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SCREENING TEST BATTERY FOR DENTAL LABORATORY SPECIALIST COURSE:--ETC(U)
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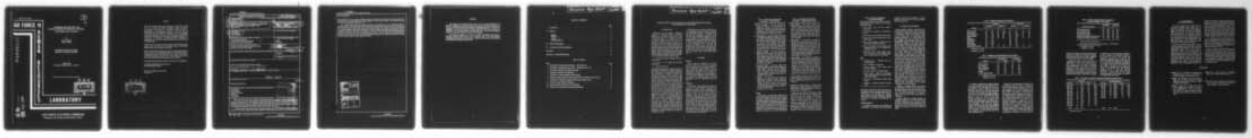

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AIR FORCE HUMAN RESOURCES LABORATORY

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SCREENING TEST BATTERY FOR DENTAL LABORATORY SPECIALIST COURSE: DEVELOPMENT AND VALIDATION

By

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October 1977
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AIR FORCE SYSTEMS COMMAND
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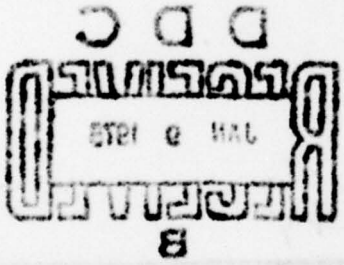

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The object of this study was to develop a valid replacement for the difficult to administer and costly Chalk Carving Test presently used in screening Dental Laboratory Specialist (DLS) candidates. An experimental battery of perceptual tests was given to 172 prospective DLS students. Dexterity tests were also given to a subsample. Experimental laboratory ratings and final course grades, if available, were obtained for the subjects. Tests were factor analyzed, and individual and multiple validity correlations were computed.

The Chalk Carving Test presently used in screening prospective DLS students did not demonstrate significant validity with laboratory ratings or final grades. This lack of relationship seems partly due to somewhat subjective

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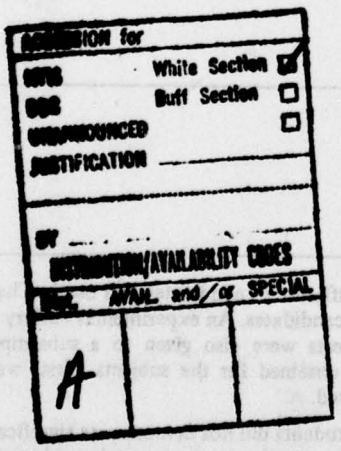
scoring reflected by a low interrater reliability. Several of the experimentally administered perceptual tests and a finger dexterity test (Peg Turning) did correlate significantly with laboratory ratings. A few perceptual tests also were valid for predicting DLS final grades.

The General Aptitude Index was significantly related to final grades, but was not substantially related to laboratory ratings. A composite based on four perceptual tests appeared able to screen out about one-half of the 15% of students with the lowest performance in DLS course laboratory work. While the Peg Turning test appeared to make an independent contribution to prediction of laboratory ratings, this apparatus test presents cost and test administration problems which make it less attractive. In contrast, the use of the Perceptual Composite (in place of the Chalk Carving Test) would reduce test administration time about 15%, test scoring time at least 50%, and test material costs would also be reduced. In addition, this study indicates that DLS training attrition should be lowered somewhat through utilization of the Perceptual Composite.



PREFACE

This research was conducted under project 7719, Air Force Development of Selection, Assignment, Performance Evaluation, Retention and Utilization Devices; task 771912, Air Force Selection and Classification Technologies. Work unit 77191218 was established in response to Request for Personnel Research (RPR 73-13), submitted by ATC/XPTT (Lt Col Wayne Shore and Maj Ralph Crow, Requirements Managers), entitled "Comparison of Selection Tests for Dental Training."

