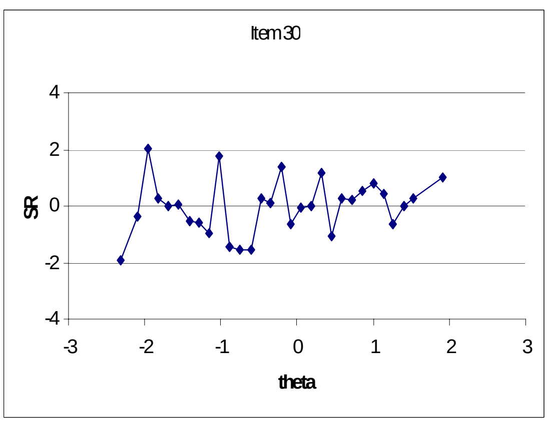

Item 24
SR
4
2
0
-2
-4
-3 -2 -1 0 1 2 3
theta

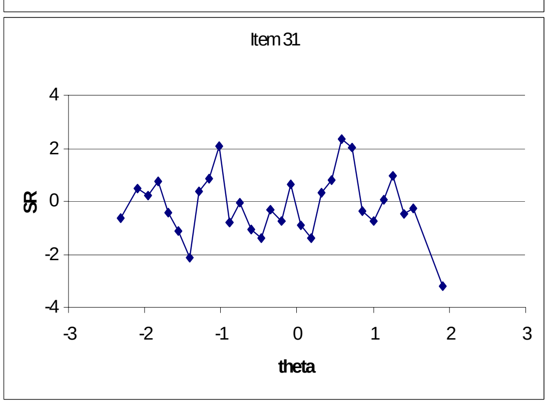

Item 21
SR
4
2
0
-2
-4
-3 -2 -1 0 1 2 3
theta

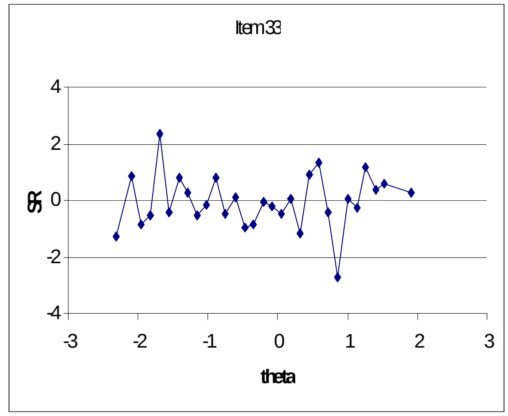

Item 27
SR
4
2
0
-2
-4
-3 -2 -1 0 1 2 3
theta

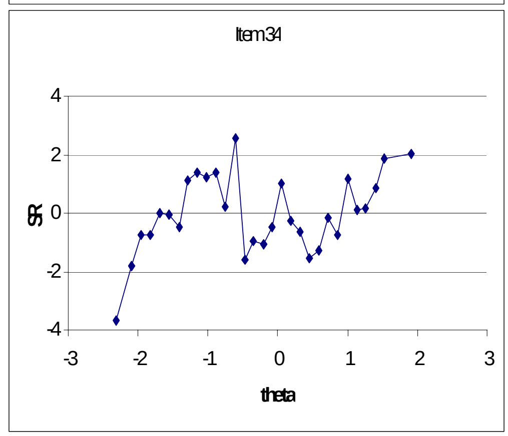

Item 28
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta

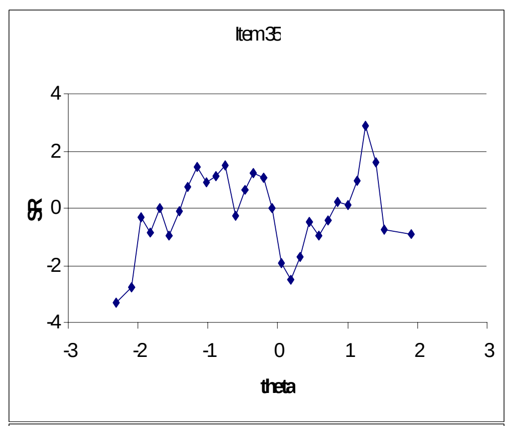

Item 29
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta

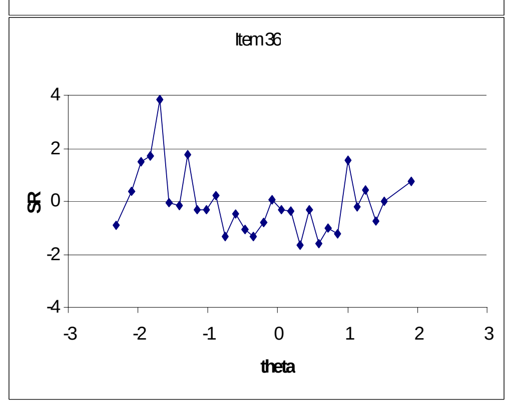

