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A Comparison of the Effects of Random Versus Fixed Order of Item Presentation Via the Computer

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Terry A. Ackerman
Judith A. Spray
Mark D. Reckase
James E. Carlson

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ABSTRACT

The effect of random versus fixed order of item presentation was studied using a computerized testing system at the Marine Corps Communication-Electronics School (MCCES) at the Twentynine Palms Marine Base in southern California. Classes from four different annexes were randomly divided between the two administrative formats. Similar results were found for each annex. The results suggest that when MCCES items are administered via the computer, order of item presentation makes at most a very small difference. Implications and future directions are discussed.

A COMPARISON OF THE EFFECTS OF RANDOM VERSUS FIXED ORDER OF ITEM PRESENTATION VIA THE COMPUTER

Introduction

As part of the research on the Office of Naval Research Contract N00014-85-C0241, a computerized testing system was designed and installed at the Marine Corps Communication-Electronics School (MCCES) at the Twentynine Palms Marine Base in southern California. The hardware was designed as part of a research project which had three phases. Phase I was designed to compare paper and pencil and computer-administered modes of test administration. In the second phase, all testing utilized the computer administration mode and comparisons of the effects of random vs. fixed item order were investigated. The final phase consisted of implementating a complete computerized adaptive testing system using item parameter estimates which were calibrated from Phase I and Phase II response data.

Results from Phase I are completely described in (Spray, Ackerman, Carlson & Reckase, 1985.) This report, which summarizes the results of Phase II, parallels the Phase I report.

Method

In Phase II, the effect of random versus fixed item order was studied in four courses called "annexes": GR01, GR02, GR03 and GR05. For the purposes of this study, classes within each of the four annexes were divided into two groups according to the last four digits of their social security number. If a student's social security number was odd he or she would be assigned to a "fixed order" group; if the number was even he or she was assigned to a "random order" group. Both groups were given the exact same items, however, each member of the fixed group was presented the items in exactly the same

fixed order; where as each member of the random group was presented the items in a different random arrangement. All tests for each of the four annexes were 25 items in length.

During the period of this study 13 classes were tested in GR01, 12 classes in GR02, 14 classes in GR03, and 15 classes in GR05. The number of students who were administered items in a fixed order were 131, 143, 127 and 87 for annexes GR01, GR02, GR03 and GR05, respectively. The number who received items in a random order were 138, 123, 137 and 108, respectively.

The item pool for GR01 was the largest, containing 83 items. Item pools for each of the remaining annexes contained 75 items each. Items were pseudo-randomly selected without replacement to comprise the 25-item tests. Thus each of the 25-item tests consisted of different items, and no items were allowed to repeat until every third class.

A typical testing session was as follows:

1. A student was randomly assigned to either a fixed or random item presentation format by the computer after logging on.
2. Students would respond to items using a series of training manuals containing schematics and other pertinent wiring diagrams. Sometimes students would have to refer to several manuals to arrive at the answer.
3. Students could also use scrap paper for simple calculations as well as any class notes that they may have written into their manuals.
4. Each testing session would last 125 minutes and was monitored by at least one instructor.
5. If students completed the test early, they could sign off their computer and leave the room.
6. A review of the test and results was conducted immediately following the testing session.

Results

Data collection from the equivalent groups started in November of 1987 and concluded in June of 1988. Based on the analysis of these data, it was concluded that although some statistically significant differences existed, no substantial, practical real differences between the two administrative formats were detected.

Total test score comparisons were made between testing formats for each of the four annexes. Figures 1, 2, 3 and 4 display the 95% confidence intervals about the total test score for both the pencil and paper and the computer groups for each class for each annex. In all cases except two, the confidence bands overlap indicating a nonsignificant difference between the mean test scores for each format. Only for the third and thirteenth GRO3 classes do the confidence bands not overlap. These can be partly explained by the small sample, N = 3, for both the computer groups for each of these classes.

Mean scores and standard deviations for each class for each annex are shown in Tables 1, 2, 3 and 4. A two-way analysis of variance was performed on each class to determine whether any class or administration median effect was present.

Between-class differences yielded ANOVA F-statistics and p-values of $F(12,110) = 1.82$, $p = .0540$; $F(11,162) = 21.95$, $p < .0000$, $F(13,112) = 3.58$, $p < .0001$; and, $F(11,91) = 1.67$, $p = .0925$ for each of the four respective annexes. Between-format differences were $F(1,114) = .10$, $p = .7547$; $F(1,163) = 1.03$, $p = .3117$; $F(1,121) = 1.97$, $p = .1626$; and, $F(1,94) = 3.98$, $p = .0490$ respectively. All tests of the interaction between class and administrative formats were nonsignificant.

Annex GR05 was the only annex to yield a difference in mean scores that was significant at the .05 level. This was also the annex on which the students scored the highest, possibly resulting in some restriction of range effects, resulting in smaller standard deviations for the scores.

Tests between the empirical cummulative raw score distributions were also computed. The cummulative distributions are graphically displayed in Figures 5, 6, 7, and 8, respectively.

A two-sided Kolmogorov-Smirnov test of no cummulative distribution differences was computed for each annex. The test statistics, T, and the associated p-value for GR01, GR02, GR03 and GR05 were T = .519, p = .950; T = .774, p = .586; T = .631, p = .821, and T = 1.028, p = .241, respectively. The fact that the Kolnogerov-Smirnov has slightly less power than the ANOVA, may explain the differences in the results. However, the two analyses show that any differences are difficult to interpret.

Frequency distributions of the proportion-correct values were similar for both administrative formats across the four annexes. These results are displayed in Table 5. Note also that the proportion-correct also shown for items to which at least 50 examinees responded.

Stepwise logistic regression analyses were performed on each item within each annex to test for administrative format differences of item discrimination and item difficulty. The process is described in detail in the Appendix. The results of the item logistic regression analyses are reported by annex in Tables 6, 7, 8 and 9. In all, 308 items were tested. Of the items tested, seven items had difficulty (format) differences at a probability less than .01. These items were numbers 60 and 68 from GR01; 13, 23, 41 and 50 from GR03; and 43 from GR05. Discrimination (format X score) differences for five items were determined to be significant at the same level: numbers 30 and 44

from GR01; 8 and 30 from GR02; and 60 from GR03. The position of each of these items in both the fixed and random order formats were examined. No consistent pattern of a shift in difficulty or discrimination was found to coincide with a shift in item location.

For the majority of items the power to detect difficulty or discrimination differences may have been extremely small because of the small sample sizes. Also because of the criterion-referenced nature of the test, most of the items tended to have a high proportion-correct values, thus making item difficulty or discrimination parameters more homogeneous.

Summary

The results of this eight month research study suggest that when the GRRC items are administered via the computer, order of item presentation makes at most a very small difference. This would imply a lack of dependence between items. That is, the response to a given item is not affected by responses to any previous items, nor will it effect the response to any subsequent items.

Items which were found to have either statistically significant difficulty or discrimination differences were reviewed for possible clues as to why the differences exist. An analysis of the surface features of the items revealed no clue to the cause of the differences, if indeed the differences are real. Given that three significant values would be expected by chance, the fact that there were only seven and five significant results found implies that any effects are very weak indeed. However, a detailed analysis of the items by content experts, or a thorough questioning of the students, might reveal some explanation for the minor differences that were detected. Such analyses were not completed.

REFERENCES

Spray, J. A., Ackerman, T. A., Carlson, J. E., Reckase, M. D. (1985). Comparison of the effects of presentation mode on characteristics of test scores and test items. (ONR Research Report). Iowa City, IA: American College Testing Program.

TABLE 1

Test Score Summary Statistics by Class--GR01

	Fixed Order			Random Order		
Class	N	$\bar{X}$	SD	N	$\bar{X}$	SD
1	8	19.8	3.2	9	19.2	1.9
2	5	19.0	3.4	11	20.3	2.1
3	11	20.8	2.5	11	20.3	3.0
4	11	19.4	3.2	14	20.1	1.7
5	9	21.6	1.9	14	21.5	1.7
6	11	20.5	2.5	11	20.0	2.6
7	11	19.6	1.7	13	20.8	2.0
8	11	20.8	2.0	11	20.5	2.2
9	6	21.8	1.5	12	20.2	3.1
10	13	20.0	2.1	7	19.4	.8
11	13	19.6	2.8	10	21.0	2.1
12	13	21.3	1.8	6	22.0	1.9
13	9	20.4	2.5	9	18.2	3.8
Overall	131	20.4	2.4	138	20.5	2.9

TABLE 2

Test Score Summary Statistics by Class--GR02

	Fixed Order			Random Order		
Class	N	$\bar{X}$	SD	N	$\bar{X}$	SD
1	12	16.7	2.1	8	14.1	2.9
2	9	21.7	2.2	13	19.8	2.6
3	10	21.5	1.6	11	21.7	2.0
4	9	21.1	3.1	14	21.9	2.3
5	12	20.7	3.9	10	20.5	2.5
6	8	14.9	2.0	15	15.6	2.2
7	13	17.2	1.7	8	16.8	2.6
8	15	16.1	1.6	10	16.7	1.9
9	12	16.7	2.1	8	14.1	2.9
10	13	17.2	1.7	8	16.8	2.6
11	12	19.2	3.4	6	21.0	1.7
12	18	18.1	2.7	12	18.0	2.6
Overall	143	18.3	3.1	123	18.3	3.5

TABLE 3

Test Score Summary Statistics by Class--CR03

	Fixed Order			Random Order		
Class	N	$\bar{X}$	SD	N	$\bar{X}$	SD
1	5	20.2	3.7	7	20.3	2.1
2	8	16.3	2.2	8	16.5	3.5
3	12	20.0	1.9	3	17.7	.6
4	8	19.0	3.2	11	18.3	2.8
5	10	19.7	2.9	13	18.1	2.5
6	9	19.3	3.1	15	18.5	3.7
7	8	17.9	2.6	15	17.5	3.1
8	14	17.1	4.0	11	17.7	4.3
9	6	18.3	2.8	13	17.2	2.0
10	10	21.1	2.2	9	19.2	3.7
11	5	20.2	3.7	7	20.3	2.1
12	8	16.3	2.2	8	16.5	3.5
13	12	19.7	1.9	3	17.7	.6
14	12	18.4	2.5	12	20.3	2.4
Overall	127	18.8	3.0	137	18.3	3.1

