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Predicting Target Detection Performance Using the Armed Services Vocational Aptitude Battery Subtests and Cognitive Factor Tests

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13. ABSTRACT *(Maximum 200 words)*

For this research, a simulation of a remotely piloted vehicle (RPV) Sensor Station Operator situation was created in which soldiers who had completed initial training were required to seek and report targets that appeared on a black and white TV screen. Targets were military vehicles, buildings, and other manmade objects that appeared in 90 of 1,440 photos taken from a helicopter flying over and near Fort Sill, OK. When transferred to videotape these photos appeared for 4.5 seconds, with a 15-second dark period between views. This process resulted in a 2-hour presentation that appeared to be an uninterrupted overflight. Subjects were also given six cognitive tests representing three cognitive factors (speed of closure, flexibility of closure, and perceptual speed), and ASVAB subtests were obtained and biographic information was collected. The speed of closure, measured by the Gestalt completion, Concealed Words, and Snowy Pictures tests--all of which are significantly correlated --and several biographic items correlated beyond the $p=.05$ level, but ASVAB test scores did not significantly correlate. One of the two flexibility of closure tests, Hidden Figures, was significantly correlated, but the overall factor correlations

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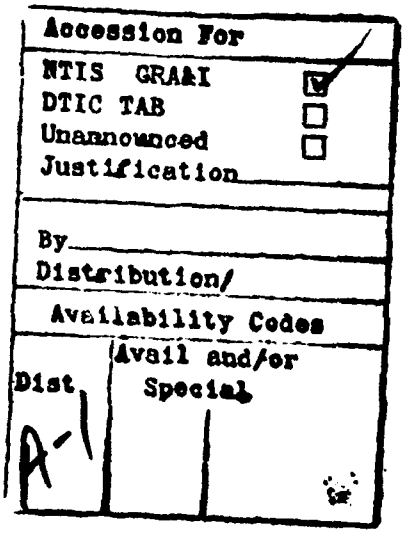
were not significant when the Hidden Pattern score was merged to create a single factor value. Biographic items implied that persons who fished, were not heavy coffee drinkers, and did not need glasses performed better.



FOREWORD

As systems are automated and technology improves communication on the battlefield, there is an increased need for operators who can extract information from real-time presentations of video material. An example of the types of systems these individuals will operate is the Sensor Station in Remotely Piloted Vehicle (RPV) systems. Such systems are designed to fly over enemy units and transmit video as they proceed. Operators must be able to detect targets that are poorly visible and that remain on the screen for limited periods. Operators must also maintain a high level of attentiveness so that they do not miss targets because of inattention.

This report presents the results of research conducted to determine if the Armed Services Vocational Aptitude Battery (ASVAB) subtests or cognitive style tests can be used to predict performance in this narrow role. It is suggested that the cognitive factor speed of closure and possibly the flexibility of closure factor do predict target detection performance. It is also suggested that the ASVAB subscale relationships to target detection are weaker but, to the extent they exist, the Field Artillery Aptitude Area Composite Score contains the best representation of the weakly related subtests.

The data on which this report is based were collected during the period when the Aquila RPV system was under development. The original work was undertaken at the request of the RPV Training and Doctrine Command Systems Manager (TSM). The TSM wanted to know if there was reason to believe that persons selected from an aptitude area other than Field Artillery would be better suited to be RPV Sensor Station Operators. The TSM also requested information on the possible use of cognitive style measures as operator aptitude prediction instruments. The TSM was briefed after the data were collected and analyzed. This report, based on a subset of the original data, makes results available to other parties who may need to predict target detection performance for persons assigned to similar operator roles.

ACKNOWLEDGMENTS

This report was prepared by the two senior authors. It was prepared from data, analyses, and draft material to which Robert C. Schwalm, Jay S. Coke, and Johnsie C. Brown contributed significantly. Schwalm, Coke, and Brown were, at that time, researchers at the U.S. Army Research Institute for the Behavioral and Social Sciences.

