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Incremental Validity of Enhanced Computer Administered Testing (ECAT)

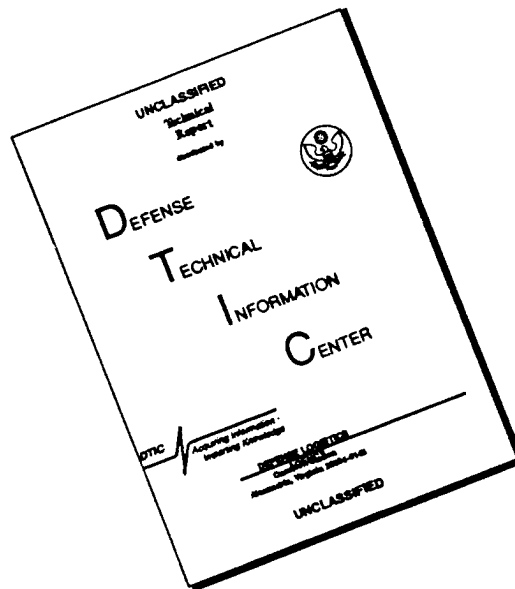
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Incremental Validity of Enhanced Computer Administered Testing (ECAT)

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| 13. ABSTRACT (Maximum 200 words) The Enhanced Computer Administered Testing (ECAT) project was a joint-service effort to estimate the potential increase in validity that could be obtained by adding new computerized tests to the current Armed Services Vocational Aptitude Battery (ASVAB). Over 10,000 recruits were tested with nine experimental computerized tests of working memory, spatial ability, and psychomotor ability. Data on the examinees' subsequent technical school performance for three Army, two Air force, and 13 Navy schools were collected, measuring laboratory, shop, training simulator and other tests of hands-on performance as well as school grades. The corrected multiple correlation of all ten ASVAB tests with each criterion was compared with the multiple correlation from the ECAT added to the predictor set. Results showed very large increases in validity (exceeding .10) for prediction of Air Force and Navy Air Traffic Control performance using Working Memory and Spatial tests, and even larger increases for the Army's 11H Heavy Antiarmor Weapons Crewman time-on-target averages, using psychomotor and spatial tests. Other schools, where ASVAB's validity was already high, did not show higher validity when ECAT tests were added. Averaged over all schools, validity for predicting schools' grades increased two percent, and validity for predicting performance increased nearly six percent. | | | |
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Foreword

The Navy Personnel Research and Development Center is the lead laboratory for the Enhanced Computerized Aptitude Testing (ECAT) project. The purpose of the project is to assess the cost/benefits of adding new aptitude tests to the Armed Services Vocational Aptitude Battery (ASVAB). This report presents results of a large-sample study that shows the incremental validity of adding new tests to the ASVAB for predicting both written and practical measures of technical school performance.

This effort was sponsored by the Navy Chief of Personnel (PERS-234). Portions of the work were funded under three related projects: the New Measures of Intelligence project (Work Unit 0603707N.L1770.MP105), the CAT research and development project (Work Unit 0604703N.R1822.MH001), and the Joint Services CAT-ASVAB project (Work Unit 93WRE5083). Results are intended for use by BUPERS, the joint services Manpower Accession Policy Steering Committee, and the research community.

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Summary

Background

All applicants for military enlistment are selected and classified by using the scores on the Armed Services Vocational Aptitude Battery (ASVAB). Previous studies by the Army, Air Force, and Navy suggested that the ASVAB might have increased validity if new tests were added or substituted for the existing ones, particularly computerized tests of abilities not easily measured by paper-and-pencil tests. The utility of a 3% increase in validity had been estimated to be in the tens of millions of dollars from the resulting improvement in selection and classification. Accordingly, the military services, under the guidance of DOD, undertook a large-scale validation of the most promising experimental tests developed by the services' personnel laboratories. This joint-service battery of nine experimental tests was called the Enhanced Computer Administered Testing (ECAT) battery.

Objective

The ECAT project was designed to estimate how much validity gain could be obtained from adding the ECAT tests to the ASVAB, determine which tests were most promising, and determine in what military occupational specialties the gains were the largest.

Approach

Over 10,000 recruits scheduled for training in 3 Army schools, 2 Air Force schools, or 13 Navy schools were administered the ECAT battery. Seventy-seven criteria for training performance were collected among the 18 schools, including many hands-on performance measures. The validity of the ASVAB tests in a multiple regression equation was compared with the validity of the combined ECAT and ASVAB battery. Four kinds of analyses were done for incremental validity in terms of (1) general ability, (2) ability factors, (3) individual tests, and (4) unit-weighted selector composites.

Results

Working memory and spatial ability tests produced large increases in validity for predicting Air Traffic Control training performance in two Air Force samples and one Navy Sample. Psychomotor tracking tests and spatial ability tests greatly increased prediction of Heavy Antiarmor Weapons firing accuracy.

Using all ECAT tests, six of 13 Navy schools showed significant increase in validity. Averaged over all schools, the prediction of hands-on performance increased over 5%, while the prediction of School Grades improved only 2%.

About 75% of the incremental validity of ECAT can be attained by using just three of the nine tests: Two-Hand Tracking, Mental Counters, and Assembling Objects, each of which represents a different ability factor.

Conclusions

Many ECAT tests have substantial simple validities for predicting school performance. In some military training courses, the ASVAB's prediction of school practical performance can be substantially improved by using ECAT tests in optimally-weighted composites. Validity increases are greatest (averaging 5.7%) when laboratory or simulator performance criteria are used, rather than school grades (averaging 1.7%). Increases for some schools are much larger than this, while other schools have no significant validity improvement. Factor scores are more than 98% as valid as individual tests in multiple regression, but relying on "g" alone reduces validity by as much as 8.9% on the average. ECAT tests can be used to broaden the estimate of general mental ability, or "g" produced by the ASVAB. This enhanced "g" has validity increments for predicting practical performance criteria which are nearly as large as the validity increments from using all tests in multiple regression. Existing selector composites can be improved by adding ASVAB tests to them. In many cases, the validity improvements from doing so exceed those from adding an ECAT test with unit weights.

Recommendations

1. Consideration should be given toward the eventual incorporation into ASVAB of a Spatial Ability measure, such as Assembling Objects.
2. If CAT-ASVAB is universally implemented, then consideration should be given toward including computerized tests of working memory, such as Mental Counters.
3. The Mental Counters test should be considered for supplementary administration to potential students in the Air Force and Navy Air Traffic Control schools.
4. The Two-Hand Tracking test should be considered for supplementary administration to potential students in the Army Heavy Antiarmor Weapons school (11H). Its cost/benefits for wider operational testing should be evaluated under different concepts of operations.
5. A variety of alternative tracking tests should be investigated, to determine if a mouse, trackball, or other off-the-shelf equipment could serve as well as slide potentiometers and joysticks. Human factors work on alternative tracking item types and screen displays should be supported.
6. Development of alternate forms and/or adaptive item pools should be started for the most promising ECAT tests.
7. The most promising ECAT tests should be normed.
8. Research on optimal non-negative weighting of ASVAB tests for maximal cross-validated classification efficiency should be given high priority. Operational selector composites eventually should be replaced by these optimal weighting methods.
9. Military training schools should be encouraged to incorporate continuously-scored practical performance measures in their intermediate and final grades. The statistical properties of Final School Grades, including reliability and validity, should be continuously monitored and updated, particularly following any shift in curricula.

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Introduction

Purpose

This report describes the Enhanced Computer Administered Test (ECAT) battery and the results from the Joint-Service validity study that evaluated the battery, which was the largest validation of a single computerized test battery ever undertaken.¹ ECAT has a significance beyond this simple fact; it may fundamentally alter the future of military aptitude testing. To better understand the importance of ECAT, including how it came about, the first section of this report places ECAT in the larger context of the last decade of military aptitude research. The second section describes subjects in the validity study, the content of the ECAT battery and its factor structure. ECAT is then contrasted with the Armed Services Vocational Aptitude Battery (ASVAB), which is the present military selection battery. The results of the ECAT validity study are then described in some detail, followed by conclusions.

Historical Background

We are nearing the culmination of a 10-year wave of research on military manpower testing, the largest since World War II. The impetus for this research began in 1973, following the end of the Vietnam War when the draft was terminated and the Services reverted to an All-Volunteer Force. Over the next decade the quality of service applicants declined severely (Eitelberg, Laurence, Waters, & Perelman, 1984), as did the quantity (Ramsberger & Means, 1987; Laurence & Ramsberger, 1991). Further complicating the grim manpower outlook was the military's tremendous technological modernization, a development placing even greater intellectual demands on the average enlistee. Yet even as the military's need for talented people grew more acute, our tools for identifying talent (i.e., aptitude tests) came under growing attack from critics. In 1978, the *Uniform Guidelines on Employee Selection Procedures* (EEOC, 1978) were adopted by the Federal Government — an action that, in part, led to the 1981 Congressional directive requiring that the Services better document the relationship between education, test scores, and actual job performance.

Collectively, these forces fostered a modern, resurgent interest in military manpower testing beginning in 1981. The focus of these efforts was to improve the ASVAB since it was the sole military selection battery. There were two main *ASVAB improvement* themes. One was an effort to *reformat* the ASVAB and improve the measurement properties of the battery. The other theme was to add new aptitude constructs and thus *broaden* the ASVAB. The underlying logic was straightforward. If we had more accurate and greater information about an applicant's intellectual

¹While this was a Joint-Service study that received technical guidance from several Joint-Service committees, as the lead Service laboratory the work was conducted by the Navy Personnel Research and Development Center. In particular, Kathleen E. Moreno was solely responsible for the data collection effort; she let and monitored the data collection contract, obtained all the necessary military command approvals for testing, insured that equipment was manufactured and available, that test administrators were hired and trained, and throughout the conduct of the study she maintained an intimate relationship with the telephone, handling daily crises and logistics. Without her dedicated hard work, there would have been no ECAT study.

strengths and weaknesses, then the military would be better able to select and place applicants; psychometrically, this amounts to increasing validity. By increasing validity, it was expected that job performance would increase, job satisfaction would increase, attrition would be reduced, and collectively the military would be more capable.

Computerized Adaptive Testing Version of the Armed Services Vocational Aptitude Battery: CAT-ASVAB

The ASVAB reformatting project was CAT-ASVAB which formally began in 1979 when the Navy Personnel Research and Development Center was designated as Lead Laboratory for Computerized Testing. The program's approach was shaped by two technological advances: the availability of powerful microcomputers and developments in statistical theories of test scores. Blending these two advances produced the concept for CAT-ASVAB which was to develop a computer administered version of the ASVAB redesigned using modern psychometric theory, referred to as Item Response Theory. By combining Item Response Theory with computer administration, the ASVAB's power tests could be made adaptive by specifically selecting test items for an examinee based on his or her previous responses. Adaptive test administration could reduce test length by as much as one-half while improving reliability, particularly in the extremes of score distributions where applicant discrimination was poor. Administratively, computer-based testing could improve test security, reduce scoring errors, and provide immediate feedback to examinees and their recruiters.

Although adaptive tests had been a theoretical possibility for a number of years, no one had ever successfully produced an adaptive, multiple aptitude test battery intended for large-scale use. As such, hundreds of difficult, pragmatic, and unanticipated problems had to be solved in the development of a working CAT-ASVAB system. There were problems such as how the system should be organized, what fail-safe and failure-recovery procedures should be included, what hardware and networking system should be chosen, how items should be protected, and how the frequency of item use should be controlled. These and many more problems were solved to produce a functional delivery system.

More importantly though, there were several critical research questions that had to be answered as a prelude to operational use. One issue was a concern that the medium of administration alone (i.e., paper-and-pencil (P&P) versus computer), would produce important differences in test items and scores. A large scale 1987 study explicitly addressed this concern and found it to be generally unwarranted (Hetter, Segall, & Bloxom, 1992). A second concern was that test score intercorrelations, within and across mediums of administration, would differ markedly. This issue was addressed in an important 1988 study (Moreno & Segall, 1992) and the results clearly demonstrated that there were no substantial differences among the intercorrelation matrices of ASVAB tests, either within or across test mediums.

Having solved the practical testing issues and assuaged the concerns of many psychometricians and policy makers, a final step was required before CAT-ASVAB could actually be used. Specifically, conversion or equating tables were required that would allow CAT-ASVAB and P&P ASVAB scores to be used interchangeably. In 1988, an elaborately designed

study was conducted, requiring data collection in several sites across the country. The data were used to develop preliminary tables equating CAT and ASVAB test scores. However, since the original equating tables were based on individuals who were required to take several nonoperational versions of the ASVAB, the validity of the equating tables had to be verified in one final study. This study was initiated, and as a result, in September 1990, CAT-ASVAB was operationally used for the first time. CAT-ASVAB has become the first operational, computer administered, adaptive selection and classification battery in use.

Enhanced Computer Administered Tests: ECAT

While efforts to reformat the ASVAB were focused and localized, attempts to *broaden* the abilities measured by the ASVAB were dispersed, with each of the services conducting research. In 1981 the Army's Project A was commissioned with a very broad charter and sweeping objectives. In the same time frame, the Air Force's Learning Abilities Measurement Project (LAMP) began with the goal of developing new predictors of learning. Smaller testing programs were also started in the Navy.

Several common contextual stimulants independently shaped the Services' attempts to broaden the ASVAB, producing similarities in their research programs. For example, the availability of inexpensive microcomputers and the momentum behind the computerization of the ASVAB, led the Services to develop new tests that were primarily computer-based. Moreover, the cognitive *zeitgeist* in American psychology during the mid-1970s and 1980s strongly influenced the programs. For example, all of the Services investigated the use of reaction time measures; the Air Forces' program was built around a cognitive model; and, the Navy's research was driven by cognitive theories of aptitude, working memory, and mental imagery.

Though there were commonalties across Services, there was little collaboration. However, as work on CAT-ASVAB progressed and a national renorming of ASVAB was anticipated, additional impetus was provided to the possibility of adding new aptitude dimensions to the ASVAB. In December of 1988, the Office of the Assistant Secretary of Defense (Force Management and Personnel) (OASD/FM&P) redirected the CAT-ASVAB program to "include a Joint-Service validation of the Services' new computerized cognitive and psychomotor tests" (Sellman, 1988). This directive was in recognition of two facts. First, an early cost-benefit study suggested that fielding a computer version of the ASVAB may not be cost effective relative to the P&P version. (This assessment has since been rendered obsolete by the plummeting prices of computer technology and by subsequent experience with an operational CAT system.). Second, other research indicated that broadening the ASVAB's ability measures could result in large improvements in productivity per accession (Schmidt, Hunter, & Dunn, 1987). Combining these findings, a new computer-based ASVAB augmented with new ability measures could produce a better and cost effective selection and classification system. Just as importantly though, the directive was a realization that if decisions were to be made about the usefulness of new ability measures, they needed to be evaluated in a single study using the most probable delivery system for a computerized ASVAB, the CAT-ASVAB system. This formally integrated the two research strains to improve the ASVAB.

In response to OASD's redirection, the Technical Advisory Selection Panel (TASP) was established in January of 1989 to evaluate and select tests for the Joint-Service validation battery. The panel's charter was to select the best tests in terms of their psychometric properties and theoretical justifications within the constraint that the battery could not exceed three hours. Across Services, hundreds of pages of documentation were submitted supporting the use of dozens of new aptitude measures². Nine tests were chosen and combined into a battery named ECAT. A research design was approved, the necessary software and hardware were developed and/or acquired, and in February 1990 the study began. Twenty-one months later, testing ended. The sample included enlisted personnel in the Army, Navy, and Air Force representing 18 Military Occupational Specialties (MOS). (Additional details will be provided in later sections.)

Enhanced Computer Administered Test Validity Study

Enhanced Computer Administered Test Sample

Over 11,700 enlisted personnel were tested with the ECAT battery in the Navy, Army, and Air Force. Individuals were tested prior to entering training in one of 18 different MOSs (these will be described later). The sample was 95.5% male and 97.5% used English as their dominate language. Nearly 84% of the sample had obtained a high school diploma, an additional 6.7% had at least some college level schooling; only 9.5% failed to complete high school.

For descriptive purposes subjects were divided into six *ethnic* groups: Caucasian, Afro-American, Asian, Hispanic, North American Indian, and other. The categories are a combination of the population and ethnic group codes taken from enlistment records. *Caucasian* was defined by the population code Caucasian (C) and the ethnic code none (Y). *Afro-American* was defined by the population code Negroid/African/Black (N) unless a Hispanic ethnic code was also checked (then the person would be defined as Hispanic, see below). The *Asian* group was defined by the population code Asian/Mongoloid/Yellow (M) and/or ethnic codes for other Asian descent (3), Filipino (5), Chinese (G), Japanese (J), Korean (K), Vietnamese (V), Melanesian (E), Micronesian (W), Polynesian (L), and other Pacific Island descent (Q). Regardless of the population code, the *Hispanic* group was defined by ethnic codes for other Hispanic descent (1), Puerto Rican (4), Mexican (6), Cuban (9), and Latin American with Hispanic descent (S). The *North American Indian* group was defined by the population code for American Indian/Red (R) and by ethnic codes for U.S./Canadian Indian Tribes (2), Eskimo (7), and Aleut (8). A final group labeled *Other* was created from the population code Other (X) and the ethnic codes Other (X) (unless Caucasian), Indian (from India; D), and Unknown (Z). The distribution of subjects

²The contributions of the TASP to the planning and design of this project are greatly appreciated. The panel was chaired by Dr. Bruce Bloxom, who provided the overall framework by which the proposed tests were to be evaluated, provided leadership, organization, and technical guidance, and documented the deliberations of the panel in the minutes of the meetings. Clint Walker, of the Army Research Institute, Lonnie Valentine, from the Air Force Human Resources Laboratory, and John Wolfe, from the Navy Personnel Research and Development Center, provided detailed proposals for tests to be considered by the panel. The panel also proposed and decided on the particular samples that were to be collected, and established contacts for arranging the testing of research subjects.

across the six ethnic groups was 71.1% Caucasian, 16.5% Afro-American, 5.9% Hispanic, 2.2% Asian, 0.8% North American Indian, and 3.4% Other/Unknown.

Enhanced Computer Administered Test Content

The goal of ECAT was to broaden the ASVAB. Table 1 shows the 10 tests that comprise the ASVAB. These tests represent Verbal Ability, Mathematical Ability, Technical Knowledge, and Perceptual Speed. Across Services, the ASVAB's four factor structure was the focal or starting point for new predictor research. Specifically, the assumption was made that the scope of human intellectual and nonintellectual skills was much greater than that represented by the ASVAB, and that capturing this breadth held the greatest promise for improving personnel selection and/or classification.

Table 1

Tests in the Armed Services Vocational Aptitude Battery (ASVAB)

| Construct | Test | Description |
|----------------------------|--------------------------------|--|
| Verbal Ability | Paragraph Comprehension (PC) | A 15-item reading comprehension test |
| | Word Knowledge (WK) | A 35-item vocabulary test using words embedded in sentences or synonyms |
| | General Science (GS) | A 25-item knowledge test of physical and biological sciences |
| Math Ability | Arithmetic Reasoning (AR) | A 30-item arithmetic word problem test |
| | Math Knowledge (MK) | A 25-item test of algebra, geometry, fractions, decimals, and exponents |
| Technical Knowledge | Mechanical Comprehension (MC) | A 25-item test of mechanical and physical principles |
| | Auto and Shop Information (AS) | A 25-item knowledge test of automobiles, shop practices, tools, and tool use |
| | Electronic Information (EI) | A 20-item test about electronics, radio, and electrical principles and information |
| Clerical Skills | Numerical Operations (NO) | A 50-item speeded addition, subtraction, multiplication, and division test using one and two digit numbers |
| | Coding Speed (CS) | An 84-item speeded test requiring the recognition of number strings arbitrarily associated with words in a table |

Table 2 shows the 9 tests that comprise the ECAT battery including a brief description of each test. The battery requires a maximum of 3 hours with most individuals finishing in under

2 hours. The tests are grouped by the aptitude construct they were designed to measure: Nonverbal Reasoning, Spatial Ability, Psychomotor Skill, and Perceptual Speed. The tests were administered on Hewlett-Packard portable IPCs, which are the delivery systems for the Computerized Adaptive Testing version of the ASVAB (CAT-ASVAB). The keyboard was modified by using a plastic mask that revealed only the designated response keys along with a key labeled *HELP* that could be pressed during testing to suspend the program and request assistance. The *S*, *F*, *H*, *K*, and *;* keys were relabeled: *A*, *B*, *C*, *D*, and *E*. The space bar was relabeled *ENTER*. The numeric keypad keys retained their meanings. The last three ECAT tests used a custom-made input device referred to as a response pedestal. The response pedestal has color-coded buttons, two slide-potentiometers, and two joy-sticks which are used to respond to items (see Figure 1). In addition, the response pedestal contains a key labeled *HELP* that behaved like the corresponding key on the keyboard.

Table 2

Tests in the Joint-Service ECAT Battery

| Construct | Test | Description |
|----------------------------|----------------------------|---|
| Nonverbal Reasoning | Mental Counters (CT) | A 40-item Working Memory test using figural content; a nonverbal reasoning test |
| | Sequential Memory (SM) | A 35-item Working Memory test using numerical content; a nonverbal reasoning test |
| | Figural Reasoning (FR) | A 35-item series extrapolation test using figural content; a nonverbal reasoning test |
| Spatial Ability | Integrating Details (ID) | A 40-item spatial problem solving test |
| | Assembling Objects (AO) | A 32-item spatial and semi-mechanical test |
| | Spatial Orientation (SO) | A 24-item spatial apperception/rotation test |
| Psychomotor Skill | One-Hand Tracking (T1) | An 18-item single limb psychomotor tracking test |
| | Two-Hand Tracking (T2) | An 18-item multi-limb psychomotor tracking test |
| Perceptual Speed | Target Identification (TI) | A 36-item reaction time-based figural perceptual speed test |

Note. ECAT = Enhanced Computer Administered Testing.

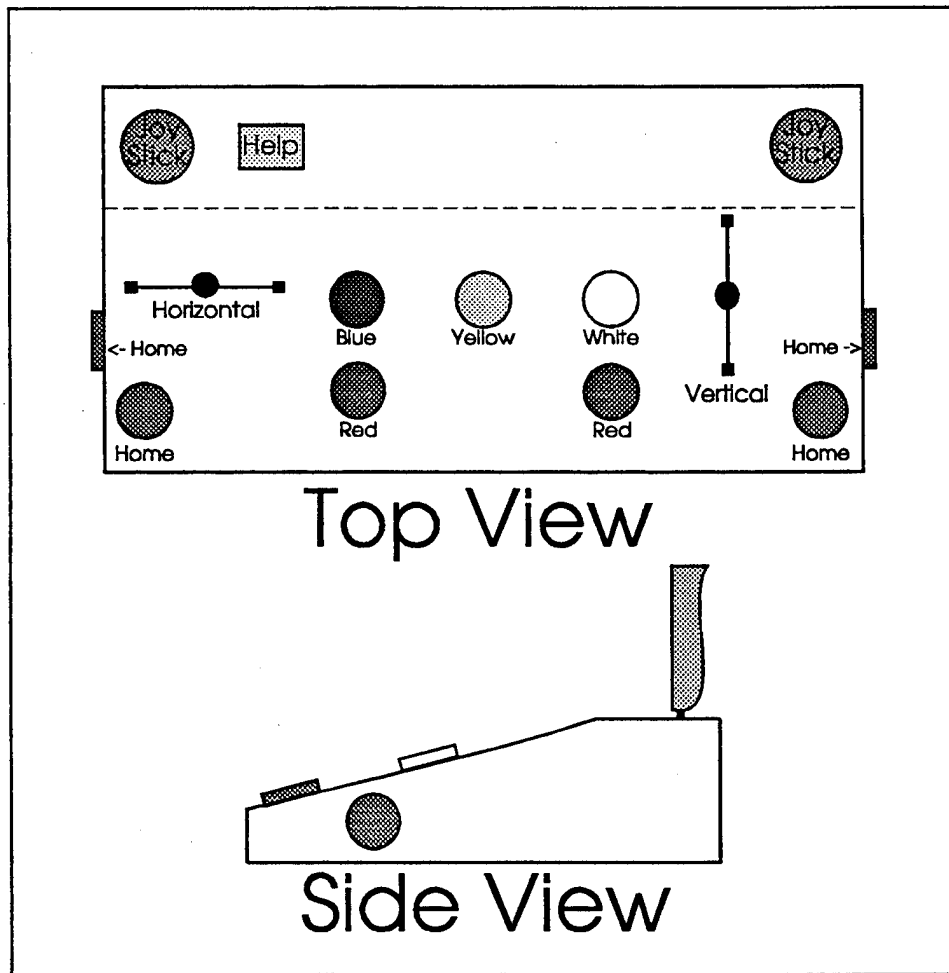
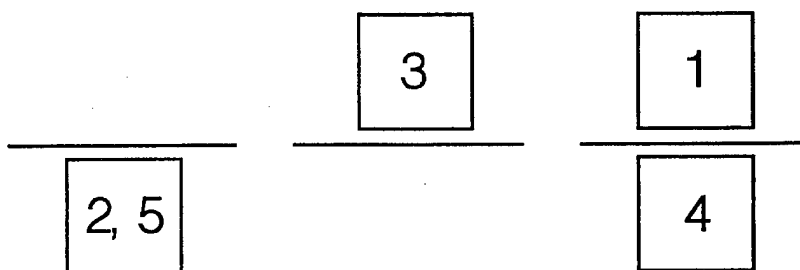


Figure 1. Response Pedestal (two views).

Since most of the ECAT tests are quite novel, a brief description of each test is warranted. Each test will be illustrated with a sample item accompanied by an abstract of the actual instructions, which often require five to ten screens, some with animation.

Nonverbal Reasoning Tests

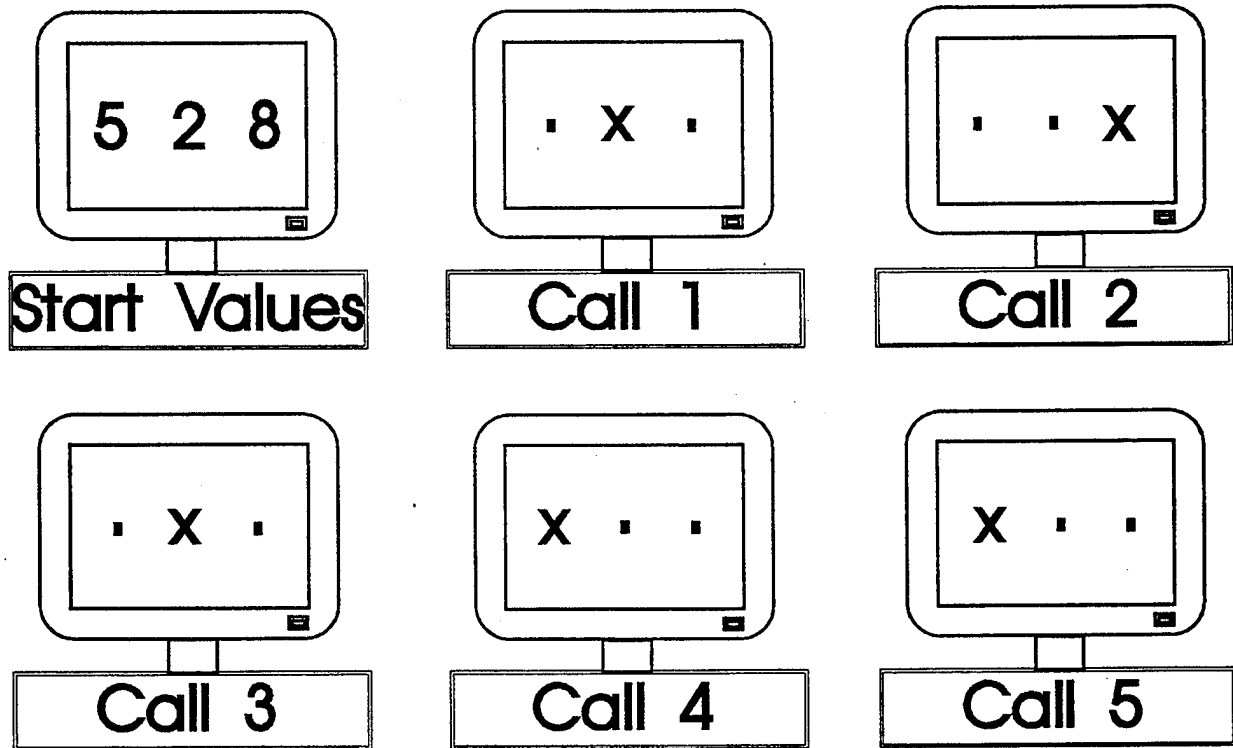
Mental Counters (CT)--is a complex 40 item working memory test. See Figure 2 for an example. Each screen contains three horizontal lines, arrayed left to right. Each line represents a counter with an initial value of zero. During an item, boxes appear sequentially, one at a time, either above or below one of the three lines. If a box appears above a line, the value for that counter is incremented by +1. If a box appears below a line, that counter is decremented by 1. On each trial either five or seven boxes appear. The boxes appear at one of two rates, either one every 1.33 seconds or one every .75 seconds. The task is to make a series of rapid calculations and to select, from a four-alternative multiple choice menu, the set of correct final counter values. Number of correct responses is the summary score.



Three independent counters (center horizontal lines) begin with starting values of 0. Boxes are sequentially displayed, then removed, in the order shown. If a box appears above a line the counter is incremented by 1, if below the line, it is decremented by 1. The final counter values for this item would be (in order) -2, +1, 0.

Figure 2. Mental Counters test.

Sequential Memory (SM)--is another complex test of working memory. See Figure 3 for an example. Each item consists of three to five horizontally arrayed dots on the screen. Each dot is given a numerical value; these must be memorized. The item is then presented in a series of 5 to 7 "calls" to the dots; where each call is announced by briefly turning one of the dots into an "X." The person must report the digit string that corresponds to the order that the dots were "called." In the second half of the test, after all the calls for an item have been made, the examinee is told to translate each number in the ordered number list into a different number and then type in the new ordered list. There are 10 items in the first half of the test and 25 in the second half of the test. The dependent variable is the proportion of digits correct.

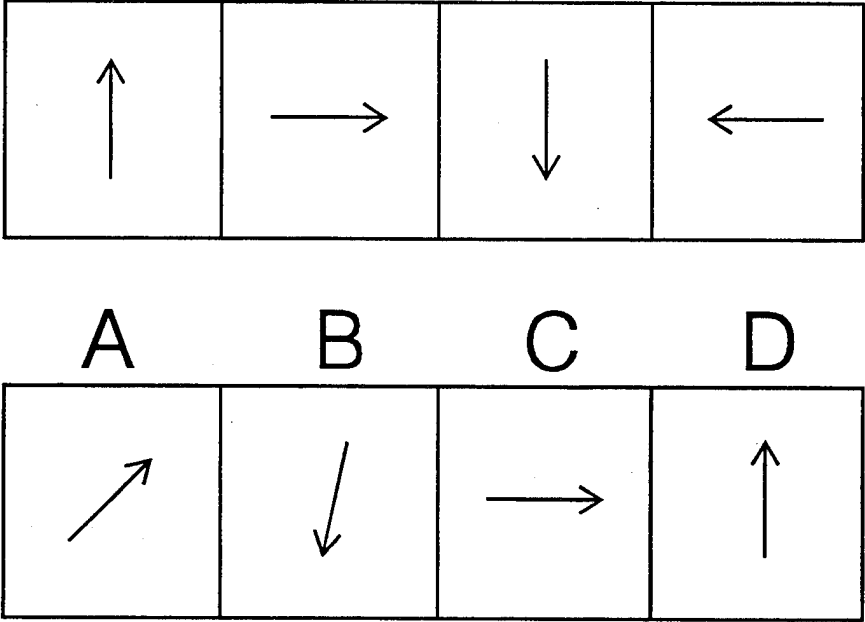


The start values indicate the numbers assigned to each position. Following this, each time an X appears, it "calls" the corresponding number. When the X appears in the center position, the 2 is called. When the X appears in the left position, the 5 is called. When the X appears in the right position, the 8 is called. Remember the sequence of calls. (Answer: 2, 8, 2, 5, 5)

Figure 3. Sequential Memory test.

Figural Reasoning (FR)--is a figural inductive reasoning (or series extrapolation) test. See Figure 4 for an example. Items use a combination of geometric forms and arbitrary figures presented in a series of four frames. The task is to induce the transformation rule controlling the series and then select one of five alternatives that correctly completes the series. The dependent variable is number correct of 30 items.

Figure Series

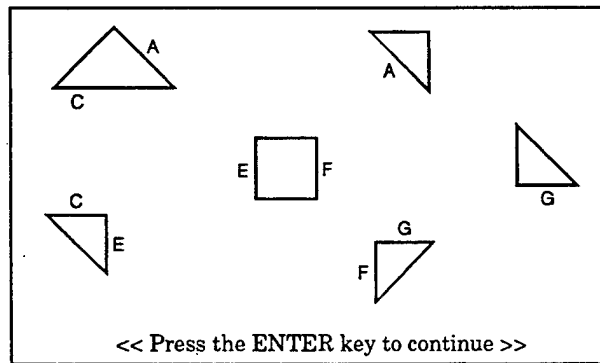


Which alternative shows the next frame in the figure series? (Answer: D)

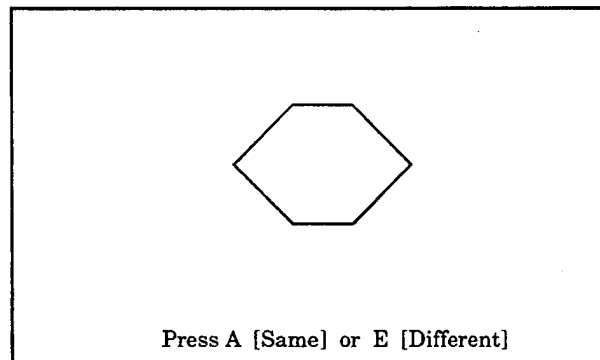
Figure 4. Figural Reasoning test.

Spatial Ability Tests

Integrating Details (ID)--is a complex 40 item spatial problem solving test. See Figure 5 for an example. Each item consists of two separate screens. The first screen contains from two to six regular geometric puzzle pieces that must be mentally fused to form a complete object. This is much like a jig-saw puzzle. Having connected all of the puzzle pieces, the individual must remember the final object, then press a response key. The puzzle pieces are replaced by a new screen with a single completed object. The task is to indicate if the displayed object is the product of the original puzzle pieces. Accuracy is the dependent measure.



Screen 1

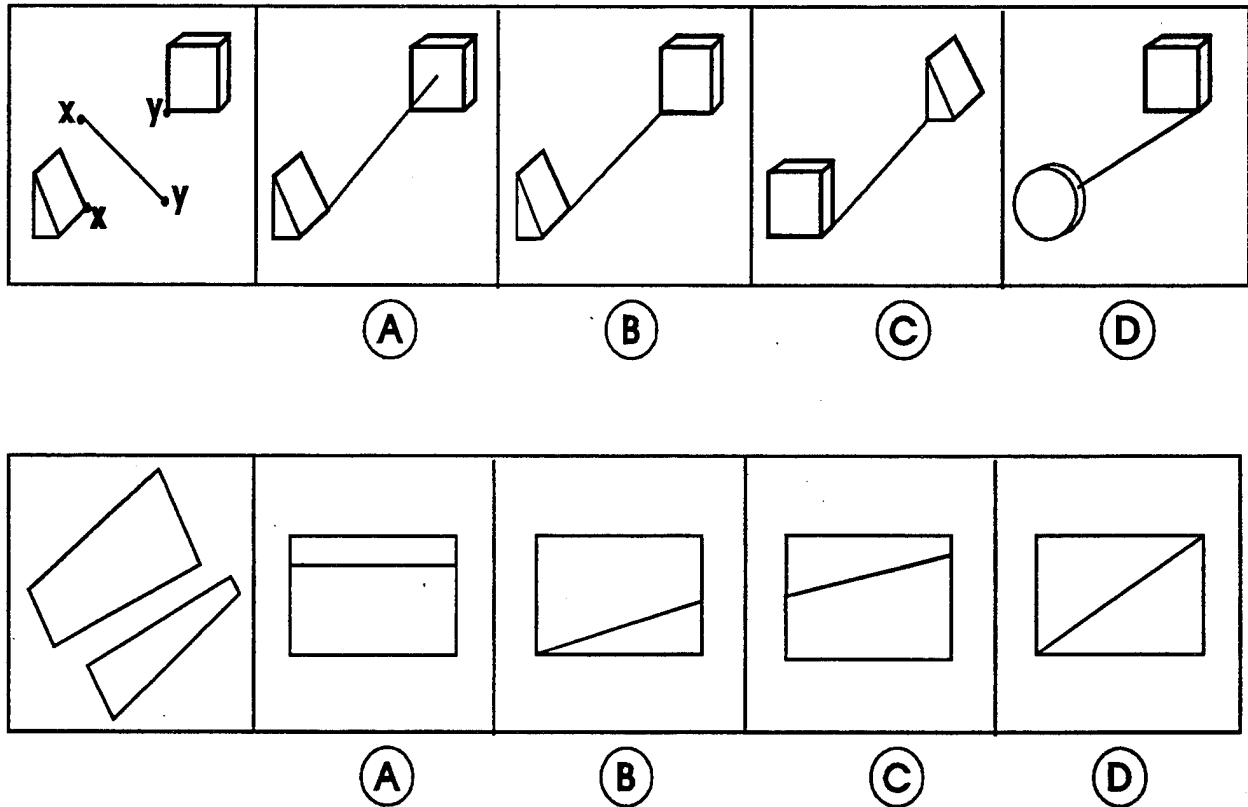


Screen 2

The top frame is presented and the examinee has as long as necessary to mentally construct a complete object. Following a key press, the bottom frame is presented. The subject has as long as necessary to decide if the puzzle pieces would have constructed this object. Toggling between screens is not allowed. (Answer: Same.)

Figure 5. Integrating Details test.

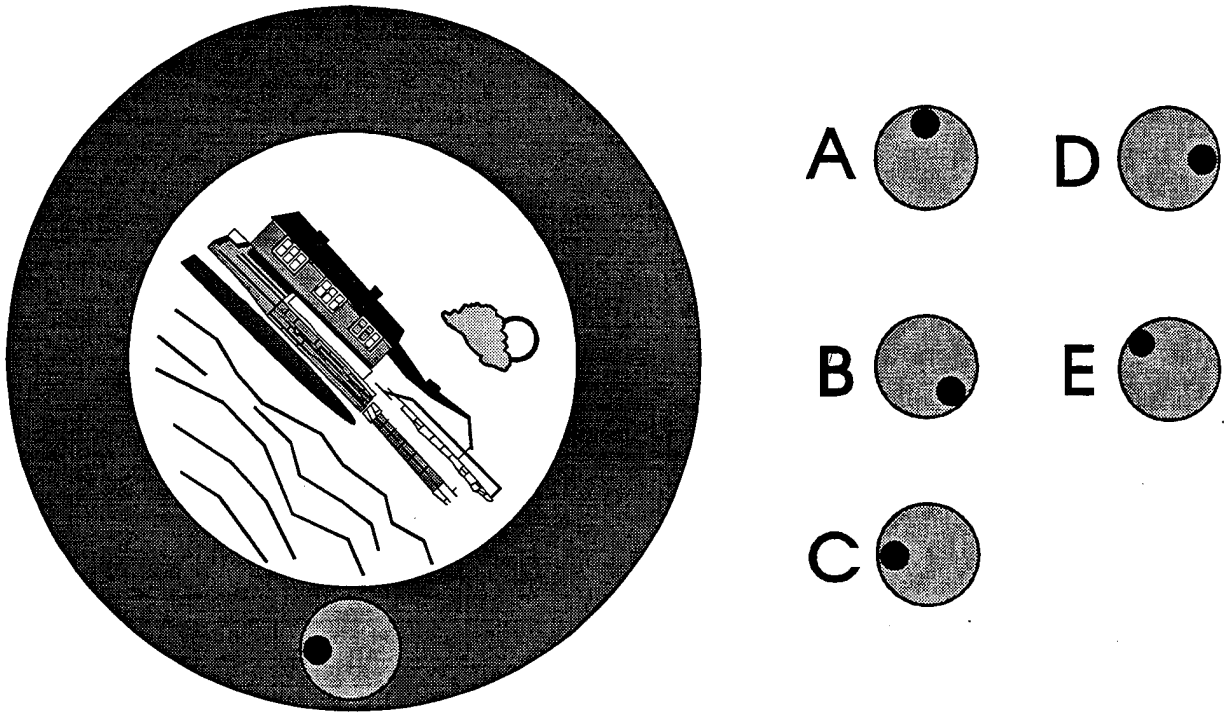
Assembling Objects (AO)--is a spatial construction test. See Figure 6 for an example. Each item consists of a frame with several (2-6) separate elements. The task is to choose from four alternatives the answer that correctly represents how the elements should be connected. There are 32 items in the test. The first 15 items are semi-mechanical items with labels indicating how the elements should be connected. The final 17 items consist of a disheveled jig-saw and four complete ones; the task is to choose the correct alternative. The dependent variable is number correct.



Which alternative shows the correctly constructed object?
 (Answers: Top, B; Bottom, C)

Figure 6. Assembling Objects item types.

Spatial Orientation (SO)--is a spatial perspective test. See Figure 7 for an example. Each item consists of an environmental view, such as a bridge over a river or a house with an apparent horizon. These views are rotated away from the "natural" horizon. At the bottom of the frame is a circle with a dot on the perimeter. The task is to rotate the frame around the view until it corresponds with the natural horizon and determine where the dot on the circle would be located. This information is used to select which of five alternatives correctly shows the dot following rotation. The dependent variable is the number of items correct.



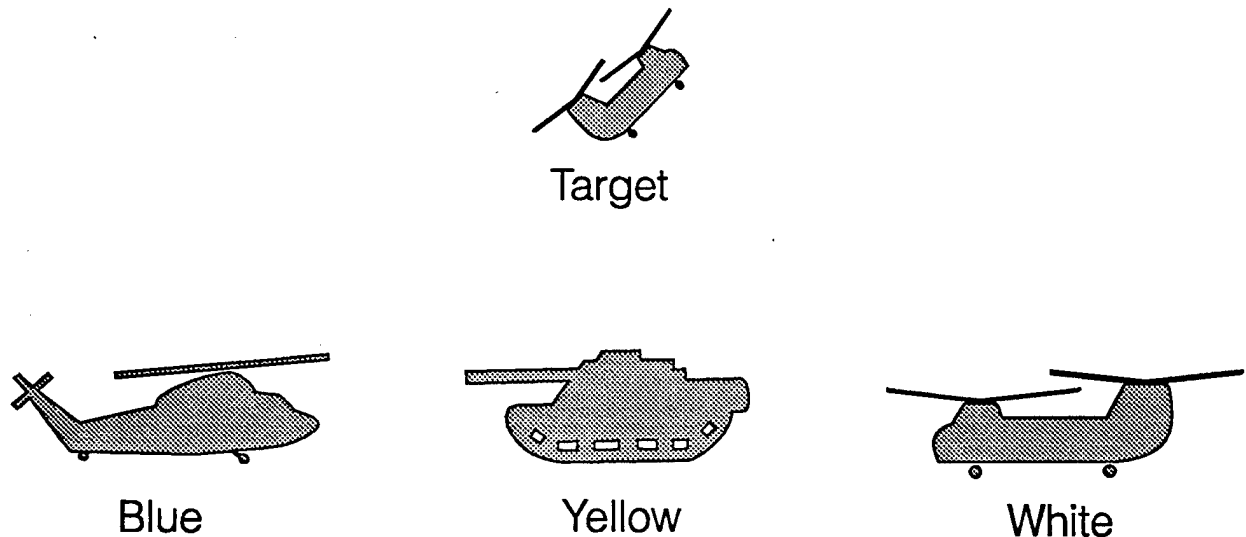
The sample problem contains a picture with a frame around it. The bottom of the frame has a circle with a dot inside, carved into the frame. Imagine that only the frame can be turned, and the picture inside can not be moved. Then, to match up the bottom of the frame with the bottom of the picture, you would turn the frame until the circle with a dot is located at the bottom of the picture. Your task is to figure out exactly what the circle with the dot inside will look like in its new position, after the frame has been turned. (Answer: E)

Figure 7. Spatial Orientation test.

Two-Hand Tracking (T2)--is another psychomotor test that has exactly the same structure and task constraints as One-Hand Tracking (see Figure 8). The difference is that cross-hair movement is controlled by two slide potentiometers: one slide controls horizontal (left/right) movement while the other controls vertical (up/down) motion (see Figure 1). One hand must be used for each slide control. Number of items, scoring, and final score are the same as One-Hand Tracking.

Perceptual Speed

Target Identification (TI)--is a hybrid test combining aspects of choice reaction time and spatial mental rotation tests. See Figure 9 for an example. Each item consists of a target figure in the top half of the screen and three alternative figures in the bottom half. The figures are schematic line drawings of simple objects, such as trucks, helicopters, and tanks. The target may be rotated, distorted (e.g., shrunken), or both, but the correct alternative will be in a "natural" upright position. The task is to select the correct alternative as rapidly as possible. Before each item examinees must simultaneously press four "Home" buttons, two on the left and two on the right side of the response pedestal, essentially pinning their hands (see Figure 1). As soon as the examinee decides upon an answer, either hand may be used to press the button corresponding to the selected alternative. The dependent variable is the average correct decision time across the 36 items, where decision time is defined as the time between item presentation and button release.



While keeping fingers on Home keys, determine which object matches the Target, then press the correctly colored key. (Answer: White)

Figure 9. Target Identification test.

Six of the ECAT tests (i.e., FR, AO, SO, T1, T2, and TI) were developed by the Army Research Institute as part of Project A (Peterson, Hough, Dunnette, Rosse, Houston, & Toquam, 1990). The remaining three tests (CT, SM, and ID) were developed by the Navy Personnel Research and Development Center.

Descriptive Statistics

Table 3 contains simple descriptive statistics for the ASVAB and ECAT tests. The sample was lightly edited for unmotivated and extremely poor performing individuals before analyses were conducted. The first entry in Table 3, the Armed Services Qualification Test (AFQT), is a composite of the mathematical (Arithmetic Reasoning and Mathematical Knowledge) and verbal (Word Knowledge and Paragraph Comprehension) tests and is used to determine eligibility for military service. The AFQT is also a good estimate of general intellectual performance. The AFQT composite is expressed as a cumulative percentile with a mean of 50 and a standard deviation of 28.7 in a nationally representative sample of service eligible individuals. The current sample had a mean AFQT of 60.3 and a standard deviation of 18.0. Thus, the sample was .36 standard deviation units above the mean resulting in a 37% reduction in the standard deviation due to explicit selection (truncating the lower tail of the distribution). The individual ASVAB tests are all scaled to a mean of 50 with a standard deviation of 10; they all show elevated means and truncated standard deviations due to selection effects. Little can be said about the ECAT tests except that they all have reasonable distributional properties and that the means and standard deviations reported here are similar to those found in other samples where the tests were used.

The last column of Table 3 contains uncorrected test reliability estimates. The ASVAB reliabilities are based on a 4 week retest period using alternate forms; the median reliability is .74 (Moreno & Segall, 1992). As described in Appendix E, the ECAT reliabilities were computed on a five week delayed readministration of the same forms; the median reliability is .80 (Larson & Alderton, 1992a, 1992b)

Table 4 shows the means, standard deviations, and correlations of the ASVAB and ECAT tests after correction for multivariate range restriction using the 10 ASVAB variables as explicitly selected variables with population covariances equal to those of the 1991 joint-services applicant population ($N = 650,278$).

Table 3**Descriptive Statistics for the ASVAB and ECAT Test Batteries**

| Test | Mean | Standard Deviation | Minimum | Maximum | Retest Reliability |
|--|-------------|-------------------------------|----------------|----------------|-------------------------------|
| Armed Forces Qualification Test (AFQT) | 61.179 | 17.917 | 17.000 | 99.000 | |
| General Science (GS) | 53.255 | 7.419 | 23.000 | 69.000 | .73 |
| Arithmetic Reasoning (AR) | 53.610 | 6.905 | 31.000 | 66.000 | .77 |
| Word Knowledge (WK) | 53.044 | 5.354 | 20.000 | 61.000 | .82 |
| Paragraph Comprehension (PC) | 53.229 | 5.740 | 20.000 | 62.000 | .48 |
| Numerical Operations (NO) | 54.208 | 6.583 | 20.000 | 62.000 | .71 |
| Coding Speed (CS) | 53.248 | 6.937 | 22.000 | 72.000 | .75 |
| Auto-Shop Information (AS) | 53.614 | 8.051 | 28.000 | 69.000 | .77 |
| Math Knowledge (MK) | 55.125 | 6.876 | 30.000 | 68.000 | .82 |
| Mechanical Comprehension (MC) | 54.958 | 7.703 | 27.000 | 70.000 | .70 |
| Electronics Information (EI) | 52.593 | 7.945 | 23.000 | 70.000 | .65 |
| Mental Counters (CT) | 0.724 | 0.175 | 0.200 | 1.000 | .79 |
| Sequential Memory (SM) | 0.688 | 0.134 | 0.160 | 1.000 | .81 |
| Figural Reasoning (FR) | 0.669 | 0.188 | 0.100 | 1.000 | .75 |
| Integrating Details (ID) | 0.760 | 0.127 | 0.375 | 1.000 | .79 |
| Assembling Objects (AO) | 0.629 | 0.193 | 0.094 | 1.000 | .83 |
| Spatial Orientation (SO) | 0.517 | 0.247 | 0.125 | 1.000 | .75 |
| One-Hand Tracking (T1) | 2765.374 | 391.724 | 2003.611 | 4867.111 | .84 |
| Two-Hand Tracking (T2) | 3639.163 | 471.978 | 2391.278 | 5460.722 | .91 |
| Target Identification (TI) | 1.835 | 0.604 | 0.280 | 5.610 | .80 |

Note. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

Table 4

Range-Corrected Means, Standard Deviations, and Intercorrelations of ASVAB and ECAT Tests (N = 10,963)

| Test | GS | AR | WK | PC | NO | CS | AS | MK | MC | EI |
|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Mean | 50.6150 | 50.6636 | 51.3114 | 51.1558 | 52.5122 | 52.2662 | 51.4087 | 51.2103 | 51.9408 | 50.3326 |
| Std.Dev. | 8.7726 | 8.6454 | 7.3541 | 7.9640 | 8.0131 | 7.8118 | 9.1677 | 8.6890 | 9.1272 | 8.8559 |
| GS | 1.0000 | 0.6111 | 0.7201 | 0.6079 | 0.2751 | 0.2487 | 0.5202 | 0.5542 | 0.6377 | 0.6245 |
| AR | 0.6111 | 1.0000 | 0.5963 | 0.5743 | 0.4703 | 0.3953 | 0.4004 | 0.7069 | 0.6134 | 0.4868 |
| WK | 0.7201 | 0.5963 | 1.0000 | 0.7316 | 0.3244 | 0.3278 | 0.4366 | 0.4968 | 0.5473 | 0.5344 |
| PC | 0.6079 | 0.5743 | 0.7316 | 1.0000 | 0.3959 | 0.3859 | 0.3391 | 0.4997 | 0.4852 | 0.4445 |
| NO | 0.2751 | 0.4703 | 0.3244 | 0.3959 | 1.0000 | 0.6401 | 0.0470 | 0.4961 | 0.2279 | 0.1452 |
| CS | 0.2487 | 0.3953 | 0.3278 | 0.3859 | 0.6401 | 1.0000 | 0.0583 | 0.4078 | 0.2212 | 0.1471 |
| AS | 0.5202 | 0.4004 | 0.4366 | 0.3391 | 0.0470 | 0.0583 | 1.0000 | 0.1966 | 0.6181 | 0.6692 |
| MK | 0.5542 | 0.7069 | 0.4968 | 0.4997 | 0.4961 | 0.4078 | 0.1966 | 1.0000 | 0.4939 | 0.3696 |
| MC | 0.6377 | 0.6134 | 0.5473 | 0.4852 | 0.2279 | 0.2212 | 0.6181 | 0.4939 | 1.0000 | 0.6304 |
| EI | 0.6245 | 0.4868 | 0.5344 | 0.4445 | 0.1452 | 0.1471 | 0.6692 | 0.3696 | 0.6304 | 1.0000 |
| CT | 0.3684 | 0.5582 | 0.3409 | 0.3529 | 0.3705 | 0.3490 | 0.2093 | 0.5163 | 0.4259 | 0.2685 |
| SM | 0.3606 | 0.5318 | 0.3682 | 0.3704 | 0.3412 | 0.3387 | 0.1703 | 0.4892 | 0.3854 | 0.2373 |
| FR | 0.5026 | 0.5945 | 0.4727 | 0.4425 | 0.3073 | 0.2872 | 0.3108 | 0.5457 | 0.5313 | 0.3914 |
| ID | 0.5024 | 0.5695 | 0.4310 | 0.3909 | 0.2601 | 0.2584 | 0.3787 | 0.5174 | 0.5743 | 0.4315 |
| AO | 0.4743 | 0.5142 | 0.3990 | 0.3611 | 0.2371 | 0.2669 | 0.3889 | 0.4675 | 0.5559 | 0.4254 |
| SO | 0.4888 | 0.5366 | 0.4392 | 0.3930 | 0.2250 | 0.2380 | 0.3955 | 0.4824 | 0.5622 | 0.4291 |
| T1 | -0.2882 | -0.2956 | -0.2440 | -0.2272 | -0.2008 | -0.1967 | -0.2589 | -0.2608 | -0.3677 | -0.2659 |
| T2 | -0.3405 | -0.3369 | -0.2967 | -0.2614 | -0.1910 | -0.2104 | -0.3230 | -0.2806 | -0.4362 | -0.3233 |
| TI | -0.3151 | -0.2651 | -0.2537 | -0.2224 | -0.1781 | -0.1917 | -0.2274 | -0.2300 | -0.3216 | -0.2349 |

| Test | CT | SM | FR | ID | AO | SO | T1 | T2 | TI |
|----------|---------|---------|---------|---------|---------|---------|----------|----------|---------|
| Mean | 0.6772 | 0.6554 | 0.6113 | 0.7209 | 0.5746 | 0.4447 | 2827.3 | 3722.98 | 1.9156 |
| Std.Dev. | 0.1920 | 0.1456 | 0.2106 | 0.1404 | 0.2112 | 0.2726 | 406.0732 | 494.5723 | 0.6219 |
| GS | 0.3684 | 0.3606 | 0.5026 | 0.5024 | 0.4743 | 0.4888 | -0.2882 | -0.3405 | -0.3151 |
| AR | 0.5582 | 0.5318 | 0.5945 | 0.5695 | 0.5142 | 0.5366 | -0.2956 | -0.3369 | -0.2651 |
| WK | 0.3409 | 0.3682 | 0.4727 | 0.4310 | 0.3990 | 0.4392 | -0.2440 | -0.2967 | -0.2537 |
| PC | 0.3529 | 0.3704 | 0.4425 | 0.3909 | 0.3611 | 0.3930 | -0.2272 | -0.2614 | -0.2224 |
| NO | 0.3705 | 0.3412 | 0.3073 | 0.2601 | 0.2371 | 0.2250 | -0.2008 | -0.1910 | -0.1781 |
| CS | 0.3490 | 0.3387 | 0.2872 | 0.2584 | 0.2669 | 0.2380 | -0.1967 | -0.2104 | -0.1917 |
| AS | 0.2093 | 0.1703 | 0.3108 | 0.3787 | 0.3889 | 0.3955 | -0.2589 | -0.3230 | -0.2274 |
| MK | 0.5163 | 0.4892 | 0.5457 | 0.5174 | 0.4675 | 0.4824 | -0.2608 | -0.2806 | -0.2300 |
| MC | 0.4259 | 0.3854 | 0.5313 | 0.5743 | 0.5559 | 0.5622 | -0.3677 | -0.4362 | -0.3216 |
| EI | 0.2685 | 0.2373 | 0.3914 | 0.4315 | 0.4254 | 0.4291 | -0.2659 | -0.3233 | -0.2349 |
| CT | 1.0000 | 0.6288 | 0.5586 | 0.5530 | 0.5700 | 0.5067 | -0.3787 | -0.3889 | -0.2964 |
| SM | 0.6288 | 1.0000 | 0.5422 | 0.4939 | 0.4885 | 0.4583 | -0.3162 | -0.3343 | -0.2807 |
| FR | 0.5586 | 0.5422 | 1.0000 | 0.5930 | 0.5768 | 0.5431 | -0.3464 | -0.3713 | -0.2939 |
| ID | 0.5530 | 0.4939 | 0.5930 | 1.0000 | 0.6461 | 0.5736 | -0.3808 | -0.4061 | -0.3287 |
| AO | 0.5700 | 0.4885 | 0.5768 | 0.6461 | 1.0000 | 0.5779 | -0.3801 | -0.4276 | -0.3664 |
| SO | 0.5067 | 0.4584 | 0.5431 | 0.5736 | 0.5779 | 1.0000 | -0.3668 | -0.4084 | -0.2815 |
| T1 | -0.3787 | -0.3162 | -0.3464 | -0.3808 | -0.3801 | -0.3668 | 1.0000 | 0.7522 | 0.3631 |
| T2 | -0.3889 | -0.3343 | -0.3713 | -0.4061 | -0.4276 | -0.4084 | 0.7522 | 1.0000 | 0.3844 |
| TI | -0.2964 | -0.2807 | -0.2939 | -0.3287 | -0.3664 | -0.2815 | 0.3631 | 0.3844 | 1.0000 |

Note. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing. See Tables 1 & 2 for test names.

Adverse Impact

From inspection of the content of the sample items, one can conclude that the ECAT tests are relatively knowledge-free as compared with the ASVAB (i.e., they do not require knowledge acquired through formal education). They may be described as tests of fluid intelligence, rather than the crystallized intelligence measured by the ASVAB. Table 5 demonstrates this empirically by correlating the ASVAB and ECAT tests with Years of Education. With the exception of Auto-Shop Information, the ASVAB correlations with education are generally larger than the ECAT correlations. The correlations were not corrected for range-restriction, but such corrections should increase the correlation with education more for the ASVAB tests, which are explicitly used for selection, than for the ECAT tests. Lower correlations of the ECAT tests with education should cause the ECAT tests to have less adverse impact on educationally disadvantaged subgroups.

Table 5

Correlations of ASVAB and ECAT Tests With Years of Education ($N = 10756$)

| Test | Correlation with Years of Education |
|--|--|
| Armed Forces Qualification Test (AFQT) | .166 * |
| General Science (GS) | .085 * |
| Arithmetic Reasoning (AR) | .107 * |
| Word Knowledge (WK) | .109 * |
| Paragraph Comprehension (PC) | .078 * |
| Numerical Operations (NO) | .111 * |
| Coding Speed (CS) | .116 * |
| Auto-Shop Information (AS) | .011 ns |
| Math Knowledge (MK) | .179 * |
| Mechanical Comprehension (MC) | .058 * |
| Electronics Information (EI) | .064 * |
| Mental Counters (CT) | .058 * |
| Sequential memory | .049 * |
| Integrating Details (ID) | .055 * |
| Assembling Objects (AO) | .039 * |
| Spatial Orientation (SO) | .061 * |
| Figural Reasoning (FR) | .065 * |
| One-hand Tracking | .036 * |
| Two-hand Tracking | .014 ns |
| Target Identification (TI) | .014 ns |

Note. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

* $p < .01$.

ns = not significant.

Table 6 confirms this hypothesis. It shows the differences in mean test scores between Caucasians, and Afro-Americans, Asians, and Hispanics (See Appendix F for further details). The four tests with the largest adverse impact are all ASVAB tests - GS, WK, AS, and MC. The subgroups differ on which tests have the least adverse impact, but the ECAT tests compare favorably with the ASVAB tests. Since the sample was explicitly selected by ASVAB scores, correction for range restriction should increase the adverse impact of ASVAB tests more than of ECAT tests.

Table 6
Subgroup Differences in ASVAB and ECAT Test Means

| Variable | Caucasian - Afro-American Z | Caucasian - Asian Z | Caucasian - Hispanic Z |
|-------------------------------|-----------------------------------|---------------------------|------------------------------|
| Years of Education | -.058 * | -.288 ** | .133 ** |
| Educational Level | .030 | .265 ** | -.146 ** |
| Language | .006 | -1.988 ** | -.234 ** |
| AFQT | .736 ** | .302 ** | .370 ** |
| General Science (GS) | .818 ** | .609 ** | .475 ** |
| Arithmetic Reasoning (AR) | .753 ** | .187 ** | .293 ** |
| Word Knowledge (WK) | .736 ** | .755 ** | .532 ** |
| Paragraph Comprehension (PC) | .515 ** | .375 ** | .219 ** |
| Numerical Operations (NO) | .023 | -.189 ** | .022 |
| Coding Speed (CS) | .142 ** | -.073 | .051 |
| Auto-Shop Information (AS) | 1.106 ** | .829 ** | .638 ** |
| Math Knowledge (MK) | .164 ** | -.396 ** | -.017 |
| Mechanical Comprehension (MC) | .901 ** | .430 ** | .440 ** |
| Electronics Information (EI) | .719 ** | .358 ** | .344 ** |
| Mental Counters (CT) | .656 ** | -.100 | .089 * |
| Sequential Memory (SM) | .445 ** | .139 * | .248 ** |
| Integrating Details (ID) | .729 ** | -.023 | .116 ** |
| Assembling Objects (AO) | .713 ** | .010 | .097 * |
| Spatial Orientation (SO) | .694 ** | .165 * | .169 ** |
| Figural Reasoning (FR) | .546 ** | .103 | .196 ** |
| One-hand Tracking | -.565 ** | -.292 ** | -.026 |
| Two-hand Tracking | -.701 ** | -.314 ** | -.113 ** |
| Target Identification (TI) | -.485 ** | -.400 ** | -.179 ** |

Note. ASVAB = Armed Services Vocational Aptitude Battery. ECAT = Enhanced Computer Administered Testing. Z values are differences in ECAT sample means divided by the Caucasian group standard deviations.

