REEXAMINATION OF THE NORMALIZATION OF THE ARMED SERVICES

APR 80 W H SIMS, A R TRUSS

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A REEXAMINATION OF THE NORMALIZATION OF THE ARMED SERVICES VOCATIONAL APTITUDE BATTERY (ASVAB) FORMS 6, 7, 6E, and 7E.

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**Performing Organization Name and Address:**
Center for Naval Analyses
2000 N. Beauregard Street
Alexandria, Virginia 22311

**Abstract:**
This study checks the normalization of the Armed Services Vocational Aptitude Battery (ASVAB) forms 6 and 7 and normalized the ASVAB forms 6E and 7E. The ASVAB measures the mental aptitude of prospective recruits. Since ASVAB 6 and 7 were first used (January 1976) questions about the correctness of the normalization have been raised. We checked the normalization of ASVAB 6 and 7 and developed the normalization of 6E and 7E using a reference test—AFQT 7. In this effort we used a large sample of Marine Corps recruits. We found that the current normalization of ASVAB 6 and 7 is too easy; it overstates the mental ability of low aptitude recruits by 15 to 17 percentiles.
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2. The objective of the study was to examine the normalization of the ASVAB.  

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A REEXAMINATION OF THE NORMALIZATION OF THE ARMED SERVICES VOCATIONAL APTITUDE BATTERY (ASVAB) FORMS 6, 7, 6E, and 7E

William H. Sims, Study Director
Ann R. Truss

Enclosure (1) to CMC ltr RDS-41-eh dated 27 October 1980

CNS 1152 / April 1980

CENTER FOR NAVAL ANALYSES
2000 North Beauregard Street, Alexandria, Virginia 22311
EXECUTIVE SUMMARY

In January 1976, all branches of the armed services began using the Armed Services Vocational Aptitude Battery (ASVAB) to measure the mental aptitude of prospective recruits.

Since its first use there have been questions about whether the ASVAB had been correctly normalized—that is, whether the proper relationship had been established between the number of questions answered correctly (the raw score) and the percentile score. Some evidence suggested that the normalization of the ASVAB was too "easy"—that raw scores were being assigned percentile scores that were too high. In January 1979, the Assistant Secretary of Defense for Manpower, Reserve Affairs, and Logistics, requested that the Center for Naval Analyses (CNA) conduct an independent study of the normalization of the ASVAB.

Preliminary results from our analysis were made available in May 1979. These results indicated that the current operational normalization of ASVAB was incorrect and that for this reason official reports on the mental aptitude of recruits were seriously in error. Because of the magnitude of the possible error and its attendant policy implications, the Department of Defense (DoD) set up two independent studies, one by DoD and the other by the Educational Testing Service (ETS), to determine if our results were correct. While these two additional studies were being conducted we carried out an extensive investigation of normalization methodology and further refined our results.

The data for our analyses was obtained by administering both the ASVAB and a reference test—Armed Forces Qualification Test (AFQT) 7a—to a large sample of Marine Corps recruits at two recruits depots. Testing was done under carefully controlled conditions designed to minimize any effects of test compromise and to provide equal motivation and opportunity to do well on both tests.

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1 Various authors use the terms "normalization", "calibration", or "equating" to describe the same procedure.
2 Center for Naval Analyses, Memorandum (CNA) 78-3055, "A Model Reexamination of the Normalization of the Armed Services Vocational Aptitude Battery (ASVAB) Forms 6A, 7A, 6B, and 7B," by William H. Sims and Ann R. Truss, Unclassified, 20 May 1978. (This document was originally issued as a working paper.)
The findings of our study are summarized as follows:

- The current normalization of ASVAB is too easy; it overestimates the mental ability of low aptitude recruits by 15 to 17 percentiles. (For example, in figure I we show that a raw score of 31 converts to the 31st percentile by the current DoD norms but to only the 16th percentile by our norms.)

- Because the normalization has been incorrect, DoD reports have overstated the mental aptitude of recruits since January 1976. For the past 3 years, approximately 25 to 30 percent of all DoD accessions have been in mental category IV (the lowest acceptable category) rather than the 5 to 6 percent reported by DoD (see figure I).

- Although the mental quality of recruits enlisted since 1976 is lower than indicated by DoD reports, it is similar to that during the peak of the Vietnam War and better than that during the Korean War (see figure II).

- The analytical technique of sample stratification often used in the normalization of military aptitude tests will not, in general, produce correct results.

A correctly normalized test is important to managers as well as unit commanders and military trainers. The principal virtue of maintaining a correctly normalized test is that a certain score on a current version of the accession test reflects the same ability to absorb training as that same score did on previous versions of the test. Because of this continuity, managers can make informed judgments about changes over time in the aptitude of recruits. By the continued use of correctly normalized tests, a rational basis, founded on years of service experience in peace and in war, can be formed for both enlistment and job classification standards.

If the normalization of the ASVAB were changed to the one developed in this study, the supply of qualified applicants would probably decrease sharply unless compensating steps—such as a change in accession criteria, increased recruiting assets, increased enlistment incentives, or other actions—are taken.

RECOMMENDATION

We recommend that the conversion tables for the AFQT score shown in table I and for the classification composites shown in appendices M and O be used for the normalization of ASVAB 6, 7, 6E, and 7E.¹

¹We refer to these four tests as ASVAB 6/7/6E/7E.
FIG. 1: COMPARISON OF CURRENT OPERATIONAL ASVAB AFQT CONVERSION TABLE WITH THE ONE DEVELOPED IN THIS ANALYSIS.
FIG. II: COMPARISON OF PERCENTAGE OF MALE DOD ACCESSIONS IN MENTAL GROUP IV AS OFFICIALLY REPORTED AND BY THIS ANALYSIS
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*For form 7E only, add two raw score points to the AFQT raw score before using this table to convert raw score to percentile score.*
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<tr>
<td>O-3</td>
<td>ASVAB 6E/7E/6/7 subtest conversion tables (in Navy Standard Score)</td>
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<tr>
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<td>Correlation coefficients of ASVAB composites</td>
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CHAPTER I

INTRODUCTION

BACKGROUND

The Armed Services Vocational Aptitude Battery (ASVAB) is the screening test the armed services currently use to measure the mental aptitude of prospective recruits. On 1 January 1976, two forms (6 and 7) developed by the Air Force Human Resources Laboratory (reference 1) were implemented at the Armed Forces Examining and Entrance Stations (AFEES). In this report we refer to these as ASVAB 6/7.

During the first months ASVAB 6/7 was used, an unexpectedly large number of recruits, particularly those in the Navy, were scoring high on the tests. This suggested that the normalization of ASVAB 6/7 was too "easy." Each of the armed services then initiated an independent analysis to examine the normalization of the test. Based on these analyses, the ASVAB Working Group revised the normalization on 29 July 1976.