PREDICTING TARGET DETECTION PERFORMANCE USING ARMED SERVICES VOCATIONAL APTITUDE BATTERY SUBTESTS AND COGNITIVE FACTOR TESTS

EXECUTIVE SUMMARY

Requirement:

The research described in this report is part of a larger effort to determine how well persons perform on automated systems. One of the tasks required by increases in automation is extraction of data from real-time presentations of transmitted video information presented on TV screens. Operators need to be able to see and identify targets and be able to avoid any tendency to become inattentive as their duty cycle proceeds. Remotely Piloted Vehicle (RPV) systems require skilled operators to examine such real-time presentations. This research effort was undertaken to determine if Sensor Station Operators (SSOs) who would be more able to detect potential targets from real-time video presentation, could be selected using an aptitude area composite score other than Field Artillery.

Procedure:

Persons who had finished their basic and advanced training at the U.S. Army Field Artillery Training Center were tested in a situation that simulated the Sensor Station of an RPV system. In the test situation the subjects saw a black and white video presentation of 1,440 views of Fort Sill, Oklahoma, and the immediate surrounding area. In 90 of the slides there were targets. Each slide was visible for 4½ seconds, and there was a .05 second dark period between slides. The video presentation lasted 2 hours, and subjects depressed a switch when they detected a target.

Before they were tested in the SSO simulation, the subjects completed a brief biographic inventory and took six short cognitive style tests. The six tests represented three cognitive parameters: speed of closure, flexibility of closure, and perceptual speed. After subjects were tested, Armed Services Vocational Aptitude Battery (ASVAB) data were obtained from the Soldier Support Center. Biographic items and scores on the ASVAB subtests and cognitive tests were then correlated with target detection scores.

Findings:

Four ASVAB subtest scores (General Information, Space Perception, Electronic Information, and Automotive Information) correlated weakly--.140 to .163--with target detection performance before a correction for multiple variables was applied. After the correction, no ASVAB subtest correlated beyond the $p<.05$ level. The three tests that measured the cognitive factor speed of closure all correlated significantly, and one of the two tests that measured flexibility of closure correlated significantly. The single perceptual speed test did not correlate significantly. When the three speed of closure and two flexibility of closure test scores were averaged and the resulting correlations corrected for multiple variables, speed of closure still correlated significantly but flexibility of closure did not. The results suggested that the Snowy Pictures test, which measures speed of closure, and perhaps the Hidden Figures test, which measures flexibility of closure, would be of value for predicting target detection ability in situations similar to the test situation. The results also suggest that research needs to be done to determine why some cognitive style tests (e.g., Hidden Figures and Hidden Patterns) that purport to measure the same factor give such variant results. Our results suggest that use of the Snowy Pictures test to screen potential SSOs and use of operators who score well above average on that test could improve target detections per mission performance by 10 to 15%.

Utilization of Findings:

Detecting targets in situations where targets are poorly visible and search time is limited is difficult. This study suggests that cognitive tests could form a basis for selecting persons for additional training and development after they are assigned to military occupational specialties in which such SSO-type assignments are possible. Hence, these type tests could be valuable in a Field Artillery--or other service arm--program similar to the "Top Gun" program in the Air Defense Artillery or the periodically discussed "Master Gunner" concept of the Field Artillery. These tests could also be used to select and classify subjects where researchers need to create high- or low-aptitude groups for research purposes.

PREDICTING TARGET DETECTION PERFORMANCE USING ARMED SERVICES VOCATIONAL APTITUDE BATTERY SUBTESTS AND COGNITIVE FACTOR TESTS

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Introduction

An important function of an effective Field Artillery system is the detection of potential targets. Successful target detection requires that information be obtained from areas that are occupied by enemy forces. One method considered for obtaining such data from behind enemy lines is a Remotely Piloted Vehicle (RPV) system that can transmit a real-time video signal from cameras carried on the flight vehicle. In such systems the cameras are controlled from a ground station where a crew member, often designated the Sensor Station Operator (SSO), observes the terrain picture on a TV screen as it is transmitted from the RPV.

The RPV transmits a continuous picture of the terrain as it flies a search pattern over enemy territory. The transmitted picture is displayed in such a manner that, as the air vehicle moves forward, new material enters the top of the TV display and moves downward until RPV forward motion causes the item to exit the bottom of the screen. When a potential target is detected, the SSO can control the RPV and the camera to obtain a longer or closer view of the object of interest.

