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Uniqueness of a Psychomotor Construct to ASVAB

Paul W. Mayberry
D. R. Divgl

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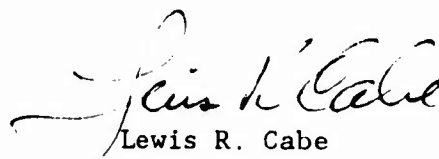
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Uniqueness of a Psychomotor Construct to ASVAB

Paul W. Mayberry
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ABSTRACT

Computerized administration of the Armed Services Vocational Aptitude Battery (ASVAB) potentially offers several benefits over the current paper-and-pencil administration. One benefit is the possible expansion of predictor tests beyond the dominant mathematical and verbal orientation of the ASVAB. This research memorandum first examines the comparability of measurement for the computerized and paper-and-pencil tests. Second, several new tests that measure psychomotor skills (hand-eye coordination and manual dexterity) are examined for their ability to expand the range of dimensions currently assessed by the ASVAB, as well as to improve the prediction of performance in mechanical maintenance jobs.

EXECUTIVE SUMMARY

The Department of Defense (DOD) is investigating the potential of a computerized adaptive testing (CAT) version of its selection battery, the Armed Services Vocational Aptitude Battery (ASVAB). However, before implementing CAT-ASVAB, it is necessary to confirm that this computerized version of ASVAB results in the same measurements as the paper-and-pencil (PP) version. The computerized administration of ASVAB also allows for the possible assessment of many new constructs that could not be measured using the PP format. A psychomotor construct is one such dimension. The purpose of this research memorandum is to address each of these issues: comparability of factor structure of CAT-ASVAB and PP-ASVAB; uniqueness of psychomotor tests to the ASVAB structure; and ability of psychomotor measures to improve prediction of mechanical performance.

The sample was composed of Marine Corps automotive and helicopter mechanics who were tested as part of the Job Performance Measurement (JPM) project. Only complete data cases were used for the factor analyses, which resulted in a sample size of 1,252. The analyses of incremental validity were based on 775 automotive mechanics who had complete predictor and hands-on performance criterion data. Two sources of aptitude information were available: enlistment PP aptitude scores and current aptitude scores obtained from administration of the CAT-ASVAB. Five measures of psychomotor skills were concurrently administered with CAT-ASVAB. Two of these tests assessed general hand-eye coordination and the other tests measured dexterity. Hands-on performance tests served as the performance criterion for the ground mechanics.

RESULTS

Factor Structure of PP and CAT-ASVAB

A four-factor solution of the ASVAB subtests resulted in a simple structure for separate analyses of PP and CAT scores. Examining the factor-pattern matrix showed that the CAT speed factor was more mathematically oriented than the PP speed factor. Several subtest differences also were noted between the CAT and PP administrations. However, care must be taken in interpreting factor-structure differences for the subtests because of the unknown effect of intervening training on the CAT scores (relative to PP scores at time of enlistment) and the analysis of selected samples.

Essentially equal communality estimates were found for the CAT and PP subtests, which showed little, if any, improvement in reliability was gained from using computerized adaptive tests. Factor intercorrelations showed that the CAT factors were less correlated and, therefore, may possibly provide more differential validity than the PP version.

Similar factor analyses were conducted with the psychomotor tests included to determine their uniqueness relative to the ASVAB dimensions. The dexterity tests and the coordination tests defined distinct factors. The same results were achieved whether based on enlistment PP scores or CAT-ASVAB scores. Therefore, all of the psychomotor measures satisfied the initial requirement of being unique and different from the constructs currently assessed by the ASVAB.

Incremental Validity of Psychomotor Measures

The ten ASVAB subtests, time in service, and its square were excellent predictors of automotive hands-on performance. The multiple correlations, corrected for range restriction and shrinkage, were .68 and .74 for enlistment PP scores and CAT scores, respectively. These multiple correlations served as the base for measuring increments in validity achieved by the psychomotor tests. To limit the number of significance tests and thereby not overly capitalize on chance, aggregated measures of the dexterity and coordination dimensions, not their respective subtests, were entered into the regression. Less than one validity point was gained by combining these two aggregated psychomotor measures compared to the corrected enlistment validities. No improvement in validity was made relative to the concurrent CAT aptitude subtests. Thus, despite the uniqueness of the psychomotor measures evidenced by the results of the factor analyses, the tests were not able to enhance the prediction of the mechanical hands-on performance tests.

