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Research Memorandum 77-27

THE DEVELOPMENT OF DISCRIMINATORS FOR PREDICTING SUCCESS IN ARMOR CREW POSITIONS

Robert B. Greenstein and
Ronald G. Hughes

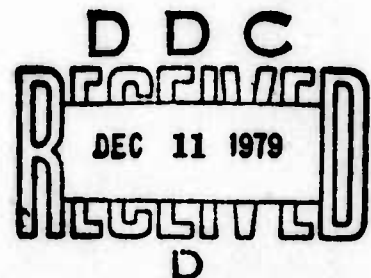
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FOR PREDICTING SUCCESS
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10 Robert B. Greenstein and
Ronald G. Hughes

Submitted by:
Donald F. Haggard, Chief
ARI Field Unit, Fort Knox, Kentucky

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Approved by:

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THE DEVELOPMENT OF DISCRIMINATORS FOR PREDICTING SUCCESS IN ARMOR CREW POSITIONS

INTRODUCTION

Training for armor crewmen (MOS 11E) is currently conceptualized as producing an individual who is a "qualified loader," a "licensed driver," and a "familiarized gunner." Rather than attempting to maximize the performance of individuals with respect to the duties and skills of a specific crew position (for example, driver), the current training strategy seeks to maximize the interchangeability of crew functions through cross-training of individual tank crewmen.

If the existing Advanced Individual Training (AIT) structure is to be changed from its present emphasis on cross-training to an emphasis on differential training and assignment of drivers, gunners, and/or loaders, careful consideration of several key points is necessary. First, it must be determined if, given the present training requirements for driving, loading and firing the main gun, differential performances are obtained from individuals across these areas. That is to say, are the areas of driving, loading and main gun firing relatively independent, such that knowledge of an individual's performance in one area gives little indication of his level of performance in the other two? Second, given that differential performances are obtained from individuals, can the factors underlying these performances be identified? And third, can these factors be quantified and measured in such a way that these measures can be used to make differential predictions about success and failure in a given area of training?

Thomas and Sternberg (1964) attempted to identify the cognitive factors underlying the performances of the armor crewman. Following an analysis of the tasks performed by the gunner, driver, loader, and tank commander, each task was analyzed further against a list of hypothesized behavioral characteristics. On the basis of these behavioral characteristics, constructs were developed. Plotting the constructs against the four crew positions yielded a model for selecting general and position-specific tests. In the Thomas and Sternberg study, no attempt was made to validate the model against actual armor crewman criterion performances. Although Kaplan (1965) reported on the relation of some of the measures suggested by Thomas and Sternberg to various aircrew performances, to date there exists no data relating these measures to the performances of armor crewmen.

OBJECTIVES

↙ The primary objectives of this study were:

1. Development of intermediate criteria for assessment of armor crewman performance; — / one

2. ↘ Exploitation of the statistical relationships among criterion performances; *and*

3. ↘ Exploration of pool of potential armor crewman performance predictors. → 6 pg 17

METHOD

SUBJECTS

In order to evaluate the relation between potential "predictor" variables and AIT performance measures in driving, loading, and firing, 113 Armor trainees from Company C, 2d Battalion, 1st Brigade, U. S. Army Training Center, Armor (USATCA), were used as subjects. The particular training cycle began 23 June 1975 and ended 15 August 1975. During the course of the training cycle, 20 subjects were dropped from the sample because of discharges, ANOL, transfers, illnesses, etc. Of those remaining, because of incomplete criterion data predictor-criterion relations were analyzed from samples varying from 46 to 91 subjects.

PROCEDURE

The general procedure used in this study involved (1) administration of a group of predictor tests to a representative training company during the first few weeks of training and (2) administration of the criterion tests for evaluation of driving, loading and main gun firing performances. This was done in the context of regular AIT training.¹ A more detailed discussion of the test procedure is given below.

AIT Predictor Measures. Eleven paper-and-pencil tests were selected for use in this study.²

1. Attention to Detail Test
2. Patterns Test

¹The ARI Field Unit, Ft Knox wishes to acknowledge the support and cooperation given by LTC Bruce McConnell, Commander, 2nd Battalion, 1st Training Brigade, Ft Knox; CPT James Brown, Commander, C Company, 2nd Battalion, 1st Training Brigade and his successor as Commander, C Company, CPT Robert Strickland.

²Tests 1, 3, 4, 6 and 7 were reported by Lauer (1952). Tests 2, 6, 8 and 10 were reported by Thomas and Sternberg (1964). Tests 5, 8 and 9 were reported by Kaplan (1965). Test 11 was developed by the Army Research Institute Ft Knox Field Unit.

3. Related Forms Test
4. Locations Test
5. Army Perceptual Speed Test
6. Visual Recognition Test
7. Visual Memory Test
8. Speed of Perception Test (revised)
9. Lateral Perception Span
10. Reaction to Signals Test
11. Simulated Zeroing

In addition, the following tests were administered:

12. Vision Tests

Far acuity

Vertical phorias

Lateral phorias

Wearing of corrective lenses noted

13. Placing and Turning Segments of the Minnesota Rate of Manipulation Tests (MRMT)

14. Hand Dominance

15. Army Two-Hand Coordination Test (Lauer, 1952)

Scores from the following Army-administered tests were recorded:

16. Army Classification Battery (ACB)

Combat (CO)

Field Artillery (FA)

Motor Maintenance (MM)

17. Armed Forces Qualification Test (AFQT)

18. Advanced Physical Fitness Test

Inverted crawl

Horizontal ladder

19. Visual Reaction Time

20. Field of Vision

For a further description of the above tests, see Appendix A.