RPV missions can involve flights of up to two and one-half hours. During this period, SSOs, to be maximally effective, must remain alert in order not to miss targets due to lack of attention. SSOs must also be able to recognize, as potential targets, objects that are poorly visible, since most enemy material will be camouflaged to some extent. Since the value of the RPV as a target detection system is affected by the operator's attentiveness and by the ability of the operator to see targets as the RPV camera passes over an area, an opportunity exists to improve RPV system performance by assigning as SSOs the persons most suited to the role requirements of attention and visual skill.

Anything that can be done to increase the operator's ability to detect targets will increase the effectiveness of the system. With any detection system, the marginal detection is the critical detection. Operators who detect targets that less able operators would miss provide two advantages to friendly forces. One is that good operators will detect more targets. The second is that better detection and, hence, destruction of more targets will force the enemy to take more care in hiding his assets. Since better camouflage techniques require the expenditure of more assets and time, the enemy's fighting effectiveness will be reduced further.

RPV mission length and the nature of the display suggest two areas which might be improved by an operator selection procedure.

RPV missions are relatively long; hence, the ability to monitor the screen constantly and not miss targets due to inattention may well be related to some element of aptitude, experience, or character which can be used as a basis for identifying operators with the best potential for maintaining a high level of performance at the SSO position. Also, since the operator will be seeking obscured or hidden targets, there may be some cognitive factor which influences performance in situations where the presence or nonpresence of a target is not easy to determine. This research deals with the target detection function.

Purpose

The purpose of the present research project was to determine if Armed Services Vocational Aptitude Battery (ASVAB) subtest scores, scores from a group of cognitive factor tests, or selected biographic items predict the ability of persons to detect targets, such as vehicles, weapons, and buildings on a display that simulates an SSO's duty situation over a period which approximates the length of an RPV mission.

Procedure

The experiment was conducted in a laboratory in which a simulation of the SSO target detection task had been created. Subjects were obtained from among enlisted persons who had completed their basic and advanced individual training at the Field Artillery Training Center, Fort Sill, Oklahoma. Data collected on each subject included ASVAB subtest scores, scores on selected cognitive factor tests, a number of biographic items, and two related measures of performance--targets detected and false detections.

Subjects

Subjects for the experiment were obtained from the "holdover" pool at the U.S. Army Field Artillery Training Center where enlisted personnel are trained in the various Field Artillery specialties. Holdovers are predominantly soldiers, male and female, who have been trained in specialties which require a security clearance, and who are not available for assignment to a duty station until the required investigations are completed. A small portion of the holdovers are held over for other reasons such as discipline, illness, or personal problems which delay further assignment. It is our belief that, considering the manner in which the subjects were obtained, the subjects were representative of the type of people in the personnel pool from which RPV operators would be selected. A total of 240 subjects were tested, but data on some of the subjects were incomplete. Discrepancies occurred because of occasional equipment malfunctions, missing ASVAB data, or subjects not being available for portions of the testing because of transfer to duty assignments. Data from 209 subjects were

available for the cognitive factor and biographic item analyses, and 196 were available for the ASVAB related analyses.

Experimental Setup

Subjects were tested in groups of four in an air conditioned 15' X 18' room. Windows in the room were masked and, during the data collection process, the room was darkened with the only light sources being a lamp on the desk of the experimenter and a single tube, ceiling mounted fluorescent light. Both light sources were behind the subjects. Subjects were seated behind small tables with the back edge of each table 10'6" from the center of a 19" black-and-white television screen. Subjects were provided with a push button switch, mounted on a small block of wood which subjects could move to whatever position they considered comfortable.

When subjects saw, or thought they saw, a target on the screen the subject depressed the switch. Switch closures were recorded by an event recorder (Lafayette Instrument Company, Model 56042, Six Channel Mini Recorder). The video tape on which the stimulus materials had been recorded had also been marked so that a pulse appeared on the audio track during the interval when a target was present. This pulse, which did not cause an audible sound, was detected and recorded on a separate channel of the event recorder.

Work Sample Simulation Test

The stimuli seen by the subjects consisted of a video presentation of 1440 slides showing aerial views of terrain on and near Fort Sill, Oklahoma. The original photographs were taken with a 35mm camera from a low flying helicopter whose altitude varied between 400 and 800 feet. The slides were taken on Kodak Ektachrome 64, 36-exposure color slide film. The camera was held so that it pointed approximately 30° out and 30° forward of the helicopter. Photographs were taken as the helicopter approached, passed over, and flew beyond targets. As the photographs were taken the pilot tried to adjust his speed so that each photograph showed a terrain section that only slightly overlapped the previous picture. When the pilot was successful the target appeared on only one slide in the sequence. If the speed was low, the overlap was greater, and a target could appear twice or three times in a series. When this occurred, two or three series were created by taking alternate slides, or every third slide, from the set to form multiple series with the same target and approach flight path.