Testing was accomplished at the School of Health Care Sciences, Department of Dentistry, Sheppard AFB, Texas, and at Lackland AFB, Texas. We gratefully acknowledge the contributions of personnel at Sheppard AFB. Sgt Louis Kaluza assisted in testing and data analysis at Lackland AFB.

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SCREENING TEST BATTERY FOR DENTAL LABORATORY SPECIALIST COURSE: DEVELOPMENT AND VALIDATION

I. INTRODUCTION

Since the Air Force makes a considerable investment in selecting enlistees for technical training, one of the primary goals of the operational testing program is to maximize the return on training expenses by predicting and, subsequently, selecting enlistees who will be as successful as possible in a training program. One of the longer Air Force training courses is the 24-week course for Dental Laboratory Specialist (DLS, AFSC 98230), at the School of Health Care Sciences (SHCS), Sheppard AFB, Texas. This specialty mainly involves fabricating and repairing dental prostheses and appliances; such as jackets, crowns, bridges, and inlays. Selection of airmen for the DLS course is based on three criteria:

1. A minimum General Aptitude Index percentile of 60.

2. A score of 10 or higher on the Chalk Carving Test.

3. Normal color vision.

The General Aptitude Index consists of the Word Knowledge and Arithmetic Reasoning subtests of the Armed Services Vocational Aptitude Battery. This requirement is employed to ensure that students have adequate academic ability to learn the material presented in the course. The Chalk Carving Test is a carving dexterity exercise which measures ability in the psychomotor domain. This test was introduced in 1963 to ensure that the students possess the dexterity required to perform the exercises in the course. The Chalk Carving Test has also been used by the American Dental Association as the manual abilities portion of a battery for selection of dental students. In recent years, the Chalk Carving Test has been replaced in civilian use by the Perceptual Motor Ability Test (PMAT). The PMAT is a paper-and-pencil test designed to measure line and angle discrimination, point location, block counting, space relations, and object visualization (Graham, 1972). A preliminary Air Force study indicated the PMAT correlates higher with end-of-course grades for Dental Laboratory Specialist students than does the Chalk Carving Test ($r = .57$ and .48, respectively). This paper-and-pencil test also has advantages in being less expensive and easier to administer and score.

Initial plans were to validate the PMAT for Air Force operational utilization. However, the PMAT was unavailable because the American Dental Association felt the danger of compromise of the two test forms precluded releasing the test for research purposes. Therefore, available tests with content similar to that of the PMAT were selected. In addition, several dexterity tests were included in the experimental battery. This was done because the evidence is not conclusive that perceptual tests can adequately predict dexterity. In fact, both types of tests may make unique contributions to prediction of training performance (see French, 1951; Harrel, 1940; Zullo, 1971).

II. METHOD

Subjects

Airmen selected as candiates for the DLS course in 1975 and 1976 were the subjects ($N = 172$). Sample 1 ($N = 114$) was utilized for factor analysis and initial validation of experimental tests. The majority of this group was administered dexterity tests in addition to perceptual tests. Sample 2 ($N = 58$) was composed of the last three DLS classes of 1976. This group was utilized for additional validation and was administered only the experimental perceptual tests.

Predictors

Descriptions of the perceptual and dexterity parts of the experimental test battery are presented in Tables 1 and 2, respectively. The operational General Aptitude Index (GEN AI) and Chalk Carving Test were also included as predictors. Under normal conditions, all DLS candidates would have taken the Chalk Carving Test, but for experimental purposes, members of several classes who had volunteered for the course were exempted from taking the tests. In the Chalk Carving Test, the student is furnished an 80mm piece of chalk, a knife, and sandpaper and is given 1 hour to carve the chalk evenly and smoothly to the dimensions and shape specified in the instructions. The score range is from 1 to 20 with five subscores, one for overall appearance and the rest for preciseness of dimensions.