The eleven paper-and-pencil tests were administered by ARI personnel in two consecutive evening sessions of approximately two hours each. Two platoons, consisting of 25-30 men each, were tested at a time. Testing was completed during the first week of the training cycle. In addition to those tests administered as part of the experimental test battery, scores of the Army Two Hand Coordination Test, Reaction Time and Field of Vision tests were administered by Motor Vehicle Officer personnel prior to driver training. All other vision tests as well as the Minnesota Rate of Manipulation tests were administered by ARI personnel during the first week of training.

AIT Criterion Measures. The criterion measures in driving, loading and firing are discussed in detail below. These criterion measures are experimental in nature; they have not been validated and they should not be construed as "true" criterion measures.

1. Driving Criterion Measure.

The AIT driver criterion test, which was developed by the Army Research Institute, Ft Knox Field Unit, consisted of three terrain driving exercises and two exercises scored during a road march. Terrain driving was conducted during the third week of the training cycle. The road march portion was conducted during the seventh week.

After the regularly scheduled driving period of approximately 45 minutes per subject, a terrain driving test was conducted by the tank commander. For the terrain driving course the driver was required to negotiate a ditch and a vertical obstacle, and to perform a neutral steer maneuver. Each requirement was performed under daylight conditions and with the driver's hatch closed. Selected aspects of each performance were rated by the tank commander on a 1-9 scale (see Appendix B). An individual's score for a particular exercise was the sum of the ratings for each component of the task.

For the road march portion of the driving criterion each subject drove for 2 kilometers (km) on a 16 km course mapped out in advance to insure comparability of the segments. Each subject was scored over the entire 2 km segment by the tank commander using the rating form shown in

Appendix C. The road march criterion requirements consisted of maneuvering on level terrain and ascending and descending a hill. Performance was rated using the same 1-9 scale used in terrain driving.

Before using the terrain driving scoring sheet, interrater reliability was assessed. Seven tank commanders (TCs) were provided by the training company along with two M60A1 tanks. Tank commanders alternated as driver and rater with from 2 to 4 raters on each tank. The driver was given a list of preselected errors and was instructed as to which errors to commit in advance of each run. Raters were not aware of the errors to be committed. Interrater reliabilities, indicated as percent agreements, were 78% (ditch crossing), 79% (vertical obstacle), and 56% (neutral steer).

2. Firing and Loading Criterion Measures.

Criterion performances in firing and in loading were both conducted in the context of normal training received in firing the tank main gun under daylight conditions. The gunnery exercise consisted of both day and night phases. However, the night phase was not analyzed because of scoring difficulties associated with the low visibility conditions. The day phase consisted of six (6) rounds. The first two rounds were fired at stationary panel targets and the last four at moving target panels. Fifteen trainees designated by the cadre as "outstanding" were selected as scorers. Five additional scorers from ARI brought the total number of scorers to 20. One scorer was positioned on each tank above the loader's hatch to observe and record loading times and loading errors, using the score sheet shown in Appendix D. A second scorer on the ground behind each tank used the score sheet in Appendix E and recorded opening time (i.e., the time from the moment the command "gunner" was announced in the fire command to the firing of the first round) and overall time for each two-round engagement. The tank commander, using the score sheet in Appendix F, recorded the following: (1) his scoring of the gunner for proper sighting and tracking, (2) his sensing of the point of impact of the round, (3) his scoring of crew procedures, and (4) his scoring of opening times and total times for each two-round engagement.³

Data Analysis. Data analysis was conducted as follows. First, individual correlations were obtained between each predictor and criterion measure. Next, the predictor tests were factor analyzed. Finally, the factor scores were related to criterion performances by means of a stepwise linear regression analysis.

RESULTS

The primary focus of this study is on the experimental criterion measures and their relation to the predictor tests. Accordingly, descriptive

³ Opening and total firing times were not analyzed because of low inter-observer agreement.

data obtained on the predictor tests have been placed in appendixes as indicated in the following section. Succeeding sections will present results obtained on the criterion tests and the relation between predictor and criterion measures for each crew position.

AIT PREDICTOR VARIABLES

The means, standard deviations, and sample sizes for the eleven paper-and-pencil tests in the experimental test battery, as well as for dexterity, coordination, ACB, and AFQT scores, are given in Appendix G. The intercorrelations among the predictor variables are given in Appendixes H, I, and J.

Appendixes I and J show that not only were the paper-and-pencil tests intercorrelated to a significant degree, but that these tests also correlated with the Combat, Field Artillery, and Motor scores of the Army Classification Battery (ACB) as well as with the Armed Forces Qualifications Test (AFQT). Appendix H shows few significant correlations between scores on the Army Physical Fitness (PT) Test and tests in the experimental portion of the battery. The Army Two-Hand Coordination Test and the Minnesota Rate of Manipulation Test were significantly correlated in numerous instances with tests in the experimental battery.

AIT CRITERION PERFORMANCES

As shown in Table 1, all three gunnery measures--hit performance, tracking, and procedure--were significantly intercorrelated. This may have been because of a "halo" effect--a tendency in rating one aspect of behavior to be influenced by another aspect of behavior or one's general impression of the person. No significant correlations were found, however, when comparing the subjects' own gunnery scores with either their loading times or loading errors (see Table 2). The performance of the gunner was not affected by either the time required to load or the number of errors made by the loader. No significant relations were found between either of the loader measures and the mean score obtained for all five driving exercises. Although no correlation appeared between total driving score and either hit performance or procedure scores, a positive correlation was shown between driving and gunnery tracking scores (see Table 2).