Target Selection

Two target sources were used: pre-positioned military vehicles and targets of opportunity. Therefore, some of the targets were 2 1/2-ton trucks, Go-ers, and Jeeps which were specifically placed so that photographs could be taken. These

vehicles were directed by a radio link with the helicopter and were placed in appropriate places to be photographed. Photographs were also taken of civilian and military traffic along local roads, and of buildings, bridges, and helicopters on the ground. From the available pool of slides that contained targets, 90 target series were selected for inclusion in the test sequence. The researchers made the selection based on the following criteria: (a) a good transition between target series had to be possible, (b) only one target should appear on a slide, (c) a target should not be so obscure that no subject would be likely to see it or so obvious that everyone would probably see it.

Obtaining good transition was possible because each series had a sequence of views as the target was approached and a sequence after the target slide. The various sequences were arranged in an order that matched the background and terrain at the end of one series with the first frame of the subsequent series. A good transition could be obtained by omitting slides or inserting slides from an excess pile in order to create a good match. Since the Fort Sill terrain is quite homogeneous, this sequence matching could be done with very little distortion of the overall continuity of the total flight simulation. The single target only constraint was assured by examining an approximately 4' by 6' projection of the original color slide, and assuring that the portion projected for the video tape creation process contained only one target.

After the slides were examined, they were mounted in a carrousel projector and displayed on a rear projection screen. A video camera mounted facing the front of the screen was then used to create the three 40-minute tapes used in the experiment. Because the 4/3 aspect ratio of the video screen was smaller than the aspect ratio of the 35mm pictures, the location of targets and content of the individual views could be controlled somewhat by adjusting the projected image left or right. This feature was used to position the target further left or right, and to avoid situations where some feature near the edge of the film was detrimental to the appearance of the terrain view. The final criteria, target detectability, was assured by having the researchers examine the black-and-white video display of the slides containing the targets to be certain that each target was indeed visible.

Prediction Variables

The independent variables in this experiment were a brief list of biographic items, 12 subtest scores from the ASVAB and six cognitive factor tests. The biographic data were requested partly to introduce the subjects to the test situation. The biographic items asked for information concerning gender, smoking habits, coffee drinking, if the subject wore glasses, in what kind of general environment the subject was raised, and if the subject read, hunted, or fished for amusement. Some items were

used because target detection and vigilance studies have reported significant correlations with them or with very similar items.

Some investigators (e.g., Waag, Halcomb, & Tyler, 1973; Thackray, Touchstone, & Bailey, 1978; Whittenburg, Ross, & Andrews, 1956; Tolin & Fisher, 1974) have reported differences in vigilance performance between males and females. Other investigators (Whittenburg & Collins, 1974) have reported that persons who hunted, and persons who grew up in rural areas were significantly better at detecting both camouflaged and uncamouflaged targets. Smokers have also been found to perform differently than nonsmokers in visual detection situations. Tarriere, Hartemann, and Niarfeix (1966), for example, reported that smokers allowed to smoke performed best in a 150-minute vigilance task; Myrsten, Andersson, Frankenhaeuser, and Mardh (1972) and Frankenhaeuser, Myrsten, Post, and Johansson (1971) reported that the performance effect of smoking was related to the arousal effect of the experimental situation; and Johnston (1966) reported that smokers who reduced or abstained from smoking for two weeks improved their performance more than nonsmokers or smokers who smoked on a later retest.

Caffeine, found in coffee, is a stimulant; and stimulants have sometimes been found to affect performance in vigilance situations in a most complex manner. Results of an auditory vigilance study by Keister and McLaughlin (1972), for example, showed that caffeine taken during the test kept performance from falling off during the 45-minute test period. Amphetamines taken during the test period were also found to result in less performance decrement (Mackworth, 1965). It appears that the impact of drugs on target detection performance is not well known and that such research is often tied to the arousal concept which is tested in most introversion-extroversion vigilance performance research.