After the normalization of ASVAB 6/7 was revised, questions about the correctness of the revision continued among members of the ASVAB Working Group. In 1978, the Center for Naval Analyses (CNA) published a study (reference 2) that criticized the revised norms as unlikely to be correct.

In response to concern about test compromise, two additional forms, ASVAB 6E and ASVAB 7E, were scheduled for implementation in June 1979, making a total of four different forms of the test. To prepare for this implementation, CNA began a study to check the normalization of these two additional forms. The study was done at the request of the ASVAB Steering Committee, through Headquarters, Marine Corps (reference 3). At about the same time that the ASVAB Steering Committee made its request, the Office of the Assistant Secretary of Defense for Manpower, Reserve Affairs, and Logistics (MRA&L) requested (reference 4) the study be

1Normalization as used here is a procedure that converts raw scores into percentile scores of a standard reference population.
2Easy means that a raw score has incorrectly been assigned a percentile score higher than would have been made by the proper percentage of the standard reference population.
3A joint service group that deals with ASVAB issues and is composed of policy and technical representatives from each service.
4The joint service flag officer oversight committee for the ASVAB Working Group.
expanded to include a reexamination of the norming of ASVAB 6/7. Accordingly, the study was designed to examine the normalization of the entire series--ASVAB 6, 7, 6E, and 7E. This report documents that analysis.

Because normalization information on ASVAB 6E and ASVAB 7E was needed before the scheduled June 1979 implementation, preliminary results (reference 5) of our analysis were made available in May 1979. These results showed that ASVAB 6E and ASVAB 7E could, with minor adjustments, use the same norming tables as ASVAB 6/7. The preliminary results also indicated that the normalization of the entire ASVAB series (6, 7, 6E, and 7E) was much too easy and that consequently there was a high probability that Department of Defense (DoD) reports of recruits' mental aptitude were seriously in error.

As a result of concerns raised by our preliminary report, two studies were conducted to try to verify our preliminary findings. One study was conducted by DoD \(^1\) and used data on applicants tested at AFEES. The other study was conducted by the Educational Testing Service (ETS) and used data collected in high schools.

**STRUCTURE OF THE ASVAB**

The ASVAB is a group of 16 tests (sometimes referred to as subtests) that focus on different mental aptitudes. Scores from these tests are combined to form composite scores. The tests and composites are described in detail in appendix A. The Armed Forces Qualification Test (AFQT) composite is the common composite score all services use to measure general ability. Other composites are used primarily for job classification. For quality monitoring purposes, DoD reports scores of recruits in terms of broad categories known as mental groups. These mental groups are based on AFQT scores and range from I (most qualified) to V (unqualified). The normalization discussed in this report focuses on the normalization of the AFQT score, although normalizations of the other composites are also developed.

**ORGANIZATION OF THE REPORT**

Chapter II discusses the experimental design. In chapter III we develop our norming results from a stratified and unstratified

\(^1\)This study, which initially was known as the Army Research Institute (ARI) study, is officially a Department of Defense study. It was conducted by an ARI research psychologist temporarily attached to the Office of the Assistant Secretary of Defense (MRA&L) with computational support from ARI. In this report we refer to it as the "DoD" study.
sample, respectively. In chapter IV we discuss possible problems with the results of the analysis. In chapter V we examine the effects of sample truncation, and in chapter VI we discuss whether samples should be stratified. Our recommended normalization, which is shown in chapter VII, is contrasted with alternative normalizations.
CHAPTER II
EXPERIMENTAL DESIGN

INTRODUCTION

We administered the various forms of the ASVAB along with a reference test to a large sample of Marine Corps recruits at recruit depots. We chose this approach over an administration at AFEES because it was much easier to obtain permission to give additional tests to Marine Corps recruits than to AFEES applicants. We understood that the use of a recruit sample instead of a more traditional applicant sample might cause added analytical difficulties. But, we believed these difficulties could be handled.

The testing was carried out under carefully controlled conditions designed to minimize any effects of test compromise and to provide equal motivation and opportunity for the recruits to do well on both the ASVAB and the reference test. The ASVAB forms were normalized by equating ASVAB scores to scores on the reference test.

The reference test chosen for this analysis was AFQT 7A. It was used at AFEES from 1962 through 1973 and was normalized (see reference 6) to the traditional reference population according to a test known as "R-9." R-9 is an editorial revision of the Army General Classification Test used to define the World War II mobilization population.

The experimental design is discussed in detail in appendix B.

DATA SAMPLES

Our data sample consisted of test scores for 3,295 Marine Corps recruits. The tests were administered between 16 February and 3 April 1979 at the Marine Corps Recruit Depots (MCRD) located at Parris Island, South Carolina, and San Diego, California. Before enlistment, recruits took either ASVAB 6 or ASVAB 7 at the AFEES or ASVAB 5 (if they entered via the high school testing program). Once at the recruit depots, recruits took three tests: ASVAB 6 or ASVAB 7, ASVAB 6E or ASVAB 7E (AFQT parts only), and AFQT 7A (the reference test). Recruits were tested in platoon-size groups of about 60 persons.

Definitions of ASVAB tests and composites are given in appendix A.
The order in which the three tests were given was counter-balanced; i.e., as many platoons were administered any one test first as were administered it second or third in the sequence. Total testing time was about 5 hours, and either a lunch break or overnight break separated the tests. All tests were given to recruits within a few days after their arrival at recruit depots and before they started recruit training.

In our analysis we used only results from tests administered at recruit depots. This reduced the effect of any coaching that may have occurred during testing at AFEES.

For our analysis, we separated the sample into five subsamples, as shown in table 1.

### TABLE 1
DEFINITIONS OF SUBSAMPLES

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sample size</th>
<th>Used to normalize:</th>
<th>Tests used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (total)</td>
<td>3,295</td>
<td>Not used as a unit</td>
<td>AFQT 7A ASVAB 6 or 7 ASVAB 6E or 7E</td>
</tr>
<tr>
<td>2</td>
<td>1,634</td>
<td>6E</td>
<td>AFQT 7A ASVAB 6E</td>
</tr>
<tr>
<td>3</td>
<td>1,660</td>
<td>7E</td>
<td>AFQT 7A ASVAB 7E</td>
</tr>
<tr>
<td>4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>227</td>
<td>6/7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>AFQT 7A ASVAB 6/7</td>
</tr>
<tr>
<td>5&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2,208</td>
<td>6/7</td>
<td>AFQT 7A ASVAB 6/7</td>
</tr>
</tbody>
</table>

<sup>a</sup>These recruits were enlisted on the basis of scores on ASVAB 5, which they took in high school—they had not seen ASVAB 6/7 before being tested at recruit depots.

<sup>b</sup>Only as supporting evidence for sample 5 results.