Table 3 presents an intercorrelation matrix for the three areas of criterion performance. The measure taken as representative of firing was the number of hits obtained on rounds 1-6; the measure for driving, the overall driving score for exercises 1-5; and for loading, the mean loading time for rounds 1-6. The absence of any significant correlations between criteria indicates that individual performances in the three areas tested were statistically independent. That is, the individual who performed well at loading did not necessarily perform well in driving and firing. The independence of these performances suggests that different skills or aptitudes may underlie performances in each of these areas.

Table 1

Intercorrelations of Gunnery Performance

	Hits	Procedure	Tracking
Hits		$r = .48$ $n = 54$	$r = .51$ $n = 58$
Procedure			$r = .35$ $n = 55$
Tracking			

All correlations were significant at .01 level

Table 2

Correlations between Loader, Gunner and Driver Performance

<u>Variable 1</u>	<u>Variable 2</u>	<u>df</u>	<u>r</u>
Loading time	Gun tracking	48	-.05
Loading time	Hits (same s)	47	-.11
Loading time	Procedure (same s)	46	.06
Loading errors	Gun tracking (same s)	49	-.07
Loading errors	Hits (same s)	48	.03
Loading errors	Procedure (same s)	47	.10
Loading time	Gunnery tracking	35	.16
Loading time	Gunnery hits	32	.06
Loading time	Crew procedures	33	-.10
Loading time	Combined gunner score	44	-.05
Loading errors	Gunnery tracking	35	.16
Loading errors	Gunnery hits	34	.24
Loading errors	Crew procedure	34	.18
Loading errors	Combined gunner score	44	-.04
Loading time	Driving score-ex. 1-5	30	.04
Loading errors	Driving score-ex. 1-5	30	-.23
Gun tracking	Driving score-ex. 1-5	25	.44*
Hit performance	Driving score-ex. 1-5	22	.05
Crew procedure	Driving score-ex. 1-5	21	.32
Combined gunner score	Driving score-ex. 1-5	20	.18

* Correlations significant at .05 level

Table 3

Matrix of Intercorrelations Between Criterion Exercises in Driving, Loading, and Gunnery

	Firing ¹	Loading ²	Driving ³
Firing		r= -.11 n= 34	r= .05 n= 24
Loading			r= .04 n= 32
Driving			

¹Hits

²Mean Loading Time

³Driving Exercises 1-5

Predictor-Criterion Relation in Loading. Table 4 shows the relation of paper-and-pencil predictor scores to criterion performance in loading. Measures of loading performance were Mean Loading Time and Loading Errors. Table 4 shows that only two tests (Lateral Perception and Reaction to Signals) were significantly correlated with both measures of loading performance. The inverse relation indicated by the negative sign of the coefficient means that the higher the performance on these predictor tests, the fewer errors were committed in loading, and the faster the loading time. Also correlating significantly with loading errors were scores on the following tests: Visual Memory, Related Forms, Locations, Visual Recognition, and Speed of Perception. Again the relations are inverse, indicating that the higher the scores on the predictor tests, the fewer errors were committed. Table 5 shows that the Field Artillery (FA) and Motor Maintenance (MM) scores of the ACB, as well as the AFQT score, were significantly correlated with loading errors. Performance on the Turning subtest of the MRMT was also correlated with loading errors. The direction of the relations between loading errors and Turning scores is positive, indicating that poor performance on the Turning subtest was positively related to the number of loading errors committed. Neither reaction time nor measures of two-hand coordination correlated with measures of loading performance.

Predictor-Criterion Relationships in Driving. In the area of driving, considering first the total score for the terrain driving exercise (Total 1-3) Table 6 shows that five of the eleven paper-and-pencil predictor tests correlated significantly with the criterion performance. These tests were Visual Recognition, Visual Memory, Related Forms, Locations and Patterns. However, only Related Forms and Locations correlated significantly with the road march portion of the driving criterion (Total 4-5). The terrain and road march portions combined (Total 1-5) significantly correlated with eight of the eleven tests in the paper-and-pencil battery.

That portion of Table 5 relating driving criterion performances to predictor scores shows that only the road march portion of the criterion exercise was predicted from the set of predictors used and then by only one of the nine predictor variables, the AFQT score.

Predictor-Criterion Relations in Firing the Main Gun. In the area of main gun firing performance, the relations between tests in the experimental test battery and criterion performances are given in Table 7, where main gun firing performance is broken down into measures of tracking, hit performance, and procedure. In the area of tracking performance, four of the eleven paper-and-pencil tests (Visual Memory, Locations, Speed of Perception, Patterns) were found to correlate significantly with the criterion measure. Only two predictors (Simulated Zeroing, Attention to Detail) were found to be significantly related to main gun hit performance. With respect to the procedural criterion, only Visual Memory was found to correlate significantly. Composite gunnery scores based on the three areas were significantly correlated with only one measure: Attention to Detail (inverse relationship).

Table 4

Correlations between Criterion Measures in Loading and Paper-and-Pencil Tests in Experimental Test Battery

	<u>Mean Loading Time (n=75)</u>	<u>Loading Errors (n=75)</u>
Lateral Perception	-.31*	-.33*
Visual Recognition	-.12	-.23*
Reaction to Signals	-.24*	-.30*
Attention to Detail	-.20	-.16
Visual Memory	-.22	-.39*
Perceptual Speed	.08	-.08
Related Forms	-.15	-.25*
Locations	-.04	-.31*
Speed of Perception	-.17	-.31*
Patterns	-.04	-.06
Simulated Zeroing	.02	.06

* Correlations significant at .05 level.