CONCLUSIONS

Aptitude measurements made by CAT-ASVAB may differ slightly from the current PP-ASVAB. These differences may have implications for changing the historical meaning and, consequently, the validity of the service aptitude composites. However, these results should not be overinterpreted. Factor analyses of selected samples, even with corrections for range restriction, pose difficult issues for interpreting factoring outcomes. There are also unknown effects associated with comparing the same samples on aptitude measures administered at different times with substantial intervening events that affect the predictor tests (i.e., training). This study clearly was not designed to properly or fully address this comparability of measurement issue. Similar analyses should be conducted and reported based on sufficiently large samples of military applicants.

The coordination tests and the dexterity tests were found to represent unique and distinct factors relative to the constructs measured by the ASVAB. The two sets of tests were also unique relative to each other and did not define a common psychomotor factor as was anticipated. From the perspective of expanding the predictor space of the ASVAB, either set of measures would accomplish this goal. Despite the uniqueness of the coordination and dexterity tests, neither set of tests was able to add significantly to the ASVAB's prediction of

mechanical hands-on performance. This is not to say that the coordination and dexterity tests would not significantly improve prediction for other specialties in which these psychomotor dimensions relate to job performance.

ASVAB was shown to be an excellent predictor of mechanical job performance. New tests measuring aptitude dimensions different from those of the current ASVAB are not necessary for selection purposes. Large payoffs potentially exist in the realm of improved recruit assignments for job classification, although this study did not find such gains for automotive mechanics. To satisfy the stringent requirements for inclusion of a new test into the joint-service battery, the test must demonstrate incremental validity across all services as well as multiple jobs within a service. A new test sufficiently unique to produce incremental validity is likely to measure a specialized trait and thus will improve prediction in only a narrow range of jobs. Therefore, the likely benefit of any new predictor test is not in the form of supplementing or revising a joint-service instrument, but rather in terms of potentially addressing service-specific needs for improving classification for selected specialties.

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INTRODUCTION

The Department of Defense (DOD) is investigating the potential of a computerized adaptive testing (CAT) version of its selection battery, the Armed Services Vocational Aptitude Battery (ASVAB). CAT-ASVAB potentially promises more precise aptitude measurement, reduced testing time, better test security, and more efficient test administration, scoring, and reporting. However, before implementing CAT-ASVAB, it is necessary to confirm that this computerized version of ASVAB results in the same measurements as the paper-and-pencil (PP) version.

The computerized administration of ASVAB also allows for the possible assessment of many new constructs that could not be measured in PP format (e.g., psychomotor skills, reaction time, memory). Some have argued that the ASVAB is limited in the number of constructs that it effectively measures and that all of the predictive power results from the measurement of general cognitive ability [1]. Consideration of new constructs that are unique relative to the existing ASVAB content may have potential for effectively expanding the range of predictors and thereby potentially improving the overall military selection and classification system. A psychomotor construct is one such dimension that is not currently measured by the ASVAB.

The purpose of this study is to compare the factor structure of CAT-ASVAB to PP-ASVAB. Past factor analysis of the ASVAB has shown that the ten subtests can typically be reduced to four correlated factors: verbal, mathematical, technical, and speed [2]. Factor solutions for both CAT-ASVAB and PP-ASVAB will be constrained to four factors and the structure will be compared to note similarity. Next, several psychomotor measures are included in the factor analysis of the ASVAB to determine if the overall factor structure can be expanded or if such new measures are highly related to the current ASVAB subtests. Although unique structure is necessary for new tests to potentially augment the ASVAB, this alone is not a sufficient condition. Such new measures must be shown to have incremental validity, above and beyond what the current ASVAB is able to achieve. Therefore, the incremental validity will be assessed for these psychomotor measures to determine the extent to which they improve the prediction of military job performance.

METHOD

Aptitude Measures

The ASVAB is composed of ten subtests that the Services combine into different composites to classify recruits as eligible for particular military jobs. The ASVAB subtests are as follows:

General Science (GS)
Arithmetic Reasoning (AR)
Work Knowledge (WK)
Paragraph Comprehension (PC)
Numerical Operations (NO)

Coding Speed (CS)
Auto and Shop Information (AS)
Mathematical Knowledge (MK)
Mechanical Comprehension (MC)
Electronics Information (EI)

Aptitude information for each of these subtests was available at two levels: aptitude scores used to enlist in the Marine Corps based on a PP administration of the ASVAB and current aptitude scores obtained from an administration of the CAT-ASVAB. These two sources of aptitude information are distinguished throughout this paper by prefixing each subtest abbreviation with ENL for enlistment scores and CAT for computerized scores.

To achieve motivated testing conditions for CAT-ASVAB, examinees were promised that their aptitude scores of record would be changed to reflect improvements during the computerized administration. Such an incentive is significant, as many young Marines seek to transfer to other occupational fields or to officer programs. About 40 percent of the Marines tested satisfied the criteria for improving their scores of record.