<sup>c</sup>These recruits had been previously tested on ASVAB 6 or 7 at AFEES. When retested at the recruit depot they were given the opposite form to reduce the effect of practice; i.e., if they were tested at AFEES on form 6 they were given form 7 at the recruit depot and vice versa.
Samples 2 and 3 are appropriate for the normalization of ASVAB 6E and ASVAB 7E, respectively, because none of the recruits had seen AFQT 7A (the reference test) or ASVAB 6E or ASVAB 7E before being tested at the recruit depot.

Sample 5 is a good sample for the normalization of ASVAB 6/7, but has some imperfections. These imperfections result because the recruits were previously tested at AFEES on ASVAB 6 or 7. Effects from practice (taking the same test before) were eliminated because only recruits who were retested at recruit depots on the opposite form of ASVAB 6/7 were included in sample 5. However, it is possible that some recruits were coached on both forms 6 and 7 before taking the test at AFEES. If this occurred and if they remembered this coaching when retested at recruit depots, their scores on ASVAB 6/7 would artificially be raised. The resulting normalization would be too hard.

To control for the possibility just discussed, we used sample 4. This sample is small but very "clean." All recruits in this sample were enlisted on the basis of scores on ASVAB 5, which they took in high school. That is, recruits in sample 4 had not seen ASVAB 6 or 7 before being tested at recruit depots; hence, results were not biased by a practice effect or by coaching. Our confidence in the results of our normalization for ASVAB 6/7 will be enhanced to the extent that the results from the larger sample 5 are confirmed by those of the small, but clean, sample 4.

Summary statistics for the entire data sample are given in appendix C.

\footnote{Those tested at AFEES on form 6 and at recruit depots on form 7 and vice versa.}

\footnote{Retesting at recruit depots generally took place within 3 months of AFEES testing.}

\footnote{Clean refers to tests on which recruits were not coached.}
CHAPTER III
NORMALIZATION

INTRODUCTION

Two methods are commonly used in the normalization of military aptitude tests. We refer to one method as "unstratified graphical equating"—also known as "equipercentile equating." The other method may be called the "stratification procedure." This chapter describes normalization results obtained using both procedures.

STRATIFICATION PROCEDURE

The method of equating reported in this section was stratifying each subsample (table 1) on the AFQT 7A percentile score thereby simulating the reference mobilization population within each subsample. Cumulative frequency distributions of ASVAB 6, 7, 6E, and 7E AFQT raw scores were then made from this simulated mobilization population. The raw score-to-percentile score conversions for each form of ASVAB can be read directly from these cumulative frequency distributions.

For example, figure 1 shows the distribution of percentile scores from the reference test—AFQT 7A—in sample 5. The solid line is the distribution observed in the sample. The dashed line is that expected in the mobilization population. The mobilization population is simulated in the sample by weighting individuals in the observed population in proportion to their expected occurrence in the mobilization population. The procedure is illustrated in table 2. For example, in the percentile interval 1 through 5, we observe 29 recruits. The mobilization population is expected to contain 110.4 in this interval. We calculated a weight factor, 3.807, which is the expected number divided by the observed number. We attached one of these weight factors to each recruit in the sample based on their score on the AFQT 7A reference test.

By using these weight factors we simulated the mobilization population within the sample. All distributions derived from these weighted recruits will look as they would if the mobilization population had taken the test. For example, if figure 1 were made using weighted recruits the distribution would be flat.

---

1The definition of percentile score is such that 5 percent of the reference population have a percentile score of five or less, 10 percent have a percentile score of 10 or less, and so on; hence, the expected distribution is flat.
FIG. 1: COMPARISON OF PERCENTILE DISTRIBUTION OF
SAMPLE 5 AND THE MOBILIZATION POPULATION

TABLE 2
CALCULATION OF WEIGHT FACTORS FOR
SAMPLE 5

<table>
<thead>
<tr>
<th>AFQT 7A percentile interval</th>
<th>Number observed in sample</th>
<th>Number expected in mobilization population</th>
<th>Weight factor^a</th>
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<tr>
<td>1-5</td>
<td>29</td>
<td>110.4</td>
<td>3.807</td>
</tr>
<tr>
<td>6-10</td>
<td>56</td>
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<td>1.971</td>
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<td>11-15</td>
<td>152</td>
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<td>0.726</td>
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<tr>
<td>16-20</td>
<td>169</td>
<td>110.4</td>
<td>0.653</td>
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<tr>
<td>21-25</td>
<td>171</td>
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<td>0.646</td>
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<td>0.661</td>
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<td>66-70</td>
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<td>110.4</td>
<td>1.571</td>
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<td>110.4</td>
<td>1.871</td>
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<td>3.345</td>
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<tr>
<td>96-100</td>
<td>9</td>
<td>110.4</td>
<td>12.267</td>
</tr>
<tr>
<td>Total</td>
<td>2,208</td>
<td>2,208</td>
<td></td>
</tr>
</tbody>
</table>

^aColumn (3) divided by column (2).
To get the required conversion tables we simulated\(^1\) the mobilization population in samples 2, 3, 4, and 5 and formed (using weighted recruits) the cumulative frequency distribution of raw AFQT scores for each form of the ASVAB.\(^2\) The resulting tables for converting raw scores into percentile scores are tabulated in appendix D, table D-6.

**EQUIPERCENTILE EQUATING**

Normalization without stratification may be done by graphically equating the new test to a reference test. The procedure, known as equipercentile equating, is described in reference 7 and illustrated in figure 2. Two scores are considered equivalent if they are obtained by the same cumulative percentage of a sample (point "A" in figure 2). Hence, the raw score for the ASVAB test at point "B" would be defined as equal to the percentile score on the reference test at point "C".

ASVAB 6/7, 6E, and 7E were normalized using this procedure. Details and results are in appendix E.

**DISCUSSION OF RESULTS**

A comparison of the ASVAB 6/7 AFQT normalization results (conversion tables) from both the stratification and equipercentile procedures with the current operational conversion table is shown in figure 3. It shows, for example, that by the current operational norms, an ASVAB 6/7 raw score of 30 converts into a percentile score of 28. From the results of this analysis, the same raw score of 30 will convert into a percentile score of 15 using the equipercentile method, or 11, using the stratification procedure.

Figure 3 clearly shows that the results from the stratification procedure and the equipercentile method are systematically different in the highest and lowest percentiles. Because both methods have been used in the past to normalize military tests, it is important to understand the reasons for this difference and to determine which method is preferred. This question will be examined in detail in chapter VI.

It is also evident from figure 3 that regardless of which method of analysis is used, the results of this analysis strongly disagree with the current operational norms. Various services have established minimum acceptable AFQT percentile scores in the

\(^1\)The calculation of the weight factors for each sample is shown in appendix D.