Item 30
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta

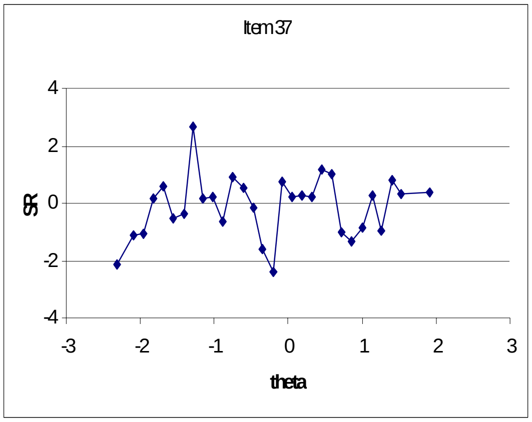

Item 31
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta

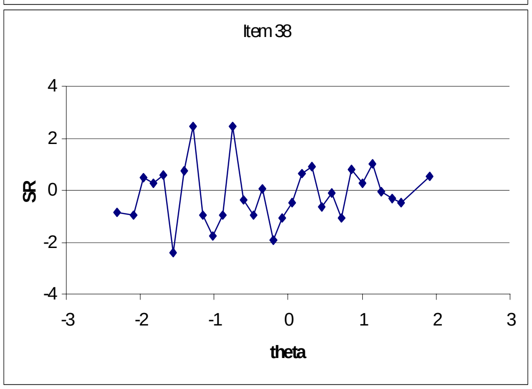

Item 33
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta


Item 34
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta


Item 35
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta


Item 36
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta


Item 37