Fishing as a means of recreation, it was thought, may well appeal to persons who do not become restive in situations where attention must be maintained over fairly extended periods. Reading is a visually-oriented, attention-narrowing, amusement that may appeal to persons who do not dislike tasks which require little movement and extended attention. Information concerning glasses was sought because glasses often are not well suited for particular viewing distances or are not used when they should be worn.

ASVAB subtest scores which are available from Army records and were obtained for each subject are listed in Table 1. Six cognitive tests were used in this research. They were taken from a kit of factor-referenced cognitive tests prepared by the Educational Testing Service on contract to the Office of Naval Research (Ekstrom, French, Harman, & Dermen, 1976). The tests used represented three factors: Speed of Closure, Flexibility of Closure, and Perceptual Speed. The factors were selected because the Speed of Closure and Flexibility of Closure tests appeared to

involve factors important to the task of seeing partially obscured items, and the Perceptual Speed factor seemed relevant because a faster operator might be able to make a better examination in a situation where targets remained only a short time. The tests and the factors are shown in Table 2.

Table 1

List of ASVAB Subtest and Classification Scale Scores Available for Subjects

Subtest Scores			
GI	General Information	MK	Mathematical Knowledge
NO	Numerical Operations	EI	Electronics Information
AD	Attention-to-Detail	MC	Mechanical Comprehension
WK	Word Knowledge	GS	General Science
AR	Arithmetic Reasoning	SI	Shop Information
SP	Space Perception	AI	Automotive Information

Classification Inventory Scales*	
Mechanical (CM)	Attentiveness (CA)
Electronics (CE)	Outdoors (CC)

Composite Score**

AFQT

* The classification inventory scales are obtained by adding selected subtest scores (see Table 8).

** The AFQT is a composite score obtained by adding the Word Knowledge, Arithmetic Reasoning, and Space Perception scores.

Because testing time was limited, we did not use all of the tests available for these factors. We used the three Speed of Closure tests: the Gestalt Completion Test, whose items appear to be almost identical to the visual and intellectual tasks involved in detecting camouflaged targets where portions of the items blend into the background; the Concealed Words Test, which seems to be the same test unencumbered by the need to recognize physical objects (but requiring some word knowledge); and the Snowy Pictures Test, which seems a direct analog of the target detection problem since much camouflage activity involves attempts at extending the surrounding visual field over the edges of the object in order to obscure it.

The Hidden Figures and Hidden Pattern tests, which measure Flexibility of Closure, were included because there may be a relationship between this ability and the detection of items that have a specific shape or pattern but are embedded in other visual material. The Identical Pictures Test, which measures Perceptual Speed, seemed promising because of its resemblance to the SSO role, which requires the operator to scan rapidly and to compare quickly what is being seen to a mental reference. It was felt that this test might identify persons who would detect more targets because they were able, as a result of their speed, to examine each frame more carefully.

Table 2

Cognitive Factors and Tests Used in the Experiment

FACTORS	TESTS
A. Speed of Closure: The ability to unite an apparently disparate perceptual field into a single concept.	1. Gestalt Completion 2. Concealed Words 3. Snowy Pictures
B. Flexibility of Closure: The ability to hold a given visual percept or configuration in mind so as to disembed it from other well defined perceptual material.	1. Hidden Figures 2. Hidden Patterns
C. Perceptual Speed: Speed in comparing figures or symbols, scanning to find figures or symbols, or carrying out other very simple tasks involving visual perception. It may be the centroid of several subfactors (including form discrimination and symbol discrimination) which can be separated but are more usefully treated as a single concept for research purposes.	1. Identical Pictures

Testing Process

Subjects were given the biographic item inventory and the cognitive factor tests in groups of 25 to 30 on Monday morning. They were then tested in groups of four later in the week, either in the morning or afternoon. ASVAB data for the subjects were obtained from the Soldier Support Center.

Prior to the detection test, the subjects were read instructions which described the nature of the test, the types of targets, and the purpose of the research. Subjects then saw two training tapes. First they saw a 16-frame videotape containing targets, and the experimenter pointed out the location and type of target as the frames passed. Subjects were instructed to report as targets any manmade object other than roads, railroads, powerlines and fences; and were told that targets were considered to be such things as vehicles, both civilian and military, buildings of any type, and bridges. Subjects then were shown a six and one-half-minute training tape containing 80 slides of which 27 had single or multiple targets. As the tape was played, subjects depressed their switches when they saw a target (these data were not recorded). The same tape was then played with a pointer overlay showing the locations of each of the targets. The experimenter then answered questions, after which the subjects took a brief break before the data collection process began.