* p < .05

** p < .01.

Factor Analysis

One of the goals in selecting tests for inclusion in the ECAT battery was to expand upon the domain of abilities measured by the ASVAB. To determine how successful the efforts were, factor analyses were conducted to determine: (1) the underlying dimensions in each test battery, (2) the overlap in measuring general intelligence across the batteries, and (3) the factor structure when both batteries are combined. A number of factor analytic solutions were obtained by varying factor extraction methods, number of factors extracted, method of rotation, and initial communality estimates. Only the hierarchical solutions will be described. For hierarchical analyses, a Promax rotation was used at the primary level(s) with the entire hierarchical solution orthogonalized using the Schmid-Leiman technique (Schmid & Leiman, 1957). In the Schmid-Leiman orthogonalization, the effects of the second-order (*g*) loadings are removed from the first-order loadings. These residuals of the first-order loadings will be reported, rather than the original first-order loadings, which are much larger. Therefore, residual loadings as small as .20 can be reported as useful, in contrast to the .40 standard that is commonly used for interpreting primary rotated solutions.

All analyses are based on the corrected correlations reported in Table 4. Appendix B contains the uncorrected and corrected correlations with other measures, as well. The primary factor loadings before orthogonalization are reported in Appendix C.

Armed Services Vocational Aptitude Battery Factor Structure

Table 7 reports the results of the hierarchical solution for the ASVAB. In this and the next two tables, where the tests had Promax loadings greater than .40, the hierarchical residual loadings appear in bold-face type. The four primary factors are: (1) Technical Knowledge defined by Auto-Shop Information, Mechanical Comprehension, and Electronics Information; (2) Verbal Ability defined by Word Knowledge and Paragraph Comprehension; (3) Clerical Speed defined by Numerical Operations and Coding Speed; and (4) Mathematical Ability defined by Arithmetic Reasoning and Math Knowledge. The only factorially complex test is General Science, which splits its specific variance across the Technical and Verbal factors. This factor structure is routinely found to describe the ASVAB's intercorrelations. All of the tests load on the hierarchical general ability measure (*g*) which accounted for 40% of the intercorrelational variance.

Table 7

Orthogonalized Hierarchical Factor Solution for the ASVAB

| Test | <i>g</i> | Technical | Verbal | Clerical | Math |
|-------------------------------|----------|-------------|-------------|-------------|-------------|
| General Science (GS) | .738 | .245 | .241 | -.073 | .135 |
| Arithmetic Reasoning (AR) | .753 | .164 | .054 | .110 | .303 |
| Word Knowledge (WK) | .782 | .024 | .504 | -.009 | -.025 |
| Paragraph Comprehension (PC) | .703 | .019 | .360 | .124 | .023 |
| Numerical Operations (NO) | .461 | -.012 | -.014 | .683 | .058 |
| Coding Speed (CS) | .412 | .011 | .036 | .654 | -.024 |
| Auto-Shop Information (AS) | .402 | .776 | -.023 | .027 | -.089 |
| Math Knowledge (MK) | .741 | -.069 | .003 | .037 | .480 |
| Mechanical Comprehension (MC) | .632 | .488 | .017 | -.005 | .158 |
| Electronics Information (EI) | .547 | .569 | .061 | -.015 | .028 |

Notes:

1. ASVAB = Armed Services Vocational Aptitude Battery, *g* = General Intellectual Ability.
2. Entries in bold correspond to Promax loadings greater than .40

Enhanced Computer Administered Test Factor Structure

Table 8 reports the results of the hierarchical solution for the ECAT battery. Three primary factors were found: (1) Spatial Ability defined by Integrating Details, Assembling Objects, Figural Reasoning, and Spatial Orientation; (2) Psychomotor Skill defined by the One- and Two-Hand Tracking tests; and (3) Working Memory which was defined by Mental Counters and Sequential Memory. This factor pattern roughly matches the *a priori* categorization of the tests described earlier, except that the Figural Reasoning Test loaded higher on the Space factor than on the Memory (i.e. Nonverbal Reasoning) factor, and the fourth construct of Perceptual Speed could not be verified. The Target Identification test, however, did not load highly on any of the first three factors. If the ECAT battery had included additional tests of perceptual speed, it is likely that Target Identification would have loaded on a fourth Perceptual Speed factor. All of the tests loaded on the general factor which accounted for just over 40% of the correlational variance.

Table 8

Orthogonalized Hierarchical Solution for ECAT

| Test | <i>g</i> | Spatial | Psychomotor | Working Memory |
|----------------------------|----------|-------------|-------------|----------------|
| Mental Counters (CT) | .690 | .130 | -.046 | .313 |
| Sequential Memory (SM) | .643 | .019 | .000 | .583 |
| Figural Reasoning (FR) | .703 | .210 | -.002 | .149 |
| Integrating Details (ID) | .751 | .279 | -.018 | .009 |
| Assembling Objects (AO) | .757 | .281 | -.036 | -.003 |
| Spatial Orientation (SO) | .677 | .231 | -.057 | .033 |
| One-Hand Tracking (T1) | -.484 | .004 | .696 | -.017 |
| Two-Hand Tracking (T2) | -.524 | -.017 | .716 | .009 |
| Target Identification (TI) | -.402 | -.082 | .241 | -.021 |

Notes.

1. ECAT = Enhanced Computer Administered Testing, *g* = General Intellectual Ability.
2. Entries in bold correspond to Promax loadings greater than .40

Enhanced Computer Administered Test and Armed Services Vocational Aptitude Battery Factor Structure

Although the factor patterns appear quite different across the batteries this does not directly address the question of the degree of overlap between the batteries. A partial answer to this question can be found by correlating the general ability scores across the batteries. The range corrected correlation of the ECAT-*g* and ASVAB-*g* scores was a moderate .71, implying that while there is some redundancy across the batteries there is substantial uniqueness as well. A final factor analysis was conducted across the combined test batteries (19 tests); the results are reported in Table 9. The ASVAB primary factors (Technical, Verbal, Clerical, and Math) were relatively unchanged in the combined analysis. The Psychomotor factor for ECAT also reemerged intact in the combined analysis, The Space factor reemerged, although only Integrating Details and Assembling Objects have substantial loadings on Space, and both tests have higher loadings on another factor. The ECAT Working Memory factor appears to have captured the nonverbal reasoning variance in many of the ECAT tests and thus was recast as a nonverbal reasoning factor. This latter factor, begging the point that it is at the primary level, appears very much like a fluid intelligence factor. This result is not surprising. Alderton and Larson (1992a, 1992b) argue that the net effect of the efforts to expand the ability dimensions measured by the ASVAB was to augment the crystallized intelligence measures of the ASVAB with fluid intelligence measures, thus providing a more complete sampling of intellectual performance. Later in this report, however, we will present evidence showing that additional specific ability factors are also required to maximize incremental validity.

Table 9

Orthogonalized Hierarchical Solution of ASVAB With ECAT

| Test | g | Reas | Tech | Verb | Motr | Cler | Math | Spat |
|-------------------------------|-------|-------------|-------------|-------------------------|-------------|-------------|-------------|-------------|
| General Science (GS) | .740 | .012 | .161 | .315^c | -.024 | -.046 | .119 | .064 |
| Arithmetic Reasoning (AR) | .762 | .212 | .152 | .070 | .038 | .082 | .258 | -.126 |
| Word Knowledge (WK) | .706 | .016 | .024 | .605 | -.004 | -.015 | -.049 | -.014 |
| Paragraph Comprehension (PC) | .637 | .028 | .025 | .449 | .006 | .117 | .004 | -.042 |
| Numerical Operations (NO) | .406 | -.026 | .010 | -.019 | -.013 | .725 | .101 | -.018 |
| Coding Speed (CS) | .371 | .033 | -.007 | .048 | -.008 | .690 | -.047 | .077 |
| Auto-Shop Information (AS) | .519 | .003 | .727 | -.023 | .011 | .018 | -.114 | -.040 |
| Math Knowledge (MK) | .699 | .139 | -.080 | .029 | .009 | .096 | .425 | -.021 |
| Mechanical Comprehension (MC) | .724 | .125 | .353 | .038 | -.058 | -.015 | .095 | .074 |
| Electronics Information (EI) | .616 | -.024 | .477 | .091 | -.001 | -.003 | .040 | .025 |
| Mental Counters (CT) | .571 | .537 | -.004 | -.041 | -.037 | .051 | -.002 | -.036 |
| Sequential Memory (SM) | .536 | .534 | -.035 | .054 | -.006 | .000 | -.028 | -.119 |
| Figural Reasoning (FR) | .656 | .384 | -.001 | .076 | -.012 | -.045 | .079 | .083 |
| Integrating Details (ID) | .661 | .371 | .049 | -.010 | -.024 | -.016 | .062 | .245 |
| Assembling Objects (AO) | .633 | .421 | .044 | -.023 | -.008 | .049 | -.056 | .388 |
| Spatial Orientation (SO) | .630 | .316 | .099 | .023 | -.053 | -.050 | .056 | .134 |
| One-Hand Tracking (T1) | -.441 | -.013 | .017 | .014 | .736 | .003 | -.012 | .021 |
| Two-Hand Tracking (T2) | -.492 | -.014 | -.030 | -.004 | .725 | .007 | .003 | -.001 |
| Target Identification (TI) | -.365 | -.115 | -.012 | -.048 | .232 | -.078 | .067 | -.152 |

Notes.

1. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing, g:=General Intellectual Ability, Motr: =Psychomotor Skill, Reas:= Nonverbal Reasoning, Cler: =Clerical Speed, Tech: =Technical Knowledge, Math: =Mathematical Ability, Verb: =Verbal Ability, Spat: =Spatial Ability.
2. Entries in bold correspond to Promax loadings greater than .40

The fact that the factor analysis of the combined ASVAB and ECAT battery produced three more factors than ASVAB alone shows that the ECAT battery indeed does measure ability factors not adequately measured by the ASVAB. Nevertheless, the overlap between the batteries is substantial, as shown in Table 10, which displays the correlations between the ASVAB and ECAT factor scores. Even within the ASVAB, the factor scores are highly correlated, as illustrated by the .72 correlation between Math and Verbal, but the .71 correlation between Math and Space is nearly as large.

Table 10

Range-Corrected Correlations Among ASVAB and ECAT Factor Scores

| Factor | Verbal | Math | Technical | Clerical | Working Memory | Space | Psychomotor |
|----------------|--------|-------|-----------|----------|----------------|-------|-------------|
| Verbal | 1.000 | .722 | .672 | .489 | .491 | .587 | -.365 |
| Math | .722 | 1.000 | .558 | .647 | .641 | .711 | -.405 |
| Technical | .672 | .558 | 1.000 | .166 | .387 | .603 | -.430 |
| Clerical | .489 | .647 | .166 | 1.000 | .472 | .420 | -.271 |
| Working Memory | .491 | .641 | .387 | .472 | 1.000 | .789 | -.480 |
| Space | .587 | .711 | .603 | .420 | .789 | 1.000 | -.605 |
| Psychomotor | -.365 | -.405 | -.430 | -.271 | -.480 | -.605 | 1.000 |

Note. ASVAB = Armed Services Vocational Aptitude Battery. ECAT = Enhanced Computer Administered Testing.

The same problem is evident at the second-order level with the correlations among the *g* factors derived from the different batteries. Table 11 shows that the ECAT and ASVAB *g* factor scores correlate a moderately high .71, which suggests some redundancy across the batteries, but which implies some uniqueness as well.

Table 11

Range-Corrected Correlations Between *g* Factor Scores From Different Batteries (N = 10,963)

| Battery | ASVAB | ECAT | ASVAB + ECAT |
|--------------|-------|-------|--------------|
| ASVAB | 1.000 | .707 | .948 |
| ECAT | .707 | 1.000 | .865 |
| ASVAB + ECAT | .948 | .865 | 1.000 |

Note. *g* = General Intellectual Ability, ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

Conclusions

The goal in selecting tests for the ECAT battery was to broaden the range of abilities measured by the ASVAB, the rationale being that this would maximize the probability that ECAT would improve the ASVAB's validity. The results suggest that the effort was largely successful. While the two *g* measures are highly correlated, they are by no means redundant. Although the ECAT spatial and nonverbal reasoning factors are also highly correlated with several ASVAB factors, substantial amounts of unique variance remain which may improve upon the ASVAB's validity. Moreover, the ECAT psychomotor and perceptual speed tests are nearly independent of the ASVAB and thus may capture aspects of training and job performance untouched by the ASVAB. Finally, the ECAT tests have less adverse impact than ASVAB tests because they measure fluid intelligence, rather than crystallized knowledge acquired in school.

Criteria for Validation

Background

In 1980, the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics) directed the Military Services to establish a research and development program to link enlistment standards to job performance. Some of these job performance measurement projects were still underway at the beginning of the ECAT project, and we were fortunate to be able to arrange a cooperative effort with the Marine Corps to administer ECAT tests to automotive and helicopter mechanics at the same time that job knowledge and hands-on job performance tests were administered. The results of that study were presented by Carey (1994).

The samples described in this report all came from students at military technical training schools. Instead of relying on Final School Grades, as has been traditional for most validation studies conducted in service schools, every effort was made to collect information on practical skills taught in shop, laboratory, simulator, or other exercises. In many cases, these were hands-on performance measures similar to the kinds of tests used in Job Performance measurement projects.

Kieckhafer et al. (1992) describe their development of the ECAT criteria. They collected data on every quiz, homework assignment, and laboratory/shop exercise for samples of several hundred students at each school. Based on factor analysis, they constructed composites of scores designed to measure different dimensions of achievement in each school. These composites will be referred to as "internal school criteria," because they are seldom published outside of the school, as the Final School Grades are. They include all of the hands-on performance measures, as well as composites of written tests, and grades on each learning module. Table 12, Table 13, and Table 14 list the 77 criteria that were used.

Table 12

Criteria in Army Courses for ECAT Validation

| Location | Code | Title/Description |
|---------------------|---|--|
| Fort Benning | 11H | Heavy Antiarmor Weapons Crewman |
| | 11H(A) | HMMWV Curriculum: |
| | TOALL | Sum of scores on 8 Training Objectives |
| | EVT1TO | TOW Tracking Time on Target for 10 shots, Event 1 |
| | EVT2TO | TOW Tracking Time on Target for 10 shots, Event 2 |
| | EVT3TO | TOW Tracking Time on Target for 10 shots, Event 3 |
| | EVTSUM | Sum of Events 1-3 Scores |
| | TO_1 | M966 TOW Simulator Tracking Event 1 Total |
| | 11H(B) | ITV Curriculum: |
| | TOALL | Sum of scores on 8 Training Objectives |
| | EVT1TO | TOW Tracking Time on Target for 10 shots, Event 1 |
| | EVT2TO | TOW Tracking Time on Target for 10 shots, Event 2 |
| | EVT3TO | TOW Tracking Time on Target for 10 shots, Event 3 |
| | EVTSUM | Sum of Events 1-3 Scores |
| | TO_1 | ITV TOW Simulator Tracking Event 1 Total |
| | TO_2 | ITV TOW Simulator Tracking Event 2 Total |
| | TO_3 | ITV TOW Simulator Tracking Event 3 Total |
| ITVTOW | ITV TOW Simulator Tracking Total Events 1-3 | |
| Fort Sill | 13F | Field Artillery Fire Support Specialist |
| | MPRAD | Map Reading and Radio composite |
| | FIRING | Firing composite |
| | FSG | Final School Grade |
| Fort Knox | 19K | Tank Crewman |
| | COMM | Communications Performance |
| | WEAPON | Weapons Maintenance and Preparation |
| | LANDNAV | Land Navigation and Map Reading |
| | LOADER | Load/Unload main tank gun and machine gun |
| | MAINT | Preventive maintenance and trouble shooting/repair |
| | NBC | Nuclear/Biological/Chemical countermeasures |
| AVERAGE | Mean of the 6 scores above | |

Note. ECAT = Enhanced Computer Administered Testing, HMMWV = High Mobility Multipurpose Wheeled Vehicle, TOW = Tube-launched Optically-tracked Wire-guided missile, ITV = Improved Tow Vehicle, TO = Training Objective.

Table 13

Criteria in Navy Schools for ECAT Validation

| CDP | School/Criteria | Title/Description |
|---------|---------------------------------|--|
| 6278 | AC PERF | Air Traffic Controller Mean of 4 Performance Tests |
| 6515 | AE SUM2 | Aviation Electrician's Mate Average of Performance Tests loading on Factor 2 |
| 6518 | AMS PERF | Aviation Structural Mechanic - Structures Average of performance tests and practical work |
| 6506 | AO PRACTL | Aviation Ordnanceman Average of all practical work |
| 6239-41 | AV BSCAV ADVAV PERFORM | Avionics Technician Average of all Basic Avionics Tests Average of all Advanced Avionics Tests Average of all Performance Tests |
| 6070 | EM PHASE 1 | Electrician's Mate Average of all Phase I tests |
| 6487 | EN | Engineman |
| 603V | ET(AEF) FSG FSG2 PERF | Electronics Technician - Advanced Electronics Field Final School Grade for Phase I Final School Grade for Phase II Average of Phase II Performance Tests |
| 609W | FC RADAR | Fire Controlman Average of all Radar Tests |
| 6400 | GMG HALF1 HALF2 | Gunner's Mate - Gun Average of Tests 1-14 Average of Tests 14-27/30 |
| 6492 | MM | Machinist's Mate |
| 6540 | OS WRIT PERF | Operations Specialist Average of all Written Tests Average of all Performance Tests |
| 611E | RM PHASE3 | Radioman Average of All Knowledge and Performance Tests in Last Phase |

Notes. 1. ECAT = Enhanced Computer Administered Testing, CDP = Course Data Processing code.

2. FSG (Final School Grade) was also used as a criterion in each school.

Table 14

Criteria in Air Force Schools for ECAT Validation

| Location | AFSC/Criterion | Title |
|-------------|----------------|--|
| Keesler AFB | 73230 | Apprentice Personnel Specialist (APS) |
| | ZHRS | Standardized training hours on Blocks II-VII |
| | AFPT70 | Air Force Performance Test Words per Minute Typing |
| | FSG | Final School Grade |
| Keesler AFB | 27230 | Apprentice Air Traffic Control Operator (ATC) |
| | BLK2 | Control Tower Procedures (Written test – standardized hours) |
| | BLK3A | Basic Control Tower Operation (Perf test – standardized hours) |
| | BLK3B | Advanced Control Tower Operation (Perf test – standardized hours) |
| | BLK5A | Basic Approach Control Operation (Perf test – standardized hours) |
| | BLK5B | Advanced Approach Control Operation (Perf test – standardized hours) |
| | FAA | Federal Aviation Administration Examination |
| | FSG | Final School Grade |

Note. ECAT = Enhanced Computer Administered Testing, AFSC = Air Force Specialty Code.

Several difficulties were encountered in the criterion development.

1. Many of the laboratory exercises were scored as Pass/Fail, with almost all of the students passing. Composites derived from these exercises were highly skewed with small variances.
2. Some schools had alternative tracks or major curriculum changes during the course of the ECAT study. Criteria that were available for one curriculum were absent in the next. In these cases, the sample from a given school had to be split into smaller subsamples, thus reducing statistical power.
3. The Trank Crewman (19K) school was selected for study because Smith and Graham (1987) had found excellent incremental validities with a combination of psychomotor and perceptual tests for predicting performance on the Unit Conduct of Fire Trainer (UCOFT), a high-fidelity tank gunnery simulator. Unfortunately, budget cuts at the school forced this simulator to be shut down. Other available criteria turned out to have low reliability.

Because of minor curriculum changes and other factors, most students missed one or more of the examinations or exercises that comprised the composite criteria. Therefore, the criteria were defined to be the means of the tests or exercises actually taken. However, these means were sometimes bizarre for students that dropped out from school early in the curriculum. In the course of the data analysis, rules were formulated to reduce the number of outliers due to missing data. These are described in Appendix E.

Criterion Statistics

Tables G-1, G-2, and G-3 show the basic statistics for some 77 criteria collected at three Army schools, two Air Force Schools, and 13 Navy schools. The Army's 11H school was divided into two curricula, labeled 11H(A) and 11H(B). The Air Force Air Traffic Control school (ATC) had two curricula, labeled ATC(A) and ATC(B). For some purposes, these were combined into a single group, ATC. In the tables, the digit at the end of the school abbreviation refers to the number of the criterion. Thus, 11H(A) had 6 criteria, while 11H(B) had 9 criteria.

Reliabilities were derived from those computed by Kieckhafer et al. (1992) In several schools (19K, AV, ET, EN, MM, OS) different curricula were combined into one group, and the weighted average of the reliabilities of corresponding criteria was used.

To correct the criterion means and standard deviations for range-restriction, Lawley's (1943) multivariate range correction procedure was used, with all 10 ASVAB tests used as explicitly selected variables. The corrected reliability was computed from the formula

$$R_{xx} = (1 - \frac{s_x^2}{S_x^2})(1 - r_{xx}),$$

where r_{xx} is the uncorrected reliability, s_x is the uncorrected standard deviation, and the corresponding corrected values are in upper case (Gulliksen, 1950/1987, Chapter 10, Eq. 5).

Corrected reliabilities will be used in the last stage of correcting validities. Multiple correlations are first tested for significance, then corrected for range restriction, then corrected for bias using the Wherry formula, and finally divided by the square root of the corrected reliability. In cases where the uncorrected reliability was unknown or smaller than 0.35, no correlation for criterion reliability was used. Such cases are designated by a period in the reliability column of the tables.

Selecting Criteria for Meta-analysis

For some purposes, it will be necessary to compute mean validities or combine probabilities across schools. If all criteria were combined, schools with the most criteria would receive larger weights in the averages. Moreover, the criteria within a school are not independent, thus complicating the analysis. The best approach seems to be to select one criterion per school when combining results across schools.

Criterion reliabilities in the Army's 19K school were so low that all results from this school were reluctantly dropped from the meta-analysis.

Four sets of criteria were selected for averaging:

1. School Grades Because school grades have been the traditional measures of training success used in validation studies, we felt obligated to include an analysis in terms of school grades, even though we expected some of the ECAT tests, such as psychomotor tracking, to have no relation to the kinds of written tests that usually form the basis for final school grades. In the 11H Army school where FSG was unavailable, a summary average score, EVTSUM, was used. This was actually a hands-on performance measure.

2. Internal School Criteria Among the measures collected for each school, criteria were selected according to the following *a priori* rules, which were applied in order:

- a.. If possible, the criterion is not the same as the School Grade. If there is no other criterion, then School Grade is chosen. This rule tries to minimize overlap between the Internal Criteria and School Grades.
- b.. If possible, the criterion should be a practical performance score, rather than a knowledge score.
- c.. If the reliabilities of two measures are substantially different (i.e. by 0.10 or more) then the more reliable one is used.
- d.. A measure with greatest face or construct validity is to be preferred over others.
- e.. A score collected late in training should be preferred to one taken earlier.

In the Army 11H school, after Rule (a) was applied, rules (d) and (e) resulted in selecting the TOW simulator tracking performance scores taken toward the end of training: TO_1 and ITVTOW. In the 13F school, face validity favored Firing as a criterion. In the Navy, there was never more than one performance criterion to choose from. The only remaining choice occurred in the GM school, where Rule (e) selected a measure taken in the last half of the course in preference to the earlier measure. In the Air Force APS school, the only practical performance criterion consisted of words per minute on the AFPT70 typing test.

One exception to the *a priori* selection was made in the Air Force Air Traffic Controllers, where Rule (c) suggested the BLK3B criterion for ATC(A) and the BLK5A criterion for ATC(B). However in order to maintain consistency with ATC(B), the preferred ATC(A) criterion was changed to BLK5A.

3. Final School Grades for 10 Schools with Performance Criteria Ten schools had both FSG and practical performance criteria available. For those samples, the corresponding two sets of criteria were used for some analyses. The 10 schools were 13F, APS, ATC, AC, AE, AMS, AO, AV, ET, and OS.

4. Performance Criteria for 10 Schools with Final School Grades These are practical performance measures on the same 10 schools for which FSGs were available. Because the Air Force ATC school was split into two different curricula, the number of samples was 11.

The last two sets of criteria are subsets of the first two, with sample sizes only a third of the total. However, they permit a strict comparison between FSG and performance criteria for the average magnitude of incremental validity³.

³This analysis was suggested by Dr. Norm Abrahams, of RGI, Inc.

Validity of General Ability Factors

Theoretical Background

It has been argued that the search for additional tests to enhance the validity of ASVAB is futile. Many previous studies have shown that the general ability factor, or “*g*”, is the major predictor of school and job performance, and the ASVAB is an excellent measure of *g* (Ree & Earles, 1991; Hunter, 1986).

Others have argued that *g* is imperfectly measured by the ASVAB, which seems to concentrate on verbal and numerical crystallized intelligence. Enhancing the ASVAB with spatial and reasoning tests, and tests which require fluid intelligence, should produce a better measure of *g* with greater predictive validity.

A third position is that *g*, although important, may be over-rated for predicting certain kinds of jobs requiring special abilities. Hence, additional tests of spatial and psychomotor ability, for example, should have incremental validity over ASVAB for predicting mechanical repair, targeting, vehicle operations, etc.

Method

Three different measures of *g* were developed, using the matrix of range-corrected correlations.

1. *Hierarchical g* scores were computed using weights derived from a second-order factor analysis of the variables.
2. *Principal Component g* was computed using the factor score weights from the first principal component. This method should maximize the variance accounted for by a single factor.
3. *Psychological g* scores were computed by weighting each test’s z-score by its correlation with the Figural Reasoning test. The rationale was that the Figural Reasoning test measures the same fluid reasoning ability as the Raven Progressive Matrices test, which often has been used as a marker for *g*.

Each of these three methods were applied to three different sets of variables: ASVAB only, ECAT only, and ASVAB + ECAT combined.

The validity of each g score was computed for each criterion and corrected for multivariate range-restriction and criterion unreliability. The validity of the ASVAB + ECAT g was compared with the validity of the g derived from ASVAB alone. The significance of the difference was tested with an asymptotic test for range-corrected dependent multiple correlations (Hedges, Becker, & Wolfe, 1992, Eq. 12). When applied to zero-order correlations, this formula is equivalent to comparing the value of

$$z = \frac{(c_2 r_2 - c_1 r_1) \sqrt{n}}{\sqrt{c_1^2 (1 - r_1^2)^2 + c_2^2 (1 - r_2^2)^2 - c_1 c_2 [2r_{12} (1 - r_1^2 - r_2^2) - r_1 r_2 (1 - r_1^2 - r_2^2 - r_{12}^2)]}}$$

with the (0,1) normal distribution, where

r_1 is the uncorrected validity of ASVAB g ,

r_2 is the uncorrected validity of ASVAB + ECAT g ,

r_{12} is the uncorrected correlation between ASVAB g and ASVAB + ECAT g ,

c_1 is the ratio of range-corrected to uncorrected validity for ASVAB g ,

c_2 is the ratio of range-corrected to uncorrected validity for ASVAB + ECAT g ,

and n is the sample size.

For each school, a probability is determined by comparing the value of z with the upper tail of the normal distribution. The combined probability for the entire sample across schools is given by the chi-square distribution of $\sum_{i=1}^{Schools} (-2 \log P_i)$ with $2 \times Schools$ degrees of freedom (Fisher, 1932). The degrees of freedom are 36 for the School Grade set and 38 for the Internal School Criteria Validities, where the Air Traffic Control school was split into two groups.

Mean validities were weighted averages of the multiple correlations for each school, weighted by their sample sizes.

Results

Table 15 shows the range-corrected correlations of the First Principal Component scores with Psychological and Hierarchical g factor scores for the three data sets. It is apparent the Psychological g is virtually identical to the First Principal Component. Hence Psychological g was eliminated from the subsequent validity analyses.

Table 15

Range-corrected Correlations of g With First Principal Components
($N = 10,963$)

| Battery | Psychological g | Hierarchical g |
|--------------|-------------------|------------------|
| ASVAB | .999 | .966 |
| ECAT | .994 | .985 |
| ASVAB + ECAT | .998 | .987 |

Note. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

While the correlations between different measures of g within the same battery of tests are large, the correlations between batteries are considerably lower, as was shown by Table 11.

Table 16 and Table 17 present the validities of six different measures of g for School Grades and for Internal School Criteria, respectively. All validities were corrected both for range-restriction and for criterion unreliability. The mean validities were obtained by weighting these values by the sample sizes.

The mean validities for the Hierarchical g were smaller than the First Principal Component validities for the ASVAB battery only, but not for the ECAT only or ASVAB + ECAT batteries. This reversal makes interpretation difficult for subsequent comparisons. For the First Principal Component, the inclusion of ECAT tests does not significantly improve validity for predicting School Grades, while for the Hierarchical g , ECAT significantly increases validity for five of the school samples as well as for the mean across schools. A similar result was obtained for the Internal Criteria, with only the Hierarchical g showing a significant increase in mean validity.

Discussion

The hypothesis that the g derived from a broader sampling of tests contained in the ASVAB + ECAT battery will have greater validity seems to be confirmed by these data for Hierarchical g .

As we shall see, full least squares multiple regression produces validities that average .02 to .06 larger than those for g for all batteries. This means that the validity partly comes from specific ability factors relevant to specific criterion measures, rather than from the general ability factor alone.

Table 16

Corrected Validities of Hierarchical and First Principal Component Measures of "G" From ASVAB, ECAT, and ASVAB + ECAT Sets of Variables for School Grade Criteria

| School | Criterion | N | Index of Reliability | ASVAB | | ECAT | | ASVAB + ECAT | |
|---------|-----------|------|----------------------|---------|------|---------|------|--------------|------|
| | | | | Hier. G | P.C. | Hier. G | P.C. | Hier. G | P.C. |
| 11H(A)5 | EVTSUM | 546 | .981 | .330 | .354 | .368 | .376 | .387* | .392 |
| 11H(B)5 | EVTSUM | 316 | .981 | .358 | .388 | .394 | .425 | .416* | .435 |
| 13F1 | FSG | 821 | .894 | .744 | .774 | .719 | .709 | .791* | .804 |
| APS1 | FSG | 446 | .933 | .817 | .812 | .674 | .649 | .812 | .797 |
| ATC1 | FSG | 484 | .914 | .713 | .722 | .621 | .624 | .733 | .729 |
| AC1 | FSG | 72 | .977 | .782 | .774 | .636 | .612 | .769 | .757 |
| AE1 | FSG | 278 | .961 | .639 | .669 | .616 | .607 | .687 | .691 |
| AMS1 | FSG | 244 | .965 | .799 | .843 | .641 | .631 | .820 | .803 |
| AO1 | FSG | 234 | .946 | .694 | .701 | .582 | .584 | .706 | .698 |
| AV1 | FSG | 544 | .983 | .762 | .772 | .668 | .654 | .789 | .776 |
| EM1 | FSG | 797 | .972 | .654 | .664 | .539 | .525 | .665 | .649 |
| EN1 | FSG | 750 | .956 | .707 | .751 | .590 | .582 | .743* | .726 |
| ET2 | FSG2 | 86 | .987 | .779 | .799 | .761 | .755 | .828 | .842 |
| FC1 | FSG | 778 | .983 | .793 | .817 | .655 | .632 | .813 | .791 |
| GM1 | FSG | 420 | .976 | .709 | .722 | .588 | .579 | .727 | .708 |
| MM1 | FSG | 801 | .948 | .505 | .546 | .464 | .452 | .546* | .542 |
| OS1 | FSG | 713 | .955 | .768 | .768 | .665 | .649 | .772 | .771 |
| RM1 | FSG | 277 | .934 | .761 | .763 | .606 | .572 | .743 | .730 |
| Mean | Grades | 8607 | | .676 | .696 | .592 | .582 | .702** | .695 |

Notes. 1. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing, Hier. G = Hierarchical g, P.C. = first principal component.

2. For definitions of schools and criteria, see Tables 12-14.

* $p < .05$ for the null hypothesis of no difference from the corresponding ASVAB g. ** $p < .01$.

Table 17

**Corrected Validities of Hierarchical and First Principal Component
Measures of "G" From ASVAB, ECAT, and ASVAB + ECAT Sets of Variables
for Internal School Criteria**

| School | Criterion | N | Index of Reliability | ASVAB | | ECAT | | ASVAB + ECAT | |
|---------|-----------|------|-------------------------|---------|-------|---------|------|--------------|-------|
| | | | | Hier. G | P.C. | Hier. G | P.C. | Hier. G | P.C. |
| 11H(A)6 | TO_1 | 542 | .945 | .216 | .221 | .212 | .234 | .239 | .244 |
| 11H(B)9 | ITVTOW | 318 | .960 | -.018 | -.008 | .078 | .095 | .046 | .041 |
| 13F3 | FIRING | 821 | .814 | .690 | .711 | .612 | .611 | .713 | .718 |
| APS3 | AFPT70 | 432 | .965 | .318 | .286 | .315 | .278 | .291 | .308 |
| ATC(A)4 | BLK5A | 205 | .711 | .432 | .482 | .624 | .633 | .549 | .598 |
| ATC(B)4 | BLK5A | 295 | .911 | .390 | .375 | .518 | .532 | .455 | .485 |
| AC2 | PERF | 76 | .825 | .287 | .269 | .497 | .476 | .345 | .398 |
| AE2 | SUM2 | 273 | .916 | .548 | .587 | .545 | .532 | .601 | .607 |
| AMS2 | PERF | 244 | .880 | .532 | .598 | .553 | .546 | .602 | .620 |
| AO2 | PRACTL | 229 | .871 | .453 | .448 | .435 | .437 | .458 | .478 |
| AV4 | PERFORM | 352 | .820 | .507 | .561 | .561 | .558 | .608 | .605 |
| EM2 | PHASE1 | 797 | .943 | .687 | .687 | .570 | .552 | .697 | .676 |
| EN1 | FSG | 750 | .956 | .707 | .751 | .590 | .582 | .743* | .726 |
| ET3 | PERF | 86 | .941 | .643 | .635 | .632 | .665 | .684 | .700 |
| FC2 | RADAR | 780 | .891 | .682 | .731 | .543 | .540 | .712 | .692 |
| GM3 | HALF2 | 397 | .959 | .687 | .721 | .561 | .551 | .709 | .693 |
| MM1 | FSG | 801 | .948 | .505 | .546 | .464 | .452 | .546* | .542 |
| OS3 | PERF | 815 | .896 | .721 | .741 | .714 | .705 | .766* | .784* |
| RM2 | PHASE3 | 277 | .832 | .679 | .689 | .575 | .547 | .685 | .674 |
| Mean | Internal | 8490 | | .556 | .579 | .517 | .511 | .591** | .592 |

Notes. 1. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing, Hier. G = Hierarchical g, P.C. = first principal component.

2. For definitions of schools and criteria, see Tables 12-14.

* $p < .05$ for the null hypothesis of no difference from the corresponding ASVAB g. ** $p < .01$.

Full-Model Regression Analysis for Each Criterion

Rationale

This section will compare the validities of regression equations based on the ASVAB + ECAT battery with equations based on ASVAB alone to determine how much the addition of ECAT tests can improve validity. The use of optimally-weighted ASVAB tests in regression is controversial. Integer-weighted ASVAB composites have been used operationally in preference to regression equations. In part this is an historical accident, dating from the times of hand calculation. However, regression equations may involve negative weights, penalizing high test scores, and may not cross-validate as well as simpler weighting schemes on small samples. Some people believe that ECAT tests should be evaluated against the operational composites by comparing the validity of the operational composite with an optimally weighted combination of the ECAT tests and the operational composite. Unfortunately, this method would quickly show that the ASVAB itself has incremental validity over the operational composite. In other words, an "ECAT" test that was merely an alternate form of an existing ASVAB test would appear to have incremental validity, because the operational composite is suboptimal, and does not represent the full predictive power of the ASVAB. We must reject the fallacy of such an approach.

Others have suggested using stepwise regression, so that only the significant ASVAB predictors for a particular criterion are used to establish the restricted model. The problem with this approach is more subtle: the degrees of freedom for significance testing will be incorrect. Stepwise regression capitalizes on chance by selecting the best predictors from a larger pool. Significance tests will be biased unless the number of predictors in the larger pool are used for the degrees of freedom. But in that case, one might as well use all of the predictors to begin with.

It is important to realize that we are recommending and using regression for analysis, not prediction. The best equation for prediction is not the sample regression equation, but some variation on it, perhaps ridge regression, perhaps integer weighted composites. Since the appropriate prediction equation has not yet been determined, cross-validation is premature, and is not covered here. Instead, regression will be used to test hypotheses and estimate population validities of population regression equations from their sample values.

Method

Significance Testing

For each criterion in every school, the multiple correlation was computed using the 10 ASVAB tests as predictors. A second multiple correlation was determined by all 10 ASVAB tests plus 6 additional ECAT predictors: Memory Composite (the sum of z-scores for Mental Counters and Sequential Memory), Spatial Composite (the sum of z-scores of Integrating Details and Assembling Objects), Tracking Composite (the sum of z-scores for One-Hand and Two-Hand Tracking), Figural Reasoning, Target Identification, and Spatial Orientation. The tests in the composites were chosen because a priori inspection of the contents of the tests suggested that each pair in a composite was measuring the same construct. Moreover, each test in a pair

correlates higher with the other test than it does with any other test, as shown in Tables B-1 and B-2 of Appendix B. For each criterion, the probability associated with the difference was determined from the F-distribution with degrees of freedom equal to 6 and $N - (10 + 6) - 1$, where

$$F_{6,N-17} = \frac{\Delta R^2}{1 - R^2_{ASVAB+ECAT}} \cdot \frac{N-17}{6}$$

The composites were used instead of the nine ECAT individual tests in order to decrease the degrees of freedom in the numerator and thus increase the statistical power of the F-test.

Correction for Range Restriction

Next, the correlation matrix of predictors and criterion was corrected for multivariate range-restriction, using a two stage process. First, the uncorrected matrix of 10 ASVAB tests and 9 ECAT tests was obtained for the sample of 10,963 subjects in the ECAT sample. This matrix was corrected for range restriction using the 10 ASVAB variables as explicitly selected variables with population covariances equal to those of the 1991 joint-services applicant population ($N = 650,278$). The population matrix is shown in Table A-1 of Appendix A.

The corrected 19×19 matrix (Table 4) was treated as if it were the population. The correlation matrix of ASVAB and ECAT tests and a school criterion was then corrected for range restriction as if all 19 tests were explicitly selected. This method has the advantage of having a common, shared matrix of predictor covariances among schools.

After correcting the correlation matrix, the multiple correlations were recomputed for the 10-predictor and 16-predictor models.

Estimating the Population Multiple R^2

The sample multiple correlations were “shrunk” to produce unbiased estimates of the population R^2 using the Wherry formula. However, negative estimates of R^2 were replaced by zero, which re-introduced some bias. Finally, shrunk multiple correlations were generated by taking the square roots of the shrunk R^2 .

Correction for Criterion Unreliability

The shrunk range-corrected correlations were divided by the square roots of the range-corrected criterion reliabilities to produce the “fully corrected” multiple correlations. The incremental validities were the differences between fully corrected multiple correlations for the ASVAB-only and ASVAB + ECAT regression models. The “percent increase” was defined as 100 times the validity increment divided by the fully-corrected ASVAB multiple correlation. Where the fully-corrected ASVAB validity was zero, the percent increase was undefined.

Combining Results Across Samples

Using one criterion per school, the results were combined across samples for the School Grade criterion set. Another analysis was done for the set of Internal School Criteria.

The combined probability is given by the chi-square distribution of $\sum_{i=1}^{Schools} (-2 \log P_i)$ with $2 \times Schools$ degrees of freedom (Fisher, 1932). The degrees of freedom are 36 for the School Grade set and 38 for the Internal School Criteria Validities, where the Air Traffic Control school was split into two groups.

Mean validities were weighted averages of the multiple correlations for each school, weighted by their degrees of freedom, $N - p - 1$, where p = the number of predictors in the regression equation

Weighting by degrees of freedom is contrary to the method advocated by Hedges, Becker and Wolfe (1992), who recommend weighting each correlation by the inverse of its asymptotic variance. However, two anomalies were observed when using the variances for weighting the multiple R's.

1. For a subsample of ECAT, the mean of the uncorrected full model multiple R's was .956, even though 17 of the 19 schools had multiple R's below .67. It turned out that performance criteria for two schools, AC and ET, had only 19 cases with 16 predictors in the full model, leaving multiple R's of .995 and .983 respectively. These inflated multiple R's produced variance estimates of .000007 and .000076 respectively. The low variances resulted in huge weights for these schools when averaging took place. Although one can argue that the correct "fix" would be to throw out schools with such small samples, this experience suggests that variance weighting may distort the averages obtained when even one multiple R is inflated.

2. Hedges, Becker, and Wolfe recommend that the variance of the range-corrected multiple R_c be estimated by multiplying the variance of the uncorrected R_u by the factor c^2 , where $c = \frac{R_c}{R_u}$. For the AO school practical criterion ($N = 132$), the simple validity of Two-Hand Tracking was -.00896, corrected to .00027. The obtained value of c was 0.0300, resulting in an estimate of the variance of the corrected R of .000009 and a weight of 111,790 for averaging purposes. The resulting mean validity of Two-Hand Tracking was -.004, even though several large schools had validities greater than .30 in absolute value.

Based on these experiences, weighting multiple correlations by their degrees of freedom appears to be the safest method of averaging multiple correlations.

Results

Incremental Validities of ECAT Tests

Incremental validities for all Army, Air Force, and Navy criteria are presented in Tables I-1, I-2, and I-3 of Appendix I. The incremental validities for School Grade criteria appear below in Table 18. Table 19 presents the results for the Internal School Criteria.

The combined probability values are less than 1.4×10^{-17} for all sets of criteria, indicating the overall findings are highly significant. The mean corrected validity increase was .015 for School Grades and .031 for the Internal criteria. However, the Grades criteria actually included the EVTSUM performance criteria for the Army's 11H school, which showed very large validity increments. Seven of the 13 Navy schools showed no significant validity increment in Grades, and nine Navy schools showed no significant increment for the Internal School criteria. Where the criteria exhibited significant validity increments, they were often quite large, but their effects were diluted when averaged with zero-effect criteria.

Table 20 compares the summary results for pure FSG criteria with those for pure practical performance measures. The mean validity gain for predicting FSG is 1.7%, while the gain for predicting performance measures is 5.7%. These findings are consistent with those reported by Wolfe and Alderton (1992) and Wolfe, Alderton, and Larson (1993) for a related battery administered to recruits for nine Navy schools. The mean incremental validity for predicting FSG is about the same as those reported for Project A Core Technical Proficiency by McHenry, Hough, Toquam, Hanson, and Ashworth (1990), but the validity reported for the ASVAB was only .63 in their study.

The mean validity increments are quite substantial, particularly for the performance criteria. If these means were representative of all military training schools, they would provide strong evidence for the utility of enhancing the ASVAB with new tests.

For both FSG and Internal Criteria, all but one of the Air Force and Army schools had above-average validity increments, while 10-11 out of 13 Navy schools were below average. The best Army results were in the 11H Heavy Antiarmor Weapons simulator training performance, where the validity increase was 0.24 correlation points. In the Air Force, both Air Traffic Controller and Personnel Specialist showed validity gains, but the increments were about four times greater for performance criteria (as large as 0.10 for ATC Basic Approach Control Operations). In the Navy, the largest significant validity improvement was 0.031 for Operations Specialist performance. The large nonsignificant .149 validity increase for Navy Air Traffic Control performance should be noted, since it is consistent with the large and significant improvements in predicting Air Force Air Traffic Control Performance.

Incremental Validities of Ability Factors

In order to guard against overestimating incremental validity by underestimating the predictive validity of the ASVAB, it has been necessary to represent the ASVAB by using all 10 of its subtests as predictors in the regression equations. Nevertheless, many of the results are more interpretable in terms of ability factors, rather than individual tests. Therefore, the entire

analysis was repeated, using a 4-factor score representation of the ASVAB and a 3-factor representation of the ECAT battery. Each criterion was first fit to a regression equation with the four ASVAB factor scores as independent variables. Then three ECAT factor scores were added, making a 7-predictor regression equation. The results for each school were remarkably similar to those reported in Table 18, Table 19, and Table 20. The mean incremental validities are shown in Table 21, and should be compared with the bottom lines of Table 18, Table 19, and Table 20 (See Appendix J for further details on factor validities.) Although the validities are slightly less for factor scores, the incremental validities are about the same, except for Performance criteria, which show larger gains with the factor score representation.

Figure 10 conveniently summarizes the incremental validities obtained from different forms of predictor representation. It is immediately clear that the incremental validity is about the same, whether in terms of tests, factors, or Hierarchical *g*. This suggests that the validity improvement from ECAT is due to a better sampling of the tests comprising *g*. However, the same figure also shows that *g* misses more predictive validity than ECAT adds, that is, the validity of enhanced *g* is less than the validity of the four ASVAB factors combined into a multiple regression equation. Thus, using *g* for prediction wastes a significant part of the ASVAB's validity, contrary to the point of view expressed by Ree and Earles (1991). On the other hand, basing prediction on factor scores is nearly as effective as using individual tests, and may be an excellent way of reducing the errors associated with using too many predictors in regression, while retaining the potential for differential prediction.

Table 18

ECAT Incremental Validities for School Grades

| School | Criterion | Sample Size | Uncorrected Multiple R | | | | Corrected Multiple R | | |
|---------|-----------|-------------|------------------------|-------|--------------------|-------------------------------------|----------------------|----------|---------------------|
| | | | ASVAB | +ECAT | Percent Variance | Probability of $F_{6,N-17}$ | ASVAB | Increase | Percent Increase |
| 11H(A)5 | EVTSUM | 546 | .321 | .373 | 4.119 | 1.53×10^{-3} | .392 | .036 | 9.2 ** |
| 11H(B)5 | EVTSUM | 316 | .330 | .446 | 11.216 | 1.64×10^{-5} | .382 | .091 | 23.7 ** |
| 13F1 | FSG | 821 | .544 | .597 | 9.483 | 9.81×10^{-14} | .790 | .024 | 3.0 ** |
| APS1 | FSG | 446 | .545 | .581 | 6.233 | 2.17×10^{-4} | .828 | .012 | 1.5 ** |
| ATC1 | FSG | 484 | .403 | .445 | 4.540 | 1.98×10^{-3} | .727 | .020 | 2.7 ** |
| AC1 | FSG | 72 | .627 | .649 | 4.978 | 8.37×10^{-1} | .839 | .000 | 0.0 |
| AE1 | FSG | 278 | .489 | .542 | 7.810 | 3.04×10^{-3} | .659 | .023 | 3.5 ** |
| AMS1 | FSG | 244 | .599 | .602 | .555 | 9.73×10^{-1} | .848 | .000 | 0.0 |
| AO1 | FSG | 234 | .504 | .522 | 2.434 | 5.10×10^{-1} | .717 | .005 | 0.7 |
| AV1 | FSG | 544 | .517 | .536 | 2.772 | 2.49×10^{-2} | .810 | .005 | 0.7 * |
| EM1 | FSG | 797 | .451 | .459 | .864 | 3.47×10^{-1} | .687 | .000 | 0.0 |
| EV 1 | FSG | 750 | .584 | .588 | .721 | 5.09×10^{-1} | .763 | .000 | 0.0 |
| ET2 | FSG2 | 86 | .504 | .566 | 9.738 | 3.60×10^{-1} | .813 | .027 | 3.3 |
| FC1 | FSG | 778 | .499 | .528 | 4.180 | 2.28×10^{-5} | .828 | .010 | 1.2 ** |
| GM1 | FSG | 420 | .428 | .454 | 2.911 | 7.10×10^{-2} | .731 | .004 | 0.6 |
| MM1 | FSG | 801 | .402 | .425 | 2.362 | 5.41×10^{-3} | .557 | .012 | 2.2 ** |
| OS1 | FSG | 713 | .565 | .582 | 2.969 | 2.33×10^{-3} | .804 | .007 | 0.9 ** |
| RM1 | FSG | 277 | .536 | .587 | 8.796 | 1.17×10^{-3} | .775 | .022 | 2.8 ** |
| Summary | Grades | 8607 | .467 ^a | .510 | 4.194 ^b | $<1.4 \times 10^{-17}$ ^c | .713 | .015 | 2.0 ^d ** |

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.

2. For definitions of schools and criteria, see Tables 12-14.

^aMean multiple Rs are means of Wherry-shrunken Rs.

$$\text{Percent Variance} = 100 \times \frac{\Delta R^2}{1 - R^2_{ASVAB+ECAT}}$$

^cSummary probability = $P(\chi^2_{36})$.

^dThe summary percent increase is defined as $100 \times$ the ratio of the mean increase to the mean corrected ASVAB validity.

* $p < .05$ for uncorrected R increase. ** $p < .01$ for uncorrected R increase.

Table 19

ECAT Incremental Validities for Internal School Criteria

| School | Criterion | Sample Size | Uncorrected Multiple R | | | | Corrected Multiple R | | |
|---------|-----------|-------------|------------------------|-------|--------------------|--------------------------------------|----------------------|----------|------------------|
| | | | ASVAB | +ECAT | Percent Variance | Probability of $F_{6,N-17}$ | ASVAB | Increase | Percent Increase |
| 11H(A)6 | TO_1 | 542 | .210 | .269 | 3.031 | 1.52×10^{-2} | .240 | .046 | 19.1 * |
| 11H(B)9 | ITVTOW | 318 | .154 | .350 | 11.203 | 1.51×10^{-5} | .075 | .237 | 316.3 ** |
| 13F3 | FIRIN G | 821 | .444 | .466 | 2.507 | 2.82×10^{-3} | .730 | .007 | 1.0 ** |
| APS3 | AFPT70 | 432 | .294 | .404 | 9.129 | 2.28×10^{-6} | .388 | .079 | 20.4 ** |
| ATC(A)4 | BLK5A | 205 | .322 | .404 | 7.127 | 4.18×10^{-2} | .614 | .079 | 12.9 * |
| ATC(B)4 | BLK5A | 295 | .312 | .408 | 8.316 | 1.04×10^{-3} | .450 | .100 | 22.2 ** |
| AC2 | PERF | 76 | .330 | .460 | 13.033 | 2.80×10^{-1} | .381 | .149 | 39.2 |
| AE2 | SUM2 | 273 | .440 | .487 | 5.808 | 2.39×10^{-2} | .608 | .022 | 3.7 * |
| AMS2 | PERF | 244 | .393 | .431 | 3.892 | 1.89×10^{-1} | .650 | .016 | 2.4 |
| AO2 | PRACTL | 229 | .343 | .374 | 2.652 | 4.69×10^{-1} | .490 | .010 | 2.1 |
| AV4 | PERFORM | 352 | .379 | .409 | 2.853 | 1.48×10^{-1} | .673 | .016 | 2.4 |
| EM2 | PHASE1 | 797 | .474 | .482 | .950 | 2.86×10^{-1} | .729 | .001 | 0.1 |
| EN 1 | FSG | 750 | .584 | .588 | .721 | 5.09×10^{-1} | .763 | .000 | 0.0 |
| ET3 | PERF | 86 | .482 | .574 | 14.533 | 1.41×10^{-1} | .735 | .075 | 10.2 |
| FC2 | RADAR | 780 | .345 | .381 | 3.053 | 7.93×10^{-4} | .733 | .016 | 2.1 ** |
| GM3 | HALF2 | 397 | .458 | .467 | 1.033 | 6.87×10^{-1} | .734 | .000 | 0.0 |
| MM1 | FSG | 801 | .402 | .425 | 2.362 | 5.41×10^{-3} | .557 | .012 | 2.2 ** |
| OS3 | PERF | 815 | .523 | .564 | 6.510 | 3.81×10^{-9} | .791 | .025 | 3.1 ** |
| RM2 | PHASE3 | 277 | .420 | .464 | 4.907 | 5.08×10^{-2} | .702 | .017 | 2.4 |
| Summary | Internal | 8490 | .373 ^a | .440 | 3.966 ^b | $< 1.4 \times 10^{-17}$ ^c | .619 | .031 | 5.0d ** |

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.

2. For definitions of schools and criteria, see Tables 12-14.

^aMean multiple Rs are means of Wherry-shrunken Rs.

$$\text{Percent Variance} = 100 \times \frac{\Delta R^2}{1 - R^2_{\text{ASVAB+ECAT}}}$$

^cSummary probability = $P(\chi^2_{38})$.

^dThe summary percent increase is defined as $100 \times$ the ratio of the mean increase to the mean corrected ASVAB validity.

* $p < .05$ for uncorrected R increase. ** $p < .01$ for uncorrected R increase.

Table 20

Comparison of FSG and Performance Criteria for 10 Schools With Both Criteria

| Criterion Set | Sample Size | Uncorrected Multiple R | | | Corrected Multiple R | | | |
|---------------|-------------|------------------------|-------------|-------------------------------|--|----------------|---------------|------------------|
| | | ASVAB ^a | ASVAB +ECAT | Percent Variance ^b | Probability ^c of $F_{6,N-17}$ | ASVAB Increase | ECAT Increase | Percent Increase |
| FSG | 3922 | 0.505 | 0.551 | 5.219 | 4.163×10^{-17} | 0.783 | 0.013 | 1.7 * |
| Performance | 3828 | 0.373 | 0.453 | 5.578 | 2.442×10^{-15} | 0.638 | 0.036 | 5.7 * |

Notes. FSG = Final School Grade, ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

^aMean multiple Rs are means of Wherry-shrunken Rs.

$$^b\text{Percent Variance} = 100 \times \frac{\Delta R^2}{1 - R^2_{ASVAB+ECAT}}$$

^cSummary probability = $P(X^2_{20})$ for FSG and $P(X^2_{22})$ for Performance.

* $p < 10^{-14}$ for uncorrected R increase.

Table 21

Incremental Validities of 3 ECAT Factor Scores Over 4 ASVAB Factor Scores

| Criterion Set | Sample Size | Uncorrected Multiple R | | | Corrected Multiple R | | |
|---------------|-------------|------------------------|-------------|-------------------------------|----------------------|---------------|-------------------------------|
| | | ASVAB ^a | ASVAB +ECAT | Percent Variance ^b | ASVAB Increase | ECAT Increase | Percent Increase ^c |
| Internal | 8490 | .342 | .413 | 3.370 | .608 | .031 | 5.1 * |
| Grades | 8607 | .447 | .488 | 3.325 | .708 | .013 | 1.9 * |
| Performance | 3828 | .328 | .424 | 5.374 | .620 | .041 | 6.6 * |
| FSG | 3922 | .487 | .534 | 4.838 | .778 | .014 | 1.9 * |

Notes. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.

^aMean multiple Rs are means of Wherry-shrunken Rs.

$$^b\text{Percent Variance} = \text{Mean of } 100 \times \frac{\Delta R^2}{1 - R^2_{ASVAB+ECAT}}$$

^cSummary probability = $P(X^2_{36})$ for Grades, $P(X^2_{38})$ for Internal Criteria, $P(X^2_{20})$ for FSG, and $P(X^2_{22})$ for

Performance, where $X^2_{2 \times Schools} = \sum_{k=1}^{Schools} -2 \log(P(F_{3, N_k - 8}))$.

* $p < 1.4 \times 10^{-17}$ for uncorrected R increase.

ECAT Mean Validity Increase for Internal Criteria

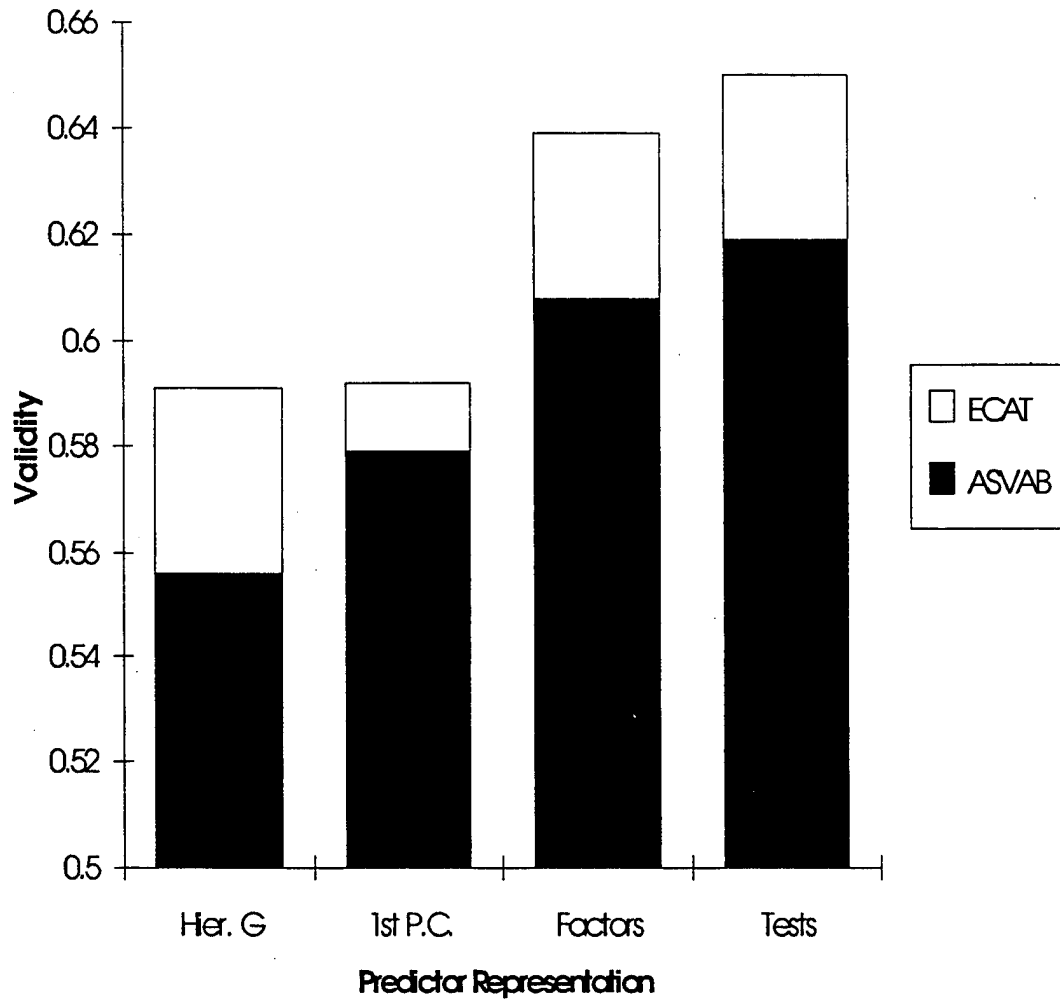


Figure 10. ASVAB validities and ECAT validity increases for different predictor representations.

Regression Analyses for Each Predictor's Incremental Validity

Method

Significance

For each criterion in each school and each predictor, two hypotheses were tested:

1. Adding just this one predictor to the ASVAB does not significantly increase the multiple R:

$$\Delta R^2 = R^2_{ASVAB+1} - R^2_{ASVAB} .$$
$$F_{1,N-12} = (N - 12) \frac{\Delta R^2}{1 - R^2_{ASVAB+1}} .$$

2. Deleting just this one predictor from the full battery of ASVAB plus ECAT does not significantly decrease the multiple R:

The general approach was to examine the validity of composites first; if significant, then the component tests in a composite were examined for significance. When it was necessary to split a composite up into its components, then the remaining composites were also split. Thus, if the predictor was a test that was also part of a composite, then the battery of ASVAB plus nine individual tests was compared with the same battery with the one test deleted; otherwise, the full battery consisting of ASVAB plus three composites plus three tests was compared with the same battery with the one predictor deleted. For example, the effect of deleting One-Hand tracking was tested by comparing the multiple R of ASVAB plus nine ECAT predictors with the Multiple R of ASVAB plus eight ECAT predictors.

$$\Delta R^2 = R^2_{ASVAB+9ECAT} - R^2_{ASVAB+8ECAT} .$$
$$F_{1,N-20} = (N - 20) \frac{\Delta R^2}{1 - R^2_{ASVAB+9ECAT}} .$$

The effect of deleting Target Identification was tested by comparing the Multiple R of ASVAB plus six ECAT predictors with the Multiple R of ASVAB plus five ECAT predictors.

$$\Delta R^2 = R^2_{ASVAB+6ECAT} - R^2_{ASVAB+5ECAT} .$$
$$F_{1,N-17} = (N - 17) \frac{\Delta R^2}{1 - R^2_{ASVAB+6ECAT}} .$$

Corrected Multiple Correlations and Increments

After significance testing, all correlations were corrected for multivariate range restriction, shrunken to their population values (Wherry), and corrected for criterion unreliability.

Combining Results Across Samples

For the two subset of criteria (School Grades and Internal School Criteria), the Fisher chi-square method was used to combine probabilities. Mean validities were computed by weighting each multiple correlation by its degrees of freedom.

For the nine schools that had both FSG and practical performance criteria available, comparative summaries were prepared combining results across samples.

Display of Selected Test \times Criterion Results

In order to reduce the Type I error associated with multiple significance tests, incremental validities for individual predictors were displayed only for criteria that proved significant in the full-model regression comparing ASVAB with ASVAB plus six ECAT predictors.

Results

Combined Results Across Samples

Table 22 and Table 23 show the mean incremental validities and combined probabilities for each ECAT predictor for the School Grade criteria and the Internal School Criteria. The two tables are remarkably consistent with one another. In both tables, the accretion probabilities show that every ECAT predictor (except for Target Identification in Table 23) significantly increases the validity of ASVAB by itself.

The deletion probability is a measure of redundancy with other ECAT tests. From both Table 22 and Table 23, it is clear that either Integrating Details or Assembling Objects can be deleted without significant decrease in validity, but not both, because the Spatial Composite cannot be deleted. On the other hand, neither working memory test and neither tracking test can be deleted without significant decrease in validity.⁴ Spatial Orientation can be deleted.