TABLE 4

Test Score Summary Statistics by Class - GR05

	Fixed Order			Random Order		
Class	N	$\bar{X}$	SD	N	$\bar{X}$	SD
1	7	20.4	2.2	6	20.7	3.1
2	6	21.5	1.9	7	20.7	.8
3	6	20.8	3.2	5	20.8	2.4
4	8	22.6	1.8	14	22.1	2.2
5	5	21.8	1.6	12	19.8	3.2
6	7	20.3	3.4	5	19.6	1.1
7	6	21.0	1.3	14	18.7	2.4
8	4	21.8	2.6	13	19.9	3.7
9	10	21.3	2.5	7	21.9	2.0
10	6	21.5	1.6	8	22.3	1.8
11	10	22.4	2.5	6	20.7	2.3
12	12	20.3	2.1	11	20.3	2.4
Overall	87	21.3	2.3	108	20.5	2.7

Table 5

Frequency Distributions of Proportion Correct Values

	GR01		GR02		GR03		GR05	
p	Fixed	Random	Fixed	Random	Fixed	Random	Fixed	Random
.90-1.00	39 (12)	41 (11)	20 (12)	27 (12)	22 (5)	15 (6)	41 (0)	32 (2)
.80-.89	16 (5)	14 (4)	19 (9)	13 (7)	13 (5)	14 (4)	7 (0)	22 (3)
.70-.79	10 (3)	8 (0)	16 (7)	7 (3)	11 (3)	18 (9)	7 (0)	9 (3)
.60-.69	6 (1)	8 (1)	3 (2)	14 (4)	13 (2)	9 (2)	4 (0)	3 (1)
.50-.59	8 (4)	7 (0)	3 (0)	2 (1)	6 (0)	12 (6)	4 (0)	5 (2)
.40-.49	1 (0)	2 (0)	0 (0)	0 (0)	5 (1)	3 (2)	1 (0)	3 (1)
.30-.39	3 (1)	3 (0)	3 (0)	1 (0)	4 (2)	2 (1)	1 (0)	1 (0)
.20-.29	0 (0)	0 (0)	1 (0)	2 (1)	1 (0)	2 (1)	0 (0)	0 (0)
.10-.19	0 (0)	0 (0)	1 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)
.00-.09	0 (0)	0 (0)	9 (2)	8 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total Items	83 (26)	83 (16)	75 (32)	75 (28)	75 (17)	75 (31)	75 (0)	75 (12)

Note: Frequencies in parentheses represent examinee samples ≥ 50.

TABLE 6

Logistic Regression Results of GR01

Item #	N_f	N_r	Proportion Correct f	Proportion Correct r	Improvement $\times^2$ p-values: Format Effect (Difficulty)	Improvement $\times^2$ p-values: Format by Score Effect (Discrimination)
1	11	11	1.00	1.00	1.000	1.000
2	35	33	.83	.94	.285	.955
4	21	19	.52	.68	.297	.265
5	15	21	1.00	1.00	1.000	1.000
6	11	11	.91	1.00	.251	.995
7	13	7	.92	.86	.549	.466
8	11	11	.91	.91	.924	.055
9	14	25	1.00	1.00	1.000	1.000
10	39	45	.97	.96	.622	.727
11	51	48	.96	.96	.961	.207
12	53	64	1.00	.98	.315	.989
13	46	41	.89	.85	.578	.748
14	43	43	.88	.84	.540	.292
15	46	43	.72	.63	.318	.637
16	53	64	1.00	.94	.052	.974
17	35	35	1.00	1.00	1.000	1.000
18	38	42	.74	.71	.821	.970
19	31	33	.97	1.00	.223	.987
20	50	53	.84	.85	.845	.423
21	35	29	.69	.55	.303	.419
22	44	61	.80	.80	.975	.183
23	46	53	.83	.81	.815	.205
24	56	47	.80	.81	.931	.964
25	43	41	.91	1.00	.018	.984

Table 6, cont.

Item #	N_f	N_r	Proportion Correct: f	Proportion Correct: r	Improvement $\times^2$ p-values: Format Effect (Difficulty)	Improvement $\times^2$ p-values: Format by Score Effect (Discrimination)
26	27	32	.89	.91	.814	.601
27	53	58	.92	.90	.566	.678
28	30	31	.97	1.00	.213	.988
29	61	67	.74	.70	.679	.230
30	48	47	.81	.89	.066	.000
31	23	34	.96	.85	.208	.046
32	54	50	.98	.98	.988	.435
33	54	54	.96	.96	.996	.235
34	29	29	1.00	.90	.037	.995
35	50	56	.98	.96	.612	.472
36	52	53	1.00	1.00	1.000	1.000
37	54	55	.98	.98	.968	.445
38	39	43	.97	.95	.628	.723
39	39	40	.80	.75	.978	.499
40	63	67	.95	.97	.593	.554
41	44	43	.98	.98	.963	.469
42	25	33	.92	.97	.349	.923
43	41	41	.51	.49	.803	.557
44	48	47	.38	.34	.740	.004
45	41	45	1.00	1.00	1.000	1.000
46	26	40	1.00	1.00	1.000	1.000
47	56	44	.98	1.00	.307	.989
48	49	54	.90	.93	.622	.789
49	33	30	.97	.93	.949	.073
50	35	32	.94	1.00	.106	.999

Table 6, cont.

Item #	N_f	N_r	Proportion Correct f	Proportion Correct r	Improvement $\times^2$ p-values: Format Effect (Difficulty)	Improvement $\times^2$ p-values: Format by Score Effect (Discrimination)
51	13	6	1.00	1.00	1.000	1.000
52	15	26	1.00	.96	.338	.999
53	16	22	.88	.91	.740	.409
54	19	22	.68	.82	.335	.178
55	33	31	1.00	1.00	1.000	1.000
56	51	56	.55	.75	.029	.379
57	53	46	.32	.26	.536	.976
58	28	32	.64	.78	.128	1.000
59	53	64	.57	.50	.563	.549
60	74	72	.93	1.00	.005	.985
61	49	48	.94	.88	.294	.545
62	24	21	.50	.71	.155	.906
63	50	53	.62	.57	.859	.078
64	42	37	.69	.49	.028	.384
65	44	59	.50	.48	.859	.463
66	27	35	.74	.91	.076	.905
67	53	49	.81	.88	.414	.777
68	20	25	.70	.28	.004	.951
69	25	34	.36	.59	.068	.420
70	59	52	.75	.69	.453	.612
71	53	55	.59	.64	.503	.460
72	52	55	.56	.53	.691	.603
73	38	40	.82	.73	.341	.480
74	38	44	.74	.61	.189	.103
75	61	64	.80	.83	.692	.906

Table 6, cont.

Item #	N_f	N_r	Proportion Correct f	Proportion Correct r	Improvement $\times^2$ p-values: Format Effect (Difficulty)	Improvement $\times^2$ p-values: Format by Score Effect (Discrimination)
76	65	61	.89	.89	.900	.765
77	39	45	.72	.69	.755	.479
78	28	37	.89	.95	.398	.058
79	33	32	.64	.66	.864	.835
80	30	29	.73	.76	.768	.407
81	37	39	.97	.90	.143	.378
82	69	75	.75	.64	.155	.111
83	46	46	.43	.54	.316	.472
84	25	33	.92	.94	.756	.131

TABLE 7

Logistic Regression Results of GR02

Item #	N_f	N_r	Proportion Correct f	Proportion Correct r	Improvement $\times^2$ p-values: Format Effect (Difficulty)	Improvement $\times^2$ p-values: Format by Score Effect (Discrimination)
1	30	18	.87	.94	.390	.013
2	34	31	.00	.03	.252	.994
3	39	26	.82	.65	.685	.063
4	47	41	.00	.00	1.000	1.000
5	30	18	.77	.78	.991	.348
6	26	16	1.00	1.00	1.000	1.000
7	58	47	.03	.06	.484	.795
8	15	10	.33	.20	.434	.004
9	30	18	.90	.90	.802	.163
10	63	53	.97	.98	.643	.635
11	42	43	.74	.65	.349	.799
12	22	17	.77	.82	.910	.549
13	70	60	.94	.95	.775	.516
14	78	75	.73	.71	.748	.651
15	80	81	.68	.57	.176	.138
16	26	16	.31	.38	.590	.049
17	44	37	.00	.08	.051	.992
18	33	22	.67	.77	.397	.950
19	74	79	.60	.61	.866	.950
20	55	46	.87	.80	.369	.110
21	73	70	.90	.94	.470	.439
22	44	48	.89	.81	.306	.055
23	71	56	.89	.96	.082	.090
24	40	29	.88	.97	.202	.748
25	63	73	.92	.90	.726	.726

Table 7 (cont.)

Item #	N_f	N_r	Proportion Correct f	Proportion Correct r	Improvement $\times^2$ p-values: Format Effect (Difficulty)	Improvement $\times^2$ p-values: Format by Score Effect (Discrimination)
26	74	65	.88	.82	.232	.860
27	46	33	.89	.73	.096	.623
28	72	53	.90	.89	.148	.742
29	38	48	.55	.92	.568	.010
30	33	22	.76	.86	.339	.001
31	30	18	.93	.94	.936	.312
32	44	48	.89	.81	.325	.297
33	69	57	.71	.67	.628	.210
34	57	52	1.00	1.00	1.000	1.000
35	70	66	.93	.94	.864	.867
36	56	53	.98	1.00	.299	.974
37	34	27	.94	.96	.543	.089
38	68	59	.99	.92	.061	.044
39	41	45	.93	.93	.988	.153
40	15	10	.93	1.00	.096	.931
41	30	18	.80	.94	.159	.192
42	64	53	.78	.70	.315	.403
43	69	67	.88	.84	.428	.977
44	74	79	.95	.90	.271	.095
45	12	6	.08	.60	.891	.947
46	44	28	.07	.07	.972	.012
47	33	22	.21	.18	.792	.515
48	61	60	.98	.97	.469	.463
49	55	47	.71	.66	.549	.043
50	70	66	.81	.82	.751	.458
51	62	64	.76	.64	.170	.433
52	50	32	.08	.00	.015	.983
53	59	51	.19	.22	.272	.926
54	33	22	.00	.00	1.000	1.000
55	34	31	.79	.68	.518	.974

Table 7, cont.