The test process took two hours. Each of the 1,440 videotaped frames remained visible for four and one-half seconds, and there was a one-half-second dark period between frames. The test material was recorded on three videotapes with 40 minutes of material on each tape. Each tape contained 480 frames. The experimenter, who sat behind the subjects, monitored the subjects and changed the tapes. Changing a tape took approximately 15 seconds. When the new tape approached the playing position, the experimenter informed the subjects that the next picture was due. There were 25, 37, and 28 targets in blocks one, two, and three respectively, and a total of 90 among the 1,440 total frames. A total of 240 subjects were tested. Data from 209 subjects were available for the cognitive factor and biographic item analyses, and 196 were available for the ASVAB related analyses.

Results

The data collected were analyzed to determine the nature and extent of the relationship between the subjects' ability to detect targets and the biographic items, the ASVAB subtest scores, and the cognitive factor test scores.

Correct Detection Data, Biographic Items

Table 3 shows the results of a one-way analysis of variance run on the biographic data. The Fishing, Glasses, and Coffee items were significantly related to correct target detection scores. A further analysis shown in Table 4 showed that persons who fished, did not require glasses, and were not heavy coffee drinkers were slightly better performers.

Correct Detection Data, ASVAB

Table 5 shows the relationships between the various ASVAB scores and 196 subjects' performance at detecting targets. Note

that General Information, Space Perception, Electronics Information, and Automotive Information, had Pearson r values that exceed the level that would be measured by chance. Because we had not stated hypotheses concerning the nature of the relationship of ASVAB scores to test variables, significance

Table 3

Results Analysis of Variance on Biographic Data and Correct Detection Scores for 209 Subjects for the 120-Minute Test

Item	Categories	F Ratio	Probability
Sex	2	3.67	.057
Fishing	3	3.30	.039*
Hunting	3	1.01	.364
Location	4	2.12	.101
Reading	4	2.26	.083
Glasses	2	5.09	.025*
Coffee	3	4.34	.014*
Smoking	3	1.86	.158

* $p < .05$

Table 4

Mean Values for Significant Biographic Items

Item/Response	Mean Detections
Do you go fishing?	
Often	30.91*
Sometimes, but not often	30.75*
No	24.16
Do you wear glasses?	
Yes	26.27
No	31.06
How much coffee do you drink?	
Heavy (more than 6 cups)	15.14
Moderate (less than 6 cups)	29.60*
Little (2 cups or less)	30.39*

*Indicates that the pair of means differed from the remaining mean at the $p < .05$ level

levels were determined using a two tailed test. Since data were available, correlations were also computed for the AFQT score and the four Classification Inventory Scores. These items were not significantly correlated with target detection.

In examining the significance of the correlation coefficients there are two other factors that should be considered: the appropriateness of using the two tailed test, and the fact that there were 12 subtest scores. It could be

Table 5

Pearson r Values for ASVAB Scales and Target Detection

ASVAB Subtests	r	ASVAB Subtests	r
General Information	.147*	Mathematical Knowledge	.040
Numerical Operations	-.018	Electronics Information	.163*
Attention to Detail	.014	Mechanical Comprehension	.078
Word Knowledge	.074	General Science	-.013
Arithmetic Reasoning	-.011	Shop Information	.108
Space Perception	.140*	Automotive Information	.152*
Classification Inventory Scales			
Mechanical	.066	Electronic	.037
Attentiveness	-.053	Combat	.036
Composite			
AFQT	.085		

*Exceeds $p<.05$ level, two tailed test of significance before correction for multiple variables. None are significant after correction using a two tailed test or one tailed test.

argued that the very nature of the ASVAB testing and selection process results in the implicit assumption that higher scores will result in better performance; hence, that a one tailed test is justified. It is also customary, when examining data arrays that involve many variables correlated to a single variable, to correct for the fact that as the number of correlation coefficients increases the chance of obtaining a given significance level by chance alone also increases. If the $p<.05$ alpha level is adjusted to compensate for the fact that there were 12 comparisons, by the commonly used method of dividing the desired alpha level by the number of comparisons (.05/12), the required alpha level is $p<.0041$. With a one tailed test a correlation coefficient of .164 is required to exceed the $p<.01$ level, with 200 degrees of freedom. Since none of the

correlations exceed even this level and there are only 194 degrees of freedom, none of the ASVAB subscale scores are significant at the .0041 level.