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta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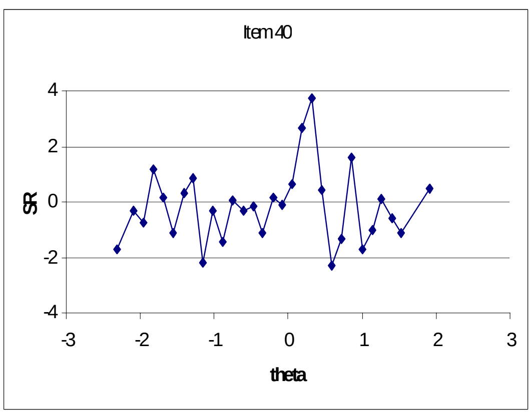
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta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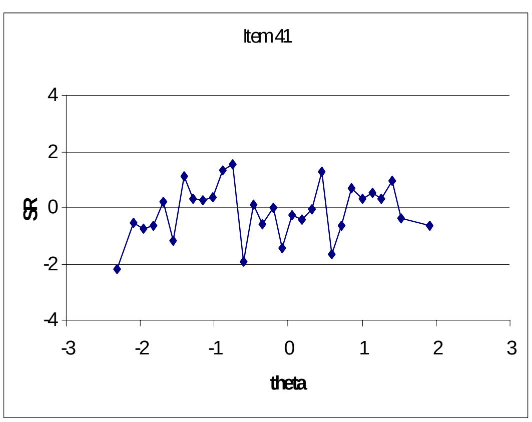
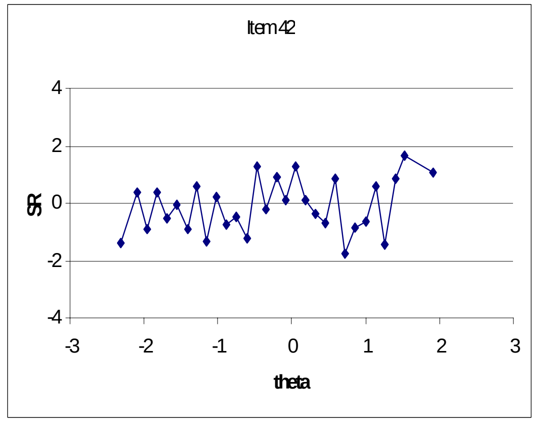
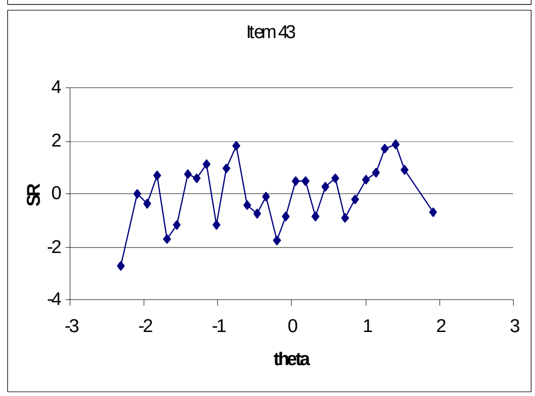
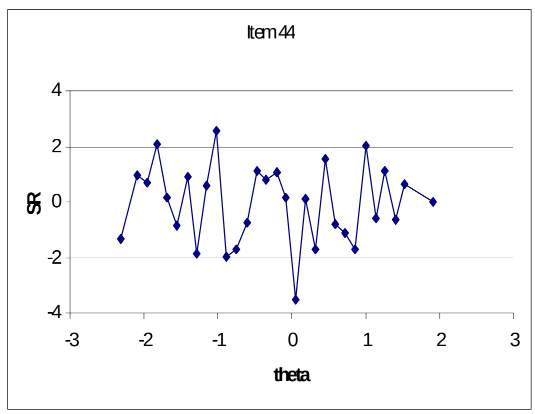
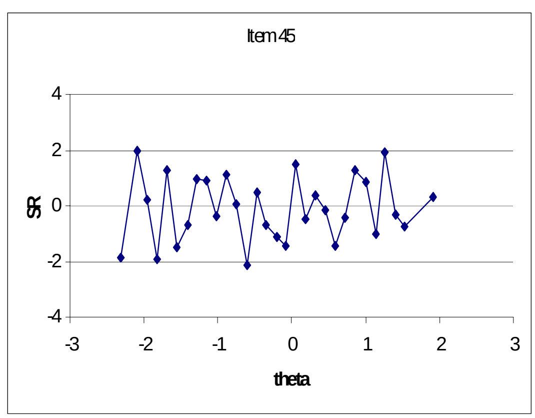
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta


Item 41
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta

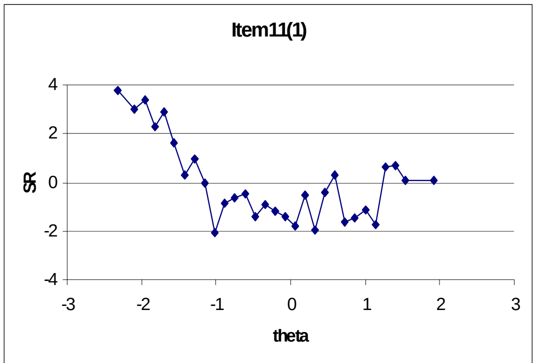

Item 42
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta

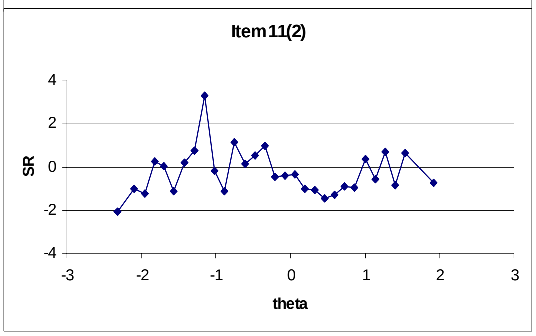

Item 43
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta

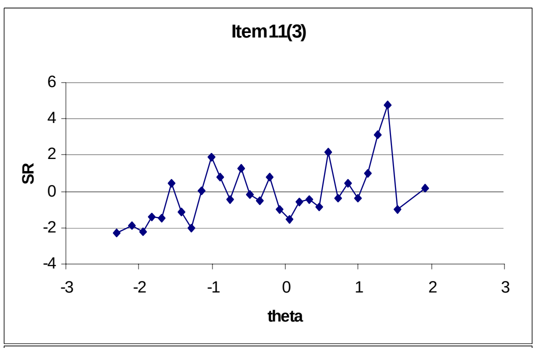

Item 44
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta

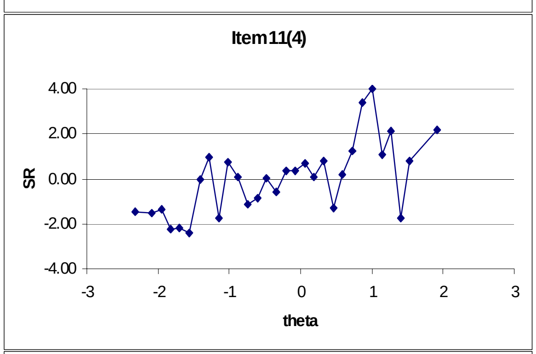

Item 45
SR
4
2
0
-2
-4
-3
-2
-1
0
1
2
3
theta

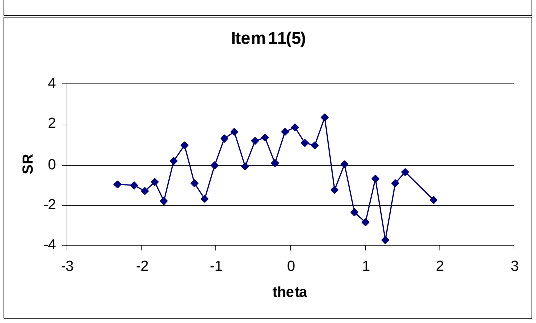
Part II: Standardized Residual (SR) Plots for Polytomous Items