Item #	N_f	N_r	Proportion Correct: f	Proportion Correct: r	Improvement $\times^2$ p-values: Format Effect (Difficulty)	Improvement $\times^2$ p-values: Format by Score Effect (Discrimination)
56	89	81	.80	.64	.045	.803
57	39	26	.00	.00	1.000	1.000
58	65	52	.86	.83	.440	.821
59	26	16	.39	.50	.350	.001
60	55	58	.86	.86	.992	.154
61	38	33	.76	.94	.016	.618
62	39	26	.74	.65	.442	.365
63	50	32	.76	.69	.867	.894
64	47	47	.77	.70	.436	.619
65	39	26	.90	.96	.297	.239
66	44	28	.52	.61	.466	.845
67	36	22	1.00	.91	.162	.986
68	34	31	.71	.87	.105	.187
69	63	73	.75	.75	.924	.776
70	39	26	.82	.69	.133	.121
71	61	60	.90	.83	.128	.054
72	53	62	.87	.90	.602	.281
73	26	16	.85	1.00	.037	.996
74	12	6	.83	1.00	.231	.998
75	36	22	.58	.68	.076	.151

Table 8

Logistic Regression Results of GR03

Item #	N_f	N_r	Proportion Correct f	Proportion Correct r	Improvement $\times^2$ p-values Format Effect (Difficulty)	Improvement $\times^2$ p-values Format by Score Effect (Discrimination)
1	41	51	.98	1.00	.204	.987
2	48	43	.98	.98	.829	.089
3	38	41	.84	.85	.900	.500
4	34	19	.32	.37	.255	.056
5	44	52	.96	.96	.980	.731
6	49	64	.65	.77	.152	.327
7	48	43	1.00	1.00	1.000	1.000
8	45	52	1.00	.96	.096	.990
9	34	40	.53	.50	.967	.864
10	40	53	.63	.59	.792	.728
11	40	50	.75	.84	.276	.969
12	47	32	.92	.75	.064	.695
13	68	53	.88	.64	.001	.361
14	28	38	.71	.63	.564	.429
15	31	44	1.00	.89	.019	.994
16	41	51	.68	.59	.337	.361
17	44	28	.98	1.00	.204	.986
18	42	56	.43	.39	.785	.461
19	44	49	.64	.78	.063	.107
20	45	52	.76	.85	.383	.022
21	43	56	.35	.43	.451	.204
22	31	41	.55	.59	.988	.198
23	40	40	.58	.85	.003	.943
24	52	39	.94	.85	.479	.763
25	48	51	.77	.65	.175	.618

Table 8, cont.

Item #	N_f	N_r	Proportion Correct: f	Proportion Correct: r	Improvement $\times^2$ p-values: Format Effect (Difficulty)	Improvement $\times^2$ p-values: Format by Score Effect (Discrimination)
26	32	40	.69	.76	.432	.123
27	50	41	.96	.93	.602	.996
28	26	29	.69	.66	.772	.411
29	50	62	.76	.77	.610	.018
30	58	44	.86	.86	.876	.755
31	40	51	.88	.75	.059	.937
32	41	32	.68	.72	.514	.346
33	52	44	.31	.52	.027	.406
34	36	49	.69	.80	.151	.964
35	36	54	.42	.52	.342	.098
36	33	40	.55	.53	.757	.552
37	53	44	.91	.91	.794	.970
38	38	34	1.00	.97	.469	.982
39	41	53	.73	.55	.101	.827
40	53	63	.81	.86	.613	.664
41	36	38	.94	.63	.000	.403
42	38	34	.76	.77	.721	.064
43	35	51	.86	.71	.222	.567
44	41	32	.56	.53	.835	.239
45	51	46	.94	.85	.222	.569
46	54	61	.80	.78	.686	.035
47	58	65	.79	.71	.193	.468
48	40	53	.88	.70	.055	.405
49	36	38	.86	.63	.024	.823
50	40	40	.98	.78	.004	.018

Table 8, cont.

Item #	N_f	N_r	Proportion Correct: f	Proportion Correct: r	Improvement $\times^2$ p-values: Format Effect (Difficulty)	Improvement $\times^2$ p-values: Format by Score Effect (Discrimination)
51	37	54	.97	.94	.503	.293
52	64	52	.41	.29	.314	.364
53	20	27	.90	.96	.330	.961
54	32	21	.91	.67	.065	.399
55	66	50	.33	.46	.095	.270
56	34	19	.91	1.00	.031	.990
57	51	46	.69	.76	.467	.853
58	33	42	.49	.41	.479	.235
59	58	65	.78	.72	.352	.950
60	19	29	.21	.24	.849	.002
61	35	51	.80	.90	.110	.237
62	49	51	.49	.59	.227	.287
63	42	49	.62	.59	.845	.473
64	37	49	.89	.86	.823	.586
65	34	51	.88	.92	.274	.454
66	44	54	.68	.70	.804	.342
67	54	43	.87	.88	.772	.192
68	44	47	.71	.66	.743	.871
69	44	33	.68	.79	.191	.078
70	26	29	.54	.79	.055	.775
71	52	44	.90	.89	.933	.562
72	30	44	.70	.66	.719	.858
73	52	65	.63	.59	.588	.610
74	38	52	.90	.85	.497	.707
75	47	32	.98	.97	.766	.745

TABLE 9

Logistic Regression Results of GR05

Item #	N_f	N_r	Proportion Correct f	Proportion Correct r	Improvement $\times^2$ p-values: Format Effect (Difficulty)	Improvement $\times^2$ p-values: Format by Score Effect (Discrimination)
1	25	47	.96	.96	.968	.768
2	41	49	.95	.92	.548	.171
3	35	30	.94	.90	.506	.440
4	32	43	.88	.77	.210	.223
5	12	13	1.00	.92	.146	.986
6	29	34	.97	.97	.866	.110
7	33	47	.94	.94	.752	.858
8	48	56	.92	.80	.096	.593
9	31	33	.90	.79	.147	.783
10	21	28	.95	1.00	.110	.970
11	34	37	.85	.81	.518	.414
12	16	32	.69	.84	.134	.111
13	22	25	.91	.84	.549	.730
14	35	43	.97	.98	.750	.849
15	28	42	.96	.88	.239	.442
16	21	25	.71	.48	.153	.400
17	31	31	.52	.61	.376	.869
18	28	33	1.00	.97	.365	.990
19	17	33	.88	.91	.740	.383
20	28	33	1.00	.94	.194	.990
21	28	30	.39	.33	.869	.849
22	48	56	.83	.84	.952	.667
23	36	46	.97	.96	.920	.217
24	10	18	1.00	1.00	1.000	1.000
25	43	42	.81	.88	.419	.847

Table 9, cont.

Item #	N_f	N_r	Proportion Correct f	Proportion Correct r	Improvement $\times^2$ p-values: Format Effect (Difficulty)	Improvement $\times^2$ p-values: Format by Score Effect (Discrimination)
26	35	52	.63	.44	.139	.760
27	16	14	1.00	.93	.155	.985
28	29	40	.93	.80	.165	.963
29	25	37	.92	.81	.243	.859
30	22	19	1.00	1.00	1.00	1.00
31	19	28	.90	.93	.507	.236
32	20	27	.80	.85	.660	.381
33	32	43	.91	.81	.346	.946
34	41	49	1.00	.94	.059	.995
35	44	43	1.00	.93	.036	.995
36	34	39	.97	.97	.902	.555
37	22	37	1.00	.89	.095	.990
38	32	38	.94	.95	.881	.293
39	28	30	.86	.80	.812	.692
40	32	51	.47	.51	.432	.334
41	28	35	.89	.86	.916	.546
42	35	38	.83	.76	.711	.936
43	17	25	.77	1.00	.001	.982
44	40	45	.98	.98	.656	.010
45	24	32	1.00	.94	.153	.993
46	48	64	1.00	.97	.155	.995
47	19	28	.95	.97	.362	.018
48	45	58	.80	.78	.660	.934
49	22	21	.91	.95	.462	.563
50	42	38	.76	.79	.718	.876

Table 9, cont.