The mean increments or decrements from a single test are small. All ECAT tests show validity increments in some schools that are much larger than their means, as will be shown in the next section.

⁴These findings for the spatial ability tests and working memory tests confirm those of Wolfe, Alderton, and Larson (1993) for nine Navy schools.

Table 22

Mean Incremental Validities From Adding or Deleting one ECAT Test to the ASVAB
for 18 School Grade Criteria ($N = 8607$)

| Predictor | Simple Validity | $R_{ASVAB+1}$ | Validity Increase | $P(X_{36}^2)$ for Accretion | $R_{ASVAB+ECAT-1}$ | Validity Decrease | $P(X_{36}^2)$ for Deletion |
|-----------------------|--------------------|---------------|----------------------|--------------------------------|--------------------|----------------------|-------------------------------|
| Mental Counters | .451 | .718 | .005 | 4.86×10^{-16} | .728 | .001 | .007 |
| Sequential Memory | .410 | .717 | .004 | 1.84×10^{-10} | .728 | .001 | .011 |
| Integrating Details | .498 | .717 | .004 | 5.46×10^{-12} | .729 | .001 | .178 |
| Assembling Objects | .474 | .718 | .005 | 1.47×10^{-12} | .728 | .001 | .089 |
| One-Hand Tracking | -.301 | .718 | .005 | 1.97×10^{-8} | .728 | .001 | .039 |
| Two-Hand Tracking | -.339 | .719 | .006 | 1.43×10^{-8} | .728 | .002 | .011 |
| Target Identification | -.257 | .716 | .003 | 5.76×10^{-5} | .726 | .001 | .006 |
| Spatial Orientation | .475 | .717 | .004 | 6.98×10^{-10} | .727 | .001 | .302 |
| Figural Reasoning | .499 | .717 | .004 | 6.12×10^{-12} | .726 | .001 | .003 |
| Memory Composite | .477 | .719 | .006 | $<1.4 \times 10^{-17}$ | .726 | .002 | .000 |
| Spatial Composite | .535 | .719 | .006 | $<1.4 \times 10^{-17}$ | .726 | .001 | .016 |
| Tracking Composite | -.342 | .719 | .006 | 4.48×10^{-10} | .725 | .003 | .006 |
| Memory Factor | .492 | .714 | .006 | $<1.4 \times 10^{-17}$ | .720 | .001 | .010 |
| Space Factor | .590 | .717 | .009 | 1.39×10^{-17} | .718 | .003 | .000 |
| Psychomotor Factor | -.378 | .714 | .007 | 9.20×10^{-12} | .717 | .003 | .001 |

- Notes.** 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery.
 2. The first six rows of the table use a 9-predictor representation of the ECAT and a 10-predictor representation of the ASVAB. The second set of six rows represent the ECAT by 6 predictors (3 tests and 3 composites) and the ASVAB by 10 predictors. The last three rows represent the ECAT by 3 factors and the ASVAB by 4 factors.

Table 23

**Mean Incremental Validities From Adding or Deleting one ECAT Test to the ASVAB
for 19 Internal School Criteria ($N = 8490$)**

| Predictor | Simple Validity | $R_{ASVAB+1}$ | Validity Increase | $P(X_{38}^2)$ for Accretion | $R_{ASVAB+ECAT-1}$ | Validity Decrease | $P(X_{38}^2)$ for Deletion |
|-----------------------|--------------------|---------------|----------------------|--------------------------------|--------------------|----------------------|-------------------------------|
| Mental Counters | .393 | .628 | .009 | 2.37×10^{-11} | .650 | .003 | .010 |
| Sequential Memory | .354 | .626 | .007 | 1.18×10^{-9} | .650 | .003 | .001 |
| Integrating Details | .427 | .624 | .005 | 4.45×10^{-6} | .653 | .001 | .848 |
| Assembling Objects | .418 | .627 | .009 | 1.57×10^{-9} | .651 | .002 | .155 |
| One-Hand Tracking | -.289 | .633 | .015 | 1.71×10^{-9} | .650 | .003 | .016 |
| Two-Hand Tracking | -.301 | .632 | .014 | 5.93×10^{-9} | .649 | .004 | .001 |
| Target Identification | -.223 | .620 | .002 | 6.32×10^{-2} | .650 | .002 | .136 |
| Spatial Orientation | .411 | .625 | .006 | 1.21×10^{-5} | .650 | .001 | .300 |
| Figural Reasoning | .438 | .626 | .007 | 7.12×10^{-9} | .649 | .002 | .049 |
| Memory Composite | .414 | .630 | .011 | 1.54×10^{-14} | .645 | .006 | .000 |
| Spatial Composite | .465 | .629 | .010 | 6.34×10^{-12} | .649 | .002 | .039 |
| Tracking Composite | -.315 | .635 | .016 | 1.25×10^{-10} | .639 | .012 | .000 |
| Memory Factor | .427 | .622 | .013 | $<1.4 \times 10^{-17}$ | .637 | .004 | .000 |
| Space Factor | .514 | .625 | .016 | $<1.4 \times 10^{-17}$ | .637 | .004 | .000 |
| Psychomotor Factor | -.344 | .626 | .016 | 5.68×10^{-12} | .630 | .011 | .000 |

- Notes.** 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery.
2. The first six rows of the table use a 9-predictor representation of the ECAT and a 10-predictor representation of the ASVAB. The second set of six rows represent the ECAT by 6 predictors (3 tests and 3 composites) and the ASVAB by 10 predictors. The last three rows represent the ECAT by 3 factors and the ASVAB by 4 factors.

Table 24 and Table 25 show the similar results for the 10 schools that had both FSG and Performance criteria available. The results are somewhat different from the summaries across all 18 schools. For the FSG criteria, only three predictors cannot be deleted without significant loss: the Memory composite and the Memory and Space Factors. Either Mental Counters or Sequential Memory could be deleted, but not both.

The performance criteria for the same 10 schools show much larger incremental validities and more significant effects. In Table 25, the Memory and Tracking composites plus Sequential memory and both tracking tests have unique predictive power, as shown by their significant deletion probabilities. The strong showing for the psychomotor tests is impressive, considering that the sample did not include the Army's 11H school, which showed extremely large validity increments. In addition, the same significant finding for the Memory composite that was observed for the FSG criteria also applies to the performance criteria.

Table 24

**Mean Incremental Validities From Adding or Deleting one ECAT Test to the ASVAB
for Final School Grade Criteria of 10 Schools With Dual Criteria (N = 3922)**

| Predictor | Simple Validity | $R_{ASVAB+1}$ | Validity Increase | $P(X^2_{20})$ for Accretion | $R_{ASVAB+ECAT-1}$ | Validity Decrease | $P(X^2_{20})$ for Deletion |
|-----------------------|--------------------|---------------|----------------------|--------------------------------|--------------------|----------------------|-------------------------------|
| Mental Counters | .520 | .791 | .007 | 9.54×10^{-14} | .795 | .002 | .071 |
| Sequential Memory | .489 | .789 | .006 | 2.39×10^{-11} | .796 | .001 | .109 |
| Integrating Details | .550 | .789 | .005 | 2.59×10^{-10} | .796 | .001 | .253 |
| Assembling Objects | .523 | .788 | .005 | 5.62×10^{-9} | .797 | .000 | .847 |
| One-Hand Tracking | -.325 | .786 | .003 | 1.93×10^{-4} | .796 | .001 | .128 |
| Two-Hand Tracking | -.362 | .785 | .002 | 3.01×10^{-3} | .797 | .000 | .387 |
| Target Identification | -.299 | .785 | .002 | 5.36×10^{-2} | .796 | .001 | .705 |
| Spatial Orientation | .529 | .788 | .004 | 5.97×10^{-9} | .796 | .001 | .325 |
| Figural Reasoning | .559 | .788 | .005 | 1.34×10^{-10} | .796 | .001 | .076 |
| Memory Composite | .559 | .792 | .009 | $<1.4 \times 10^{-17}$ | .794 | .002 | .000 |
| Spatial Composite | .591 | .791 | .008 | 1.19×10^{-14} | .796 | .001 | .210 |
| Tracking Composite | -.367 | .786 | .003 | 1.78×10^{-4} | .796 | .000 | .420 |
| Memory Factor | .575 | .788 | .010 | $<1.4 \times 10^{-17}$ | .790 | .001 | .011 |
| Space Factor | .659 | .790 | .013 | 1.75×10^{-11} | .789 | .003 | .000 |
| Psychomotor Factor | -.408 | .780 | .003 | 2.05×10^{-5} | .792 | .001 | .339 |

- Notes.** 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery.
 2. The first six rows of the table use a 9-predictor representation of the ECAT and a 10-predictor representation of the ASVAB. The second set of six rows represent the ECAT by 6 predictors (3 tests and 3 composites) and the ASVAB by 10 predictors. The last three rows represent the ECAT by 3 factors and the ASVAB by 4 factors.

Table 25

**Mean Incremental Validities From Adding or Deleting one ECAT Test to the ASVAB
for Performance Criteria of 10 Schools With Dual Criteria (N = 3828)**

| Predictor | Simple Validity | $R_{ASVAB+1}$ | Validity Increase | $P(X^2_{22})$ for Accretion | $R_{ASVAB+ECAT-1}$ | Validity Decrease | $P(X^2_{22})$ for Deletion |
|-----------------------|--------------------|---------------|----------------------|--------------------------------|--------------------|----------------------|-------------------------------|
| Mental Counters | .466 | .657 | .019 | 8.18×10^{-12} | .675 | .005 | .057 |
| Sequential Memory | .441 | .653 | .015 | 5.70×10^{-11} | .675 | .004 | .030 |
| Integrating Details | .459 | .648 | .010 | 3.74×10^{-6} | .679 | .001 | .767 |
| Assembling Objects | .449 | .650 | .012 | 1.96×10^{-8} | .678 | .001 | .525 |
| One-Hand Tracking | -.309 | .651 | .013 | 4.41×10^{-7} | .675 | .004 | .018 |
| Two-Hand Tracking | -.301 | .647 | .010 | 5.21×10^{-6} | .674 | .005 | .008 |
| Target Identification | -.252 | .642 | .004 | 4.17×10^{-2} | .674 | .002 | .313 |
| Spatial Orientation | .435 | .646 | .008 | 1.21×10^{-5} | .675 | .001 | .360 |
| Figural Reasoning | .469 | .650 | .012 | 4.99×10^{-7} | .674 | .001 | .641 |
| Memory Composite | .502 | .661 | .023 | 3.33×10^{-16} | .668 | .007 | .000 |
| Spatial Composite | .501 | .654 | .016 | 4.25×10^{-11} | .673 | .002 | .135 |
| Tracking Composite | -.326 | .650 | .013 | 2.66×10^{-7} | .668 | .007 | .000 |
| Memory Factor | .513 | .649 | .028 | $< 1.4 \times 10^{-17}$ | .659 | .004 | .001 |
| Space Factor | .559 | .652 | .030 | $< 1.4 \times 10^{-17}$ | .658 | .005 | .000 |
| Psychomotor Factor | -.358 | .635 | .014 | 2.04×10^{-8} | .656 | .008 | .000 |

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery.
2. The first six rows of the table use a 9-predictor representation of the ECAT and a 10-predictor representation of the ASVAB. The second set of six rows represent the ECAT by 6 predictors (3 tests and 3 composites) and the ASVAB by 10 predictors. The last three rows represent the ECAT by 3 factors and the ASVAB by 4 factors.

Test × Criterion Results

Validity increments for adding just one new predictor to the ASVAB are shown for each predictor and each significant criterion in Table 26 and Table 28 for the School Grade criteria and in Table 27 and Table 29 for the Internal School criteria. (Table I-4 of Appendix I gives the results for all significant criteria for all schools.)

There are a large number of significant findings shown in the tables. We mention below those significant incremental validities greater than .02. Values larger than .04 are listed in parentheses. This does not imply that the lesser values are not important, however.

Memory Factor: 11H(B) EVTSUM, AE FSG, APS typing speed (AFPT70) (.05), ATC Basic Approach Control Operations (.09 and .06), Navy AC performance (.15), AE performance (SUM2), and OS performance.

Psychomotor Factor: 11H all criteria (as high as .178), ATC Basic Approach Control Operations (.05).

Table 26

**Incremental Validities From Adding one ECAT Factor to Four ASVAB Factors
for Significant School Grades From Full Model**

| School | Criterion | Memory | Psychomotor | Space |
|---------|-----------|--------|-------------|--------|
| 11H(A)5 | EVTSUM | .012* | .034** | .027** |
| 11H(B)5 | EVTSUM | .021** | .086** | .023** |
| 13F1 | FSG | .018** | .007** | .028** |
| APS1 | FSG | .009** | .000 | .006** |
| ATC1 | FSG | .012** | .006* | .013** |
| AC1 | FSG | .000 | .000 | .000 |
| AE1 | FSG | .024** | .003* | .022** |
| AV1 | FSG | .005** | .001 | .004** |
| FC1 | FSG | .000 | .000 | .003** |
| MM1 | FSG | .000 | .000 | .006** |
| OS1 | FSG | .007** | .000 | .008** |
| RM1 | FSG | .005* | .001 | .004 |

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.

2. For definitions of schools and criteria, see Tables 12-14.

* $p < .05$ for uncorrected R increase. ** $p < .01$ for uncorrected R increase.

Table 27

**Incremental Validities From Adding one ECAT Factor to Four ASVAB Factors
for Significant Internal Criteria From Full Model**

| School | Criterion | Memory | Psychomotor | Space |
|---------|-----------|--------|-------------|--------|
| 11H(A)6 | TO_1 | .000 | .055** | .003 |
| 11H(B)9 | ITVTOW | .000 | .178** | .039** |
| 13F3 | FIRING | .011** | .005** | .009** |
| APS3 | AFPT70 | .051** | .015* | .034** |
| ATC(A)4 | BLK5A | .089* | .047* | .120** |
| ATC(B)4 | BLK5A | .060** | .053** | .078** |
| AC2 | PERF | .150* | .019 | .142 |
| AE2 | SUM2 | .024** | .000 | .013** |
| AV4 | PERFORM | .009 | .014* | .011* |
| FC2 | RADAR | .002* | .004 | .000 |
| MM1 | FSG | .000 | .000 | .006** |
| OS3 | PERF | .020** | .008** | .025** |

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.

2. For definitions of schools and criteria, see Tables 12-14.

* $p < .05$ for uncorrected R increase. ** $p < .01$ for uncorrected R increase.

Table 28

**Incremental Validities From Adding one ECAT Test to the ASVAB
for Significant School Grade Criteria**

| School | Criterion | Mental Counters | Sequential Memory | Integrating Details | Assembling Objects |
|---------|-----------|--------------------|----------------------|------------------------|-----------------------|
| 11H(A)5 | EVTSUM | .013* | .008 | .004 | .027** |
| 11H(B)5 | EVTSUM | .008 | .024* | .016* | .003 |
| 13F1 | FSG | .010** | .009** | .012** | .012** |
| APS1 | FSG | .002 | .006** | .003* | .000 |
| ATC1 | FSG | .015** | .004 | .001 | .005* |
| AE1 | FSG | .010** | .020** | .019** | .009* |
| AV1 | FSG | .007** | .002* | .002* | .002* |
| FC1 | FSG | .000 | .000 | .001 | .003** |
| MM1 | FSG | .000 | .000 | .003 | .009** |
| OS1 | FSG | .007** | .003* | .002* | .002* |
| RM1 | FSG | .004 | .002 | .004 | .000 |

| School | Criterion | One-Hand Tracking | Two-Hand Tracking | Target Identification | Spatial Orientation |
|---------|-----------|----------------------|----------------------|--------------------------|------------------------|
| 11H(A)5 | EVTSUM | .019** | .029** | .011* | .010* |
| 11H(B)5 | EVTSUM | .059** | .078** | .021* | .022** |
| 13F1 | FSG | .005** | .003** | .003* | .010** |
| APS1 | FSG | .000 | .000 | .000 | .002* |
| ATC1 | FSG | .006* | .003 | .008** | .010** |
| AE1 | FSG | .004* | .000 | .004 | .004* |
| AV1 | FSG | .000 | .002 | .000 | .001 |
| FC1 | FSG | .000 | .001* | .001* | .000 |
| MM1 | FSG | .003* | .000 | .000 | .000 |
| OS1 | FSG | .000 | .001 | .000 | .003* |
| RM1 | FSG | .002 | .000 | .011** | .002 |

| School | Criterion | Memory Composite | Spatial Composite | Tracking Composite | Figural Reasoning |
|---------|-----------|---------------------|----------------------|-----------------------|----------------------|
| 11H(A)5 | EVTSUM | .015* | .020** | .028** | .000 |
| 11H(B)5 | EVTSUM | .023* | .013 | .080** | .001 |
| 13F1 | FSG | .013** | .017** | .005** | .000 |
| APS1 | FSG | .006** | .002* | .000 | .010** |
| ATC1 | FSG | .013** | .004* | .005* | .010** |
| AE1 | FSG | .021** | .020** | .003* | .002 |
| AV1 | FSG | .007** | .003* | .001 | .001 |
| FC1 | FSG | .000 | .003** | .000 | .015 |
| MM1 | FSG | .000 | .008** | .000 | .002* |
| OS1 | FSG | .007** | .003** | .000 | .009** |
| RM1 | FSG | .005 | .002 | .002 | .004** |

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.

2. For definitions of schools and criteria, see Tables 12-14.

* $p < .05$ for uncorrected R increase. ** $p < .01$ for uncorrected R increase.

Table 29

**Incremental Validities From Adding one ECAT Test to the ASVAB
for Significant Internal School Criteria**

| School | Criterion | Mental Counters | Sequential Memory | Integrating Details | Assembling Objects |
|---------|-----------|--------------------|----------------------|------------------------|-----------------------|
| 11H(A)6 | TO_1 | .000 | .000 | .000 | .000 |
| 11H(B)9 | ITVTOW | .000 | .000 | .006 | .056* |
| 13F3 | FIRING | .002* | .007** | .002* | .002* |
| APS3 | AFPT70 | .018** | .034** | .025** | .010* |
| ATC(A)4 | BLK5A | .111** | .006 | .026* | .015 |
| ATC(B)4 | BLK5A | .060* | .032 | .014 | .040* |
| AC2 | PERF | .048 | .135* | .045 | .126* |
| AE2 | SUM2 | .008* | .018** | .005 | .004 |
| FC2 | RADAR | .000 | .005** | .000 | .001 |
| MM1 | FSG | .000 | .000 | .003 | .009** |
| OS3 | PERF | .017** | .011** | .006** | .010** |
| RM2 | PHASE3 | .004 | .000 | .002 | .000 |

| School | Criterion | One-Hand Tracking | Two-Hand Tracking | Target Identification | Spatial Orientation |
|---------|-----------|----------------------|----------------------|--------------------------|------------------------|
| 11H(A)6 | TO_1 | .036** | .044** | .000 | .008 |
| 11H(B)9 | ITVTOW | .159** | .172** | .000 | .047* |
| 13F3 | FIRING | .006** | .002* | .002 | .002* |
| APS3 | AFPT70 | .006 | .028** | .000 | .004 |
| ATC(A)4 | BLK5A | .030 | .015 | .005 | .000 |
| ATC(B)4 | BLK5A | .049** | .034** | .023* | .044** |
| AC2 | PERF | .063 | .000 | .000 | .033 |
| AE2 | SUM2 | .000 | .000 | .009* | .000 |
| FC2 | RADAR | .002 | .004* | .000 | .000 |
| MM1 | FSG | .003* | .000 | .000 | .000 |
| OS3 | PERF | .003* | .006** | .000 | .011** |
| RM2 | PHASE3 | .000 | .000 | .006 | .006 |

| School | Criterion | Memory Composite | Spatial Composite | Tracking Composite | Figural Reasoning |
|---------|-----------|---------------------|----------------------|-----------------------|----------------------|
| 11H(A)6 | TO_1 | .000 | .000 | .047** | .007 |
| 11H(B)9 | ITVTOW | .004 | .047** | .185** | .000 |
| 13F3 | FIRING | .006** | .003** | .005** | .003** |
| APS3 | AFPT70 | .036** | .024** | .018** | .014** |
| ATC(A)4 | BLK5A | .066** | .031** | .027 | .060** |
| ATC(B)4 | BLK5A | .063* | .038* | .049** | .036 |
| AC2 | PERF | .128 | .123 | .025 | .070 |
| AE2 | SUM2 | .019** | .007 | .000 | .003 |
| FC2 | RADAR | .003* | .000 | .004* | .003 |
| MM1 | FSG | .000 | .008** | .000 | .009** |
| OS3 | PERF | .019** | .012** | .005** | .007** |
| RM2 | PHASE3 | .003 | .002 | .000 | .000 |

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.

2. For definitions of schools and criteria, see Tables 12-14.

* $p < .05$ for uncorrected R increase. ** $p < .01$ for uncorrected R increase.

Space Factor: 11H EVTSUM and ITVTOW. 13F FSG, APS Typing Speed, AE FSG, ATC Basic Approach Control Operations (.12 and .08), and OS performance.

Mental Counters: ATC Basic Approach Control Operations (.11).

Sequential Memory: 11H EVTSUM, Aviation Electrician FSG, APS typing speed, and Navy Air Traffic Control performance (.14).

Integrating Details: APS Typing Speed and ATC Basic Approach Control Operations (.052).

Assembling Objects: 11H TOW Simulator Tracking (ITVTOW .06), ATC Basic Approach Control Operations (.04), and Navy Air Traffic Control performance (.13).

One-Hand Tracking 11H TOW Firing (EVTSUM .06), TOW Simulator Tracking (TO_1 and ITVTOW .16); ATC Basic Approach Control Operations (.05).

Two-Hand Tracking: 11H TOW Firing (EVTSUM .08), TOW Simulator Tracking (TO_1 .04 and ITVTOW .17), APS typing speed, ATC Basic Approach Control Operations.

Target Identification: ATC Basic Approach Control Operations, and 11H TOW Firing EVTSUM.

Spatial Orientation: ATC Basic Approach Control Operations (.04), 11H TOW Firing EVTSUM and ITVTOW.

Figural Reasoning: ATC Basic Approach Control Operations (.06).

It is interesting that Working Memory seems to predict typing speed better than Tracking does (.036 vs. .018).

It is evident that even a single test added to the ASVAB can produce large validity gains for some criteria, with the largest gains exceeding .10 from the two tracking tests, the two memory tests, and Assembling Objects.

Stepwise Meta-analysis

Method

The last section showed the mean validity changes resulting from adding or deleting a single predictor from the battery. This information could be used to select the best predictor to add or delete from the battery in order to maximize validity averaged across samples. Suppose we were to add or delete that predictor, and then re-do the whole analysis in each sample, then average across samples to determine the mean incremental validities of the remaining predictors with respect to the modified battery. Repeat the process in order to determine the next predictor to add or delete. This, in essence, is what we mean by a stepwise meta-analysis.

The algorithm is quite simple. For accretion, select the predictor with the greatest mean incremental validity. Add it to the battery. In each sample, compute the incremental validities of each of the remaining unused predictors with respect to the modified battery. Average across samples to compute the mean incremental validities of each of the remaining unused predictors with respect to the modified battery. Select the predictor with the greatest mean incremental validity, and repeat the procedure until all predictors have entered the battery. For deletion, find the predictor that decreases mean validity the least, delete it from the battery, then compute the mean validity decrements from deleting each of the remaining predictors from the modified battery. Repeat the procedure until all predictors have been removed from the battery.⁵

Appendix K gives a concrete representation of this procedure in the form of a SAS program to carry out both accretion and deletion meta-analyses. All of the results in this section were produced by this program.

Three types of meta-analyses were done.

1. ASVAB Kernel. The first type of analysis assumed that all 10 ASVAB tests remained in regression at all times, and concentrated on adding or deleting only the ECAT variables. Four analyses were done with different subsets of the ECAT variables:

- a. All nine ECAT tests.
- b. Six ECAT tests that did not use the psychomotor response pedestal.
- c. Three P&P ECAT tests only.
- d. Several combinations of three ECAT tests.

⁵A similar procedure was independently developed by Abrahams and Alf and used in the ECAT analyses done by Abrahams, Pass, Kusulas, Cole, and Kieckhafer (1993). Both procedures bear a strong similarity to Horst (1955), who showed how to maximize the mean squared multiple correlation.

These analyses made it possible to determine the incremental value of P&P tests, computerized cognitive tests, and computerized psychomotor tests, respectively.

2. AFQT Kernel. The second type of analysis assumed that only the four AFQT tests (WK, PC, AR, MK) remained in regression at all times, and allowed either an ECAT test or another ASVAB test to enter or exit the regression equations.

3. Null Kernel. The third type of analysis allowed even the AFQT tests to be replaced by ECAT tests if the result were higher multiple correlations.

All analyses used fully corrected mean validities, i.e., range-corrected, then Wherry-shrunk, then corrected for criterion reliability, then averaged by weighting them by their degrees of freedom.

Results

Deletion generally produced multiple correlations equal to or larger than accretion in the range of 10-12 predictors, so only the deletion results are shown.

The three analyses with all nine ECAT tests are presented in Table 30, Table 31, and Table 32. Certain ECAT tests seem to enter regression early: Two-Hand Tracking, Mental Counters, and Assembling Objects. The first ASVAB tests to be displaced are Numerical Operations, Mechanical Comprehension, and General Science.

The *substitutional* validity of the ECAT tests can be determined by comparing the validities for 10-test batteries. From Table 31, line 10, it is easy to see that replacing NO, MC, and GS with Assembling Objects, Two-Hand tracking, and one of the Working Memory tests increases the mean battery validity for predicting School Grades by 1.4% and internal criteria by 3.6%. These gains can be achieved without changing the AFQT or increasing total testing time.

Figure 11 depicts the results from Table 30 and Table 31. When the regression equations start with all 10 ASVAB tests, the validity curve tends to level out after three ECAT tests are entered. These three ECAT tests correspond to the three underlying factors in the ECAT battery: Psychomotor Ability, Working Memory, and Spatial Ability. Three ECAT tests produce 76% of the gain from using the full battery of nine tests for predicting Internal Criteria. The two curves on the left show what happens when the four tests in the AFQT are used as the starting point, and other ASVAB or ECAT tests are free to enter. With seven or eight tests, the curve rises above the validity line for the 10-test ASVAB.

Table 30

Means of Fully Corrected Multiple Correlations for
Stepwise Deletion Meta-analysis Assuming 10 ASVAB Tests in Model

| Number of Predictors | School Grade Criteria | | Internal Criteria | |
|----------------------|-------------------------|-----------|-------------------------|-----------|
| | Predictor | \bar{R} | Predictor | \bar{R} |
| 10 | 10 ASVAB Tests | .714 | 10 ASVAB Tests | .620 |
| 11 | + Two-Hand Tracking | .719 | + Two-Hand Tracking | .633 |
| 12 | + Mental Counters | .723 | + Mental Counters | .642 |
| 13 | + Assembling Objects | .725 | + Figural Reasoning | .646 |
| 14 | + Figural Reasoning | .727 | + One-Hand Tracking | .648 |
| 15 | + One-Hand Tracking | .728 | + Sequential Memory | .651 |
| 16 | + Sequential Memory | .729 | + Assembling Objects | .652 |
| 17 | + Target Identification | .730 | + Target Identification | .653 |
| 18 | + Spatial Orientation | .730 | + Spatial Orientation | .654 |
| 19 | + Integrating Details | .730 | + Integrating Details | .653 |

Note. ASVAB = Armed Services Vocational Aptitude Battery.

Table 31

Means of Fully Corrected Multiple Correlations for
Stepwise Deletion Meta-analysis Assuming Four AFQT Tests in Model

| Number of Predictors | School Grade Criteria | | Internal Criteria | |
|----------------------|----------------------------|-----------|----------------------------|-----------|
| | Predictor | \bar{R} | Predictor | \bar{R} |
| 4 | 4 AFQT Tests | .671 | 4 AFQT Tests | .565 |
| 5 | + Auto-Shop Information | .697 | + Auto-Shop Information | .594 |
| 6 | + Assembling Objects | .706 | + Two-Hand Tracking | .613 |
| 7 | + Two-Hand Tracking | .711 | + Mental Counters | .624 |
| 8 | + Coding Speed | .716 | + Coding Speed | .632 |
| 9 | + Electronics Information | .721 | + Electronics Information | .638 |
| 10 | + Mental Counters | .724 | + Assembling Objects | .642 |
| 11 | + Figural Reasoning | .725 | + One-Hand Tracking | .645 |
| 12 | + General Science | .726 | + Sequential Memory | .647 |
| 13 | + One-Hand Tracking | .727 | + Figural Reasoning | .649 |
| 14 | + Sequential Memory | .728 | + General Science | .651 |
| 15 | + Target Identification | .729 | + Mechanical Comprehension | .652 |
| 16 | + Spatial Orientation | .730 | + Target Identification | .653 |
| 17 | + Integrating Details | .730 | + Numerical Operations | .653 |
| 18 | + Numerical Operations | .730 | + Spatial Orientation | .654 |
| 19 | + Mechanical Comprehension | .730 | + Integrating Details | .653 |

Note. AFQT = Armed Forces Qualification Test.

Table 32

**Means of Fully Corrected Multiple Correlations for
Stepwise Deletion Meta-analysis With or Without ASVAB Tests in Model**

| Number of Predictors | School Grade Criteria | | Internal Criteria | |
|----------------------|----------------------------|-----------|----------------------------|-----------|
| | Predictor | \bar{R} | Predictor | \bar{R} |
| 1 | Mathematics Knowledge | .563 | Arithmetic Reasoning | .517 |
| 2 | + Auto-Shop Information | .648 | + Auto-Shop Information | .553 |
| 3 | + Arithmetic Reasoning | .679 | + Mathematics Knowledge | .582 |
| 4 | + Paragraph Comprehension | .694 | + Two-Hand Tracking | .601 |
| 5 | + Assembling Objects | .703 | + Coding Speed | .614 |
| 6 | + Electronics Information | .709 | + Mental Counters | .624 |
| 7 | + Coding Speed | .715 | + Electronics Information | .631 |
| 8 | + Two-Hand Tracking | .719 | + Paragraph Comprehension | .636 |
| 9 | + Mental Counters | .722 | + Assembling Objects | .639 |
| 10 | + Word Knowledge | .724 | + One-Hand Tracking | .642 |
| 11 | + Figural Reasoning | .725 | + Word Knowledge | .645 |
| 12 | + General Science | .726 | + Sequential Memory | .647 |
| 13 | + One-Hand Tracking | .727 | + Figural Reasoning | .649 |
| 14 | + Sequential Memory | .728 | + General Science | .651 |
| 15 | + Target Identification | .729 | + Mechanical Comprehension | .652 |
| 16 | + Spatial Orientation | .730 | + Target Identification | .653 |
| 17 | + Integrating Details | .730 | + Numerical Operations | .653 |
| 18 | + Numerical Operations | .730 | + Spatial Orientation | .654 |
| 19 | + Mechanical Comprehension | .730 | + Integrating Details | .653 |

Note. ASVAB = Armed Services Vocational Aptitude Battery.

Mean Multiple Correlation Increment

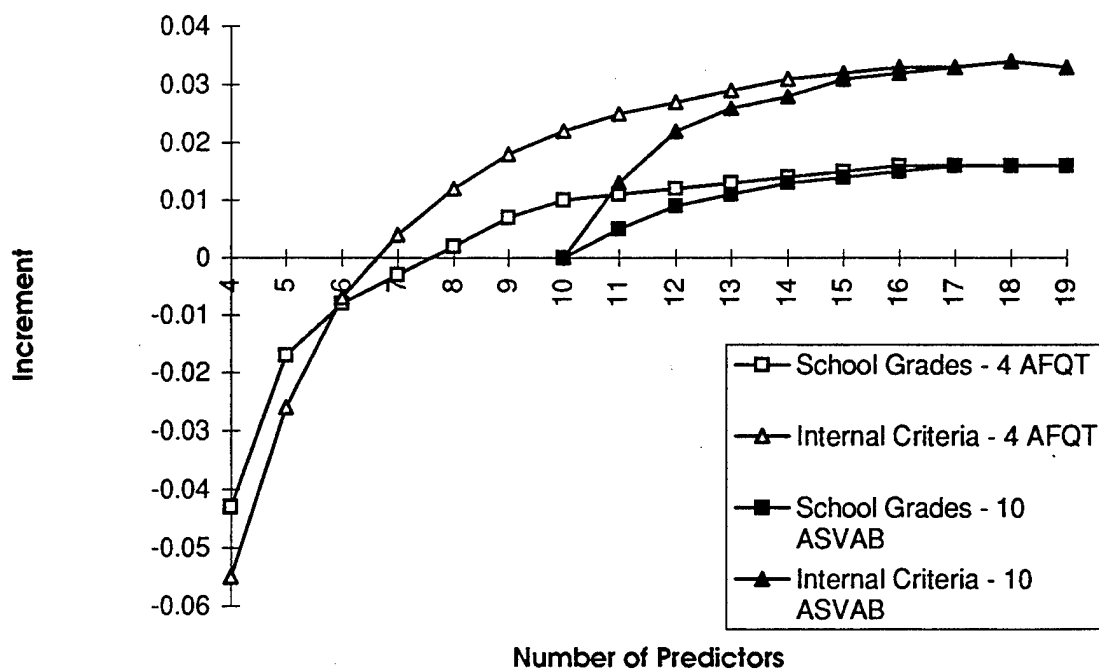


Figure 11. Incremental validity as a function of number of ECAT tests.

In all three analyses, the same three ECAT tests emerge first: Two-Hand Tracking, Mental Counters, and Assembling Objects. Each of these tests represents a different ability factor. How sensitive are the results to the choice of the particular test representing a factor? Table 33 shows the validities of several alternative test combinations. To three decimal places, the validity is the same whether One-Hand or Two-Hand Tracking is chosen to represent Psychomotor Ability. Using Integrating Details instead of Assembling Objects, or Sequential Memory instead of Mental Counters decreases validity for Internal Criteria by only .001 and leaves School Grade prediction unchanged. The decrease is twice as large if Figural Reasoning is used instead of Mental Counters, but is still quite small. It seems that the important thing is to include good measures of the three ECAT factors. The particular test chosen may be largely a matter of chance.

Table 33

Means of Fully Corrected Multiple Correlations for Alternative Combinations of Three ECAT Tests Assuming 10 ASVAB Tests in Model

| Predictors | School Grade Criteria | Internal Criteria |
|--|-----------------------|-------------------|
| | \bar{R} | \bar{R} |
| 10 ASVAB Tests | .714 | .620 |
| + Two-Hand Tracking + Mental Counters + Assembling Objects | .725 | .645 |
| + One-Hand Tracking + Mental Counters + Assembling Objects | .725 | .645 |
| + Two-Hand Tracking + Mental Counters + Integrating Details | .725 | .644 |
| + Two-Hand Tracking + Sequential Memory + Assembling Objects | .725 | .644 |
| + Two-Hand Tracking + Figural Reasoning + Assembling Objects | .725 | .643 |

Note. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery.

Turning to considerations of practicability, the ECAT tests can be classified according to ease of implementation. The three (formerly) P&P tests, Assembling Objects, Figural Reasoning, and Spatial Orientation, are easiest to implement. The three computerized cognitive tests, Mental Counters, Sequential memory, and Integrating Details, require availability of computers for administration. The psychomotor tests require not only a computer, but also a special Response Pedestal, making them the most expensive to implement and maintain.

How much of the incremental validity of ECAT is due to the psychomotor tests? Table 34 shows the results of a stepwise analysis with the psychomotor tests excluded. The last line of the table should be compared with the last line of Table 30. Without psychomotor tests, ECAT increases validity only .012 instead of .016 for School grades and only .019 instead of .033 for Internal Criteria. Thus 25% to 42% of ECAT's incremental validity comes from the psychomotor tests (principally Two-Hand Tracking), even if they are entered last into regression.

Table 34

Means of Fully Corrected Multiple Correlations for Stepwise Accretion Meta-analysis Without Psychomotor Tests in Model

| Number of Predictors | School Grade Criteria | | Internal Criteria | |
|----------------------|-----------------------|-----------|-----------------------|-----------|
| | Predictor | \bar{R} | Predictor | \bar{R} |
| 10 | 10 ASVAB Tests | .714 | 10 ASVAB Tests | .620 |
| 11 | + Mental Counters | .719 | + Mental Counters | .629 |
| 12 | + Assembling Objects | .722 | + Assembling Objects | .634 |
| 13 | + Figural Reasoning | .723 | + Figural Reasoning | .637 |
| 14 | + Sequential Memory | .724 | + Sequential Memory | .638 |
| 15 | + Spatial Orientation | .725 | + Spatial Orientation | .640 |
| 16 | + Integrating Details | .726 | + Integrating Details | .639 |

Suppose the Spatial Orientation test and all tests which require computer administration were omitted from the battery, leaving only Assembling Objects and Figural Reasoning. Table 35 shows that validity increases .009 for predicting Grades and .014 for predicting Internal Criteria, over the ASVAB alone. Thus these P&P tests can account for 56% and 42% of the ECAT incremental validity for predicting Grades or the Internal Criteria, respectively, if they are entered first into regression.

Table 35

Means of Fully Corrected Multiple Correlations for
Stepwise Deletion Meta-analysis Without Computerized Tests in Model

| Number of Predictors | School Grade Criteria | | Internal Criteria | |
|----------------------|-----------------------|-----------|-----------------------|-----------|
| | Predictor | \bar{R} | Predictor | \bar{R} |
| 10 | 10 ASVAB Tests | .714 | 10 ASVAB Tests | .620 |
| 11 | + Assembling Objects | .719 | + Assembling Objects | .628 |
| 12 | + Spatial Orientation | .721 | + Figural Reasoning | .632 |
| 13 | + Figural Reasoning | .723 | + Spatial Orientation | .634 |

These relationships are depicted in Figure 12. It is clear that, once the P&P tests are forced into regression first, the other computerized cognitive tests produce very little further improvement. However, even after all cognitive tests are forced into regression, the psychomotor tests have substantial predictive power. Nevertheless, about half of the criterion variance is still unaccounted for.

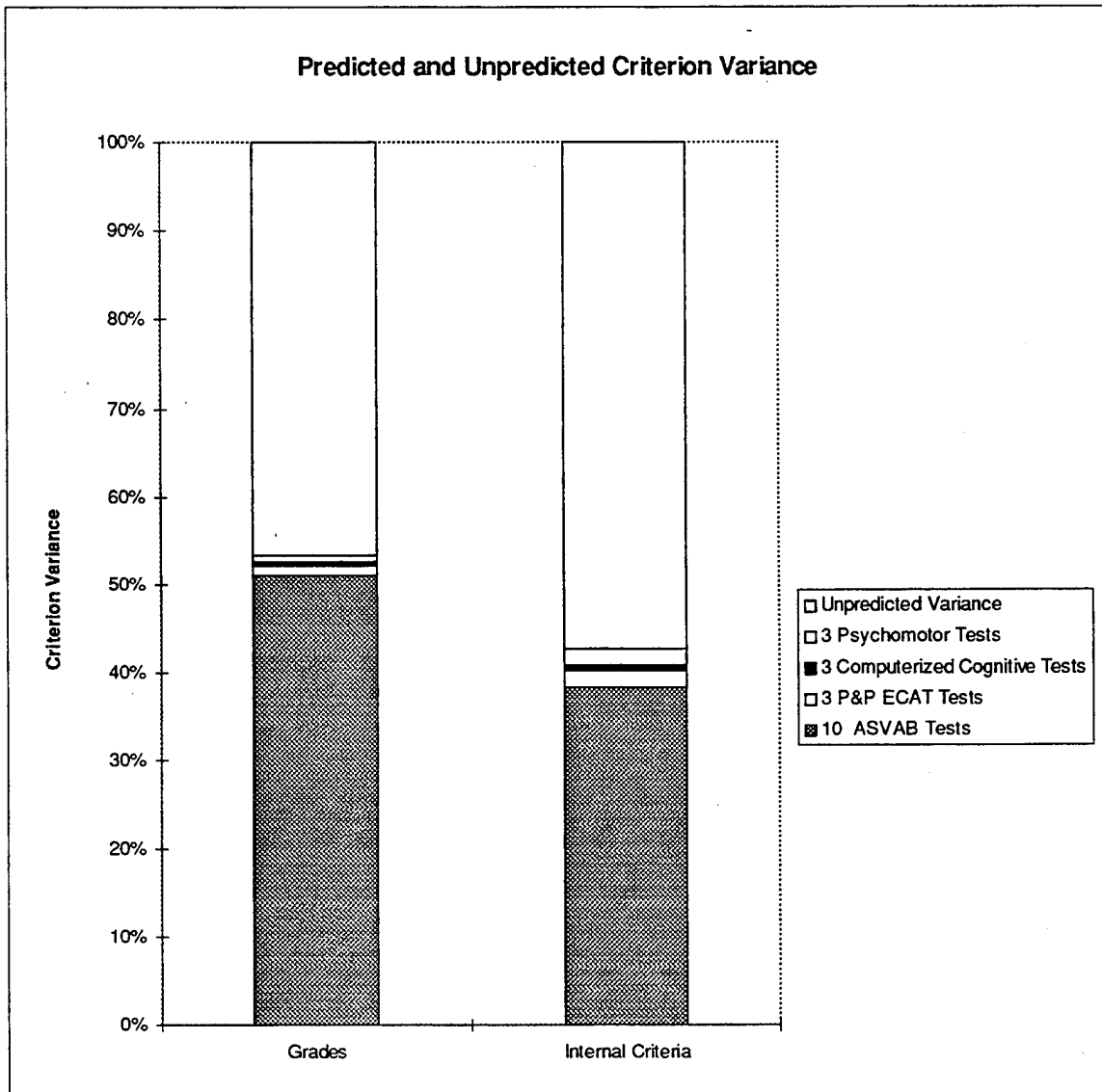


Figure 12. Prediction variance from paper-and-pencil, computerized cognitive, and psychomotor tests.

Discussion

It appears that chance plays a large role in the order of accretion or deletion. For example, Integrating Details was the first ECAT test deleted in all of the analyses, while Assembling Objects remained until only three ECAT tests were left. Yet, as the previous section has shown, there is no significant difference in the incremental validities for these two tests. The *nonsignificantly* lower incremental validity for Integrating Details caused it to be removed first. Since the two tests measure similar constructs, and since spatial ability is essential, removing one of the tests causes the other one to assume an important position. Several other caveats are in order:

1. The battery that maximizes mean validity may not maximize differential prediction, which is important when the tests are used for classification.
2. Some tests require much less time or equipment to administer than others. Optimal battery construction should take these costs into account.
3. The mean validities are the averages over a set of schools that are not a representative, random sample of all military training schools.
4. Minor changes in the set of schools or criteria can cause large changes in the order with which predictors enter or leave the equations.
5. It may not be a good idea to select tests based on averages that include schools where the incremental validities are so small that the test will never be used there. Instead, tests may be selected for their maximum incremental validities, or the frequency with which their validities exceed a certain threshold for inclusion in selection equations.
6. It is unlikely that least-squares multiple regression weights will be used for selection or classification. Current practice is to use unit or low integer weights.

Validities of Unit-weighted Composites

Introduction

All of the results up to now have relied on least-squares linear multiple regression. In the ASVAB's operational use, integer-weighted composites of tests are used for selection and classification for two very good reasons:

1. On small samples, regression equations do not cross-validate as well as integer-weighted composites.
2. Full least-squares regression equations often involve negative weights, which, in effect, penalize examinees for doing well on those tests with negative weights.

Additionally, the regression analysis of incremental validity has been criticized as being too conservative. By optimally weighting all 10 ASVAB tests as a basis for comparison, it is argued, the ASVAB's validity has been inflated to unrealistic levels,⁶ leaving little room for new tests to improve the validity.

The recommended alternative would be to estimate the incremental validity of new tests over the existing selector composite.

It is therefore desirable to examine the use of ECAT tests under conditions similar to the way the ASVAB is used now.

Method

Programs were developed to compute the validity of any given unit-weighted composite, and then search for the best test to add (with unit weights) to a composite to maximize validity. All correlations were corrected for range-restriction, but not for criterion unreliability. The programs were first applied to the existing selector composites to find which ECAT test would increase validity the most for a given school and find which additional ASVAB test would increase the validity the most. The purpose was to determine whether adding an ECAT test to a selector composite would increase validity more than adding an ASVAB test. In addition, since Assembling Objects appeared to be a particularly promising test, it was evaluated for possible addition to each operational selector composite.

For comparison, optimal regression equations were computed for each set of variables that had appeared in the unit-weighted composites.

⁶However, the Wherry correction should shrink these estimates to their population values. Part of our purpose is to show that these criticisms are not valid, and that, on the contrary, the existing selector composites greatly *underestimate* the ASVAB's validity, resulting in incorrect estimates of incremental validity.

Results

The range-corrected validities of the additions to the operational selector composites are shown in Table 36 for Final School Grades and in Table 37 for Internal School Criteria. The three right-most columns give the validities of the integer-weighted composites and their differences. The first column of the three, labeled "Comp" gives the validity of the composite defined at the far left of the page. The second column, "Comp - OP," gives the difference between the first column and the validity of the operational composite. The third column, "Comp - (OP+ASVAB)," gives the difference between the first column and the validity of the operational composite plus the best ASVAB test to add to it. This column is the best comparison of ECAT with ASVAB.

With the exceptions of AC, EM, and EN Final School Grades, an ECAT test can be added to the operational composite to improve validity. However, in about half the cases, an ASVAB test will improve validity even more than an ECAT test. Significant cases where an ECAT test has much greater incremental validity than any ASVAB test are the 11H criteria using Two-Hand Tracking, APS Typing Speed using Sequential memory, and ATC Basic Ground Approach Control using Mental Counters,

Assembling Objects is seldom better than an ASVAB test for improving an operational selector composite if added with unit weight except for the 11H and ATC criteria, which are inconsistent between the alternate curricula for those schools..

The columns on the left give the results of the regression analyses with the same variables. In many cases, the integer weights have validities about the same as the regression's multiple correlation. However, the differences are large for 11H, APS, AV, EN, and EM Grades, and 11H(B), AV, AO, ATC, AC, and ET Internal Criteria. In many of these schools, the optimal weights for one or more ASVAB tests were close to zero or negative, suggesting that the operational selector composite could be improved by deleting a test.

The relative incremental validities for ECAT and ASVAB tests that were observed for integer weighted composites are confirmed in regression-weighted equations in all but six instances, that is., the $(Op+ECAT) - (Op+ASVAB)$ validities have the same sign as the Multiple correlation differences except in GM and AE grades and ET, FC, OS, and AE performance, where the differences are close to zero. Thus, in most cases, the results are not due to the weighting method, but to the exclusion of some important ASVAB predictors from the operational selector composites. This exclusion permits the selector composite to be improved more by adding an ASVAB test than by adding an ECAT test.

Table 36

Beta Weights, Multiple Rs, and Validities for Composites of Tests
(Operational Composite, Adding One ASVAB, One ECAT, or Assembling Objects)
for School Grade Criteria

| School/Criterion/ Composite | Standardized Regression Weights | | | | Regression Weight Analyses Multiple Rs & Differences | | | | Integer Weight Analyses Validities & Differences | | | | |
|--------------------------------|---------------------------------|-------|------|------|---|------|------|-------|---|------|------|------|------|
| | AR | CS | MC | AS | Added Test | Comp | -Op | Comp | -Op | Comp | -Op | Comp | -Op |
| | | | | | | | | | | | | | |
| 11H(A)5 (EVTSUM) | .044 | .019 | .196 | | | .347 | | | | | .327 | | |
| OP | -.012 | -.005 | .166 | .143 | .148(VE) | .361 | .014 | .013 | .013 | .340 | .013 | .019 | .017 |
| Op+ASVAB | .033 | -.001 | .141 | .147 | .177(T2) | .379 | .032 | .032 | .032 | .359 | .032 | .019 | .019 |
| OP+ECAT | -.005 | -.000 | .125 | .148 | .207(AO) | .382 | .035 | .035 | .030 | .357 | .030 | .017 | .017 |
| OP+AO | | | | | | | | | | | | | |
| 11H(B)5 (EVTSUM) | .072 | .099 | .233 | .061 | | .346 | | | | | .353 | | |
| OP | .007 | -.010 | .237 | .081 | .206(NO) | .374 | .028 | .016 | .016 | .369 | .016 | .041 | .006 |
| Op+ASVAB | .054 | .066 | .141 | .033 | .293(T2) | .431 | .085 | .057 | .057 | .410 | .057 | .041 | .006 |
| OP+ECAT | .050 | .090 | .201 | .054 | .091(AO) | .349 | .004 | -.024 | .009 | .362 | .009 | .041 | .006 |
| OP+AO | | | | | | | | | | | | | |
| 13F1 (FSG) | .261 | .189 | .271 | .151 | | .682 | | | | | .680 | | |
| OP | .225 | .200 | .165 | .191 | .172(AS) | .694 | .012 | .015 | .015 | .696 | .015 | .001 | .000 |
| Op+ASVAB | .220 | .185 | .207 | .117 | .186(ID) | .696 | .014 | .016 | .016 | .697 | .016 | .001 | .000 |
| OP+ECAT | .234 | .178 | .206 | .126 | .173(AO) | .695 | .013 | .016 | .016 | .696 | .016 | .000 | .000 |
| OP+AO | | | | | | | | | | | | | |
| APSI (FSG) | .579 | .154 | .071 | | | .686 | | | | | .608 | | |
| OP | .347 | .041 | .052 | | .449(AR) | .761 | .075 | .086 | .086 | .693 | .086 | .008 | .008 |
| Op+ASVAB | .443 | .118 | .053 | | .321(FR) | .739 | .053 | .077 | .077 | .685 | .077 | .008 | .008 |
| OP+ECAT | .501 | .147 | .047 | | .216(AO) | .712 | .026 | .050 | .050 | .658 | .050 | .008 | .008 |
| OP+AO | | | | | | | | | | | | | |
| AO1 (FSG) | .146 | .361 | .185 | .130 | | .670 | | | | | .666 | | |
| OP | .108 | .321 | .195 | .131 | .155(CS) | .683 | .013 | .018 | .018 | .684 | .018 | .013 | .013 |
| Op+ASVAB | .135 | .358 | .179 | .104 | .119(TI) | .678 | .008 | .005 | .005 | .671 | .005 | .013 | .013 |
| OP+ECAT | .121 | .344 | .167 | .115 | .107(AO) | .674 | .004 | .004 | .004 | .670 | .004 | .013 | .013 |
| OP+AO | | | | | | | | | | | | .014 | .014 |

Table 36 (continued)

| School/Criterion/ Composite | Standardized Regression Weights | | | | | Regression Weight Analyses Multiple Rs & Differences | | | | Integer Weight Analyses Validities & Differences | | | | | | |
|--------------------------------|---------------------------------|------|------|------|------------|---|------|------|-------|---|-------|------|-------|-------|------|--|
| | AR | MK | EI | GS | Added Test | Comp | - Op | Comp | - Op | Comp | - Op | Comp | - Op | Comp | - Op | |
| | | | | | | Comp | - Op | Comp | - Op | Comp | - Op | Comp | - Op | Comp | - Op | |
| AV1 (FSG) | | | | | | | | | | | | | | | | |
| OP | .296 | .363 | .261 | .038 | Added Test | .791 | | .776 | | .776 | | .776 | | | | |
| Op+ASVAB | .281 | .347 | .265 | .038 | .063(CS) | .792 | .002 | .773 | -.003 | .773 | -.003 | .773 | -.003 | | | |
| Op+ECAT | .236 | .326 | .263 | .037 | .155(CT) | .800 | .010 | .792 | .015 | .792 | .015 | .792 | .015 | .018 | | |
| Op+AO | .272 | .346 | .244 | .024 | .104(AO) | .795 | .004 | .778 | .002 | .778 | .002 | .778 | .002 | .005 | | |
| ET2 (FSG2) | | | | | | | | | | | | | | | | |
| OP | .432 | .187 | .156 | .175 | Added Test | .790 | | .789 | | .789 | | .789 | | | | |
| Op+ASVAB | .383 | .135 | .170 | .176 | .200(CS) | .808 | .018 | .814 | .025 | .814 | .025 | .814 | .025 | | | |
| Op+ECAT | .351 | .140 | .168 | .166 | .216(SM) | .808 | .018 | .815 | .026 | .815 | .026 | .815 | .026 | .002 | | |
| Op+AO | .389 | .156 | .126 | .150 | .183(AO) | .802 | .012 | .804 | .015 | .804 | .015 | .804 | .015 | -.010 | | |
| FC1 (FSG) | | | | | | | | | | | | | | | | |
| OP | .316 | .230 | .275 | .155 | Added Test | .798 | | .796 | | .796 | | .796 | | | | |
| Op+ASVAB | .282 | .224 | .234 | .125 | .124(MC) | .802 | .004 | .799 | .003 | .799 | .003 | .799 | .003 | | | |
| Op+ECAT | .272 | .201 | .267 | .135 | .136(FR) | .805 | .007 | .802 | .006 | .802 | .006 | .802 | .006 | .003 | | |
| Op+AO | .287 | .209 | .254 | .137 | .125(AO) | .804 | .006 | .801 | .004 | .801 | .004 | .801 | .004 | .002 | | |
| GMI (FSG) | | | | | | | | | | | | | | | | |
| OP | .344 | .182 | .192 | .119 | Added Test | .693 | | .689 | | .689 | | .689 | | | | |
| Op+ASVAB | .297 | .174 | .175 | .024 | .192(VE) | .703 | .010 | .697 | .008 | .697 | .008 | .697 | .008 | | | |
| Op+ECAT | .297 | .153 | .194 | .119 | .120(CT) | .699 | .006 | .698 | .009 | .698 | .009 | .698 | .009 | .001 | | |
| Op+AO | .330 | .172 | .182 | .111 | .063(AO) | .694 | .001 | .686 | -.003 | .686 | -.003 | .686 | -.003 | -.011 | | |
| MM1 (FSG) | | | | | | | | | | | | | | | | |
| OP | .126 | .144 | .186 | .162 | Added Test | .500 | | .502 | | .502 | | .502 | | | | |
| Op+ASVAB | .094 | .186 | .095 | .127 | .167(AS) | .513 | .013 | .515 | .013 | .515 | .013 | .515 | .013 | | | |
| Op+ECAT | .090 | .118 | .160 | .140 | .154(AO) | .514 | .015 | .517 | .015 | .517 | .015 | .517 | .015 | .002 | | |
| Op+AO | .090 | .118 | .160 | .140 | .154(AO) | .514 | .015 | .517 | .015 | .517 | .015 | .517 | .015 | .002 | | |

Table 36 (continued)

| School/Criterion/ Composite | Standardized Regression Weights | | | | Regression Weight Analyses Multiple Rs & Differences | | | | Integer Weight Analyses Validities & Differences | | | | | |
|--------------------------------|---------------------------------|------|------|------------|---|------------|------------|------------|---|------------|------------|------------|------------|------------|
| | VE | MK | CS | Added Test | Comp | -Op | Comp | -Op | Comp | -Op | Comp | -Op | Comp | -Op |
| | | | | | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) |
| OSI (FSG) | | | | | | | | | | | | | | |
| OP | .277 | .431 | .208 | | .738 | | | | .729 | | | | | |
| Op+ASVAB | .191 | .303 | .191 | .255(AR) | .755 | .017 | | | .754 | .024 | | | | |
| Op+ECAT | .258 | .355 | .180 | .187(CT) | .754 | .016 | | | .749 | .019 | | | | -.005 |
| Op+AO | .241 | .379 | .200 | .158(AO) | .750 | .012 | | | .743 | .013 | | | | -.011 |
| RM1 (FSG) | | | | | | | | | | | | | | |
| OP | .399 | .270 | .193 | Added Test | .690 | | | | .685 | | | | | |
| Op+ASVAB | .296 | .116 | .172 | .307(AR) | .717 | .026 | | | .714 | .029 | | | | |
| Op+ECAT | .353 | .195 | .190 | .194(ID) | .708 | .017 | | | .706 | .021 | | | | -.008 |
| Op+AO | .372 | .231 | .187 | .119(AO) | .696 | .006 | | | .688 | .003 | | | | -.026 |
| EN1 (FSG) | | | | | | | | | | | | | | |
| OP | .446 | .440 | | Added Test | .684 | | | | .685 | | | | | |
| Op+ASVAB | .337 | .360 | | .236(VE) | .708 | .024 | | | .706 | .022 | | | | |
| Op+ECAT | .376 | .396 | | .150(ID) | .694 | .010 | | | .683 | -.002 | | | | -.024 |
| Op+AO | .401 | .405 | | .111(AO) | .689 | .006 | | | .671 | -.014 | | | | -.036 |
| ATC1 (FSG) | | | | | | | | | | | | | | |
| OP | .245 | .391 | | Added Test | .575 | | | | .574 | | | | | |
| Op+ASVAB | .187 | .304 | | .203(MC) | .594 | .019 | | | .595 | .021 | | | | |
| Op+ECAT | .239 | .283 | | .201(CT) | .598 | .023 | | | .600 | .026 | | | | .005 |
| Op+AO | .218 | .317 | | .178(AO) | .594 | .018 | | | .593 | .019 | | | | -.002 |
| AC1 (FSG) | | | | | | | | | | | | | | |
| OP* | .270 | .458 | .218 | Added Test | .821 | | | | .829 | | | | | |
| Op+ASVAB | .225 | .406 | .226 | .196(CS) | .837 | .017 | | | .847 | .019 | | | | |
| Op+ECAT | .233 | .436 | .198 | .108(FR) | .822 | .002 | | | .830 | .001 | | | | -.017 |
| Op+AO | .247 | .445 | .198 | .086(AO) | .821 | .000 | | | .826 | -.003 | | | | -.021 |

* The integer-weighted composite is AR + 2MK + GS.

Table 36 (continued)

| School/Criterion/ Composite | Standardized Regression Weights | | | | Regression Weight Analyses Multiple Rs & Differences | | | | Integer Weight Analyses Validities & Differences | | | | | |
|--------------------------------|---------------------------------|------|------|------------|---|--------------|--------------------|------|---|--------------|--------------------|------|--------------|--------------------|
| | AR | MK | GS | Added Test | Comp | Comp --Op | Comp (Op+ASVAB) | Comp | Comp | Comp --Op | Comp (Op+ASVAB) | Comp | Comp --Op | Comp (Op+ASVAB) |
| | | | | | | | | | | | | | | |
| AEI (FSG) | | | | | | | | | | | | | | |
| OP* | .292 | .091 | .317 | | .608 | | | .583 | | | | | | |
| Op+ASVAB | .225 | .155 | .208 | .219(AS) | .632 | .025 | | .624 | .041 | | | | | |
| Op+ECAT | .217 | .048 | .266 | .239(ID) | .635 | .027 | .002 | .613 | .030 | | | | | -.011 |
| Op+AO | .242 | .062 | .275 | .185(AO) | .625 | .017 | -.007 | .607 | .024 | | | | | -.017 |
| EM1 (FSG) | | | | | | | | | | | | | | |
| OP* | .320 | .240 | .184 | Added Test | .650 | | | .643 | | | | | | |
| Op+ASVAB | .283 | .254 | .091 | .173(EI) | .663 | .013 | | .659 | .016 | | | | | |
| Op+ECAT | .289 | .222 | .164 | .099(ID) | .654 | .004 | -.009 | .649 | .006 | | | | | -.010 |
| Op+AO | .311 | .235 | .177 | .034(AO) | .650 | .000 | -.013 | .638 | -.005 | | | | | -.021 |
| AMS1 (FSG) | | | | | | | | | | | | | | |
| OP | .379 | .312 | .214 | Added Test | .757 | | | .755 | | | | | | |
| Op+ASVAB | .283 | .301 | .246 | .228(CS) | .785 | .027 | | .788 | .032 | | | | | |
| Op+ECAT | .326 | .293 | .228 | .111(SM) | .762 | .005 | -.023 | .757 | .002 | | | | | -.030 |
| Op+AO | .349 | .275 | .207 | .107(AO) | .761 | .004 | -.024 | .755 | -.000 | | | | | -.032 |

Notes 1ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade

2For definitions of ASVAB and ECAT tests, see Tables 1-2; for definitions of schools and criteria, see Tables 12-14.

* The integer-weighted composite is AR + 2MK + GS.

