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COMPARABILITY STUDY OF ARMED SERVICES VOCATIONAL APTITUDE BATTERY SCORES FROM ANSWER SHEET AND ANSWER CARD ADMINISTRATION

By

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January 1974

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It was found that the answer form change had negligible effect on average examinee performance overall score distributions, or correlations among the battery's tests. Significant interaction between initial ability (as measured by the AFQT) and answer form used was found for two tests (Word Knowledge and Coding Speed); however, the

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Interaction did not follow a clearcut pattern. It was recommended that existing ASVAB conversion tables continue in use until completion of a full restandardization study.

PREFACE

This report describes effect of answer form change (from a sheet to IBM size cards) on performance on the Armed Services Vocational Aptitude Battery. Work was accomplished under Project 7719, Air Force Personnel System Development on Selection, Assignment, Evaluation, Quality Control, Retention, Promotion, and Utilization; Task 771910, Armed Forces Operational Selection Tests.

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COMPARABILITY STUDY OF ARMED SERVICES VOCATIONAL APTITUDE BATTERY SCORES FROM ANSWER SHEET AND ANSWER CARD ADMINISTRATION

I. INTRODUCTION

The Armed Services Vocational Aptitude Battery (ASVAB), described by Vitola and Alley (1968) and Bayroff and Fuchs (1970), is currently operational for testing of high school seniors in voluntarily participating high schools throughout the United States. The current form of ASVAB requires the use of a DIGITEK answer sheet, scored on a DIGITEK DM-100 optical scanner located at Randolph Air Force Base, Texas.

With only one form of the ASVAB available, test security requirements dictated that alternate forms of the test be produced. Consequently, ASVAB-2 and -3 were developed and were normed using a geographically representative sample tested at specified Armed Forces Entrance and Examining Stations (AFEES). Beginning in September 1973, ASVAB-2 will be used for high school testing, with ASVAB-3 reserved as the joint services qualifying entrance test.

Form-2 of the ASVAB was standardized on the DIGITEK answer sheets, but with the beginning of high school testing during the fall of 1973, the DIGITEK DM-100 scoring capability at Randolph AFB will be inadequate to handle the anticipated load.

A revised answer form, printed on a three part IBM card, was designed to replace the answer sheet, with a resultant reduction in the amount of space allowed examinees for answer marking. The revised form was designed for scoring via the Hewlett-Packard model WAOO/D mark sense reader also at Randolph AFB.

A preliminary study, to compare the two test response recording methods, was conducted at Lackland AFB, Texas, to determine whether there was test norm slippage due to answer form change.

II. PROCEDURE

Two matched samples, each consisting of 248 male USAF basic airmen assigned to Lackland AFB for processing and training, were administered Form 2 of the ASVAB. One sample was administered Form 2XC (answer card format) while the other was tested on ASVAB Form 2X (answer sheet format). The samples were matched on Armed Forces Qualification Test (AFQT) scores contained in their records. Matching was completed for as many percentile scores as available from within the total number of airmen tested. Distribution of AFQT deciles for the samples is given in Table 1.

Testing was accomplished under normal testing room conditions. ASVAB-2XC and -2X were administered alternately during morning and afternoon testing sessions; each form was administered an equal number of times during each half-day to preclude time-of-day effects. Scoring was accomplished at Randolph AFB on the DIGITEK DM-100 for Form 2X and on the Hewlitt-Packard mark sense reader for Form 2XC.

Two samples were processed separately. Means, standard deviations, and Pearson Product Moment intercorrelation matrices were computed for twenty variables (these included years of education, AFQT, four composites from the Airman Qualifying Examination, data on completion of specific high school courses, and all nine tests of the ASVAB). In addition, each of the two samples was divided into eight subsamples based on AFQT decile, and means and standard deviations of the ASVAB tests were computed for each resulting subsample. Raw score distributions on the nine ASVAB tests were prepared for each of the two samples.

For each ASVAB test, a two-way classification analysis of variance was computed to assess effects of format and of the format x AFQT decile interaction on scores. In this regard, it is noted that a significant effect for AFQT decile would be expected in all cases as a function of correlation between AFQT and the test. Test norms, as previously established, are appropriate if inconsequential effects are found both for format and for the interaction of AFQT decile with format; a significant F ratio on either of these effects, however, would suggest normative adjustments as a consequence of format change.