Table 5

Correlations Between Army Classification Battery (ACB) Scores, Armed Forces Qualification Test (AFQT) Scores, Minnesota Rate of Manipulation Tests (MRMT), Reaction Time, Two-Hand Coordination Scores and AIT Criterion Measures

	Loading Time	Loading Errors	Driving 1-3	Driving 4-5	Driving 1-5	Tracking	Hits	Procedure	Combined
ACB									
Combat Score	.07	-.22	.10	.06	.12	.25	.12	.16	.19
Field Artillery Score	-.16	-.35**	.10	.24	.20	.12	.06	.16	.11
Motor Maintenance Score	-.07	-.24*	.13	.07	.13	.15	-.02	.02	.02
AFQT Score	-.07	-.25*	.01	.31*	.13	.20	.01	.14	.10
Sample size	74	74	90	45	41	61	59	55	53
MRMT									
Placing	.12	.02	.05	.24	.04	-.02	.09	-.21	.04
Turning	.08	.24*	.08	.16	.03	-.08	-.01	-.29	-.12
Combined	.11	.15	.07	.21	.04	-.06	.04	-.28	-.05
†Reaction Time	.06	-.22	-.15	-.06	-.19	.08	-.06	-.08	-.21
Two-Hand Coordination	-.06	-.04	-.12	-.02	-.09	.01	-.00	.28	.03
††Mean Sample Size	73	73	89	44	42	58	56	52	50

*Correlations significant at .05 level.

**Correlations significant at .01 level.

†Reciprocal

††Sample sizes vary ± 3

Table 6

Correlations between Driving Criterion Measures and Paper-and-Pencil Predictor Scores

	#1	#2	#3	#4	#5	Total 1-3	Total 4-5	Total 1-5
Lateral Perception	.10	.13	.12	.20	.08	.15	.17	.20
Visual Recognition	.11	.22*	.24*	.01	-.11	.23*	-.03	.32*
Reaction to Signals	-.03	.16	.09	.12	-.01	.08	.10	.15
Attention to Detail	.13	-.00	.08	.19	.15	.09	.21	.32*
Visual Memory	.09	.27**	.14	.20	.19	.21*	.25	.44**
Perceptual Speed	.01	.13	.15	.11	.13	.11	.05	.22
Related Forms	.17	.28**	.11	.18	.17	.25*	.23	.23
Locations	.24*	.27**	.19	.21	.15	.30**	.21	.47**
†Speed of Perception	-.01	.22	.13	.26	.27*	.14	.27	.23
Patterns	.24*	.33**	.16	.22	.09	.32**	.24	.50**
Simulated Zeroing	-.09	-.13	.03	-.17	-.19	-.09	-.18	-.20
	n=92	n=92	n=91	n=47	n=56	n=91	n=46	n=42
	†n=91	n=91	n=90	n=46	n=55	n=90	n=45	n=41

* Correlations significant at .05 level.

** Correlations significant at .01 level.

Table 7

Correlations Between Gunner Criterion Measures and Paper-and-Pencil Predictor Scores

	<u>Tracking</u>	<u>Hits</u>	<u>Procedure</u>	<u>Combined Score</u>
Lateral Perception	.09	.10	.07	.06
Visual Recognition	.03	-.17	-.15	-.23
Reaction to Signals	.10	-.05	.12	-.07
Attention to Detail	.03	-.33*	.00	-.27*
Visual Memory	.29*	.06	.28*	.12
Perceptual Speed	.11	.01	.12	-.02
Related Forms	.25	-.01	-.07	.03
Locations	.35**	.11	.08	.19
Speed of Perception	.26*	.08	.12	.10
Patterns	.28*	-.04	.19	.11
Simulated Zeroing	-.07	.27*	.15	.25
	n=61	n=59	n=55	n=53
	n=61	n=59	n=55	n=53

* Significant at .05 level.

** Significant at .01 level.

FACTOR ANALYSIS AND MULTIPLE REGRESSION

Given the statistical independence of criterion performances in the areas of driving, loading, and firing (see Table 3), a further analysis was conducted⁴ in order to answer the following questions:

1. Are criterion performances in driving, loading, and firing based on different abilities, when abilities are defined in terms of factor scores derived from predictors used in the present study?

2. How well do these factor scores correlate with performances in driving, loading, and firing?

In order to identify the various ability components sampled by the predictors, a factor analysis was conducted on the overall battery. One run consisted of a factor analysis of the paper-and-pencil tests only. A second run consisted of a factor analysis performed on all predictors. Varimax rotation was used on both runs. As shown in Table 8, two factors were isolated from the original group of 11 paper-and-pencil predictor tests. Six factors were isolated in the run containing all predictor variables. Stepwise linear regression analyses were then performed to determine the extent to which the criterion performances in driving, loading, and firing could be predicted from the factors.

Two analyses were performed. The first used only Factors 1 and 2 derived from the battery of 11 original paper-and-pencil tests. The second analysis used all six factors. The results, presented in Table 9, show that for both the two-factor and six-factor solutions Factor 1 was significantly correlated with the loading criterion; Factor 2 was significantly correlated with both portions of the driving criterion. None of the factors was found to predict the main gun firing criterion.⁵

⁴ Although the results are discussed within the context of a multiple regression approach for establishing the relations between aptitude variables and criterion performances, these results in no way should be viewed as an attempt to validate the predictive validity of such relations, for such validation must be conducted on an independent sample.

⁵ In order to reduce the total number of criterion variables, four criterion variables associated with the various crew positions were selected for use in the multiple regression analysis. They were: Mean hit performance; a combined loading score composed of loading time and loading errors (this was obtained by converting to standard scores and then adding) terrain driving (exercises 1-3) and terrain driving and road march combined (exercises 1-5).