Table 37

Beta Weights, Multiple Rs, and Validities for Composites of Tests
(Operational Composite, Adding One ASVAB, One ECAT, or Assembling Objects
for Internal School Criteria

| School/Criterion/ Composite | Standardized Regression Weights | | | | Regression Weight Analyses Multiple Rs & Differences | | | | Integer Weight Analyses Validities & Differences | | | |
|--------------------------------|---------------------------------|-------|------|-------|---|------------|------|------------|---|------------|------|------------|
| | CS | | AS | | Comp | | Comp | | Comp | | Comp | |
| | AR | OP | MC | AS | --Op | (Op+ASVAB) | --Op | (Op+ASVAB) | --Op | (Op+ASVAB) | --Op | (Op+ASVAB) |
| 11H(A)6 (TO_1) | | | | | | | | | | | | |
| OP | -.003 | .123 | .134 | .040 | .203 | .208 | .208 | .208 | .208 | .208 | .208 | .208 |
| Op+ASVAB | -.041 | .060 | .136 | .052 | .216 | .222 | .222 | .222 | .222 | .222 | .222 | .222 |
| Op+ECAT | -.014 | .103 | .080 | .023 | .251 | .241 | .241 | .241 | .241 | .241 | .241 | .241 |
| Op+AO | -.006 | .122 | .130 | .039 | .198 | .204 | .204 | .204 | .204 | .204 | .204 | .204 |
| 11H(B)9 (ITVTOW) | | | | | | | | | | | | |
| OP | -.134 | -.062 | .165 | .016 | .114 | .003 | .003 | .003 | .003 | .003 | .003 | .003 |
| Op+ASVAB | -.156 | -.064 | .145 | .003 | .109 | .016 | .016 | .016 | .016 | .016 | .016 | .016 |
| Op+ECAT | -.150 | -.091 | .083 | -.010 | .252 | .067 | .067 | .067 | .067 | .067 | .067 | .067 |
| Op+AO | -.172 | -.077 | .110 | .003 | .162 | .034 | .034 | .034 | .034 | .034 | .034 | .034 |
| 13F3 (FIRING) | | | | | | | | | | | | |
| OP | .250 | .166 | .176 | .132 | .568 | .569 | .569 | .569 | .569 | .569 | .569 | .569 |
| Op+ASVAB | .196 | .144 | .130 | .115 | .580 | .582 | .582 | .582 | .582 | .582 | .582 | .582 |
| Op+ECAT | .220 | .153 | .167 | .113 | .573 | .574 | .574 | .574 | .574 | .574 | .574 | .574 |
| Op+AO | .237 | .161 | .143 | .119 | .571 | .570 | .570 | .570 | .570 | .570 | .570 | .570 |
| APS3 (AFPT70) | | | | | | | | | | | | |
| OP | .187 | .118 | .157 | .118 | .358 | .365 | .365 | .365 | .365 | .365 | .365 | .365 |
| Op+ASVAB | .111 | .081 | .150 | .111 | .372 | .381 | .381 | .381 | .381 | .381 | .381 | .381 |
| Op+ECAT | .125 | .086 | .126 | .125 | .405 | .406 | .406 | .406 | .406 | .406 | .406 | .406 |
| Op+AO | .147 | .114 | .144 | .114 | .369 | .379 | .379 | .379 | .379 | .379 | .379 | .379 |
| AO2 (PRACTL) | | | | | | | | | | | | |
| OP | .036 | .314 | .117 | -.010 | .375 | .364 | .364 | .364 | .364 | .364 | .364 | .364 |
| Op+ASVAB | -.023 | .252 | .133 | -.009 | .429 | .410 | .410 | .410 | .410 | .410 | .410 | .410 |
| Op+ECAT | -.021 | .277 | .106 | -.036 | .395 | .385 | .385 | .385 | .385 | .385 | .385 | .385 |
| Op+AO | .007 | .294 | .096 | -.027 | .384 | .378 | .378 | .378 | .378 | .378 | .378 | .378 |

Table 37 (continued)

| School/Criterion/ Composite | Standardized Regression Weights | | | | | | | | | | Regression Weight Analyses Multiple Rs & Differences | | | | Integer Weight Analyses Validities & Differences | | | | |
|--------------------------------|---------------------------------|------|------|-------|------------|------|-------|------|------------|------|---|-------|-----------|------|---|------|-----------|------|-------|
| | AR | | MK | | EI | | GS | | Added Test | | Comp - Op | | Comp - Op | | Comp - Op | | Comp - Op | | |
| | AR | MK | EI | GS | Added Test | Comp | Op | Comp | Op | Comp | Op | Comp | Op | Comp | Op | Comp | Op | Comp | Op |
| AV4 (PERFORM) | | | | | | | | | | | | | | | | | | | |
| OP | .166 | .209 | .369 | -.135 | Added Test | .513 | | | | | .476 | | | | | | | | |
| Op+ASVAB | .093 | .197 | .281 | -.198 | .266(MC) | .541 | .028 | | | | .500 | .024 | | | | | | | |
| Op+ECAT | .125 | .180 | .340 | -.159 | .179(AO) | .532 | .019 | | | | .497 | .021 | | | | | | | -.004 |
| Op+AO | .125 | .180 | .340 | -.159 | .179(AO) | .532 | .019 | | | | .497 | .021 | | | | | | | -.004 |
| ET3 (PERF) | | | | | | | | | | | | | | | | | | | |
| OP | .503 | .262 | .137 | -.142 | Added Test | .679 | | | | | .624 | | | | | | | | |
| Op+ASVAB | .454 | .210 | .150 | -.141 | .198(CS) | .698 | .019 | | | | .663 | .039 | | | | | | | |
| Op+ECAT | .469 | .251 | .104 | -.170 | .216(T2) | .704 | .025 | | | | .651 | .028 | | | | | | | -.011 |
| Op+AO | .494 | .255 | .131 | -.148 | .039(AO) | .675 | -.004 | | | | .620 | -.004 | | | | | | | -.043 |
| FC2 (RADAR) | | | | | | | | | | | | | | | | | | | |
| OP | .239 | .054 | .264 | .187 | Added Test | .616 | | | | | .608 | | | | | | | | |
| Op+ASVAB | .210 | .093 | .179 | .155 | .156(AS) | .625 | .009 | | | | .627 | .018 | | | | | | | |
| Op+ECAT | .221 | .049 | .245 | .172 | .122(T2) | .626 | .009 | | | | .619 | .011 | | | | | | | -.008 |
| Op+AO | .217 | .038 | .248 | .174 | .095(AO) | .620 | .004 | | | | .611 | .003 | | | | | | | -.016 |
| GM3 (HALF2) | | | | | | | | | | | | | | | | | | | |
| OP | .302 | .101 | .182 | .216 | Added Test | .662 | | | | | .662 | | | | | | | | |
| Op+ASVAB | .248 | .173 | .028 | .158 | .285(AS) | .692 | .030 | | | | .687 | .025 | | | | | | | |
| Op+ECAT | .277 | .084 | .165 | .202 | .104(AO) | .667 | .004 | | | | .666 | .004 | | | | | | | -.021 |
| Op+AO | .277 | .084 | .165 | .202 | .104(AO) | .667 | .004 | | | | .666 | .004 | | | | | | | -.021 |
| OS3 (PERF) | | | | | | | | | | | | | | | | | | | |
| OP | .175 | .415 | .207 | .207 | Added Test | .646 | | | | | .635 | | | | | | | | |
| Op+ASVAB | .058 | .335 | .222 | .222 | .275(MC) | .682 | .035 | | | | .669 | .034 | | | | | | | |
| Op+ECAT | .150 | .313 | .170 | .170 | .255(CT) | .680 | .034 | | | | .675 | .040 | | | | | | | .006 |
| Op+AO | .122 | .335 | .195 | .195 | .241(AO) | .678 | .032 | | | | .672 | .037 | | | | | | | .002 |

Table 37 (continued)

| School/Criterion/ Composite | Standardized Regression Weights | | | Regression Weight Analyses Multiple Rs & Differences | | | | Integer Weight Analyses Validities & Differences | | | | |
|--------------------------------|---------------------------------|------------|------------|---|------------|------------|------------|---|------------|------------|------------|-------|
| | VE | MK | CS | Comp | -Op | Comp | - | Comp | -Op | Comp | - | |
| | Added Test | Added Test | Added Test | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | (Op+ASVAB) | |
| RM2 (PHASE3) | | | | | | | | | | | | |
| OP | .331 | .226 | .092 | .528 | .030 | | .518 | | | | | |
| Op+ASVAB | .230 | .157 | .105 | .558 | .019 | -.011 | .559 | .041 | | | | |
| Op+ECCAT | .288 | .155 | .089 | .547 | .014 | -.016 | .545 | .027 | | | | -.014 |
| Op+AO | .296 | .174 | .084 | .543 | | | .539 | .021 | | | | -.020 |
| ATC(A)4 (BLK5A) | | | | | | | | | | | | |
| OP | .025 | .414 | | .421 | .013 | | .396 | | | | | |
| Op+ASVAB | -.022 | .344 | | .434 | .077 | .064 | .418 | .023 | | | | |
| Op+ECCAT | .015 | .237 | | .498 | .013 | -.000 | .478 | .082 | | | | .059 |
| Op+AO | .003 | .354 | | .434 | | | .421 | .025 | | | | .003 |
| ATC(B)4 (BLK5A) | | | | | | | | | | | | |
| OP | -.041 | .420 | | .389 | .025 | | .342 | | | | | |
| Op+ASVAB | -.071 | .286 | | .414 | .076 | .051 | .385 | .043 | | | | .040 |
| Op+ECCAT | -.050 | .252 | | .465 | .045 | .019 | .426 | .084 | | | | .013 |
| Op+AO | -.076 | .322 | | .433 | | | .398 | .056 | | | | |
| AC2 (PERF) | | | | | | | | | | | | |
| Op* | .135 | .275 | .001 | .332 | .066 | | .372 | | | | | |
| Op+ASVAB | .073 | .204 | .010 | .398 | .113 | .047 | .419 | .047 | | | | .010 |
| Op+ECCAT | -.000 | .192 | -.006 | .446 | .064 | -.003 | .428 | .056 | | | | -.009 |
| Op+AO | .058 | .231 | -.065 | .396 | | | .410 | .038 | | | | |
| AE2 (SUM2) | | | | | | | | | | | | |
| Op* | .284 | .035 | .314 | .555 | .007 | | .522 | | | | | |
| Op+ASVAB | .246 | .072 | .252 | .562 | .012 | .005 | .551 | .029 | | | | -.007 |
| Op+ECCAT | .270 | .031 | .282 | .567 | .010 | .003 | .543 | .022 | | | | -.010 |
| Op+AO | .245 | .013 | .282 | .565 | | | .540 | .019 | | | | |

* The integer-weighted composite is AR + 2MK + GS

Table 37 (continued)

| School/Criterion/ Composite | Standardized Regression Weights | | | Regression Weight Analyses Multiple Rs & Differences | | | | Integer Weight Analyses Validities & Differences | | | | |
|--------------------------------|---------------------------------|------|------|---|--------------|--------------------|------|---|--------------------|------|--------------|--------------------|
| | AR | MK | GS | Comp | Comp --Op | Comp (Op+ASVAB) | Comp | Comp --Op | Comp (Op+ASVAB) | Comp | Comp --Op | Comp (Op+ASVAB) |
| EM2 (PHASE1) | | | | | | | | | | | | |
| OP* | .331 | .286 | .148 | .672 | | | .667 | | | | | |
| Op+ASVAB | .292 | .300 | .051 | .686 | .014 | | .680 | .013 | | | | |
| OP+ECAT | .297 | .265 | .130 | .676 | .004 | -.010 | .672 | .005 | | | | -.008 |
| OP+AO | .315 | .276 | .135 | .674 | .001 | -.012 | .665 | -.002 | | | | -.015 |
| AMS2 (PERF) | | | | | | | | | | | | |
| OP | .261 | .217 | .176 | .539 | | | .545 | | | | | |
| Op+ASVAB | .160 | .205 | .210 | .579 | .040 | | .587 | .042 | | | | |
| OP+ECAT | .203 | .145 | .163 | .562 | .023 | -.018 | .570 | .025 | | | | -.017 |
| OP+AO | .203 | .145 | .163 | .562 | .023 | -.018 | .570 | .025 | | | | -.017 |

Notes. 1. ECAT = Enhanced Computer Administered Testing, ASVAB = Armed Services Vocational Aptitude Battery, FSG = Final School Grade.

2. For definitions of ASVAB and ECAT tests, see Tables 1-2; for definitions of schools and criteria, see Tables 12-14.

* The integer-weighted composite is AR + 2MK + GS.

Discussion

Although these conclusions must remain tentative, until confirmed by cross-validation in new samples, it appears that the operational composites could be substantially improved by adding more ASVAB tests to most of them. The use of integer weights degrades validity where exact weights are negative, as they often are with the Internal Criteria, and in these cases the operational composite could be improved by removing a test. In many cases potential validity improvements from revising the operational composites exceed those from enhancing the ASVAB with the ECAT tests, although both improvements would be desirable.

So far, we have ignored the benefits that might be derived from improved differential validity and classification efficiency that a larger and more diverse battery could produce. However, the exact weights derived from these analyses could be evaluated to determine ASVAB tests that could be replaced by ECAT tests. Eliminating one of two ASVAB tests with the same underlying dimension for even a few selector composites should improve classification efficiency by lowering the intercorrelations of the operational selector composites. For that matter, leaving all operational composites intact and adding an ECAT test to composites of an occupational group (where incremental validity has been shown) would improve classification efficiency.

Given the vagaries of the operational selector composites, the best index of the predictive potential of ECAT tests remains the incremental validity determined from full-model regression equations in the earlier sections of this report. At the same time, the ultimate utility of ECAT can only be assessed in the context of the way the tests will be used operationally for selection and classification decisions.

General Discussion

We have analyzed the incremental validities of ECAT from four different perspectives: general ability, ability factors in multiple regression, tests and composites in multiple regression, and unit-weighted selector composites. The results of the different approaches are consistent with one another, with the exception of the unit-weighted selector composites, where the problem was inadequate ASVAB weighting. The incremental validity of ECAT is not the result of tricky regression weighting, however, because it shows up even in the simple validity of "g".

What are we to make of the fact that the ECAT validity increments depend so strongly on which criteria are used to measure school performance? If the ECAT project were to be evaluated solely on the basis of its ability to improve prediction of Final School Grades, or even school attrition, it would have to be considered a failure. The highest significant validity gain for predicting FSG was .024, with many schools showing no gain at all. This result was expected: we had no reason to think that psychomotor ability, for example, would be related to performance on the kinds of written tests that form the basis for most Final School Grades. The ASVAB probably is optimized already for predicting academic achievement. It contains tests of electronics, science, verbal, and mathematical knowledge that was acquired in school. Our results show that its corrected validity averages better than .78 for predicting FSG, an extremely high value for most aptitude batteries. It is, perhaps, surprising that the ECAT battery could boost the mean validity as high as it did, to .80.

On the other hand, the incremental validity of ECAT for predicting hands-on performance averaged better than .03 and exceeded .10 for some schools. Potentially, these validity increases could mean better hands-on job performance if recruits were classified on the basis of the relevant ECAT tests. Unfortunately, hands-on performance is seldom measured or publicly available, which is why we labeled these "internal" criteria. Because hands-on performance is nearly invisible to external decision makers without special studies, validity improvements are likely to go unnoticed. Worse, these criteria are ephemeral; they change or completely disappear when the curriculum changes, as it frequently does. It may be impossible to cross-validate a regression equation on the same school a year later because the criterion no longer exists! Nevertheless, the same ability that was needed to perform one laboratory exercise may show up on a different one, or on subsequent job performance.

Are any of the results reproducible? Yes, the ECAT results for the Army's 11H Heavy Antiarmor Weapons school are actually cross-validations of earlier studies at the same school by Smith and Walker (1988) who confirmed a study by Grafton, Czarnolewski, and Smith (1989) showing the validity of tracking and spatial tests for predicting 11H TOW simulator performance. In addition, the ECAT study found that psychomotor and spatial tests improved prediction of EVTSUM criteria in two different samples from the 11H school.

Another result that was replicated within the ECAT study itself was a very large validity improvement from Working Memory and Spatial tests for predicting Air Traffic Control operations. The same result was found for two different samples from the Air Force ATC school and from the Navy's AC school. Because Air Traffic control is so critical to human lives and to the safety of equipment, anything that could improve the selection of Air Traffic Controllers would be very valuable to both military and civilian aviation.

The ultimate use of these findings depends on practical and economic considerations beyond the scope of this scientific study. It is not clear, for example, that testing every incoming military enlisted applicant with the ECAT tests is an efficient way to proceed. It may be possible to give ECAT tests to only those applicants who are likely to be assigned to 11H, Air Traffic Control, or certain other specialties. Although computerized testing will become nearly universal with the full-scale implementation of CAT-ASVAB, the response pedestals needed for the psychomotor tests will not be part of that system. Each response pedestal costs more than a computer. On the other hand, further research might develop a mouse-based tracking test that is equally effective in measuring psychomotor ability. In that case, routine psychomotor testing of all applicants might become feasible.

Conclusions

1. Many ECAT tests have substantial simple validities for predicting school performance.
2. In some military training courses, the ASVAB's prediction of school practical performance can be substantially improved by using ECAT tests in optimally-weighted composites.
3. All ECAT tests have statistically significant incremental validity over the ASVAB alone.
4. Validity increases are greatest (averaging 5.7%) when laboratory or simulator performance criteria are used, rather than school grades (averaging 1.7%).
5. Increases for some schools are much larger than this, while other schools have no significant validity improvement.
6. Very large cross-validated incremental validities were found for predicting Air Traffic Control operations, using Working memory and Spatial tests.
7. Very large cross-validated incremental validities were found for predicting 11H Heavy Antiarmor Weapons performance.
8. Factor scores are more than 98% as valid as individual tests in multiple regression, but relying on "g" alone reduces validity by as much as 8.9% on the average.
9. ECAT tests can be used to broaden the estimate of general mental ability, or "g" produced by the ASVAB. This enhanced "g" has validity increments for predicting practical performance criteria which are nearly as large as the validity increments from using all tests in multiple regression.
10. The Spatial ability dimension is essential for prediction. Either Assembling Objects or Integrating Details tests can be omitted from the battery, provided the other remains.
11. Both working memory tests, Mental Counters and Sequential Memory, are essential for maximal prediction and neither can be deleted from the ECAT battery without a significant decrease in validity.

12. The Psychomotor tests account for 25% of the mean validity gain in predicting school grades and 44% of the gain in predicting the Internal school criteria, even after all other predictors are entered.
13. Two P&P tests, Assembling Objects and Figural Reasoning, together can produce 44% and 35% of the ECAT mean validity gain for predicting Grades and Internal Criteria, respectively, if they are entered first into regression.
14. The Spatial Orientation test is redundant and can be eliminated from the ECAT battery without a significant decrease in validity, provided that the other ASVAB and ECAT tests remain.
15. About 75% of the incremental validity of ECAT can be attained by using just three tests, each one representing a different ECAT factor.
16. The best three ECAT tests for increasing validity are Two-Hand Tracking, Mental Counters, and Assembling Objects.
17. Existing selector composites can be improved by adding ASVAB tests to them. In most cases, the validity improvements from doing so exceed those from adding an ECAT test with unit weights.
18. The estimates of ECAT's incremental validity are very sensitive to the type and quality of criteria used to evaluate the tests. Continued improvement of the ASVAB's predictive validity requires improved quality in the criterion measures used for validation.

Recommendations

1. Consideration should be given toward the eventual incorporation into ASVAB of a Spatial Ability measure, such as Assembling Objects.
2. If CAT-ASVAB is universally implemented, then consideration should be given toward including computerized tests of working memory, such as Mental Counters.
3. The Mental Counters test should be considered for supplementary administration to potential students in the Air Force and Navy Air Traffic Control schools.
4. The Two-Hand Tracking test should be considered for supplementary administration to potential students in the Army Heavy Antiarmor Weapons school (11H). Its cost/benefits for wider operational testing should be evaluated under different concepts of operations.
5. A variety of alternative tracking tests should be investigated, to determine if a mouse, trackball, or other off-the-shelf equipment could serve as well as slide potentiometers and joysticks. Human factors work on alternative tracking item types and screen displays should be supported.
6. Development of alternate forms and/or adaptive item pools should be started for ECAT tests.

7. The most promising ECAT tests should be normed.

8. Research on optimal non-negative weighting of ASVAB tests for maximal cross-validated classification efficiency should be given high priority. Operational selector composites eventually should be replaced by these optimal weighting methods.

9. Military training schools should be encouraged to incorporate continuously-scored practical performance measures in their intermediate and final grades. The statistical properties of FSG, including reliability and validity, should be continuously monitored and updated, particularly following any shift in curricula.

References

- Abrahams, N. M., Pass, J. J., Kusulas, J. W., Cole, D. R., & Kieckhaefer, W. F. (1993, February). *Incremental validity of experimental computerized tests for predicting training criteria in military technical schools* (Contract N66001-90-D-9502, DO 7J13). San Diego, CA: Navy Personnel Research and Development Center.
- Alderton, D. L. & Larson, G. E. (1992a, May). *Dimensions of ability: Diminishing returns?* Paper presented at the Army Research Institute's Conference on Selection and Classification, Alexandria, VA.
- Alderton, D. L. & Larson, G. E. (1992b, May). *Navy and Joint-Service validity research : Interim conclusions*. Paper presented to NATO Research Group 15 on Computer-Based Selection and Classification in the Military, Monterey, CA.
- Carey, N. B. (1994). Computer predictors of mechanical job performance: Marine Corps findings. *Military Psychology*, 6, 1-30.
- Equal Employment Opportunity Commission, U. S. Civil Service Commission, U. S. Department of Labor, & U. S. Department of Justice (1978, August 25). *Uniform guidelines on employee selection procedures*. 43 *Fed. Reg.* 166, 38290-38309.
- Eitelberg, M. J., Laurence, J. H., Waters, B. K., & Perelman, L. S. (1984, September). *Screening for Service: Aptitude and education criteria for military entry*. Washington, DC: Office of Assistant Secretary of Defense (Manpower, Installations, and Logistics).
- Fisher, R. (1932). *Statistical methods for research workers* (4th ed.). London: Oliver & Boyd.
- Grafton, F., Czarnolewski, M. Y., & Smith, E. P. (1989). *Relationship between Project A psychomotor and spatial tests and TOW2 gunnery performance: A preliminary investigation* (ARI-WP-RS-89-1). Alexandria, VA: U. S. Army Research Institute for the Behavioral and Social Sciences.
- Gulliksen, H. (1950/1987). *Theory of mental tests*. New York: Wiley.
- Hedges, L. V., Becker, B. J., & Wolfe, J. H. (1992). *Detecting and measuring improvements in validity* TR-93-2. San Diego, CA: Navy Personnel Research and Development Center.
- Hetter, R. D., Segall, D. O., & Bloxom, B. M. (1992, October). Item calibration medium effect on CAT scores. *Proceedings of the 34th Annual Conference of the Military Testing Association*, 34, 16-21.
- Horst, P. (1955). A technique for the development of a multiple absolute prediction battery. *Psychological Monographs: General and Applied*, 69, 1-21.
- Hunter, J. E. (1986). Cognitive ability, cognitive aptitudes, job knowledge, and job performance. *Journal of Vocational Behavior*, 29, 340-362.
- Kieckhaefer, W. F., Ward, D. G., Kusulas, J. W., Cole, D. R., Rupp, L. M., & May, M. H. (1992, September). *Criterion development for 18 technical training schools in the Navy, Army, and Air Force*. (Contract # N66001-90-D-9502, Delivery Order 7J08). San Diego, CA: Navy Personnel Research and Development Center.

- Larson, G. E., & Alderton, D. L. (1992a, October). Reliabilities and practice effects for the ECAT battery. *Proceeding of the 34th Annual Conference of the Military Testing Association, 34*, 33-38.
- Larson, G. E., & Alderton, D. L. (1992b, August). *Test/retest results for the enhanced computer-administered test (ECAT) battery*. Paper presented at the annual meeting of the American Psychological Association, Washington, DC.
- Laurence, J. H., & Ramsberger, P. F. (1991). *Low-aptitude men in the military: Who profits, who pays?* New York: Praeger.
- Lawley, D. (1943). A note on Karl Pearson's selection formulae. *Royal Society of Edinburgh Proceedings, Section, A, 62*, 28-30.
- McHenry, J. J., Hough, L. M., Toquam, J. L., Hanson, M. A., & Ashworth, S. (1990). Project A validity results: The relationship between predictor and criterion domains. *Personnel Psychology, 43*, 335-354.
- Moreno, K. E., & Segall, D. O. (1992). CAT-ASVAB precision. *Proceedings of the 34th Annual Conference of the Military Testing Association, 34*, 22-26
- Peterson, N. G., Hough, L. M., Dunnette, M. D., Rosse, R. L., Houston, J. S., & Toquam, J. L. (1990). Project A: Specification of the predictor domain and development of new selection/classification tests. *Personnel Psychology, 43*, 247-276.
- Ramsberger, P., & Means, B. (1987). *Military performance of low-aptitude recruits: A reexamination of data from Project 100,000 and the ASVAB misnorming period* (Final Report 87-31). Alexandria, VA: Human Resources Research Organization.
- Ree, M. J., & Earles, J. A. (1991). Predicting training success: Not much more than *g*. *Personnel Psychology, 44*, 321-332.
- Schmid, J., & Leiman, J. M. (1957). The development of hierarchical factor solutions. *Psychometrika, 22*, 53-61.
- Schmidt, F., Hunter, J., & Dunn, W. (1987). *Potential utility increases from adding new tests to the Armed Services Vocational Aptitude Battery (ASVAB)* TCN 86-698. (Contract No. DAAL03-86-D-0001, DO 0053). Research Triangle Park, NC: U. S. Army Research Office.
- Sellman, S. (1988, December 14). *Memorandum for Manpower Accession Policy Steering Committee: Appointment of technical representative to a Joint-Service computerized test selection committee*. Washington, DC: Office of the Assistant Secretary of Defense.
- Smith, E. P., & Graham, S. E. (1987). *Validation of psychomotor and perceptual predictors of Armor Officer M-1 gunnery performance* (ARI Technical Report No. 766). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD-A 191333)
- Smith, E. P., & Walker, M. R. (1988). Testing psychomotor and spatial abilities to improve selection of TOW gunners. *Proceedings of the 30th Annual Conference of the Military Testing Association, 30*, 647-652.

Wolfe, J. H. (1993, November). The Enhanced Computer Administered Test (ECAT) battery validity study. *Proceedings of the 35th Annual Conference of the Military Testing Association*, 35, 462-467.

Wolfe, J. H., & Alderton, D. L. (1992, October). Navy incremental validity study of new predictors. *Proceedings of the 34th Annual Conference of the Military Testing Association*, 34, 39-44.

Wolfe, J. H., Alderton, D. L., & Larson, G. E. (1993). *Incremental validity of new computerized aptitude tests for predicting training performance in nine Navy technical schools*. Unpublished manuscript.

Appendix A
ASVAB Population Statistics

Table A-1

Means, Standard Deviations, and Correlations of ASVAB Tests
for Fiscal Year 1991 Military Applicants (N = 650,278)

| Variable | AFQT | GS | AR | WK | PC | NO |
|-----------|----------|----------|----------|----------|----------|----------|
| Mean | 52.59779 | 50.61501 | 50.66362 | 51.31136 | 51.15582 | 52.51222 |
| Std. Dev. | 23.6111 | 8.772641 | 8.645407 | 7.354141 | 7.964013 | 8.013076 |
| AFQT | 1 | 0.746484 | 0.874185 | 0.829683 | 0.760957 | 0.479759 |
| GS | 0.746484 | 1 | 0.611079 | 0.720105 | 0.607873 | 0.275094 |
| AR | 0.874185 | 0.611079 | 1 | 0.596262 | 0.574273 | 0.470311 |
| WK | 0.829683 | 0.720105 | 0.596262 | 1 | 0.731601 | 0.324392 |
| PC | 0.760957 | 0.607873 | 0.574273 | 0.731601 | 1 | 0.395913 |
| NO | 0.479759 | 0.275094 | 0.470311 | 0.324392 | 0.395913 | 1 |
| CS | 0.434399 | 0.248734 | 0.39535 | 0.327805 | 0.385869 | 0.640106 |
| AS | 0.406062 | 0.520184 | 0.400411 | 0.43662 | 0.339055 | 0.046951 |
| MK | 0.829985 | 0.554223 | 0.706944 | 0.49678 | 0.499731 | 0.496123 |
| MC | 0.641152 | 0.637695 | 0.613441 | 0.547276 | 0.485226 | 0.227886 |
| EI | 0.547772 | 0.624531 | 0.486796 | 0.534385 | 0.444472 | 0.14525 |
| VE | 0.860154 | 0.727385 | 0.625712 | 0.972128 | 0.86498 | 0.368634 |

| Variable | CS | AS | MK | MC | EI | VE |
|-----------|----------|----------|----------|----------|----------|----------|
| Mean | 52.2662 | 51.40873 | 51.2103 | 51.94077 | 50.33257 | 51.33477 |
| Std. Dev. | 7.811829 | 9.167697 | 8.689045 | 9.127189 | 8.855934 | 7.306167 |
| AFQT | 0.434399 | 0.406062 | 0.829985 | 0.641152 | 0.547772 | 0.860154 |
| GS | 0.248734 | 0.520184 | 0.554223 | 0.637695 | 0.624531 | 0.727385 |
| AR | 0.39535 | 0.400411 | 0.706944 | 0.613441 | 0.486796 | 0.625712 |
| WK | 0.327805 | 0.43662 | 0.49678 | 0.547276 | 0.534385 | 0.972128 |
| PC | 0.385869 | 0.339055 | 0.499731 | 0.485226 | 0.444472 | 0.86498 |
| NO | 0.640106 | 0.046951 | 0.496123 | 0.227886 | 0.14525 | 0.368634 |
| CS | 1 | 0.058285 | 0.40777 | 0.221165 | 0.147078 | 0.368472 |
| AS | 0.058285 | 1 | 0.196576 | 0.61808 | 0.669217 | 0.429827 |
| MK | 0.40777 | 0.196576 | 1 | 0.493874 | 0.369617 | 0.527314 |
| MC | 0.221165 | 0.61808 | 0.493874 | 1 | 0.630407 | 0.560015 |
| EI | 0.147078 | 0.669217 | 0.369617 | 0.630407 | 1 | 0.536475 |
| VE | 0.368472 | 0.429827 | 0.527314 | 0.560015 | 0.536475 | 1 |

Appendix B

Means, Standard Deviations, and Correlations of ASVAB and ECAT Predictors

Table B - 1

Uncorrected Means, Standard Deviations, and Intercorrelations of Predictors and Other Measures
(N = 10,963)

| VARIABLE | GS | AR | WK | PC | NO | CS | AS | MK | MC | EI | VE | AFQT | CT | SM | ID | AO |
|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| MEAN | 53.2548 | 53.6095 | 53.0435 | 53.2287 | 54.2075 | 53.2479 | 53.6141 | 55.1249 | 54.9579 | 52.5929 | 53.2058 | 61.1787 | 0.7242 | 0.6878 | 0.7597 | 0.6288 |
| STD | 7.4186 | 6.9048 | 5.3537 | 5.7400 | 6.5828 | 6.9367 | 8.0510 | 6.8750 | 7.7035 | 7.9453 | 5.0966 | 17.9174 | 0.1754 | 0.1339 | 0.1266 | 0.1929 |
| GS | 1.0000 | 0.4251 | 0.6044 | 0.4254 | 0.0086 | -0.0088 | 0.4218 | 0.3450 | 0.5197 | 0.5211 | 0.6025 | 0.6128 | 0.1917 | 0.1917 | 0.3595 | 0.3370 |
| AR | 0.4251 | 1.0000 | 0.3991 | 0.3415 | 0.2582 | 0.1841 | 0.2445 | 0.5346 | 0.4477 | 0.3161 | 0.4185 | 0.7968 | 0.4298 | 0.4020 | 0.4287 | 0.3700 |
| WK | 0.6044 | 0.3991 | 1.0000 | 0.5200 | 0.0399 | 0.0830 | 0.3192 | 0.2699 | 0.3961 | 0.4031 | 0.9087 | 0.7406 | 0.1616 | 0.1955 | 0.2711 | 0.2458 |
| PC | 0.4254 | 0.3415 | 0.5200 | 1.0000 | 0.1201 | 0.1617 | 0.1947 | 0.2457 | 0.2918 | 0.2789 | 0.7262 | 0.6100 | 0.1638 | 0.1852 | 0.2037 | 0.1848 |
| NO | 0.0086 | 0.2582 | 0.0399 | 0.1201 | 1.0000 | 0.5214 | -0.1271 | 0.1992 | -0.0240 | -0.0617 | 0.0714 | 0.2446 | 0.2145 | 0.1825 | 0.0708 | 0.0588 |
| CS | -0.0088 | 0.1841 | 0.0830 | 0.1617 | 0.5214 | 1.0000 | -0.0925 | 0.1982 | 0.0058 | -0.0369 | 0.1148 | 0.2051 | 0.2072 | 0.1986 | 0.0914 | 0.1170 |
| AS | 0.4218 | 0.2445 | 0.3192 | 0.1947 | -0.1271 | -0.0925 | 1.0000 | 0.0063 | 0.4917 | 0.5691 | 0.3045 | 0.2601 | 0.0782 | 0.0407 | 0.2526 | 0.2705 |
| MK | 0.3450 | 0.5346 | 0.2699 | 0.2457 | 0.2982 | 0.1992 | 0.0063 | 1.0000 | 0.3106 | 0.1969 | 0.2849 | 0.7240 | 0.3728 | 0.3437 | 0.3683 | 0.3198 |
| MC | 0.5197 | 0.4477 | 0.3961 | 0.2918 | -0.0240 | 0.0058 | 0.4917 | 0.3106 | 1.0000 | 0.5142 | 0.3996 | 0.4986 | 0.2863 | 0.2453 | 0.4573 | 0.4422 |
| EI | 0.5211 | 0.3161 | 0.4031 | 0.2789 | -0.0617 | -0.0369 | 0.5691 | 0.1969 | 0.3996 | 1.0000 | 0.8014 | 0.8014 | 0.1783 | 0.2105 | 0.2743 | 0.2494 |
| VE | 0.6025 | 0.4185 | 0.9087 | 0.7262 | 0.0714 | 0.1148 | 0.3045 | 0.2849 | 0.3996 | 0.3996 | 1.0000 | 1.0000 | 0.3937 | 0.3903 | 0.4446 | 0.3918 |
| AFQT | 0.6128 | 0.7968 | 0.7406 | 0.6100 | 0.2446 | 0.2051 | 0.2601 | 0.7240 | 0.4986 | 0.4080 | 0.8014 | 1.0000 | 0.3937 | 0.3903 | 0.4446 | 0.3918 |
| CT | 0.1917 | 0.4020 | 0.1955 | 0.1852 | 0.1825 | 0.1986 | 0.0407 | 0.3478 | 0.2453 | 0.0917 | 0.2105 | 0.3903 | 0.5911 | 1.0000 | 0.4605 | 0.4884 |
| SM | 0.1917 | 0.4020 | 0.1955 | 0.1852 | 0.1825 | 0.1986 | 0.0407 | 0.3478 | 0.2453 | 0.0917 | 0.2105 | 0.3903 | 0.5911 | 1.0000 | 0.4605 | 0.4884 |
| ID | 0.3595 | 0.4287 | 0.2711 | 0.2037 | 0.0708 | 0.0914 | 0.2526 | 0.3683 | 0.4573 | 0.3009 | 0.2743 | 0.4446 | 0.4605 | 0.3947 | 1.0000 | 0.5709 |
| AO | 0.3370 | 0.3700 | 0.2458 | 0.1848 | 0.0588 | 0.1170 | 0.2705 | 0.3198 | 0.4422 | 0.3010 | 0.2494 | 0.3918 | 0.4884 | 0.3965 | 0.5709 | 1.0000 |
| T1 | -0.1859 | -0.1808 | -0.1318 | -0.1049 | -0.0893 | -0.0978 | -0.1736 | -0.1469 | -0.2793 | -0.1732 | -0.1359 | -0.1948 | -0.3113 | -0.2441 | -0.3082 | -0.3106 |
| T2 | -0.2303 | -0.2111 | -0.1769 | -0.1257 | -0.0621 | -0.1007 | -0.2288 | -0.1521 | -0.3427 | -0.2213 | -0.1743 | -0.2290 | -0.3121 | -0.2528 | -0.3236 | -0.3522 |
| FR | 0.3441 | 0.4494 | 0.3006 | 0.2444 | 0.1115 | 0.1099 | 0.1733 | 0.3894 | 0.3988 | 0.2482 | 0.3077 | 0.4772 | 0.4614 | 0.4450 | 0.4959 | 0.4848 |
| SO | 0.3464 | 0.3915 | 0.2844 | 0.2112 | 0.0362 | 0.0750 | 0.2743 | 0.3316 | 0.4448 | 0.2990 | 0.2889 | 0.4257 | 0.4094 | 0.3562 | 0.4792 | 0.4911 |
| MEMORY | -0.2303 | -0.1573 | -0.1548 | -0.1095 | -0.0712 | -0.0985 | -0.1512 | -0.1190 | -0.2392 | -0.1486 | -0.1540 | -0.1859 | -0.2261 | -0.2111 | -0.2582 | -0.3040 |
| SPATIAL | 0.2204 | 0.4710 | 0.2022 | 0.1977 | 0.2249 | 0.2298 | 0.0673 | 0.4058 | 0.3011 | 0.1215 | 0.2202 | 0.4440 | 0.8831 | 0.8828 | 0.4843 | 0.5012 |
| TRACKING | -0.2236 | -0.2106 | -0.1658 | -0.1239 | -0.0814 | -0.1067 | -0.2161 | -0.1607 | -0.3342 | -0.2119 | -0.1666 | -0.2277 | -0.3350 | -0.2675 | -0.3395 | -0.3561 |
| AORT | 0.0196 | 0.0776 | 0.0311 | 0.0391 | -0.0326 | -0.0387 | -0.0058 | 0.1175 | 0.0603 | 0.0413 | 0.0359 | 0.0925 | 0.1704 | 0.0579 | 0.1455 | 0.2759 |
| IDCT | 0.0081 | 0.0511 | 0.0146 | 0.0518 | 0.0176 | -0.0028 | -0.0419 | 0.1209 | 0.0308 | 0.0178 | 0.0318 | 0.0805 | 0.1269 | 0.0305 | 0.2475 | 0.0819 |
| IDDT | -0.1185 | -0.1002 | -0.1026 | -0.0726 | -0.0666 | -0.0889 | -0.1180 | -0.0446 | -0.1142 | -0.0940 | -0.1038 | -0.1093 | -0.0392 | -0.0978 | -0.0611 | -0.0668 |
| SORT | -0.0270 | 0.0116 | -0.0136 | 0.0077 | -0.0330 | -0.0484 | -0.0643 | 0.0501 | -0.0317 | -0.0132 | -0.0086 | 0.0192 | 0.0694 | -0.0149 | 0.0564 | 0.0876 |
| FRRT | 0.0109 | 0.0647 | 0.0313 | 0.0492 | -0.0463 | -0.0498 | -0.0441 | 0.1201 | 0.0344 | 0.0347 | 0.0388 | 0.0906 | 0.0351 | -0.0683 | 0.1096 | 0.0575 |
| AO-1 | 0.2741 | 0.3251 | 0.1984 | 0.1617 | 0.0431 | 0.0872 | 0.2083 | 0.3099 | 0.3709 | 0.2499 | 0.2063 | 0.3482 | 0.4514 | 0.3547 | 0.4957 | 0.8368 |
| AO-2 | 0.3084 | 0.3178 | 0.2245 | 0.1595 | 0.0573 | 0.1156 | 0.2578 | 0.2511 | 0.3956 | 0.2712 | 0.2244 | 0.3334 | 0.3980 | 0.3355 | 0.4975 | 0.8949 |

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
 AO = Assembling Objects Proportion Correct
 FR = Figural Reasoning Proportion Correct
 SM = Sequential Memory Proportion Correct
 T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 SO = Spatial Orientation Proportion Correct
 ID = Integrating Details Proportion Correct
 T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 T1 = Target Identification Mean Clipped Decision RTs

Table B-1 (continued)

| VARIABLE | TI | T2 | FR | SO | TI | MEMORY | SPATIAL | TRACKING | AORT | IDCT | IDDT | SORT | FRRT | AO-1 | AO-2 |
|----------|----------|----------|---------|---------|---------|---------|---------|----------|---------|---------|---------|---------|---------|---------|---------|
| MEAN | 2765.37 | 3639.16 | 0.6689 | 0.5166 | 1.8350 | 0.0053 | 0.0134 | -0.0008 | 18.6950 | 12.5066 | 2.8663 | 13.9647 | 18.7153 | 0.6344 | 0.5807 |
| STD | 391.7238 | 471.9778 | 0.1877 | 0.2473 | 0.6039 | 0.9956 | 1.0007 | 1.0032 | 5.5288 | 5.1293 | 0.7763 | 3.8645 | 4.6116 | 0.1995 | 0.2279 |
| GS | -0.1859 | -0.2303 | 0.3441 | 0.3464 | -0.2303 | 0.2204 | 0.3929 | -0.2236 | 0.0196 | 0.0081 | -0.1185 | -0.0270 | 0.0109 | 0.2741 | 0.3084 |
| AR | -0.1808 | -0.2111 | 0.4494 | 0.3915 | -0.1573 | 0.4710 | 0.4505 | -0.2106 | 0.0776 | 0.0511 | -0.1002 | 0.0116 | 0.0647 | 0.3251 | 0.3178 |
| WK | -0.1318 | -0.1769 | 0.3006 | 0.2844 | -0.1548 | 0.2022 | 0.2915 | -0.1658 | 0.0311 | 0.0146 | -0.1026 | -0.0136 | 0.0313 | 0.1984 | 0.2245 |
| PC | -0.1049 | -0.1257 | 0.2444 | 0.2112 | -0.1095 | 0.1977 | 0.2191 | -0.1239 | 0.0391 | 0.0518 | -0.0726 | 0.0077 | 0.0492 | 0.1617 | 0.1595 |
| NO | -0.0893 | -0.0621 | 0.1115 | 0.0362 | -0.0712 | 0.2249 | 0.0731 | -0.0814 | -0.0326 | 0.0176 | -0.0666 | -0.0330 | -0.0463 | 0.0431 | 0.0573 |
| CS | -0.0978 | -0.1007 | 0.1099 | 0.0750 | -0.0985 | 0.2298 | 0.1176 | -0.1067 | -0.0387 | -0.0028 | -0.0889 | -0.0484 | -0.0498 | 0.0872 | 0.1156 |
| AS | -0.1736 | -0.2288 | 0.1733 | 0.2743 | -0.1512 | 0.0673 | 0.2952 | -0.2161 | -0.0058 | -0.0419 | -0.1180 | -0.0643 | -0.0441 | 0.2083 | 0.2578 |
| MK | -0.1469 | -0.1521 | 0.3894 | 0.3316 | -0.1190 | 0.4058 | 0.3881 | -0.1607 | 0.1175 | 0.1209 | -0.0446 | 0.0501 | 0.1201 | 0.3099 | 0.2511 |
| MC | -0.2793 | -0.3427 | 0.3988 | 0.4448 | -0.2392 | 0.3011 | 0.5075 | -0.3342 | 0.0603 | 0.0338 | -0.1142 | -0.0317 | 0.0344 | 0.3709 | 0.3956 |
| EI | -0.1732 | -0.2213 | 0.2482 | 0.2990 | -0.1486 | 0.1215 | 0.3396 | -0.2119 | 0.0413 | 0.0178 | -0.0940 | -0.0132 | 0.0347 | 0.2499 | 0.2712 |
| VE | -0.1359 | -0.1743 | 0.3077 | 0.2889 | -0.1540 | 0.2202 | 0.2954 | -0.1666 | 0.0359 | 0.0805 | -0.1038 | -0.0086 | 0.0388 | 0.2063 | 0.2244 |
| AFQT | -0.1948 | -0.2290 | 0.4772 | 0.4257 | -0.1859 | 0.4440 | 0.4718 | -0.2277 | 0.0925 | 0.0805 | -0.1093 | -0.0086 | 0.0906 | 0.3482 | 0.3334 |
| CT | -0.3113 | -0.3121 | 0.4614 | 0.4094 | -0.2261 | 0.8831 | 0.5354 | -0.3350 | 0.1704 | 0.1269 | -0.0392 | 0.0694 | 0.0351 | 0.4514 | 0.3980 |
| SM | -0.2441 | -0.2538 | 0.4450 | 0.3562 | -0.2111 | 0.8828 | 0.4464 | -0.2675 | 0.0579 | 0.0305 | -0.0978 | -0.0149 | -0.0683 | 0.3547 | 0.3355 |
| ID | -0.3082 | -0.3236 | 0.4959 | 0.4792 | -0.2582 | 0.4843 | 0.8854 | -0.3395 | 0.1455 | 0.2475 | -0.0611 | 0.0564 | 0.1096 | 0.4957 | 0.4975 |
| AO | -0.3106 | -0.3522 | 0.4848 | 0.4911 | -0.3040 | 0.5012 | 0.8871 | -0.3561 | 0.2759 | 0.0819 | -0.0668 | 0.0876 | 0.0575 | 0.8368 | 0.8949 |
| T1 | 1.0000 | 0.7317 | -0.2672 | -0.2940 | 0.3205 | -0.3146 | -0.3491 | 0.9308 | -0.0939 | -0.0901 | 0.0338 | -0.0251 | -0.0475 | -0.2740 | -0.2654 |
| T2 | 0.7317 | 1.0000 | -0.2818 | -0.3280 | 0.3381 | -0.3205 | -0.3813 | 0.9302 | -0.0983 | -0.0332 | 0.0803 | -0.0080 | -0.0222 | -0.3056 | -0.3052 |
| FR | -0.2672 | -0.2818 | 1.0000 | 0.4379 | -0.2156 | 0.5133 | 0.5532 | -0.2950 | 0.1554 | 0.1471 | -0.0563 | 0.0548 | 0.1264 | 0.4396 | 0.4054 |
| SO | -0.2940 | -0.3280 | 0.4379 | 1.0000 | -0.2062 | 0.4336 | 0.5474 | -0.3342 | 0.1435 | 0.1085 | -0.0792 | 0.0549 | 0.0599 | 0.4375 | 0.4178 |
| TI | 0.3205 | 0.3381 | -0.2156 | -0.2062 | 1.0000 | -0.2476 | -0.3173 | 0.3539 | 0.0980 | 0.0862 | 0.1276 | 0.1109 | 0.1476 | -0.2124 | -0.3086 |
| MEMORY | -0.3146 | -0.3205 | 0.5133 | 0.4336 | -0.2476 | 1.0000 | 0.5560 | -0.3412 | 0.1293 | 0.0892 | -0.0776 | 0.0309 | -0.0188 | 0.4565 | 0.4154 |
| SPATIAL | -0.3491 | -0.3813 | 0.5532 | 0.5474 | -0.3173 | 0.5560 | 1.0000 | -0.3925 | 0.2380 | 0.1855 | 0.0613 | -0.0178 | 0.0941 | 0.7524 | 0.7863 |
| TRACKING | 0.9308 | 0.9302 | -0.2950 | -0.3342 | 0.3539 | -0.3412 | -0.3925 | 1.0000 | -0.1033 | -0.0663 | 0.0613 | -0.0178 | -0.0375 | -0.3114 | -0.3066 |
| AORT | -0.0939 | -0.0983 | 0.1554 | 0.1435 | 0.0980 | 0.1293 | 0.2380 | -0.1033 | 1.0000 | 0.3099 | 0.2317 | 0.4802 | 0.4703 | 0.4344 | 0.0705 |
| IDCT | -0.0901 | -0.0332 | 0.1471 | 0.1085 | 0.0862 | 0.0892 | 0.1855 | -0.0663 | 0.3099 | 1.0000 | 0.4644 | 0.3229 | 0.4584 | 0.1593 | -0.0067 |
| IDDT | 0.0338 | 0.0803 | -0.0563 | -0.0792 | 0.1276 | -0.0776 | -0.0722 | 0.0613 | 0.2317 | 0.4644 | 1.0000 | 0.2951 | 0.3746 | 0.0030 | -0.1128 |
| SORT | -0.0251 | -0.0080 | 0.0548 | 0.0549 | 0.1109 | 0.0309 | 0.0813 | -0.0178 | 0.4802 | 0.3229 | 0.2951 | 1.0000 | 0.4323 | 0.1781 | -0.0118 |
| FRRT | -0.0475 | -0.0222 | 0.1264 | 0.0599 | 0.1476 | -0.0188 | 0.0941 | -0.0375 | 0.4703 | 0.4584 | 0.3746 | 0.4323 | 1.0000 | 0.1638 | -0.0463 |
| AO-1 | -0.2740 | -0.3056 | 0.4396 | 0.4375 | -0.2124 | 0.4565 | 0.7524 | -0.3114 | 0.4344 | 0.1593 | 0.0030 | 0.1781 | 0.1638 | 1.0000 | 0.5109 |
| AO-2 | -0.2654 | -0.3052 | 0.4054 | 0.4178 | -0.3086 | 0.4154 | 0.7863 | -0.3066 | 0.0705 | -0.0067 | -0.1128 | -0.0118 | -0.0463 | 0.5109 | 1.0000 |

Other ECAT Exploratory Measures

AORT = AO Arithmetic Mean Item Response Latency IDCT = ID Geometric Mean Component Latency IDDT = ID Geometric Mean Decision Latency
 SORT = SO Arithmetic Mean Item Response Latency FRRT = FR Arithmetic Mean Item Response Latency AO-1 = AO Proportion Correct of First 15 Items (Semi-mechanical)
 AO-2 = AO Proportion Correct of Final 17 Items (Jig-saw)

Table B - 2

Range-Corrected Means, Standard Deviations, and Intercorrelations of Predictors and Other Measures
(N = 10,963)

| VARIABLE | GS | AR | WK | PC | NO | CS | AS | MK | MC | EI | VE | AFQT | CT | SM | ID | AO |
|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| MEAN | 50.6150 | 50.6636 | 51.3114 | 51.1558 | 52.5122 | 52.2662 | 51.4087 | 51.2103 | 51.9408 | 50.3326 | 51.3518 | 51.0176 | 0.6772 | 0.6554 | 0.7209 | 0.5746 |
| STD | 8.7726 | 8.6454 | 7.3541 | 7.9640 | 8.0131 | 7.8118 | 9.1677 | 8.6890 | 9.1272 | 8.8559 | 7.2490 | 26.3284 | 0.1920 | 0.1456 | 0.1404 | 0.2112 |
| GS | 1.0000 | 0.6111 | 0.7201 | 0.6079 | 0.2751 | 0.2487 | 0.5202 | 0.5542 | 0.6377 | 0.6245 | 0.7213 | 0.7488 | 0.3684 | 0.3606 | 0.5024 | 0.4743 |
| AR | 0.6111 | 1.0000 | 0.5963 | 0.5743 | 0.4703 | 0.3953 | 0.4004 | 0.7069 | 0.6134 | 0.4868 | 0.6199 | 0.8673 | 0.5582 | 0.5318 | 0.5695 | 0.5142 |
| WK | 0.7201 | 0.5963 | 1.0000 | 0.7316 | 0.3244 | 0.3278 | 0.4366 | 0.4968 | 0.5473 | 0.5344 | 0.9508 | 0.8455 | 0.3409 | 0.3682 | 0.4310 | 0.3990 |
| PC | 0.6079 | 0.5743 | 0.7316 | 1.0000 | 0.3959 | 0.3859 | 0.3391 | 0.4997 | 0.4852 | 0.4445 | 0.8533 | 0.7877 | 0.3529 | 0.3704 | 0.3909 | 0.3611 |
| NO | 0.2751 | 0.4703 | 0.3244 | 0.3959 | 1.0000 | 0.6401 | 0.0470 | 0.4961 | 0.2279 | 0.1452 | 0.3635 | 0.4972 | 0.3705 | 0.3412 | 0.2601 | 0.2371 |
| CS | 0.2487 | 0.3953 | 0.3278 | 0.3859 | 0.6401 | 1.0000 | 0.0583 | 0.4078 | 0.2212 | 0.1471 | 0.3609 | 0.4448 | 0.3490 | 0.3387 | 0.2584 | 0.2669 |
| AS | 0.5202 | 0.4004 | 0.4366 | 0.3391 | 0.0470 | 0.0583 | 1.0000 | 0.1966 | 0.6181 | 0.6692 | 0.4253 | 0.4139 | 0.2093 | 0.1703 | 0.3787 | 0.3889 |
| MK | 0.5542 | 0.7069 | 0.4968 | 0.4997 | 0.4961 | 0.4078 | 0.1966 | 1.0000 | 0.4939 | 0.3696 | 0.5216 | 0.8163 | 0.4892 | 0.4892 | 0.5174 | 0.4675 |
| MC | 0.6377 | 0.6134 | 0.5473 | 0.4852 | 0.2279 | 0.2212 | 0.6181 | 0.4939 | 1.0000 | 0.6304 | 0.5542 | 0.6436 | 0.4259 | 0.3854 | 0.5743 | 0.5559 |
| EI | 0.6245 | 0.4868 | 0.5344 | 0.4445 | 0.1452 | 0.1471 | 0.6692 | 0.3696 | 0.6304 | 1.0000 | 0.5326 | 0.5520 | 0.2685 | 0.2373 | 0.4315 | 0.4254 |
| VE | 0.7213 | 0.6199 | 0.9508 | 0.8533 | 0.3635 | 0.3609 | 0.4253 | 0.5216 | 0.5542 | 0.5326 | 1.0000 | 0.8860 | 0.3624 | 0.3874 | 0.4401 | 0.4077 |
| AFQT | 0.7488 | 0.8673 | 0.8455 | 0.7877 | 0.4972 | 0.4448 | 0.4139 | 0.8163 | 0.6436 | 0.5520 | 0.8860 | 1.0000 | 0.5309 | 0.5272 | 0.5762 | 0.5261 |
| CT | 0.3684 | 0.5582 | 0.3409 | 0.3529 | 0.3705 | 0.3490 | 0.2093 | 0.5163 | 0.4259 | 0.2685 | 0.3624 | 0.5309 | 1.0000 | 0.6288 | 0.5530 | 0.5700 |
| SM | 0.3606 | 0.5318 | 0.3682 | 0.3704 | 0.3412 | 0.3387 | 0.1703 | 0.4892 | 0.3854 | 0.2373 | 0.3874 | 0.5272 | 0.6288 | 1.0000 | 0.4939 | 0.4885 |
| ID | 0.5024 | 0.5695 | 0.4310 | 0.3909 | 0.2601 | 0.2584 | 0.3787 | 0.5174 | 0.5743 | 0.4315 | 0.4401 | 0.5762 | 0.5530 | 0.4939 | 1.0000 | 0.6461 |
| AO | 0.4743 | 0.5142 | 0.3990 | 0.3611 | 0.2371 | 0.2669 | 0.3889 | 0.4675 | 0.5559 | 0.4254 | 0.4077 | 0.5261 | 0.5700 | 0.4885 | 0.6461 | 1.0000 |
| T1 | -0.2882 | -0.2956 | -0.2440 | -0.2272 | -0.2008 | -0.1967 | -0.2589 | -0.2608 | -0.3677 | -0.2659 | -0.2514 | -0.3083 | -0.3787 | -0.3162 | -0.3808 | -0.3801 |
| T2 | -0.3405 | -0.3369 | -0.2967 | -0.2614 | -0.2104 | -0.2104 | -0.3230 | -0.2806 | -0.4362 | -0.3233 | -0.2989 | -0.3527 | -0.3889 | -0.3343 | -0.4061 | -0.4276 |
| FR | 0.5026 | 0.5945 | 0.4727 | 0.4425 | 0.3073 | 0.2872 | 0.3108 | 0.5457 | 0.5313 | 0.3914 | 0.4854 | 0.6162 | 0.5586 | 0.5422 | 0.5930 | 0.5768 |
| SO | 0.4888 | 0.5366 | 0.4392 | 0.3930 | 0.2250 | 0.2380 | 0.3955 | 0.4824 | 0.5622 | 0.4291 | 0.4480 | 0.5592 | 0.5067 | 0.4584 | 0.5736 | 0.5779 |
| T1 | -0.3151 | -0.2651 | -0.2537 | -0.2224 | -0.1781 | -0.1917 | -0.2274 | -0.2300 | -0.3216 | -0.2349 | -0.2563 | -0.2916 | -0.2964 | -0.2807 | -0.3287 | -0.3664 |
| MEMORY | 0.4039 | 0.6040 | 0.3928 | 0.4007 | 0.3944 | 0.3811 | 0.2104 | 0.5571 | 0.4496 | 0.2803 | 0.4154 | 0.5862 | 0.9032 | 0.9017 | 0.5802 | 0.5866 |
| SPATIAL | 0.5384 | 0.5973 | 0.4575 | 0.4145 | 0.2741 | 0.2895 | 0.4230 | 0.5429 | 0.6230 | 0.4723 | 0.4673 | 0.6076 | 0.6189 | 0.5415 | 0.9078 | 0.9066 |
| TRACKING | -0.3359 | -0.3379 | -0.2889 | -0.2611 | -0.2093 | -0.2175 | -0.3109 | -0.2892 | -0.4296 | -0.3149 | -0.2940 | -0.3532 | -0.4101 | -0.3475 | -0.4204 | -0.4316 |
| AORT | 0.0506 | 0.1016 | 0.0590 | 0.0673 | -0.0007 | -0.0094 | 0.0188 | 0.1322 | 0.0809 | 0.0611 | 0.0642 | 0.1084 | 0.1809 | 0.0781 | 0.1581 | 0.2767 |
| IDDT | -0.1860 | -0.1750 | -0.1758 | -0.1536 | -0.1357 | -0.1489 | -0.1692 | -0.1264 | -0.1822 | -0.1570 | -0.1785 | -0.1889 | -0.0994 | -0.1507 | -0.1239 | -0.1257 |
| SORT | -0.0330 | -0.0013 | -0.0216 | -0.0040 | -0.0385 | -0.0516 | -0.0699 | 0.0316 | -0.0421 | -0.0256 | -0.0176 | 0.0011 | 0.0559 | -0.0203 | 0.0415 | 0.0707 |
| FRRT | 0.0362 | 0.0830 | 0.0540 | 0.0700 | -0.0182 | -0.0243 | -0.0242 | 0.0483 | 0.0461 | 0.0609 | 0.0994 | 0.0994 | 0.0517 | -0.0427 | 0.1187 | 0.0706 |
| AO-1 | 0.4043 | 0.4577 | 0.3399 | 0.3186 | 0.2016 | 0.2229 | 0.3192 | 0.4382 | 0.4794 | 0.3641 | 0.3513 | 0.4693 | 0.5281 | 0.4416 | 0.5718 | 0.8592 |
| AO-2 | 0.4339 | 0.4541 | 0.3640 | 0.3212 | 0.2169 | 0.2496 | 0.3666 | 0.3949 | 0.5045 | 0.3882 | 0.3690 | 0.4636 | 0.4834 | 0.4258 | 0.5750 | 0.9095 |

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
 AO = Assembling Objects Proportion Correct
 FR = Figural Reasoning Proportion Correct
 SM = Sequential Memory Proportion Correct
 T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 SO = Spatial Orientation Proportion Correct
 ID = Integrating Details Proportion Correct
 T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 T1 = Target Identification Mean Clipped Decision RTs

Table B-2 (continued)

| VARIABLE | T1 | T2 | FR | SO | TI | MEMORY | SPATIAL | TRACKING | AORT | IDCT | IDDT | SORT | FRRT | AO-1 | AO-2 |
|----------|----------|----------|---------|---------|---------|---------|---------|----------|---------|---------|---------|---------|---------|---------|---------|
| MEAN | 2827.3 | 3722.98 | 0.6113 | 0.4447 | 1.9156 | -0.2824 | -0.3184 | 0.1801 | 18.3497 | 12.1886 | 2.9240 | 13.9463 | 18.4711 | 0.5842 | 0.5266 |
| STD | 406.0732 | 494.5723 | 0.2106 | 0.2726 | 0.6219 | 1.1104 | 1.1287 | 1.0517 | 5.5418 | 5.1455 | 0.7869 | 3.8673 | 4.6202 | 0.2135 | 0.2448 |
| GS | -0.2882 | -0.3405 | 0.5026 | 0.4888 | -0.3151 | 0.4039 | 0.5384 | -0.3359 | 0.0506 | 0.0472 | -0.1860 | -0.0330 | 0.0362 | 0.4043 | 0.4339 |
| AR | -0.2956 | -0.3369 | 0.5945 | 0.5366 | -0.2651 | 0.6040 | 0.5973 | -0.3379 | 0.1016 | 0.0877 | -0.1750 | -0.0013 | 0.0830 | 0.4577 | 0.4541 |
| WK | -0.2440 | -0.2967 | 0.4727 | 0.4392 | -0.2537 | 0.3928 | 0.4575 | -0.2889 | 0.0590 | 0.0550 | -0.1758 | -0.0216 | 0.0540 | 0.3399 | 0.3640 |
| PC | -0.2272 | -0.2614 | 0.4425 | 0.3930 | -0.2224 | 0.4007 | 0.4145 | -0.2611 | 0.0673 | 0.0867 | -0.1536 | -0.0040 | 0.0700 | 0.3186 | 0.3212 |
| NO | -0.2008 | -0.1910 | 0.3073 | 0.2250 | -0.1781 | 0.3044 | 0.2741 | -0.2093 | -0.0007 | 0.0532 | -0.1357 | -0.0385 | -0.0182 | 0.2016 | 0.2169 |
| CS | -0.1967 | -0.2104 | 0.2872 | 0.2380 | -0.1917 | 0.3811 | 0.2895 | -0.2175 | -0.0094 | 0.0315 | -0.1489 | -0.0516 | -0.0243 | 0.2229 | 0.2496 |
| AS | -0.2589 | -0.3230 | 0.3108 | 0.3955 | -0.2274 | 0.2104 | 0.4230 | -0.3109 | 0.0188 | -0.0154 | -0.1692 | -0.0699 | -0.0242 | 0.3192 | 0.3666 |
| MK | -0.2608 | -0.2806 | 0.5457 | 0.4824 | -0.2300 | 0.5571 | 0.5429 | -0.2892 | 0.1322 | 0.1427 | -0.1264 | 0.0316 | 0.1270 | 0.4382 | 0.3949 |
| MC | -0.3677 | -0.4362 | 0.5313 | 0.5622 | -0.3216 | 0.4496 | 0.4296 | -0.4296 | 0.0809 | 0.0614 | -0.1822 | -0.0421 | 0.0483 | 0.4794 | 0.5045 |
| EI | -0.2659 | -0.3233 | 0.3914 | 0.4291 | -0.2349 | 0.2803 | 0.4723 | -0.3149 | 0.0611 | 0.0413 | -0.1570 | -0.0256 | 0.0461 | 0.3641 | 0.3882 |
| VE | -0.2514 | -0.2989 | 0.4854 | 0.4480 | -0.2563 | 0.4154 | 0.4673 | -0.2940 | 0.0642 | 0.0704 | -0.1785 | -0.0176 | 0.0609 | 0.3513 | 0.3690 |
| AFQT | -0.3787 | -0.3889 | 0.5586 | 0.5067 | -0.2916 | 0.5862 | 0.6076 | -0.3532 | 0.1084 | 0.1098 | -0.1889 | 0.0011 | 0.0994 | 0.4693 | 0.4636 |
| CT | -0.3162 | -0.3343 | 0.5422 | 0.4583 | -0.2807 | 0.9017 | 0.6189 | -0.4101 | 0.1809 | 0.1465 | -0.0994 | 0.0559 | 0.0517 | 0.5281 | 0.4834 |
| SM | -0.3808 | -0.4061 | 0.5930 | 0.5736 | -0.3287 | 0.5802 | 0.9078 | -0.3475 | 0.0781 | 0.0584 | -0.1507 | -0.0203 | -0.0427 | 0.4416 | 0.4258 |
| ID | -0.3801 | -0.4276 | 0.5768 | 0.5779 | -0.3664 | 0.5866 | 0.9066 | -0.4316 | 0.2767 | 0.1030 | -0.1257 | 0.0707 | 0.0706 | 0.8592 | 0.9095 |
| AO | 1.0000 | 0.7522 | -0.3464 | -0.3668 | 0.3631 | -0.3851 | -0.4194 | 0.9356 | -0.1056 | -0.1043 | 0.0750 | -0.0174 | -0.0562 | -0.3398 | -0.3340 |
| T1 | 0.7522 | 1.0000 | -0.3713 | -0.4084 | 0.3844 | -0.4008 | -0.4594 | 0.9364 | -0.1109 | -0.0512 | 0.1243 | 0.0002 | -0.0329 | -0.3776 | -0.3797 |
| T2 | -0.3464 | -0.3713 | 1.0000 | 0.5431 | -0.2939 | 0.6099 | 0.6448 | -0.3834 | 0.1670 | 0.1646 | -0.1223 | 0.0401 | 0.1348 | 0.5260 | 0.4992 |
| FR | -0.3668 | -0.4084 | 0.5431 | 1.0000 | -0.2815 | 0.5348 | 0.6346 | -0.4142 | 0.1563 | 0.1279 | -0.1387 | 0.0406 | 0.0738 | 0.5205 | 0.5060 |
| SO | -0.3851 | -0.3844 | -0.2939 | -0.2815 | 1.0000 | -0.3197 | -0.3830 | 0.3993 | 0.0808 | 0.0667 | 0.1615 | 0.1134 | 0.1329 | -0.2771 | -0.3658 |
| TI | -0.3851 | -0.4008 | 0.6099 | 0.5348 | -0.3197 | 1.0000 | 0.6431 | -0.4199 | 0.1437 | 0.1137 | -0.1384 | 0.0199 | 0.0052 | 0.5375 | 0.5039 |
| MEMORY | -0.4194 | -0.4594 | 0.6448 | 0.6346 | -0.3830 | 0.6431 | 1.0000 | -0.4695 | 0.2394 | 0.1967 | -0.1375 | 0.0618 | 0.1044 | 0.7882 | 0.8176 |
| SPATIAL | 0.9356 | 0.9364 | -0.3834 | -0.4142 | 0.3993 | -0.4199 | -0.4695 | 1.0000 | -0.1157 | -0.0830 | 0.1065 | -0.0092 | -0.0476 | -0.3833 | -0.3813 |
| TRACKING | -0.1056 | -0.1109 | 0.1670 | 0.1563 | 0.0808 | 0.1437 | 0.2394 | -0.1157 | 1.0000 | 0.3133 | 0.2186 | 0.4782 | 0.4723 | 0.4274 | 0.0878 |
| AORT | -0.1043 | -0.0512 | 0.1646 | 0.1279 | 0.0667 | 0.1137 | 0.1967 | -0.0830 | -0.3133 | 1.0000 | 0.4455 | 0.3211 | 0.4605 | 0.1737 | 0.0189 |
| IDCT | 0.0750 | 0.1243 | -0.1223 | -0.1387 | 0.1615 | -0.1384 | -0.1375 | 0.1065 | 0.2186 | 0.4455 | 1.0000 | 0.2950 | 0.3620 | -0.0542 | -0.1625 |
| IDDT | -0.0174 | 0.0002 | 0.0401 | 0.0406 | 0.1134 | 0.0199 | 0.0618 | -0.0092 | 0.4782 | 0.3211 | 0.2950 | 1.0000 | 0.4314 | 0.1586 | -0.0196 |
| SORT | -0.0562 | -0.0329 | 0.1348 | 0.0738 | 0.1329 | 0.0052 | 0.1044 | -0.0476 | 0.4723 | 0.4605 | 0.3620 | 0.4314 | 1.0000 | 0.1691 | -0.0271 |
| FRRT | -0.3398 | -0.3776 | 0.5260 | 0.5205 | -0.2771 | 0.5375 | 0.7882 | -0.3833 | 0.4274 | 0.1737 | -0.0542 | 0.1586 | 0.1691 | 1.0000 | 0.5742 |
| AO-1 | -0.3340 | -0.3797 | 0.4992 | 0.5060 | -0.3658 | 0.5039 | 0.8176 | -0.3813 | 0.0878 | 0.0189 | -0.1625 | -0.0196 | -0.0271 | 0.5742 | 1.0000 |
| AO-2 | | | | | | | | | | | | | | | |

Other ECAT Exploratory Measures
 AORT = AO Arithmetic Mean Item Response Latency
 SORT = SO Arithmetic Mean Item Response Latency
 AO-2 = AO Proportion Correct of Final 17 Items (Jig-saw)
 IDCT = ID Geometric Mean Component Latency
 FRRT = FR Arithmetic Mean Item Response Latency
 IDDT = ID Geometric Mean Decision Latency
 AO-1 = AO Proportion Correct of First 15 Items (Semi-mechanical)

Appendix C
Factor Loadings and Scoring Weights

Table C-1

Promax Oblique Factor Pattern Loadings for ASVAB Tests

| Test | Technical | Verbal | Clerical | Math |
|-------------------------------|-----------|--------|----------|------|
| General Science (GS) | 30 | 46* | -8 | 25 |
| Arithmetic Reasoning (AR) | 20 | 10 | 13 | 57* |
| Word Knowledge (WK) | 3 | 95* | -1 | -5 |
| Paragraph Comprehension (PC) | 2 | 68* | 14 | 4 |
| Numerical Operations (NO) | -1 | -3 | 79* | 11 |
| Coding Speed (CS) | 1 | 7 | 76* | -4 |
| Auto-Shop Information (AS) | 96* | -4 | 3 | -17 |
| Mathematical Knowledge (MK) | -8 | 1 | 4 | 90* |
| Mechanical Comprehension (MC) | 60* | 3 | -1 | 30 |
| Electronics Information (EI) | 70* | 11 | -2 | 5 |

Note. 1. ASVAB = Armed Services Vocational Aptitude Battery.