Table 1. **Description of Experimental Test Battery – Perceptual Tests**

1. **Block Counting** – this test requires the examinee to "see into" a 3-dimensional pile of blocks and determine how many pieces are touched by a certain numbered block. This test is divided into two sections of 45 items each, with a time limit of 4 minutes per section.
2. **Point Distance** – this test requires the examinee to compare small distances rapidly. Each item has a marked central point surrounded by lines and circles, among which there is a dot marked "a" and "b." The examinee must quickly decide which of the two lettered dots is nearer to the central point. This test is divided into two sections, each containing 30 items with a maximum time limit of 2 minutes per section.
3. **Pattern Matching** – this test requires the examinee to solve pattern matching problems. Each item has a pattern with a part of the whole missing. The examinee must look at the parts under the pattern and decide which one belongs in the blank space, thereby completing the pattern. This test contains 37 items with a time limit of 20 minutes.
4. **Rotated Blocks** – this test requires the examinee to select from among five choices, the block which is identical to the "question" block. Each of the five options is presented from a different angle or side than the "question" block. This test has 20 items with a time limit of 20 minutes.
5. **Designs** – this test requires the examinee to select, from a number of parts, those parts which will fit together to form the "question" design correctly. Pieces used for the construction may vary from two to a maximum of ten. This test contains 22 items and has a time limit of 20 minutes.

Table 2. **Description of Experimental Test Battery – Manual Dexterity Tests**

1. **Mark Making** – this exercise requires the examinee to make three pencil marks, working as fast as he/she can, in a series of boxes. The marks to be made consist of two vertical lines with a 0 between them. The exercise consists of one 10-second practice period and another 20-second practice period. The final part is a 60-second period from which the reported score is derived.
2. **Peg Placing**[a] – the examinee is required to remove two pegs from the upper part of the pegboard, one in each hand, and place them in corrrsponding holes in the bottom half. This procedure is performed three times with the examinee working as rapidly as he/she can to remove as many pegs as possible in three 15-second time trials. The reported score is the total number of pegs successfully transferred by the examinee in the three periods.
3. **Peg Turning**[a] – the examinee is required to remove one wooden peg from a hole and, using only that one hand, turn the peg upside down so that the alternately colored end will go into the hole. The examinee works as rapidly as possible to turn and place as many pegs as he/she can in three 30-second time trials. The reported score is the total number of pegs successfully turned and replaced by the examinee in the examinee in the three periods.

[a]The equipment for these two exercises consists of a rectangular pegboard divided into two sections, each section containing 48 cyclindrical holes. For each exercise, 48 cylindrical pegs are placed in one section of the pegboard.

Criteria

Performance in the laboratory portion of the course was deemed to be the appropriate criterion on which to validate the tests. An Air Training Command regulation requires laboratory performance to be assessed on a satisfactory/unsatisfactory basis. To avoid the psychometric disadvantages of a dichotomous measure for which most of the subjects are in the pass group, an experimental rating form was devised. It was requested that the course instructor rate seven performance categories for each student on a 7-point rating scale (Table 3). Several ratings were obtained for most students; therefore, ratings were converted to T-scores (mean = 50 and *SD* = 10).

Some of those tested did not pass the Chalk Carving Test, and some were not assigned to the DLS course for other reasons; consequently, laboratory ratings were available for 137 tested subjects. DLS final grades also were used as a criterion. These grades were obtained from technical training files at the same time GEN AI scores were obtained from the Processing and Classification of Enlistees (PACE) files. These files are maintained by the Computational Sciences Division of the Air Force Human Resources

Table 3. **Performance Categories for Laboratory Ratings**

Each student is rated on a scale of 1 to 7 for each of these categories:

A. How much work can the student accomplish?

B. How good is the quality of the student's work?

C. How accurate is the student in his/her work?

D. How much does the student know about his/her work?

E. How much aptitude or facility does the student have for this kind of work?

F. How resourceful is the student when something new comes up or something out of ordinary occurs?

G. Considering all the factors already rated, how acceptable is the student's work (his/her all-around ability to do the job)?