Psychomotor Tests

Five measures of various psychomotor skills were concurrently administered with CAT-ASVAB. Two of these tests assessed general hand-eye coordination: one-hand tracking and two-hand tracking. These two tests are part of the joint-service Enhanced Computer Administered Testing (ECAT) project. The tests required a special response pedestal with a joy stick for one-hand tracking and two sliding knobs (one moving vertically, the other horizontally) for two-hand tracking. For both tests, a cursor moved in a random pattern across the screen and the object was to use the joy stick or slides to move a cross-hair so as to minimize the distance between the moving cursor and the cross-hair. Each test was composed of 24 trials. The two tests were counterbalanced in administration across examinees. Because of the controlled presentation of the tests, no time limits were necessary. Scores for the tests were the average root mean square error distance over all trials, standardized to a mean of 50 and a standard deviation of 10 in the sample of examinees.

The five subtests from the psychomotor composite of the General Aptitude Test Battery (GATB) were also administered. These five subtests were combined into three aptitude scores that were used as the unit of analysis for this study. The three aptitude scores and the constructs they measure were as follows:

- o Motor coordination--ability to make precise movements with hands and fingers
- o Finger dexterity--ability to move fingers and manipulate small objects with the fingers rapidly and accurately
- o Manual dexterity--ability to move the hands easily and skillfully.

All three aptitudes were composed of highly speeded subtests, but each subtest score was based on repeated trials. Finger dexterity and manual dexterity required special apparatus boards for administration, whereas motor coordination was a PP test. Scores for each aptitude were determined from norm tables in which each aptitude has a mean of 100 and a standard deviation of 20 in the reference population [3].

Criterion

The incremental validity of the psychomotor tests (i.e., their ability to improve the prediction of mechanical performance) depends partly on the accuracy of the criterion as a measure of actual job performance. The Marine Corps Job Performance Measurement (JPM) project has produced representative hands-on tests that require performance of job tasks under standardized conditions. Thus, the tests achieved high fidelity to actual job conditions and assessed the same skills and abilities required to perform the tasks on the job. These performance tests were constructed on the basis of extensive job analyses and a review of Marine Corps technical manuals and training materials. Based on considerable input and review by Marine Corps subject-matter experts and job incumbents, tasks were sampled for testing so as to be representative of the broad and diverse requirements of mechanical jobs. Extensive tryouts were conducted of each hands-on task to ensure that the performance test accurately assessed the skills and abilities required to perform the job. Eighteen of the 20 hands-on performance tasks to varying degrees involved using tools, maneuvering hands in small (often unseen) places, removing and replacing small parts, and setting up delicate precision measuring equipment. Therefore, the hands-on performance test contained a broad range of psychomotor skills that included coordination and dexterity.

Sample

The sample was composed of Marine Corps automotive and helicopter mechanics who were tested as part of the JPM project. Mechanics were randomly selected for testing to satisfy pay-grade, time-in-service, and aptitude requirements. Each Marine was tested for two days; one day was devoted to hands-on performance testing and the second day covered written performance measures, new predictor tests, and CAT-ASVAB. Only complete data cases were used for the factor analyses, which resulted in a sample size of 1,252. The analyses of incremental validity were based on 775 automotive mechanics who had complete predictor and criterion data.

Factor Analysis

Correlation matrices of all ASVAB subtests and the five psychomotor measures were computed based on complete data for both the enlistment and CAT aptitude scores. Because the number of women in the original testing sample was small, and because there is evidence that the CAT-ASVAB tends to underestimate their aptitude in Auto-Shop Information, women were excluded from all analyses.

The mechanics who participated in the study are a selected sample. To account for these selection effects, the sample correlations were corrected for range restriction by using a multivariate procedure based on all ten ASVAB subtests [4]. The 1980 youth population restricted to males served as the reference population from which all corrections were derived [5]. All factor analyses were computed on the corrected correlation matrices.

Based on historical factor analyses of the ASVAB [2], the factor solutions were constrained to four factors. An iterative principal factors procedure was used with a promax rotation. Squared multiple correlations were used as the initial estimates of communalities. Based on factor loadings greater than 0.30, each factor was named. Separate analyses were conducted for both the enlistment and CAT scores. In addition to comparing factor loadings and the variance explained by each factor, estimates of communality and interfactor correlations were noted.

Similar factor analyses and comparisons were conducted, including the five psychomotor measures. Multiple analyses were conducted with the solutions constrained to four to seven factors. The simplest structure was selected for reporting.