2. Printed values are multiplied by 100 and rounded to the nearest integer. * Values greater than 0.391348 have been flagged by an '*' by the SAS program automatically.

Table C-2

Promax Oblique Factor Pattern Loadings for ECAT Tests

| Test | Space | Psychomotor | Memory |
|----------------------------|-------|-------------|--------|
| Mental Counters (CT) | 36 | -5 | 45* |
| Sequential Memory (SM) | 6 | 0 | 82* |
| Integrating Details (ID) | 78* | -2 | 1 |
| Assembling Objects (AO) | 79* | -4 | 0 |
| One-hand Tracking (T1) | 1 | 84* | -3 |
| Two-hand Tracking (T2) | -4 | 87* | 2 |
| Figural Reasoning (FR) | 58* | 0 | 22 |
| Spatial Orientation (SO) | 64* | -7 | 5 |
| Target Identification (TI) | -22 | 29 | -4 |

Note. 1. ECAT = Enhanced Computer Administered Testing.

2. Printed values are multiplied by 100 and rounded to the nearest integer * Values greater than 0.415805 have been flagged by an '*' by the SAS program automatically.

Table C-3

Promax Oblique Factor Pattern Loadings for the Combined ASVAB and ECAT Battery

| Test | Reasoning | Technical | Verbal | Psychomotor | Clerical | Math | Space |
|-------------------------------|-----------|-----------|--------|-------------|----------|------|-------|
| General Science (GS) | 2 | 23 | 50* | -3 | -5 | 19 | 7 |
| Arithmetic Reasoning (AR) | 32* | 21 | 11 | 5 | 9 | 42* | -14 |
| Word Knowledge (WK) | 2 | 3 | 95* | -1 | -2 | -8 | -2 |
| Paragraph Comprehension (PC) | 4 | 3 | 71* | 1 | 13 | 0 | -5 |
| Numerical Operations (NO) | -4 | 1 | -3 | -2 | 80* | 16 | -2 |
| Coding Speed (CS) | 5 | -1 | 8 | -1 | 75* | -7 | 8 |
| Auto-Shop Information (AS) | 0 | 101* | -4 | 2 | 2 | -19 | -4 |
| Mathematical Knowledge (MK) | 21 | -11 | 4 | 1 | 10 | 71* | -2 |
| Mechanical Comprehension (MC) | 19 | 50* | 6 | -7 | -2 | 16 | 8 |
| Electronics Information (EI) | -3 | 67* | 14 | 0 | 0 | 6 | 2 |
| Mental Counters (CT) | 81* | -1 | -6 | -4 | 5 | -1 | -5 |
| Sequential Memory (SM) | 80* | -5 | 8 | -1 | 0 | -5 | -15 |
| Integrating Details (ID) | 57* | 7 | -2 | -3 | -2 | 11 | 26 |
| Assembling Objects (AO) | 65* | 6 | -3 | -1 | 5 | -9 | 42* |
| One-hand Tracking (T1) | -3 | 2 | 2 | 86* | 0 | -1 | 2 |
| Two-hand Tracking (T2) | -1 | -4 | 0 | 86* | 1 | 0 | 1 |
| Figural Reasoning (FR) | 59* | -1 | 12 | -1 | -5 | 12 | 8 |
| Spatial Orientation (SO) | 48* | 14 | 4 | -6 | -5 | 10 | 14 |
| Target Identification (TI) | -18 | -1 | -9 | 28 | -8 | 11 | -15 |

Note. 1. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

2. Printed values are multiplied by 100 and rounded to the nearest integer. * Values greater than 0.281284 have been flagged by an '*' by the SAS program automatically.

Table C-4

Factor Scoring Weights for ASVAB Tests

| Test | 1st P.C. | G | Tech | Verbal | Clerical | Math |
|-------------------------------|----------|-----------|-----------|-----------|-----------|-----------|
| General Science (GS) | 0.160683 | 0.124446 | 0.133155 | 0.129648 | -0.057020 | 0.112672 |
| Arithmetic Reasoning (AR) | 0.159335 | 0.146021 | 0.081161 | 0.035249 | 0.084910 | 0.249897 |
| Word Knowledge (WK) | 0.157517 | 0.323136 | 0.021085 | 0.666432 | 0.012406 | -0.014665 |
| Paragraph Comprehension (PC) | 0.149042 | 0.096288 | 0.003873 | 0.162562 | 0.085677 | 0.028766 |
| Numerical Operations (NO) | 0.099969 | 0.041851 | -0.036032 | 0.006235 | 0.523072 | 0.061948 |
| Coding Speed (CS) | 0.093965 | 0.015380 | -0.014673 | 0.021730 | 0.352370 | -0.002553 |
| Auto-Shop Information (AS) | 0.116956 | -0.028556 | 0.460053 | -0.026813 | -0.025900 | -0.070284 |
| Mathematical Knowledge (MK) | 0.140915 | 0.285771 | -0.034976 | 0.022025 | 0.071517 | 0.556523 |
| Mechanical Comprehension (MC) | 0.150609 | 0.078880 | 0.216210 | 0.018429 | -0.012580 | 0.122707 |
| Electronics Information (EI) | 0.138763 | 0.038099 | 0.237005 | 0.033869 | -0.028370 | 0.023542 |

Note. ASVAB = Armed Services Vocational Aptitude Battery.

Table C-5

Factor Scoring Weights for ECAT Tests

| Test | 1st P. C. | G | Space | Motor | Memory |
|----------------------------|-----------|-----------|-----------|-----------|-----------|
| Mental Counters (CT) | 0.165977 | 0.128933 | 0.120076 | -0.019311 | 0.213172 |
| Sequential Memory (SM) | 0.153585 | 0.136731 | 0.045455 | -0.004377 | 0.649339 |
| Integrating Details (ID) | 0.169586 | 0.227111 | 0.284949 | -0.013117 | 0.016019 |
| Assembling Objects (AO) | 0.171295 | 0.239514 | 0.299980 | -0.028144 | 0.011417 |
| One-hand Tracking (T1) | -0.139523 | -0.040399 | -0.002292 | 0.395484 | -0.023413 |
| Two-hand Tracking (T2) | -0.146363 | -0.075038 | -0.037161 | 0.538013 | 0.010827 |
| Figural Reasoning (FR) | 0.164337 | 0.155273 | 0.178162 | -0.002159 | 0.099054 |
| Spatial Orientation (SO) | 0.160100 | 0.141189 | 0.173487 | -0.014118 | 0.025063 |
| Target Identification (TI) | -0.112932 | -0.033752 | -0.036392 | 0.048906 | -0.005721 |

Note. ECAT = Enhanced Computer Administered Testing.

Table C-6

Factor Scoring Weights for the Combined ASVAB + ECAT Battery

| Test | 1st P. C. | G | Reason | Tech | Verbal | Motor | Clerical | Math | Space |
|------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| GS | 0.090579 | 0.116335 | -0.034671 | 0.111760 | 0.161069 | -0.022415 | -0.055684 | 0.162183 | 0.185986 |
| AR | 0.096290 | 0.130532 | 0.128058 | 0.080836 | 0.040947 | 0.030155 | 0.065727 | 0.278467 | -0.202079 |
| WK | 0.085628 | 0.149597 | -0.008025 | 0.012588 | 0.608242 | 0.005813 | 0.014046 | -0.045200 | -0.022326 |
| PC | 0.080589 | 0.051041 | 0.009681 | 0.002968 | 0.173970 | 0.006195 | 0.081571 | 0.011507 | -0.058461 |
| NO | 0.056952 | 0.022474 | 0.003039 | -0.023324 | 0.006026 | -0.015418 | 0.528277 | 0.067475 | -0.105927 |
| CS | 0.054997 | -0.001776 | 0.022181 | -0.023014 | 0.024441 | -0.010357 | 0.353765 | -0.052457 | -0.002383 |
| AS | 0.065821 | 0.050973 | -0.021986 | 0.497251 | -0.027584 | -0.008116 | -0.026905 | -0.095979 | 0.004112 |
| MK | 0.086100 | 0.169459 | 0.053638 | -0.016666 | 0.039568 | 0.018550 | 0.058531 | 0.487683 | 0.022571 |
| MC | 0.092277 | 0.098669 | 0.027074 | 0.183168 | 0.029127 | -0.032932 | -0.040648 | 0.125279 | 0.160677 |
| EI | 0.076877 | 0.067393 | -0.040685 | 0.205582 | 0.044227 | -0.000405 | -0.028735 | 0.075567 | 0.096809 |
| CT | 0.081635 | 0.031194 | 0.265625 | -0.031717 | -0.030791 | -0.021858 | 0.055230 | -0.054647 | -0.183917 |
| SM | 0.076796 | 0.021827 | 0.246721 | -0.046320 | 0.007499 | -0.009879 | 0.039513 | -0.077266 | -0.254183 |
| ID | 0.088906 | 0.068834 | 0.118889 | 0.030635 | -0.006643 | -0.015380 | -0.033802 | 0.066089 | 0.250892 |
| AO | 0.086896 | 0.062514 | 0.159494 | 0.033105 | -0.014639 | -0.018382 | -0.004921 | -0.023972 | 0.474977 |
| T1 | -0.062314 | -0.049516 | -0.021145 | 0.003902 | 0.010864 | 0.427301 | -0.010019 | 0.007525 | 0.025159 |
| T2 | -0.068199 | -0.061412 | -0.015797 | -0.028762 | 0.006100 | 0.494301 | -0.007478 | 0.021261 | -0.015228 |
| FR | 0.088221 | 0.057712 | 0.131330 | 0.000021 | 0.022948 | -0.004831 | -0.024276 | 0.050549 | 0.042384 |
| OR | 0.085175 | 0.047980 | 0.084762 | 0.033637 | 0.001384 | -0.014488 | -0.031107 | 0.043616 | 0.097557 |
| TI | -0.053969 | -0.009628 | -0.016264 | -0.001558 | -0.010262 | 0.047934 | -0.018351 | 0.023192 | -0.0666429 |

Note. 1. ASVAB = Armed Services Vocational Aptitude Battery, ECAT = Enhanced Computer Administered Testing.

2. For each battery, "G" refers the second-order factor in a hierarchical factor analysis, and 1st P. C. is the first principal component.

3. First-order factor weights are those printed by the SAS FACTOR procedure. They are the result of multiplying the oblique factor structure matrix by the inverse of the correlation matrix of tests.

4. Weights for G were computed by multiplying the pattern matrix for G in terms of tests by the inverse of the test inter-correlation matrix. (The pattern matrix for "G" in terms of tests was computed by multiplying the pattern matrix for G in terms of first-order factors by the first-order pattern matrix.)

5. Factor scores are computed by applying the weights to the test z-scores, i.e. $Factor\ Score = \sum_{i=1}^{tests} W_i \frac{(X_i - \bar{X}_i)}{\sigma_i}$, where the means and standard deviations are range-corrected values taken from Table B-2.

Appendix D

Test Scoring and Subject Deletion Rules

Test Scoring and Subject Deletion Rules

David L. Alderton

For Mental Counters, Integrating Details, Figural Reasoning, Assembling Objects, and Spatial Orientation the final summary score was the proportion correct of the total number of items. For Sequential Memory, the final score was the proportion of digits correct (of all possible).

Subject deletion rules were by and large empirically based. For Mental Counters and Sequential Memory, Jerry Larson provided the cut scores. For Integrating Details, David Alderton provided the cut scores. For all three of these tests, the score cut values were based on the ECAT database and past empirical research. For Figural Reasoning, Assembling Objects, and Spatial Orientation the cut scores were set by David Alderton since AIR and ARI said that there were no established cut score rules or subject screening algorithms. The conservative cut scores for these tests were based on logic (subjects attempting less than 1/3 of the items were eliminated) and empirical score distributions. Cut scores for the three response pedestal tests were provided by AIR (see notes).

Mental Counters

MCPCOR < .19

MCPAT < .75

Sequential Memory

SMPDCOR < .15

SMPIAT < .65

Integrating Details

IDJP > 9

IDPAT < .75

IDPCOR/IDPCAT < .38

Figural Reasoning

SRPAT < .33

SRPCOR < (2.5/30)

Assembling Objects

AOPAT < (11/32)

AOPCOR < (2.75/32)

Spatial Orientation

ORPAT < (8/24)

ORPCOR < (2/24)

Target Identification (see attached notes on scoring response pedestal tests)

Items that time out are treated as valid but wrong,

Items with Decision Times < .1 are treated as invalid,

Items with Movement Times < .01 are treated as invalid.

If the proportion of VALID items correct < 1/3 the subject is eliminated

One- and Two-Hand Tracking (see attached notes on scoring response pedestal tests)

If two (or more) items are missing the subject is eliminated.

Notes on Response Pedestal Tests

The following is a comment from the SAS file ARISAS on the ECAT (193) IBM disk. The comments are self-explanatory. I developed the scoring code based on conversations with Scott Oppler and Dianne Steele. After writing the SAS code, I scored the same data they did (Fort Knox, I believe), faxed them the descriptive statistics, and they notified me that our results were in perfect agreement. I later gave this information (and my SAS code) to RGI who used it to create the .merge files.

```
/*=====*/
/* THESE NOTES ARE BASED ON A 4/17/92 CONVERSATION WITH */
/* SCOTT OPPLER AND DIANNE STEELE FROM AIR ON HOW THE */
/* TARGET IDENTIFICATION TEST SHOULD BE SCORED AND HOW */
/* PEOPLE SHOULD BE SCREENED. THERE IS ALSO A NOTE ON */
/* SCREENING SUBJECTS FOR THE TRACKING TESTS */
/*=====*/
/* TARGET IDENTIFICATION */
/* ^^^^^^^^^^^^^^^^^^^^^^ */
/* THE TEST SHOULD BE SCORED IN THE FOLLOWING STEPS: */
/* A. IF AN ITEM TIMES OUT, SET THE MT, DT SET TO MISS */
/* BUT SET AC TO WRONG */
/* B. IF AC IS WRONG, SET MT AND DT TO MISSING */
/* C. IF DT IS < .1 THEN SET DT, MT, ACC TO MISSING */
/* D. IF MT IS < .01 THEN SET DT, MT, ACC TO MISSING */
/* E. IF RECALCULATED ACCURACY IS < 1/3 THEN SET FINAL */
/* SCORES TO MISSING */
/* */
/* FINAL SCORES */
/* ^^^^^^^^^^^^^^^^^^ */
/* PROPORTION CORRECT (AFTER SCREENS) */
/* MEDIAN MT ACROSS ALL VALID, CORRECT ITEMS */
/* AVERAGE OF THE CLIPPED EASY MEAN DT AND THE */
/* CLIPPED HARD MEAN DT: */
/* (1) AFTER ABOVE SCREENS, SORT ITEMS BY EASY AND HARD */
/* (2) THROUGH OUT THE MIN AND MAX DTS WITHIN A GROUP */
/* (3) CALCULATE THE (CLIPPED) W/I GROUP MEAN */
/* (4) AVERAGE THE TWO CLIPPED MEANS = MDT */
/* */
/* FOLLOWING THE THREE PRACTICE ITEMS, THE EASY AND ITEM */
/* (ORDINAL) POSITIONS ARE: */
/* EASY ITEMS ARE: 1, 3, 5, 6, 7, 10, 13, 14, 15, 17, 18, */
/* 19, 23, 26, 27, 28, 30, 32, 34, 36 */
/* HARD ITEMS ARE: 2, 4, 8, 9, 11, 12, 16, 20, 21, 22, 24, */
/* 25, 29, 31, 33, 35 */
/*=====*/
/* 1 AND 2 HAND TRACKING TESTS */
/* ^^^^^^^^^^^^^^^^^^^^^^ */
/* DROP SUBJECTS THAT HAVE MORE THAN 2 MISSING ITEMS */
/* SCOTT AND DIANNE THINK THAT THE AVERAGE OF THE ITEM LEVEL */
/* SCORES, I.E., THE AVERAGE OF THE LOG[(RMS DIST) + 1], */
/* IS BEING TRUNCATED IN ECAT, SO I'LL RECALCULATE IT */
/*=====*/
```

Appendix E

Test/Retest Results for the ECAT Battery

Test/Retest Results for the ECAT Battery¹

Gerald E. Larson
David L. Alderton

There are several reasons why it is critical to conduct a test-retest analysis of new tests. First, the reliability coefficient can be used to disattenuate correlations between predictor and criterion measures, providing a better estimate of the true relationship. Second, reliability is often a consideration in decisions regarding test implementation. Third, retest studies provide information on practice effects and perhaps even on coachability. For these reasons the ECAT battery was administered twice across 4- to 5-week intervals. The details of the study are presented below.

Method

Subjects

While it would have been optimal to test military recruits, military scheduling considerations made recruit testing impractical for the current research. Thus, high school and junior college students in the San Diego vicinity were recruited as subjects, with the restrictions that subjects must be between the ages of 16 and 26, with the total sample having no more than 35% females and no less than 60% caucasians. The purpose of these restrictions was to ensure comparability between the sample and military recruits. As an incentive to participate in the study, each subject was paid \$15.00 for each test session plus a \$40.00 bonus upon completing the retest session and submitting a copy of the subjects' high school transcripts. Further details of the data collection are provided in Brantner (1992).

Three hundred and thirteen subjects (223 males, 90 females) completed both test sessions. They averaged 19.3 years-of-age, with a standard deviation of 2.8. The ethnic breakdown was as follows: 73% Caucasian, 10% Hispanic, 6% Asian, 4% Filipino, 3% African-American, 4% "Other."

¹ Presented at the Centennial Convention of the American Psychological Association; Washington, D. C., August 1992

Aptitude Tests

Each subject completed an approximately 3-hour battery of 10 computerized tests, presented on Hewlett-Packard Integral microcomputers operating under UNIX™. Nine of the 10 tests comprised the actual ECAT battery. The tenth, "Perceptual Speed," was included as a supplemental measure about which information was desired. All tests were written in standard C. Tests 1-7 below used a simplified keyboard. The keyboard was modified by using a plastic mask that revealed only the designated response keys along with a key labeled HELP that could be pressed during testing to suspend the program and request assistance. The S, F, H, K, and ; keys were relabeled as: A, B, C, D, and E. The space bar was relabeled ENTER. The numeric keypad keys retained their meanings. Tests 8-10 below (Target Identification, One-hand Tracking, and Two-hand Tracking) used a custom built "response pedestal" with response buttons, sliders, and a joy stick.

1. Integrating Details - A complex 40 item spatial problem solving test. Each item consists of two separate screens. The first screen contains from 2 to 6 regular geometric puzzle pieces that must be mentally brought together to form a completed object. This is much like a jig-saw puzzle. Having connected all of the puzzle pieces, the individual must remember the final object, then press a response key indicating that she/he is ready. Once the key is pressed, the puzzle pieces are replaced by a new screen with a single completed object. The subject must indicate if the completed object shown is a product of the original puzzle pieces. There are three dependent measures for each trial; time spent studying the puzzle pieces, time spent deciding if the completed form is valid, and response accuracy.

2. Mental Counters - Mental Counters is a complex 40 item working memory test. Each screen contains three horizontal lines, arrayed left to right. Each line represents a counter with an initial value of zero. During an item, boxes appear sequentially, one at a time, either above or below one of the three lines. If a box appears above a line, the value for that counter is incremented by +1. If a box appears below a line, that counter is decremented by -1. On each trial either 5 or 7 boxes appear. The boxes appear at one of two rates, either one every 1.33 seconds or one every .75 seconds. The subject's task is to make a series of rapid calculations and to select, from a four-alternative multiple choice menu, the set of correct final counter values. Number of correct responses is used as the summary score.

3. Sequential Memory - Sequential Memory is another complex test of working memory. Each item consists of three to five horizontally arrayed dots on the screen. Each dot is given a numerical value; these must be memorized. The item is then presented in a series of 5 to 7 "calls" to the dots; where each call is announced by briefly turning one of the dots into an "X." The person must report the digit string that corresponds to the order that the dots were "called." In the second half of the test, after all the calls for an item have been made, the examinee is told to translate each number in the ordered number list into a different number and then type in the new ordered list. There are 10 items in the first half of the test and 25 in the second half of the test. The dependent variable is the proportion

of digits correctly reported by the examinee.

4. Spatial Reasoning - A figural inductive reasoning (or series extrapolation) test, similar to the Cognitive Abilities Figural subtests. Items use a combination of geometric forms and arbitrary figures presented in a series of four frames. The subject's task is to induce the transformation rule controlling the series and then select one of five alternatives that correctly completes the series. The dependent variable is number correct across the 30 items. There is a 12 minute time limit.

5. Perceptual Speed - Perceptual Speed (Alderton, 1990) is a clerical/perceptual speed test. Each item consists of two side-by-side symbol strings of the same length. The examinee's task is to determine whether the two symbol strings are identical, and to make these judgements as rapidly as possible while maintaining 90% accuracy. Symbol string length is systematically varied from 1 to 7 elements. The test is divided into 3 subtests based on string content: Numbers (56 items), letters (56 items), or abstract stick figures (60 items). Each item type (number of elements X symbol type) has a minimum and maximum response time bracket associated with it. If an examinee responds too quickly or too slowly she/he is warned to slow down or speed up. Cumulative accuracy is retained and used in feedback after every 10-14 items. To control for speed/accuracy tradeoffs, the examinee is warned to slow down if accuracy drops below 85% or to speed up if accuracy goes above 95%. The primary dependent variable is the average rate score across the three subtests where rate is defined as the proportion correct divided by the geometric mean of item reaction times.

6. Assembling Objects - A spatial construction test. Each item consists of a frame with several (2-6) separate elements. The subject's task is to choose, from four alternatives, the answer that correctly represents how the elements should be connected. There are 32 items in the test. The first 15 items are semi-mechanical items with labels indicating how the elements should be connected. The final 17 items in the test consist of small jigsaw puzzles similar to those used in the Minnesota Paper Form Board test. There are no labels showing how the puzzle pieces are to be connected but only one of the four answer choices includes all of the puzzle elements. The dependent variable is the number of correct items solved in 16 minutes.

7. Spatial Orientation - A spatial perspective test. Each item consists of an environmental view, such as a bridge over a river or a farm house. In each view the horizon is apparent. These views are rotated away from the "natural" horizon in a frame. At the bottom of the frame is a circle with a dot on the perimeter. The subject's task is to rotate the frame around the view until it corresponds with the natural horizon of the view and determine where the dot on the circle would be located. This information is then used to select which of 5 alternatives correctly shows where the dot would be on the circle (following the rotation). The dependent variable is the number of items (of 24) solved correctly in the allotted time.

The next 3 tests use the ECAT response pedestal to input responses.

8. Target Identification - A hybrid test combining aspects of choice reaction time and spatial mental rotation tests. Each item consists of a figure in the top half of the screen and three alternative figures in the bottom half of the screen. The correct answer is the alternative (at screen bottom) that represents the same object as the standard, even though the standard may be distorted (e.g., rotated, shrunken, or both) relative to the answer choice. (Answer choices are always presented in a "natural" upright position) The examinee's task is to select the correct alternative as rapidly as possible. The figures are schematic line drawings of simple objects, such as trucks, helicopters, and tanks. Before each item the subject is required to hold down 4 "home" buttons, two on the left and two on the right. The "home" buttons are located on the sides and top of the response pedestal in such a way that one must use thumbs and forefingers to hold the buttons down, thus freezing the hands in place. While all four buttons are simultaneously depressed the item is presented. As soon as the examinee decides upon an answer, either hand may be used to press the button (on the top of the pedestal) that corresponds to the selected alternative. As soon as any of the four "home" buttons are released the alternatives are masked (blacked out). The dependent variable is the average correct decision time where decision time is defined as the time between item presentation and "home" button release. There are 36 items administered with a maximum 7 minute total test time.

9. One-Hand Tracking - A psychomotor test that uses a response pedestal. Each item begins with a "path" on the computer screen. The path is simply a contiguous string of lighted screen pixels. The path goes up/down and/or right/left, parallel with the sides of the screen and makes only 90 degree turns. At one end of the path is a diamond indicating the path's termination point. Starting at the other end is a box that travels forward along the path. The subject moves a joy-stick that controls the movement of a "cross-hair." The subject's task is to keep the cross-hair on the moving box. Items vary in terms of the length of the path which is inversely related to the speed at which the box moves (total item duration is thus constant). For each item, the "score" is the average absolute Cartesian pixel distance between the cross-hair and the moving box (a distance reading is taken every 50 msec during the item). There are 18 items. The dependent variable for the test is the average of the 18 item scores.

10. Two-Hand Tracking - Another psychomotor test that has exactly the same structure and task constraints as One-Hand Tracking described above. The only difference is that movement of the cross-hair is controlled by two slide potentiometers. One of the slides controls the horizontal (left/right) movement of the cross-hair while the second slide controls the vertical (up/down) motion of the cross hair. One hand must be used for each slide control. The slides are arranged such that the horizontal slide's physical movement is right and left while the vertical slide's physical movement is up and down. Number of items, test scoring, and final test score are the same as above.

Two test administration sequences were used, corresponding to odd and even social security numbers.

Even SSN Sequence

Sequential Memory
Spatial Reasoning
Integrating Details
One Hand Tracking
Target Identification
Two Hand Tracking
Assembling Objects
Spatial Orientation
Mental Counters
Perceptual Speed

Odd SSN Sequence

Integrating Details
Spatial Reasoning
Sequential Memory
Two Hand Tracking
Target Identification
One Hand Tracking
Mental Counters
Spatial Orientation
Assembling Objects
Perceptual Speed

Perceptual Speed was always administered last because it was not part of the ECAT battery per se.

Results

Prior to the main analyses the data were trimmed to eliminate subjects who scored 10% or more below chance on the power tests. Also, subjects were eliminated if their scores declined 50% or more from session one to session two, or if the score for either session lagged four standard deviations below the sample mean. Finally, speed test scores were discarded if accuracy was below 70%. These data editing rules were designed to eliminate unmotivated or severely impaired examinees. Upon implementing these rules, the proportion of subjects excluded from the analyses ranged from a high of 6% on Assembling Objects and Mental Counters to a low of .3% on One-hand Tracking.

Practice Effects

Descriptive statistics and practice effects for the remaining subjects are shown in Table E-1. As can be seen, practice effects (reflecting improved performance) were significant for all tests except Assembling Objects. Given the relative novelty of the experimental measures, some improvement with practice was to be expected. In many cases, however, improvements were of little practical importance despite statistical significance. For example, note the slight (less than one tenth of a standard deviation) though significant gain for the Integrating Details test. In general, score gains were greatest for speeded and/or psychomotor tests (especially Two-hand Tracking) and it is therefore this category of measures which should be the focus of concern for issues such as practice and coaching.

Table E-1

Descriptive Statistics and Practice Effects

| Variable | Session 1 | | Session 2 | | Session Difference | | |
|-----------|-----------|------|-----------|------|--------------------|-----|-----------------|
| | Mean1 | SD1 | Mean2 | SD2 | <i>t</i> Value | df | 2-tail Prob. |
| PSRATE | .709 | .089 | .753 | .101 | -12.89 | 308 | .000 |
| SEQMEM | .707 | .140 | .761 | .141 | -10.76 | 307 | .000 |
| SP_REAS | .692 | .199 | .733 | .175 | -5.22 | 295 | .000 |
| INTEGRATE | .773 | .132 | .784 | .128 | -2.24 | 306 | .026 |
| ASSEMBLE | .673 | .214 | .686 | .211 | -1.77 | 292 | .079 |
| ORIENT | .530 | .258 | .628 | .256 | -9.21 | 294 | .000 |
| COUNTERS | .781 | .160 | .795 | .183 | -2.04 | 292 | .042 |
| TARGETID | 1.66 | .568 | 1.37 | .504 | 14.99 | 310 | .000 |
| TRACK1 | 2913 | 432 | 2777 | 475 | 9.35 | 312 | .000 |
| TRACK2 | 3863 | 531 | 3549 | 619 | 21.03 | 309 | .000 |

Reliabilities

Test reliabilities are shown in Table E-2. Retest reliabilities range from .75 to .91, with a median of .81. These figures compare favorably with ASVAB retest reliabilities, which range from .63 to .88, with a median of .79 (Wolfe, in preparation). Internal consistency estimates are also quite acceptable, ranging from .78 to .97 across both sessions. In general, reliabilities were somewhat higher for speeded and/or psychomotor tests than for power tests. Since as noted above the former also showed the greatest practice effects, one may infer that practice caused an upward shift in the psychomotor score distribution without a substantial reordering of individual ranks.

Table E-2
Test Reliabilities

| Variable | Session 1 Alpha | Session 2 Alpha | Retest Reliability |
|-----------|--------------------|--------------------|-----------------------|
| PSRATE | .95 ^a | .94 ^a | .86 |
| SEQMEM | .88 | .89 | .81 |
| SP_REAS | .87 | .86 | .75 |
| INTEGRATE | .79 | .78 | .79 |
| ASSEMBLE | .87 | .89 | .83 |
| ORIENT | .89 | .90 | .75 |
| COUNTERS | .89 | .91 | .79 |
| TARGETID | .97 ^a | .97 ^a | .80 |
| TRACK1 | .97 ^a | .97 ^a | .84 |
| TRACK2 | .97 ^a | .97 ^a | .91 |

^a Split-half reliabilities.

Gender Effects

Table E-3 shows test performance as a function of gender. Females scored significantly below males on five of the ten tests; two of these tests were spatial in nature (Integrating Details and Spatial Orientation) and three were psychomotor (Target ID, One- and Two-hand Tracking). To provide a better context for these findings, it should be noted that there were no gender differences in academic standing (i.e., grade point average) within the sample, nor were there differences on the ECAT reasoning and working memory tests. Therefore, there is no reason to believe that the gender effects reflect underlying general intelligence differences rather than specific spatial and psychomotor differences.

Table E-3

Gender Differences in Test Performance

| Variable | Session 1 | | | | Session 2 | | | | Gender | | Gender x Session | |
|-----------|-----------|------|---------|------|-----------|------|---------|------|--------|-------|------------------|-------|
| | Males | | Females | | Males | | Females | | Effect | | Effect | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD | F | Prob. | F | Prob. |
| PSRATE | .707 | .092 | .716 | .082 | .750 | .104 | .760 | .092 | .76 | NS | .07 | NS |
| SEQMEM | .707 | .146 | .708 | .125 | .753 | .149 | .780 | .119 | .73 | NS | 5.42 | .02 |
| SP_REAS | .700 | .209 | .674 | .175 | .734 | .185 | .731 | .151 | .41 | NS | 1.84 | NS |
| INTEGRATE | .791 | .130 | .729 | .128 | .791 | .131 | .766 | .121 | 8.17 | .00 | 12.00 | .00 |
| ASSEMBLE | .684 | .218 | .648 | .203 | .699 | .209 | .658 | .214 | 2.22 | NS | .07 | NS |
| ORIENT | .565 | .264 | .444 | .221 | .662 | .257 | .545 | .234 | 15.78 | .00 | .03 | NS |
| COUNTERS | .794 | .153 | .750 | .172 | .799 | .186 | .783 | .176 | 2.18 | NS | 3.74 | NS |
| TARGETID | 1.560 | .548 | 1.910 | .536 | 1.260 | .447 | 1.620 | .547 | 34.69 | .00 | .00 | NS |
| TRACK1 | 2778. | 378. | 3247. | 375. | 2648. | 418. | 3096. | 457. | 91.75 | .00 | .39 | NS |
| TRACK2 | 3670. | 466. | 4334. | 359. | 3339. | 537. | 4063. | 493. | 142.10 | .00 | 3.36 | NS |

Females: Ns range from 86 to 9.
Males: Ns range from 205 to 223.

Further examination of Table E-3 reveals significant Gender by Session interactions for the Sequential Memory and Integrating Details tests. In both cases the significant interaction reflects the fact that, given practice, females improved substantially more than males on these tests. For Integrating Details, this female score gain served to diminish an initial (i.e., session 1) male advantage. For Sequential Memory, females advanced ahead of males in session 2 after equivalent performance in session 1.

Correlations

Table E-4 shows correlations of the tests with high school grade point average (GPA) and with each other. For this analysis Session 1 and Session 2 scores were averaged to create one global score per test. All variables except Target ID were significantly correlated with GPA. Prediction of GPA would seem to be strongest when based on working memory scores (i.e., Mental Counters and Sequential Memory) and mixed when based on spatial scores, with Integrating Details faring the best in the latter category. The table also shows numerous significant correlations among the experimental tests themselves. The strength and pattern of these test interrelationships is simplified via the factor pattern shown in Table E-5, which shows that the global scores for the nine ECAT tests (ignoring, for the moment, the non-ECAT perceptual speed test) cluster into two dimensions, the first representing cognitive problem solving abilities and the second representing psychomotor skills. When the data from sessions one and two are analyzed separately the same two-factor pattern emerges, suggesting that the pattern shown in Table E-5 is a fairly reliable portrayal of the dimensionality of the ECAT battery, and that limited practice does not overtly change the pattern.

Table E-4

Pearson Correlation Coefficients

| Variable | GPA | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|--------------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|
| 1. PSRATE | .20** | 1.00 | | | | | | | | |
| 2. SEQMEM | .36** | .32** | 1.00 | | | | | | | |
| 3. SP_REAS | .30** | .24** | .60** | 1.00 | | | | | | |
| 4. INTEGRATE | .35** | .19** | .58** | .65** | 1.00 | | | | | |
| 5. ASSEMBLE | .26** | .27** | .62** | .68** | .72** | 1.00 | | | | |
| 6. ORIENT | .27** | .14** | .55** | .62** | .67** | .67** | 1.00 | | | |
| 7. COUNTERS | .38** | .35** | .70** | .63** | .64** | .68** | .55** | 1.00 | | |
| 8. TARGETID | -.07 | -.28** | -.23** | -.24** | -.27** | -.33** | -.28** | -.26** | 1.00 | |
| 9. TRACK1 | -.16** | -.23** | -.33** | -.45** | -.46** | -.43** | -.43** | -.42** | .37** | 1.00 |
| 10. TRACK2 | -.11* | -.21** | -.33** | -.41** | -.48** | -.46** | -.47** | -.41** | .44** | .84** |

* p < .05

** p < .01

Table E-5

Factor Analysis of ECAT Tests

| Variable | g Factor | Varimax Rotated | |
|-----------|----------|-----------------|-------------|
| | | Problem Solving | Psychomotor |
| SEQMEM | .72 | .79 | -.09 |
| SP_REAS | .79 | .80 | -.21 |
| INTEGRATE | .82 | .78 | -.29 |
| ASSEMBLE | .85 | .82 | -.29 |
| ORIENT | .78 | .75 | -.27 |
| COUNTERS | .79 | .81 | -.19 |
| TARGETID | -.47 | -.14 | .66 |
| TRACK1 | -.67 | -.24 | .88 |
| TRACK2 | -.69 | -.27 | .89 |

54% of Variance accounted for by g.

Discussion And Conclusions

Results from our test/retest administration of the ECAT battery are, for the most part, highly encouraging. Test reliabilities are at least as good as those for the operational ASVAB, and although the present study was not specifically designed as a validation effort the correlations of ECAT tests with high school GPA were numerous and highly significant. The latter result supports an optimistic prognosis for test validities in military education and training settings.

Of concern in the present study are the significant practice effects observed for nearly all tests, and the female score deficit observed on some spatial tests and all psychomotor tests. These issues should be addressed by follow-on research prior to operational use of ECAT tests. An important question is whether adding more practice items at the beginning of the tests can stabilize performance prior to the administration of operational items. With regard to gender differences, follow-on analyses must include actual military criterion performance measures. For example, if females under-perform (relative to males) on criterion as well as predictor measures then the latter deficit does not reflect test bias. A finding of gender equivalence on the criteria would, however, suggest that the test is a biased predictor and that alternative tests or administration formats must be sought.

Appendix F

Group Differences in the ECAT Validity Study

Group Differences in the ECAT Validity Study

David L. Alderton

Subjects were divided into six ethnic groups: White, Black, Asian, Hispanic, North American Indian, and Other. The categories are a combination of the population and ethnic group codes taken from enlistment records. White was defined by the population code Caucasian (C) and the ethnic code none (Y). Black was defined by the population code Negroid/African/Black (N) unless a Hispanic ethnic code was also checked (then the person would be defined as Hispanic, see below). The Asian group was defined by the population code Asian/Mongoloid/Yellow (M) and/or ethnic codes for other Asian descent (3), Filipino (5), Chinese (G), Japanese (J), Korean (K), Vietnamese (V), Melanesian (E), Micronesian (W), Polynesian (L), and other Pacific Island descent (Q). Regardless of the population code, the Hispanic group was defined by ethnic codes for other Hispanic descent (1), Puerto Rican (4), Mexican (6), Cuban (9), and Latin American with Hispanic descent (S). The North American Indian group was defined by the population code for American Indian/Red (R) and by ethnic codes for U.S./Canadian Indian Tribes (2), Eskimo (7), and Aleut (8). A final group labeled Other was created from the population code Other (X) and the ethnic codes Other (X) (unless Caucasian), Indian (from India; D), and Unknown (Z). The distribution of subjects across the six ethnic groups was:

| Group | N | Percent |
|----------------|-------|---------|
| White | 7636 | 71.1 |
| Black | 1771 | 16.5 |
| Asian | 241 | 2.2 |
| Hispanic | 631 | 5.9 |
| No. Am. Indian | 85 | 0.8 |
| Other/Unknown | 369 | 3.4 |
| Total | 10733 | 100 |

For the analyses that follow, the North American Indian group was eliminated because the sample size was too small to be meaningful. The Other category was also eliminated since the results could not be interpreted.

Entries in the following table were computed in several steps. First, for each of the 10 ASVAB tests and 9 ECAT tests, z-scores were computed by taking the first named ethnic group's mean minus the second named ethnic group's mean, divided by the standard deviation from the total sample. Second, the within test battery median, mean, minimum, maximum, and range of z-scores were computed: these are the entries in the Table. For example, the first entry (.727) is the median z-score advantage of Whites (since it is positive) over Blacks across the ten

ASVAB tests. For the ECAT tests, the median advantage of Whites over Blacks is .656 z-score units. (Note that for the ECAT tests, the three response pedestal tests [Target Identification, One- and Two-Hand Tracking] use speed and error scores so the sign of these z-scores were reflected to properly indicate which group had the advantage before descriptive statistics were calculated.)

| | | Median | Mean | Minimum | Maximum | Range |
|-------------|-------|--------|-------|---------|---------|-------|
| White minus | ASVAB | .727 | .588 | .023 | 1.106 | 1.083 |
| Black | ECAT | .656 | .615 | .445 | .729 | .284 |
| White minus | ASVAB | .367 | .289 | -.396 | .829 | 1.225 |
| Asian | ECAT | .139 | .144 | -.100 | .400 | .508 |
| White minus | ASVAB | .314 | .299 | -.017 | .638 | .655 |
| Hispanic | ECAT | .116 | .137 | .026 | .248 | .222 |
| Black minus | ASVAB | -.246 | -.299 | -.566 | .020 | .586 |
| Asian | ECAT | -.443 | -.470 | -.756 | -.085 | .671 |
| Black minus | ASVAB | -.320 | -.288 | -.486 | -.001 | .467 |
| Hispanic | ECAT | -.539 | -.478 | -.615 | -.197 | .418 |
| Asian minus | ASVAB | -.002 | .011 | -.224 | .379 | .603 |
| Hispanic | ECAT | .087 | -.007 | -.266 | .189 | .455 |

Paying close attention to the sign of the z-scores reveals several facts about the test batteries and ethnic groups. Whites outperform all ethnic groups on both batteries, but the median ethnic difference is higher for ASVAB than ECAT in all cases. All ethnic groups outperformed Blacks on both test batteries. While the ECAT battery produces a smaller median advantage for Whites over the other ethnic groups in comparison with the ASVAB, ECAT does produce slightly larger differences among Black, Asian, and Hispanic groups relative to one another (and the ASVAB). That is, ECAT reduces the advantage of the majority group (White) but it increases the differentiation among minority groups. However, concerns over adverse impact and group differences invariably focus only on majority-minority comparisons.

In terms of individual tests within the ASVAB, clearly the largest consistent differences appear for Auto-Shop Information where Whites have an advantage ranging from 1.106 to .638 standard deviation units over the other groups. The ASVAB math tests provided the largest advantage for Asians over Black (Arithmetic Reasoning) and Hispanic (Math Knowledge) groups. The largest Hispanic advantage over Blacks was also for the Auto-Shop Information test. For the individual ECAT tests, no one test consistently differentiated any of the groups

across the six comparisons. Indeed, six different tests produced the largest z-score difference in the six comparisons.

More detailed information follow these pages. The next two pages contain the variable names and descriptions used in the analyses. The variables include years of education, educational level, and dominant language as demographics, then test scores from the ASVAB and ECAT batteries. Following that are the six pairwise group comparison analyses (White-Black, White-Asian, White-Hispanic, Black-Asian, Black-Hispanic, Asian-Hispanic). Each group comparison is contained in a two-page table. The ASVAB variables included the ten subtest standard scores, AFQT, and VE. For the ECAT tests, at least the following variables were looked at: time spent in instructions, time spent on the test, average item response times, proportion of items attempted, and proportion correct. Generally, the results converge: if a group does less well on proportion correct, they spent more time in the instructions and in the test, had longer item response times, and when there was variation in the number of items attempted, they attempted fewer. The nine ECAT scores that should be focused on are: IDPCOR (Integrating Details Proportion Correct), MCPCOR (Mental Counters Proportion Correct), ORPCOR (Spatial Orientation Proportion Correct), SMPDCOR (Sequential Memory Proportion of Digits Correct), SRPCOR (Spatial/Figural Reasoning Proportion Correct), AOPCOR (Assembling Objects Proportion Correct), TIDDT (Target Identification Decision Time), T1MN (One-Hand Tracking Mean $1000 * \text{Log}(1 + \text{RMS})$); a distance off-target measure, i.e., an error score), and T2MN (Two-Hand Tracking error score).

The remaining pages of this letter report consist of:

- A. List of the variables and their abbreviations used in the analyses (2 pages, F4-F5)
- B. White vs. Black comparisons (2 pages, F6-F7)
- C. White vs. Asian comparisons (2 pages, F8-F9)
- D. White vs. Hispanic comparisons (2 pages, F10-F11)
- E. Black vs. Asian comparisons (2 pages, F12-F13)
- F. Black vs. Hispanic comparisons (2 pages, F14-F15)
- G. Asian vs. Hispanic comparisons (2 pages, F16-F17)

| Variable | Variable Description |
|----------|--|
| YRSED | YEARS OF EDUCATION |
| EDLEV | EDUCATION LEVEL |
| LANG | LANGUAGE |
| AFQT1 | PRE-ENLISTMENT AFQT PERCENTILE SCORE |
| GS1 | PRE-ENLISTMENT GS STANDARD SCORE |
| AR1 | PRE-ENLISTMENT AR STANDARD SCORE |
| WK1 | PRE-ENLISTMENT WK STANDARD SCORE |
| PC1 | PRE-ENLISTMENT PC STANDARD SCORE |
| NO1 | PRE-ENLISTMENT NO STANDARD SCORE |
| CS1 | PRE-ENLISTMENT CS STANDARD SCORE |
| AS1 | PRE-ENLISTMENT AS STANDARD SCORE |
| MK1 | PRE-ENLISTMENT MK STANDARD SCORE |
| MC1 | PRE-ENLISTMENT MC STANDARD SCORE |
| EI1 | PRE-ENLISTMENT EI STANDARD SCORE |
| VE1 | PRE-ENLISTMENT VE STANDARD SCORE |
| IDIT | ID INSTRUCTION TIME (IN SECONDS) |
| IDTT | ID TESTING TIME (IN SECONDS) |
| IDDT | ID GEOMETRIC MEAN DECISION LATENCY |
| IDCT | ID GEOMETRIC MEAN COMPONENT LATENCY |
| IDPAT | ID PROPORTION OF ITEMS ATTEMPTED |
| IDPCOR | ID PROPORTION OF TEST ITEMS CORRECT |
| MCIT | MC INSTRUCTION TIME (IN SECONDS) |
| MCTT | MC TESTING TIME (IN SECONDS) |
| MCRT | MC ARITHMETIC MEAN ITEM RESPONSE LATENCY |
| MCPAT | MC PROPORTION OF ITEMS ATTEMPTED |
| MCPCOR | MC PROPORTION OF ITEMS CORRECT |
| ORIT | OR INSTRUCTION TIME (IN SECONDS) |
| ORTT | OR TESTING TIME (IN SECONDS) |
| ORRT | OR ARITHMETIC MEAN ITEM RESPONSE LATENCY |
| ORPAT | OR PROPORTION OF ITEMS ATTEMPTED |
| ORPCOR | OR PROPORTION OF ITEMS CORRECT |

| Variable | Variable Description |
|----------|--|
| SMIT | SM INSTRUCTION TIME (IN SECONDS) |
| SMTT | SM TESTING TIME (IN SECONDS) |
| SMRT | SM AVERAGE ITEM RESPONSE LATENCY |
| SMPIAT | SM PROPORTION OF DIGITS ATTEMPTED |
| SMPICOR | SM PROPORTION WITH ALL 5 DIGITS CORRECT |
| SMPDCOR | SM PROPORTION DIGITS ENTERED CORRECTLY |
| SRIT | SR INSTRUCTION TIME (IN SECONDS) |
| SRTT | SR TESTING TIME (IN SECONDS) |
| SRRT | SR ARITHMETIC MEAN ITEM RESPONSE LATENCY |
| SRPAT | SR PROPORTION OF TEMS ATTEMPTED |
| SRPCOR | SR PROPORTION OF TEST ITEMS CORRECT |
| AOIT | AO INSTRUCTION TIME (IN SECONDS) |
| AOTT | AO TESTING TIME (IN SECONDS) |
| AORT | AO ARITHMETIC MEAN ITEM RESPONSE LATENCY |
| AOPAT | AO PROPORTION OF ITEMS ATTEMPTED |
| AOPCOR | AO PROPORTION OF ALL ITEMS CORRECT |
| TIDIT | TID INSTRUCTION TIME (IN SECONDS) |
| TIDTT | TID TESTING TIME (IN SECONDS) |
| TIDAT | TARGET ID NUMBER OF VALID ATTEMPTS |
| TIDCOR | TARGET ID NUMBER OF VALID ITEMS CORRECT |
| TIDDT | TARGET ID MEAN CLIPPED DECISION RTS |
| TIDMT | TARGET ID MEDIAN VALID MOVEMENT TIME |
| T1IT | TR1 INSTRUCTION TIME (IN SECONDS) |
| T1TT | TR1 TESTING TIME (IN SECONDS) |
| T1NAT | TRACK1 NUMBER VALID ITEM ATTEMPTS |
| T1MN | TRACK1 MEAN $1000 * \log(1 + \text{RMS}(\text{ATTEMPTED}))$ |
| T1RMS | TRACK1 AVERAGE RMS DISTANCE OFF TARGET |
| T1SD | TRACK1 SD OF $1000 * \log(1 + \text{RMS}(\text{ATTEMPTED}))$ |
| T2IT | TR2 INSTRUCTION TIME (IN SECONDS) |
| T2TT | TR2 TESTING TIME (IN SECONDS) |
| T2NAT | TRACK2 NUMBER VALID/SCORED ITEM ATTEMPTS |
| T2MN | TRACK2 MEAN $1000 * \log(1 + \text{RMS}(\text{ATTEMPTED}))$ |
| T2RMS | TRACK2 AVERAGE RMS DISTANCE OFF TARGET |
| T2SD | TRACK2 SD OF $1000 * \log(1 + \text{RMS}(\text{ATTEMPTED}))$ |

| Variable | All | | White | | Black | | Z | t |
|----------|---------|---------|---------|---------|---------|---------|--------|---------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| YRSED | 11.947 | 0.843 | 11.944 | 0.860 | 11.993 | 0.703 | -0.058 | -2.230 |
| EDLEV | 1.939 | 0.665 | 1.941 | 0.672 | 1.921 | 0.607 | 0.030 | 1.131 |
| LANG | 1.047 | 0.333 | 1.022 | 0.240 | 1.020 | 0.209 | 0.006 | 0.318 |
| AFQTI | 60.291 | 18.004 | 63.289 | 17.751 | 50.032 | 15.192 | 0.736 | 29.009 |
| GSI | 52.901 | 7.435 | 54.364 | 6.936 | 48.280 | 7.067 | 0.818 | 33.085 |
| ARI | 53.310 | 6.943 | 54.400 | 6.779 | 49.173 | 6.119 | 0.753 | 29.709 |
| WK1 | 52.866 | 5.377 | 53.883 | 4.880 | 49.926 | 5.463 | 0.736 | 29.988 |
| PC1 | 53.091 | 5.740 | 53.779 | 5.408 | 50.822 | 6.082 | 0.515 | 20.201 |
| NO1 | 54.077 | 6.629 | 54.083 | 6.610 | 53.930 | 6.779 | 0.023 | 0.872 |
| CS1 | 53.095 | 6.926 | 53.274 | 6.861 | 52.293 | 7.246 | 0.142 | 5.355 |
| AS1 | 53.479 | 8.059 | 55.626 | 7.372 | 46.714 | 6.398 | 1.106 | 46.862 |
| MK1 | 54.816 | 6.926 | 54.967 | 7.194 | 53.834 | 6.011 | 0.164 | 6.138 |
| MC1 | 54.613 | 7.745 | 56.165 | 7.358 | 49.188 | 6.802 | 0.901 | 36.395 |
| EI1 | 52.310 | 7.917 | 53.609 | 7.657 | 47.913 | 7.224 | 0.719 | 28.455 |
| VE1 | 53.041 | 5.113 | 53.992 | 4.669 | 50.234 | 5.111 | 0.735 | 29.915 |
| IDIT | 415.618 | 124.096 | 399.628 | 110.441 | 466.671 | 152.415 | -0.540 | -20.943 |
| IDTT | 883.350 | 329.687 | 852.722 | 306.326 | 957.900 | 379.784 | -0.319 | -12.212 |
| IDDT | 2.886 | 0.806 | 2.787 | 0.696 | 3.207 | 1.017 | -0.521 | -20.441 |
| IDCT | 12.582 | 5.737 | 12.139 | 5.154 | 13.590 | 7.180 | -0.253 | -9.684 |
| IDPAT | 0.995 | 0.038 | 0.997 | 0.028 | 0.989 | 0.061 | 0.211 | 8.163 |
| IDPCOR | 0.754 | 0.129 | 0.771 | 0.123 | 0.677 | 0.126 | 0.729 | 27.246 |
| MCIT | 316.175 | 86.308 | 304.433 | 75.190 | 359.543 | 113.640 | -0.639 | -24.538 |
| MCTT | 583.965 | 72.991 | 575.217 | 67.243 | 617.073 | 86.139 | -0.573 | -21.936 |
| MCRT | 5.026 | 1.591 | 4.870 | 1.449 | 5.773 | 1.959 | -0.568 | -9.952 |
| MCPAT | 1.00 | 0.015 | 1.00 | 0.012 | 0.999 | 0.024 | 0.067 | 2.485 |
| MCPCOR | 0.718 | 0.180 | 0.739 | 0.172 | 0.621 | 0.184 | 0.656 | 25.084 |
| ORIT | 302.231 | 92.953 | 290.645 | 87.810 | 341.029 | 100.075 | -0.542 | -20.843 |
| ORIT | 340.486 | 92.540 | 333.076 | 87.630 | 358.716 | 102.610 | -0.277 | -10.560 |
| ORRT | 14.090 | 4.000 | 13.752 | 3.728 | 14.942 | 4.597 | -0.297 | -11.371 |
| ORPAT | 0.999 | 0.016 | 0.999 | 0.013 | 0.997 | 0.025 | 0.125 | 4.675 |
| ORPCOR | 0.510 | 0.248 | 0.544 | 0.247 | 0.372 | 0.198 | 0.694 | 26.444 |

| Variable | All | | White | | Black | | Z | t |
|----------|---------|---------|---------|---------|---------|---------|--------|---------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| SMIT | 435.323 | 200.754 | 403.400 | 177.446 | 537.521 | 223.650 | -0.668 | -26.766 |
| SMTT | 959.016 | 146.053 | 938.342 | 131.968 | 1018.79 | 159.099 | -0.551 | -21.840 |
| SMRT | 1.717 | 0.661 | 1.621 | 0.560 | 2.034 | 0.832 | -0.625 | -11.519 |
| SMPIAT | 0.997 | 0.029 | 0.999 | 0.024 | 0.994 | 0.038 | 0.172 | 6.862 |
| SMPICOR | 0.436 | 0.184 | 0.455 | 0.184 | 0.374 | 0.172 | 0.440 | 16.630 |
| SMPDCOR | 0.683 | 0.137 | 0.697 | 0.134 | 0.636 | 0.142 | 0.445 | 16.765 |
| SRIT | 163.657 | 71.791 | 154.186 | 64.014 | 193.363 | 87.179 | -0.546 | -21.203 |
| SRIT | 574.197 | 118.696 | 564.277 | 117.913 | 599.163 | 119.241 | -0.294 | -11.022 |
| SRRT | 18.812 | 4.883 | 18.350 | 4.489 | 20.080 | 5.758 | -0.354 | -13.584 |
| SRPAT | 0.984 | 0.062 | 0.988 | 0.053 | 0.969 | 0.085 | 0.306 | 11.755 |
| SRPCOR | 0.658 | 0.194 | 0.682 | 0.185 | 0.576 | 0.200 | 0.546 | 20.991 |
| AOIT | 214.630 | 68.918 | 208.183 | 66.369 | 234.964 | 76.975 | -0.389 | -14.594 |
| AOTT | 599.530 | 138.005 | 596.453 | 134.946 | 597.908 | 155.889 | -0.011 | -0.390 |
| AORT | 18.748 | 5.812 | 18.404 | 5.231 | 19.649 | 7.780 | -0.214 | -8.015 |
| AOPAT | 0.972 | 0.082 | 0.980 | 0.067 | 0.944 | 0.124 | 0.439 | 16.614 |
| AOPCOR | 0.620 | 0.195 | 0.646 | 0.190 | 0.507 | 0.179 | 0.713 | 27.566 |
| TIDIT | 126.386 | 38.638 | 121.976 | 35.381 | 138.735 | 44.758 | -0.434 | -16.761 |
| TIDTT | 158.130 | 42.534 | 153.760 | 37.574 | 172.077 | 51.540 | -0.431 | -16.853 |
| TIDAT | 31.442 | 6.825 | 31.207 | 6.887 | 32.347 | 6.425 | -0.167 | -6.242 |
| TIDCOR | 29.791 | 7.133 | 29.630 | 7.135 | 30.352 | 7.011 | -0.101 | -3.781 |
| TIDDT | 1.857 | 0.625 | 1.791 | 0.570 | 2.094 | 0.737 | -0.485 | -18.655 |
| TIDMT | 0.350 | 0.150 | 0.341 | 0.135 | 0.380 | 0.194 | -0.260 | -9.821 |
| TIIT | 184.165 | 45.812 | 180.307 | 42.331 | 195.618 | 54.597 | -0.334 | -12.731 |
| TITT | 225.515 | 7.996 | 225.480 | 7.667 | 225.380 | 6.414 | 0.013 | 0.501 |
| TINAT | 17.992 | 0.320 | 17.989 | 0.379 | 17.999 | 0.034 | -0.031 | -1.092 |
| TIMN | 2772.92 | 402.89 | 2728.97 | 368.572 | 2956.49 | 479.32 | -0.565 | -21.669 |
| TIRMS | 18.881 | 11.867 | 17.688 | 10.291 | 23.843 | 15.893 | -0.519 | -19.877 |
| TISD | 383.731 | 113.471 | 379.052 | 110.989 | 412.109 | 126.899 | -0.291 | -10.807 |
| T2IT | 141.582 | 36.627 | 139.589 | 34.919 | 148.125 | 42.535 | -0.233 | -8.737 |
| T2TT | 225.550 | 8.916 | 225.479 | 7.842 | 225.814 | 11.607 | -0.038 | -1.441 |
| T2NAT | 17.995 | 0.223 | 17.994 | 0.243 | 17.994 | 0.219 | 0.000 | 0.000 |
| T2MN | 3645.07 | 476.94 | 3579.64 | 457.75 | 3913.79 | 469.53 | -0.701 | -27.106 |
| T2RMS | 49.067 | 23.462 | 45.771 | 21.448 | 62.701 | 26.843 | -0.722 | -27.997 |
| T2SD | 415.329 | 89.205 | 414.958 | 88.966 | 420.915 | 90.341 | -0.067 | -2.491 |