Scale

1. Unsatisfactory – Dismissed from the training program.
2. Poor – Deficient in many areas.
3. Below Average – Work usually meets acceptable standards.
4. Average – Work is of acceptable quality.
5. Above Average – Work is of acceptable quality and occasionally demonstrates a high degree of proficiency.
6. Very Good – Performance is usually of high quality.
7. Excellent – Unusually proficient in his/her work.

Laboratory, Brooks AFB, Texas. These data were not available for the last DLS class since they were requested prior to its graduation date. Data for some students were not available in technical training and/or PACE files. Final grades and GEN AI scores were available (in common) for 95 subjects.

Statistical Methods

A principal components factor analysis was accomplished for the predictor variables. Multiple correlation analyses were employed to obtain estimates for the utility of the tests in predicting criterion performance.

III. RESULTS AND DISCUSSION

Means, standard deviations, and intercorrelations for predictors are listed in Tables A2 and A3 of Appendix A. Validities of predictors for sample 1 are presented in Table 4. With laboratory ratings as the criterion, only two experimental tests correlated significantly (i.e., Rotated Blocks and Peg Turning). One other perceptual test had near-significant validity (Designs, p less than .10). Against DLS final grade, only Pattern Matching and Rotated Blocks demonstrated significant validity. Neither operational selection test correlated with laboratory ratings, but the GEN AI was valid for prediction of final grades. Explanations for the lack of validity of the Chalk Carving Test were sought. The effect of pre-screening was partially tested by comparing laboratory ratings of those passing the Chalk Carving Test with ratings of those not taking the test. If the selection test is valid, those not screened should perform less well on the criterion. Virtually no difference was found between laboratory ratings of these two groups. The degree of subjectivity in scoring the Chalk Carving Test was examined. Pieces of chalk for 55 airmen tested at Lackland AFB, Texas, were sent to the School of Health Care Sciences at Sheppard AFB, Texas, for independent scoring by qualified raters. The correlation between the two sets of scores was only .28. This indicates that low inter-rater reliability may account for the lack of validity in this study for the Chalk Carving Test. In comparison, test-retest reliabilities obtained for perceptual tests as reported elsewhere (Guinn, Tupes, & Alley, 1970) ranged from .90 for Block Counting to .73 for Point Distance.

Validities of available predictors for sample 2 are also shown in Table 4. The results for the perceptual tests were somewhat better, but due to the smaller sample size, only two experimental tests correlated significantly with laboratory ratings. The GEN AI was valid for prediction of final grades.

Predictor validities for combined samples are presented in Table 5. Four of the perceptual tests correlated significantly with laboratory ratings, and three of them correlated significantly with final grades. The GEN AI was again valid with final grades as the criterion, but not with laboratory grades.

Table 4. **Validities for Samples of DLS Students**

Predictor	Lab Rating				Final Grade			
	Sample 1		Sample 2		Sample 1		Sample 2	
	N	r	N	r	N	r	N	r
Block Counting	79	.15	58	.32*	62	−.10	33	.26
Point Distance	79	.09	58	.35**	62	−.01	33	−.09
Pattern Matching	79	.14	58	.20	62	.36**	33	.27
Rotated Blocks	79	.22*	58	.24	62	.42**	33	.29
Design	79	.20	58	.22	62	.20	33	.23
Mark Making	79	.10	..	..	62	−.19	..	..
Peg Placing	51	−.02	..	..	38	−.10	..	..
Peg Turning	51	.27*	..	..	38	−.14	..	..
Chalk Carving	54	−.12	..	..	48	.17	..	..
General Aptitude Index	68	.10	33	.28	62	.42**	33	.47**

*Significant at .05 level.