Incremental Validity Analysis

Increments in validity were computed simply as the difference between two validity coefficients (increments in sums of squares are also presented). The multiple correlation between all ASVAB subtests, time in service, and its square, with the hands-on performance test for the automotive mechanics was computed to provide the basis for judging increments in validity by the psychomotor measures. Time in service was required in the regression because of the significant amounts of service by most personnel (mean = 38.7 months, standard deviation = 22.4 months, range = 4 to 168 months).

To reduce capitalization on chance caused by the number of significance tests to be made, the five psychomotor tests were aggregated and then entered as two separate variables into the regression. Consistent with the results of the factor analysis, a coordination variable was computed by standardizing and summing the scores for the one-hand and two-hand tests. Similarly, the three aptitude scores from the GATB were aggregated according to documented

procedures in computing the psychomotor composite [3]. If these aggregated scores were found to make significant improvements above the ASVAB validity base, separate significance tests would then be conducted for each psychomotor test.

All comparisons of multiple correlations were based on estimates adjusted for the number of predictors to correct for shrinkage.

RESULTS

Factor Structure of PP- and CAT-ASVAB

The range-corrected correlation matrix for the enlistment and CAT subtests are presented in table 1. Note the increase in the AS subtest mean score and substantial reduction in standard deviation from the enlistment administration to the more current assessment by the CAT subtest. Also, the correlations among the subtests were similar for the enlistment and CAT administrations, except for the AS subtest. The correlations between the CAT subtests and AS subtest were consistently lower than the same correlations based on the enlistment PP subtests. Such changes and differences in the descriptive statistics may reflect the substantial training and on-the-job experience received by the mechanics since their enlistment.

A four-factor solution of the ASVAB subtests resulted in a simple structure for separate analyses of PP and CAT scores. (See table 2.) The variance explained by each factor showed that the variance among PP subtests was predominantly explained by the first two common factors of technical skill and speed. About an equal percentage of the variance in CAT subtests was explained by the speed and verbal factors. Thus, the CAT version of ASVAB has become slightly more verbal than technical and continues to emphasize the speed factor.

The factor pattern matrix showed that the CAT speed factor was more related to mathematics than the PP speed factor. The CAT EI subtest equally stressed verbal and technical skills; PP EI loaded mainly on the technical factor. The CAT MC subtest had equal loadings on the technical and math factors; the PP MC subtest was more technical. PP GS incorporated the verbal, technical, and math factors; CAT GS loaded entirely on the verbal factor. Similar conclusions were found if both sources of aptitude information were factor analyzed as a single data set (i.e., the number of variables equaled 20 as opposed to two sets of 10). (See table 3.) Care must be taken not to overinterpret these results because of the unknown effects of training on the CAT scores and because selected samples were analyzed.

Table 1. Corrected correlation matrices of ASVAB and psychomotor subtests

	ENLGS	ENLAR	ENLWK	ENLPC	ENLNO	ENLCS	ENLAS	ENLMK	ENLMC	ENLEI	MOTOR	MANUAL	FINGER	ONEHAND	TWOHAND
ENLGS	1.00														
ENLAR	0.74	1.00													
ENLWK	0.84	0.72	1.00												
ENLPC	0.75	0.72	0.82	1.00											
ENLNO	0.58	0.68	0.62	0.62	1.00										
ENLCS	0.55	0.61	0.58	0.57	0.72	1.00									
ENLAS	0.67	0.56	0.65	0.57	0.43	0.42	1.00								
ENLMK	0.72	0.83	0.68	0.67	0.65	0.60	0.43	1.00							
ENLMC	0.73	0.70	0.68	0.64	0.50	0.50	0.75	0.62	1.00						
ENLEI	0.79	0.69	0.78	0.69	0.53	0.50	0.75	0.62	0.77	1.00					
MOTOR	0.27	0.34	0.31	0.34	0.44	0.40	0.14	0.35	0.23	0.24	1.00				
MANUAL	0.26	0.28	0.26	0.22	0.34	0.36	0.25	0.26	0.30	0.27	0.46	1.00			
FINGER	0.24	0.27	0.23	0.22	0.28	0.32	0.23	0.26	0.27	0.25	0.51	0.51	1.00		
ONEHAND	0.44	0.46	0.42	0.40	0.42	0.42	0.34	0.44	0.47	0.41	0.27	0.25	0.20	1.00	
TWOHAND	0.46	0.45	0.43	0.39	0.40	0.41	0.40	0.42	0.51	0.45	0.26	0.27	0.24	0.78	1.00
MEAN	51.67	51.33	49.92	49.13	49.13	47.93	55.18	50.71	53.79	53.56	95.88	97.95	93.22	47.82	47.99
STD	10.45	10.23	10.23	10.41	10.17	9.70	9.82	10.32	10.22	10.02	16.96	22.50	20.67	11.24	11.33