III. RESULTS

Although the answer sheet sample (2X) contains fewer cases with education beyond high school than does the answer card sample (2XC), the average educational levels are comparable.

Answer sheet sample airmen (2X) indicated completion for more high school math and science courses than did answer card sample cases (2XC) even though sample 2XC had more airmen completing 12 or more years of education (Tables 2 and 3).

The two samples were matched on AFQT score; each case in sample 2X was matched with a sample 2XC case with the same AFQT score. AFQT scores appear to be fairly evenly distributed across the deciles 20 through 90; there were no scores below 20. Actual score range was 21 through 98. Enlistment is not authorized for mental category V (AFQT score 0 - 9) applicants, and recent policy has also excluded those scoring below 21 on AFQT. The percentage of airmen in the samples' AFQT categories I through IV appear to be quite similar to the distribution for recent first term USAF airman accessions. (Unpublished data. See Table 4 for AFQT category distributions.)

Further evidence of comparability of the two samples was found in the distribution of AQE percentile scores. While statistically significant differences were not found between the two groups on any of the four AQE aptitude composites, there were small mean differences in favor of the answer sheet sample; the largest of these were on the Administrative (2.27) and Electronics (1.77) AIs. Distributions, means, and standard deviations of the AQE composites are shown in Table 5.

Minor differences of no significance were noted among the intercorrelations for the two samples. This serves as further evidence that format change did not materially affect the battery (Table 6).

Table 7 shows, for both samples, means and standard deviations for each ASVAB test. In addition, no significant ASVAB test mean differences were found; the largest difference (.62) is on space perception. Thus, it can be seen that the format change makes no difference in average performance.

Outcomes of the nine two-way classification analysis of variance problems are summarized in Table 8. As expected, highly significant F ratios were obtained in all cases for AFQT decile, reflecting correlation between the test and AFQT. In no instance was there a statistically significant answer format main effect; this finding is consistent with the quite small overall mean differences between the two samples (largest difference was .62 on space perception). Significant format x AFQT decile effects were found for two of the nine tests. This interaction was significant at the .01 level for word knowledge and at the .05 level for coding speed. Interestingly, the largest interaction effect would have been expected on coding speed since it is a closely timed test of simple clerical speed and accuracy; consequently, a change in size of the response form had greater potential for affecting performance of "high intelligence" and "low intelligence" subjects differentially. An inspection of the decile-by-decile group means for the two format groups (Table 9) reveals that in AFQT decile 20-29, mean coding speed performance of the answer sheet group is 6.16 raw score points higher than that of the answer card group, and that in decile 50-59, a difference of about the same magnitude occurs, but in favor of the answer card group. Other decile group means for coding speed are approximately equal. In the case of the word knowledge test, format group means differ in favor of the card format group by a little more than three raw score points in the AFQT decile 50-59 and by a little over two raw score points in favor of the answer sheet format in the AFQT decile 60-69. Other decile group means are approximately equal.

These two significant interaction effects would suggest possible differential effect of test response format change on test performance as a function of level of AFQT performance. In both format samples, correlation between AFQT and coding speed is quite modest (low .30s), and correlation between AFQT and word knowledge in both samples is in the low .50s. AFQT has served as the standard against which ASVAB norms are calibrated, but with these relatively modest correlations, it is possible that part of the within AFQT decile difference washes out in conversions utilizing the full samples (as a function of AFQT decile distributional overlap). However, this cannot be clearly determined from these data because of the truncation of the samples on AFQT (approximately the bottom 20 percent of the normative reference population is not represented here).

Raw score distribution for both groups on all nine ASVAB tests are presented in Tables 10 and 11. It is noteworthy that the ASVAB test distributions of the two format samples differ very little from each other.

IV. CONCLUSIONS AND RECOMMENDATIONS

The results of this study suggest comparable ASVAB score results using either the answer card

or the DIGITEK answer sheet. Presently established ASVAB-Form 2 norms may be satisfactory for answer card administration. Although a significant format by AFQT decile interaction was found on coding speed and word knowledge, overall means, standard deviations, and intercorrelations for the two format conditions are nearly the same. This suggests that, despite the significant interaction on these two tests, conversion tables may be affected very little if at all.