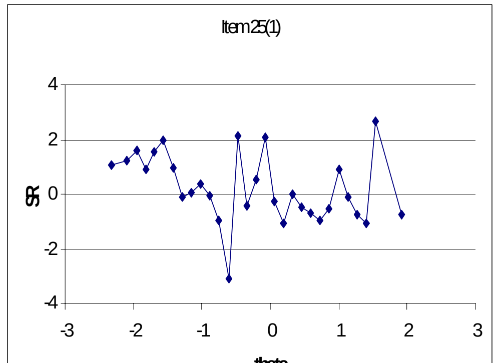


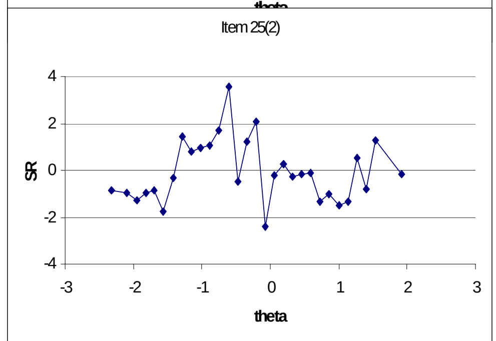


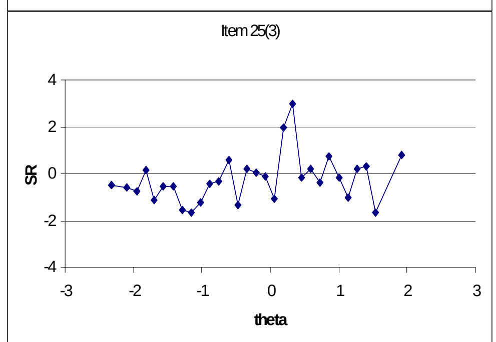


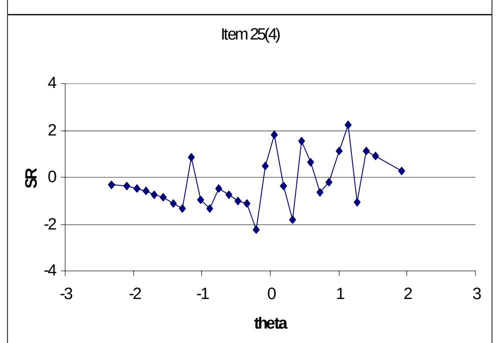


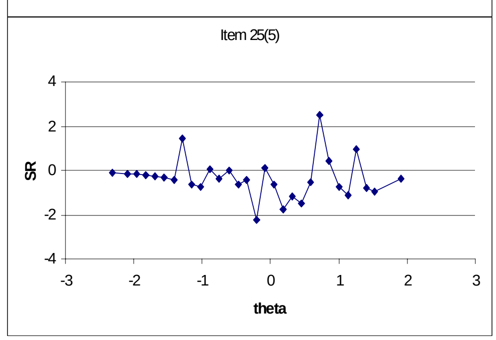


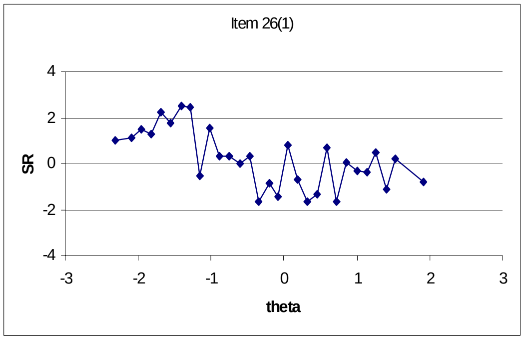


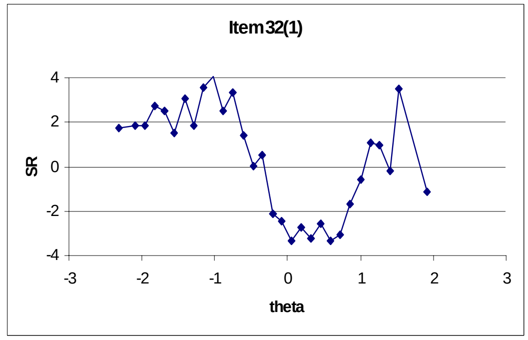


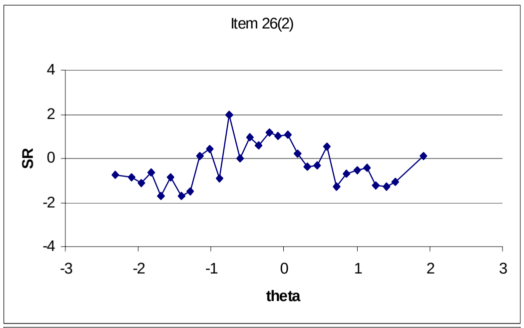


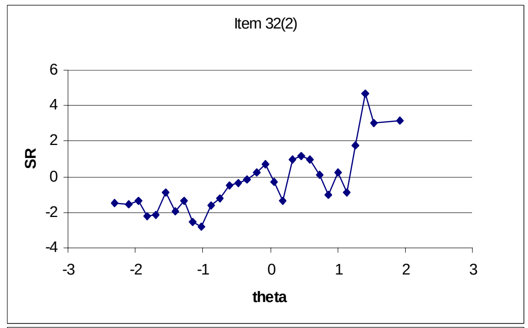


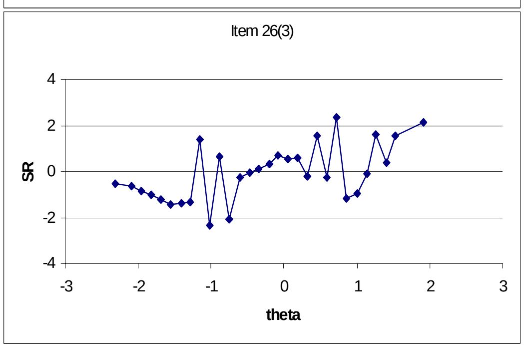


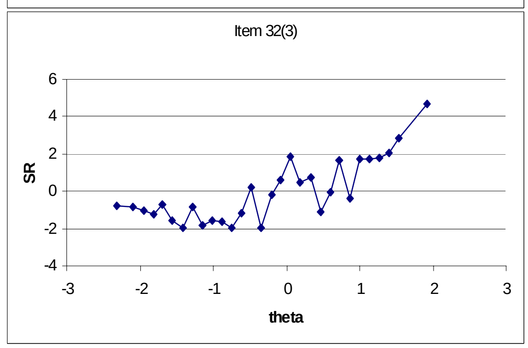