Item #	N_f	N_r	Proportion Correct f	Proportion Correct r	Improvement $\times^2$ p-values: Format Effect (Difficulty)	Improvement $\times^2$ p-values: Format by Score Effect (Discrimination)
51	30	45	.87	.98	.036	.288
52	16	34	1.00	.97	.480	1.000
53	34	36	.88	.89	.732	.865
54	28	23	.75	.83	.519	.362
55	29	44	.69	.50	.248	.877
56	18	32	.94	.91	.914	.082
57	31	29	.55	.72	.153	.582
58	33	33	.61	.58	.429	.591
59	49	55	.53	.55	.884	.954
60	44	55	.84	.91	.271	.133
61	10	18	1.00	.83	.117	.988
62	43	51	.70	.65	.577	.369
63	12	15	.92	.53	.027	.490
64	34	54	.94	.80	.443	.268
65	16	32	.75	.69	.729	.488
66	28	25	.82	.88	.536	.791
67	29	35	.52	.40	.430	.302
68	33	23	.94	.87	.367	.897
69	26	18	.85	.89	.757	.112
70	28	53	.82	.76	.851	.944
71	16	24	.94	.83	.315	.043
72	20	19	.95	.90	.310	.572
73	23	41	.87	.73	.484	.145
74	23	18	1.00	.94	.032	.856
75	39	51	.74	.78	.321	.720

APPENDIX

The 3 steps used in the stepwise logistic regression analyses are as follows:

Step 1. Fit

$$Y_{ij} = \frac{\exp\left[\beta_{oj} + \beta_{1j}X_i + \beta_{2j}M_i + \beta_{3j}M_i{*}X_i\right]}{1 + \exp\left[\beta_{oj} + \beta_{1j}X_i + \beta_{2j}M_i + \beta_{3j}M_i{*}X_i\right]},$$

where

$$Y_{ij} = \begin{cases} 1, & \text{if } \underline{i}\text{th examinee answered item } \underline{j} \text{ correctly,} \\ 0, & \text{otherwise,} \end{cases}$$

X_i = $\underline{i}$th examinee's total test score minus Y_{ij},

$$M_i = \begin{cases} +1, & \text{if } \underline{i}\text{th examinee used paper-pencil,} \\ -1, & \text{if } \underline{i}\text{th examinee used computer,} \end{cases}$$

and Test $G^2(\beta_{oj}, \beta_{1j}, \beta_{2j}, \beta_{3j})$.

Step 2. Fit

$$Y_{ij} = \frac{\exp\left[\beta_{oj} + \beta_{1j}X_i + \beta_{2j}M_i\right]}{1 + \exp\left[\beta_{oj} + \beta_{1j}X_i + \beta_{2j}M_i\right]} ,$$

Test $G^2(\beta_{oj}, \beta_{1j}, \beta_{2j})$,

and

$$G^2(\beta_{oj}, \beta_{1j}, \beta_{2j}) - G^2(\beta_{oj}, \beta_{1j}, \beta_{2j}, \beta_{3j}) .$$

Step 3. Fit

$$Y_{ij} = \frac{\exp\left[\beta_{oj} + \beta_{1j}X_i\right]}{1 + \exp\left[\beta_{oj} + \beta_{1j}X_i\right]} ,$$

Test $G^2(\beta_{oj}, \beta_{1j})$,

and

$$G^2(\beta_{oj}, \beta_{1j}) - G^2(\beta_{oj}, \beta_{1j}, \beta_{2j}) .$$

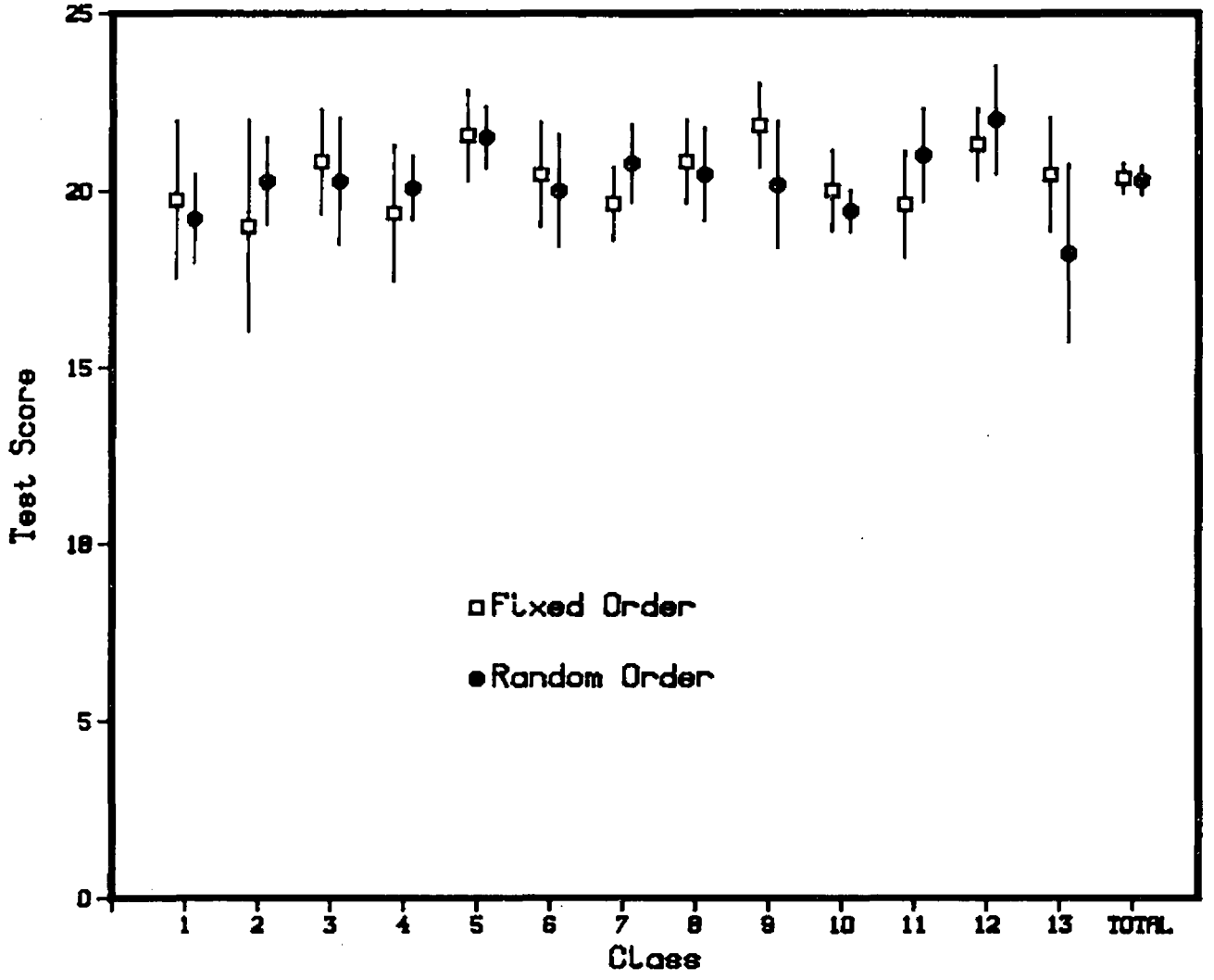

Figure 1. The 95% Confidence Interval about the Mean Total Test Score for Both the Pencil & Paper and Computer Groups for Each GR01 Class.

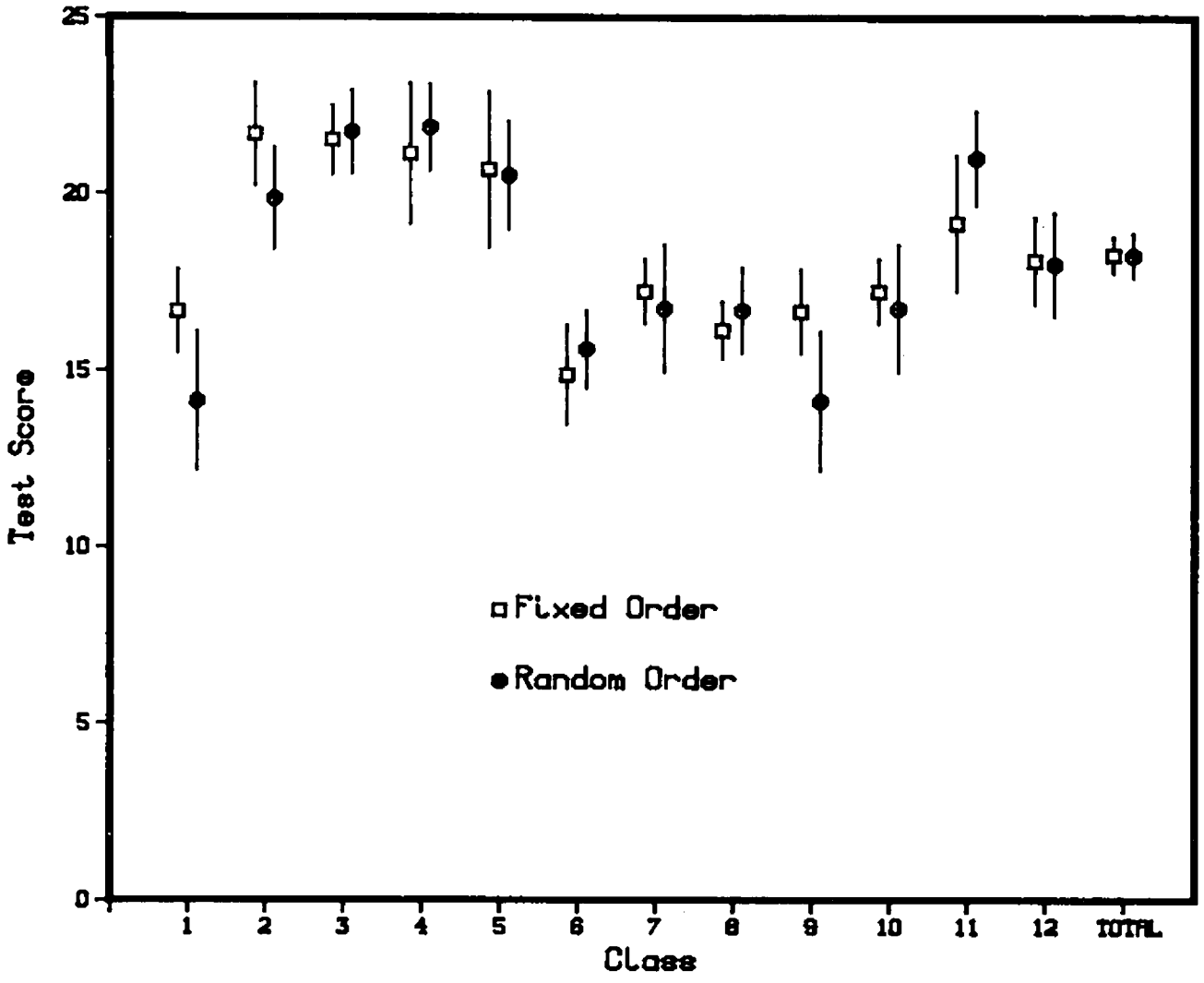

Figure 2. The 95% Confidence Interval about the Mean Total Test Score for Both the Pencil & Paper and Computer Groups for Each GR02 Class.