Because of AFQT truncation in the data for this study, a final determination of whether conversions for the ASVAB tests are affected by answer form format change must await completion of a full standardization study. Data for such a study have been collected and are being analyzed. It is recommended that present conversions for ASVAB Form 2 continue in use until completion of this standardization study.

Table 1. **Sample Distribution by AFQT Decile**

AFQT Decile	Sample* 2XC	2X	Total	Percent
90-99	35	35	70	14.11
80-89	28	28	56	11.29
70-79	30	30	60	12.10
60-69	27	27	54	10.89
50-59	33	33	66	13.31
40-49	33	33	66	13.31
30-39	37	37	74	14.91
20-29	25	25	50	10.08
Total	248	248	496	100.00

*The two samples are evenly distributed across the range of AFQT scores. No score lower than 21 nor higher than 98 was reported. The two samples are precisley matched on AFQT scores.

Table 2. **Distribution of Educational Level**

Education (years)	Sample* 2XC	2X	Total
8	2	3	5
9	4	9	13
10	23	19	42
11	28	37	65
12	147	145	292
13	20	21	41
14	15	10	25
15	3	3	6
16	6	1	7
Total	248	248	496
Mean	11.96	11.76	11.86
S.D.	1.25	1.16	1.21

*A *t* test of difference between the sample means revealed no significant difference ($t = 1.83$).

Table 3. **Number of Cases Reporting Completion of High School Mathematics and Science Courses**

Course	Sample* 2XC	2X
Algebra	154	162
Geometry	95	106
Trigonometry	29	40
Chemistry	63	76
Physics	34	42

*Chi square tests revealed no significant differences between the two groups.

Table 4. **AFQT Mental Category Distribution of Samples**

Mental Category	Sample* 2XC	2X	Total	Percent*
I (93-100)	23	23	46	9.27
II (65-92)	80	80	160	32.26
III (31-64)	116	116	232	46.77
IV (10-30)	29	29	58	11.69
Total	248	248	496	99.99

*Percentage of Basic Airmen in each mental category is similar to the percentage in each category enlisted into USAF during recent years (July 69 through September 71).

Table 5. **Distribution of AQE Scores**

Percentile	Sample 2XC				Sample 2X			
	Adm	Elect	Gen	Mech	Adm	Elect	Gen	Mech
95	9	19	15	11	8	14	16	11
90	2	10	6	13	7	18	8	14
85	11	15	6	13	12	11	7	19
80	4	20	8	5	10	22	16	13
75	8	11	16	14	6	10	6	8
70	15	13	18	8	17	7	21	13
65	17	5	15	10	12	10	16	13
60	22	29	22	42	26	24	23	32
55	14	31	18	35	12	35	15	21
50	30	18	25	25	25	18	26	22
45	21	28	33	16	20	14	35	16
40	22	17	44	7	25	25	31	15
35	16	3	11	11	21	4	13	14
30	6	15	5	4	15	13	5	7
25	19	10	0	14	9	12	5	6
20	20	2	4	8	13	7	4	8
15	4	2	1	11	3	1	1	10
10	8	3	1	0	6	2	0	4
05	0	4	0	1	0	0	0	1
01	0	2	0	0	1	1	0	1
Total	248	248	248	248	248	248	248	248
Mean	49.25	56.44	56.43	55.89	51.52	58.21	57.34	56.51
S.D.	21.25	21.68	18.24	21.14	21.38	21.80	19.06	22.71