**Significant at .01 level.

Table 5. **Validities for Combined Samples of DLS Students**

Predictor	Lab Rating		Final Grade	
	N	Validity	N	Validity
Block Counting	137	.22**	95	.14
Point Distance	137	.21*	95	.06
Pattern Matching	137	.15	95	.23*
Rotated Blocks	137	.21*	95	.28**
Designs	137	.20*	95	.22*
General Aptitude Index	101	.18	95	.44**

*Significant at .05 level.

**Significant at .01 level.

A multiple correlation (R) was computed based on all five perceptual tests (see Table 6). The R was significant with both laboratory ratings and final grades as criteria. Multiple Rs were then computed using the four most valid perceptual tests. The R with laboratory ratings remained at .35, and the R with final grades dropped insignificantly from .36 to .35. A composite was formed (based on these four tests) in which Block Counting and Designs were unit-weighted. Point Distance was double-weighted, and Rotated Blocks was triple-weighted. These weights were chosen as approximations to the raw score regression weights. This Perceptual Composite had significant validities of .32 with laboratory ratings and .24 with final grades. A drop in validity is expected when compared to the multiple R, because of the simple weighting system.

Because any DLS screening test would be used in conjunction with the GEN AI, multiple Rs based on the Perceptual Composite and GEN AI were computed. The Rs with laboratory ratings and final grades were .36 and .49, respectively. For both criteria, the addition of the Perceptual Composite represented a significant increase over that obtained with the GEN AI as sole predictor. For the limited data available (N = 51), when the Peg Turning dexterity test was added to the Perceptual Composite, a multiple R of .44 with laboratory ratings was obtained. This represents a significant increase in prediction. However, this test, which is considered a measure of finger dexterity, shares several of the disadvantages of the Chalk Carving Test. The apparatus is somewhat expensive and requires a room with tables for administration. In addition, it must be scored at

Table 6. **Multiple Correlations (Rs) of Combinations of Tests for Prediction of DLS Criteria**

Predictor Combination	Lab Rating		Final Grade	
	N	r	N	r
Five Perceptual Tests	137	.35**	95	.36*
Four Perceptual Tests[a]	137	.35**	95	.35*
Three Dexterity Tests	51	.30	43	.22
Perceptual Composite[b]	137	.32**	95	.24*
Perceptual Composite and Peg Turning	51	.44*	43	.26
Perceptual Composite and GEN AI	95	.36**	95	.49**

[a]Does not include Pattern Matching.

[b]Composed of Block Counting + 2 x Point Distance + 3 x Rotated Blocks + Designs. Coefficients are simple correlations.

*Significant at .05 level.

**Significant at .01 level.

once by the examiners, and the scoring cannot be verified later. Unlike the Perceptual Composite, the Peg Turning test did not make a significant contribution to prediction of DLS final grades.

Correlational analyses indicate the degree of relationship of two or more variables over the entire range of scores and assume multivariate normal distributions. The utility of a screening instrument, however, is often determined by the relationship of low predictor scores to criterion performance. In this instance, a cutoff score on the Perceptual Composite was sought below which laboratory performance would likely be marginal or unsatisfactory. Grouped frequency distributions of these variables are presented in Table 7. Twenty-two or 16.1% of the students had Perceptual Composite scores of less than 150. Their average laboratory rating was 42.9 compared to 51.5 for those with Perceptual Composites of 150 or higher. Nine or 40.9% of the 22 had laboratory ratings of less than 40 (1 SD below the mean), and an additional 18.2% had laboratory ratings of 40–44. Of those with Perceptual Composites of 150 or more, only 9.6% had laboratory ratings below 40. The average Composite score for the 19 students with laboratory ratings below 40 was 158.1.