\(^2\)Forms 6 and 7 are known to be similar (see references 1 and 2); hence, they are treated together.
FIG. 2: ILLUSTRATION OF EQUIPERCENTILE EQUATING
Current operational norms

This analysis (stratification method)

This analysis (equipercentile method)

FIG. 3: COMPARISON OF OUR NORMALIZATION RESULTS FROM TWO METHODOLOGIES WITH CURRENT OPERATIONAL NORMALIZATION
area from the 16th through the 31st percentile. Our results differ from the current operational norms between these percentiles by 15 to 17 percentile points. If our norms are correct, a large percentage of current recruits would no longer be qualified for enlistment.

The seriousness of the potential error in current norms dictates that we must explore all avenues to determine if there are any flaws in our analysis. Recall that our tests were administered to Marine recruits because access was not possible to the more standard sample of applicants from all services. In chapter V we explore the question of whether this restriction could have produced a biased result.

Because ASVAB 6/7 is an operational test it is reasonable to assume that some recruits are coached on the answers. In chapter IV we examine our results for bias from this source and examine possible biases due to mistakes in administering the test and testing fatigue.
CHAPTER IV
COACHING AND ADMINISTRATIVE PROBLEMS

INTRODUCTION

We examined a number of areas in which problems could have biased our results. The areas we examined in detail are coaching, mal-administration, and test fatigue. We discuss each of these areas in turn.

In our discussion of sources of possible bias, we base our conclusions on norming results using the stratification technique. Our tests for these biases are based on the observations (or lack thereof) of relative differences between norming results under various conditions. Hence, we believe that the conclusions reached in this chapter are insensitive to the particular normalization method used.

Coaching

As we have noted, one virtue of administering tests at recruit depots is that the effects of coaching will be smaller than at AFEES. Because the recruits are already enlisted, there is little reason for anyone to coach them on ASVAB. Moreover, most of those recruits who were enlisted based on ASVAB 6 scores are retested on ASVAB 7 and vice versa. Nonetheless, if recruits were coached on both ASVAB 6 and 7 before enlistment, they might recall enough material to bias ASVAB scores upward.

There are several ways to look at the coaching issue. For one, we compared the normalization results for ASVAB 6/7 found in sample 5 (which may be biased by coaching) with those from sample 4 (which cannot be biased by coaching). This comparison, shown in figure 4 is based on data in appendix D, table D-6. We see that results from the small, but clean, sample 4 agree very well with those from the full sample 5. This result suggests that coaching did not seriously bias the norming results for ASVAB 6/7.

For another approach to the coaching issue we removed from sample 5 those recruits who were most likely to have been coached. This procedure, which is discussed in detail in appendix F, relies on the Pseudo AFQT\(^1\) developed by reference 2 specifically for detecting coaching.

\[ \text{Pseudo AFQT} = \text{GI} + \text{GS} + \text{MC} + \text{MK}, \]
\[ \text{AFQT} = \text{WK} + \text{AR} + \text{SP}, \]

where:
- \(\text{GI}\) = general information
- \(\text{GS}\) = general science
- \(\text{MC}\) = mechanical comprehension
- \(\text{MK}\) = mathematics knowledge.
- \(\text{WK}\) = word knowledge
- \(\text{AR}\) = arithmetic reasoning
- \(\text{SP}\) = space perception.

---

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FIG. 4: COMPARISON OF ALTERNATIVE NORMALIZATIONS OF ASVAB 6/7
Referring to figure 5, we see the expected distribution in AFEES AFQT score minus the predicted AFEES AFQT score ($\Delta$). For recruits who were not coached, this distribution is expected to be symmetric about zero. Recruits who were coached will tend to have AFEES AFQT scores higher than their predicted AFEES AFQT scores (i.e., positive values of $\Delta$); these are shown in the shaded area of figure 5.

\[ \Delta (\text{AFEES AFQT-predicted AFEES AFQT}) \]

**FIG. 5: ILLUSTRATION OF $\Delta$ DISTRIBUTION USED TO ESTIMATE AMOUNT OF COACHING**

In appendix F we show results for removing suspect recruits from the sample. We removed suspects in two stages: the first is all recruits with $\Delta > 10$, and the second is all recruits with $\Delta > 0$. The two resulting subsamples were normalized and the results compared with those from the full sample 5. In both cases the resulting normalizations were statistically consistent with the hypothesis that coaching does not distort the norming curve for ASVAB 6/7.

Chi-squared tests for the homogeneity of parallel samples were applied to the data here and elsewhere in the report. This test is not, strictly speaking, appropriate because the samples are not completely independent, but it is useful as an approximate quantification of the homogeneity of the samples.
For a third approach to the coaching issue we compared scores on ASVAB 6/7 with those on ASVAB 6E/7E in an operational environment at AFES. We found in this analysis that all forms of ASVAB can use the same conversion table. It has been argued that our results for forms 6/7 are biased by test compromise and that if this effect were removed then ASVAB 6/7 would have a markedly different conversion table than ASVAB 6E or 7E.

Table 3 addresses this contention. It shows mean ASVAB AFQT scores for Marine Corps recruits for the months following the first use of ASVAB 6E/7E. Because ASVAB 6/7 has been used since January 1976 we assumed it was significantly compromised. ASVAB 6E/7E were first used in June 1979. We assumed they were not compromised much during the first few months of their use but have been compromised thereafter.

Based on the preliminary results from our analysis (reference 5), when ASVAB 6E/7E was first used (with only minor adjustments) it would have had the same conversion table currently used for ASVAB 6/7. Note that the first line of Table 3 indicates that the mean ASVAB AFQT percentile scores from both ASVAB 6/7 and ASVAB 6E/7E are identical (53.8). If one assumes that our norms for ASVAB 6/7 are grossly distorted by test compromise in our sample while the norms for ASVAB 6E/7E are not, then one should expect that over time as ASVAB 6E/7E becomes more compromised the mean score on ASVAB 6E/7E would become greater than that observed for ASVAB 6/7. But, as seen in table 3, this effect is not observed. We believe this result argues strongly that there is no significant bias in our ASVAB 6/7 norming results due to test compromise.

After examining all the material in this chapter and the details shown in appendix F, we concluded that there are indeed some cases in sample 5 that are probably distorted by coaching but that these do not seem to have had a significant effect on the normalization results for ASVAB 6/7.

---

1ASVAB 6/7 had been used for about 2 years when our data were collected and were certainly compromised. ASVAB 6E/7E were not in use then and were not compromised.