Item 26(1)
SR
theta

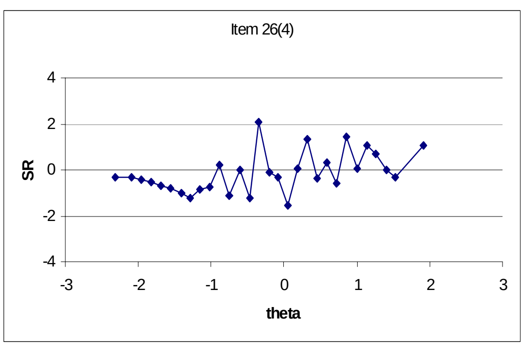

Item 32(1)
SR
theta

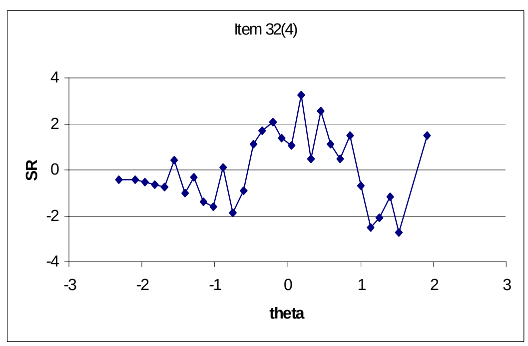

Item 26(2)
SR
theta

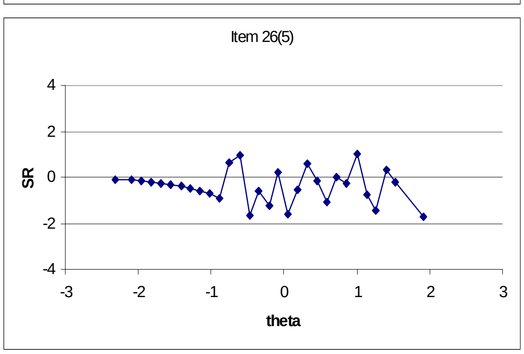

Item 32(2)
SR
theta

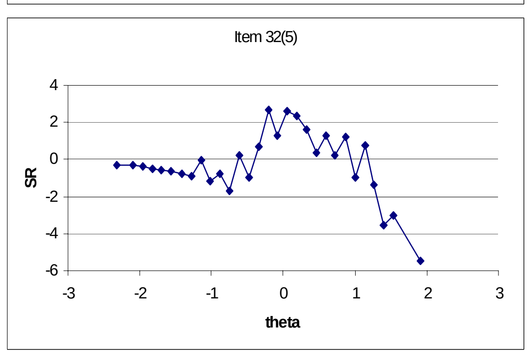

Item 26(3)
SR
theta

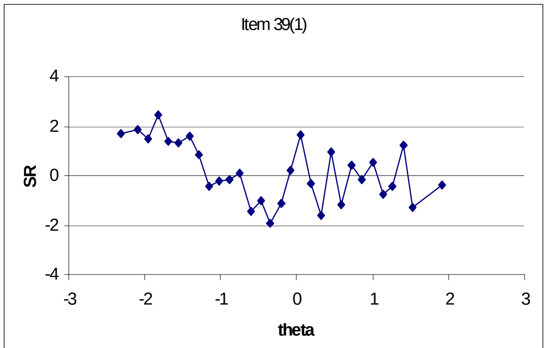

Item 32(3)
SR
theta

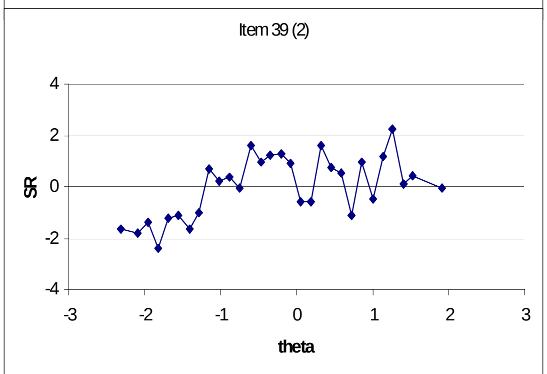

Item 26(4)
SR
theta

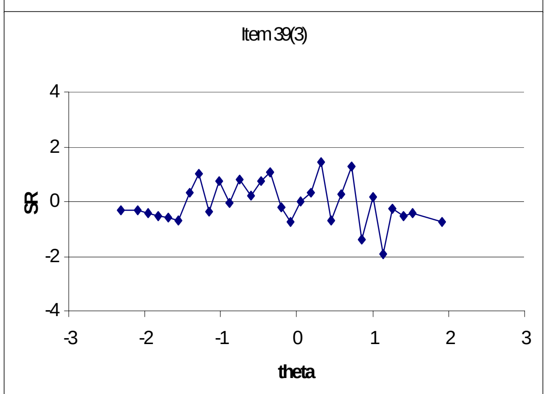

Item 32(4)
SR
theta