Table 8

Rotated Factors Showing Variables Which Load at Least .5 on the Factor

<u>11 Variable Solution</u>	
<u>Factor 1</u>	<u>Factor 2</u>
Lateral Perception	Visual Memory
Visual Recognition	Perceptual Speed
Reaction to Signals	Locations
Speed of Perception	Patterns

<u>30 Variable Solution</u>	
<u>Factor 1</u>	<u>Factor 2</u>
Lateral Perception	Perceptual Speed
Visual Recognition	Locations
Reaction to Signals	Patterns
Speed of Perception	
<u>Factor 3</u>	<u>Factor 4</u>
PT-Inverted Crawl	ACB-Combat
PT-Horizontal Ladder	ACB-Field Artillery
PT-Combined	ACB-Motor Maintenance
	AFQT
<u>Factor 5</u>	<u>Factor 6</u>
MRMT-Placing	Height
MRMT-Turning	Weight
MRMT-Combined	

Table 9

Stepwise Multiple Regression Using Factor Scores to Predict Loading, Driving and Gunnery Performance

Criterion Variable	2-Factor Solution ^a		
	Predictors	Multiple R	Significance Level
Loading (n=75)	Factor 1 Only	.40	.01
Driving Exercises 1-3 (n=91)	Factor 2 only	.32	.01
Exercises 1-5 (n=42)	Factor 2 only	.51	.01
Gunnery (n=59)	no significant predictors	.20	

^a None of the results for the 6-Factor solution was significant. This is a result of the shrinkage of the multiple R with large numbers of independent variables.

DISCUSSION AND CONCLUSIONS

The primary importance of the present study lies in its identification of the statistical independence of driving, loading, and firing performances among the Armor AIT trainees sampled. The lack of any significant correlation between criterion performances indicates that although some individuals may have consistently performed well or poorly in all three criterion areas (i.e., in driving, loading, and firing), the majority of individuals sampled performed best in one area. Proceeding on the assumption that individual differences in driving, loading, and in firing are the result of individual differences in the abilities necessary to perform these tasks, the remainder of the study sought to determine (a) if these "abilities" could be identified, and (b) if prediction of performances in each criterion area could be made on the basis of these abilities.

As would be expected from the high degree of intercorrelation between tests in the experimental battery, far fewer "abilities" (i.e., factors) were sampled than might have been supposed on the basis of the number of predictors used. Although criterion performances in loading and driving were significantly correlated with factors 1 and 2, respectively, these results do not necessarily indicate that criterion performances in

loading and in driving are based on unitary ability dimensions--for although multiple correlation coefficients as high as .51 were obtained (for driving exercises 1-5), neither factor was able to account for more than 25 percent of the variability in the criterion variables. Furthermore, regression of the gunnery criterion on the factor scores showed that firing performance was not predicted from either of the two factors. The inclusion of four additional factors (see Table 8) did not improve these predictions.

Although the present results support the relevance of these predictors for driving and loading criterion performances, it would be premature at this point to associate criterion performances in driving, loading, and firing with particular "abilities" or combinations of predictor tests. Instead, the results can be viewed as broadly indicating the existence of empirically identified relations between a class of predictor variables and criterion performance in driving and in loading.

Of the three criterion areas, the gunnery criterion remains the most poorly differentiated. All things considered, one might expect the gunnery criterion to have been the most difficult to predict. First it must be remembered that the six trials comprising the criterion measure represented the initial practice trials on a complicated task, the outcome of which is not solely a function of the individual's performance but also of the state of the equipment and the conditions under which the task is performed. The latter point is significant in that the primary objective of main gun firing experience in Armor AIT is familiarization, not accuracy. Thus, if variables should be identified which are capable of predicting some measures of firing performance at the AIT level, such results would not necessarily predict firing performances outside AIT.

The present research can thus be viewed as a screening process whereby the most promising tests are selected for further consideration and remaining tests eliminated.

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APPENDIX A
DESCRIPTION OF PREDICTOR TESTS

A. Predictor Tests Administered by ARI

1. Attention to Detail, PT 4489. This is a 60 item four minute hand scored perceptual speed test of the "C-Cancellation" type. The examinee is required to count the C's in a row of O's. Score is number of items correct.
2. Patterns Test, PT 2788(R). The examinee is required to reproduce on an answer sheet a line pattern which conforms to a pattern presented in a different part of the answer sheet. Score is number of pattern segments in the correct position.
3. Related Forms Test, PT 2855 (R). This is an 84-item, nonverbal timed reasoning test printed directly on the answer sheet. In 28 groups of three items each, it required the classification of each item (a geometrical pattern) in Type A or Type B according to a set of model patterns with each of the 28 groups having its own set of Type A and Type B model patterns. Score is number of items correct.
4. Locations Test, PT 2852(R) (CRT 445). This 48-item timed visual test consists of sets of four small photographs, each set being accompanied by a large photograph having five lettered locations marked. The examinee is required to identify the lettered location in the larger photograph from which each of the four small photographs were taken. Six of the 12 sets of four small photographs are darkened to give a "night" effect. Score is number of items correct.

5. Army Perceptual Speed Test, PT 2644 (R). This is a 48-item, five-minute test printed directly on the answer sheet. Each set of four items requires the examinee to match four groups of sketched objects with the proper four of five sketch groups from which they are taken. Score is number of items correct.

6. Visual Recognition Test, PT 5089 (CRT 68). This is a forty item timed test in which the examinee is required to match a geometrical design given on the left with one of five geometrical designs given on the right. Score is number of items correct.

7. Visual Memory Test-ARL, PT 5087 (CRT 64). This is a 20-item timed test in which the examinee is first required to commit to memory each design in a matrix of 20 different geometrical designs. The examinee is then, in the absence of the matrix, required to view 20 rows each containing designs similar to those viewed in the matrix. In each row the examinee is required to choose the design which was presented in the matrix. Score is number of items correct.