	CATGS	CATAR	CATWK	CATPC	CATNO	CATCS	CATAS	CATMK	CATMC	CATEI	MOTOR	MANUAL	FINGER	ONEHAND	TWOHAND
CATGS	1.00														
CATAR	0.73	1.00													
CATWK	0.87	0.70	1.00												
CATPC	0.78	0.74	0.79	1.00											
CATNO	0.58	0.68	0.56	0.57	1.00										
CATCS	0.53	0.60	0.53	0.55	0.68	1.00									
CATAS	0.50	0.39	0.45	0.41	0.16	0.20	1.00								
CATMK	0.67	0.81	0.65	0.67	0.73	0.62	0.21	1.00							
CATMC	0.71	0.71	0.67	0.68	0.43	0.46	0.62	0.59	1.00						
CATEI	0.72	0.59	0.73	0.66	0.44	0.44	0.60	0.54	0.70	1.00					
MOTOR	0.31	0.32	0.31	0.30	0.48	0.44	0.01	0.36	0.20	0.21	1.00				
MANUAL	0.27	0.29	0.26	0.25	0.31	0.37	0.15	0.28	0.31	0.23	0.46	1.00			
FINGER	0.24	0.27	0.24	0.24	0.23	0.31	0.18	0.24	0.32	0.22	0.27	0.51	1.00		
ONEHAND	0.44	0.47	0.41	0.42	0.41	0.40	0.20	0.45	0.49	0.34	0.27	0.25	0.20	1.00	
TWOHAND	0.44	0.47	0.42	0.41	0.37	0.38	0.28	0.41	0.52	0.37	0.26	0.27	0.24	0.78	1.00
MEAN	51.99	51.54	52.70	51.28	49.39	49.38	60.40	48.16	55.86	55.80	95.88	97.95	93.22	47.82	47.99
STD	9.80	9.96	7.70	9.19	9.65	8.92	6.04	10.20	10.63	8.35	16.96	22.50	20.67	11.24	11.33

NOTE: Matrices are based on 1,252 complete data cases and are corrected for range restriction. ASVAB subtests from time of enlistment are preceded by ENL. ASVAB subtests administered as part of the study using a computer are preceded by CAT. ASVAB subtests include: GS=general science, AR=arithmetic reasoning, WK=work knowledge, PC=paragraph comprehension, NO=numerical operations, CS=coding speed, AS=auto shop, MK=math knowledge, MC=mechanical comprehension, EI=electronics information, GATB aptitude measures include: MOTOR=motor coordination, MANUAL=manual dexterity, and FINGER=finger dexterity. ECAT subtests include: ONEHAND=one-hand tracking and TWOHAND=two-hand tracking.

Table 2. Factor pattern matrix for ASVAB subtests

	PP-ASVAB		CAT-ASVAB	
	Subtest (loading)	Variance explained	Subtest (loading)	Variance explained
Verbal	WK (.83)	1.56	WK (.98)	2.42
	PC (.54)		GS (.71)	
	GS (.45)		PC (.57)	
	EI (.27)		EI (.47)	
Math	MK (.85)	1.68	AR (.65)	1.07
	AR (.63)		MK (.56)	
	MC (.25)		MC (.45)	
	GS (.25)		PC (.27)	
Tech	AS (.92)	2.72	AS (.90)	1.87
	MC (.74)		MC (.45)	
	EI (.61)		EI (.40)	
	GS (.33)			
Speed	NO (.81)	2.03	NO (.97)	2.50
	CS (.69)		CS (.53)	
			MK (.37)	
			AR (.25)	
Total variance explained		7.99		7.86

NOTE: Analysis based on correlation matrices corrected for range restriction. Only subtests for which loadings exceeded .25 are listed.

Table 3. Factor analysis of CAT-ASVAB and PP-ASVAB subtests combined

	Factor pattern matrix				Communality estimate
	Tech	Speed	Verb	Math	
ENLGS	--	--	0.57	--	0.81
CATGS	--	--	0.72	--	0.87
ENLAR	--	--	--	0.59	0.84
CATAR	--	--	--	0.73	0.85
ENLWK	--	--	0.85	--	0.90
CATWK	--	--	0.89	--	0.89
ENLPC	--	--	0.65	--	0.74
CATPC	--	--	0.57	0.30	0.71
ENLNO	--	0.78	--	--	0.75
CATNO	--	0.62	--	0.29	0.73
ENLCS	--	0.84	--	--	0.70
CATCS	--	0.62	--	--	0.59
ENLAS	0.86	--	--	--	0.83
CATAS	0.91	--	--	--	0.69
ENLMK	--	--	--	0.67	0.82
CATMK	--	--	--	0.72	0.84
ENLMC	0.60	--	--	--	0.74
CATMC	0.61	--	--	0.38	0.77
ENLEI	0.48	--	0.39	--	0.78
CATEI	0.44	--	0.41	--	0.67
Variance explained	4.36	4.20	4.09	2.86	

Interfactor correlations

	Tech	Speed	Verb	Math
Tech	1.00	0.39	0.65	0.49
Speed	0.39	1.00	0.62	0.64
Verb	0.65	0.62	1.00	0.69
Math	0.49	0.64	0.69	1.00

NOTE: Only loadings greater than .25 are noted. Correlation matrix was corrected for range restriction.