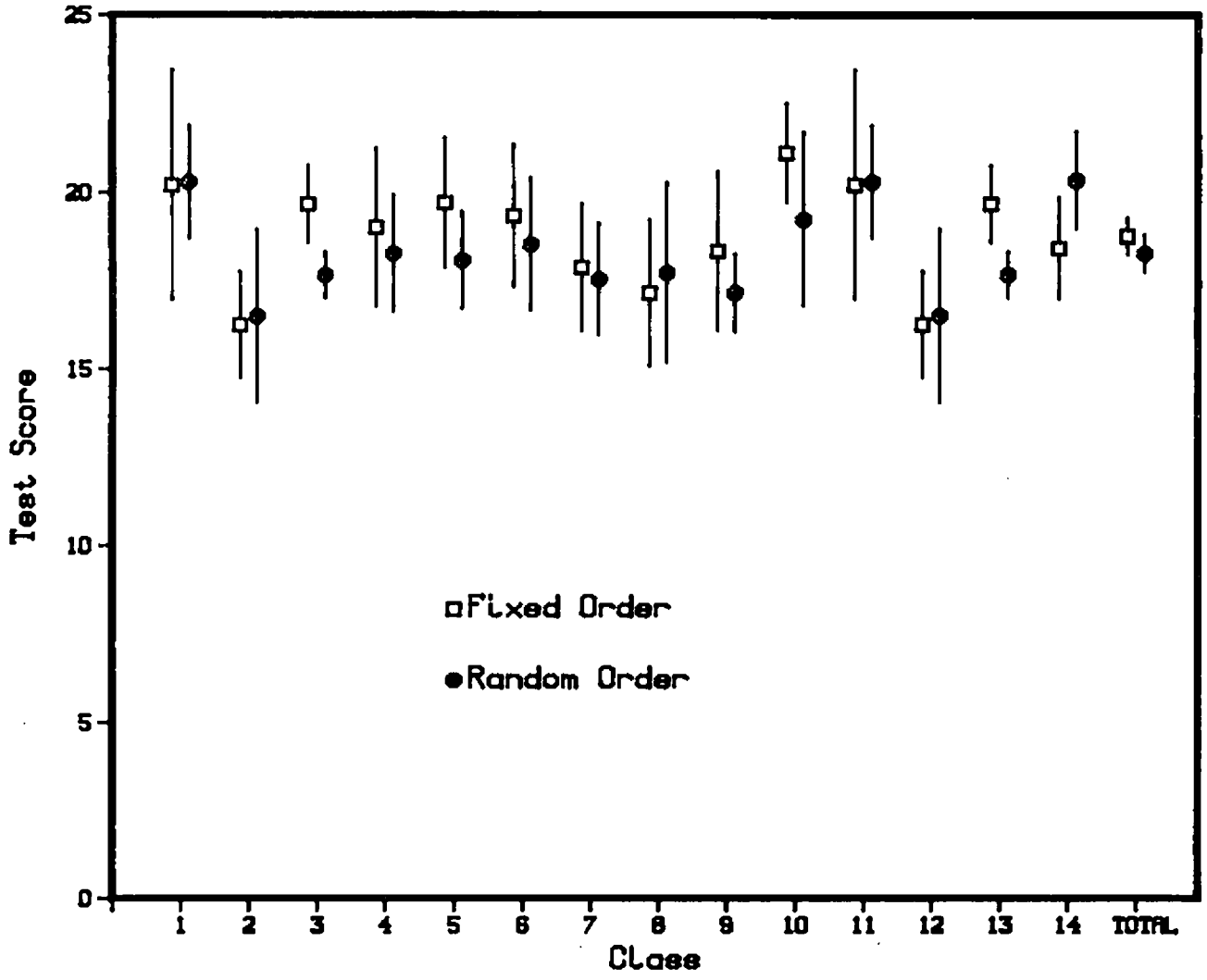

Figure 3. The 95% Confidence Interval about the Mean Total Test Score for Both the Pencil & Paper and Computer Groups for Each GR03 Class.

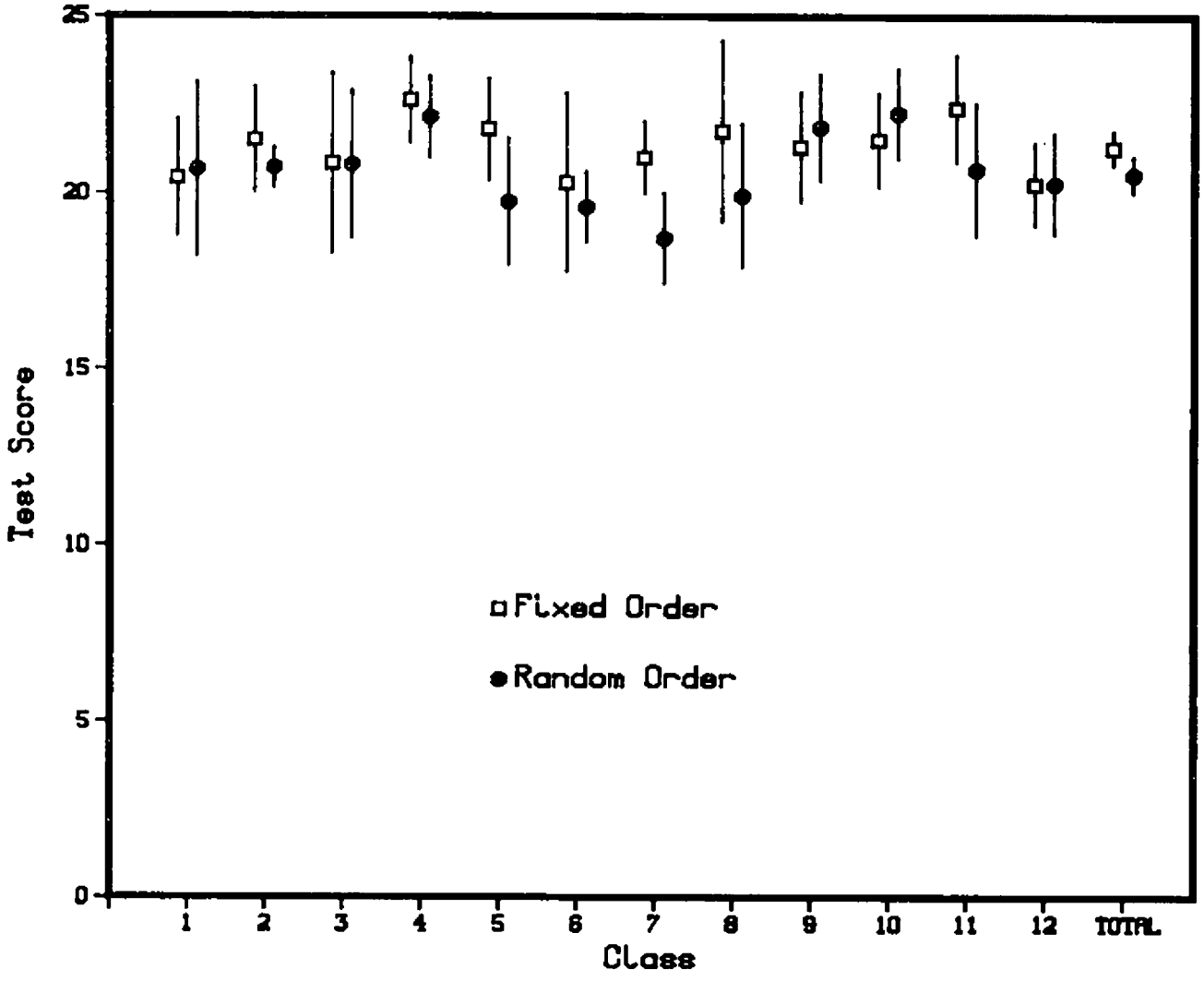

Figure 4. The 95% Confidence Interval about the Mean Total Test Score for Both the Pencil & Paper and Computer Groups for Each GR05 Class.