| Variable | All | | White | | Asian | | Z | t |
|----------|---------|---------|---------|---------|---------|---------|--------|---------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| YRSED | 11.947 | 0.843 | 11.944 | 0.860 | 12.187 | 0.914 | -0.288 | 4.310 |
| EDLEV | 1.939 | 0.665 | 1.941 | 0.672 | 1.765 | 0.675 | 0.265 | 3.944 |
| LANG | 1.047 | 0.333 | 1.022 | 0.240 | 1.684 | 1.247 | -1.988 | -31.007 |
| AFQTI | 60.291 | 18.004 | 63.289 | 17.751 | 57.854 | 18.959 | 0.302 | 4.660 |
| GS1 | 52.901 | 7.435 | 54.364 | 6.936 | 49.837 | 8.050 | 0.609 | 9.903 |
| ARI | 53.310 | 6.943 | 54.400 | 6.779 | 53.100 | 6.850 | 0.187 | 2.924 |
| WK1 | 52.866 | 5.377 | 53.883 | 4.880 | 49.821 | 7.412 | 0.755 | 12.451 |
| PC1 | 53.091 | 5.740 | 53.779 | 5.408 | 51.629 | 7.068 | 0.375 | 6.000 |
| NO1 | 54.077 | 6.629 | 54.083 | 6.610 | 55.333 | 6.377 | -0.189 | -2.888 |
| CS1 | 53.095 | 6.926 | 53.274 | 6.861 | 53.783 | 6.731 | -0.073 | -1.132 |
| AS1 | 53.479 | 8.059 | 55.626 | 7.372 | 48.946 | 7.202 | 0.829 | 13.831 |
| MK1 | 54.816 | 6.926 | 54.967 | 7.194 | 57.708 | 6.375 | -0.396 | -5.831 |
| MCI | 54.613 | 7.745 | 56.165 | 7.358 | 52.833 | 7.350 | 0.430 | 6.908 |
| EI1 | 52.310 | 7.917 | 53.609 | 7.657 | 50.775 | 8.006 | 0.358 | 5.638 |
| VE1 | 53.041 | 5.113 | 53.992 | 4.669 | 50.392 | 6.953 | 0.704 | 11.549 |
| IDIT | 415.618 | 124.096 | 399.628 | 110.441 | 433.209 | 136.102 | -0.271 | -4.543 |
| IDTT | 883.350 | 329.687 | 852.722 | 306.326 | 957.051 | 339.782 | -0.316 | -5.111 |
| IDDT | 2.886 | 0.806 | 2.787 | 0.696 | 3.118 | 1.169 | -0.411 | -6.971 |
| IDCT | 12.582 | 5.737 | 12.139 | 5.154 | 13.573 | 6.000 | -0.250 | -4.168 |
| IDPAT | 0.995 | 0.038 | 0.997 | 0.028 | 0.993 | 0.041 | 0.105 | 2.115 |
| IDPCOR | 0.754 | 0.129 | 0.771 | 0.123 | 0.774 | 0.124 | -0.023 | -0.351 |
| MCIT | 316.175 | 86.308 | 304.433 | 75.190 | 317.551 | 67.673 | -0.152 | -2.635 |
| MCTT | 583.965 | 72.991 | 575.217 | 67.243 | 583.667 | 55.983 | -0.116 | -1.901 |
| MCRT | 5.026 | 1.591 | 4.870 | 1.449 | 5.155 | 1.202 | -0.179 | -1.593 |
| MCPAT | 1.00 | 0.015 | 1.00 | 0.012 | 1.000 | 1.000 | 0.000 | 0.000 |
| MPCOR | 0.718 | 0.180 | 0.739 | 0.172 | 0.757 | 0.165 | -0.100 | -1.575 |
| ORIT | 302.231 | 92.953 | 290.645 | 87.810 | 310.051 | 80.126 | -0.209 | -3.337 |
| ORIT | 340.486 | 92.540 | 333.076 | 87.630 | 369.103 | 99.403 | -0.389 | -6.165 |
| ORRT | 14.090 | 4.000 | 13.752 | 3.728 | 15.280 | 4.316 | -0.382 | -6.141 |
| ORPAT | 0.999 | 0.016 | 0.999 | 0.013 | 0.998 | 0.016 | 0.062 | 1.149 |
| ORPCOR | 0.510 | 0.248 | 0.544 | 0.247 | 0.503 | 0.250 | 0.165 | 2.451 |

| Variable | All | | White | | Asian | | Z | t |
|----------|---------|---------|---------|---------|---------|---------|--------|---------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| SMIT | 435.323 | 200.75 | 403.40 | 177.45 | 469.35 | 231.4 | -0.329 | -5.538 |
| SMTT | 959.02 | 146.05 | 938.34 | 131.97 | 1027.53 | 179.78 | -0.611 | -10.047 |
| SMRT | 1.717 | 0.661 | 1.621 | 0.560 | 2.097 | 0.782 | -0.720 | -6.754 |
| SMPDAT | 0.997 | 0.029 | 0.999 | 0.024 | 0.996 | 0.018 | 0.103 | 1.895 |
| SMPICOR | 0.436 | 0.184 | 0.455 | 0.184 | 0.417 | 0.186 | 0.207 | 3.109 |
| SMPDCOR | 0.683 | 0.137 | 0.697 | 0.134 | 0.678 | 0.135 | 0.139 | 2.135 |
| SRIT | 163.657 | 71.791 | 154.186 | 64.014 | 170.004 | 74.783 | -0.220 | -3.701 |
| SRIT | 574.197 | 118.696 | 564.277 | 117.913 | 620.799 | 101.430 | -0.476 | -7.248 |
| SRRT | 18.812 | 4.883 | 18.350 | 4.489 | 20.905 | 5.448 | -0.523 | -8.511 |
| SRPAT | 0.984 | 0.062 | 0.988 | 0.053 | 0.966 | 0.085 | 0.355 | 6.106 |
| SRPCOR | 0.658 | 0.194 | 0.682 | 0.185 | 0.662 | 0.190 | 0.103 | 1.627 |
| AOIT | 214.630 | 68.918 | 208.183 | 66.369 | 208.718 | 54.285 | -0.008 | -0.122 |
| AOIT | 599.530 | 138.005 | 596.453 | 134.946 | 627.496 | 116.370 | -0.225 | -3.478 |
| AORT | 18.748 | 5.812 | 18.404 | 5.231 | 19.725 | 4.894 | -0.227 | -3.811 |
| AOPAT | 0.972 | 0.082 | 0.980 | 0.067 | 0.965 | 0.078 | 0.183 | 3.354 |
| AOPCOR | 0.620 | 0.195 | 0.646 | 0.190 | 0.644 | 0.184 | 0.010 | 0.159 |
| TIDIT | 126.386 | 38.638 | 121.976 | 35.381 | 139.444 | 52.710 | -0.452 | -7.301 |
| TIDTT | 158.130 | 42.534 | 153.760 | 37.574 | 170.333 | 56.155 | -0.390 | -6.521 |
| TIDAT | 31.442 | 6.825 | 31.207 | 6.887 | 32.410 | 6.067 | -0.176 | -2.640 |
| TIDCOR | 29.791 | 7.133 | 29.630 | 7.135 | 30.368 | 6.863 | -0.103 | -1.559 |
| TIDDT | 1.857 | 0.625 | 1.791 | 0.570 | 2.041 | 0.729 | -0.400 | -6.502 |
| TIDMT | 0.350 | 0.150 | 0.341 | 0.135 | 0.348 | 0.121 | -0.047 | -0.778 |
| T1IT | 184.165 | 45.812 | 180.307 | 42.331 | 186.791 | 45.874 | -0.142 | -2.301 |
| T1TT | 225.515 | 7.996 | 225.480 | 7.667 | 226.850 | 14.732 | -0.171 | -2.587 |
| T1NAT | 17.992 | 0.320 | 17.989 | 0.379 | 17.996 | 0.065 | -0.022 | -0.282 |
| T1MNI | 2772.92 | 402.89 | 2728.97 | 368.572 | 2846.66 | 492.87 | -0.292 | -4.752 |
| T1RMS | 18.881 | 11.867 | 17.688 | 10.291 | 21.314 | 15.028 | -0.306 | -5.217 |
| T1SD | 383.731 | 113.471 | 379.052 | 110.989 | 368.839 | 93.150 | 0.090 | 1.392 |
| T2IT | 141.582 | 36.627 | 139.589 | 34.919 | 141.880 | 40.535 | -0.063 | -0.983 |
| T2TT | 225.550 | 8.916 | 225.479 | 7.842 | 225.607 | 4.994 | -0.014 | -0.248 |
| T2NAT | 17.995 | 0.223 | 17.994 | 0.243 | 18.000 | 1.000 | -0.027 | -0.305 |
| T2MNI | 3645.07 | 476.94 | 3579.64 | 457.75 | 3729.56 | 517.478 | -0.314 | -4.912 |
| T2RMS | 49.067 | 23.462 | 45.771 | 21.448 | 54.010 | 26.864 | -0.351 | -5.736 |
| T2SD | 415.329 | 89.205 | 414.958 | 88.966 | 396.848 | 81.750 | 0.203 | 3.073 |

| Variable | All | | White | | Hispanic | | Z | t |
|----------|---------|---------|---------|---------|----------|---------|--------|--------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| YRSED | 11.947 | 0.843 | 11.944 | 0.860 | 11.832 | 0.882 | 0.133 | 3.138 |
| EDLEV | 1.939 | 0.665 | 1.941 | 0.672 | 2.038 | 0.749 | -0.146 | -3.398 |
| LANG | 1.047 | 0.333 | 1.022 | 0.240 | 1.100 | 0.316 | -0.234 | -7.513 |
| AFQTI | 60.291 | 18.004 | 63.289 | 17.751 | 56.620 | 15.770 | 0.370 | 9.143 |
| GSI | 52.901 | 7.435 | 54.364 | 6.936 | 50.835 | 7.439 | 0.475 | 12.212 |
| ARI | 53.310 | 6.943 | 54.400 | 6.779 | 52.368 | 6.653 | 0.293 | 7.246 |
| WK1 | 52.866 | 5.377 | 53.883 | 4.880 | 51.024 | 5.469 | 0.532 | 14.006 |
| PC1 | 53.091 | 5.740 | 53.779 | 5.408 | 52.523 | 5.891 | 0.219 | 5.567 |
| NO1 | 54.077 | 6.629 | 54.083 | 6.610 | 53.937 | 6.651 | 0.022 | 0.533 |
| CS1 | 53.095 | 6.926 | 53.274 | 6.861 | 52.922 | 6.722 | 0.051 | 1.240 |
| AS1 | 53.479 | 8.059 | 55.626 | 7.372 | 50.488 | 7.884 | 0.638 | 16.733 |
| MK1 | 54.816 | 6.926 | 54.967 | 7.194 | 55.086 | 5.607 | -0.017 | -0.405 |
| MC1 | 54.613 | 7.745 | 56.165 | 7.358 | 52.758 | 7.411 | 0.440 | 11.171 |
| EI1 | 52.310 | 7.917 | 53.609 | 7.657 | 50.889 | 7.983 | 0.344 | 8.547 |
| VE1 | 53.041 | 5.113 | 53.992 | 4.669 | 51.477 | 5.194 | 0.492 | 12.887 |
| IDIT | 415.618 | 124.096 | 399.628 | 110.441 | 439.551 | 127.728 | -0.322 | -8.473 |
| IDTT | 883.350 | 329.687 | 852.722 | 306.326 | 976.003 | 352.798 | -0.374 | -9.437 |
| IDDT | 2.886 | 0.806 | 2.787 | 0.696 | 2.985 | 0.836 | -0.246 | -6.642 |
| IDCT | 12.582 | 5.737 | 12.139 | 5.154 | 14.050 | 6.056 | -0.333 | -8.676 |
| IDPAT | 0.995 | 0.038 | 0.997 | 0.028 | 0.994 | 0.040 | 0.079 | 2.448 |
| IDPCOR | 0.754 | 0.129 | 0.771 | 0.123 | 0.756 | 0.128 | 0.116 | 2.785 |
| MCIT | 316.175 | 86.308 | 304.433 | 75.190 | 328.637 | 86.239 | -0.280 | -7.557 |
| MCTT | 583.965 | 72.991 | 575.217 | 67.243 | 590.666 | 63.689 | -0.212 | -5.479 |
| MCRT | 5.026 | 1.591 | 4.870 | 1.449 | 5.380 | 1.674 | -0.321 | -4.350 |
| MCPAT | 1.00 | 0.015 | 1.00 | 0.012 | 1.000 | 1.000 | 0.000 | 0.000 |
| MPCOR | 0.718 | 0.180 | 0.739 | 0.172 | 0.723 | 0.169 | 0.089 | 2.209 |
| ORIT | 302.231 | 92.953 | 290.645 | 87.810 | 319.291 | 92.960 | -0.308 | -7.714 |
| ORRT | 340.486 | 92.540 | 333.076 | 87.630 | 359.624 | 96.764 | -0.287 | -7.137 |
| ORRT | 14.090 | 4.000 | 13.752 | 3.728 | 14.883 | 4.185 | -0.283 | -7.136 |
| ORPAT | 0.999 | 0.016 | 0.999 | 0.013 | 0.999 | 0.016 | 0.000 | 0.000 |
| ORPCOR | 0.510 | 0.248 | 0.544 | 0.247 | 0.502 | 0.242 | 0.169 | 4.010 |

| Variable | All | | White | | Hispanic | | Z | t |
|----------|---------|---------|---------|---------|----------|---------|--------|---------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| SMIT | 435.323 | 200.754 | 403.400 | 177.446 | 467.337 | 212.544 | -0.318 | -8.421 |
| SMTT | 959.016 | 146.053 | 938.342 | 131.968 | 1008.76 | 181.026 | -0.482 | -12.270 |
| SMRT | 1.717 | 0.661 | 1.621 | 0.560 | 2.157 | 0.948 | -0.811 | -11.229 |
| SMPIAT | 0.997 | 0.029 | 0.999 | 0.024 | 0.995 | 0.036 | 0.138 | 3.783 |
| SMPICOR | 0.436 | 0.184 | 0.455 | 0.184 | 0.406 | 0.172 | 0.266 | 6.357 |
| SMPDCOR | 0.683 | 0.137 | 0.697 | 0.134 | 0.663 | 0.129 | 0.248 | 6.035 |
| SRIT | 163.657 | 71.791 | 154.186 | 64.014 | 181.805 | 75.943 | -0.385 | -10.094 |
| SRIT | 574.197 | 118.696 | 564.277 | 117.913 | 602.339 | 107.123 | -0.321 | -7.720 |
| SRRT | 18.812 | 4.883 | 18.350 | 4.489 | 19.880 | 5.223 | -0.313 | -7.989 |
| SRPAT | 0.984 | 0.062 | 0.988 | 0.053 | 0.980 | 0.067 | 0.129 | 3.507 |
| SRPCOR | 0.658 | 0.194 | 0.682 | 0.185 | 0.644 | 0.199 | 0.196 | 4.831 |
| AOIT | 214.630 | 68.918 | 208.183 | 66.369 | 231.556 | 65.740 | -0.339 | -8.372 |
| AOTT | 599.530 | 138.005 | 596.453 | 134.946 | 627.923 | 120.847 | -0.228 | -5.582 |
| AORT | 18.748 | 5.812 | 18.404 | 5.231 | 19.773 | 5.603 | -0.236 | -6.182 |
| AOPAT | 0.972 | 0.082 | 0.980 | 0.067 | 0.968 | 0.083 | 0.146 | 4.171 |
| AOPCOR | 0.620 | 0.195 | 0.646 | 0.190 | 0.627 | 0.189 | 0.097 | 2.376 |
| TIDIT | 126.386 | 38.638 | 121.976 | 35.381 | 135.245 | 39.609 | -0.343 | -8.824 |
| TIDTT | 158.130 | 42.534 | 153.760 | 37.574 | 163.565 | 52.452 | -0.231 | -5.986 |
| TIDAT | 31.442 | 6.825 | 31.207 | 6.887 | 31.895 | 6.361 | -0.101 | -2.383 |
| TIDCOR | 29.791 | 7.133 | 29.630 | 7.135 | 30.328 | 6.669 | -0.098 | -2.332 |
| TIDDT | 1.857 | 0.625 | 1.791 | 0.570 | 1.903 | 0.642 | -0.179 | -4.617 |
| TIDMT | 0.350 | 0.150 | 0.341 | 0.135 | 0.354 | 0.161 | -0.087 | -2.250 |
| TIT | 184.165 | 45.812 | 180.307 | 42.331 | 193.735 | 50.769 | -0.293 | -7.413 |
| TITT | 225.515 | 7.996 | 225.480 | 7.667 | 226.173 | 8.811 | -0.087 | -2.121 |
| TINAT | 17.992 | 0.320 | 17.989 | 0.379 | 18.000 | 0.000 | -0.034 | -0.717 |
| TIMN | 2772.92 | 402.89 | 2728.97 | 368.57 | 2739.36 | 377.28 | -0.026 | -0.668 |
| TIRMS | 18.881 | 11.867 | 17.688 | 10.291 | 17.930 | 10.687 | -0.020 | -0.557 |
| T1SD | 383.731 | 113.471 | 379.052 | 110.989 | 368.924 | 103.953 | 0.089 | 2.178 |
| T2IT | 141.582 | 36.627 | 139.589 | 34.919 | 147.383 | 35.167 | -0.213 | -5.299 |
| T2IT | 225.550 | 8.916 | 225.479 | 7.842 | 226.036 | 10.923 | -0.062 | -1.630 |
| T2NAT | 17.995 | 0.223 | 17.994 | 0.243 | 18.000 | 1.000 | -0.027 | -0.394 |
| T2MN | 3645.07 | 476.94 | 3579.64 | 457.75 | 3633.37 | 450.9 | -0.113 | -2.792 |
| T2RMS | 49.067 | 23.462 | 45.771 | 21.448 | 47.986 | 21.651 | -0.094 | -2.451 |
| T2SD | 415.329 | 89.205 | 414.958 | 88.966 | 410.716 | 92.755 | 0.048 | 1.129 |

| Variable | All | | Black | | Asian | | Z | t |
|----------|---------|---------|---------|---------|---------|---------|--------|---------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| YRSED | 11.947 | 0.843 | 11.993 | 0.703 | 12.187 | 0.914 | -0.230 | -3.863 |
| EDLEV | 1.939 | 0.665 | 1.921 | 0.607 | 1.765 | 0.675 | 0.235 | 3.637 |
| LANG | 1.047 | 0.333 | 1.020 | 0.209 | 1.684 | 1.247 | -1.994 | -20.122 |
| AFQTI | 60.291 | 18.004 | 50.032 | 15.192 | 57.854 | 18.959 | -0.434 | -7.247 |
| GSI | 52.901 | 7.435 | 48.280 | 7.067 | 49.837 | 8.050 | -0.209 | -3.147 |
| ARI | 53.310 | 6.943 | 49.173 | 6.119 | 53.100 | 6.850 | -0.566 | -9.190 |
| WK1 | 52.866 | 5.377 | 49.926 | 5.463 | 49.821 | 7.412 | 0.020 | 0.266 |
| PC1 | 53.091 | 5.740 | 50.822 | 6.082 | 51.629 | 7.068 | -0.141 | -1.890 |
| NO1 | 54.077 | 6.629 | 53.930 | 6.779 | 55.333 | 6.377 | -0.212 | -3.029 |
| CS1 | 53.095 | 6.926 | 52.293 | 7.246 | 53.783 | 6.731 | -0.215 | -3.014 |
| AS1 | 53.479 | 8.059 | 46.714 | 6.398 | 48.946 | 7.202 | -0.277 | -4.992 |
| MK1 | 54.816 | 6.926 | 53.834 | 6.011 | 57.708 | 6.375 | -0.559 | -9.299 |
| MCI | 54.613 | 7.745 | 49.188 | 6.802 | 52.833 | 7.350 | -0.471 | -7.712 |
| EI1 | 52.310 | 7.917 | 47.913 | 7.224 | 50.775 | 8.006 | -0.362 | -5.682 |
| VE1 | 53.041 | 5.113 | 50.234 | 5.111 | 50.392 | 6.953 | -0.031 | -0.428 |
| IDIT | 415.618 | 124.096 | 466.671 | 152.415 | 433.209 | 136.102 | 0.270 | 3.189 |
| IDTT | 883.350 | 329.687 | 957.900 | 379.784 | 957.051 | 339.782 | 0.003 | 0.032 |
| IDDT | 2.886 | 0.806 | 3.207 | 1.017 | 3.118 | 1.169 | 0.110 | 1.232 |
| IDCT | 12.582 | 5.737 | 13.590 | 7.180 | 13.573 | 6.000 | 0.003 | 0.035 |
| IDPAT | 0.995 | 0.038 | 0.989 | 0.061 | 0.993 | 0.041 | -0.105 | -0.973 |
| IDPCOR | 0.754 | 0.129 | 0.677 | 0.126 | 0.774 | 0.124 | -0.752 | -10.587 |
| MCIT | 316.175 | 86.308 | 359.543 | 113.640 | 317.551 | 67.673 | 0.487 | 5.520 |
| MCTT | 583.965 | 72.991 | 617.073 | 86.139 | 583.667 | 55.983 | 0.458 | 5.768 |
| MCRT | 5.026 | 1.591 | 5.773 | 1.959 | 5.155 | 1.202 | 0.388 | 2.487 |
| MCPAT | 1.00 | 0.015 | 0.999 | 0.024 | 1.000 | 1.000 | -0.067 | -0.041 |
| MPCOR | 0.718 | 0.180 | 0.621 | 0.184 | 0.757 | 0.165 | -0.756 | -10.704 |
| ORIT | 302.231 | 92.953 | 341.029 | 100.075 | 310.051 | 80.126 | 0.333 | 4.541 |
| ORIT | 340.486 | 92.540 | 358.716 | 102.610 | 369.103 | 99.403 | -0.112 | -1.458 |
| ORRT | 14.090 | 4.000 | 14.942 | 4.597 | 15.280 | 4.316 | -0.085 | -1.063 |
| ORPAT | 0.999 | 0.016 | 0.997 | 0.025 | 0.998 | 0.016 | -0.062 | -0.595 |
| ORPCOR | 0.510 | 0.248 | 0.372 | 0.198 | 0.503 | 0.250 | -0.528 | -8.997 |

| Variable | All | | Black | | Asian | | Z | t |
|----------|---------|---------|---------|---------|---------|---------|--------|---------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| SMIT | 435.323 | 200.754 | 537.521 | 223.650 | 469.350 | 231.399 | 0.340 | 4.356 |
| SMTT | 959.016 | 146.053 | 1018.79 | 159.099 | 1027.53 | 179.776 | -0.060 | -0.775 |
| SMRT | 1.717 | 0.661 | 2.034 | 0.832 | 2.097 | 0.782 | -0.095 | -0.570 |
| SMPIAT | 0.997 | 0.029 | 0.994 | 0.038 | 0.996 | 0.018 | -0.069 | -0.793 |
| SMPICOR | 0.436 | 0.184 | 0.374 | 0.172 | 0.417 | 0.186 | -0.234 | -3.552 |
| SMPDCOR | 0.683 | 0.137 | 0.636 | 0.142 | 0.678 | 0.135 | -0.307 | -4.268 |
| SRIT | 163.657 | 71.791 | 193.363 | 87.179 | 170.004 | 74.783 | 0.325 | 3.907 |
| SRIT | 574.197 | 118.696 | 599.163 | 119.241 | 620.799 | 101.430 | -0.182 | -2.648 |
| SRRT | 18.812 | 4.883 | 20.080 | 5.758 | 20.905 | 5.448 | -0.169 | -2.069 |
| SRPAT | 0.984 | 0.062 | 0.969 | 0.085 | 0.966 | 0.085 | 0.048 | 0.507 |
| SRPCOR | 0.658 | 0.194 | 0.576 | 0.200 | 0.662 | 0.190 | -0.443 | -6.205 |
| AOIT | 214.630 | 68.918 | 234.964 | 76.975 | 208.718 | 54.285 | 0.381 | 5.047 |
| AOTT | 599.530 | 138.005 | 597.908 | 155.889 | 627.496 | 116.370 | -0.214 | -2.799 |
| AORT | 18.748 | 5.812 | 19.649 | 7.780 | 19.725 | 4.894 | -0.013 | -0.146 |
| AOPAT | 0.972 | 0.082 | 0.944 | 0.124 | 0.965 | 0.078 | -0.256 | -2.523 |
| AOPCOR | 0.620 | 0.195 | 0.507 | 0.179 | 0.644 | 0.184 | -0.703 | -10.944 |
| TIDIT | 126.386 | 38.638 | 138.735 | 44.758 | 139.444 | 52.710 | -0.018 | -0.222 |
| TIDTT | 158.130 | 42.534 | 172.077 | 51.540 | 170.333 | 56.155 | 0.041 | 0.480 |
| TIDAT | 31.442 | 6.825 | 32.347 | 6.425 | 32.410 | 6.067 | -0.009 | -0.142 |
| TIDCOR | 29.791 | 7.133 | 30.352 | 7.011 | 30.368 | 6.863 | -0.002 | -0.033 |
| TIDDT | 1.857 | 0.625 | 2.094 | 0.737 | 2.041 | 0.729 | 0.085 | 1.027 |
| TIDMT | 0.350 | 0.150 | 0.380 | 0.194 | 0.348 | 0.121 | 0.213 | 2.443 |
| TIIT | 184.165 | 45.812 | 195.618 | 54.597 | 186.791 | 45.874 | 0.193 | 2.362 |
| TIIT | 225.515 | 7.996 | 225.380 | 6.414 | 226.850 | 14.732 | -0.184 | -2.676 |
| TINAT | 17.992 | 0.320 | 17.999 | 0.034 | 17.996 | 0.065 | 0.009 | 1.103 |
| TIMN | 2772.92 | 402.89 | 2956.49 | 479.32 | 2846.66 | 492.87 | 0.273 | 3.277 |
| TIRMS | 18.881 | 11.867 | 23.843 | 15.893 | 21.314 | 15.028 | 0.213 | 2.298 |
| TIISD | 383.731 | 113.471 | 412.109 | 126.899 | 368.839 | 93.150 | 0.381 | 5.034 |
| T2IT | 141.582 | 36.627 | 148.125 | 42.535 | 141.880 | 40.535 | 0.171 | 2.119 |
| T2TT | 225.550 | 8.916 | 225.814 | 11.607 | 225.607 | 4.994 | 0.023 | 0.269 |
| T2NAT | 17.995 | 0.223 | 17.994 | 0.219 | 18.000 | 1.000 | -0.027 | -0.214 |
| T2MN | 3645.07 | 476.944 | 3913.79 | 469.530 | 3729.56 | 517.478 | 0.386 | 5.560 |
| T2RMS | 49.067 | 23.462 | 62.701 | 26.843 | 54.010 | 26.864 | 0.370 | 4.646 |
| T2SD | 415.329 | 89.205 | 420.915 | 90.341 | 396.848 | 81.750 | 0.270 | 3.865 |

| Variable | All | | Black | | Hispanic | | Z | t |
|----------|---------|---------|---------|---------|----------|---------|--------|---------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| YRSED | 11.947 | 0.843 | 11.993 | 0.703 | 11.832 | 0.882 | 0.191 | 4.604 |
| EDLEV | 1.939 | 0.665 | 1.921 | 0.607 | 2.038 | 0.749 | -0.176 | -3.838 |
| LANG | 1.047 | 0.333 | 1.020 | 0.209 | 1.100 | 0.316 | -0.240 | -7.028 |
| AFQTI | 60.291 | 18.004 | 50.032 | 15.192 | 56.620 | 15.770 | -0.366 | -9.255 |
| GS1 | 52.901 | 7.435 | 48.280 | 7.067 | 50.835 | 7.439 | -0.344 | -7.686 |
| AR1 | 53.310 | 6.943 | 49.173 | 6.119 | 52.368 | 6.653 | -0.460 | -10.997 |
| WK1 | 52.866 | 5.377 | 49.926 | 5.463 | 51.024 | 5.469 | -0.204 | -4.332 |
| PC1 | 53.091 | 5.740 | 50.822 | 6.082 | 52.523 | 5.891 | -0.296 | -6.079 |
| NO1 | 54.077 | 6.629 | 53.930 | 6.779 | 53.937 | 6.651 | -0.001 | -0.022 |
| CS1 | 53.095 | 6.926 | 52.293 | 7.246 | 52.922 | 6.722 | -0.091 | -1.907 |
| AS1 | 53.479 | 8.059 | 46.714 | 6.398 | 50.488 | 7.884 | -0.468 | -11.930 |
| MK1 | 54.816 | 6.926 | 53.834 | 6.011 | 55.086 | 5.607 | -0.181 | -4.569 |
| MC1 | 54.613 | 7.745 | 49.188 | 6.802 | 52.758 | 7.411 | -0.461 | -11.047 |
| EI1 | 52.310 | 7.917 | 47.913 | 7.224 | 50.889 | 7.983 | -0.376 | -8.634 |
| VE1 | 53.041 | 5.113 | 50.234 | 5.111 | 51.477 | 5.194 | -0.243 | -5.221 |
| IDIT | 415.618 | 124.096 | 466.671 | 152.415 | 439.551 | 127.728 | 0.219 | 3.931 |
| IDTT | 883.350 | 329.687 | 957.900 | 379.784 | 976.003 | 352.798 | -0.055 | -1.030 |
| IDDT | 2.886 | 0.806 | 3.207 | 1.017 | 2.985 | 0.836 | 0.275 | 4.841 |
| IDCT | 12.582 | 5.737 | 13.590 | 7.180 | 14.050 | 6.056 | -0.080 | -1.414 |
| IDPAT | 0.995 | 0.038 | 0.989 | 0.061 | 0.994 | 0.040 | -0.132 | -1.885 |
| IDPCOR | 0.754 | 0.129 | 0.677 | 0.126 | 0.756 | 0.128 | -0.612 | -12.758 |
| MCIT | 316.175 | 86.308 | 359.543 | 113.640 | 328.637 | 86.239 | 0.358 | 6.123 |
| MCTT | 583.965 | 72.991 | 617.073 | 86.139 | 590.666 | 63.689 | 0.362 | 6.932 |
| MCRT | 5.026 | 1.591 | 5.773 | 1.959 | 5.380 | 1.674 | 0.247 | 2.222 |
| MCPAT | 1.00 | 0.015 | 0.999 | 0.024 | 1.000 | 0.000 | -0.067 | -0.041 |
| MPCOR | 0.718 | 0.180 | 0.621 | 0.184 | 0.723 | 0.169 | -0.567 | -11.979 |
| ORIT | 302.231 | 92.953 | 341.029 | 100.075 | 319.291 | 92.960 | 0.234 | 4.697 |
| ORTT | 340.486 | 92.540 | 358.716 | 102.610 | 359.624 | 96.764 | -0.01 | -0.191 |
| ORRT | 14.090 | 4.000 | 14.942 | 4.597 | 14.883 | 4.185 | 0.015 | 0.279 |
| ORPAT | 0.999 | 0.016 | 0.997 | 0.025 | 0.999 | 0.016 | -0.125 | -1.847 |
| ORPCOR | 0.510 | 0.248 | 0.372 | 0.198 | 0.502 | 0.242 | -0.524 | -12.950 |

| Variable | All | | Black | | Hispanic | | Z | t |
|----------|---------|---------|---------|---------|----------|---------|--------|---------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| SMIT | 435.323 | 200.75 | 537.521 | 223.650 | 467.337 | 212.544 | 0.350 | 6.748 |
| SMTT | 959.02 | 146.05 | 1018.79 | 159.1 | 1008.76 | 181.026 | 0.069 | 1.290 |
| SMRT | 1.717 | 0.661 | 2.034 | 0.832 | 2.157 | 0.948 | -0.186 | -1.487 |
| SMPIAT | 0.997 | 0.029 | 0.994 | 0.038 | 0.995 | 0.036 | -0.034 | -0.566 |
| SMPICOR | 0.436 | 0.184 | 0.374 | 0.172 | 0.406 | 0.172 | -0.174 | -3.949 |
| SMPDCOR | 0.683 | 0.137 | 0.636 | 0.142 | 0.663 | 0.129 | -0.197 | -4.125 |
| SRIT | 163.657 | 71.791 | 193.363 | 87.179 | 181.805 | 75.943 | 0.161 | 2.908 |
| SRTT | 574.197 | 118.696 | 599.163 | 119.241 | 602.339 | 107.123 | -0.027 | -0.580 |
| SRRT | 18.812 | 4.883 | 20.080 | 5.758 | 19.880 | 5.223 | 0.041 | 0.755 |
| SRPAT | 0.984 | 0.062 | 0.969 | 0.085 | 0.980 | 0.067 | -0.177 | -2.895 |
| SRPCOR | 0.658 | 0.194 | 0.576 | 0.200 | 0.644 | 0.199 | -0.351 | -7.199 |
| AOIT | 214.630 | 68.918 | 234.964 | 76.975 | 231.556 | 65.740 | 0.049 | 0.975 |
| AOTT | 599.530 | 138.005 | 597.908 | 155.889 | 627.923 | 120.847 | -0.217 | -4.320 |
| AORT | 18.748 | 5.812 | 19.649 | 7.780 | 19.773 | 5.603 | -0.021 | -0.362 |
| AOPAT | 0.972 | 0.082 | 0.944 | 0.124 | 0.968 | 0.083 | -0.293 | -4.443 |
| AOPCOR | 0.620 | 0.195 | 0.507 | 0.179 | 0.627 | 0.189 | -0.615 | -14.016 |
| TIDIT | 126.386 | 38.638 | 138.735 | 44.758 | 135.245 | 39.609 | 0.090 | 1.705 |
| TIDTT | 158.130 | 42.534 | 172.077 | 51.540 | 163.565 | 52.452 | 0.200 | 3.490 |
| TIDAT | 31.442 | 6.825 | 32.347 | 6.425 | 31.895 | 6.361 | 0.066 | 1.495 |
| TIDCOR | 29.791 | 7.133 | 30.352 | 7.011 | 30.328 | 6.669 | 0.003 | 0.073 |
| TIDDT | 1.857 | 0.625 | 2.094 | 0.737 | 1.903 | 0.642 | 0.306 | 5.677 |
| TIDMT | 0.350 | 0.150 | 0.380 | 0.194 | 0.354 | 0.161 | 0.173 | 2.965 |
| TIIT | 184.165 | 45.812 | 195.618 | 54.597 | 193.735 | 50.769 | 0.041 | 0.746 |
| TITT | 225.515 | 7.996 | 225.380 | 6.414 | 226.173 | 8.811 | -0.099 | -2.364 |
| TINAT | 17.992 | 0.320 | 17.999 | 0.034 | 18.000 | 0.000 | -0.003 | -0.727 |
| TIMN | 2772.92 | 402.89 | 2956.49 | 479.32 | 2739.36 | 377.28 | 0.539 | 10.135 |
| TIRMS | 18.881 | 11.867 | 23.843 | 15.893 | 17.930 | 10.687 | 0.498 | 8.535 |
| TISD | 383.731 | 113.471 | 412.109 | 126.899 | 368.924 | 103.953 | 0.381 | 7.558 |
| T2IT | 141.582 | 36.627 | 148.125 | 42.535 | 147.383 | 35.167 | 0.020 | 0.387 |
| T2TT | 225.550 | 8.916 | 225.814 | 11.607 | 226.036 | 10.923 | -0.025 | -0.412 |
| T2NAT | 17.995 | 0.223 | 17.994 | 0.219 | 18.000 | 1.000 | -0.027 | -0.233 |
| T2MN | 3645.07 | 476.94 | 3913.79 | 469.53 | 3633.37 | 450.9 | 0.588 | 12.809 |
| T2RMS | 49.067 | 23.462 | 62.701 | 26.843 | 47.986 | 21.651 | 0.627 | 12.209 |
| T2SD | 415.329 | 89.205 | 420.915 | 90.341 | 410.716 | 92.755 | 0.114 | 2.380 |

| Variable | All | | Asian | | Hispanic | | Z | t |
|----------|---------|---------|---------|---------|----------|---------|--------|--------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| YRSED | 11.947 | 0.843 | 12.187 | 0.914 | 11.832 | 0.882 | 0.421 | 5.262 |
| EDLEV | 1.939 | 0.665 | 1.765 | 0.675 | 2.038 | 0.749 | -0.411 | -4.869 |
| LANG | 1.047 | 0.333 | 1.684 | 1.247 | 1.100 | 0.316 | 1.754 | 10.721 |
| AFQTI | 60.291 | 18.004 | 57.854 | 18.959 | 56.620 | 15.770 | 0.069 | 0.974 |
| GS1 | 52.901 | 7.435 | 49.837 | 8.050 | 50.835 | 7.439 | -0.134 | -1.729 |
| ARI | 53.310 | 6.943 | 53.100 | 6.850 | 52.368 | 6.653 | 0.105 | 1.439 |
| WK1 | 52.866 | 5.377 | 49.821 | 7.412 | 51.024 | 5.469 | -0.224 | -2.615 |
| PC1 | 53.091 | 5.740 | 51.629 | 7.068 | 52.523 | 5.891 | -0.156 | -1.890 |
| NO1 | 54.077 | 6.629 | 55.333 | 6.377 | 53.937 | 6.651 | 0.211 | 2.799 |
| CS1 | 53.095 | 6.926 | 53.783 | 6.731 | 52.922 | 6.722 | 0.124 | 1.688 |
| AS1 | 53.479 | 8.059 | 48.946 | 7.202 | 50.488 | 7.884 | -0.191 | -2.640 |
| MK1 | 54.816 | 6.926 | 57.708 | 6.375 | 55.086 | 5.607 | 0.379 | 5.932 |
| MC1 | 54.613 | 7.745 | 52.833 | 7.350 | 52.758 | 7.411 | 0.01 | 0.134 |
| EI1 | 52.310 | 7.917 | 50.775 | 8.006 | 50.889 | 7.983 | -0.014 | -0.188 |
| VE1 | 53.041 | 5.113 | 50.392 | 6.953 | 51.477 | 5.194 | -0.212 | -2.496 |
| IDIT | 415.618 | 124.096 | 433.209 | 136.102 | 439.551 | 127.728 | -0.051 | -0.634 |
| IDTT | 883.350 | 329.687 | 957.051 | 339.782 | 976.003 | 352.798 | -0.057 | -0.706 |
| IDDT | 2.886 | 0.806 | 3.118 | 1.169 | 2.985 | 0.836 | 0.165 | 1.840 |
| IDCT | 12.582 | 5.737 | 13.573 | 6.000 | 14.050 | 6.056 | -0.083 | -1.027 |
| IDPAT | 0.995 | 0.038 | 0.993 | 0.041 | 0.994 | 0.040 | -0.026 | -0.323 |
| IDPCOR | 0.754 | 0.129 | 0.774 | 0.124 | 0.756 | 0.128 | 0.140 | 1.768 |
| MCIT | 316.175 | 86.308 | 317.551 | 67.673 | 328.637 | 86.239 | -0.128 | -1.769 |
| MCTT | 583.965 | 72.991 | 583.667 | 55.983 | 590.666 | 63.689 | -0.096 | -1.477 |
| MCRT | 5.026 | 1.591 | 5.155 | 1.202 | 5.380 | 1.674 | -0.141 | -1.002 |
| MCPAT | 1.00 | 0.015 | 1.000 | 0.000 | 1.000 | 0.000 | 0.000 | 0.000 |
| MCPCOR | 0.718 | 0.180 | 0.757 | 0.165 | 0.723 | 0.169 | 0.189 | 2.629 |
| ORIT | 302.231 | 92.953 | 310.051 | 80.126 | 319.291 | 92.960 | -0.099 | -1.341 |
| ORIT | 340.486 | 92.540 | 369.103 | 99.403 | 359.624 | 96.764 | 0.102 | 1.265 |
| ORRT | 14.090 | 4.000 | 15.280 | 4.316 | 14.883 | 4.185 | 0.099 | 1.223 |
| ORPAT | 0.999 | 0.016 | 0.998 | 0.016 | 0.999 | 0.016 | -0.062 | -0.813 |
| ORPCOR | 0.510 | 0.248 | 0.503 | 0.250 | 0.502 | 0.242 | 0.004 | 0.052 |

| Variable | All | | Asian | | Hispanic | | Z | t |
|----------|---------|---------|---------|---------|----------|---------|--------|--------|
| | Mean | SD | Mean | SD | Mean | SD | | |
| SMIT | 435.323 | 200.754 | 469.350 | 231.399 | 467.337 | 212.544 | 0.010 | 0.120 |
| SMTT | 959.016 | 146.053 | 1027.52 | 179.776 | 1008.76 | 181.026 | 0.128 | 1.351 |
| SMRT | 1.717 | 0.661 | 2.097 | 0.782 | 2.157 | 0.948 | -0.091 | -0.460 |
| SMP1AT | 0.997 | 0.029 | 0.996 | 0.018 | 0.995 | 0.036 | 0.034 | 0.406 |
| SMP1COR | 0.436 | 0.184 | 0.417 | 0.186 | 0.406 | 0.172 | 0.060 | 0.813 |
| SMPDCOR | 0.683 | 0.137 | 0.678 | 0.135 | 0.663 | 0.129 | 0.109 | 1.492 |
| SRIT | 163.657 | 71.791 | 170.004 | 74.783 | 181.805 | 75.943 | -0.164 | -2.030 |
| SRTT | 574.197 | 118.696 | 620.799 | 101.430 | 602.339 | 107.123 | 0.156 | 2.274 |
| SRRT | 18.812 | 4.883 | 20.905 | 5.448 | 19.880 | 5.223 | 0.210 | 2.522 |
| SRPAT | 0.984 | 0.062 | 0.966 | 0.085 | 0.980 | 0.067 | -0.226 | -2.514 |
| SRPCOR | 0.658 | 0.194 | 0.662 | 0.190 | 0.644 | 0.199 | 0.093 | 1.190 |
| AOIT | 214.630 | 68.918 | 208.718 | 54.285 | 231.556 | 65.740 | -0.331 | -4.732 |
| AOTT | 599.530 | 138.005 | 627.496 | 116.370 | 627.923 | 120.847 | -0.003 | -0.046 |
| AORT | 18.748 | 5.812 | 19.725 | 4.894 | 19.773 | 5.603 | -0.008 | -0.115 |
| AOPAT | 0.972 | 0.082 | 0.965 | 0.078 | 0.968 | 0.083 | -0.037 | -0.478 |
| AOPCOR | 0.620 | 0.195 | 0.644 | 0.184 | 0.627 | 0.189 | 0.087 | 1.179 |
| TIDIT | 126.386 | 38.638 | 139.444 | 52.710 | 135.245 | 39.609 | 0.109 | 1.252 |
| TIDTT | 158.130 | 42.534 | 170.333 | 56.155 | 163.565 | 52.452 | 0.159 | 1.645 |
| TIDAT | 31.442 | 6.825 | 32.410 | 6.067 | 31.895 | 6.361 | 0.075 | 1.066 |
| TIDCOR | 29.791 | 7.133 | 30.368 | 6.863 | 30.328 | 6.669 | 0.006 | 0.077 |
| TIDDT | 1.857 | 0.625 | 2.041 | 0.729 | 1.903 | 0.642 | 0.221 | 2.678 |
| TIDMT | 0.350 | 0.150 | 0.348 | 0.121 | 0.354 | 0.161 | -0.040 | -0.514 |
| T1IT | 184.165 | 45.812 | 186.791 | 45.874 | 193.735 | 50.769 | -0.152 | -1.826 |
| T1TT | 225.515 | 7.996 | 226.850 | 14.732 | 226.173 | 8.811 | 0.085 | 0.817 |
| T1NAT | 17.992 | 0.320 | 17.996 | 0.065 | 18.000 | 0.000 | -0.013 | -1.523 |
| T1MN | 2772.92 | 402.89 | 2846.66 | 492.87 | 2739.36 | 377.278 | 0.266 | 3.384 |
| T1RMS | 18.881 | 11.867 | 21.314 | 15.028 | 17.930 | 10.687 | 0.285 | 3.655 |
| T1SD | 383.731 | 113.471 | 368.839 | 93.150 | 368.924 | 103.953 | -0.001 | -0.011 |
| T2IT | 141.582 | 36.627 | 141.880 | 40.535 | 147.383 | 35.167 | -0.150 | -1.949 |
| T2TT | 225.550 | 8.916 | 225.607 | 4.994 | 226.036 | 10.923 | -0.048 | -0.578 |
| T2NAT | 17.995 | 0.223 | 18.000 | 0.000 | 18.000 | 0.000 | 0.000 | 0.000 |
| T2MN | 3645.07 | 476.944 | 3729.56 | 517.478 | 3633.37 | 450.897 | 0.202 | 2.661 |
| T2RMS | 49.067 | 23.462 | 54.010 | 26.864 | 47.986 | 21.651 | 0.257 | 3.376 |
| T2SD | 415.329 | 89.205 | 396.848 | 81.750 | 410.716 | 92.755 | -0.155 | -2.008 |

Appendix G

Criterion Data Editing and Outlier Detection

Criterion Data Editing and Outlier Detection

Criteria were of two types: (1) Final School Grades (FSG) and other test scores (such as the FAA exam or the AFPT70 typing test) supplied by the training school, and (2) Composites of more elementary measures of classroom or shop/laboratory performance. For the latter, a contractor (RGI Inc.) collected vast amounts of detailed records of homework, quizzes, tests scores, simulator performance measures, etc. Based on factor analyses, they formed composites of variables loading on the corresponding factors (Kieckhaefer, et al., 1992). In addition, some composites were constructed on rational grounds, e.g. FSG scores in the Army 13F, Air Force APS, and Navy AC schools, were computed rather than taken from school records.

One problem with composites of internal measures is that the curricula change frequently, so that some students do not take tests that other students take. Another problem is that most students are likely to miss a few quizzes or laboratory exercises for a variety of personal reasons. The approach that was adopted for handling the missing data was to define a composite for a given student as equal to the mean of the component measures that were present for that student. Thus a composite criterion that was supposed to consist of 14 test scores would be computed for a student that missed five exams and took only 9 of them, for example. In most cases, the component measures ranged from 0 to 100, but their standard deviations sometimes differed by a factor of two. There was no attempt to scale the tests to have equal means and standard deviations, nor to use regression estimates for the missing values.

The criteria were subjected to a very careful review and multi-stage editing process. The first step was to run a regression analysis for each criterion against all 10 ASVAB tests plus 9 ECAT tests (19 predictors). For each sample point, a DFFITS measure of influence was computed, as described by Belsley, Kuh, and Welsch (1980). The authors estimate the standard deviation of DFFITS to be $\sqrt{p/n}$ and recommend a cutoff of 2 standard deviations for selecting influential observations for further examination. In the ECAT sample, this rule would have produced far too many cases for study; instead we selected cases whose DFFITS values were ± 4 standard deviations for further study.

On the first pass, we simply tried omitting all such outliers from the analysis and compared the results with the first regression analyses. The effects of deleting the high influence cases were sometimes quite large; e.g. the multiple correlation for the Army's 13F Final School Grade went from .415 to .597 and the standard error of prediction on a jackknife cross-validation went from 6.432 to 3.452 when only 5 of 831 cases were deleted. Similarly large changes were found for 13F Firing, 11H(A) EVT2TO, ATC BLK5A, AE SUM2, and RM FSG. Results with the outliers removed were presented by Wolfe(1993, November).

Next, we began an investigation into why the outliers occurred. The approach was to try to find general principles or rules for excluding troublesome cases, and to retain outliers in the data base unless a clear-cut rule could be found for deleting them. The first explanation that turned up was scoring error. Several types of programming errors were detected and corrected:

1. Missing test or performance scores were treated as if they were zeros when summing up criterion composites. This occurred in all criteria for 11H, 13F, and possibly some others.
2. Test scores that were supposed to be in the composite were omitted (AE and ET).
3. Variables that were not supposed to be in the composite were included (AE and ET).
4. Miscellaneous programming errors with unknown effects, if any. These included hanging DO loops without END statements (AV and ET), attempts to compare alphabetic strings with numeric values (AV), and defining an array of variables with the same variable twice (OS).

After rescoreing the data, the regression analyses for outlier detection were run again. The data were examined again for possible causes of strange behavior. A large percentage (sometimes all) of the outliers came from students who dropped out of school either because of academic failure or because of administrative reasons, such as bereavement, illness, AWOL, personality difficulties, alcohol, drugs, or disciplinary reasons. The Navy sample included 66 academic dropouts and 314 administrative dropouts. However, no information on student status was available for any Army or Air Force schools, or for the Navy FC or OS schools.

The major reason that dropouts had atypical scores was that their data were incomplete. The administrative drops sometimes had above-average scores on some criteria, and very deviant scores on others. Some of them had FSGs in their records, but based on only the part of the curriculum that they completed. Different schools apparently had different policies for computing these grades: sometimes they were missing, sometimes they were quite high (evidently means of tests completed), and sometimes they were very low (possibly assigning zeros to missing test scores). Even where no dropout codes were available, a frequent characteristic of outliers was very incomplete data regarding test or performance scores. A composite criterion that was supposed to be the mean of 10-14 measures might contain only 1 or 2 of them, for example.

Another, but related, cause of outliers was non-normal criterion distributions arising from binary (Pass/Fail) component scores. For example, in the Air Force ATC school, several criteria were defined as the difference between a binary performance standard score and a standardized measure of time on course section. In other cases, distributional problems arose when the mean of 4 to 12 binary measures was reduced to the mean of only 1 or 2, due to incomplete data.

To improve the quality of the data, the administrative school dropouts were all deleted from the ECAT data base. Next, the number of components going into each composite was tabulated for each student. (These counts were labeled N_FSG, N_ADV, etc.) Rules were formulated that eliminated most of the remaining outliers as follows:

- APS Drop cases with $N_{FSG} < 3$ out of 6 tests.
- AC Drop cases with $N_{PRF} < 2$ out of 4 tests.
- AV Drop cases if $N_{ADV} + N_{PERF} < 2$ out of 8 tests.
- ET Drop cases where $MEAN(N_{PRF1}, N_{PRF2}) \leq 1$ out of 10 or 14 tests, respectively.
- FC Drop 37 cases with $N_{RADAR} = 0$.

Four outliers appeared to be associated with previously undetected problems with their ECAT tests. In ECAT a "jump" is defined as a fast response to a difficult test item. In AMS school, one examinee had 26 jumps in the Mental Counters test and got 27% of the items correct. In OS school, one outlier had 21 jumps in the Figural Reasoning test with only 16.7% correct. In ATC and APS schools, two outliers had high jumps and low scores on the Mental Counters test. These examinees were obviously not trying, but were pressing keys at random. Further examination of the the entire ECAT sample showed that of 19 cases with more than 6 jumps on Figural Reasoning, none scored higher than 50% on the test. On Mental Counters, none of the 73 cases that had more than 15 jumps scored higher than 50% correct. Because some high jump cases scored above chance, it was difficult to formulate a general principle for screening outliers that did not also exclude too many legitimate cases. Thus the four outliers previously identified were retained in the ECAT sample.

In a few remaining outliers, the reasons for their atypical behavior could not be determined. For example, in 11H(B), the EVT1TO, EVT2TO, and EVT3TO scores were each the sum of scores on ten "shots". The individual shots were scored on a scale from 0 to 100. One student received scores of 0 on all ten of his EVT1TO shots and on eight of his EVT2TO shots. He was retained in the ECAT sample, because there was no way of knowing why he behaved as he did. Perhaps he had some basic misconception about the task, perhaps he forgot his glasses that day, perhaps the equipment malfunctioned, etc.

On the final analyses, the policy was to exclude only those cases (and all such cases), that violated some clear-cut principle, regardless of whether they were outliers or not. This policy resulted in excluding many more non-outliers than outliers (e.g. the 314 administrative dropouts) while retaining some outliers for which it was difficult to formulate a rationale for deleting them.

It should be noted that in the majority of academic failures, no Final School Grades were available, and we did not choose to impute scores to these failures. However, knowledge and performance test averages were present in most cases.

As a final check, regression analyses were run with and without the remaining outliers to determine the magnitudes of the effects on multiple correlations. Tables G-1 to G-3 show, with some exceptions, that the remaining outliers have little effect on the multiple correlations, and even less on the differences between ASVAB and ASVAB + ECAT multiple correlations, which are the incremental validities.