As shown in table 4, essentially equal communality estimates were found for the separate factor analyses CAT and PP subtests, which indicates that little, if any, improvement in reliability was gained from the computerized adaptive tests. Tables 2 and 4 report results from the same analyses. Substantial improvement was noted for the NO subtest, which is more accurately controlled and administered using a computer. However, the low communality observed for CS (in combination with the high communality noted for NO) could not be explained.

Table 4. Communality estimates for ASVAB subtests

Subtest	Enlistment aptitude	CAT aptitude
GS	.81	.83
AR	.83	.85
WK	.94	.92
PC	.73	.74
NO	.80	.95
CS	.64	.53
AS	.79	.78
MK	.87	.80
MC	.78	.77
EI	.79	.69

NOTE: Analysis based on correlation matrices corrected for range.

The factor intercorrelations noted in table 5 showed that the CAT factors were less correlated and, therefore, may possibly provide more differential validity than the PP version. The most striking difference in factor correlations was between the speed and technical factors, .19 for CAT and .51 for PP.

Table 5. Factor intercorrelations for ASVAB subtests

	Enlistment aptitude				CAT aptitude			
	Verb	Math	Tech	Speed	Verb	Math	Tech	Speed
Verb	1.00				1.00			
Math	.69	1.00			.71	1.00		
Tech	.70	.61	1.00		.57	.46	1.00	
Speed	.62	.67	.51	1.00	.57	.58	.19	1.00

NOTE: Analysis based on correlation matrices corrected for range restriction.

Consideration of Psychomotor Measures

The correlations of table 1 showed one- and two-hand tracking to be strongly related to each other ($r = .78$), but only slightly related to the three dexterity measures of the GATB. Among the dexterity measures, the finger dexterity was least related to motor coordination ($r = .27$); moderate correlations were noted among the GATB tests. The two ECAT tests were more related to the ASVAB subtests than were the GATB tests; both ECAT tests were about equally correlated to each of the ASVAB subtests; and the GATB tests correlated more with the two speed subtests of the ASVAB. Again, the AS subtest had markedly smaller correlations with the psychomotor measures than did any other ASVAB subtest.

The five psychomotor measures were added to ASVAB, and similar factor analyses were conducted to determine their uniqueness relative to the other ASVAB dimensions. Successive analyses were performed, with the number of factors ranging from four to seven. For each of the analyses, the dexterity tests of the GATB and the coordination tests of the ECAT defined distinct and separate factors; never did these tests load highly on the same dimension. Each of the factor outcomes were examined for interpretability and simple structure and the six-factor solution was determined to be the best. Tables 6 and 7 present this outcome respectively for enlistment and CAT subtests.

The same results were achieved regardless of the source of aptitude information. That is, for both enlistment and CAT scores, the coordination and dexterity factors were unique and distinct dimensions, defined by exactly the same psychomotor measures, and had no ASVAB subtest to load on either of them. The motor coordination test of the GATB also had a significant loading on the speed factor that is consistent with the highly speeded nature of this test. The correlation of the coordination and dexterity factors was only .32 and .38, based on enlistment and CAT aptitude scores, respectively. The communality for both motor coordination and finger dexterity were exceptionally low relative to the enlistment and CAT subtests and the other psychomotor measures. As discussed earlier, the GATB psychomotor tests are highly speeded, yet only motor coordination loaded on the speed factor. Such low communalities may partially result from the low reliabilities of these tests.

Incremental Validity of Psychomotor Measures

Table 8 presents the correlations between the ASVAB, ECAT, and GATB subtests with the mechanical hands-on performance test. All correlations between the hands-on criterion and the ASVAB subtests (both enlistment and CAT) exceeded those correlations between hands-on performance and the GATB and ECAT subtests. The two ECAT subtests were moderately related to hands-on performance. The aggregate score of the three GATB aptitudes correlated only slightly with hands-on performance, .24.