Table 6. **Intercorrelations Among Twenty Variables***

Variable	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Education (1)	13	36	22	35	12	28	30	32	05	10	10	09	04	24	33	46	41	39	36
	14	42	36	37	22	43	29	32	−05	10	15	00	00	10	35	43	30	40	24
AFQT Score (2)		43	67	58	62	32	50	65	50	68	64	50	48	50	36	33	11	27	10
		52	74	63	60	36	56	67	46	68	64	42	43	48	24	25	26	29	20
AQE Admin (3)			56	74	33	53	40	57	01	28	27	09	08	26	43	45	35	36	29
			62	77	49	57	52	60	05	31	30	09	11	22	41	41	40	45	27
AQE Elect (4)				69	60	38	42	65	36	54	54	38	32	49	38	38	24	34	27
				71	72	46	51	67	42	60	65	38	45	53	35	37	32	46	32
AQE Gen (5)					62	44	51	63	20	46	43	26	17	37	41	52	41	47	33
					65	49	57	62	19	42	46	19	19	33	35	41	39	47	26
AQE Mech (6)						24	37	48	58	56	61	57	49	49	24	27	12	23	16
						30	38	45	53	49	62	45	55	52	27	23	32	37	21
Coding Speed (7)							34	49	04	19	27	15	14	18	39	36	24	28	14
							39	41	06	29	21	15	09	11	27	33	26	37	25
Word Knowledge (8)								58	24	41	55	37	33	51	29	39	19	30	18
								55	17	36	48	30	22	43	29	29	26	34	17
Arith Reasoning (9)									29	56	59	38	27	44	45	52	31	42	30
									22	54	53	22	30	36	43	31	29	38	20
Tool Knowledge (10)										45	59	70	62	49	04	06	−04	09	−01
										44	58	56	63	53	01	−02	05	09	12
Space Perception (11)											64	37	35	41	28	30	10	21	13
											64	33	39	37	22	18	17	19	14
Mech Comprehension (12)												60	59	57	21	31	08	25	11
												54	57	60	23	18	17	22	12
Shop Information (13)													68	61	02	05	−06	10	00
													54	53	−02	−02	04	07	05
Auto Information (14)														50	−00	01	−15	11	−00
														58	00	−03	04	05	02
Elect Information (15)															15	24	15	25	14
															20	13	14	18	12
Algebra (16)																56	28	40	29
																56	32	47	22
Geometry (17)																	46	51	39
																	49	56	37
Trigonometry (18)																		45	55
																		37	30
Chemistry (19)																			49
																			42
Physics (20)																			

Decimal points omitted. In each cell, the top entry is based on sample 2XC while the bottom entry is based on sample 2X.

Table 7. **ASVAB Means and Standard Deviations for Samples 2XC and 2X**

Test	Sample			
	2XC		2X	
	Mean	SD	Mean	SD
Coding Speed	43.60	11.42	43.87	11.95
Word Knowledge	14.95	4.26	14.91	4.59
Arithmetic Reasoning	15.00	5.36	14.72	5.43
Tool Knowledge	15.11	5.30	15.19	5.05
Space Perception	16.68	5.05	17.30	5.07
Mechanical Comprehension	14.98	4.58	15.40	4.72
Shop Information	15.67	4.70	15.26	4.57
Automotive Information	15.99	4.68	16.00	4.85
Electronics Information	15.06	4.35	15.49	4.94