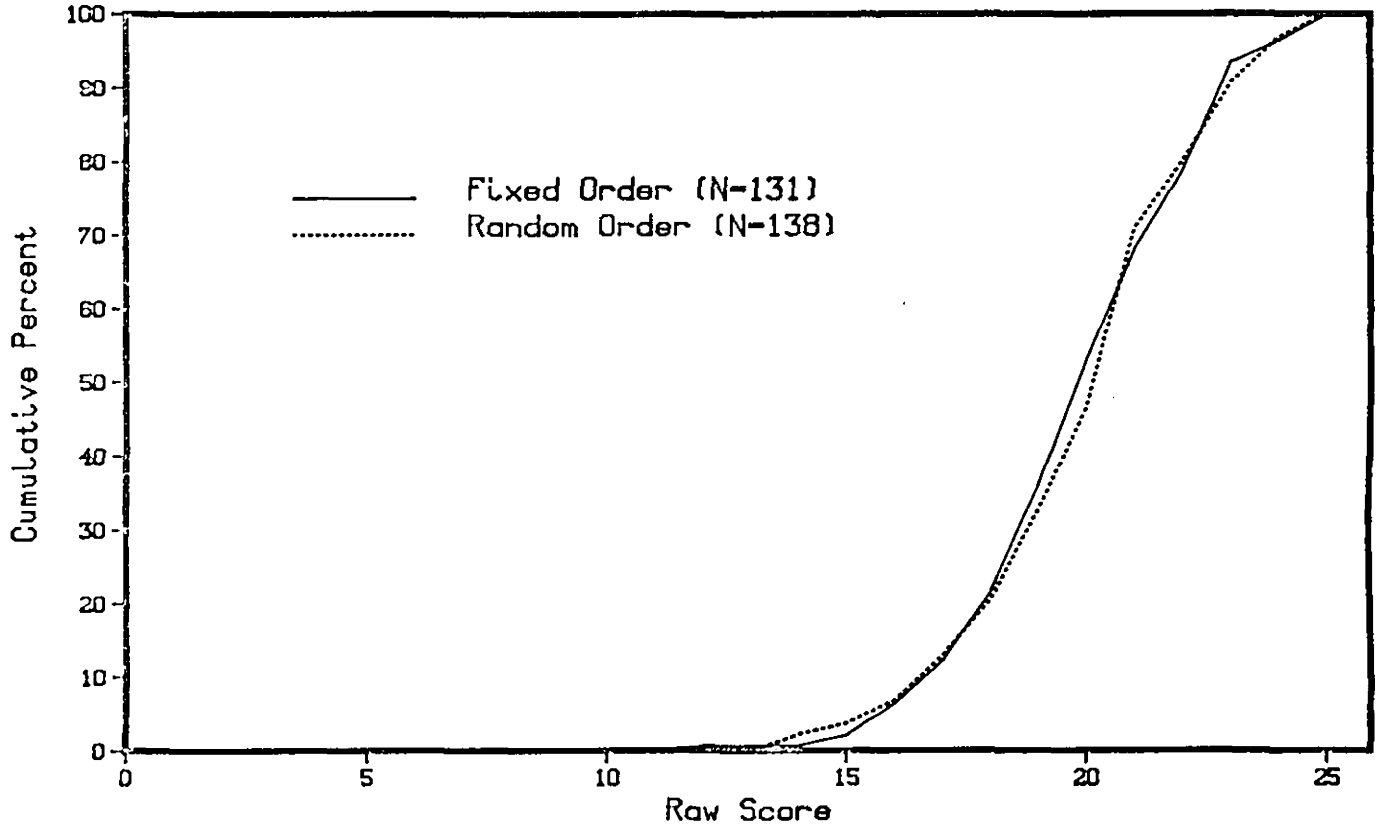

Figure 5. Cumulative Frequency Polygons of Total Test Scores for Fixed and Random Order Presentations for Annex GR01.

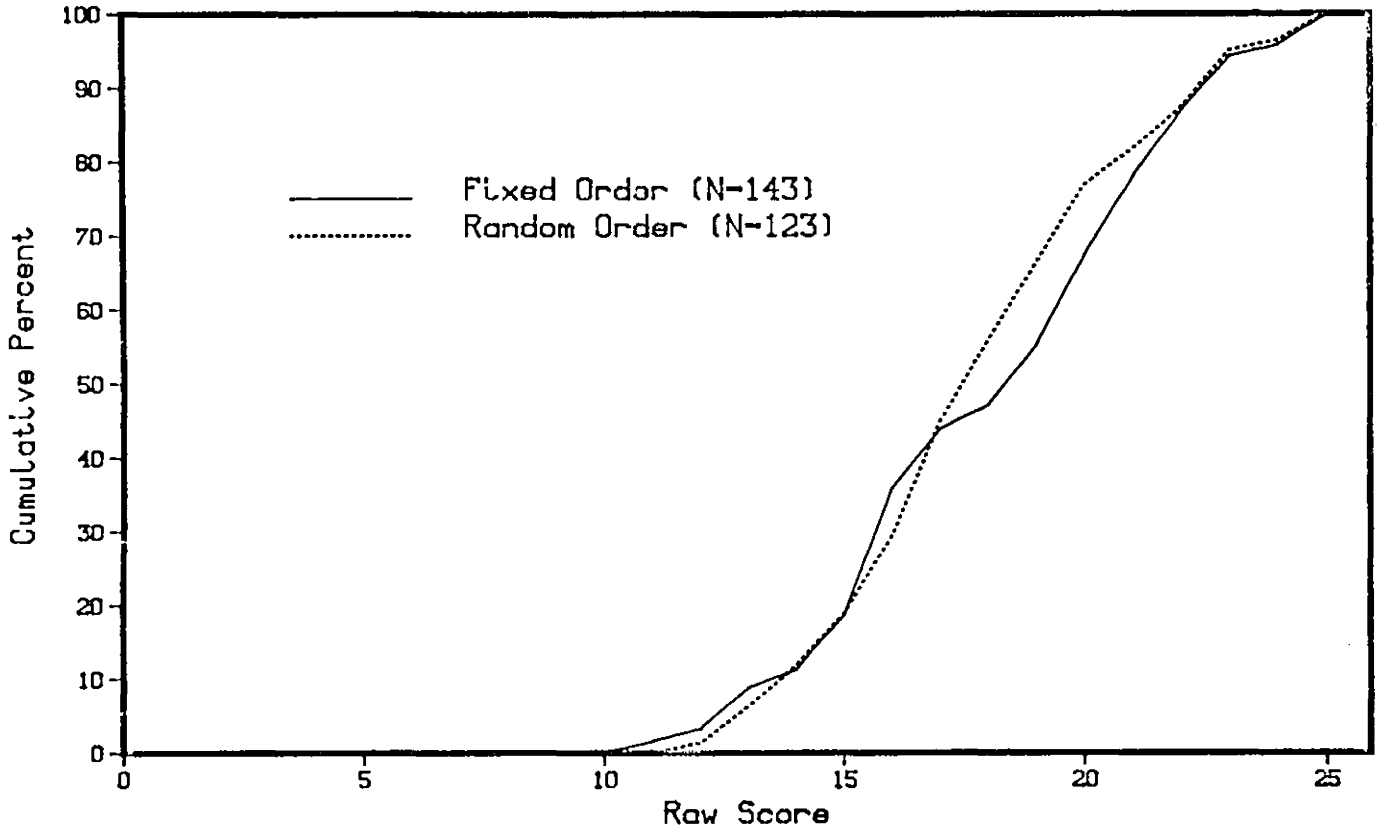

Figure 6. Cumulative Frequency Polygons of Total Test Scores for Fixed and Random Order Presentations for Annex GR02.

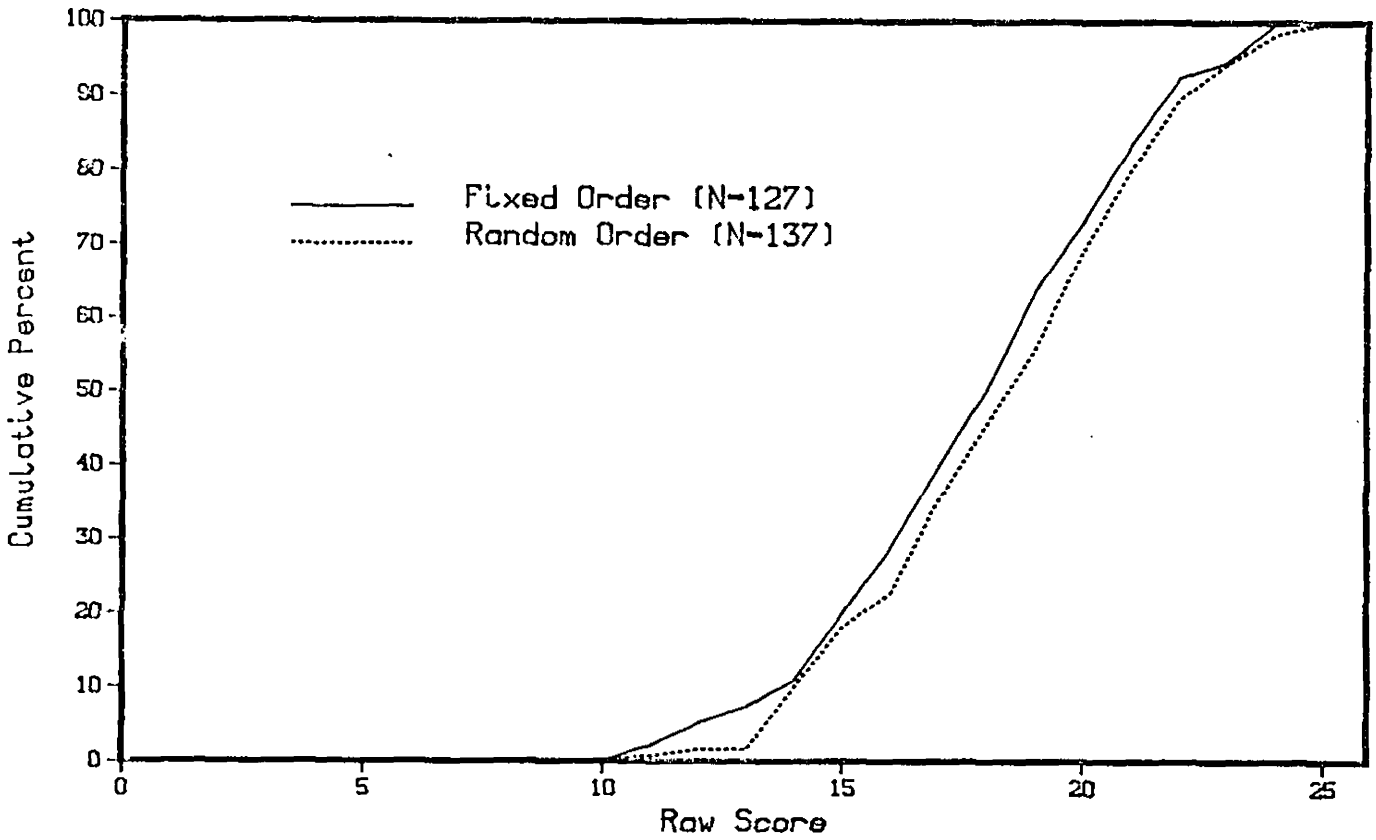

Figure 7. Cumulative Frequency Polygons of Total Test Scores for Fixed and Random Order Presentations for Annex GR03.