Table 7. **Comparison of Laboratory Ratings and Perceptual Composite Scores**

Lab Rating[a]					Perceptual Composite				
PC Range	N	Mean	Cumul. N	%	LR Range	N	Mean	Cumul. N	%
240 & more	7	54.1	137	100.0	65 & more	10	200.8	137	100.0
230–239	3	50.7	130	94.9	60–64	14	198.9	127	92.7
220–229	5	50.8	127	92.7	55–59	20	192.3	113	82.5
210–219	4	52.5	122	89.1	50–54	33	183.1	93	67.9
200–209	21	55.0	118	86.1	45–49	18	170.8	60	43.8
190–199	21	50.7	97	70.8	40–44	23	180.5	42	30.7
180–189	14	53.8	76	55.5	35–39	13	154.5	19	13.9
170–179	14	48.5	62	45.3	34 & less	6	166.0	6	4.4
160–169	18	51.1	48	35.0					
150–159	8	44.8	30	21.9					
140–149	5	42.2	22	16.1					
130–139	7	41.7	17	12.4					
129 & less	10	44.1	10	7.3					
Total	137	50.1			Total	137	181.8		

[a]Converted to T-scores.

IV. CONCLUSIONS AND RECOMMENDATIONS

The Chalk Carving Test presently used in screening prospective DLS students did not demonstrate significant validity with laboratory ratings or final grades. This lack of relationship seems partly due to the somewhat subjective scoring as reflected by a low interrater reliability ($r = .28$). Several of the experimentally administered perceptual tests and a finger dexterity test (Peg Turning) did correlate significantly with laboratory ratings. A few perceptual tests also were valid for predicting DLS final grades.

The General Aptitude Index which is used for academic screening of DLS candidates was significantly related to final grades ($r = .44$), but was not substantially related to laboratory ratings. A composite, based on four perceptual tests, appeared able to screen out about one-half of the 15% of students with the lowest performance in DLS course laboratory work. Of the 13.9% with the lowest laboratory ratings, 47.4% were also among the 16.1% with the lowest Perceptual Composite scores. While the Peg Turning test appeared to make an independent contribution to prediction of laboratory ratings, this apparatus test presents cost and test administration problems which make its use less attractive. In contrast, the use of the Perceptual Composite in place of the Chalk Carving Test would reduce test administration time about 15%, test scoring time at least 50%, and test material costs would also be reduced. In addition, this study indicates that DLS training attrition should be lowered somewhat through utilization of the Perceptual Composite.

It is recommended that the Perceptual Composite be instituted as a screening instrument in place of the Chalk Carving Test for selection of airmen for DLS training. A cutoff score of 150 appears to be the most efficient minimum requirement for selection on this test.

Due to the validity of the Peg Turning test for the limited sample given this test, it is recommended that additional DLS students be administered Peg Turning and also rated on laboratory performance. Then, if Peg Turning continues to demonstrate useful validity, it could be added to the Perceptual Composite or replace one of the four subtests for operational administration in a centralized location.

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APPENDIX A: SUPPLEMENTAL STATISTICS

Prior to collection of criterion data, factor analysis of the experimental tests was accomplished using sample 1 data. Three factors resulted which accounted for 57.4% of the total variance after the matrix was rotated. Table A1 shows the tests loading the highest on each factor (only loadings of .3 or more are given). Factor 1 is clearly perceptual in nature, as Rotated Blocks, Designs, Block Counting, and Pattern Matching all had loadings of greater than .7. Factor 2 appears to be dexterity. Peg Turning and Peg Placing both had loadings of greater than .7 on this factor. Factor 3 was labeled length estimation because Point Distance had by far the highest value on this factor. Somewhat surprisingly, the Chalk Carving Test was not high on the dexterity factor. All three factors seemed to have some relevance to the DLS course. All of the tests loaded highly on at least one factor.

Table A1. **Results of Factor Analysis of Predictors**

	Factor		
Test	1	2	3
Block Counting	.75	*	
Point Distance			.79
Pattern Matching	.74		
Rotated Blocks	.79		
Designs	.76		
Chalk Carving			.48
Mark Making		.57	
Peg Placing		.71	.42
Peg Turning		.78	
Percent of Total Variance	27.3	16.8	13.4

[a]Only loadings of .3 or more are listed.