2In testimony before the House Armed Services Military Personnel Subcommittee, a recruiter stated that there wasn't a test devised "that I couldn't compromise in three months." (Navy Times, 7 June 1976). Other recruiters have given estimates of time required that are even shorter.
<table>
<thead>
<tr>
<th>Dates tested at AFEES</th>
<th>Mean ASVAB AFQT percentile score from AFEES testing</th>
<th>Estimated extent of test compromise</th>
</tr>
</thead>
<tbody>
<tr>
<td>June-September 1979</td>
<td>ASVAB 6/7&lt;sup&gt;a&lt;/sup&gt; 53.8 ± 0.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>ASVAB 6/7 Significant</td>
</tr>
<tr>
<td>October-December 1979</td>
<td>ASVAB 6E/7E&lt;sup&gt;b&lt;/sup&gt; 53.8 ± 0.4&lt;sup&gt;d&lt;/sup&gt;</td>
<td>ASVAB 6E/7E Negligible</td>
</tr>
<tr>
<td></td>
<td>ASVAB 6/7E 54.8 ± 0.5&lt;sup&gt;f&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Implemented in January 1976: assumed to be compromised as of June 1979.

<sup>b</sup>Implemented in June 1979: assumed to be relatively free of compromise during the first months of use (June-September 1979) and significantly compromised in later months (October-December 1979).

<sup>c</sup>Sample = 6,887 Marine Corps recruits.

<sup>d</sup>Sample = 1,755 Marine Corps recruits.

<sup>e</sup>Sample = 2,391 Marine Corps recruits.

<sup>f</sup>Sample = 1,096 Marine Corps recruits.
Maladministration

As part of the quality control procedure, one of us visited the two testing sites when testing began. Each test site seemed to conduct the testing in the same way. In appendix G we examine the data to determine if there is any difference in normalization results between the two test sites. Such a difference might indicate that at some time during the testing one of the sites may have deviated from the proper procedure.

We separated the data from sample 5 into two subsets, one from each test site, and did a separate normalization on each. Details are given in appendix G. The two resulting normalizations were very similar. (A chi-squared test indicated that the observed differences could well be due to chance.) We concluded that there was no reason to doubt that the two test sites followed the same testing procedures.

Test Fatigue

Because the sample design specified a counterbalanced series of three tests, it may be argued that norming results for the last test in the series may be biased due to recruits' fatigue. The counterbalanced design tends to reduce this problem. However, in appendix H we examine the test fatigue issue in some detail.

We selected a subsample of sample 5 consisting of those recruits who took the reference test and ASVAB 6/7 either first or second in the three-test sequence. We assumed these recruits would be less fatigued than the average recruit in sample 5. We stratified the low-fatigue subsample separately and developed a normalization curve. From our comparison of these results with those for all of sample 5 we concluded in appendix H that biases due to test fatigue, if any, are negligible.

In the next chapter we explore another source of bias due to truncation of the sample from preselection at the AFEES.
CHAPTER V
EFFECT OF TRUNCATION OF RECRUIT SAMPLE FROM PRESELECTION AT AFEES

INTRODUCTION

By necessity, we based our analysis on tests administered to recruits rather than the traditional sample of applicants for military service. Only those applicants who meet established minimums on the ASVAB are accepted for enlistment and become recruits. For this reason individuals who scored below these minimums were not present in our sample, and it may be argued that this biased our normalization results. However, our results are based on a reference test and an ASVAB both administered to recruits at recruit depots. Therefore, it may also be argued that any bias due to preselection at AFEES affects both tests equally and, in effect, the biases cancel each other out. We examine these questions in this chapter.

Our initial exploration of the truncation question involved further truncation of our data set followed by norming the residual sample to see if bias had been introduced. This analysis is described in detail in appendix I and suggests that some truncation bias may be present if the stratification method of norming is used. The limitations inherent in this already truncated data set precluded reaching a more definitive conclusion.

To fully address the effect of sample truncation on norms we used a full-range untruncated data set. First we developed norms from the full-range data set. Then we truncated this data set in the same way that our recruit data set was truncated and developed norms from the truncated data. A comparison of the norms developed from the full-range and truncated data enabled us to quantify the effect, if any, of truncation on norms.

An alternative approach would have involved using computer simulated data. We used real data to simulate the truncation rather than computer simulated data because there may be factors operating that we cannot know a priori, and hence cannot otherwise accurately simulate.

SIMULATION

We obtained a suitable full-range data set through the courtesy of the Office of the Assistant Secretary of Defense, who made available the data set¹ they were using in their study of

¹This data set will be referred to as the "DoD" data set.
ASVAB norms. The data was collected at AFEES on a full-range of male applicants in June and July 1979. ASVAB forms and the reference test (APQT 7A) were given in the counterbalanced fashion previously described. The sample sizes for the ASVAB 6/7, 6E, and 7E subsamples were 5,069, 2,870, and 2,650 cases, respectively. The data are described more fully in reference 8.

The concept behind the simulation of the truncation effect is illustrated in figure 6. The top panel of figure 6 illustrates the three-test CNA data set: the ASVAB 6/7 APQT administered at AFEES, the ASVAB 6E APQT administered at the Marine Corps Recruit Depots (MCRD), and the reference test also administered at the recruit depots. Note that scores on the ASVAB 6/7 APQT administered at AFEES are directly selected (truncated) by virtue of the minimum enlistment standards at AFEES. Because scores on all three tests are highly correlated, this direct selection on the AFEES test results in an indirect selection that removed some low scoring individuals from the distribution of the two tests taken at the recruit depots.

The DoD data set consists of scores from only two (not three) separate test batteries. However, we simulated a three-test system by using the Pseudo APQT developed in reference 2 (see chapter 4). Reference 2 found that in addition to the APQT test embodied in the ASVAB, there is also a Pseudo APQT. Because it is highly correlated (0.87) with the APQT, the Pseudo APQT is a good proxy for it.

The Pseudo APQT may be constructed from parts of the ASVAB that do not make up the APQT and, hence, may be viewed as a separate test. The Pseudo APQT may be used to accurately predict an independent APQT score for each applicant.

After simulating a three-test system we truncated the full-range sample on the predicted APQT to simulate the truncation of the CNA data set. The real ASVAB APQT and the reference test then show incidental selection similar to the one that occurred in the CNA data set (see the lower panel of figure 6). We normalized ASVAB 6E using those variables that are subject to incidental selection. Results were compared with those obtained from the non-truncated full-range data set.

The effects of the simulated truncation on the DoD ASVAB 6E data set and the comparison of them with the truncated CNA ASVAB 6E data set are shown in figure 7. The truncated distribution (open areas of figure 7) from the two data sets are very similar, indicating that we successfully simulated in the DoD data set a truncation like that observed in the CNA sample. The shaded areas of figure 7 represent individuals who were removed from the DoD full-range data set to simulate truncation like that observed.
CNA 6E sample (truncated by preselection)

Real data simulation (DOD full-range sample)

FIG. 6: ILLUSTRATION OF REAL DATA SIMULATION OF SAMPLE TRUNCATION
CNA 6E sample (truncated by preselection)

(a) (b) (c)

M 400 0

E 200 – 0

0 10 20 30 40 50 60 70

0 10 20 30 40 50 60 70

0 20 40 60 80 100

ASVAB 6/7 AFQT (AFEES) ASVAB 6E AFQT (MCRD) Reference test (MCRD)

DOD full-range sample

(d) (e) (f)

Note: Full-range distribution (dots plus cross-hatched area) was scaled (for illustration only) to the truncated distribution in the upper percentiles.