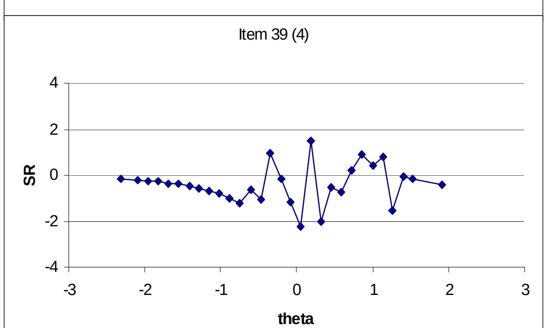

Item 26(5)
SR
theta

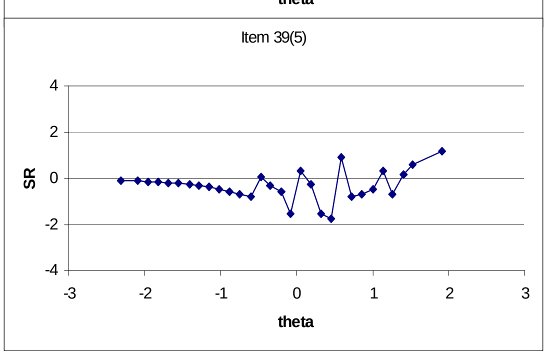

Item 32(5)
SR
theta


Item 39(1)
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
theta


Item 39 (2)
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
theta


Item 39(3)
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
theta


Item 39 (4)
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
theta


Item 39(5)
4
2
SR 0
-2
-4
-3 -2 -1 0 1 2 3
theta