Table 6. Factor analysis of enlistment ASVAB subtests and psychomotor subtests

	Factor pattern matrix						Communality estimate
	Tech	Speed	Coord	Dext	Math	Verb	
ENLGS	0.62	--	--	--	--	--	0.81
ENLAR	0.30	--	--	--	0.59	--	0.83
ENLWK	0.59	--	--	--	--	0.54	0.92
ENLPC	0.44	--	--	--	--	0.38	0.74
ENLNO	--	0.80	--	--	--	--	0.80
ENLCS	--	0.66	--	--	--	--	0.65
ENLAS	0.99	--	--	--	--	--	0.81
ENLMK	--	--	--	--	0.79	--	0.87
ENLMC	0.74	--	--	--	--	--	0.78
ENLEI	0.79	--	--	--	--	--	0.79
MOTOR	--	0.31	--	0.35	--	--	0.36
MANUAL	--	--	--	0.99	--	--	0.95
FINGER	--	--	--	0.47	--	--	0.31
ONEHAND	--	--	0.87	--	--	--	0.78
TWOHAND	--	--	0.87	--	--	--	0.80
Variance explained	4.26	1.96	1.78	1.67	1.15	0.38	

Interfactor correlations

	Tech	Speed	Coord	Dext	Math	Verb
Tech	1.00	0.53	0.49	0.29	0.57	0.34
Speed	0.53	1.00	0.48	0.41	0.65	0.48
Coord	0.49	0.48	1.00	0.32	0.46	0.25
Dext	0.29	0.41	0.32	1.00	0.25	0.17
Math	0.57	0.65	0.46	0.25	1.00	0.58
Verb	0.34	0.48	0.25	0.17	0.58	1.00

NOTE: Only loadings greater than .30 are noted. Correlation matrix was corrected for range restriction. "Coord" represents a coordination factor. "Dext" represents a dexterity factor.

Table 7. Factor analysis of CAT-ASVAB subtests and psychomotor subtests

	Factor pattern matrix						Communality estimate
	Verb	Speed	Coord	Dext	Tech	Math	
CATGS	0.83	--	--	--	--	--	0.84
CATAR	0.31	--	--	--	--	0.50	0.84
CATWK	1.02	--	--	--	--	--	0.90
CATPC	0.71	--	--	--	--	--	0.74
CATNO	--	0.91	--	--	--	--	0.85
CATCS	--	0.56	--	--	--	--	0.59
CATAS	--	--	--	--	0.86	--	0.78
CATMK	--	0.41	--	--	--	0.45	0.80
CATMC	0.31	--	--	--	0.33	0.33	0.81
CATEI	0.57	--	--	--	0.36	--	0.70
MOTOR	--	0.41	--	0.35	--	--	0.44
MANUAL	--	--	--	0.89	--	--	0.77
FINGER	--	--	--	0.57	--	--	0.36
ONEHAND	--	--	0.89	--	--	--	0.80
TWOHAND	--	--	0.86	--	--	--	0.77
Variance explained	3.59	2.26	1.82	1.54	1.35	0.41	

Inter-factor correlations

	Verb	Speed	Coord	Dext	Tech	Math
Verb	1.00	0.60	0.50	0.36	0.52	0.57
Speed	0.60	1.00	0.43	0.44	0.05	0.42
Coord	0.50	0.43	1.00	0.38	0.31	0.46
Dext	0.36	0.44	0.38	1.00	0.21	0.22
Tech	0.52	0.05	0.31	0.21	1.00	0.42
Math	0.57	0.42	0.46	0.22	0.42	1.00

NOTE: Only loadings greater than .30 are noted.
Correlation matrix was corrected for range restriction. "Coord" represents a coordination factor. "Dext" represents a dexterity factor.

All of the psychomotor measures administered in this study satisfied the initial requirement of being unique and different from the constructs currently assessed by the ASVAB.

Table 8. Correlation of ASVAB, ECAT, and GATB subtests with mechanical hands-on performance test

ASVAB subtest	Enlistment	CAT
GS	.52	.54
AR	.52	.54
WK	.49	.49
PC	.46	.52
NO	.38	.34
CS	.37	.40
AS	.61	.67
MK	.45	.41
MC	.60	.66
EI	.58	.59
GATB aptitudes		
Motor		.11
Manual		.14
Finger		.32
Dexterity		.26
ECAT subtests		
Onehand		.30
Twohand		.34
Coordination		.34

NOTE: Correlations are corrected for range restriction.

Table 9 shows that the ten ASVAB subtests, time in service, and its square provide excellent prediction of automotive hands-on performance. The corrected multiple correlations are .66 and .74 for enlistment and CAT scores, respectively. These multiple correlations serve as the basis for comparison against which all increments in validity by the psychomotor tests must be achieved.