FIG. 7: COMPARISON OF TRUNCATED CNA DATA AND TRUNCATED DOD DATA FOR THE ASVAB 6E SAMPLE
in the CNA sample. The shaded areas of figure 7 represent individuals who were removed from the DoD full-range data set to simulate truncation like that observed in the CNA data set. Note that the direct removal of cases is carried out in figure 7(d) only—all other shaded areas represent cases that were removed by incidental selection. Further details on the simulation are given in appendix J.

Normalizations from the DoD full-range and DoD truncated data sets were made using both the stratification procedure and unstratified graphical equating. Differences between norming results from the DoD full-range and DoD truncated sample were taken as estimates of the distortions in CNA results due to the truncation effect.

**STRATIFIED NORMING**

Both the DoD full-range and simulated truncated data sets were normed using the stratification procedure. The samples were stratified on the reference test, and percentile equivalents of raw ASVAB AFQT scores were read directly from stratified cumulative frequencies. Details of the norming are given in appendix J.

The results from this norming for ASVAB 6E AFQT are shown in figure 8. That figure shows the comparison of norming results from the full-range and truncated DoD data set. The results from the truncated data set produce norms that are several points harder in the lower percentiles and somewhat easier in the upper percentiles. We obtained similar results (shown in appendix J) for the DoD ASVAB 6/7 and ASVAB 7E data sets.

**UNSTRATIFIED NORMING**

Both the DoD full-range and truncated samples were also normalized by the unstratified graphical equating (equipercentile) method. The details are given in appendix K. A comparison of the results from the full-range and truncated DoD ASVAB 6E AFQT data are shown in figure 9. The difference between the results for the truncated and full-range samples is very small and confined to the region below the 16th percentile. Similar results (shown in appendix K) were obtained for the DoD ASVAB 6/7 and 7E data sets.
FIG. 8: EFFECT OF SIMULATED TRUNCATION ON STRATIFIED NORMING RESULTS FROM DOD 9E SAMPLE
FIG. 9: COMPARISON OF ASVAB 6E NORMS FROM UNSTRATIFIED GRAPHICAL EQUATING USING FULL-RANGE DOD AND TRUNCATED DOD DATA
CHAPTER VI

TO STRATIFY OR NOT TO STRATIFY

INTRODUCTION

The stratification technique and the unstratified (equipercentile) technique each have some superficial advantages. The equipercentile technique has conceptual simplicity and is therefore intuitively appealing. However, this procedure, as carried out in this report does entail drawing and smoothing graphs of cumulative frequencies and introduces some degree of subjectivity into the results. The stratified procedure superficially introduces a degree of stability in the normalization procedure by adjusting the sample so that the distribution of scores on the reference test is always flat. It also is a mechanistic procedure that introduces very little subjectivity into the normalization. The relevant criterion of whether to stratify is, however, which method produces the most accurate equating or normalization of tests. We explore this question in this chapter.

TRUNCATED DATA SETS

We have seen in figure 8 that the stratification procedure can produce significantly different results if applied to both full-range and indirectly truncated data sets. Ideally, the normalization results should be independent of the data set. For this reason, the stratification method should not be used with indirectly truncated data sets. An independent investigation of the question reached the same conclusion.

Results using the unstratified graphical equating procedure were similar when applied to either full-range or indirectly truncated data sets (see figure 9). Invariance of the results with respect to truncation indicates that this method is satisfactory for indirectly truncated data sets.

---

1The procedure could be computerized.
2As this report was in final preparation, we received portions of a draft technical report based on computer simulated data stating that the "...stratified normalization technique introduces systematic biases in the estimation of population norms." Naval Personnel Research and Development Center, Draft Technical Note, "Test Norming and Equating Using Stratified Sampling: A Simulation Study," by John H. Wolfe, April 1980.
FULL-RANGE DATA SETS

We have shown that the stratified norming procedure can be unsatisfactory for indirectly truncated data sets. We now examine whether it is appropriate for full-range data sets.

In figure 10 we show a scattergram and associated projections of a typical unstratified bivariate distribution for two hypothetical parallel tests ("A" and "B") of equal difficulty. The percentile distribution is peaked in the middle and depopulated on both ends. The distribution is similar to distributions of scores expected from applicant (or retested recruit) populations. The cell population, decile population, and cumulative percentage by decile are shown. Let us arbitrarily take test "A" as the reference test. Because the cumulative percentages by decile are the same for both tests, the unstratified graphical equating method would equate the 10th percentile on test "B" to the 10th percentile of the reference test "A", as we would expect.

Suppose we stratified the data in figure 10 so that the percentile distribution of the reference test, test "A", was flat. This procedure is illustrated in figure 10, and the weights necessary to force the test "A" distribution to be flat are shown.

The data set is stratified by applying the weights shown in figure 10. Results are shown in figure 11. The distribution of reference test scores is flat, as expected. However, the stratification procedure has only partially flattened the corresponding distribution of test "B" scores. The test "B" distribution is still too high in the area where it was originally high and too low in areas where it was originally low. A comparison of the resulting cumulative percentages by decile shows that scores on test "B" that should have been equated to the 10th percentile will actually be assigned to the 6th percentile. Similar distortions are observed in other score regions.

Figure 12 shows the results observed from applying the stratification procedure to our hypothetical bivariate data. The figure shows the comparison of results to the true normalization of test "B". As seen, the stratification procedure produces norms that are too hard in the lower percentiles and too easy in the upper percentiles.

1 The following example explains how to interpret figure 10. The scattergram projections of percentile scores are grouped into decile units. There are 30 cases in the first decile on test "A". These 30 cases are distributed on test "B" in the lower four deciles--10 in the first and second, 5 in the third and fourth. The cumulative percentage of the sample in test "A" is 2 percent in the first decile, 6 percent in the second, and so on.

-27-
FIG. 10: ILLUSTRATION OF UNSTRATIFIED BIVARIATE DISTRIBUTION
FIG. 11: ILLUSTRATION OF STRATIFIED BIVARIATE DISTRIBUTION
Figure 13 shows a comparison of the results from stratified and unstratified equating of ASVAB 6E from the full-range DoD data sample (appendices J and K). This figure shows, as expected, that the stratified procedure produces harder norms in the lower percentiles and easier norms in the upper percentiles. The crossover point is very low in this case because the DoD data set has a reference percentile distribution peaked in the second decile (see figure 7) rather than in the fifth decile, as we assumed in our hypothetical example.