8. Speed of Perception-ARL, PT 5086 (CRT 62). This is a timed test in which the examinee is required to locate in succession the numbers from 1-50 where alternate numbers vary in size and where each is presented in a random location on one side of a standard 8.5 by 11 inch sheet of paper. Score is highest number reached.

9. Lateral Perception, PT 5088 (CRT 66). This is a timed test consisting of 50 items. Each item consists of two rows of from 1 to 10 alphabetic and/or keyboard characters each. The two rows comprising each item are presented side by side with different degrees of left-right separation between rows. The examinee is required to examine the two rows of characters and respond on a separate answer sheet either "same" or "different."

Score is number of items correct.

10. Reaction to Signals Test, PT 2855(R). This is an 84-item non-verbal timed reasoning test. In 28 groups of three items each, it requires the classification of each item (a geometrical pattern) in Type A or Type B according to a set of model patterns with each of the 28 groups having its own set of Type A and Type B model patterns. Score is number of items correct.

11. Simulated Zeroing Test. A test (constructed by ARI-Ft Knox) to determine the extent to which the subject is able to locate the geometric center of a hypothetical three round shot group. Score is measure based upon deviation of perceived center from true center.

12. Vision Tests.

Visual acuity for left and right eyes was determined both with and without glasses (where appropriate) using the Army version of the Bausch and Lomb Orthorater vision testing device. Vertical and lateral phorias (muscle balance) were also measured with the Orthorater. Eye dominance was determined by asking the subject to first hold up the index fingers of his left and right hand before his face (in a plane perpendicular to and bisecting the plane of the subject's eyes) and then with both eyes open to try to align the two. The subject was then asked to successively close his left eye and his right and on each occasion to report whether he perceived one or two fingers before him. The eye in which the subject reported only one finger being seen was taken as the subject's dominant eye.

13. Test of Manual Dexterity. The Placing and the Turning subtests of the Minnesota Rate of Manipulation Test were administered to each of the forty subjects. The test measures wrist and hand dexterity as contrasted to overall psychomotor coordination. Measures of the time to complete

each of the subtests as well as an overall time score are obtained. Since good performance on the test is inversely related to one's numerical score, correlations with criteria requiring this ability will, in most instances, be negative rather than positive.

14. Hand Dominance. The subject was required to throw a dart at a dartboard. The hand the subject used to throw the dart was considered the dominant hand.

B. Other Predictor Tests

15. Two-Hand Coordination Test, DA PRT 2617. This eye-hand coordination test requires the subject to place a stylus point in successive circles on the test sheet with each hand, moving left hand and right hand alternately in three timed parts of 25 seconds each. The score is the number of circles having one clear stylus mark inside or touching the circle.

16. Army Classification Battery (ACB). This test battery administered to all military personnel upon enlistment allocates personnel into military career management fields.

17. Armed Forces Qualification Test (AFQT). This test determines an individual's eligibility for the Armed Forces.

18. Advanced Physical Fitness Test. This test is administered to the trainee by cadre during the training cycle.

19. Visual Reaction Time. In this test, using the Army Porto-Clinic device, the individual presses a foot pedal as quickly as possible in reaction to a flashed light. Score is the time interval between onset of the light and depression of the foot pedal.

20. Field of Vision. In this test, also using the Porto-Clinic device, pegs are moved by strings into the field of vision until the individual can see them. A graduated scale on the board indicates the score in degrees.

APPENDIX B

TANK DRIVER TEST (Terrain)

Evaluator _____

Unit _____

Trainee _____

Date _____

Place a check mark in the appropriate right hand column for each error.

I. Terrain Driving, hatch closed, daylight

A. Ditch crossing

APPROACHES - too fast; wrong gear, bad angle

DESCENDS - too fast; bad angle

HITS BOTTOM - too rough

CLIMBS - too slow; bad angle

PITCHES OVER - too fast

1	2	3	4	5	6	7	8	9
Poor task performance		Needs Improvement		Acceptable		Good		Outstanding Task Performance

B. Vertical Obstacle

APPROACHES - too fast, wrong gear, bad angle

CLIMBS - too slow, bad angle, roughly

PITCHES OVER - too fast

BRAKES/ACCELERATES - roughly; not enough; too much

1	2	3	4	5	6	7	8	9
Poor task performance		Needs Improvement		Acceptable		Good		Outstanding Task Performance

II. Neutral Steer hatch open, daylight

Sets wrong GEAR

Fails to move T-BAR to full extent; in correct DIRECTION

Fails to ACCELERATE smoothly, sufficiently

STOPS by braking

1	2	3	4	5	6	7	8	9
Poor task performance		Needs Improvement		Acceptable		Good		Outstanding Task Performance

APPENDIX C

TANK DRIVER TEST (Road March)

Driver _____ SSN _____

Evaluator _____ Date _____

Tank Driver Test (Road March)

Place a checkmark in the appropriate right hand column for each error.

II. Road March, hatch open, daylight

A. Level

Maintains incorrect DISTANCE from tank ahead
Drives in wrong GEAR
BRAKES/ACCELERATES roughly
STEERS ROUGHLY, steers too much
TURNS too wide; too sharp; excessive jerking

1	2	3	4	5	6	7	8	9
Poor task performance		Needs Improvement		Acceptable		Good		Outstanding Task Performance

B. Hill (Climb and descend)

Maintains incorrect DISTANCE from tank ahead
Drives in wrong GEAR
STEERS roughly; too much
Drives at wrong SPEED
BRAKES - roughly, not enough, too much

1	2	3	4	5	6	7	8	9
Poor task performance		Needs Improvement		Acceptable		Good		Outstanding Task Performance

APPENDIX D

TANK LOADER TEST (Tables IV and V)

Loader _____ SSN _____ Date _____

Gunner _____ Evaluator _____

Place a check mark in the appropriate right hand column for each error.