Correct Detection Data, Cognitive Factors

Table 6 shows the results obtained when the correlations between the cognitive factor tests were compared to 209 subjects' target detection performance. For these data significance levels were determined on the basis of a one tailed test, since it had been postulated prior to the testing that higher cognitive factor scores would result in better target detection performance. The three Speed of Closure tests and one of the two Flexibility of Closure tests were significantly correlated with target detection performance. (If a two tailed test is applied, three of the four tests exceed the $p<.05$ level and Concealed Words misses by only .001.) Table 7 shows the correlation between the six cognitive factor tests.

Table 6

Pearson Correlation Coefficients Showing the Measured Relationship Between the Cognitive Factor Scores and Target Detection Performance of 209 Subjects

Cognitive Tests	Pearson r	Cognitive Test	Pearson r
Gestalt Completion	.145*	Hidden Figures	.195**
Concealed Words	.134*	Hidden Patterns	.068
Snowy Pictures	.263**	Identical Pictures	-.071

*$p<.05$ (one tailed test) **$p<.01$ (one tailed test)

Correcting for the fact that there are multiple variables is somewhat more difficult for the cognitive factor scores. Although six tests were administered, only three cognitive factors were tested. The Gestalt Completion, Concealed Words, and Snowy Pictures tests were all tests of the Speed of Closure factor, and both Hidden Figures and Hidden Patterns measured the Flexibility of Closure factor. Therefore, before correcting for multiple factors it is appropriate to average these test scores in order to have a single score for each factor. Guilford (1965, pp 348-9) provides a method to average correlation coefficients and to weight the coefficients to adjust for sample size. Applying this method involves transforming the Pearson r values to z scores, computing the average of the z scores, and then transforming back to a Pearson r value.

When the three Speed of Closure test correlations to correct detections are averaged, a value of $r = .181$ results. The two

Flexibility of Closure test values transform to a value of r =.141. No weighting is required, since all sample sizes were the same. The Perceptual Speed Factor value measured only by the Identical Pictures Test remains the same, r = -.071, and is not significant.

Since there are three variables, the alpha value necessary to meet the $p<.05$ level for a one tailed test of significance is .0166. Commonly available statistical tables show that, for degrees of freedom = 200, a Pearson r value of .181 meets the requirement for the $p<.05$ level. Thus, the Speed of Closure factor correlation is significant but not the Flexibility of Closure factor correlation.

Table 7

Correlations Between the Six Cognitive Factor Tests. Data from 209 Subjects

	Gestalt	Conwords	Snowypic	Hidfig	Hidpat	Identpic
Gestalt	1.00					
Conwords	.30	1.00				
Snowypic	.34	.30	1.00			
Hidfig	.21	.12	.27	1.00		
Hidpat	.23	.13	.32	.50	1.0	
Identpic	.01	.15	.14	.11	.23	1.00

Discussion

The primary purpose of this research was to determine if the Field Artillery had the potential of improving target detection performance by obtaining RPV-SSO personnel based on their scores on a different ASVAB composite. The secondary goal was to determine if the cognitive tests contained in the kit of factor referenced cognitive tests reported by Ekstrom and his associates were able to identify persons good at the rather narrow target detection task. The biographic data was addressed simply because the opportunity arose.

Biographic Items

Three of the eight biographic item differences were statistically significant: fishing, glasses, and coffee. It appears that persons who fish, either a lot or a little, for amusement, make more target detections; persons who drink moderate or small amounts of coffee daily make more detections than heavy coffee drinkers; and people who do not need glasses make more detections than people who have glasses prescribed. The first item, fishing, may indicate that persons who amuse

themselves in a high attention, low payoff event type of recreational activity are better at work that requires the same type behavior. Coffee drinking may influence subject behavior (attentiveness) or have a direct physiological effect, but our data provide no basis for further conjecture.The significance of the "glasses" item may be based on the fact that some persons who had eye correction prescribed did not have glasses to wear during the test, and that our test distance, 10'6", was not a viewing distance to which corrective lenses are normally adjusted.