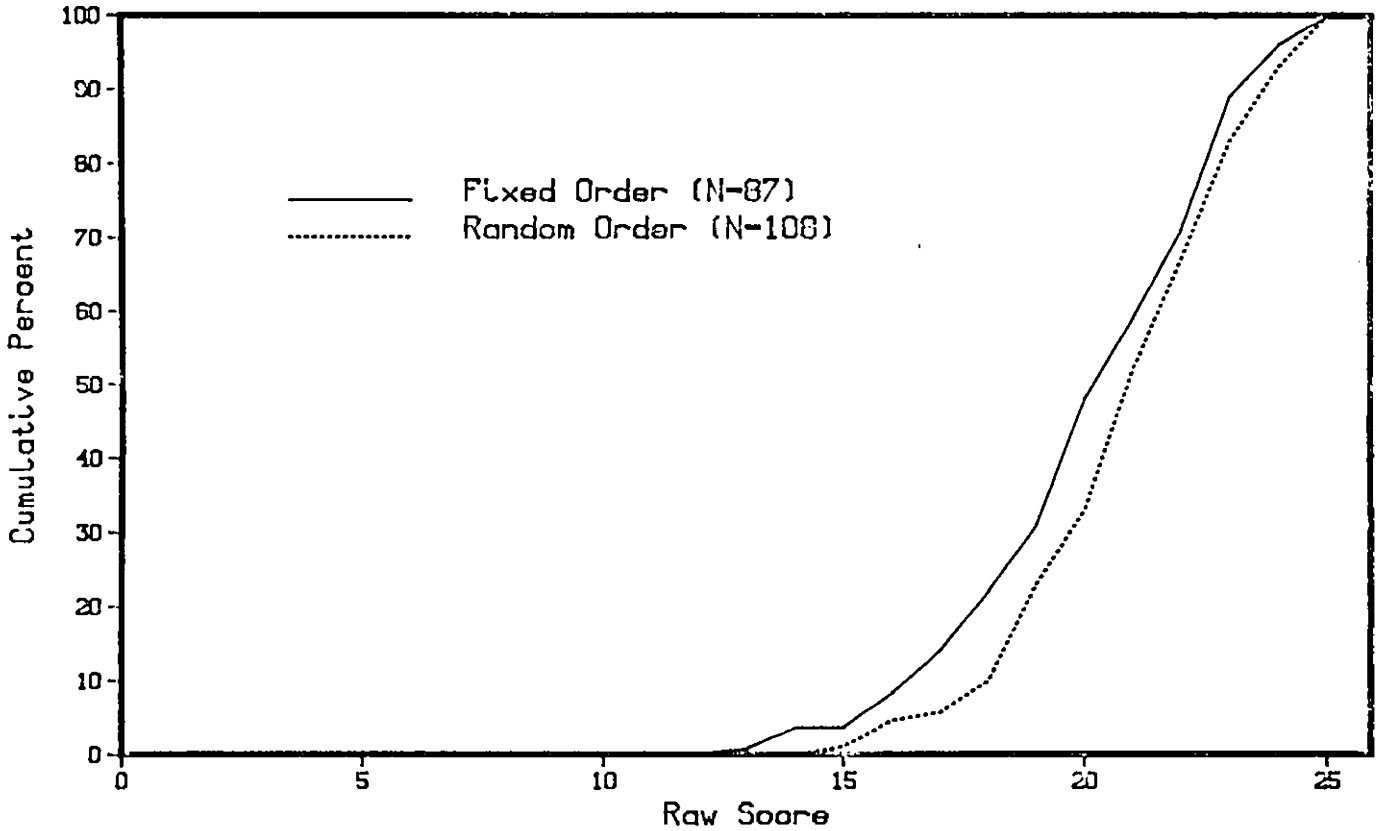

Figure 8. Cumulative Frequency Polygons of Total Test Scores for Fixed and Random Order Presentations for Annex GR05.

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Dr. Terry Ackerman
American College Testing Programs
P.O. Box 168
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Chicago, IL 60637

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1120 Brussels, BELGIUM

Dr. Robert Breaux
Code N-095R
Naval Training Systems Center
Orlando, FL 32813

Dr. Robert Brennan
American College Testing
Programs
P. O. Box 168
Iowa City, IA 52243

Dr. Lyle D. Broemeling
ONR Code 1111SP
800 North Quincy Street
Arlington, VA 22217

Mr. James W. Carey
Commandant (G-PTE)
U.S. Coast Guard
2100 Second Street, S.W.
Washington, DC 20593

Dr. James Carlson
American College Testing
Program
P.O. Box 168
Iowa City, IA 52243

Dr. John B. Carroll
409 Elliott Rd.
Chapel Hill, NC 27514

Dr. Robert Carroll
OP 0187
Washington, DC 20370

Mr. Raymond E. Christal
AFHRL/MOE
Brooks AFB, TX 78235

Dr. Norman Cliff
Department of Psychology
Univ. of So. California
University Park
Los Angeles, CA 90007

Director,
Manpower Support and
Readiness Program
Center for Naval Analysis
2000 North Beauregard Street
Alexandria, VA 22311

Dr. Stanley Collyer
Office of Naval Technology
Code 222
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. Hans Crombag
University of Leyden
Education Research Center
Boerhaavelaan 2
2334 EN Leyden
The NETHERLANDS

Dr. Timothy Davey
Educational Testing Service
Princeton, NJ 08541

Dr. C. M. Dayton
Department of Measurement
Statistics & Evaluation
College of Education
University of Maryland
College Park, MD 20742

Dr. Ralph J. DeAyala
Measurement, Statistics,
and Evaluation
Benjamin Building
University of Maryland
College Park, MD 20742

Dr. Dattprasad Divgi
Center for Naval Analysis
4401 Ford Avenue
P.O. Box 16268
Alexandria, VA 22302-0268

Dr. Hei-Ki Dong
Bell Communications Research
6 Corporate Place
PYA-1k226
Piscataway, NJ 08854

Dr. Fritz Drasgow
University of Illinois
Department of Psychology
603 E. Daniel St.
Champaign, IL 61820

Defense Technical
Information Center
Cameron Station, Bldg 5
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Attn: TC
(12 Copies)

Dr. Stephen Dunbar
Lindquist Center
for Measurement
University of Iowa
Iowa City, IA 52242

Dr. James A. Earles
Air Force Human Resources Lab
Brooks AFB, TX 78235

Dr. Kent Eaton
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. John M. Eddins
University of Illinois
252 Engineering Research
Laboratory
103 South Mathews Street
Urbana, IL 61801

Dr. Susan Embretson
University of Kansas
Psychology Department
426 Fraser
Lawrence, KS 66045

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Division of Educational Studies
Emory University
201 Fishburne Bldg.
Atlanta, GA 30322

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Performance Metrics, Inc.
5825 Callaghan
Suite 225
San Antonio, TX 78228

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Code 511
NPRDC
San Diego, CA 92152-6800

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Lindquist Center
for Measurement
University of Iowa
Iowa City, IA 52242

Dr. Richard L. Ferguson
American College Testing
Program
P.O. Box 168
Iowa City, IA 52240

Dr. Gerhard Fischer
Liebiggasse 5/3
A 1010 Vienna
AUSTRIA

Dr. Myron Fischl
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Prof. Donald Fitzgerald
University of New England
Department of Psychology
Armidale, New South Wales 2351
AUSTRALIA

Mr. Paul Foley
Navy Personnel R&D Center
San Diego, CA 92152-6800

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AFOSR/NL
Bolling AFB, DC 20332

Dr. Robert D. Gibbons
Illinois State Psychiatric Inst.
Rm 529W
1601 W. Taylor Street
Chicago, IL 60612

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University of Massachusetts
School of Education
Amherst, MA 01003

Dr. Robert Glaser
Learning Research
& Development Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15260

Dr. Bert Green
Johns Hopkins University
Department of Psychology
Charles & 34th Street
Baltimore, MD 21218

Dipl. Pad. Michael W. Habon
Universitat Dusseldorf
Erziehungswissenschaftliches
Universitatsstr. 1
D-4000 Dusseldorf 1
WEST GERMANY

Dr. Ronald K. Hambleton
Prof. of Education & Psychology
University of Massachusetts
at Amherst
Hills House
Amherst, MA 01003

Dr. Delwyn Harnisch
University of Illinois
51 Gerty Drive
Champaign, IL 61820

Dr. Grant Henning
Senior Research Scientist
Division of Measurement
Research and Services
Educational Testing Service
Princeton, NJ 08541

Ms. Rebecca Hetter
Navy Personnel R&D Center
Code 62
San Diego, CA 92152-6800

Dr. Paul W. Holland
Educational Testing Service
Rosedale Road
Princeton, NJ 08541

Prof. Lutz F. Hornke
Institut fur Psychologie
RWTH Aachen
Jaegerstrasse 17/19
D-5100 Aachen
WEST GERMANY

Dr. Paul Horst
677 G Street, #184
Chula Vista, CA 90010

Mr. Dick Hoshaw
OP-135
Arlington Annex
Room 2834
Washington, DC 20350

Dr. Lloyd Humphreys
University of Illinois
Department of Psychology
603 East Daniel Street
Champaign, IL 61820

Dr. Steven Hunka
Department of Education
University of Alberta
Edmonton, Alberta
CANADA

Dr. Huynh Huynh
College of Education
Univ. of South Carolina
Columbia, SC 29208

Dr. Robert Jannarone
Department of Psychology
University of South Carolina
Columbia, SC 29208

Dr. Dennis E. Jennings
Department of Statistics
University of Illinois
1409 West Green Street
Urbana, IL 61801

Dr. Douglas H. Jones
Thatcher Jones Associates
P.O. Box 6640
10 Trafalgar Court
Lawrenceville, NJ 08648

Dr. Milton S. Katz
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Prof. John A. Keats
Department of Psychology
University of Newcastle
N.S.W. 2308
AUSTRALIA

Dr. G. Gage Kingsbury
Portland Public Schools
Research and Evaluation Department
501 North Dixon Street
P. O. Box 3107
Portland, OR 97209-3107

Dr. William Koch
University of Texas-Austin
Measurement and Evaluation
Center
Austin, TX 78703