Table 8. Analysis of Variance Summary

Source	SS	df	MS	F	P	SS	df	MS	F	P
	Coding Speed					**Word Knowledge**				
Total	70,401.43	495	-	-	-	8,712.67	495	-	-	-
Format	18.97	1	18.97	.16	ns	.20	1	.20	.017	ns
Decile	10,078.23	7	1,439.75	11.80	<.001	2,755.13	7	393.59	33.05	<.001
Format x Decile	1,721.84	7	245.98	2.02	<.05	242.25	7	34.61	2.90	<.01
Error	58,582.39	480	122.05	-		5,715.09	480	11.91	-	
	Arithmetic Reasoning					**Automobile Information**				
Total	14,450.68	495	-	-	-	11,263.00	495	-	-	-
Format	9.88	1	9.88	.60	ns	.06	1	.06	.003	ns
Decile	6,336.65	7	905.24	55.06	<.001	2,540.38	7	362.91	20.20	<.001
Format x Decile	215.12	7	30.73	1.87	ns	98.14	7	14.02	.78	ns
Error	7,889.03	480	16.44	-		8,624.42	480	17.96	-	
	Electrical Information					**Tool Knowledge**				
Total	10,684.71	495	-	-	-	14,085.02	495	-	-	-
Format	23.52	1	23.52	1.46	ns	2.61	1	2.61	.12	ns
Decile	2,855.20	7	407.89	25.24	<.001	3,466.80	7	495.26	22.68	<.001
Format x Decile	48.24	7	6.89	.43	ns	131.97	7	18.85	.86	ns
Error	7,757.75	480	16.16	-		10,483.64	480	21.84	-	
	Space Perception					**Mechanical Comprehension**				
Total	12,751.97	495	-	-	-	10,749.56	495	-	-	-
Format	47.82	1	47.82	3.38	ns	21.39	1	21.39	1.51	ns
Decile	5,857.14	7	836.73	59.09	<.001	4,390.06	7	627.15	44.29	<.001
Format x Decile	51.21	7	7.32	.52	ns	112.02	7	16.00	1.23	ns
Error	6,795.80	480	14.16	-		6,226.09	480	12.97	-	
	Shop Information									
Total	10,677.35	495	-	-	-					
Format	20.98	1	20.98	1.25	ns					
Decile	2,494.26	7	356.32	21.15	<.001					
Format x Decile	74.41	7	10.63	.63	ns					
Error	8,087.70	480	16.85	-						

Table 9. **ASVAB Means and Standard Deviations with AFQT Deciles**

AFQT Decile		Coding Speed		Word Knowledge		Arithmetic Reasoning		Tool Knowledge		Space Perception		Mechanical Comprehension		Shop Information		Automotive Information		Electronics Information	
		2XC	2X	2XC	2X	2XC	2X	2XC	2X	2XC	2X	2XC	2X	2XC	2X	2XC	2X	2XC	2X
90-99	M	51.11	53.97	17.83	18.57	20.66	20.43	19.46	18.43	21.57	22.60	19.49	19.89	19.51	18.31	20.09	18.83	18.97	19.23
	S	8.88	11.50	3.24	3.13	4.19	3.78	3.82	4.10	3.11	3.11	3.39	2.75	3.37	2.82	3.17	3.35	4.07	4.19
80-89	M	45.18	45.00	17.29	17.71	18.50	17.96	18.21	18.46	20.96	20.54	17.54	19.11	18.64	17.86	18.96	18.50	17.79	19.04
	S	11.85	11.98	2.56	2.39	3.74	3.99	4.27	4.63	3.04	3.21	2.94	3.17	3.07	4.64	3.58	4.83	3.14	3.50
70-79	M	43.53	44.37	16.30	16.77	16.93	17.50	16.77	16.53	19.13	19.53	17.20	17.27	16.93	16.93	16.73	18.10	16.07	17.50
	S	10.03	11.90	3.02	3.89	3.86	3.94	4.35	4.27	3.21	3.13	2.90	3.58	4.69	3.95	4.16	4.10	3.74	3.30
60-69	M	44.19	47.96	14.22	16.33	14.56	15.96	15.07	14.59	17.37	19.26	15.33	15.81	15.56	15.37	14.59	15.04	14.30	14.30
	S	9.39	9.19	4.75	3.78	4.27	4.47	4.75	4.98	4.02	3.26	4.33	3.42	4.72	3.40	4.56	4.15	3.49	3.92
50-59	M	46.18	40.03	16.18	13.09	15.21	12.09	13.64	15.67	15.45	16.00	14.12	14.40	14.36	14.67	14.94	16.24	14.03	14.91
	S	11.03	11.12	3.30	4.66	4.57	4.06	4.24	4.80	4.03	4.05	3.31	4.74	3.47	4.65	4.25	4.40	4.36	4.45
40-49	M	42.61	40.45	14.12	13.45	13.42	14.21	13.70	13.87	14.00	14.88	14.24	13.24	14.91	13.45	15.85	15.30	13.97	13.88
	S	12.16	12.03	3.32	4.26	3.41	3.76	4.39	4.51	3.41	4.64	3.39	4.16	3.71	4.79	4.06	4.86	3.70	4.88
30-39	M	39.84	38.89	12.70	12.59	10.89	9.95	12.51	11.00	13.30	13.24	11.97	12.41	12.49	13.30	13.54	13.08	12.65	12.24
	S	10.29	10.60	4.17	4.37	4.30	4.08	5.42	5.74	4.86	4.21	3.82	3.70	4.50	3.91	4.07	4.31	3.18	5.41
20-29	M	34.20	40.36	10.28	10.64	9.24	9.64	11.32	11.16	11.52	12.40	9.32	10.84	13.00	12.00	12.72	12.76	12.48	12.88
	S	9.85	8.77	3.88	3.33	3.51	4.09	5.17	3.97	3.32	3.88	3.45	3.56	4.57	4.34	4.26	5.05	3.94	4.96