From the preceding discussion, we concluded that, in general, stratification is not appropriate for either truncated or full-range data samples. Such normalizations generally produce norms that are too hard in the lower percentiles and too easy in the upper percentiles.1

1This generalization will hold for all distributions of the form shown in figure 10; i.e., those that have a single maximum somewhere between the endpoints and where the endpoints tend to be depopulated.
FIG. 13: COMPARISON OF NORMING RESULTS FOR FULL-RANGE DOD ASVAB 6E DATA SET USING STRATIFIED AND UNSTRATIFIED PROCEDURE
The distortion produced by stratification will be a function of the shape of the unstratified test score distributions. In general, different population groups will have different unstratified test score distributions. For this reason, stratified norming on different educational, sex, or racial groups may produce results that "show" norming bias, even if there is none.

We believe there is only one circumstance in which stratification for norming may be acceptable: where there is no reference test for direct equating. For example, in the ASVAB, the AFQT parts can be equated directly to an AFQT reference test. For the ASVAB composites and subtests this is not the case because many of them have no direct counterparts in the reference. In this case, stratification of the sample on the AFQT score and norming by cumulative frequencies may be acceptable. It should be recognized, however, that the procedure may be biased, as indicated in figure 12.
CHAPTER VII

RECOMMENDED NORMALIZATION OF ASVAB 6/7/6E/7E

ASVAB AFQT CONVERSION TABLE

In chapter VI we showed that the unstratified equating procedure is the preferred methodology for our data sample. We also showed that there will be a very small bias of 0.5 to 2.3 percentile points in the resulting norm curve below the 16th\(^1\) percentile (see figure 9). A correction is applied for this bias and the resulting normalization curve is smoothed, as detailed in appendix L. The final smoothed set of conversion tables for ASVAB 6/7/6E/7E AFQT scores is shown in table 4.

ASVAB COMPOSITES CONVERSION TABLES

The ASVAB AFQT score is used as an overall measure of general trainability. However, to select individuals for specific military job assignments the services frequently use specific aptitude composites derived from the ASVAB. These composites are defined in appendix K and cover electrical, clerical, mechanical, and other specialties.

In order to maintain continuity of classification prerequisites these composites are normalized so that their score scale is compatible with the AFQT score scale. We accomplish this by equating each composite score (in raw score form) to the ASVAB AFQT score using unstratified equipercentile equating. This approach is possible because the composites are strongly correlated to the ASVAB AFQT score.\(^2\) Additional details and the composite conversion tables are given in appendix M.

ASVAB SUBTESTS CONVERSION TABLES

The Navy alone uses information from ASVAB subtests expressed in standard score form. The subtests are expressed in standard score form by first stratifying the sample on the ASVAB AFQT

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\(^1\)Because no service allows enlistments below the 16th percentile this bias has little practical significance.

\(^2\)Alternately we could have stratified the sample on either the reference test or the ASVAB AFQT and formed cumulative frequencies of composite scores from which composite conversion tables could be constructed. We did not use this procedure due to concern about bias from stratification.
TABLE 4
RECOMMENDED CONVERSION TABLE\textsuperscript{a} FOR
ASVAB 6/7/6E/7E AFQT SCORE

<table>
<thead>
<tr>
<th>Raw score</th>
<th>Percentile score</th>
<th>Raw score</th>
<th>Percentile score</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>99</td>
<td>35</td>
<td>22</td>
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<tr>
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</table>

\textsuperscript{a}For form 7E only, two raw score points are to be added to the AFQT raw score before using this table to convert raw score to percentile score.
score and computing the mean values and standard deviations of raw scores on each subtest in the ASVAB. Details of the stratification are given in appendix N. The subtest standard score conversions are then computed from the following equation:

$$\text{Standard score} = 50 + \frac{10(X_i - \bar{X})}{\sigma_x}$$

where:

- $X_i$ = the $i$th raw score of subtest $X$
- $\bar{X}$ = the mean raw score of subtest $X$
- $\sigma_x$ = the standard deviation of raw scores on subtest $X$.

Resulting conversion tables are given in appendix O. Correlations and sample statistics from the stratified sample are given in appendix P.

VALIDITY OF RESULTS

We compared the norming results tabulated in table 4 with results from the DoD analysis (reference 8). The comparison is shown in figure 14. The agreement is excellent except in the upper percentiles. There the DoD results are from the stratified normalization method and differ in the expected direction. In chapter VI we showed that this method generally leads to norms that are too easy in the upper percentiles. In spite of this shortcoming in the DoD study, the generally excellent agreement of these two independent studies argues strongly for the correctness of the results.

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1 In this case there is no viable alternative to stratification because no highly correlated reference subtests exist for equipercentile equating.

2 The DoD results were obtained using a stratified technique in the upper percentiles and unstratified equating in the lower percentiles.
FIG. 14: COMPARISON OF CNA AND DOD NORMING RESULTS FOR
ASVAB 6/7/6E/7E
Recall that preliminary results from our analysis (reference 5) were made available in May 1979. These results were based on the stratification methodology. We compared our preliminary and final results (figure 15). The differences are not great in the critical percentiles where enlistment decisions are made. At the 31st percentile, which is the breakpoint between mental categories IIIB and IV, the two results are identical. This agreement means that our preliminary estimates of the percentage of recruits in mental category IV were valid.

We compared the final results of this analysis with those from a 1978 CNA analysis (reference 2) and the current operational norms (figure 16). We see that in the critical percentiles (16th through 31st) the 1978 CNA study is closer to the correct norms (as represented by this analysis) than are the current operational norms. Nonetheless, the overall agreement of the 1978 CNA results with our current analysis is not good.

The 1978 CNA analysis was based on the best data available at the time. However, the data was a "sample of convenience" collected for other purposes by non-CNA personnel in 1970, 1974, and 1976. In addition, these data were analyzed using the stratification procedure, which we have shown is inappropriate. In contrast, the data for the current CNA analysis was collected under our supervision specifically for normalization purposes and utilized a sampling plan we designed. It was then analyzed using appropriate methodology. However, the most definitive test of correctness is reproducibility. No analysis has ever reproduced the results of the 1978 CNA analysis—in contrast, the results of the current CNA analysis have been closely reproduced by the independent DoD analysis. For these reasons we believe the results of the current CNA analysis are preferable to the 1978 CNA analysis.