Dr. James Kraatz
Computer-based Education
Research Laboratory
University of Illinois
Urbana, IL 61801

Dr. Leonard Kroeker
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. Daryll Lang
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. Jerry Lehnus
Defense Manpower Data Center
Suite 400
1600 Wilson Blvd
Rosslyn, VA 22209

Dr. Thomas Leonard
University of Wisconsin
Department of Statistics
1210 West Dayton Street
Madison, WI 53705

Dr. Michael Levine
Educational Psychology
210 Education Bldg.
University of Illinois
Champaign, IL 61801

Dr. Charles Lewis
Educational Testing Service
Princeton, NJ 08541

Dr. Robert Linn
College of Education
University of Illinois
Urbana, IL 61801

Dr. Robert Lockman
Center for Naval Analysis
4401 Ford Avenue
P.O. Box 16268
Alexandria, VA 22302-0268

Dr. Frederic M. Lord
Educational Testing Service
Princeton, NJ 08541

Dr. George B. Macready
Department of Measurement
Statistics & Evaluation
College of Education
University of Maryland
College Park, MD 20742

Dr. Milton Maier
Center for Naval Analysis
4401 Ford Avenue
P.O. Box 16268
Alexandria, VA 22302-0268

Dr. William L. Maloy
Chief of Naval Education
and Training
Naval Air Station
Pensacola, FL 32508

Dr. Gary Marco
Stop 31-E
Educational Testing Service
Princeton, NJ 08451

Dr. Clessen Martin
Army Research Institute
5001 Eisenhower Blvd.
Alexandria, VA 22333

Dr. James McBride
Psychological Corporation
c/o Harcourt, Brace,
Javanovich Inc.
1250 West 6th Street
San Diego, CA 92101

Dr. Clarence McCormick
HQ, MEPCOM
MEPCT-P
2500 Green Bay Road
North Chicago, IL 60064

Dr. Robert McKinley
Educational Testing Service
20-P
Princeton, NJ 08541

Dr. James McMichael
Technical Director
Navy Personnel R&D Center
San Diego, CA 92152

Dr. Barbara Means
Human Resources
Research Organization
1100 South Washington
Alexandria, VA 22314

Dr. Robert Mislevy
Educational Testing Service
Princeton, NJ 08541

Dr. William Montague
NPRDC Code 13
San Diego, CA 92152-6800

Ms. Kathleen Moreno
Navy Personnel R&D Center
Code 62
San Diego, CA 92152-6800

Headquarters, Marine Corps
Code MPI-20
Washington, DC 20380

Dr. W. Alan Nicewander
University of Oklahoma
Department of Psychology
Oklahoma City, OK 73069

Deputy Technical Director
NPRDC Code 01A
San Diego, CA 92152-6800

Director, Training Laboratory,
NPRDC (Code 05)
San Diego, CA 92152-6800

Director, Manpower and Personnel
Laboratory,
NPRDC (Code 06)
San Diego, CA 92152-6800

Director, Human Factors
& Organizational Systems Lab,
NPRDC (Code 07)
San Diego, CA 92152-6800

Fleet Support Office,
NPRDC (Code 301)
San Diego, CA 92152-6800

Library, NPRDC
Code P201L
San Diego, CA 92152-6800

Commanding Officer,
Naval Research Laboratory
Code 2627
Washington, DC 20390

Dr. Harold F. O'Neil, Jr.
School of Education - WPH 801
Department of Educational
Psychology & Technology
University of Southern California
Los Angeles, CA 90089-0031

Dr. James Olson
WICAT, Inc.
1875 South State Street
Orem, UT 84057

Office of Naval Research,
Code 1142CS
800 N. Quincy Street
Arlington, VA 22217-5000
(6 Copies)

Office of Naval Research,
Code 125
800 N. Quincy Street
Arlington, VA 22217-5000

Assistant for MPT Research,
Development and Studies
OP 01B7
Washington, DC 20370

Dr. Judith Orasanu
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Jesse Orlansky
Institute for Defense Analyses
1801 N. Beauregard St.
Alexandria, VA 22311

Dr. Randolph Park
Army Research Institute
5001 Eisenhower Blvd.
Alexandria, VA 22333

Wayne M. Patience
American Council on Education
GED Testing Service, Suite 20
One Dupont Circle, NW
Washington, DC 20036

Dr. James Paulson
Department of Psychology
Portland State University
P.O. Box 751
Portland, OR 97207

Administrative Sciences Department,
Naval Postgraduate School
Monterey, CA 93940

Department of Operations Research,
Naval Postgraduate School
Monterey, CA 93940

Dr. Mark D. Reckase
ACT
P. O. Box 168
Iowa City, IA 52243

Dr. Malcolm Ree
AFHRL/MP
Brooks AFB, TX 78235

Dr. Barry Riegelhaupt
HumRRO
1100 South Washington Street
Alexandria, VA 22314

Dr. Carl Ross
CNET-PDCD
Building 90
Great Lakes NTC, IL 60088

Dr. J. Ryan
Department of Education
University of South Carolina
Columbia, SC 29208

Dr. Fumiko Samejima
Department of Psychology
University of Tennessee
3108 AustinPeay Bldg.
Knoxville, TN 37916-0900

Mr. Drew Sands
NPRDC Code 62
San Diego, CA 92152-6800

Lowell Schoer
Psychological & Quantitative
Foundations
College of Education
University of Iowa
Iowa City, IA 52242

Dr. Mary Schratz
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. Dan Segall
Navy Personnel R&D Center
San Diego, CA 92152

Dr. W. Steve Sellman
OASD(MRA&L)
2B269 The Pentagon
Washington, DC 20301

Dr. Kazuo Shigemasu
7-9-24 Kugenuma-Kaigan
Fujusawa 251
JAPAN

Dr. William Sims
Center for Naval Analysis
4401 Ford Avenue
P.O. Box 16268
Alexandria, VA 22302-0268

Dr. H. Wallace Sinaiko
Manpower Research
and Advisory Services
Smithsonian Institution
801 North Pitt Street
Alexandria, VA 22314

Dr. Richard E. Snow
Department of Psychology
Stanford University
Stanford, CA 94306

Dr. Richard Sorensen
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. Paul Speckman
University of Missouri
Department of Statistics
Columbia, MO 65201

Dr. Judy Spray
ACT
P.O. Box 168
Iowa City, IA 52243

Dr. Martha Stocking
Educational Testing Service
Princeton, NJ 08541

Dr. Peter Stoloff
Center for Naval Analysis
200 North Beauregard Street
Alexandria, VA 22311

Dr. William Stout
University of Illinois
Department of Statistics
101 Illini Hall
725 South Wright St.
Champaign, IL 61820

Dr. Hariharan Swaminathan
Laboratory of Psychometric and
Evaluation Research
School of Education
University of Massachusetts
Amherst, MA 01003

Mr. Brad Sympson
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. John Tangney
AFOSR/NL
Bolling AFB, DC 20332

Dr. Kikumi Tatsuoka
CERL
252 Engineering Research
Laboratory
Urbana, IL 61801

Dr. Maurice Tatsuoka
220 Education Bldg
1310 S. Sixth St.
Champaign, IL 61820

Dr. David Thissen
Department of Psychology
University of Kansas
Lawrence, KS 66044

Mr. Gary Thomasson
University of Illinois
Educational Psychology
Champaign, IL 61820

Dr. Robert Tsutakawa
University of Missouri
Department of Statistics
222 Math. Sciences Bldg.
Columbia, MO 65211

Dr. Ledyard Tucker
University of Illinois
Department of Psychology
603 E. Daniel Street
Champaign, IL 61820

Dr. Vern W. Urry
Personnel R&D Center
Office of Personnel Management
1900 E. Street, NW
Washington, DC 20415

Dr. David Vale
Assessment Systems Corp.
2233 University Avenue
Suite 310
St. Paul, MN 55114

Dr. Frank Vicino
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. Howard Wainer
Division of Psychological Studies
Educational Testing Service
Princeton, NJ 08541

Dr. Ming-Mei Wang
Lindquist Center
for Measurement
University of Iowa
Iowa City, IA 52242

Dr. Thomas A. Warm
Coast Guard Institute
P. O. Substation 18
Oklahoma City, OK 73169

Dr. Brian Waters
Program Manager
Manpower Analysis Program
HumRRO
1100 S. Washington St.
Alexandria, VA 22314

Dr. David J. Weiss
N660 Elliott Hall
University of Minnesota
75 E. River Road
Minneapolis, MN 55455

Dr. Ronald A. Weitzman
NPS, Code 54Wz
Monterey, CA 92152-6800

Major John Welsh
AFHRL/MOAN
Brooks AFB, TX 78223

Dr. Douglas Wetzel
Code 12
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. Rand R. Wilcox
University of Southern
California
Department of Psychology
Los Angeles, CA 90007

German Military Representative
ATTN: Wolfgang Wildegrube
Streitkraefteamt
D-5300 Bonn 2
4000 Brandywine Street, NW
Washington, DC 20016

Dr. Bruce Williams
Department of Educational
Psychology
University of Illinois
Urbana, IL 61801

Dr. Hilda Wing
NRC GF-176
2101 Constitution Ave
Washington, DC 20418

Dr. Martin F. Wiskoff
Navy Personnel R & D Center
San Diego, CA 92152-6800

Mr. John H. Wolfe
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. George Wong
Biostatistics Laboratory
Memorial Sloan-Kettering
Cancer Center
1275 York Avenue
New York, NY 10021

Dr. Wallace Wulfeck, III
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. Kentaro Yamamoto
Educational Testing Service
Rosedale Road
Princeton, NJ 08541

Dr. Wendy Yen
CTB/McGraw Hill
Del Monte Research Park
Monterey, CA 93940

Dr. Joseph L. Young
Memory & Cognitive
Processes
National Science Foundation
Washington, DC 20550

Dr. Anthony R. Zara
National Council of State
Boards of Nursing, Inc.
625 North Michigan Ave.
Suite 1544
Chicago, IL 60611