Table G-1

Effect of Dropping High Influence Cases on Multiple Correlations
All Army Criteria

| School | Criterion | Full N | Outliers Dropped | ASVAB | | ASVAB+ECAT | | Incremental Validity Change |
|---------|-----------|-----------|---------------------|-------|----------|------------|----------|--------------------------------|
| | | | | R | R-Change | R | R-Change | |
| 11H(A)1 | TOALL | 554 | 6 | .242 | .002 | .296 | -.023 | -.026 |
| 11H(A)2 | EVT1TO | 556 | 1 | .316 | .012 | .365 | .014 | .001 |
| 11H(A)3 | EVT2TO | 555 | 0 | .242 | .000 | .294 | .000 | .000 |
| 11H(A)4 | EVT3TO | 550 | 1 | .294 | -.007 | .347 | -.006 | .001 |
| 11H(A)5 | EVTSUM | 546 | 0 | .321 | .000 | .382 | .000 | .000 |
| 11H(A)6 | TO_1 | 542 | 4 | .210 | -.004 | .274 | -.003 | .001 |
| 11H(B)1 | TOALL | 320 | 4 | .313 | -.061 | .364 | -.052 | .009 |
| 11H(B)2 | EVT1TO | 320 | 0 | .291 | .000 | .416 | .000 | .000 |
| 11H(B)3 | EVT2TO | 319 | 1 | .312 | .006 | .442 | -.005 | -.011 |
| 11H(B)4 | EVT3TO | 319 | 1 | .234 | -.007 | .301 | -.009 | -.003 |
| 11H(B)5 | EVTSUM | 316 | 1 | .330 | .016 | .456 | .001 | -.015 |
| 11H(B)6 | TO_1 | 319 | 0 | .144 | .000 | .327 | .000 | .000 |
| 11H(B)7 | TO_2 | 320 | 0 | .172 | .000 | .311 | .000 | .000 |
| 11H(B)8 | TO_3 | 319 | 2 | .176 | -.013 | .340 | .009 | .022 |
| 11H(B)9 | ITVTOW | 318 | 0 | .154 | .000 | .354 | .000 | .000 |
| 13F1 | FSG | 821 | 0 | .544 | .000 | .598 | .000 | .000 |
| 13F2 | MPRAD | 821 | 2 | .513 | .006 | .591 | -.002 | -.009 |
| 13F3 | FIRING | 821 | 0 | .444 | .000 | .472 | .000 | .000 |
| 19K1 | COMM | 1158 | 19 | .080 | .005 | .142 | -.009 | -.015 |
| 19K2 | WEAPON | 1325 | 9 | .187 | -.005 | .211 | .000 | .005 |
| 19K3 | LANDNAV | 1192 | 15 | .175 | -.012 | .198 | -.011 | .001 |
| 19K4 | LOADER | 1313 | 2 | .066 | .007 | .092 | .005 | -.003 |
| 19K5 | MAINT | 1329 | 6 | .128 | .017 | .163 | .004 | -.013 |
| 19K6 | NBC | 1313 | 11 | .119 | -.023 | .142 | -.013 | .010 |
| 19K7 | AVERAGE | 1106 | 7 | .208 | -.003 | .227 | .008 | .010 |

Table G-2

**Effect of Dropping High Influence Cases on Multiple Correlations
All Air Force Criteria**

| School | Criterion | Full N | Outliers Dropped | ASVAB | | ASVAB+ECAT | | Incremental Validity Change |
|---------|-----------|-----------|---------------------|-------|----------|------------|----------|--------------------------------|
| | | | | R | R-Change | R | R-Change | |
| APS1 | FSG | 446 | 1 | .545 | .003 | .585 | .005 | .003 |
| APS2 | ZHRS | 446 | 2 | .424 | .011 | .487 | .004 | -.008 |
| APS3 | AFPT70 | 432 | 3 | .294 | -.000 | .422 | .000 | .001 |
| APS5 | BYPAS1 | 369 | 2 | .296 | .024 | .394 | .002 | -.022 |
| APS6 | FINAL | 369 | 2 | .296 | .024 | .394 | .002 | -.022 |
| APS7 | DWPM | 357 | 3 | .213 | .037 | .244 | .036 | -.001 |
| ATC1 | FSG | 484 | 2 | .403 | .008 | .451 | .009 | .000 |
| ATC2 | BLK2 | 349 | 0 | .374 | .000 | .421 | .000 | .000 |
| ATC3 | BLK3A | 529 | 9 | .153 | .013 | .229 | .004 | -.009 |
| ATC4 | BLK3B | 217 | 3 | .165 | .004 | .367 | -.035 | -.039 |
| ATC5 | BLK5A | 500 | 6 | .267 | .002 | .374 | -.009 | -.011 |
| ATC6 | BLK5B | 495 | 3 | .216 | -.021 | .274 | -.023 | -.002 |
| ATC7 | FAA | 536 | 2 | .490 | -.009 | .540 | -.005 | .003 |
| ATC(A)1 | FSG | 200 | 0 | .389 | .000 | .471 | .000 | .000 |
| ATC(A)2 | BLK3A | 221 | 3 | .279 | .029 | .348 | .013 | -.016 |
| ATC(A)3 | BLK3B | 217 | 3 | .165 | .004 | .367 | -.035 | -.039 |
| ATC(A)4 | BLK5A | 205 | 0 | .322 | .000 | .438 | .000 | .000 |
| ATC(A)5 | BLK5B | 204 | 1 | .214 | -.007 | .276 | -.024 | -.017 |
| ATC(A)6 | FAA | 251 | 2 | .508 | -.007 | .547 | -.008 | -.001 |
| ATC(B)1 | FSG | 284 | 1 | .449 | .011 | .485 | .015 | .004 |
| ATC(B)2 | BLK2 | 349 | 0 | .374 | .000 | .421 | .000 | .000 |
| ATC(B)3 | BLK3A | 308 | 5 | .195 | -.037 | .296 | -.022 | .015 |
| ATC(B)4 | BLK5A | 295 | 5 | .312 | .017 | .414 | .037 | .020 |
| ATC(B)5 | BLK5B | 291 | 4 | .264 | -.016 | .336 | -.006 | .010 |
| ATC(B)6 | FAA | 285 | 0 | .485 | .000 | .529 | .000 | .000 |

Table G-3

Effect of Dropping High Influence Cases on Multiple Correlations
All Navy Criteria

| School | Criterion | Full N | Outliers Dropped | ASVAB | | ASVAB+ECAT | | Incremental Validity Change |
|--------|-----------|-----------|---------------------|-------|----------|------------|----------|--------------------------------|
| | | | | R | R-Change | R | R-Change | |
| AC1 | FSG | 72 | 0 | .627 | .000 | .659 | .000 | .000 |
| AC2 | PERF | 76 | 1 | .330 | .028 | .498 | .095 | .067 |
| AC3 | FAA | 76 | 0 | .454 | .000 | .562 | .000 | .000 |
| AE1 | FSG | 278 | 2 | .489 | .008 | .550 | .001 | -.007 |
| AE2 | SUM2 | 273 | 3 | .440 | -.008 | .498 | -.015 | -.007 |
| AMS1 | FSG | 244 | 1 | .599 | -.012 | .604 | -.009 | .003 |
| AMS2 | PERF | 244 | 2 | .393 | -.005 | .437 | -.009 | -.004 |
| AO1 | FSG | 234 | 0 | .504 | .000 | .537 | .000 | .000 |
| AO2 | PRACTL | 229 | 3 | .343 | .018 | .393 | .010 | -.008 |
| AV1 | FSG | 544 | 0 | .517 | .000 | .539 | .000 | .000 |
| AV2 | BSCAV | 192 | 0 | .531 | .000 | .571 | .000 | .000 |
| AV3 | ADVAV | 192 | 0 | .358 | .000 | .404 | .000 | .000 |
| AV4 | PERFORM | 352 | 4 | .379 | -.028 | .417 | -.030 | -.002 |
| EM1 | FSG | 797 | 0 | .451 | .000 | .471 | .000 | .000 |
| EM2 | PHASE1 | 797 | 0 | .474 | .000 | .485 | .000 | .000 |
| EN1 | FSG | 750 | 1 | .584 | .013 | .593 | .014 | .001 |
| ET1 | FSG | 86 | 0 | .509 | .000 | .629 | .000 | .000 |
| ET2 | FSG2 | 86 | 1 | .504 | .035 | .574 | .015 | -.020 |
| ET3 | PERF | 86 | 2 | .482 | .044 | .585 | .077 | .033 |
| FC1 | FSG | 778 | 0 | .499 | .000 | .536 | .000 | .000 |
| FC2 | RADAR | 780 | 2 | .345 | -.005 | .388 | -.009 | -.003 |
| GM1 | FSG | 420 | 1 | .428 | .005 | .465 | .010 | .005 |
| GM2 | HALF1 | 420 | 1 | .442 | .006 | .496 | .011 | .006 |
| GM3 | HALF2 | 397 | 2 | .458 | .003 | .479 | .007 | .004 |
| MM1 | FSG | 801 | 0 | .402 | .000 | .438 | .000 | .000 |
| OS1 | FSG | 713 | 2 | .565 | .008 | .588 | .009 | .001 |
| OS2 | WRIT | 815 | 2 | .478 | .001 | .496 | .000 | -.001 |
| OS3 | PERF | 815 | 1 | .523 | -.001 | .566 | -.001 | .000 |
| RM1 | FSG | 277 | 0 | .536 | .000 | .592 | .000 | .000 |
| RM2 | PHASE3 | 277 | 0 | .420 | .000 | .467 | .000 | .000 |

Appendix H

Uncorrected and Corrected Moments and Reliabilities of the Criteria

Table H-1

Army Schools
Uncorrected and Corrected Moments and Reliabilities of the Criteria

| School | Criterion | N | Missing | Skewness | Kurtosis | Uncorrected | | | Corrected | | |
|---------|-----------|------|---------|----------|----------|-------------|----------|-------------|-----------|----------|-------------|
| | | | | | | Mean | Std.Dev. | Reliability | Mean | Std.Dev. | Reliability |
| 11H(A)1 | TOALL | 554 | 4 | -7.4 | 65.5 | 2.980 | 0.060 | 0.900 | 2.975 | 0.061 | 0.903 |
| 11H(A)2 | EVT1TO | 556 | 2 | -0.5 | 0.1 | 502.128 | 149.898 | 0.900 | 477.324 | 155.650 | 0.907 |
| 11H(A)3 | EVT2TO | 555 | 3 | -0.6 | 0.5 | 578.679 | 135.408 | 0.920 | 565.440 | 137.756 | 0.923 |
| 11H(A)4 | EVT3TO | 550 | 8 | -0.5 | 1.8 | 658.964 | 92.695 | 0.910 | 645.535 | 95.488 | 0.915 |
| 11H(A)5 | EVTSUM | 546 | 12 | -0.4 | 0.3 | 1741.947 | 317.995 | 0.960 | 1691.799 | 329.836 | 0.963 |
| 11H(A)6 | TO_1 | 542 | 16 | -1.1 | 3.5 | 665.579 | 85.720 | 0.890 | 659.065 | 87.036 | 0.893 |
| 11H(B)1 | TOALL | 320 | 1 | -5.5 | 41.7 | 2.992 | 0.020 | 0.880 | 2.988 | 0.021 | 0.888 |
| 11H(B)2 | EVT1TO | 320 | 1 | -0.5 | -0.3 | 501.619 | 162.490 | 0.920 | 477.015 | 165.521 | 0.923 |
| 11H(B)3 | EVT2TO | 319 | 2 | -0.9 | 1.5 | 582.288 | 138.703 | 0.920 | 555.478 | 145.053 | 0.927 |
| 11H(B)4 | EVT3TO | 319 | 2 | -0.7 | 1.2 | 661.555 | 100.532 | 0.910 | 650.523 | 102.277 | 0.913 |
| 11H(B)5 | EVTSUM | 316 | 5 | -0.5 | 0.5 | 1744.715 | 329.589 | 0.960 | 1680.733 | 342.235 | 0.963 |
| 11H(B)6 | TO_1 | 319 | 2 | -0.6 | 0.3 | 533.317 | 150.441 | 0.860 | 534.050 | 151.833 | 0.863 |
| 11H(B)7 | TO_2 | 320 | 1 | -0.8 | 1.2 | 585.066 | 129.647 | 0.860 | 580.519 | 130.229 | 0.861 |
| 11H(B)8 | TO_3 | 319 | 2 | -0.5 | 2.9 | 477.545 | 56.184 | 0.830 | 475.174 | 56.331 | 0.831 |
| 11H(B)9 | ITVTOW | 318 | 3 | -0.4 | 0.3 | 1596.399 | 280.551 | 0.920 | 1592.245 | 282.874 | 0.921 |
| 13F1 | FSG | 821 | 5 | -0.5 | -0.1 | 90.413 | 4.127 | 0.720 | 88.769 | 4.870 | 0.799 |
| 13F2 | MPRAD | 821 | 5 | -0.9 | 0.7 | 91.546 | 5.113 | 0.600 | 89.643 | 5.939 | 0.704 |
| 13F3 | FIRING | 821 | 5 | -0.4 | -0.3 | 87.851 | 5.731 | 0.580 | 85.936 | 6.396 | 0.663 |
| 19K1 | COMM | 1158 | 201 | -6.5 | 52.6 | 1.965 | 0.175 | .046 | 1.966 | 0.175 | . |
| 19K2 | WEAPON | 1325 | 34 | -1.6 | 3.0 | 1.771 | 0.330 | .338 | 1.747 | 0.332 | . |
| 19K3 | LANDNAV | 1192 | 167 | -2.8 | 9.6 | 1.897 | 0.243 | .056 | 1.880 | 0.245 | . |
| 19K4 | LOADER | 1313 | 46 | -1.2 | 0.1 | 1.864 | 0.200 | .066 | 1.860 | 0.200 | . |
| 19K5 | MAINT | 1329 | 30 | -4.4 | 39.7 | 1.952 | 0.133 | .093 | 1.945 | 0.134 | . |
| 19K6 | NBC | 1313 | 46 | -2.0 | 4.6 | 1.902 | 0.180 | .072 | 1.891 | 0.181 | . |
| 19K7 | AVERAGE | 1106 | 253 | -1.2 | 2.7 | 1.884 | 0.106 | 0.366 | 1.874 | 0.107 | 0.381 |

Table H-2

Air Force Schools
Uncorrected and Corrected Moments and Reliabilities of the Criteria

| School | Criterion | N | Missing | Skewness | Kurtosis | Uncorrected | | | Corrected | | |
|---------|-----------|-----|---------|----------|----------|-------------|----------|-------------|-----------|----------|-------------|
| | | | | | | Mean | Std.Dev. | Reliability | Mean | Std.Dev. | Reliability |
| APS1 | FSG | 446 | 0 | 0.1 | -0.1 | 80.838 | 7.014 | 0.770 | 77.734 | 9.365 | 0.871 |
| APS2 | ZHRS | 446 | 0 | 0.7 | 0.7 | -0.081 | 0.849 | 0.840 | 0.325 | 1.017 | 0.889 |
| APS3 | AFPT70 | 432 | 14 | 1.5 | 3.6 | 30.072 | 7.840 | 0.925 | 26.365 | 8.183 | 0.931 |
| ATC1 | FSG | 484 | 148 | 0.1 | -0.5 | 83.260 | 5.520 | 0.745 | 79.399 | 6.883 | 0.836 |
| ATC2 | BLK2 | 349 | 283 | -0.8 | -0.4 | -0.034 | 1.804 | 0.690 | -0.930 | 2.080 | 0.767 |
| ATC3 | BLK3A | 529 | 103 | -2.6 | 7.8 | 0.021 | 1.620 | 0.474 | -0.318 | 1.651 | 0.493 |
| ATC4 | BLK3B | 217 | 415 | -6.7 | 53.9 | 0.041 | 1.707 | 0.790 | -0.273 | 1.766 | 0.804 |
| ATC5 | BLK5A | 500 | 132 | -2.5 | 5.1 | -0.018 | 1.824 | 0.635 | -0.785 | 1.983 | 0.691 |
| ATC6 | BLK5B | 495 | 137 | -1.9 | 4.5 | 0.008 | 1.623 | 0.599 | -0.592 | 1.723 | 0.644 |
| ATC7 | FAA | 536 | 96 | -0.7 | 0.5 | 83.215 | 7.796 | 0.730 | 76.756 | 10.602 | 0.819 |
| ATC(A)1 | FSG | 200 | 60 | 0.0 | -0.6 | 82.520 | 5.864 | 0.730 | 78.729 | 7.171 | 0.560 |
| ATC(A)2 | BLK3A | 221 | 39 | -2.6 | 5.9 | 0.038 | 1.694 | 0.550 | -0.231 | 1.713 | 0.804 |
| ATC(A)3 | BLK3B | 217 | 43 | -6.7 | 53.9 | 0.041 | 1.707 | 0.790 | -0.273 | 1.766 | 0.505 |
| ATC(A)4 | BLK5A | 205 | 55 | -2.4 | 4.5 | -0.012 | 1.686 | 0.400 | -0.671 | 1.857 | 0.599 |
| ATC(A)5 | BLK5B | 204 | 56 | -2.1 | 4.3 | -0.012 | 1.637 | 0.570 | -0.376 | 1.695 | 0.599 |
| ATC(A)6 | FAA | 251 | 9 | -0.4 | -0.0 | 79.096 | 8.057 | 0.760 | 73.389 | 10.686 | 0.854 |
| ATC(B)1 | FSG | 284 | 88 | 0.3 | -0.5 | 83.782 | 5.212 | 0.760 | 79.861 | 6.673 | 0.854 |
| ATC(B)2 | BLK2 | 349 | 23 | -0.8 | -0.4 | -0.034 | 1.804 | 0.690 | -0.930 | 2.080 | 0.767 |
| ATC(B)3 | BLK3A | 308 | 64 | -2.7 | 9.8 | 0.009 | 1.567 | 0.420 | -0.208 | 1.589 | 0.436 |
| ATC(B)4 | BLK5A | 295 | 77 | -2.6 | 5.3 | -0.022 | 1.917 | 0.800 | -0.892 | 2.081 | 0.830 |
| ATC(B)5 | BLK5B | 291 | 81 | -1.8 | 4.8 | 0.021 | 1.616 | 0.620 | -0.828 | 1.794 | 0.692 |
| ATC(B)6 | FAA | 285 | 87 | -0.4 | -0.3 | 86.842 | 5.398 | 0.620 | 82.507 | 7.147 | 0.692 |

Table H-3

Navy Schools
Uncorrected and Corrected Moments and Reliabilities of the Criteria

| School | Criterion | N | Missing | Skewness | Kurtosis | Uncorrected | | | Corrected | | |
|--------|-----------|-----|---------|----------|----------|-------------|----------|-------------|-----------|----------|-------------|
| | | | | | | Mean | Std.Dev. | Reliability | Mean | Std.Dev. | Reliability |
| AC1 | FSG | 72 | 4 | 0.4 | -0.7 | 84.525 | 4.749 | 0.900 | 79.562 | 7.035 | 0.954 |
| AC2 | PERF | 76 | 0 | -0.6 | 0.1 | 90.790 | 4.826 | 0.590 | 88.947 | 5.467 | 0.680 |
| AC3 | FAA | 76 | 0 | -0.2 | 0.6 | 79.632 | 6.335 | | 76.484 | 7.584 | |
| AE1 | FSG | 278 | 0 | -0.6 | 2.1 | 83.307 | 6.074 | 0.900 | 82.024 | 6.964 | 0.924 |
| AE2 | SUM2 | 273 | 5 | -1.6 | 4.3 | 88.170 | 7.562 | 0.804 | 86.729 | 8.325 | 0.838 |
| AMS1 | FSG | 244 | 0 | 0.1 | -0.2 | 83.585 | 4.028 | 0.860 | 80.297 | 5.741 | 0.931 |
| AMS2 | PERF | 244 | 0 | -0.5 | 0.5 | 85.100 | 3.309 | 0.700 | 83.486 | 3.815 | 0.774 |
| AO1 | FSG | 234 | 0 | 0.0 | -0.5 | 85.897 | 5.349 | 0.846 | 85.017 | 6.484 | 0.895 |
| AO2 | PRACTL | 229 | 5 | -1.7 | 3.8 | 93.560 | 4.637 | 0.724 | 93.324 | 4.959 | 0.759 |
| AV1 | FSG | 544 | 0 | 0.1 | -0.7 | 90.043 | 3.791 | 0.931 | 85.296 | 5.444 | 0.967 |
| AV2 | BSCAV | 192 | 352 | -0.2 | -0.9 | 84.771 | 7.861 | 0.884 | 72.929 | 12.228 | 0.952 |
| AV3 | ADVAV | 192 | 352 | -0.2 | -0.3 | 88.366 | 5.031 | 0.817 | 83.859 | 6.428 | 0.888 |
| AV4 | PERFORM | 352 | 192 | -2.1 | 7.2 | 96.749 | 2.712 | 0.579 | 94.891 | 3.078 | 0.673 |
| EM1 | FSG | 797 | 0 | 0.2 | -0.7 | 87.906 | 4.719 | 0.920 | 86.995 | 5.687 | 0.945 |
| EM2 | PHASE1 | 797 | 0 | -0.5 | -0.0 | 87.835 | 6.479 | 0.835 | 86.299 | 7.906 | 0.889 |
| EN1 | FSG | 750 | 0 | -0.5 | 6.6 | 84.873 | 5.185 | 0.878 | 84.007 | 6.196 | 0.915 |
| ET1 | FSG | 86 | 0 | 0.2 | -0.7 | 81.679 | 5.953 | 0.825 | 74.247 | 9.381 | 0.930 |
| ET2 | FSG2 | 86 | 0 | -0.3 | -0.1 | 82.909 | 6.025 | 0.928 | 74.693 | 9.929 | 0.973 |
| ET3 | PERF | 86 | 0 | -1.1 | 1.4 | 84.928 | 9.444 | 0.772 | 75.570 | 13.303 | 0.885 |
| FC1 | FSG | 778 | 2 | 0.3 | -0.6 | 84.965 | 4.806 | 0.924 | 78.597 | 7.313 | 0.967 |
| FC2 | RADAR | 780 | 0 | -0.3 | -0.0 | 82.470 | 7.161 | 0.675 | 76.293 | 8.992 | 0.794 |
| GM1 | FSG | 420 | 0 | 0.0 | -0.5 | 85.838 | 4.896 | 0.920 | 84.103 | 6.394 | 0.953 |
| GM2 | HALF1 | 420 | 0 | -0.1 | -0.6 | 85.456 | 5.367 | 0.870 | 83.393 | 7.168 | 0.927 |
| GM3 | HALF2 | 397 | 23 | -0.7 | 2.2 | 87.997 | 4.841 | 0.870 | 86.467 | 6.140 | 0.919 |
| MM1 | FSG | 801 | 0 | 0.2 | -0.6 | 82.689 | 6.353 | 0.880 | 81.803 | 6.896 | 0.898 |
| OS1 | FSG | 713 | 102 | -0.4 | -0.2 | 88.739 | 4.427 | 0.850 | 87.346 | 5.762 | 0.911 |
| OS2 | WRIT | 815 | 0 | -0.3 | -0.2 | 88.236 | 4.608 | 0.749 | 87.218 | 5.627 | 0.832 |
| OS3 | PERF | 815 | 0 | -0.6 | -0.1 | 89.656 | 4.904 | 0.705 | 88.309 | 5.991 | 0.802 |
| RM1 | FSG | 277 | 0 | -0.1 | -0.8 | 94.787 | 2.527 | 0.800 | 94.362 | 3.154 | 0.872 |
| RM2 | PHASE3 | 277 | 0 | -0.7 | -0.0 | 94.366 | 3.408 | 0.600 | 94.040 | 3.882 | 0.692 |

Appendix I

Test Validities and Incremental Validities for All Criteria

Table I-1

ECAT Incremental Validities for all Army Criteria

| School | Criterion | Sample Size | Uncorrected Multiple R | | | | Corrected Multiple R | | |
|---------|-----------|-------------|------------------------|-------------|------------------|-----------------------------|----------------------|----------|----------|
| | | | ASVAB | ASVAB +ECAT | Percent Variance | Probability of $F_{6,N-17}$ | ASVAB | Increase | Percent |
| 11H(A)1 | TOALL | 554 | .242 | .275 | 1.807 | 1.40×10^{-1} | .272 | .013 | 4.7 |
| 11H(A)2 | EVT1TO | 556 | .316 | .362 | 3.644 | 3.59×10^{-3} | .404 | .030 | 7.4 ** |
| 11H(A)3 | EVT2TO | 555 | .242 | .286 | 2.549 | 3.46×10^{-2} | .273 | .034 | 12.6 * |
| 11H(A)4 | EVT3TO | 550 | .294 | .329 | 2.438 | 4.48×10^{-2} | .365 | .019 | 5.3 * |
| 11H(A)5 | EVTSUM | 546 | .321 | .373 | 4.119 | 1.53×10^{-3} | .392 | .036 | 9.2 ** |
| 11H(A)6 | TO_1 | 542 | .210 | .269 | 3.031 | 1.52×10^{-2} | .240 | .046 | 19.1 * |
| 11H(B)1 | TOALL | 320 | .313 | .335 | 1.629 | 5.53×10^{-1} | .372 | .000 | 0.1 |
| 11H(B)2 | EVT1TO | 320 | .291 | .398 | 8.765 | 2.62×10^{-4} | .305 | .089 | 29.1 ** |
| 11H(B)3 | EVT2TO | 319 | .312 | .434 | 11.171 | 1.50×10^{-5} | .389 | .095 | 24.5 ** |
| 11H(B)4 | EVT3TO | 319 | .234 | .292 | 3.308 | 1.29×10^{-1} | .243 | .029 | 11.9 |
| 11H(B)5 | EVTSUM | 316 | .330 | .446 | 11.216 | 1.64×10^{-5} | .382 | .091 | 23.7 ** |
| 11H(B)6 | TO_1 | 319 | .144 | .317 | 8.843 | 2.47×10^{-4} | .014 | .269 | 1979 ** |
| 11H(B)7 | TO_2 | 320 | .172 | .309 | 7.313 | 1.48×10^{-3} | .093 | .162 | 173.6 ** |
| 11H(B)8 | TO_3 | 319 | .176 | .329 | 8.710 | 2.90×10^{-4} | .054 | .225 | 418.8 ** |
| 11H(B)9 | ITVTOW | 318 | .154 | .350 | 11.203 | 1.51×10^{-5} | .075 | .237 | 316.3 ** |
| 13F1 | FSG | 821 | .544 | .597 | 9.483 | 9.81×10^{-14} | .790 | .024 | 3.0 ** |
| 13F2 | MPRAD | 821 | .513 | .590 | 12.950 | $<1.0 \times 10^{-17}$ | .809 | .040 | 4.9 ** |
| 13F3 | FIRING | 821 | .444 | .466 | 2.507 | 2.82×10^{-3} | .730 | .007 | 1.0 ** |
| 19K1 | COMM | 1158 | .080 | .135 | 1.208 | 3.28×10^{-2} | .000 | .071 | .* |
| 19K2 | WEAPON | 1325 | .187 | .205 | .738 | 1.41×10^{-1} | .198 | .006 | 3.2 |
| 19K3 | LANDNA | 1192 | .175 | .192 | .617 | 2.99×10^{-1} | .190 | .005 | 2.5 |
| 19K4 | LOADER | 1313 | .066 | .087 | .330 | 6.40×10^{-1} | .000 | .000 | . |
| 19K5 | MAINT | 1329 | .128 | .154 | .767 | 1.23×10^{-1} | .109 | .011 | 10.4 |
| 19K6 | NBC | 1313 | .119 | .136 | .429 | 4.75×10^{-1} | .128 | .001 | 0.5 |
| 19K7 | AVERAG | 1106 | .208 | .226 | .834 | 1.70×10^{-1} | .392 | .006 | 1.7 |

$$\text{Percent Variance} = 100 \frac{\Delta R^2}{1 - R_{ASVAB+ECAT}^2}$$

* p < .05.

** p < .01.

Table I-2

ECAT Incremental Validities for all Air Force Criteria

| School | Criterion | Sample Size | Uncorrected Multiple R | | | | Corrected Multiple R | | |
|---------|-----------|-------------|------------------------|-------------|------------------|-----------------------------|----------------------|----------|---------|
| | | | ASVAB | ASVAB +ECAT | Percent Variance | Probability of $F_{6,N-17}$ | ASVAB | Increase | Percent |
| APS1 | FSG | 446 | .545 | .581 | 6.233 | 2.17×10^{-4} | .828 | .012 | 1.5 ** |
| APS2 | ZHRS | 446 | .424 | .476 | 6.059 | 2.94×10^{-4} | .680 | .023 | 3.4 ** |
| APS3 | AFPT70 | 432 | .294 | .404 | 9.129 | 2.28×10^{-6} | .388 | .079 | 20.4 ** |
| ATC1 | FSG | 484 | .403 | .445 | 4.540 | 1.98×10^{-3} | .727 | .020 | 2.7 ** |
| ATC2 | BLK2 | 349 | .374 | .410 | 3.373 | 8.60×10^{-2} | .660 | .009 | 1.4 |
| ATC3 | BLK3A | 529 | .153 | .217 | 2.481 | 4.99×10^{-2} | .267 | .062 | 23.1 * |
| ATC4 | BLK3B | 217 | .165 | .341 | 10.057 | 3.61×10^{-3} | .000 | .368 | ** |
| ATC5 | BLK5A | 500 | .267 | .359 | 6.618 | 2.45×10^{-5} | .494 | .090 | 18.2 ** |
| ATC6 | BLK5B | 495 | .216 | .263 | 2.422 | 7.45×10^{-2} | .444 | .031 | 7.0 |
| ATC7 | FAA | 536 | .490 | .523 | 4.600 | 6.64×10^{-4} | .757 | .013 | 1.7 ** |
| ATC(A)1 | FSG | 200 | .389 | .464 | 8.205 | 2.37×10^{-2} | .680 | .043 | 6.3 * |
| ATC(A)2 | BLK3A | 221 | .279 | .314 | 2.339 | 5.75×10^{-1} | .302 | .000 | 0.1 |
| ATC(A)3 | BLK3B | 217 | .165 | .341 | 10.057 | 3.61×10^{-3} | .000 | .368 | ** |
| ATC(A)4 | BLK5A | 205 | .322 | .404 | 7.127 | 4.18×10^{-2} | .614 | .079 | 12.9 * |
| ATC(A)5 | BLK5B | 204 | .214 | .254 | 2.008 | 7.10×10^{-1} | .276 | .013 | 4.6 |
| ATC(A)6 | FAA | 251 | .508 | .543 | 5.179 | 6.39×10^{-2} | .744 | .011 | 1.5 |
| ATC(B)1 | FSG | 284 | .449 | .480 | 3.788 | 1.25×10^{-1} | .758 | .009 | 1.2 |
| ATC(B)2 | BLK2 | 349 | .374 | .410 | 3.373 | 8.60×10^{-2} | .660 | .009 | 1.4 |
| ATC(B)3 | BLK3A | 308 | .195 | .284 | 4.627 | 3.92×10^{-2} | .208 | .142 | 68.4 * |
| ATC(B)4 | BLK5A | 295 | .312 | .408 | 8.316 | 1.04×10^{-3} | .450 | .100 | 22.2 ** |
| ATC(B)5 | BLK5B | 291 | .264 | .330 | 4.376 | 6.61×10^{-2} | .541 | .041 | 7.6 |
| ATC(B)6 | FAA | 285 | .485 | .516 | 4.160 | 8.83×10^{-2} | .728 | .015 | 2.1 |

$$\text{Percent Variance} = 100 \frac{\Delta R^2}{1 - R^2_{ASVAB+ECAT}}$$

* p < .05.

** p < .01.

Table I-3

ECAT Incremental Validities for all Navy Criteria

| School | Criterion | Sample Size | Uncorrected Multiple R | | | | Corrected Multiple R | | |
|--------|-----------|-------------|------------------------|-------------|------------------|-----------------------------|----------------------|----------|---------|
| | | | ASVAB | ASVAB +ECAT | Percent Variance | Probability of $F_{6,N-17}$ | ASVAB | Increase | Percent |
| AC1 | FSG | 72 | .627 | .649 | 4.978 | 8.37×10^{-1} | .839 | .000 | 0 |
| AC2 | PERF | 76 | .330 | .460 | 13.033 | 2.80×10^{-1} | .381 | .149 | 39.2 |
| AC3 | FAA | 76 | .454 | .540 | 11.968 | 3.31×10^{-1} | .551 | .043 | 7.8 |
| AE1 | FSG | 278 | .489 | .542 | 7.810 | 3.04×10^{-3} | .659 | .023 | 3.5 ** |
| AE2 | SUM2 | 273 | .440 | .487 | 5.808 | 2.39×10^{-2} | .608 | .022 | 3.7 * |
| AMS1 | FSG | 244 | .599 | .602 | .555 | 9.73×10^{-1} | .848 | .000 | 0 |
| AMS2 | PERF | 244 | .393 | .431 | 3.892 | 1.89×10^{-1} | .650 | .016 | 2.4 |
| AO1 | FSG | 234 | .504 | .522 | 2.434 | 5.10×10^{-1} | .717 | .005 | 0.7 |
| AO2 | PRACTL | 229 | .343 | .374 | 2.652 | 4.69×10^{-1} | .490 | .010 | 2.1 |
| AV1 | FSG | 544 | .517 | .536 | 2.772 | 2.49×10^{-2} | .810 | .005 | 0.7 * |
| AV2 | BSCAV | 192 | .531 | .565 | 5.494 | 1.49×10^{-1} | .844 | .008 | 0.9 |
| AV3 | ADVAV | 192 | .358 | .402 | 4.003 | 3.26×10^{-1} | .694 | .009 | 1.3 |
| AV4 | PERFOR | 352 | .379 | .409 | 2.853 | 1.48×10^{-1} | .673 | .016 | 2.4 |
| EM1 | FSG | 797 | .451 | .459 | .864 | 3.47×10^{-1} | .687 | .000 | 0 |
| EM2 | PHASE1 | 797 | .474 | .482 | .950 | 2.86×10^{-1} | .729 | .001 | 0.1 |
| EN1 | FSG | 750 | .584 | .588 | .721 | 5.09×10^{-1} | .763 | .000 | 0 |
| ET1 | FSG | 86 | .509 | .603 | 16.470 | 9.42×10^{-2} | .805 | .043 | 5.3 |
| ET2 | FSG2 | 86 | .504 | .566 | 9.738 | 3.60×10^{-1} | .813 | .027 | 3.3 |
| ET3 | PERF | 86 | .482 | .574 | 14.533 | 1.41×10^{-1} | .735 | .075 | 10.2 |
| FC1 | FSG | 778 | .499 | .528 | 4.180 | 2.28×10^{-5} | .828 | .010 | 1.2 ** |
| FC2 | RADAR | 780 | .345 | .381 | 3.053 | 7.93×10^{-4} | .733 | .016 | 2.1 ** |
| GM1 | FSG | 420 | .428 | .454 | 2.911 | 7.10×10^{-2} | .731 | .004 | 0.6 |
| GM2 | HALF1 | 420 | .442 | .478 | 4.273 | 9.48×10^{-3} | .762 | .008 | 1.0 ** |
| GM3 | HALF2 | 397 | .458 | .467 | 1.033 | 6.87×10^{-1} | .734 | .000 | 0 |
| MM1 | FSG | 801 | .402 | .425 | 2.362 | 5.41×10^{-3} | .557 | .012 | 2.2 ** |
| OS1 | FSG | 713 | .565 | .582 | 2.969 | 2.33×10^{-3} | .804 | .007 | 0.9 ** |
| OS2 | WRIT | 815 | .478 | .489 | 1.405 | 8.34×10^{-2} | .756 | .003 | 0.4 |
| OS3 | PERF | 815 | .523 | .564 | 6.510 | 3.81×10^{-9} | .791 | .025 | 3.1 ** |
| RM1 | FSG | 277 | .536 | .587 | 8.796 | 1.17×10^{-3} | .775 | .022 | 2.8 ** |
| RM2 | PHASE3 | 277 | .420 | .464 | 4.907 | 5.08×10^{-2} | .702 | .017 | 2.4 |

$$\text{Percent Variance} = 100 \frac{\Delta R^2}{1 - R^2_{\text{ASVAB+ECAT}}}$$

* p < .05.

** p < .01.

Table I-4

**Incremental Validities from Adding one ECAT test to the ASVAB
All Significant Criteria from Full Model**

| School | Criterion | Mental Counters | Sequential Memory | Integrating Details | Assembling Objects |
|---------|-----------|--------------------|----------------------|------------------------|-----------------------|
| 11H(A)2 | EVT1TO | .012* | .004 | .008* | .015** |
| 11H(A)3 | EVT2TO | .009 | .004 | .001 | .026** |
| 11H(A)4 | EVT3TO | .006 | .009 | .000 | .025** |
| 11H(A)5 | EVTSUM | .013* | .008 | .004 | .027** |
| 11H(A)6 | TO_1 | .000 | .000 | .000 | .000 |
| 11H(B)2 | EVT1TO | .000 | .037** | .018* | .007 |
| 11H(B)3 | EVT2TO | .020* | .036** | .026** | .008 |
| 11H(B)5 | EVTSUM | .008 | .024* | .016* | .003 |
| 11H(B)6 | TO_1 | .084 | .116 | .000 | .078* |
| 11H(B)7 | TO_2 | .000 | .000 | .034* | .021 |
| 11H(B)8 | TO_3 | .000 | .000 | .009 | .053* |
| 11H(B)9 | ITVTOW | .000 | .000 | .006 | .056* |
| 13F1 | FSG | .010** | .009** | .012** | .012** |
| 13F2 | MPRAD | .019** | .011** | .023** | .021** |
| 13F3 | FIRING | .002* | .007** | .002* | .002* |
| 19K1 | COMM | .000 | .000 | .000 | .000 |
| APS1 | FSG | .002 | .006** | .003* | .000 |
| APS2 | ZHRS | .003* | .023** | .000 | .000 |
| APS3 | AFPT70 | .018** | .034** | .025** | .010* |
| ATC1 | FSG | .015** | .004 | .001 | .005* |
| ATC3 | BLK3A | .022 | .038* | .005 | .000 |
| ATC4 | BLK3B | .165 | .210** | .000 | .000 |
| ATC5 | BLK5A | .078** | .019 | .018** | .027** |
| ATC7 | FAA | .018** | .001 | .001* | .004* |
| ATC(A)1 | FSG | .037** | .015* | .002 | .002 |
| ATC(A)3 | BLK3B | .165 | .210** | .000 | .000 |
| ATC(A)4 | BLK5A | .111** | .006 | .026* | .015 |
| ATC(B)3 | BLK3A | .058 | .127* | .006 | .000 |
| ATC(B)4 | BLK5A | .060* | .032 | .014 | .040* |
| AC2 | PERF | .048 | .135* | .045 | .126* |
| AE1 | FSG | .010** | .020** | .019** | .009* |
| AE2 | SUM2 | .008* | .018** | .005 | .004 |
| AV1 | FSG | .007** | .002* | .002* | .002* |
| FC1 | FSG | .000 | .000 | .001 | .003** |
| FC2 | RADAR | .000 | .005** | .000 | .001 |
| GM2 | HALF1 | .007** | .000 | .001 | .001 |
| GM3 | HALF2 | .002 | .000 | .000 | .002 |
| OS1 | FSG | .007** | .003* | .002* | .002* |
| OS3 | PERF | .017** | .011** | .006** | .010** |
| RM1 | FSG | .004 | .002 | .004 | .000 |

* p < .05.

** p < .01.

Table I-4 (continued)

| School | Criterion | One-hand Tracking | Two-hand Tracking | Target Identification | Spatial Orientation |
|---------|-----------|----------------------|----------------------|--------------------------|------------------------|
| 11H(A)2 | EVT1TO | .013* | .021** | .006 | .017** |
| 11H(A)3 | EVT2TO | .020* | .028** | .024* | .004 |
| 11H(A)4 | EVT3TO | .014* | .021** | .003 | .003 |
| 11H(A)5 | EVTSUM | .019** | .029** | .011* | .010* |
| 11H(A)6 | TO_1 | .036** | .044** | .000 | .008 |
| 11H(B)2 | EVT1TO | .057** | .081** | .026* | .038** |
| 11H(B)3 | EVT2TO | .059** | .071** | .021* | .018* |
| 11H(B)5 | EVTSUM | .059** | .078** | .021* | .022** |
| 11H(B)6 | TO_1 | .132* | .152** | .000 | .027 |
| 11H(B)7 | TO_2 | .138** | .160** | .000 | .014 |
| 11H(B)8 | TO_3 | .201** | .182** | .000 | .108** |
| 11H(B)9 | ITVTOW | .159** | .172** | .000 | .047* |
| 13F1 | FSG | .005** | .003** | .003* | .010** |
| 13F2 | MPRAD | .003** | .003** | .004** | .014** |
| 13F3 | FIRING | .006** | .002* | .002 | .002* |
| 19K1 | COMM | .000 | .000 | .030* | .000 |
| APS1 | FSG | .000 | .000 | .000 | .002* |
| APS2 | ZHRS | .000 | .000 | .004* | .000 |
| APS3 | AFPT70 | .006 | .028** | .000 | .004 |
| ATC1 | FSG | .006* | .003 | .008** | .010** |
| ATC3 | BLK3A | .030* | .059** | .000 | .000 |
| ATC4 | BLK3B | .000 | .074 | .000 | .091 |
| ATC5 | BLK5A | .047** | .031** | .012 | .023** |
| ATC7 | FAA | .001 | .003* | .000 | .007** |
| ATC(A)1 | FSG | .021* | .014* | .016* | .001 |
| ATC(A)3 | BLK3B | .000 | .074 | .000 | .091 |
| ATC(A)4 | BLK5A | .030 | .015 | .005 | .000 |
| ATC(B)3 | BLK3A | .089* | .076* | .008 | .029 |
| ATC(B)4 | BLK5A | .049** | .034** | .023* | .044** |
| AC2 | PERF | .063 | .000 | .000 | .033 |
| AE1 | FSG | .004* | .000 | .004 | .004* |
| AE2 | SUM2 | .000 | .000 | .009* | .000 |
| AV1 | FSG | .000 | .002 | .000 | .001 |
| FC1 | FSG | .000 | .001* | .001* | .000 |
| FC2 | RADAR | .002 | .004* | .000 | .000 |
| GM2 | HALF1 | .001 | .001 | .001 | .005** |
| GM3 | HALF2 | .000 | .000 | .000 | .001 |
| OS1 | FSG | .000 | .001 | .000 | .003* |
| OS3 | PERF | .003* | .006** | .000 | .011** |
| RM1 | FSG | .002 | .000 | .011** | .002 |

* p < .05.

** p < .01.

Table I-4 (continued)

| School | Criterion | Memory Composite | Spatial Composite | Tracking Composite | Figural Reasoning |
|---------|-----------|------------------|-------------------|--------------------|-------------------|
| 11H(A)2 | EVT1TO | .011* | .016** | .020** | .000 |
| 11H(A)3 | EVT2TO | .011 | .017* | .028** | .002 |
| 11H(A)4 | EVT3TO | .011* | .012* | .021** | .000 |
| 11H(A)5 | EVTSUM | .015* | .020** | .028** | .001 |
| 11H(A)6 | TO_1 | .000 | .000 | .047** | .007 |
| 11H(B)2 | EVT1TO | .022* | .019* | .080** | .000 |
| 11H(B)3 | EVT2TO | .039** | .024* | .076** | .000 |
| 11H(B)5 | EVTSUM | .023* | .013 | .080** | .000 |
| 11H(B)6 | TO_1 | .126* | .035* | .156** | .000 |
| 11H(B)7 | TO_2 | .000 | .043* | .168** | .000 |
| 11H(B)8 | TO_3 | .000 | .050* | .213** | .000 |
| 11H(B)9 | ITVTOW | .004 | .047** | .185** | .000 |
| 13F1 | FSG | .013** | .017** | .005** | .010** |
| 13F2 | MPRAD | .021** | .032** | .004** | .016** |
| 13F3 | FIRING | .006** | .003** | .005** | .003** |
| 19K1 | COMM | .000 | .000 | .000 | .000 |
| APS1 | FSG | .006** | .002* | .000 | .010** |
| APS2 | ZHRS | .016** | .000 | .000 | .004* |
| APS3 | AFPT70 | .036** | .024** | .018** | .014** |
| ATC1 | FSG | .013** | .004* | .005* | .000 |
| ATC3 | BLK3A | .043* | .000 | .051** | .015 |
| ATC4 | BLK3B | .229** | .000 | .000 | .294** |
| ATC5 | BLK5A | .062** | .032** | .045** | .041** |
| ATC7 | FAA | .011** | .004** | .002 | .004* |
| ATC(A)1 | FSG | .036** | .004 | .021* | .010 |
| ATC(A)3 | BLK3B | .229** | .000 | .000 | .294** |
| ATC(A)4 | BLK5A | .066** | .031** | .027 | .060** |
| ATC(B)3 | BLK3A | .125* | .000 | .097* | .019 |
| ATC(B)4 | BLK5A | .063* | .038* | .049** | .036 |
| AC2 | PERF | .128 | .123 | .025 | .070 |
| AE1 | FSG | .021** | .020** | .003* | .009* |
| AE2 | SUM2 | .019** | .007 | .000 | .003 |
| AV1 | FSG | .007** | .003* | .001 | .001 |
| FC1 | FSG | .000 | .003** | .000 | .004** |
| FC2 | RADAR | .003* | .000 | .004* | .003 |
| GM2 | HALF1 | .001 | .001 | .001* | .004** |
| GM3 | HALF2 | .000 | .000 | .000 | .001 |
| OS1 | FSG | .007** | .003** | .000 | .004** |
| OS3 | PERF | .019** | .012** | .005** | .007** |
| RM1 | FSG | .005 | .002 | .002 | .000 |

* p < .05.

** p < .01.

Table I-5

Uncorrected Simple Validities for all Army Criteria

| School | Criterion | N | GS | AR | WK | PC | NO | CS | AS | MK | MC | EI | CT | SM | ID | AO | T1 | T2 | FR | SO | TI | Mem Spa- Tracking | | |
|---------|-----------|------|----|-----|----|-----|-----|-----|-----|-----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------------------|-----|-----|
| 11H(A)1 | TOALL | 554 | 09 | 16 | 05 | 14 | 07 | 09 | 13 | 16 | 12 | 13 | 22 | 12 | 12 | 12 | -04 | -04 | 15 | 11 | 01 | 19 | 14 | -05 |
| 11H(A)2 | EVT1TO | 556 | 17 | 15 | 18 | 17 | 01 | 06 | 21 | 19 | 25 | 19 | 18 | 14 | 20 | 23 | -17 | -21 | 14 | 24 | -12 | 18 | 24 | -21 |
| 11H(A)3 | EVT2TO | 555 | 08 | 11 | 11 | 14 | 05 | 06 | 12 | 15 | 15 | 17 | 14 | 12 | 12 | 20 | -14 | -17 | 12 | 14 | -13 | 15 | 18 | -17 |
| 11H(A)4 | EVT3TO | 550 | 18 | 15 | 20 | 22 | 04 | 01 | 15 | 18 | 23 | 18 | 15 | 15 | 14 | 23 | -16 | -20 | 15 | 18 | -10 | 17 | 21 | -19 |
| 11H(A)5 | EVTSUM | 546 | 17 | 15 | 19 | 20 | 03 | 05 | 20 | 20 | 24 | 22 | 19 | 15 | 18 | 26 | -18 | -23 | 15 | 22 | -14 | 19 | 25 | -22 |
| 11H(A)6 | TO_1 | 542 | 13 | 09 | 12 | 08 | 12 | 11 | 05 | 14 | 12 | 04 | 06 | 09 | 10 | 07 | -16 | -18 | 14 | 14 | -08 | 09 | 10 | -18 |
| 11H(B)1 | TOALL | 320 | 11 | 18 | 23 | 22 | 09 | 06 | 08 | 03 | 15 | 11 | 07 | 13 | 20 | 03 | -09 | -10 | 20 | 08 | -06 | 12 | 13 | -10 |
| 11H(B)2 | EVT1TO | 320 | 20 | 12 | 19 | 16 | 11 | 08 | 09 | 16 | 23 | 21 | 13 | 22 | 23 | 18 | -28 | -30 | 18 | 27 | -20 | 20 | 23 | -31 |
| 11H(B)3 | EVT2TO | 319 | 20 | 17 | 22 | 21 | 20 | 15 | 07 | 14 | 19 | 19 | 18 | 25 | 25 | 17 | -29 | -31 | 16 | 24 | -21 | 24 | 23 | -32 |
| 11H(B)4 | EVT3TO | 319 | 16 | 08 | 07 | 08 | 10 | 04 | 10 | 11 | 17 | 14 | 11 | 04 | 09 | 04 | -14 | -18 | 02 | 13 | -11 | 08 | 07 | -17 |
| 11H(B)5 | EVTSUM | 316 | 24 | 16 | 21 | 19 | 18 | 12 | 11 | 17 | 25 | 23 | 17 | 23 | 25 | 18 | -31 | -34 | 16 | 28 | -22 | 23 | 23 | -35 |
| 11H(B)6 | TO_1 | 319 | 04 | -03 | 00 | -02 | -06 | -04 | 00 | 05 | 06 | 03 | -04 | -08 | 07 | 14 | -14 | -17 | 01 | 09 | 02 | -07 | 12 | -17 |
| 11H(B)7 | TO_2 | 320 | 05 | -08 | 00 | -01 | -09 | -07 | 06 | -04 | 06 | 01 | 01 | 00 | 10 | 09 | -21 | -23 | 04 | 07 | -01 | 01 | 11 | -23 |
| 11H(B)8 | TO_3 | 319 | 04 | -01 | 07 | -02 | 09 | 06 | 05 | 05 | 05 | 06 | 02 | 07 | 10 | 13 | -25 | -23 | 07 | 17 | -03 | 05 | 13 | -25 |
| 11H(B)9 | ITVTOW | 318 | 05 | -06 | 01 | -03 | -06 | -04 | 03 | 02 | 07 | 03 | -01 | -03 | 10 | 15 | -23 | -24 | 04 | 12 | 01 | -02 | 14 | -25 |
| 13F1 | FSG | 821 | 32 | 41 | 32 | 34 | 19 | 21 | 29 | 35 | 32 | 30 | 33 | 33 | 39 | 38 | -27 | -26 | 37 | 38 | -20 | 38 | 45 | -28 |
| 13F2 | MPRAD | 821 | 32 | 39 | 31 | 30 | 19 | 16 | 27 | 34 | 34 | 30 | 36 | 33 | 43 | 41 | -24 | -25 | 39 | 39 | -20 | 39 | 48 | -26 |
| 13F3 | FIRING | 821 | 26 | 34 | 27 | 29 | 14 | 18 | 23 | 29 | 22 | 23 | 21 | 26 | 25 | 25 | -23 | -19 | 26 | 25 | -15 | 27 | 29 | -22 |
| 19K1 | COMM | 1158 | 01 | 00 | 01 | 00 | 03 | 01 | -04 | -01 | 01 | 01 | 00 | -02 | -02 | -04 | 00 | 02 | 04 | -02 | -06 | -01 | -03 | 01 |
| 19K2 | WEAPON | 1325 | 14 | 11 | 06 | 07 | 06 | 09 | 06 | 15 | 08 | 09 | 08 | 10 | 10 | 09 | -08 | -05 | 04 | 05 | -09 | 10 | 11 | -07 |
| 19K3 | LANDNAV | 1192 | 10 | 12 | 03 | 05 | 11 | 04 | 04 | 13 | 10 | 07 | 10 | 10 | 07 | 09 | -09 | -08 | 07 | 06 | -02 | 11 | 09 | -10 |
| 19K4 | LOADER | 1313 | 04 | 00 | 04 | 02 | 01 | 01 | 03 | 00 | 05 | 03 | 04 | 01 | 02 | 01 | -02 | -03 | 01 | 04 | 02 | 03 | 01 | -03 |
| 19K5 | MAINT | 1329 | 07 | 06 | 02 | 07 | 00 | 05 | 03 | 08 | 04 | 05 | 02 | 06 | 04 | 05 | -04 | -02 | -02 | 06 | -05 | 05 | 05 | -03 |
| 19K6 | NBC | 1313 | 07 | 06 | 05 | 05 | 08 | 08 | 03 | 08 | 05 | 04 | 04 | 03 | 02 | 05 | -07 | -07 | 03 | 01 | -06 | 04 | 04 | -07 |
| 19K7 | AVERAGE | 1106 | 14 | 12 | 07 | 10 | 12 | 11 | 07 | 15 | 10 | 07 | 12 | 11 | 12 | 12 | -10 | -08 | 05 | 08 | -08 | 13 | 14 | -10 |

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
 AO = Assembling Objects Proportion Correct
 FR = Figural Reasoning Proportion Correct
 SM = Sequential Memory Proportion Correct
 T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 SO = Spatial Orientation Proportion Correct
 ID = Integrating Details Proportion Correct
 T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 TI = Target Identification Mean Clipped Decision RTs

Table I-6

Uncorrected Simple Validities for all Air Force Criteria

| School | Criterion | N | GS | AR | WK | PC | NO | CS | AS | MK | MC | EI | CT | SM | ID | AO | T1 | T2 | FR | SO | TI | Mem Spa-Track ory tial ing | | |
|---------|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------------------------------|-----|-----|
| APS1 | FSG | 446 | 33 | 44 | 27 | 26 | 09 | 07 | 21 | 37 | 28 | 19 | 25 | 28 | 28 | 20 | -05 | -09 | 33 | 26 | -06 | 30 | 27 | -08 |
| APS2 | ZHRS | 446 | -13 | -32 | -20 | -15 | -15 | -16 | -08 | -29 | -07 | -04 | -21 | -29 | -12 | -07 | 02 | 00 | -20 | -11 | 10 | -29 | -11 | 01 |
| APS3 | AFPT70 | 432 | -05 | 10 | 13 | 04 | 12 | 17 | -08 | 10 | -05 | -12 | 17 | 21 | 13 | 08 | 10 | 16 | 15 | 09 | 04 | 22 | 12 | 14 |
| ATC1 | FSG | 484 | 21 | 27 | 27 | 16 | 03 | 06 | 22 | 25 | 29 | 26 | 23 | 17 | 22 | 26 | -20 | -20 | 18 | 27 | -17 | 22 | 27 | -21 |
| ATC2 | BLK2 | 349 | 22 | 28 | 18 | 11 | -03 | 00 | 23 | 23 | 29 | 21 | 15 | 12 | 21 | 15 | -23 | -22 | 17 | 28 | -13 | 15 | 20 | -24 |
| ATC3 | BLK3A | 529 | 04 | 06 | 07 | 03 | -01 | 04 | 03 | 13 | 10 | 03 | 10 | 12 | 09 | 06 | -11 | -15 | 10 | 05 | -02 | 13 | 09 | -13 |
| ATC4 | BLK3B | 217 | -11 | -01 | -01 | -07 | -01 | 01 | -01 | -02 | 03 | -02 | 13 | 17 | -02 | 01 | 04 | -07 | 18 | 11 | -01 | 17 | -01 | -02 |
| ATC5 | BLK5A | 500 | 09 | 23 | 00 | 01 | 07 | 01 | 02 | 14 | 15 | 06 | 27 | 16 | 21 | 21 | -23 | -19 | 20 | 20 | -10 | 25 | 24 | -23 |
| ATC6 | BLK5B | 495 | 03 | 10 | 12 | 00 | 10 | 12 | 01 | 14 | 05 | 01 | 16 | 11 | 09 | 04 | -10 | -08 | 08 | 11 | -05 | 16 | 07 | -10 |
| ATC7 | FAA | 536 | 33 | 33 | 33 | 21 | 04 | 07 | 26 | 33 | 32 | 26 | 30 | 16 | 28 | 29 | -15 | -22 | 26 | 31 | -09 | 26 | 33 | -20 |
| ATC(A)1 | FSG | 200 | 18 | 26 | 19 | 13 | 10 | 06 | 16 | 25 | 26 | 26 | 29 | 23 | 24 | 27 | -27 | -27 | 24 | 22 | -19 | 30 | 29 | -29 |
| ATC(A)2 | BLK3A | 221 | 04 | 03 | 10 | 11 | 00 | 08 | -05 | 12 | 16 | -06 | 07 | 07 | 09 | 10 | -04 | -12 | 13 | -02 | 05 | 08 | 11 | -08 |
| ATC(A)3 | BLK3B | 217 | -11 | -01 | -01 | -07 | -01 | 01 | -01 | -02 | 03 | -02 | 13 | 17 | -02 | 01 | 04 | -07 | 18 | 11 | -01 | 17 | -01 | -02 |
| ATC(A)4 | BLK5A | 205 | 05 | 22 | -03 | 05 | -01 | 04 | 04 | 01 | 20 | 07 | 30 | 10 | 24 | 22 | -19 | -17 | 20 | 14 | -04 | 23 | 26 | -19 |
| ATC(A)5 | BLK5B | 204 | -07 | 04 | 05 | -03 | 11 | 11 | -03 | 11 | 03 | -04 | 13 | 04 | 08 | 05 | -09 | -05 | 13 | 06 | -02 | 10 | 07 | -07 |
| ATC(A)6 | FAA | 251 | 34 | 39 | 27 | 19 | -01 | 06 | 27 | 33 | 37 | 31 | 29 | 22 | 32 | 33 | -23 | -29 | 32 | 27 | -13 | 29 | 37 | -28 |
| ATC(B)1 | FSG | 284 | 24 | 27 | 30 | 19 | -06 | 05 | 26 | 24 | 32 | 26 | 14 | 12 | 19 | 23 | -16 | -15 | 12 | 30 | -15 | 15 | 24 | -17 |
| ATC(B)2 | BLK2 | 349 | 22 | 28 | 18 | 11 | -03 | 00 | 23 | 23 | 29 | 21 | 15 | 12 | 21 | 15 | -23 | -22 | 17 | 28 | -13 | 15 | 20 | -24 |
| ATC(B)3 | BLK3A | 308 | 04 | 09 | 06 | -03 | -02 | 01 | 10 | 13 | 05 | 10 | 13 | 17 | 09 | 02 | -16 | -16 | 08 | 12 | -07 | 17 | 07 | -17 |
| ATC(B)4 | BLK5A | 295 | 12 | 23 | 02 | -02 | 14 | -01 | 02 | 22 | 11 | 06 | 25 | 20 | 19 | 20 | -25 | -21 | 20 | 24 | -13 | 26 | 23 | -25 |
| ATC(B)5 | BLK5B | 291 | 10 | 15 | 17 | 01 | 10 | 12 | 04 | 16 | 07 | 04 | 19 | 17 | 09 | 03 | -11 | -11 | 04 | 15 | -07 | 21 | 07 | -12 |
| ATC(B)6 | FAA | 285 | 35 | 24 | 32 | 25 | -06 | -02 | 28 | 30 | 26 | 24 | 26 | 11 | 17 | 16 | -20 | -22 | 15 | 23 | -08 | 21 | 19 | -23 |

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
 AO = Assembling Objects Proportion Correct
 FR = Figural Reasoning Proportion Correct

SM = Sequential Memory Proportion Correct
 T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 SO = Spatial Orientation Proportion Correct

ID = Integrating Details Proportion Correct
 T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 TI = Target Identification Mean Clipped Decision RTs

Table I-7
Uncorrected Simple Validities for all Navy Criteria

| School | Criterion | N | GS | AR | WK | PC | NO | CS | AS | MK | MC | EI | CT | SM | ID | AO | T1 | T2 | FR | SO | TI | Mem Sp- ory | Track ing |
|--------|-----------|-----|-----|----|-----|-----|----|----|-----|----|-----|-----|----|-----|----|----|-----|-----|----|----|-----|----------------|--------------|
| AC1 | FSG | 72 | 37 | 42 | 20 | 34 | 12 | 19 | 33 | 43 | 24 | 34 | 34 | 26 | 24 | 23 | -11 | -20 | 31 | 25 | -16 | 35 | 27 |
| AC2 | PERF | 76 | 04 | 09 | -11 | 08 | 14 | 19 | -02 | 01 | -05 | -09 | 12 | 29 | 08 | 23 | -07 | -04 | 16 | 17 | 03 | 24 | 18 |
| AC3 | FAA | 76 | 21 | 16 | 14 | 38 | 10 | 06 | 29 | 19 | 18 | 29 | 21 | 02 | 17 | 19 | 00 | -04 | 22 | 21 | -18 | 13 | 20 |
| AE1 | FSG | 278 | 38 | 33 | 32 | 31 | 08 | 11 | 36 | 23 | 26 | 29 | 28 | 33 | 36 | 27 | -23 | -20 | 33 | 28 | -20 | 35 | 37 |
| AE2 | SUM2 | 273 | 35 | 32 | 18 | 17 | 02 | 07 | 28 | 16 | 26 | 22 | 25 | 31 | 25 | 25 | -13 | -08 | 25 | 19 | -22 | 31 | 30 |
| AMS1 | FSG | 244 | 40 | 29 | 39 | 21 | 26 | 28 | 18 | 38 | 27 | 28 | 08 | 13 | 19 | 23 | -08 | -06 | 16 | 12 | -05 | 12 | 25 |
| AMS2 | PERF | 244 | 14 | 17 | 14 | -02 | 24 | 25 | 10 | 17 | 15 | 17 | 10 | 14 | 19 | 25 | -09 | -08 | 12 | 06 | -12 | 14 | 26 |
| AO1 | FSG | 234 | 22 | 31 | 20 | 20 | 25 | 27 | 18 | 40 | 22 | 19 | 20 | 09 | 22 | 24 | -15 | -07 | 19 | 21 | -14 | 17 | 26 |
| AO2 | PRACTL | 229 | 04 | 13 | 09 | 06 | 25 | 26 | 06 | 22 | 07 | 10 | 16 | 13 | 18 | 15 | -12 | -04 | 16 | 13 | -09 | 17 | 18 |
| AV1 | FSG | 544 | 11 | 32 | 10 | 16 | 13 | 16 | 15 | 39 | 26 | 19 | 30 | 22 | 27 | 25 | -12 | -17 | 25 | 25 | -05 | 30 | 30 |
| AV2 | BSCAV | 192 | 20 | 34 | 16 | 18 | 09 | 01 | 07 | 41 | 12 | 15 | 30 | 23 | 33 | 26 | -11 | -14 | 24 | 25 | -06 | 30 | 34 |
| AV3 | ADVAV | 192 | 14 | 18 | 14 | 16 | 14 | 09 | 02 | 27 | 00 | 09 | 11 | 10 | 20 | 14 | -13 | -11 | 05 | 05 | -11 | 12 | 19 |
| AV4 | PERFORM | 352 | 00 | 16 | -02 | 06 | 01 | 04 | 19 | 20 | 24 | 20 | 18 | 14 | 17 | 19 | -18 | -16 | 17 | 18 | 02 | 18 | 20 |
| EM1 | FSG | 797 | 20 | 33 | 19 | 18 | 10 | 17 | 21 | 26 | 26 | 28 | 23 | 15 | 21 | 16 | -10 | -11 | 22 | 21 | -01 | 22 | 21 |
| EM2 | PHASE1 | 797 | 18 | 35 | 18 | 17 | 07 | 15 | 17 | 30 | 26 | 29 | 22 | 15 | 19 | 19 | -07 | -11 | 25 | 21 | -01 | 21 | 22 |
| EN1 | FSG | 750 | 41 | 42 | 35 | 31 | 09 | 18 | 36 | 31 | 43 | 41 | 26 | 20 | 33 | 28 | -14 | -20 | 31 | 31 | -16 | 26 | 34 |
| ET1 | FSG | 86 | 27 | 20 | 08 | 13 | 06 | 11 | 26 | 21 | 15 | 21 | 23 | 18 | 29 | 30 | -27 | -35 | 20 | 25 | -03 | 26 | 35 |
| ET2 | FSG2 | 86 | 16 | 33 | 09 | 16 | 25 | 24 | 10 | 30 | 06 | 07 | 22 | 25 | 23 | 28 | -19 | -21 | 22 | 16 | -03 | 29 | 31 |
| ET3 | PERF | 86 | -13 | 30 | 03 | -01 | 27 | 26 | -03 | 32 | -11 | -02 | 15 | 20 | 09 | 09 | -20 | -17 | 09 | 19 | -02 | 22 | 11 |
| FC1 | FSG | 778 | 20 | 33 | 17 | 23 | 15 | 19 | 17 | 24 | 26 | 22 | 13 | 07 | 21 | 22 | -08 | -17 | 22 | 20 | 02 | 12 | 25 |
| FC2 | RADAR | 780 | 16 | 17 | 15 | 17 | 10 | 13 | 21 | 06 | 20 | 18 | 04 | -05 | 08 | 13 | -09 | -14 | 12 | 12 | 00 | -01 | 12 |
| GM1 | FSG | 420 | 14 | 28 | 25 | 16 | 08 | 13 | 21 | 18 | 21 | 12 | 23 | 14 | 19 | 19 | -18 | -20 | 19 | 24 | -02 | 21 | 22 |
| GM2 | HALF1 | 420 | 12 | 28 | 21 | 15 | 13 | 16 | 15 | 25 | 25 | 11 | 28 | 15 | 22 | 23 | -19 | -22 | 24 | 29 | -04 | 25 | 25 |
| GM3 | HALF2 | 397 | 21 | 22 | 25 | 18 | 06 | 14 | 34 | 10 | 21 | 15 | 16 | 09 | 14 | 22 | -13 | -15 | 15 | 22 | -08 | 14 | 20 |
| MM1 | FSG | 801 | 29 | 27 | 20 | 22 | 10 | 16 | 26 | 19 | 28 | 27 | 17 | 13 | 24 | 28 | -16 | -11 | 24 | 17 | -12 | 17 | 29 |
| OS1 | FSG | 713 | 29 | 46 | 22 | 18 | 14 | 14 | 25 | 39 | 38 | 25 | 39 | 28 | 36 | 32 | -17 | -24 | 37 | 34 | -14 | 39 | 38 |
| OS2 | WRIT | 815 | 29 | 38 | 25 | 19 | 09 | 03 | 23 | 34 | 33 | 22 | 30 | 23 | 26 | 25 | -12 | -20 | 29 | 28 | -10 | 31 | 29 |
| OS3 | PERF | 815 | 23 | 41 | 13 | 16 | 13 | 14 | 25 | 34 | 37 | 21 | 39 | 31 | 36 | 35 | -22 | -27 | 36 | 34 | -17 | 41 | 40 |
| RMI | FSG | 277 | 37 | 43 | 36 | 27 | 09 | 13 | 18 | 33 | 28 | 27 | 25 | 25 | 31 | 21 | -07 | -09 | 27 | 27 | 01 | 28 | 30 |
| RM2 | PHASE3 | 277 | 25 | 33 | 24 | 23 | 00 | 05 | 12 | 23 | 27 | 24 | 21 | 19 | 24 | 19 | -08 | -11 | 19 | 26 | 00 | 23 | 25 |

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
 AO = Assembling Objects Proportion Correct
 FR = Figure Reasoning Proportion Correct

SM = Sequential Memory Proportion Correct
 T1 = 1-Hand Tracking Mean 1000*log(1 + RMS)
 SO = Spatial Orientation Proportion Correct

ID = Integrating Details Proportion Correct
 T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 TI = Target Identification Mean Clipped Decision RTs