To limit the number of significance tests, and thereby not overly capitalize on chance, the aggregated measures of the dexterity dimension and the coordination dimension were both entered into the regression. The increment in sums of squares was noted and the increase in the adjusted multiple correlation was computed. Table 9 shows that less than one validity point was gained by the combination of these two aggregated psychomotor measures over the corrected enlistment validities. No improvement in validity was made relative to the concurrent CAT aptitude subtests. Increments in the sample validities by the two psychomotor measures were slightly more but still not substantial. Thus, despite the uniqueness of the psychomotor measures evidenced by the results of the factor analyses, the tests were not able to enhance the prediction of the mechanical hands-on performance tests.

Table 9. Incremental validity for psychomotor measures above ASVAB and time-in-service base^a

	Sample values			Corrected values		
	df	SS	adj R	df	SS	adj R
Total	774	50,750.05		774	71,579.93	
Enlistment Aptitude						
ASVAB + TIS	12	12,761.53	.490	10	31,774.20	.661
+ Dext + Coord	2	787.52	.013	2	553.23	.005
+ Dext	1	354.48	.006	1	349.99	.003
+ Coord	1	513.58	.009	1	254.84	.002
CAT Aptitude						
ASVAB + TIS	12	19,188.41	.607	10	39,472.67	.739
+ Dext + Coord	2	140.77	.001	2	95.83	.000
+ Dext	1	98.88	.001	1	89.22	.000
+ Coord	1	54.13	.000	1	12.02	.000

NOTE: Multiple correlations are adjusted for the number of predictors (adj R). "TIS" represents time in service and its square. "Dext" represents the three dexterity tests of GATB, and "Coord" represents the two coordination tests of ECAT.

a. Time in service cannot be defined for the population and, therefore, the variables (TIS and its square) are not included in the regression based on the corrected correlations.

CONCLUSIONS

Unique opportunities exist with the possible advent of computerized testing for military accession in the Department of Defense. Before such opportunities can be effected, however, the comparability of aptitude measurement afforded by the computerized battery relative to the current paper-and-pencil tests must be established.

Aptitude measurements made by CAT-ASVAB may differ slightly from the current PP-ASVAB. These differences may have implications for changing the historical meaning and, thereby, the validity of the service aptitude composites. However, these results should not be overinterpreted. Factor analyses of selected samples, even with corrections for range restriction, pose difficult issues for interpreting factoring outcomes. There are also unknown effects

associated with comparing the same samples on aptitude measures administered at different times with substantial intervening events that affect the predictor tests (i.e., training). This study clearly was not designed to properly or fully address this comparability-of-measurement issue. Similar analyses based on sufficiently large samples of military applicants should be conducted and reported.

The coordination tests of the ECAT and the dexterity tests of the GATB were found to represent unique and distinct factors relative to the constructs measured by the ASVAB. The two sets of tests were also unique relative to each other and did not define a common psychomotor factor as was anticipated. From the perspective of expanding the predictor space of the ASVAB, clearly either set or both sets of measures would accomplish this goal.

Despite the uniqueness of the coordination and dexterity tests, neither set of tests was able to add significantly to the ASVAB's prediction of mechanical hands-on performance. In fact, the ASVAB was shown to be an excellent predictor of mechanical job performance. Others have argued that the variance in performance for technical jobs such as automotive mechanics is a function of cognitive abilities (measured by tests such as the ASVAB) and not psychomotor skills, although such skills are related to performance [6]. This is not to say that the coordination and dexterity tests would not significantly improve prediction for other specialties in which these psychomotor dimensions are relevant to job performance.

Given the substantial training and on-the-job experience received by most military job incumbents, using a concurrent design for aptitude, new predictor, and criterion assessment may be questioned. Although such a design attempts to control for several extraneous sources of variance, it may also affect the estimation of validity coefficients for the new predictor tests by not completely measuring the full range of scores on the new predictor tests. A longitudinal design in which all predictor measures are administered at the time of accession is certainly superior, but such studies are extremely difficult to implement and may not provide information in time to affect the decision-making process for revising the ASVAB.

New tests measuring aptitude dimensions different from those of the current ASVAB are not necessary for selection purposes. Large payoffs potentially exist in the realm of improved recruit assignments for job classification, although this study did not find such gains for automotive mechanics. To satisfy the stringent requirements for inclusion of a new test into the joint-service battery, the test must demonstrate incremental validity across all services and also apply to multiple jobs within a service. A new test sufficiently unique to produce incremental validity is likely to measure a specialized trait and thus will improve prediction in only a narrow range of jobs.

Therefore, the likely benefit of any new predictor test would not be in the form of supplementing or revising a joint-service instrument, but rather in terms of potentially addressing service-specific needs for improving classification for selected specialties.

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