ASVAB Scores

ASVAB tests are administered to all persons entering the Armed Forces, and the subtest scores are used to compute Aptitude Area Composite Scores. There are 10 aptitude area composite scores, shown in Table 8. The Field Artillery selects its personnel based on the FA composite score which includes Arithmetic Reasoning, General Information, Mathematical Knowledge, Electronics Information, and one of the Classification Inventory Scales--Attentiveness--which is a composite of subtest scores. Clearly, even if the weak correlations shown in Table 5 had held up as adjustments for the number of comparisons being made, it would not have been possible to select SSOs from a better personnel pool. There was in fact only one aptitude area composite that contained two of the four subtest scores (Field Artillery), and even in this case other subtest scores included in the composite would reduce the already low relationship.

Table 8

Aptitude Area Composites and Their Computational Formulas

Aptitude Areas	Composition
Combat (CO)	AR + SI + SP + AD + CC
Field Artillery (FA)	AR + GI + MK + EI + CA
Electronics (EL)	AR + EI + SI + MC + CE
Operators/Foods (OF)	GI + AI + CA
Surveillance/Communications (SC)	AR + WK + MC + SP
Motor Maintenance (M)	ME + EI + SI + AI + CM
General Maintenance (GM)	AR + MC + AI + GSB
Clerical (CL)	AR + WK + AD + CA
Skilled Technical (ST)	AR + MK + GSB
General Technical (GT)	AR + WK

In the course of the data analysis it was suggested that the correlation coefficients should be corrected for truncation of the subject population. This truncation results since acceptance for enlistment is based on ASVAB scores, and some persons making

lower scores are rejected. Unfortunately the ASVAB version being administered when our subjects entered the service had been mis-normed. The result was that more lower aptitude persons than expected were accepted for service, and our subject population was affected in an unknown manner. This situation, and the fact that ASVAB was then undergoing one of its periodic revisions, makes intenable to dwell too long on the analysis of marginal data.

Cognitive Test Scores

Data from this experiment indicate that the Speed of Closure factor is significantly related to successful target detection and suggest that the Snowy Pictures test is the best test for predicting target detection performance. The correlation between Snowy Pictures test scores and correct detections for 209 subjects was .263. This value is high enough to account for 6.9% of the detection variance. The mean Snowy Pictures test score for our subjects was 16.14, and the standard deviation was 4.29. Scores as high as 24 can be obtained on the Snowy Pictures test, so a group of operators with a higher group mean could be created. An ancillary analysis showed that a group with a mean score of 20.43, one standard deviation above the mean, would be predicted to detect 2.9 more targets than the experimental group. This is an improvement of about ten percent in target detection performance; a not insignificant improvement in the target detection capability for a unit in battle.

It should be noted that the Snowy Pictures test and the other cognitive factor tests which were used are from a group of tests intended for research purposes only. Indeed, the manual that describes the tests states that the "tests are not offered for use in any program of selection or assignment of people for educational or work purpose, or for any type of individual prediction." Thus, if circumstances were to develop that permitted the use of this type test to improve target detection performance, an Army version of this test should be developed. Our results were positive enough to suggest that the Snowy Pictures test could be used in research situations where it is desirable to identify subject aptitude before the subjects are tested. Our results also suggest that further research into the relationship between the three Speed of Closure tests, and a further look at the Flexibility of Closure relationships is warranted. It is worth noting that both sets of tests showed low intercorrelations with the other tests presented as marker tests for the same factors; and that the Hidden Figures test had the second highest correlation to target detection and would have survived the more conservative analysis if it had not been paired with the second Flexibility of Closure Test which had a surprisingly low correlation to target detection despite having the highest correlation with its related test, Hidden Patterns.

Conclusions

1. The Field Artillery could not improve the target detection performance of RPV SSOs by obtaining them on the basis of scores on any of the other nine ASVAB aptitude area composite scores.

2. The cognitive factor Speed of Closure does correlate significantly with target detection performance in the SSO situation, and the Snowy Pictures test could be used to assign subjects in research situations.

3. Further research should be done (a) to determine if the relationship between target detection and the Speed of Closure factor extends to other target detection situations; (b) to determine if the Flexibility factor, as tested by the Hidden Figures test, can be used to improve prediction, and (c) to determine why the relationship between tests that measure the same factor is so low.

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