FAILS to:	Round	Day						Night			
		1	2	3	4	5	6	7	8	9	10
1. Place safety switch in SAFE position											
2. LOAD round properly											
3. Clear path of RECOIL											
4. Place safety switch in FIRE position											
5. Announce UP											
6. Select ANOTHER ROUND											
7. RELOAD gun immediately after shell ejection											

Fails to load in above SEQUENCE

--	--	--	--	--	--

--	--	--	--

Time to load (in seconds)

--	--	--	--	--	--

--	--	--	--

If tank has automatic safety switch, check here ☐

Timing Guide

1st Round - From: Fire Command - HEAT
To: Loader Announces UP

Subsequent Round - From: Ejection of previous round
To: Loader Announces UP

APPENDIX E
TIME TO FIRE SCORE SHEET

DMO _____

GUNNER _____ SSN _____

TC _____ TANK NO. _____ DATE _____

	Round No.	Time
DAY	1	_____
	2	_____
	3	_____
	4	_____
	5	_____
	6	_____
NIGHT	1	_____
	2	_____
	3	_____
	4	_____

Time a one-round engagement from command "GUNNER" to report of round. Enter elapsed time.

Time a two-round engagement from command "GUNNER" to report of gun . . . Enter elapsed time . . . and let watch run to firing of second round. Enter total elapsed time at second round. For example a two-round engagement requiring 21 seconds for first round and a total of 34 for second would be recorded:

First round 21
Second round 34

APPENDIX F

TANK GUNNERS TEST

Gunner _____ SSN _____ Date _____
 Loader _____ Tank No. _____ DMO _____
 Evaluator _____

TABLES IV AND V MODIFIED

Purpose: To familiarize and teach correct crew procedures and firing techniques for stationary and moving targets, both day and night.

M73 Machine gun - Infinity 50 rds
 Silhouettes @ 400 m.

		Main gun	Target	Range					Total
		Round	Score						Score
									per engagement
DAY	STATIONARY	1 A	Stationary _____ m. Correct sighting _____	Hit _____	Crew procedures _____	Time _____	***	_____	_____
		2 A	Stationary _____ m. Correct sighting (BOT) _____	Hit _____	Crew procedures _____	Time _____	_____	_____	_____
		3 A	Moving tank _____ m. Correct tracking _____	Hit _____	Crew procedures _____	Time _____	_____	_____	_____
		4 A	Moving tank _____ m. Correct tracking (BOT) _____	Hit _____	Crew procedures _____	Time _____	_____	_____	_____
		5 A	Moving tank _____ m. Correct tracking _____	Hit _____	Crew procedures _____	Time _____	_____	_____	_____
		6 A	Moving tank _____ m. Correct tracking (BOT) _____	Hit _____	Crew procedures _____	Time _____	_____	_____	_____
NIGHT	MOVING	1 B	Moving tank _____ m. Correct tracking _____	Hit _____	Crew procedures _____	Time _____	_____	_____	_____
		2 B	Moving tank _____ m. Correct tracking (BOT) _____	Hit _____	Crew procedures _____	Time _____	_____	_____	_____
		3 B	Moving tank _____ m. Correct tracking _____	Hit _____	Crew procedures _____	Time _____	_____	_____	_____
		4 B	Moving tank _____ m. Correct tracking (BOT) _____	Hit _____	Crew procedures _____	Time _____	_____	_____	_____

Summary Scores

Score Obtained _____ + _____ + _____ + _____ = _____
 Maximum Possible _____ + _____ + _____ + _____ = _____

Total Score Obtained

Total Score Possible

Scoring Method

Score per engagement

M73 machine gun

no score

Main gun - all rounds HEAT-TPT using M-32

Correct tracking*	1
Hit	2
Crew procedures**	1
Round off in 30 sec**	<u>1</u>
Total per engagement	5

TC may enter either
+ or 0 in each blank
except time.***

Scores can be calculated
later.

* Denotes correct sighting (correct sight picture) on first two main gun engagements and correct tracking on all subsequent (moving target) engagements. On second round of two -round engagements correct sighting includes BOT adjustment.

** Where score of zero(0) is given (on crew procedures or where time exceeds 30 sec.) indicate by circling G and/or L whether gunner or loader is largely responsible for procedural errors and/or delay.

*** Enter elapsed time in seconds for each two-round engagement as follows:

First round (odd number) -- time from command "Gunner" to
1st round firing;

Second round (even number) -- time from first round firing to
second round firing.

Rounds one and two may be fired as one two-round engagement or as two one-round engagements at the discretion of the TC.

Pencil a bracket around two-round engagements, thus . . .

3A
4A

If an even numbered engagement is a single-round or first round of two, simply cross out (BOT).