Table I-8

Range-Corrected Simple Validities for all Army Criteria

| School | Criterion | N | GS | AR | WK | PC | NO | CS | AS | MK | MC | EI | CT | SM | ID | AO | T1 | T2 | FR | SO | TI | Mem Spa-Track ory tial ing | | |
|---------|-----------|------|----|-----|-----|-----|-----|-----|-----|-----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------------------------------|-----|-----|
| 11H(A)1 | TOALL | 554 | 16 | 21 | 12 | 20 | 10 | 13 | 17 | 20 | 18 | 17 | 24 | 15 | 18 | 17 | -07 | -09 | 19 | 16 | -02 | 22 | 19 | -08 |
| 11H(A)2 | EVT1TO | 556 | 27 | 24 | 27 | 25 | 06 | 11 | 32 | 25 | 34 | 28 | 25 | 21 | 29 | 31 | -23 | -28 | 24 | 32 | -19 | 25 | 33 | -27 |
| 11H(A)3 | EVT2TO | 555 | 16 | 17 | 17 | 20 | 08 | 08 | 20 | 19 | 22 | 22 | 18 | 16 | 19 | 24 | -19 | -22 | 18 | 20 | -19 | 19 | 24 | -22 |
| 11H(A)4 | EVT3TO | 550 | 26 | 24 | 28 | 29 | 09 | 06 | 24 | 25 | 30 | 25 | 21 | 22 | 23 | 30 | -21 | -25 | 23 | 25 | -16 | 24 | 29 | -25 |
| 11H(A)5 | EVTSUM | 546 | 26 | 24 | 28 | 28 | 08 | 09 | 31 | 26 | 33 | 29 | 25 | 22 | 27 | 33 | -25 | -30 | 25 | 30 | -21 | 26 | 33 | -29 |
| 11H(A)6 | TO_1 | 542 | 18 | 14 | 17 | 13 | 17 | 15 | 13 | 18 | 18 | 10 | 11 | 13 | 15 | 12 | -21 | -23 | 18 | 18 | -12 | 13 | 15 | -24 |
| 11H(B)1 | TOALL | 320 | 20 | 27 | 31 | 32 | 21 | 15 | 18 | 15 | 24 | 19 | 19 | 20 | 26 | 13 | -13 | -17 | 26 | 15 | -09 | 21 | 21 | -16 |
| 11H(B)2 | EVT1TO | 320 | 26 | 21 | 23 | 21 | 17 | 11 | 21 | 21 | 30 | 26 | 19 | 26 | 28 | 25 | -30 | -35 | 22 | 31 | -24 | 25 | 29 | -35 |
| 11H(B)3 | EVT2TO | 319 | 29 | 30 | 32 | 31 | 30 | 23 | 20 | 24 | 28 | 27 | 30 | 33 | 32 | 27 | -34 | -37 | 23 | 30 | -25 | 35 | 33 | -38 |
| 11H(B)4 | EVT3TO | 319 | 20 | 16 | 12 | 13 | 16 | 08 | 17 | 16 | 23 | 19 | 15 | 08 | 16 | 11 | -20 | -23 | 07 | 16 | -14 | 12 | 14 | -23 |
| 11H(B)5 | EVTSUM | 316 | 31 | 28 | 29 | 28 | 26 | 18 | 24 | 26 | 34 | 30 | 27 | 29 | 32 | 27 | -35 | -40 | 23 | 33 | -26 | 31 | 33 | -40 |
| 11H(B)6 | TO_1 | 319 | 03 | -04 | -03 | -04 | -10 | -08 | 02 | 02 | 06 | 03 | -10 | -12 | 03 | 10 | -14 | -15 | -01 | 07 | 03 | -12 | 07 | -15 |
| 11H(B)7 | TO_2 | 320 | 05 | -07 | -02 | -03 | -10 | -08 | 08 | -05 | 08 | 03 | -02 | -02 | 08 | 08 | -20 | -22 | 03 | 07 | -01 | -02 | 09 | -22 |
| 11H(B)8 | TO_3 | 319 | 07 | 04 | 08 | 01 | 09 | 05 | 10 | 07 | 09 | 08 | 03 | 07 | 10 | 13 | -26 | -24 | 08 | 17 | -05 | 06 | 13 | -26 |
| 11H(B)9 | ITVTOW | 318 | 04 | -06 | -02 | -05 | -09 | -08 | 06 | 00 | 08 | 03 | -06 | -07 | 06 | 11 | -21 | -22 | 02 | 10 | 01 | -07 | 10 | -23 |
| 13F1 | FSG | 821 | 52 | 61 | 52 | 54 | 38 | 42 | 41 | 55 | 55 | 45 | 49 | 47 | 54 | 51 | -33 | -36 | 53 | 51 | -30 | 53 | 58 | -37 |
| 13F2 | MPRAD | 821 | 51 | 59 | 50 | 50 | 37 | 37 | 40 | 54 | 55 | 44 | 51 | 46 | 56 | 53 | -31 | -35 | 54 | 52 | -30 | 54 | 60 | -35 |
| 13F3 | FIRING | 821 | 44 | 52 | 44 | 46 | 31 | 36 | 34 | 47 | 43 | 37 | 37 | 39 | 40 | 39 | -29 | -29 | 42 | 40 | -24 | 42 | 43 | -31 |
| 19K1 | COMM | 1158 | 02 | 01 | 02 | 01 | 03 | 01 | -03 | 00 | 01 | 01 | 00 | -01 | -02 | -03 | 01 | 03 | 03 | -02 | -06 | -01 | -03 | 02 |
| 19K2 | WEAPON | 1325 | 17 | 15 | 11 | 12 | 11 | 13 | 11 | 17 | 12 | 13 | 11 | 12 | 12 | 12 | -10 | -08 | 09 | 09 | -11 | 13 | 13 | -10 |
| 19K3 | LANDNAV | 1192 | 13 | 15 | 07 | 09 | 14 | 07 | 09 | 16 | 15 | 10 | 13 | 12 | 10 | 13 | -13 | -12 | 10 | 10 | -05 | 14 | 13 | -13 |
| 19K4 | LOADER | 1313 | 05 | 03 | 05 | 04 | 03 | 03 | 04 | 02 | 06 | 04 | 05 | 03 | 03 | 02 | -03 | -04 | 02 | 05 | 01 | 04 | 03 | -03 |
| 19K5 | MAINT | 1329 | 09 | 09 | 05 | 09 | 03 | 07 | 06 | 10 | 06 | 07 | 05 | 07 | 05 | 07 | -05 | -04 | 01 | 08 | -05 | 07 | 07 | -05 |
| 19K6 | NBC | 1313 | 11 | 10 | 09 | 09 | 12 | 12 | 06 | 11 | 09 | 07 | 07 | 06 | 05 | 08 | -09 | -09 | 06 | 05 | -08 | 07 | 07 | -09 |
| 19K7 | AVERAGE | 1106 | 19 | 19 | 14 | 16 | 18 | 17 | 12 | 20 | 17 | 13 | 16 | 15 | 16 | 17 | -13 | -13 | 11 | 14 | -11 | 17 | 18 | -14 |

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
 AO = Assembling Objects Proportion Correct
 FR = Figural Reasoning Proportion Correct
 SM = Sequential Memory Proportion Correct
 T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 SO = Spatial Orientation Proportion Correct
 ID = Integrating Details Proportion Correct
 T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 T1 = Target Identification Mean Clipped Decision RTs

Table I-9

Range-Corrected Simple Validities for all Air Force Criteria

| School | Criterion | N | GS | AR | WK | PC | NO | CS | AS | MK | MC | EI | CT | SM | ID | AO | T1 | T2 | FR | SO | TI | Mem Spa-Track ory tial ing | |
|---------|-----------|-----|----|----|----|----|----|----|-----|----|----|-----|----|----|----|----|-----|-----|----|----|-----|-------------------------------|----|
| APSI | FSG | 446 | 62 | 70 | 61 | 60 | 41 | 38 | 40 | 64 | 55 | 48 | 48 | 50 | 53 | 47 | -24 | -28 | 59 | 50 | -24 | 54 | 55 |
| APS2 | ZHRS | 446 | 43 | 58 | 49 | 46 | 42 | 40 | 23 | 55 | 35 | 30 | 42 | 49 | 37 | 32 | 19 | 19 | 45 | 34 | 25 | 51 | 38 |
| APS3 | AFPT70 | 432 | 14 | 31 | 26 | 23 | 28 | 29 | 03 | 28 | 14 | 06 | 30 | 34 | 27 | 22 | -02 | 03 | 28 | 21 | -05 | 35 | 27 |
| ATC1 | FSG | 484 | 52 | 58 | 58 | 53 | 31 | 30 | 39 | 49 | 52 | 46 | 46 | 41 | 44 | 45 | 32 | 33 | 45 | 49 | 31 | 48 | 49 |
| ATC2 | BLK2 | 349 | 47 | 53 | 47 | 43 | 18 | 20 | 39 | 39 | 48 | 38 | 35 | 33 | 41 | 33 | 31 | 30 | 39 | 44 | 26 | 38 | 41 |
| ATC3 | BLK3A | 529 | 13 | 16 | 16 | 15 | 10 | 13 | 07 | 20 | 16 | 07 | 19 | 21 | 17 | 13 | -16 | -20 | 19 | 13 | -07 | 22 | 16 |
| ATC4 | BLK3B | 217 | 01 | 14 | 08 | 05 | 08 | 09 | 03 | 07 | 11 | 01 | 22 | 25 | 05 | 06 | -05 | -15 | 28 | 16 | -08 | 26 | 06 |
| ATC5 | BLK5A | 500 | 26 | 41 | 20 | 23 | 25 | 20 | 14 | 31 | 30 | 18 | 44 | 33 | 34 | 34 | 31 | -29 | 39 | 33 | -21 | 43 | 37 |
| ATC6 | BLK5B | 495 | 21 | 30 | 28 | 21 | 26 | 26 | 10 | 29 | 20 | 12 | 32 | 27 | 22 | 17 | -20 | -20 | 25 | 24 | -15 | 32 | 21 |
| ATC7 | FAA | 536 | 62 | 66 | 66 | 60 | 35 | 34 | 44 | 56 | 56 | 48 | 53 | 43 | 50 | 49 | -30 | -37 | 54 | 53 | -27 | 53 | 54 |
| ATC(A)1 | FSG | 200 | 43 | 58 | 48 | 48 | 38 | 31 | 33 | 50 | 47 | 43 | 52 | 45 | 44 | 41 | -37 | -37 | 49 | 42 | -33 | 54 | 47 |
| ATC(A)2 | BLK3A | 221 | 08 | 08 | 08 | 12 | 09 | 14 | -04 | 16 | 16 | -05 | 12 | 13 | 11 | 11 | -10 | -20 | 13 | 05 | 00 | 14 | 12 |
| ATC(A)3 | BLK3B | 217 | 01 | 14 | 08 | 05 | 08 | 09 | 03 | 07 | 11 | 01 | 22 | 25 | 05 | 06 | -05 | -15 | 28 | 16 | -08 | 26 | 06 |
| ATC(A)4 | BLK5A | 205 | 22 | 42 | 19 | 26 | 20 | 20 | 19 | 22 | 35 | 20 | 46 | 30 | 35 | 32 | -28 | -27 | 40 | 28 | -20 | 42 | 37 |
| ATC(A)5 | BLK5B | 204 | 06 | 20 | 14 | 11 | 23 | 22 | 04 | 21 | 12 | 02 | 25 | 16 | 15 | 11 | -19 | -16 | 23 | 15 | -10 | 23 | 14 |
| ATC(A)6 | FAA | 251 | 61 | 68 | 62 | 58 | 34 | 31 | 44 | 56 | 59 | 50 | 52 | 45 | 51 | 50 | 33 | 38 | 57 | 51 | -29 | 54 | 56 |
| ATC(B)1 | FSG | 284 | 56 | 59 | 63 | 56 | 23 | 27 | 45 | 46 | 55 | 48 | 39 | 38 | 44 | 43 | -29 | -30 | 41 | 50 | -30 | 43 | 48 |
| ATC(B)2 | BLK2 | 349 | 47 | 53 | 47 | 43 | 18 | 20 | 39 | 39 | 48 | 38 | 35 | 33 | 41 | 33 | 31 | 30 | 39 | 44 | -26 | 38 | 41 |
| ATC(B)3 | BLK3A | 308 | 10 | 14 | 12 | 06 | 03 | 07 | 12 | 17 | 10 | 13 | 18 | 23 | 15 | 09 | -19 | -18 | 16 | 17 | -11 | 23 | 14 |
| ATC(B)4 | BLK5A | 295 | 27 | 39 | 20 | 19 | 30 | 21 | 10 | 38 | 25 | 17 | 43 | 37 | 33 | 36 | -32 | -29 | 39 | 37 | -25 | 44 | 38 |
| ATC(B)5 | BLK5B | 291 | 33 | 40 | 40 | 30 | 27 | 30 | 17 | 36 | 27 | 19 | 38 | 36 | 29 | 23 | -22 | -24 | 28 | 33 | -20 | 41 | 29 |
| ATC(B)6 | FAA | 285 | 61 | 60 | 64 | 61 | 25 | 27 | 45 | 52 | 53 | 45 | 50 | 41 | 45 | 42 | -33 | -37 | 48 | 47 | -26 | 51 | 48 |

ECAT Test Measures Used as Predictors

CT = Mental Counters Proportion Correct
 AO = Assembling Objects Proportion Correct
 FR = Figural Reasoning Proportion Correct
 SM = Sequential Memory Proportion Correct
 T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 SO = Spatial Orientation Proportion Correct
 ID = Integrating Details Proportion Correct
 T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 TI = Target Identification Mean Clipped Decision RTs

Table I-10
Range-Corrected Simple Validities for all Navy Criteria

| School Criterion | N | GS | AR | WK | PC | NO | CS | AS | MK | MC | EI | CT | SM | ID | AO | T1 | T2 | FR | SO | TI | Mem | Spa- | Track |
|------------------|-----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|-----|-----|----|----|-----|-----|------|-------|
| AC1 FSG | 72 | 61 | 71 | 51 | 56 | 45 | 49 | 34 | 76 | 49 | 50 | 53 | 48 | 47 | 52 | -22 | -27 | 57 | 47 | -24 | 56 | 55 | -27 |
| AC2 PERF | 76 | 17 | 28 | 06 | 19 | 24 | 33 | -05 | 31 | 09 | 05 | 35 | 43 | 29 | 36 | -27 | -14 | 34 | 26 | -02 | 43 | 36 | -22 |
| AC3 FAA | 76 | 47 | 42 | 41 | 53 | 30 | 30 | 32 | 46 | 38 | 45 | 30 | 16 | 31 | 36 | -02 | -04 | 39 | 38 | -26 | 25 | 37 | -03 |
| AE1 FSG | 278 | 54 | 55 | 51 | 48 | 31 | 28 | 45 | 47 | 50 | 47 | 43 | 45 | 52 | 46 | -31 | -32 | 49 | 45 | -29 | 49 | 54 | -34 |
| AE2 SUM2 | 273 | 50 | 50 | 36 | 35 | 24 | 23 | 36 | 40 | 46 | 39 | 39 | 40 | 43 | 40 | -22 | -20 | 41 | 38 | -30 | 44 | 46 | -22 |
| AMS1 FSG | 244 | 69 | 65 | 65 | 56 | 40 | 42 | 55 | 60 | 67 | 60 | 43 | 44 | 53 | 51 | -32 | -36 | 50 | 49 | -31 | 48 | 58 | -36 |
| AMS2 PERF | 244 | 42 | 44 | 36 | 26 | 34 | 34 | 39 | 36 | 46 | 43 | 33 | 35 | 43 | 44 | -27 | -29 | 35 | 34 | -30 | 38 | 48 | -30 |
| AO1 FSG | 234 | 53 | 57 | 49 | 49 | 40 | 39 | 34 | 61 | 47 | 46 | 42 | 34 | 46 | 45 | -36 | -31 | 47 | 43 | -31 | 42 | 50 | -36 |
| AO2 PRACIL | 229 | 26 | 31 | 31 | 29 | 35 | 35 | 14 | 38 | 24 | 25 | 30 | 29 | 31 | 29 | -25 | -18 | 34 | 27 | -21 | 33 | 33 | -23 |
| AV1 FSG | 544 | 58 | 70 | 54 | 53 | 38 | 36 | 42 | 69 | 60 | 56 | 54 | 48 | 55 | 52 | -31 | -37 | 54 | 52 | -26 | 56 | 59 | -36 |
| AV2 BSCAV | 192 | 67 | 72 | 62 | 58 | 39 | 30 | 42 | 71 | 57 | 59 | 54 | 49 | 59 | 53 | -29 | -37 | 57 | 54 | -25 | 57 | 62 | -35 |
| AV3 ADVAV | 192 | 54 | 53 | 54 | 53 | 38 | 31 | 30 | 56 | 41 | 45 | 36 | 36 | 45 | 40 | -29 | -31 | 36 | 34 | -27 | 40 | 47 | -32 |
| AV4 PERFORM | 352 | 32 | 42 | 26 | 28 | 14 | 13 | 39 | 39 | 47 | 44 | 35 | 29 | 38 | 40 | -32 | -30 | 36 | 37 | -14 | 36 | 43 | -33 |
| EM1 FSG | 797 | 51 | 60 | 47 | 45 | 34 | 33 | 35 | 57 | 50 | 46 | 43 | 36 | 46 | 39 | -26 | -27 | 46 | 43 | -18 | 43 | 47 | -28 |
| EM2 PHASE1 | 797 | 51 | 62 | 46 | 45 | 33 | 32 | 33 | 60 | 50 | 47 | 43 | 37 | 46 | 42 | -24 | -27 | 49 | 43 | -19 | 44 | 48 | -27 |
| EN1 FSG | 750 | 59 | 60 | 55 | 51 | 31 | 29 | 53 | 53 | 60 | 57 | 41 | 34 | 49 | 45 | -29 | -34 | 47 | 47 | -28 | 42 | 52 | -34 |
| ET1 FSG | 86 | 67 | 69 | 53 | 50 | 35 | 39 | 48 | 60 | 54 | 61 | 55 | 53 | 64 | 59 | -38 | -52 | 58 | 57 | -32 | 60 | 68 | -48 |
| ET2 FSG2 | 86 | 64 | 75 | 56 | 56 | 51 | 48 | 40 | 66 | 55 | 54 | 57 | 58 | 62 | 58 | -39 | -47 | 63 | 57 | -34 | 63 | 66 | -46 |
| ET3 PERF | 86 | 40 | 67 | 44 | 36 | 44 | 44 | 28 | 57 | 34 | 39 | 47 | 44 | 47 | 39 | -46 | -43 | 48 | 52 | -37 | 50 | 48 | -48 |
| FC1 FSG | 778 | 65 | 71 | 61 | 60 | 40 | 38 | 46 | 64 | 64 | 61 | 44 | 40 | 55 | 54 | -29 | -38 | 58 | 52 | -23 | 47 | 60 | -36 |
| FC2 RADAR | 780 | 54 | 53 | 52 | 50 | 30 | 29 | 46 | 43 | 53 | 52 | 31 | 24 | 40 | 41 | -29 | -35 | 45 | 41 | -21 | 30 | 45 | -34 |
| GM1 FSG | 420 | 55 | 64 | 58 | 51 | 34 | 32 | 45 | 56 | 54 | 50 | 46 | 37 | 47 | 44 | -31 | -34 | 50 | 48 | -20 | 46 | 51 | -35 |
| GM2 HALF1 | 420 | 56 | 66 | 56 | 51 | 38 | 35 | 41 | 61 | 57 | 50 | 50 | 39 | 50 | 47 | -31 | -34 | 54 | 52 | -20 | 49 | 54 | -35 |
| GM3 HALF2 | 397 | 57 | 60 | 56 | 50 | 31 | 31 | 52 | 50 | 52 | 50 | 41 | 33 | 43 | 45 | -27 | -30 | 47 | 46 | -24 | 41 | 48 | -30 |
| MM1 FSG | 801 | 44 | 42 | 36 | 38 | 24 | 25 | 38 | 39 | 43 | 41 | 30 | 27 | 38 | 39 | -25 | -23 | 40 | 31 | -20 | 31 | 42 | -26 |
| OS1 FSG | 713 | 56 | 67 | 55 | 55 | 46 | 49 | 34 | 66 | 55 | 45 | 53 | 48 | 52 | 49 | -27 | -34 | 54 | 50 | -26 | 56 | 56 | -33 |
| OS2 WRIT | 815 | 53 | 60 | 53 | 51 | 39 | 38 | 33 | 60 | 51 | 42 | 46 | 42 | 43 | 43 | -24 | -32 | 48 | 45 | -21 | 49 | 47 | -30 |
| OS3 PERF | 815 | 48 | 61 | 44 | 49 | 43 | 45 | 34 | 60 | 52 | 41 | 54 | 49 | 51 | 51 | -32 | -37 | 52 | 51 | -26 | 57 | 56 | -37 |
| RM1 FSG | 277 | 59 | 64 | 59 | 55 | 41 | 45 | 32 | 56 | 51 | 46 | 47 | 45 | 50 | 43 | -19 | -25 | 46 | 47 | -12 | 51 | 51 | -23 |
| RM2 PHASE3 | 277 | 46 | 53 | 45 | 46 | 26 | 32 | 26 | 44 | 47 | 41 | 39 | 35 | 42 | 39 | -18 | -24 | 35 | 42 | -11 | 41 | 44 | -22 |

ECAT Test Measures Used as Predictors
 CT = Mental Counters Proportion Correct
 AO = Assembling Objects Proportion Correct
 FR = Figural Reasoning Proportion Correct
 SM = Sequential Memory Proportion Correct
 T1 = 1-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 SO = Spatial Orientation Proportion Correct
 ID = Integrating Details Proportion Correct
 T2 = 2-Hand Tracking Mean 1000*log(1 + RMS(Attempted))
 TI = Target Identification Mean Clipped Decision RTs

Appendix J

Factor Validities and Incremental Validities for All Criteria

Table J-1

ECAT Factor Incremental Validities for all Army Criteria

| School | Criterion | Sample Size | Uncorrected Multiple R | | | | Corrected Multiple R | | |
|---------|-----------|-------------|------------------------|-------------|------------------|----------------------------|----------------------|----------|----------|
| | | | ASVAB | ASVAB +ECAT | Percent Variance | Probability of $F_{3,N-8}$ | ASVAB | Increase | Percent |
| 11H(A)1 | TOALL | 554 | .204 | .222 | 0.792 | 2.299×10^{-1} | .247 | .006 | 2.3 |
| 11H(A)2 | EVT1TO | 556 | .276 | .327 | 3.427 | 3.499×10^{-4} | .383 | .034 | 8.8 ** |
| 11H(A)3 | EVT2TO | 555 | .190 | .235 | 2.054 | 1.104×10^{-2} | .247 | .033 | 13.4 * |
| 11H(A)4 | EVT3TO | 550 | .260 | .300 | 2.466 | 4.192×10^{-3} | .349 | .026 | 7.3 ** |
| 11H(A)5 | EVTSUM | 546 | .279 | .334 | 3.830 | 1.513×10^{-4} | .370 | .038 | 10.4 ** |
| 11H(A)6 | TO_1 | 542 | .169 | .221 | 2.137 | 1.019×10^{-2} | .219 | .050 | 22.8 * |
| 11H(B)1 | TOALL | 320 | .244 | .266 | 1.199 | 2.929×10^{-1} | .344 | .000 | 0.0 |
| 11H(B)2 | EVT1TO | 320 | .244 | .366 | 8.614 | 1.039×10^{-5} | .304 | .089 | 29.3 ** |
| 11H(B)3 | EVT2TO | 319 | .292 | .407 | 9.656 | 2.575×10^{-6} | .401 | .082 | 20.5 ** |
| 11H(B)4 | EVT3TO | 319 | .191 | .248 | 2.686 | 4.099×10^{-2} | .238 | .036 | 15.2 * |
| 11H(B)5 | EVTSUM | 316 | .292 | .412 | 10.186 | 1.432×10^{-6} | .381 | .084 | 21.9 ** |
| 11H(B)6 | TO_1 | 319 | .102 | .281 | 7.457 | 5.377×10^{-5} | .099 | .194 | 196.5 ** |
| 11H(B)7 | TO_2 | 320 | .119 | .278 | 6.830 | 1.247×10^{-4} | .106 | .165 | 156.2 ** |
| 11H(B)8 | TO_3 | 319 | .099 | .266 | 6.536 | 1.938×10^{-4} | .052 | .196 | 376.2 ** |
| 11H(B)9 | ITVTOW | 318 | .087 | .303 | 9.303 | 4.363×10^{-6} | .088 | .214 | 243.6 ** |
| 13F1 | FSG | 821 | .523 | .583 | 10.158 | 5.551×10^{-17} | .778 | .029 | 3.7 ** |
| 13F2 | MPRAD | 821 | .503 | .586 | 13.706 | $< 10^{-17}$ | .806 | .045 | 5.6 ** |
| 13F3 | FIRING | 821 | .419 | .444 | 2.771 | 5.830×10^{-5} | .713 | .012 | 1.7 ** |
| 19K1 | COMM | 1158 | .037 | .044 | 0.056 | 8.858×10^{-1} | .000 | .000 | . |
| 19K2 | WEAPON | 1325 | .163 | .165 | 0.094 | 7.434×10^{-1} | .188 | .000 | 0.0 |
| 19K3 | LANDNAV | 1192 | .162 | .171 | 0.319 | 2.870×10^{-1} | .188 | .005 | 2.5 |
| 19K4 | LOADER | 1313 | .048 | .050 | 0.020 | 9.664×10^{-1} | .029 | .000 | 0.0 |
| 19K5 | MAINT | 1329 | .087 | .090 | 0.055 | 8.657×10^{-1} | .089 | .000 | 0.0 |
| 19K6 | NBC | 1313 | .111 | .124 | 0.330 | 2.305×10^{-1} | .137 | .005 | 4.0 |
| 19K7 | AVERAG | 1106 | .193 | .196 | 0.159 | 6.258×10^{-1} | .390 | .000 | 0.0 |

* p < .05.

** p < .01.

Table J-2

ECAT Factor Incremental Validities for all Air Force Criteria

| School | Criterion | Sample Size | Uncorrected Multiple R | | | | Corrected Multiple R | | |
|---------|-----------|-------------|------------------------|-------------|------------------|----------------------------|----------------------|----------|---------|
| | | | ASVAB | ASVAB +ECAT | Percent Variance | Probability of $F_{3,N-8}$ | ASVAB | Increase | Percent |
| APS1 | FSG | 446 | .526 | .559 | 5.326 | 4.546×10^{-5} | .823 | .013 | 1.6 ** |
| APS2 | ZHRS | 446 | .391 | .449 | 6.189 | 8.122×10^{-6} | .669 | .030 | 4.5 ** |
| APS3 | AFPT70 | 432 | .265 | .391 | 9.807 | 1.225×10^{-8} | .373 | .102 | 27.3 ** |
| ATC1 | FSG | 484 | .387 | .417 | 2.848 | 3.884×10^{-3} | .722 | .015 | 2.0 ** |
| ATC2 | BLK2 | 349 | .352 | .373 | 1.739 | 1.172×10^{-1} | .646 | .009 | 1.3 |
| ATC3 | BLK3A | 529 | .125 | .189 | 2.086 | 1.305×10^{-2} | .266 | .077 | 28.7 * |
| ATC4 | BLK3B | 217 | .046 | .210 | 4.401 | 2.899×10^{-2} | .000 | .252 | . |
| ATC5 | BLK5A | 500 | .215 | .327 | 6.809 | 4.224×10^{-7} | .460 | .103 | 22.4 ** |
| ATC6 | BLK5B | 495 | .182 | .217 | 1.444 | 7.225×10^{-2} | .430 | .028 | 6.5 |
| ATC7 | FAA | 536 | .480 | .503 | 3.065 | 1.159×10^{-3} | .751 | .011 | 1.5 ** |
| ATC(A)1 | FSG | 200 | .355 | .430 | 7.201 | 3.874×10^{-3} | .675 | .036 | 5.3 ** |
| ATC(A)2 | BLK3A | 221 | .162 | .188 | 0.935 | 5.752×10^{-1} | .169 | .027 | 16.1 |
| ATC(A)3 | BLK3B | 217 | .046 | .210 | 4.401 | 2.899×10^{-2} | .000 | .252 | . |
| ATC(A)4 | BLK5A | 205 | .153 | .299 | 7.260 | 3.130×10^{-3} | .479 | .121 | 25.2 ** |
| ATC(A)5 | BLK5B | 204 | .161 | .191 | 1.087 | 5.468×10^{-1} | .295 | .015 | 5.1 |
| ATC(A)6 | FAA | 251 | .492 | .524 | 4.488 | 1.352×10^{-2} | .740 | .013 | 1.7 * |
| ATC(B)1 | FSG | 284 | .418 | .426 | 0.888 | 4.852×10^{-1} | .749 | .003 | 0.4 |
| ATC(B)2 | BLK2 | 349 | .352 | .373 | 1.739 | 1.172×10^{-1} | .646 | .009 | 1.3 |
| ATC(B)3 | BLK3A | 308 | .138 | .237 | 3.929 | 8.962×10^{-3} | .198 | .160 | 80.9 ** |
| ATC(B)4 | BLK5A | 295 | .272 | .372 | 7.488 | 1.181×10^{-4} | .454 | .092 | 20.2 ** |
| ATC(B)5 | BLK5B | 291 | .226 | .274 | 2.594 | 6.405×10^{-2} | .528 | .035 | 6.7 |
| ATC(B)6 | FAA | 285 | .459 | .474 | 1.801 | 1.752×10^{-1} | .717 | .011 | 1.5 |

* p < .05.

** p < .01.

Table J-3

ECAT Factor Incremental Validities for all Navy Criteria

| School | Criterion | Sample Size | Uncorrected Multiple R | | | | Corrected Multiple R | | |
|--------|-----------|-------------|------------------------|-------------|------------------|----------------------------|----------------------|----------|---------|
| | | | ASVAB | ASVAB +ECAT | Percent Variance | Probability of $F_{3,N-8}$ | ASVAB | Increase | Percent |
| AC1 | FSG | 72 | .569 | .584 | 2.559 | 6.527×10^{-1} | .820 | .000 | 0.0 |
| AC2 | PERF | 76 | .228 | .383 | 11.095 | 6.561×10^{-2} | .399 | .146 | 36.7 |
| AC3 | FAA | 76 | .339 | .411 | 6.465 | 2.317×10^{-1} | .523 | .054 | 10.2 |
| AE1 | FSG | 278 | .475 | .530 | 7.702 | 1.642×10^{-4} | .666 | .025 | 3.8 ** |
| AE2 | SUM2 | 273 | .387 | .453 | 7.059 | 4.178×10^{-4} | .596 | .025 | 4.2 ** |
| AMS1 | FSG | 244 | .581 | .583 | 0.209 | 9.203×10^{-1} | .846 | .000 | 0.0 |
| AMS2 | PERF | 244 | .355 | .383 | 2.356 | 1.382×10^{-1} | .639 | .011 | 1.7 |
| AO1 | FSG | 234 | .488 | .499 | 1.428 | 3.601×10^{-1} | .716 | .006 | 0.8 |
| AO2 | PRACTL | 229 | .308 | .328 | 1.423 | 3.720×10^{-1} | .492 | .011 | 2.2 |
| AV1 | FSG | 544 | .494 | .512 | 2.505 | 4.082×10^{-3} | .804 | .005 | 0.6 ** |
| AV2 | BSCAV | 192 | .493 | .517 | 3.300 | 1.121×10^{-1} | .839 | .004 | 0.5 |
| AV3 | ADVAV | 192 | .316 | .326 | 0.703 | 7.311×10^{-1} | .690 | .000 | 0.0 |
| AV4 | PERFORM | 352 | .345 | .373 | 2.342 | 4.653×10^{-2} | .656 | .015 | 2.3 * |
| EM1 | FSG | 797 | .437 | .439 | 0.214 | 6.392×10^{-1} | .684 | .000 | 0.0 |
| EM2 | PHASE1 | 797 | .451 | .455 | 0.387 | 3.844×10^{-1} | .723 | .000 | 0.0 |
| EN1 | FSG | 750 | .581 | .585 | 0.600 | 2.174×10^{-1} | .764 | .001 | 0.1 |
| ET1 | FSG | 86 | .439 | .520 | 10.548 | 4.874×10^{-2} | .782 | .040 | 5.1 * |
| ET2 | FSG2 | 86 | .465 | .516 | 6.854 | 1.575×10^{-1} | .811 | .029 | 3.6 |
| ET3 | PERF | 86 | .384 | .434 | 5.084 | 2.733×10^{-1} | .676 | .041 | 6.1 |
| FC1 | FSG | 778 | .475 | .490 | 1.934 | 2.032×10^{-3} | .821 | .005 | 0.6 ** |
| FC2 | RADAR | 780 | .339 | .368 | 2.344 | 4.609×10^{-4} | .734 | .012 | 1.6 ** |
| GM1 | FSG | 420 | .402 | .415 | 1.236 | 1.669×10^{-1} | .727 | .001 | 0.2 |
| GM2 | HALF1 | 420 | .428 | .448 | 2.256 | 2.671×10^{-2} | .761 | .004 | 0.5 * |
| GM3 | HALF2 | 397 | .424 | .428 | 0.441 | 6.340×10^{-1} | .726 | .000 | 0.0 |
| MM1 | FSG | 801 | .391 | .402 | 1.084 | 3.583×10^{-2} | .555 | .005 | 0.9 * |
| OS1 | FSG | 713 | .549 | .567 | 2.973 | 1.234×10^{-4} | .798 | .009 | 1.1 ** |
| OS2 | WRIT | 815 | .474 | .481 | 0.864 | 7.373×10^{-2} | .756 | .003 | 0.4 |
| OS3 | PERF | 815 | .504 | .548 | 6.752 | 2.060×10^{-11} | .782 | .027 | 3.5 ** |
| RM1 | FSG | 277 | .508 | .533 | 3.646 | 2.178×10^{-2} | .767 | .011 | 1.4 * |
| RM2 | PHASE3 | 277 | .367 | .388 | 1.863 | 1.736×10^{-1} | .677 | .004 | 0.6 |

* p < .05.

** p < .01.

Table J-4

**Incremental Validities from Adding one ECAT Factor to Four ASVAB Factors
All Significant Criteria from Full Model**

| School | Criterion | Memory | Psychomotor | Space |
|---------|-----------|--------|-------------|--------|
| 11H(A)2 | EVT1TO | .010* | .026** | .028** |
| 11H(A)3 | EVT2TO | .008 | .033** | .022* |
| 11H(A)4 | EVT3TO | .010* | .025** | .016** |
| 11H(A)5 | EVTSUM | .012* | .034** | .027** |
| 11H(A)6 | TO_1 | .000 | .055** | .003 |
| 11H(B)2 | EVT1TO | .029** | .090** | .036** |
| 11H(B)3 | EVT2TO | .035** | .076** | .032** |
| 11H(B)4 | EVT3TO | .000 | .032* | .000 |
| 11H(B)5 | EVTSUM | .021** | .086** | .023** |
| 11H(B)6 | TO_1 | .063 | .098** | .000 |
| 11H(B)7 | TO_2 | .000 | .167** | .049** |
| 11H(B)8 | TO_3 | .000 | .205** | .063* |
| 11H(B)9 | ITVTOW | .000 | .178** | .039** |
| 13F1 | FSG | .018** | .007** | .028** |
| 13F2 | MPRAD | .024** | .006** | .045** |
| 13F3 | FIRING | .011** | .005** | .009** |
| APS1 | FSG | .009** | .000 | .006** |
| APS2 | ZHRS | .023** | .000 | .000 |
| APS3 | AFPT70 | .051** | .015* | .034** |
| ATC1 | FSG | .012** | .006* | .013** |
| ATC3 | BLK3A | .050* | .060** | .021 |
| ATC4 | BLK3B | .270** | .000 | .122 |
| ATC5 | BLK5A | .067** | .056** | .088** |
| ATC7 | FAA | .008** | .003 | .012** |
| ATC(A)1 | FSG | .031** | .021** | .018** |
| ATC(A)3 | BLK3B | .270** | .000 | .122 |
| ATC(A)4 | BLK5A | .089* | .047* | .120** |
| ATC(A)6 | FAA | .011** | .005* | .012** |
| ATC(B)3 | BLK3A | .134* | .089* | .030 |
| ATC(B)4 | BLK5A | .060** | .053** | .078** |
| AC2 | PERF | .150* | .019 | .142 |
| AE1 | FSG | .024** | .003* | .022** |
| AE2 | SUM2 | .024** | .000 | .013** |
| AV1 | FSG | .005** | .001 | .004** |
| AV4 | PERFORM | .009 | .014* | .011* |
| ET1 | FSG | .024 | .022* | .038* |
| FC1 | FSG | .000 | .000 | .003** |
| FC2 | RADAR | .002* | .004 | .000 |
| GM2 | HALF1 | .000 | .001 | .005** |
| MM1 | FSG | .000 | .000 | .006** |
| OS1 | FSG | .007** | .000 | .008** |
| OS3 | PERF | .020** | .008** | .025** |
| RM1 | FSG | .005* | .001 | .004 |

* p < .05.

** p < .01.

Table J-5

Uncorrected Factor Validities for all Army Criteria

| School | Criterion | N | ASVAB Factor | | | | ECAT Factor | | |
|---------|-----------|------|--------------|-------|-------|----------|-------------|--------|-------------|
| | | | Verbal | Math | Tech | Clerical | Space | Memory | Psychomotor |
| 11H(A)1 | TOALL | 554 | .094 | .167 | .149 | .105 | .173 | .165 | -.058 |
| 11H(A)2 | EVT1TO | 556 | .202 | .199 | .258 | .048 | .268 | .180 | -.224 |
| 11H(A)3 | EVT2TO | 555 | .126 | .156 | .162 | .075 | .197 | .146 | -.183 |
| 11H(A)4 | EVT3TO | 550 | .227 | .202 | .219 | .054 | .234 | .177 | -.209 |
| 11H(A)5 | EVTSUM | 546 | .214 | .210 | .256 | .060 | .274 | .194 | -.242 |
| 11H(A)6 | TO_1 | 542 | .128 | .151 | .086 | .132 | .138 | .107 | -.188 |
| 11H(B)1 | TOALL | 320 | .229 | .104 | .142 | .106 | .155 | .146 | -.111 |
| 11H(B)2 | EVT1TO | 320 | .211 | .188 | .201 | .115 | .278 | .237 | -.326 |
| 11H(B)3 | EVT2TO | 319 | .250 | .194 | .178 | .205 | .278 | .262 | -.335 |
| 11H(B)4 | EVT3TO | 319 | .103 | .138 | .161 | .082 | .103 | .067 | -.181 |
| 11H(B)5 | EVTSUM | 316 | .244 | .221 | .224 | .174 | .288 | .251 | -.361 |
| 11H(B)6 | TO_1 | 319 | .002 | .033 | .028 | -.058 | .091 | -.061 | -.165 |
| 11H(B)7 | TO_2 | 320 | .000 | -.045 | .058 | -.104 | .099 | .019 | -.230 |
| 11H(B)8 | TO_3 | 319 | .058 | .043 | .050 | .076 | .143 | .076 | -.250 |
| 11H(B)9 | ITVTOW | 318 | .008 | .004 | .047 | -.067 | .125 | -.008 | -.244 |
| 13F1 | FSG | 821 | .388 | .434 | .379 | .263 | .496 | .401 | -.308 |
| 13F2 | MPRAD | 821 | .369 | .430 | .368 | .234 | .525 | .407 | -.294 |
| 13F3 | FIRING | 821 | .318 | .353 | .292 | .217 | .329 | .298 | -.236 |
| 19K1 | COMM | 1158 | .010 | .004 | -.019 | .025 | -.017 | -.012 | .013 |
| 19K2 | WEAPON | 1325 | .097 | .153 | .098 | .091 | .103 | .102 | -.078 |
| 19K3 | LANDNAV | 1192 | .063 | .147 | .079 | .100 | .103 | .109 | -.098 |
| 19K4 | LOADER | 1313 | .038 | .014 | .039 | .012 | .022 | .019 | -.026 |
| 19K5 | MAINT | 1329 | .043 | .082 | .053 | .030 | .048 | .050 | -.035 |
| 19K6 | NBC | 1313 | .068 | .086 | .046 | .093 | .043 | .037 | -.076 |
| 19K7 | AVERAGE | 1106 | .106 | .169 | .101 | .139 | .135 | .126 | -.106 |

Table J-6

Uncorrected Factor Validities for all Air Force Criteria

| School | Criterion | N | ASVAB Factor | | | | ECAT Factor | | |
|---------|-----------|-----|--------------|-------|-------|----------|-------------|--------|-------------|
| | | | Verbal | Math | Tech | Clerical | Space | Memory | Psychomotor |
| APS1 | FSG | 446 | .361 | .472 | .316 | .163 | .341 | .329 | -.095 |
| APS2 | ZHRS | 446 | -.239 | -.327 | -.102 | -.244 | -.176 | -.306 | .025 |
| APS3 | AFPT70 | 432 | .113 | .090 | -.097 | .206 | .149 | .226 | .131 |
| ATC1 | FSG | 484 | .311 | .313 | .301 | .072 | .320 | .223 | -.230 |
| ATC2 | BLK2 | 349 | .234 | .289 | .297 | -.001 | .265 | .172 | -.246 |
| ATC3 | BLK3A | 529 | .083 | .123 | .056 | .028 | .110 | .138 | -.138 |
| ATC4 | BLK3B | 217 | -.044 | -.029 | -.018 | -.001 | .076 | .178 | -.030 |
| ATC5 | BLK5A | 500 | .044 | .197 | .086 | .067 | .287 | .231 | -.233 |
| ATC6 | BLK5B | 495 | .110 | .140 | .022 | .145 | .115 | .144 | -.101 |
| ATC7 | FAA | 536 | .401 | .397 | .349 | .085 | .380 | .246 | -.223 |
| ATC(A)1 | FSG | 200 | .242 | .311 | .251 | .120 | .340 | .292 | -.305 |
| ATC(A)2 | BLK3A | 221 | .117 | .129 | -.006 | .064 | .102 | .086 | -.090 |
| ATC(A)3 | BLK3B | 217 | -.044 | -.029 | -.018 | -.001 | .076 | .178 | -.030 |
| ATC(A)4 | BLK5A | 205 | .021 | .102 | .109 | .023 | .282 | .185 | -.199 |
| ATC(A)5 | BLK5B | 204 | .029 | .089 | -.038 | .148 | .101 | .082 | -.074 |
| ATC(A)6 | FAA | 251 | .355 | .420 | .384 | .049 | .405 | .295 | -.298 |
| ATC(B)1 | FSG | 284 | .350 | .303 | .340 | .006 | .286 | .160 | -.181 |
| ATC(B)2 | BLK2 | 349 | .234 | .289 | .297 | -.001 | .265 | .172 | -.246 |
| ATC(B)3 | BLK3A | 308 | .058 | .119 | .105 | -.000 | .120 | .182 | -.175 |
| ATC(B)4 | BLK5A | 295 | .061 | .260 | .073 | .099 | .297 | .266 | -.254 |
| ATC(B)5 | BLK5B | 291 | .171 | .177 | .065 | .143 | .126 | .193 | -.121 |
| ATC(B)6 | FAA | 285 | .391 | .347 | .342 | -.030 | .257 | .182 | -.236 |

Table J-7

Uncorrected Factor Validities for all Navy Criteria

| School | Criterion | N | ASVAB Factor | | | | ECAT Factor | | |
|--------|-----------|-----|--------------|------|-------|----------|-------------|--------|-------------|
| | | | Verbal | Math | Tech | Clerical | Space | Memory | Psychomotor |
| AC1 | FSG | 72 | .340 | .538 | .381 | .212 | .344 | .342 | -.192 |
| AC2 | PERF | 76 | -.051 | .054 | -.045 | .209 | .205 | .285 | -.063 |
| AC3 | FAA | 76 | .242 | .261 | .295 | .118 | .248 | .105 | -.049 |
| AE1 | FSG | 278 | .385 | .354 | .412 | .130 | .418 | .373 | -.254 |
| AE2 | SUM2 | 273 | .244 | .302 | .346 | .069 | .336 | .334 | -.139 |
| AMS1 | FSG | 244 | .450 | .441 | .364 | .323 | .239 | .148 | -.085 |
| AMS2 | PERF | 244 | .155 | .209 | .185 | .265 | .233 | .156 | -.106 |
| AO1 | FSG | 234 | .262 | .439 | .245 | .308 | .284 | .154 | -.132 |
| AO2 | PRACTL | 229 | .114 | .225 | .076 | .282 | .207 | .168 | -.093 |
| AV1 | FSG | 544 | .174 | .450 | .235 | .199 | .349 | .285 | -.180 |
| AV2 | BSCAV | 192 | .249 | .458 | .156 | .110 | .374 | .287 | -.157 |
| AV3 | ADVAV | 192 | .204 | .285 | .056 | .162 | .170 | .118 | -.132 |
| AV4 | PERFORM | 352 | .015 | .228 | .243 | .044 | .235 | .181 | -.186 |
| EM1 | FSG | 797 | .248 | .388 | .302 | .167 | .264 | .208 | -.126 |
| EM2 | PHASE1 | 797 | .236 | .422 | .283 | .145 | .271 | .211 | -.110 |
| EN1 | FSG | 750 | .434 | .443 | .500 | .170 | .393 | .268 | -.211 |
| ET1 | FSG | 86 | .160 | .284 | .291 | .092 | .412 | .260 | -.349 |
| ET2 | FSG2 | 86 | .166 | .389 | .113 | .291 | .355 | .305 | -.228 |
| ET3 | PERF | 86 | .026 | .314 | -.078 | .323 | .188 | .232 | -.198 |
| FC1 | FSG | 778 | .260 | .362 | .277 | .211 | .273 | .120 | -.154 |
| FC2 | RADAR | 780 | .204 | .148 | .264 | .132 | .138 | -.011 | -.133 |
| GM1 | FSG | 420 | .272 | .271 | .244 | .142 | .279 | .204 | -.220 |
| GM2 | HALF1 | 420 | .247 | .344 | .203 | .189 | .327 | .233 | -.234 |
| GM3 | HALF2 | 397 | .280 | .187 | .339 | .111 | .242 | .140 | -.168 |
| MM1 | FSG | 801 | .266 | .288 | .335 | .153 | .295 | .182 | -.159 |
| OS1 | FSG | 713 | .305 | .507 | .368 | .212 | .453 | .375 | -.252 |
| OS2 | WRIT | 815 | .311 | .437 | .335 | .127 | .353 | .301 | -.199 |
| OS3 | PERF | 815 | .212 | .448 | .341 | .208 | .466 | .397 | -.294 |
| RM1 | FSG | 277 | .421 | .445 | .324 | .174 | .334 | .290 | -.099 |
| RM2 | PHASE3 | 277 | .299 | .330 | .257 | .069 | .281 | .231 | -.114 |

Table J-8

Range-Corrected Factor Validities for all Army Criteria

| School | Criterion | N | ASVAB Factor | | | | ECAT Factor | | |
|---------|-----------|------|--------------|-------|-------|----------|-------------|--------|-------------|
| | | | Verbal | Math | Tech | Clerical | Space | Memory | Psychomotor |
| 11H(A)1 | TOALL | 554 | .158 | .222 | .200 | .142 | .220 | .198 | -.098 |
| 11H(A)2 | EVT1TO | 556 | .291 | .281 | .360 | .109 | .356 | .257 | -.297 |
| 11H(A)3 | EVT2TO | 555 | .194 | .203 | .236 | .102 | .254 | .191 | -.236 |
| 11H(A)4 | EVT3TO | 550 | .307 | .283 | .300 | .117 | .313 | .254 | -.268 |
| 11H(A)5 | EVTSUM | 546 | .303 | .290 | .352 | .119 | .357 | .268 | -.313 |
| 11H(A)6 | TO_1 | 542 | .180 | .195 | .156 | .179 | .190 | .151 | -.242 |
| 11H(B)1 | TOALL | 320 | .321 | .226 | .233 | .224 | .244 | .231 | -.170 |
| 11H(B)2 | EVT1TO | 320 | .260 | .255 | .281 | .168 | .326 | .282 | -.363 |
| 11H(B)3 | EVT2TO | 319 | .348 | .312 | .282 | .311 | .365 | .354 | -.394 |
| 11H(B)4 | EVT3TO | 319 | .149 | .194 | .217 | .140 | .163 | .112 | -.236 |
| 11H(B)5 | EVTSUM | 316 | .323 | .319 | .323 | .261 | .365 | .325 | -.417 |
| 11H(B)6 | TO_1 | 319 | -.024 | .005 | .035 | -.103 | .038 | -.107 | -.147 |
| 11H(B)7 | TO_2 | 320 | -.018 | -.043 | .072 | -.112 | .074 | -.010 | -.213 |
| 11H(B)8 | TO_3 | 319 | .074 | .070 | .101 | .074 | .141 | .083 | -.258 |
| 11H(B)9 | ITVTOW | 318 | -.021 | -.013 | .060 | -.104 | .077 | -.051 | -.222 |
| 13F1 | FSG | 821 | .586 | .638 | .543 | .477 | .638 | .548 | -.409 |
| 13F2 | MPRAD | 821 | .562 | .627 | .531 | .450 | .654 | .548 | -.397 |
| 13F3 | FIRING | 821 | .498 | .537 | .443 | .405 | .489 | .445 | -.334 |
| 19K1 | COMM | 1158 | .017 | .008 | -.011 | .026 | -.014 | -.007 | .020 |
| 19K2 | WEAPON | 1325 | .136 | .185 | .140 | .135 | .138 | .134 | -.105 |
| 19K3 | LANDNAV | 1192 | .101 | .178 | .124 | .133 | .140 | .134 | -.136 |
| 19K4 | LOADER | 1313 | .053 | .037 | .054 | .032 | .041 | .036 | -.036 |
| 19K5 | MAINT | 1329 | .071 | .101 | .075 | .061 | .069 | .072 | -.052 |
| 19K6 | NBC | 1313 | .106 | .125 | .084 | .132 | .080 | .070 | -.097 |
| 19K7 | AVERAGE | 1106 | .169 | .224 | .161 | .200 | .188 | .172 | -.147 |

Table J-9

Range-Corrected Factor Validities for all Air Force Criteria

| School | Criterion | N | ASVAB Factor | | | | ECAT Factor | | |
|---------|-----------|-----|--------------|-------|-------|----------|-------------|--------|-------------|
| | | | Verbal | Math | Tech | Clerical | Space | Memory | Psychomotor |
| APS1 | FSG | 446 | .681 | .730 | .559 | .495 | .626 | .575 | -.320 |
| APS2 | ZHRS | 446 | -.534 | -.601 | -.349 | -.503 | -.461 | -.531 | .235 |
| APS3 | AFPT70 | 432 | .268 | .305 | .093 | .337 | .303 | .359 | -.014 |
| ATC1 | FSG | 484 | .619 | .584 | .531 | .383 | .561 | .487 | -.381 |
| ATC2 | BLK2 | 349 | .511 | .492 | .498 | .255 | .472 | .395 | -.350 |
| ATC3 | BLK3A | 529 | .174 | .200 | .113 | .141 | .199 | .227 | -.203 |
| ATC4 | BLK3B | 217 | .075 | .099 | .055 | .106 | .168 | .266 | -.123 |
| ATC5 | BLK5A | 500 | .247 | .379 | .234 | .281 | .443 | .414 | -.341 |
| ATC6 | BLK5B | 495 | .292 | .318 | .164 | .306 | .280 | .311 | -.226 |
| ATC7 | FAA | 536 | .707 | .667 | .588 | .436 | .626 | .533 | -.399 |
| ATC(A)1 | FSG | 200 | .534 | .581 | .462 | .430 | .556 | .538 | -.426 |
| ATC(A)2 | BLK3A | 221 | .103 | .159 | .016 | .136 | .132 | .140 | -.163 |
| ATC(A)3 | BLK3B | 217 | .075 | .099 | .055 | .106 | .168 | .266 | -.123 |
| ATC(A)4 | BLK5A | 205 | .239 | .323 | .279 | .250 | .434 | .391 | -.317 |
| ATC(A)5 | BLK5B | 204 | .146 | .213 | .061 | .258 | .204 | .214 | -.193 |
| ATC(A)6 | FAA | 251 | .675 | .672 | .601 | .415 | .637 | .549 | -.423 |
| ATC(B)1 | FSG | 284 | .666 | .568 | .581 | .324 | .538 | .447 | -.351 |
| ATC(B)2 | BLK2 | 349 | .511 | .492 | .498 | .255 | .472 | .395 | -.350 |
| ATC(B)3 | BLK3A | 308 | .122 | .158 | .135 | .060 | .187 | .239 | -.203 |
| ATC(B)4 | BLK5A | 295 | .246 | .415 | .197 | .313 | .456 | .439 | -.349 |
| ATC(B)5 | BLK5B | 291 | .415 | .405 | .260 | .338 | .364 | .405 | -.270 |
| ATC(B)6 | FAA | 285 | .686 | .616 | .577 | .344 | .561 | .501 | -.407 |

Table J-10

Range-Corrected Factor Validities for all Navy Criteria

| School | Criterion | N | ASVAB Factor | | | | ECAT Factor | | |
|--------|-----------|-----|--------------|------|------|----------|-------------|--------|-------------|
| | | | Verbal | Math | Tech | Clerical | Space | Memory | Psychomotor |
| AC1 | FSG | 72 | .611 | .805 | .511 | .570 | .620 | .569 | -.309 |
| AC2 | PERF | 76 | .128 | .319 | .030 | .328 | .391 | .451 | -.227 |
| AC3 | FAA | 76 | .490 | .510 | .438 | .367 | .414 | .250 | -.075 |
| AE1 | FSG | 278 | .564 | .563 | .556 | .364 | .587 | .516 | -.371 |
| AE2 | SUM2 | 273 | .423 | .497 | .479 | .286 | .497 | .453 | -.256 |
| AMS1 | FSG | 244 | .708 | .707 | .705 | .480 | .618 | .507 | -.403 |
| AMS2 | PERF | 244 | .401 | .451 | .483 | .373 | .485 | .397 | -.328 |
| AO1 | FSG | 234 | .557 | .657 | .488 | .477 | .551 | .428 | -.387 |
| AO2 | PRACTL | 229 | .339 | .391 | .225 | .401 | .373 | .338 | -.246 |
| AV1 | FSG | 544 | .620 | .763 | .600 | .470 | .652 | .568 | -.405 |
| AV2 | BSCAV | 192 | .693 | .789 | .616 | .453 | .680 | .580 | -.395 |
| AV3 | ADVAV | 192 | .600 | .618 | .451 | .436 | .484 | .411 | -.347 |
| AV4 | PERFORM | 352 | .316 | .443 | .478 | .178 | .457 | .361 | -.352 |
| EM1 | FSG | 797 | .532 | .641 | .503 | .415 | .524 | .439 | -.311 |
| EM2 | PHASE1 | 797 | .531 | .668 | .493 | .407 | .539 | .450 | -.307 |
| EN1 | FSG | 750 | .610 | .628 | .655 | .374 | .569 | .430 | -.372 |
| ET1 | FSG | 86 | .615 | .699 | .642 | .444 | .734 | .616 | -.532 |
| ET2 | FSG2 | 86 | .651 | .767 | .577 | .592 | .738 | .661 | -.506 |
| ET3 | PERF | 86 | .489 | .631 | .394 | .526 | .574 | .519 | -.506 |
| FC1 | FSG | 778 | .688 | .750 | .653 | .478 | .651 | .495 | -.400 |
| FC2 | RADAR | 780 | .573 | .539 | .583 | .357 | .491 | .324 | -.371 |
| GM1 | FSG | 420 | .625 | .651 | .580 | .413 | .573 | .466 | -.379 |
| GM2 | HALF1 | 420 | .621 | .697 | .568 | .452 | .610 | .493 | -.382 |
| GM3 | HALF2 | 397 | .611 | .597 | .615 | .379 | .542 | .419 | -.338 |
| MM1 | FSG | 801 | .417 | .459 | .465 | .294 | .444 | .332 | -.279 |
| OS1 | FSG | 713 | .622 | .734 | .507 | .565 | .629 | .567 | -.369 |
| OS2 | WRIT | 815 | .589 | .664 | .484 | .473 | .546 | .494 | -.334 |
| OS3 | PERF | 815 | .523 | .669 | .479 | .522 | .631 | .571 | -.409 |
| RM1 | FSG | 277 | .652 | .663 | .504 | .509 | .565 | .518 | -.271 |
| RM2 | PHASE3 | 277 | .509 | .534 | .431 | .356 | .480 | .413 | -.255 |

Appendix K

SAS Program for Stepwise Meta-Analysis

METASTEP.SAS

```
OPTIONS LS=79 MPRINT DQUOTE ;
/* PROGRAMS TO DO STEPWISE META-ANALYSIS;
   LOW-LEVEL ROUTINES APPEAR FIRST. */

%MACRO NUMLIST(LIST); /* RETURNS THE NUMBER OF ELEMENTS OF LIST */
  %LOCAL I;
  %LET I = 1;
  %DO %WHILE( %SCAN(&LIST,&I) NE);
    %LET I = %EVAL(&I + 1);
  %END;
  %EVAL(&I - 1)
%MEND NUMLIST;

%MACRO REMOVE(J,LIST,N); /* REMOVES THE JTH MEMBER OF THE LIST */
  %LOCAL M; /* N = NUMBER OF ELEMENTS OF LIST */
  %DO M= 1 %TO &N;
    %IF &M NE &J %THEN %SCAN(&LIST,&M);
  %END;
%MEND REMOVE;

%MACRO REMOVAL(OUTS,LIST); /* RETURNS LIST - OUTS */
  %LOCAL M N V;
  %LET N = %NUMLIST(&LIST);
  %DO M= 1 %TO &N;
    %LET V = %SCAN(&LIST,&M);
    %IF %INDEX(&OUTS, &V) = 0 %THEN &V;
  %END;
%MEND REMOVAL;

%MACRO STEP(RATING); /* FOR A GIVEN SCHOOL, COMPUTES THE MULTIPLE R
   FROM ADDING OR DELETING EACH PREDICTOR */
  %IF &NVL2 NE 0 %THEN %DO; /* SKIP IF NO MORE VARIABLES */
    DATA TEMP;SET LAWCOR.N&RATING;IF GROUP=3; /* GET LAWLEY-CORRECTED */
    DATA NULL ;SET TEMP END=LAST; /* CORRELATIONS FROM DISK*/
    IF LAST THEN CALL SYMPUT('DEP',_NAME );
    DATA NULL ; SET ALL.RELX; /* RETRIEVE RELIABILITY FROM DISK */
    IF INDEX(SCHOOL,TRIM(LEFT("&RATING"))) > 0 THEN DO;
      REL = RELINDX**2;
      CALL SYMPUT('REL',REL);
    END;

    PROC RSQUARE DATA=TEMP (TYPE=CORR) NOPRINT ADJRSQ OUTEST = &RATING;
      %DO M = 1 %TO &NVL2; /* SET UP A MODEL FOR EACH REMAINING VAR */
        %LET V = %SCAN(&VNL2,&M);
        %IF &DELETION %THEN %LET VLM = %REMOVE(&M,&VNL2,&NVL2);
        %ELSE %LET VLM = &VNL1 &V;
        &V : MODEL &DEP = &LIST1 &VLM / INCLUDE=&NIV STOP=&NIV1 ;
      %END;
    DATA &RATING; SET &RATING; _ADJRSQ_ = _ADJRSQ_/&REL;
  %END; RUN;
%MEND STEP;
```

METASTEP.SAS

```

%MACRO METSTEP(RATINGS,LIST1,LIST2); /* THE MAIN META-ANALYSIS */
/* LIST1 = LIST OF VARIABLES THAT ALWAYS REMAIN IN REGRESSION */
/* LIST2 = LIST OF VARIABLES THAT ARE ADDED OR DELETED */
%LET NR = %NUMLIST(&RATINGS);
TITLE 'STEPWISE META-ANALYSIS FOR BEST MEAN WHERRY-SHRUNKEN R';
TITLE2 "&RATINGS";
TITLE3 'THE FOLLOWING PREDICTORS REMAIN IN REGRESSION AT ALL TIMES:.';
TITLE4 "&LIST1";

/* VL1 = THAT PART OF LIST2 THAT IS IN REGRESSION DURING ACCRETION
OR THAT HAS BEEN DELETED FROM LIST2 DURING DELETION */
/* VL2 = THAT PART OF LIST2 THAT IS NOT YET IN REGRESSION DURING THE
ACCRETION PHASE, OR THAT REMAINS IN REGRESSION DURING THE
DELETION PHASE */
%LET NLIST1 = %NUMLIST(&LIST1); %LET NLIST2 = %NUMLIST(&LIST2);
%DO DELETION = 0 %TO 1; /* ACCRETION PHASE FIRST, FOLLOWED BY DELETION*/
%LET VL1 = ; %LET NVL2 = &NLIST2;
%LET NVL1 = 0; %LET NVL2 = &NLIST2;
%DO PR = 1 %TO &NLIST2; /* LOOP OVER CANDIDATE PREDICTORS */
%IF &DELETION %THEN %LET NIV = %EVAL(&NLIST1 + &NVL2 - 1);
%ELSE %LET NIV = %EVAL(&NLIST1 + &NVL1 + 1);
/* NIV = NUMBER OF PREDICTORS CURRENTLY IN REGRESSION */
%LET NIV1 = %EVAL(&NIV + 1);
%DO IR = 1 %TO &NR;
%LET RATING = %SCAN(&RATINGS,&IR);
%STEP(&RATING)
%END;
DATA BASE ;SET &RATINGS;
PROC SORT DATA=BASE; BY _MODEL_;
DATA BASE;SET BASE; IF _ADJRSQ_ < 0 THEN _ADJRSQ_ = 0;
_ADJRSQ_ = SQRT(_ADJRSQ_);

PROC MEANS DATA=BASE NOPRINT; VAR _ADJRSQ_; WEIGHT _EDF_; BY _MODEL_;
OUTPUT OUT=MBASE MEAN=MEANRSQ;
DATA MAXMEAN ;SET MBASE END=LAST;
RETAIN MAXR 0 BESTV;
FORMAT NIV 4. ;
IF MEANRSQ > MAXR THEN DO;
MAXR = MEANRSQ;
BESTV = _MODEL_ ; END;
IF LAST THEN CALL SYMPUT('BESTV',BESTV); ELSE DELETE;
NIV = SYMGET('NIV');
DROP MEANRSQ _MODEL_;

PROC APPEND BASE=MAXR&DELETION NEW=MAXMEAN;

%LET VL1 = &VL1 &BESTV;
%LET VL2 = %REMOVAL(&BESTV,&VL2);
%LET NVL1 = %EVAL(&NVL1 + 1);
%LET NVL2 = %EVAL(&NVL2 - 1);
%END; /* PR LOOP OVER PREDICTORS */
PROC PRINT DATA= MAXR&DELETION; TITLE5 "MAXR&DELETION"; RUN;
%END; /* ACCRETION/DELETION LOOP */
PROC SORT DATA=MAXR1; BY NIV;
DATA MAXR1;SET MAXR1; RENAME MAXR=R_DEL BESTV = V_DEL;

DATA MAXR;MERGE MAXR0 MAXR1; BY NIV;
RENAME MAXR = R_ADD BESTV = V_ADD;
PROC PRINT DATA=MAXR_NOOBS; VAR NIV V_ADD R_ADD V_DEL R_DEL;
TITLE5 'COMBINED ACCRETION AND DELETION RESULTS'; RUN;

DATA MAXR0;SET MAXMEAN; IF 0; /* RESET FOR FUTURE APPENDING */
DATA MAXR1;SET MAXR0;

```

METASTEP.SAS

```
%MEND METSTEP;

%LET ASVAB = GS1 AR1 WK1 PC1 NO1 CS1 AS1 MK1 MC1 EI1 ;
%LET AFQT = AR1 WK1 PC1 MK1;
%LET NONAFQT = GS1 NO1 CS1 AS1 MC1 EI1;
%LET ECAT = MCPCOR SMPDCOR IDPCOR AOPCOR T1MN T2MN SRPCOR ORPCOR TIDDT;
%LET NOMOTOR = MCPCOR SMPDCOR IDPCOR AOPCOR SRPCOR ORPCOR ;
%LET NOCOMP = AOPCOR SRPCOR ORPCOR ;
%LET TLST = A11H5 B11H5 A13F1;
%LET FSGS = A11H5 B11H5 A13F1          APS1 ATC1 AC1 AE1 AMS1 AO1 AV1
           EM1 EN1 ET2 FC1 GM1 MM1 OS1 RM1;
%LET BESTD = A11H6 B11H9 A13F3          APS3 ATCX4 ATCY4
           AC2 AE2 AMS2 AO2 AV4 EM2 EN1 ET3 FC2 GM3 MM1 OS3 RM2;
%LET FSGS9=          A13F1          APS1 ATC1
           AC1 AE1 AMS1 AO1 AV1 ET2 OS1 ;
%LET BESTD9 =          A13F3          APS3 ATCX4 ATCY4
           AC2 AE2 AMS2 AO2 AV4          ET3 OS3 ;
```

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