Table A2. **Means and Standard Deviations for DLS Samples**

	Sample 1			Sample 2		
Measure	N	Mean	SD	N	Mean	SD
Block Counting	114	26.11	11.39	58	29.24	9.53
Point Distance	114	27.25	9.26	58	26.64	10.38
Pattern Matching	114	27.26	5.99	58	23.24	7.30
Rotated Blocks	114	7.80	5.13	58	5.03	4.45
Designs	114	65.54	10.55	58	69.88	6.19
Mark Making	114	46.17	6.14	..	..	..
Peg Placing	84	88.54	8.53	..	..	..
Peg Turning	84	92.30	9.61	..	..	..
Chalk Carving	89	11.40	4.15	..	..	..
General Aptitude Index	68	70.50	9.00	33	74.39	12.55
Lab Rating	79	31.71	7.14	58	28.06	7.75
Final Grade	62	80.66	6.04	33	80.91	6.12

Table A3. **Predictor Intercorrelations for Combined DLS Samples**

	PD	PM	RB	DS	MM	PP	PT	CC	GI
Block Counting	26[a]	24	18	32	25	35	12	−10	18
Point Distance		06	04	12	10	09	−09	02	00
Pattern Matching			62	14	11	07	−11	06	18
Rotated Blocks				12	06	−06	−04	−06	02
Designs					26	12	−16	05	08
Mark Making						21	03	03	−07
Peg Placing							37	23	07
Peg Turning								12	02
Chalk Carving									21
General Aptitude Index									

[a]Decimals have been omitted.

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AD-A048 120 AIR FORCE HUMAN RESOURCES LAB BROOKS AFB TEX F/G 5/9
SCREENING TEST BATTERY FOR DENTAL LABORATORY SPECIALIST COURSE:--ETC(U)
OCT 77 J J MATHEWS, H E JENSEN
UNCLASSIFIED AFHRL-TR-77-53 NL

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SUPPLEMENTARY

INFORMATION

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Errata

Number	First Author	Title
AFHRL-TR-76-87 (AD-A037 522)	Jensen	Armed Services Vocational Aptitude Battery Development (ASVAB Forms 5, 6, and 7)
AFHRL-TR-77-28 (AD-A044 525)	Hunter	Validation of a Psychomotor/Perceptual Test Battery
AD-A048120 AFHRL-TR-77-53 (AD-A048 120)	Mathews	Screening Test Battery for Dental Laboratory Specialist Course: Development and Validation
AFHRL-TR-77-74 (AD-A051 962)	Mathews	Analysis Aptitude Test for Selection of Airmen for the Radio Communications Analysis Specialist Course: Development and Validation
AFHRL-TR-78-10 (AD-A058 097)	DeVany	Supply Rate and Equilibrium Inventory of Air Force Enlisted Personnel: A Simultaneous Model of the Accession and Retention Markets Incorporating Force Level Constraints
AFHRL-TR-78-74 (AD-A066 659)	Leisey	Characteristics of Air Force Accessions: January 1975 to June 1977
AFHRL-TR-78-82 (AD-A063 656)	Mathews	Prediction of Reading Grade Levels of Service Applicants from Armed Services Vocational Aptitude Battery (ASVAB)
AFHRL-TR-79-29 (AD-A078 427)	Hendrix	Pre-Enlistment Person-Job Match System
AFHRL-TR-79-83 (AD-A090 499)	Gustafson	Recursive Forecasting System for Person-Job Match

Due to norming problems encountered with ASVAB Forms 5, 6, and 7, percentile scores derived from these test forms are in error. While the relative ranking of individuals by their percentile scores would not be affected by the norming errors, their absolute score values would be different. Therefore, descriptive statistics reported in the subject technical reports above are erroneous; other types of analyses in the report which use ASVAB percentile scores should be interpreted with caution.

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