Table 10. **Raw Score Distributions on Coding Speed***

(Samples 2XC and 2X)

Score	2XC	2X	Score	2XC	2X	Score	2XC	2X	Score	2XC	2X	Score	2XC	2X
80			64	2	2	48	12	9	32	7	9	16		1
79			63	3	2	47	8	9	31	4	2	15	1	
78	1		62	1		46	6	9	30	7	1	14	1	
77			61	1	4	45	8	4	29	3	4	13	1	
76	1	1	60	4	1	44	9	7	28	1	6	12		
75			59	5	5	43	13	9	27	3	4	11		
74			58	3		42	11	11	26	2	4	10		
73		1	57	6	3	41	10	4	25	1	1	9		
72		3	56	5	6	40	6	7	24	4	2	8		
71		1	55	9	5	39	6	13	23	4		7		
70		2	54	3	8	38	9	2	22	2	2	6		
69		1	53	5	8	37	3	8	21		2	5		
68	1		52	5	7	36	7	5	20	2		4		
67	2	2	51	9	5	35	9	8	19		2	3		
66		2	50	6	10	34	2	7	18		1	2		
65	2		49	7	8	33	4	6	17	1	2	1		
												Total *N* =	248	248

*Score range is from 0 to 100. Scoring formula: Right only

Table 11. **Raw Score* Distributions for ASVAB Tests 2 Through 9**
(Samples 2XC and 2X)

	WK		AR		TK		SP		MC		SI		AI		EI	
Scores	2XC	2X	2XC	2X	2XC	2X	2XC	2X	2XC	2X	2XC	2X	2XC	2X	2XC	2X
25	1	1	6	4	2	3	9	15	2	2	5	1	2	5	5	4
24	3	6	13	17	12	11	18	20	3	7	5	3	13	11	6	10
23													1			
22	6	6	8	10	18	15	16	21	11	10	13	10	18	16	10	12
21	4	15	18	9	14	15	24	25	12	15	20	22	17	22	10	16
20	20	14	15	17	20	20	28	23	19	19	19	17	21	25	11	22
19	1	1	5	6		1	1	2	5	2	1			3		1
18	43	30	14	12	20	18	22	19	28	32	21	25	22	14	20	23
17	19	25	24	19	21	20	17	20	21	29	31	26	26	23	27	21
16	42	30	23	18	21	25	18	22	26	30	28	39	23	21	33	22
15	3	4	2	7		1		4	5	6	2	5	2	8	1	7
14	25	31	22	19	26	25	20	19	22	18	25	23	28	18	33	22
13	22	24	17	31	18	17	22	15	32	18	24	18	20	26	34	29
12	13	14	22	14	18	18	18	10	12	9	15	9	12	12	18	13
11		2		7	1	4		3	4	4	3	4	2	5	1	9
10	16	13	18	16	18	22	14	8	10	10	14	15	12	8	11	8
9	11	7	13	11	9	10	8	9	10	13	7	9	15	18	13	10
8	6	7	11	8	14	11	5	6	11	10	5	10	9	5	8	5
7	1	5	1	3	2	1			5	3		1				3
6	5	6	4	8	2	5	5	4	4	6		5	1	2	4	3
5	3	3	6	4	5	1			3		3	1	4	4		3
4	1	1	2	3	2	2	1	1	1	3	4	2		2	1	1
3	1	1		1	1			2		1		1				1
2	2	1	2	3	3	3	2		2		1				2	1
1			1	1	1					1	2	2				2
0			1													
2		1														

*Scoring formulae: R-W/3.

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