APPENDIX G

MEANS, STANDARD DEVIATIONS AND SAMPLE SIZES OF AIT PREDICTOR TESTS

<u>Paper and Pencil Tests</u>	<u>Mean</u>	<u>Standard Deviation</u>	<u>Sample Size</u>
Lateral Perception	32.79	7.45	n = 112
Visual Recognition	23.14	7.23	n = 112
Reaction to Signals	103.78	33.08	n = 112
Attention to Detail	31.47	8.50	n = 112
Visual Memory	9.78	4.90	n = 112
Perceptual Speed	31.53	8.29	n = 112
Related Forms	64.45	12.92	n = 112
Locations	23.39	6.16	n = 112
Speed of Perception	29.14	8.74	n = 110
Patterns	86.85	13.37	n = 112
Simulated Zeroing	15.65	3.37	n = 112
<u>Manual Dexterity</u>			
MRMT Placing	171.07	14.10	n = 108
MRMT Turning	143.16	14.16	n = 108
MRMT Total	314.23	25.61	n = 108
<u>Two-Hand Coordination</u>	100.27	23.21	n = 105
<u>Army Classification Battery</u>			
CO Score	99.89	20.13	n = 105
FA Score	103.18	13.64	n = 105
MM Score	104.58	13.37	n = 105
<u>Armed Forces Qualification Test</u>	54.75	19.95	n = 105

APPENDIX H

RELATIONSHIP OF TESTS IN BATTERY WITH NON-PAPER AND PENCIL PREDICTORS

	<u>Minnesota Rate of Manipulation</u>				<u>R.T.</u>	<u>2-Hand Coord</u>	<u>PT</u>		
	<u>Placing</u>	<u>Turning</u>	<u>Combined</u>	<u>Crawl</u>			<u>Ladder</u>	<u>Combined</u>	
Lateral Perception	-.09	-.10	-.11		.05	.27*	.19*	-.14	.02
Visual Recognition	-.20*	-.18*	-.21*		.15	.09	.08	-.20*	-.08
Reaction to Signals	-.26*	-.24*	-.28*		.17	.34*	-.02	-.22*	-.15
Attention to Detail	-.23*	-.22*	-.25*		.06	.32*	.08	.11	.11
Visual Memory	-.19*	-.20*	-.21*		.18*	.33*	.04	-.01	.02
Perceptual Speed	-.16	-.10	-.14		.15	.34*	-.07	-.03	-.06
Related Forms	-.10	-.01	-.06		.06	.23*	.13	-.11	.01
Locations	-.06	-.07	-.07		-.01	.21	.12	-.22*	-.07
Speed of Perception	-.10	-.06	-.09		.16	.20*	.02	-.21*	-.12
Patterns	-.19*	-.13	-.18*		.08	.20*	.02	-.10	-.05
Simulated Zeroing	-.02	-.04	-.04		-.07	-.02	-.16	-.14	.19
	n=108	n=108	n=108		n=106	n=105	n=94	n=94	n=94
	n=106	n=106	n=106		n=105	n=103	n=93	n=94	n=93

* Correlations significant at .05 level.

APPENDIX I

CORRELATIONS BETWEEN ARMED FORCES QUALIFICATION TESTS (AFQT) SCORES, ARMY CLASSIFICATION BATTERY (ACB) SUBSCORES AND PAPER-AND-PENCIL PREDICTORS

	<u>Combat</u>		<u>Field Artillery</u>		<u>Motor</u>		<u>AFQT</u>	
	r	n	r	n	r	n	r	n
Visual Recognition	.26*	(105)	.19*	(105)	.19*	(105)	.21*	(105)
Reaction to Signals	.39*	(105)	.44*	(105)	.39*	(105)	.46*	(105)
Attention to Detail	.27*	(105)	.31*	(105)	.29*	(105)	.39*	(105)
Visual Memory	.40*	(105)	.51*	(105)	.39*	(105)	.47*	(105)
Perceptual Speed	.19*	(105)	.28*	(105)	.27*	(105)	.32*	(105)
Related Forms	.28*	(105)	.32*	(105)	.29*	(105)	.33*	(105)
Locations	.38*	(105)	.38*	(105)	.46*	(105)	.42*	(105)
Speed of Perception	.36*	(103)	.40*	(103)	.29*	(103)	.38*	(103)
Patterns	.19*	(105)	.26*	(105)	.25*	(105)	.27*	(105)
Zeroing	-.01	(105)	-.13	(105)	-.15	(105)	-.05	(105)
MRMT Placing	-.02	(104)	.01	(104)	-.07	(104)	-.00	(104)
MRMT Turning	-.19*	(104)	-.19*	(104)	-.13	(104)	-.17	(104)
MRMT Combined	-.16	(104)	-.10	(104)	-.11	(104)	-.09	(104)
Two-Hand Coordination	.09	(99)	.16	(99)	.23*	(99)	.21*	(99)
Physical Fitness Test								
Inverted Crawl	.02	(94)	-.03	(94)	-.03	(94)	-.00	(94)
Horizontal Ladder	-.11	(94)	-.15	(94)	-.11	(94)	-.17	(94)
Combined	-.06	(94)	-.11	(94)	-.09	(94)	-.11	(94)

* Correlations significant at .01 level.
 ** Correlations significant at .05 level.



APPENDIX J

INTERCORRELATIONS OF PAPER-AND-PENCIL TESTS

	1	2	3	4	5	6	7	8	9	10
1. Lateral Perception	1.0000									
2. Visual Recognition	.5192	1.0000								
3. Attention to Detail	.3758	.3018	1.0000							
4. Visual Memory	.4442	.3192	.4649	1.0000						
5. Perceptual Speed	.2524	.0879	.3631	.3421	1.0000					
6. Related Forms	.3295	.1865	.2713	.4099	.2058	1.0000				
7. Locations	.3614	.3232	.2206	.4857	.3132	.4002	1.0000			
8. Speed of Perception	.4584	.4348	.4068	.4802	.1936	.3436	.2712	1.0000		
9. Patterns	.2609	.2857	.3058	.5111	.3901	.3825	.4627	.1393	1.0000	
10. Simulated Zeroing	-.0441	-.1138	-.1971	-.2736	-.0625	-.1301	-.1748	-.1103	-.2348	1.0000

Note: Correlation coefficients greater than 0.19 are statistically significant at .05 level.