DISCUSSION OF RESULTS

A comparison of our final results for the ASVAB 6/7 AFQT with the current operational norms shows that the current operational norms are 15 to 17 percentile points too easy in the critical region between the 16th and 31st percentiles (figure 17). For example, according to the current operational norms, an ASVAB 6/7 AFQT raw score of 31 should convert to the 31st percentile. Our result indicates that a raw score of 31 really corresponds to the 16th percentile—a difference of 15 percentile points. This is the area where the services have established enlistment minimums. The current norms also appear to be about 4 percentile points too easy near the 90th percentile, but this difference is not critical because no enlistment decisions are made near the 90th percentile.
FIG. 15: COMPARISON OF PRELIMINARY AND FINAL RESULTS FROM THIS ANALYSIS
FIG. 16: COMPARISON OF RESULTS FROM THIS ANALYSIS AND AN EARLIER CNA STUDY
FIG. 17: COMPARISON OF CNA NORMS AND CURRENT OPERATIONAL NORMS FOR ASVAB 6/7/6E/7E AFQT
Because ASVAB aptitude composites\textsuperscript{1} are normed to be compatible with the AFQT score scale it is not surprising that current norms for these composites are also inaccurate. Figure 18 compares the current operational norms for one of these composites (Army GT aptitude composite) with our results (see appendix M). The current operational norms lead to an aptitude composite score as much as 10 standard score points higher than would be warranted under our results.

Decades of research by the armed services have shown the AFQT score to be a good measure of general trainability. The AFQT score is frequently grouped into broad categories, called mental groups, ranging from I (highest) to V (lowest). Mental group IV is the lowest currently acceptable category. Table 5 shows the minimum percentile score that defines each mental group and the corresponding AFQT raw score from the current operational norms (reference 8). For example, the breakpoint between mental group III\textit{C} and IVA is the 31st percentile. This percentile corresponds to an AFQT raw score of 31 by the current norms, but a 39 on either the CNA or DoD norms.

\begin{table}[h]
\centering
\caption{MENTAL GROUP DEFINITIONS BY CURRENT AND PROPOSED NORMS}
\begin{tabular}{ |c|c|c|c|c| }
\hline
Mental group & Minimum AFQT percentile score in mental group & Minimum ASVAB AFQT raw score in mental group & Current operational & CNA & DoD \\
\hline
I & 93 & 64 & 67 & 65 \\
II & 65 & 52 & 52 & 52 \\
III A & 50 & 42 & 46 & 46 \\
III B & 31 & 31 & 39 & 39 \\
IV A & 21 & 28 & 34 & 34 \\
IV B & 16 & 26 & 31 & 30 \\
IV C & 10 & 23 & 25 & 24 \\
\hline
\end{tabular}
\end{table}

\textsuperscript{1}These composites (defined in appendix A) are used mainly to assign recruits to suitable military jobs.
FIG. 18: COMPARISON OF OUR RESULTS AND CURRENT OPERATIONAL NORMS FOR THE ARMY GT APTITUDE COMPOSITE
If the CNA norms are correct, then a large number of recruits currently classified in category IIIB are really in category IV. Applying the CNA (or DoD) norms to distributions of AFQT raw scores from FY 1977, FY 1978, and FY 1979\(^1\) we find that between 25 and 30 percent of accessions in these years are really in category IV rather than the 5 or 6 percent officially reported.

A historical perspective on the percentage of male DoD accessions in mental category IV is shown in figure 19. The solid line represents officially reported percentages. The dots indicate what these percentages would have been during FY 1977, 1978, and 1979 if the norms from this analysis (or the DoD analysis) had been used. Assuming our norms are correct, the 25 to 30 percent figures for mental category IV are higher than those observed during the early 1960s, similar to those during the Vietnam War, and lower than those during the Korean War.

A correctly normalized test is important to managers as well as unit commanders and military trainers. The principal virtue of maintaining a correctly normalized test is that a certain score on a current version of the accession test reflects the same ability to absorb training as that same score did on previous versions of the test. As a result, managers can make informed judgments about changes over time in the aptitude of recruits. By the continued use of correctly normalized tests, a rational basis, founded on years of service experience in peace and in war, can be formed for both enlistment and job classification standards.

\(^1\)Supplied by the Department of Defense.
FIG. 19: COMPARISON OF PERCENTAGE OF MALE DOD ACCESSIONS IN MENTAL GROUP IV AS OFFICIALLY REPORTED AND BY THIS ANALYSIS
REFERENCES


2. Center for Naval Analyses, Study 1115, "An Analysis of the Normalization and Verification of the Armed Services Vocational Aptitude Battery (ASVAB) Forms 6 and 7," by William H. Sims, Unclassified, Apr 1978


4. Office of the Assistant Secretary of Defense, letter of 24 Jan 1979

5. Center for Naval Analyses, Memorandum (CNA)79-3059, "A Reexamination of the Normalization of the Armed Services Vocational Aptitude Battery (ASVAB) Forms 6A, 7B, 6E and 7E," by William H. Sims and Ann Truss, Unclassified, 30 May 1979. (This document was originally issued as a working paper.)


APPENDIX A

DEFINITIONS OF ASVAB TESTS AND COMPOSITES
APPENDIX A

DEFINITIONS OF ASVAB TESTS AND COMPOSITES

This appendix defines the ASVAB tests and composites used in the analysis of normalization. The information is presented in tabular form.
<table>
<thead>
<tr>
<th>Test Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>GI</td>
<td>General Information</td>
</tr>
<tr>
<td>NO</td>
<td>Numerical Operations</td>
</tr>
<tr>
<td>AD</td>
<td>Attention to Detail</td>
</tr>
<tr>
<td>WK</td>
<td>Word Knowledge</td>
</tr>
<tr>
<td>AR</td>
<td>Arithmetic Reasoning</td>
</tr>
<tr>
<td>SP</td>
<td>Space Perception</td>
</tr>
<tr>
<td>MK</td>
<td>Mathematics Knowledge</td>
</tr>
<tr>
<td>EI</td>
<td>Electronics Information</td>
</tr>
<tr>
<td>MC</td>
<td>Mechanical Comprehension</td>
</tr>
<tr>
<td>GS&lt;sup&gt;a&lt;/sup&gt;</td>
<td>General Science</td>
</tr>
<tr>
<td>SI</td>
<td>Shop Information</td>
</tr>
<tr>
<td>AI</td>
<td>Automotive Information</td>
</tr>
<tr>
<td>CC</td>
<td>Combat Scale</td>
</tr>
<tr>
<td>CA</td>
<td>Attentiveness Scale</td>
</tr>
<tr>
<td>CE</td>
<td>Electronics Scale</td>
</tr>
<tr>
<td>CM</td>
<td>Maintenance Scale</td>
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</tbody>
</table>

<sup>a</sup>Note that the full-length GS test, rather than the short General Science Biological (GSB) test, is used throughout this report.
### TABLE A-2

**MARINE CORPS AND ARMY ASVAB 6/7 COMPOSITES**

<table>
<thead>
<tr>
<th>Test composite symbol</th>
<th>Definition</th>
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<tr>
<td>FA</td>
<td>Field Artillery</td>
</tr>
<tr>
<td>OF</td>
<td>Operators and Food Handlers</td>
</tr>
<tr>
<td>MM</td>
<td>Mechanical Maintenance</td>
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<tr>
<td>GM</td>
<td>General Maintenance</td>
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<tr>
<td>CL</td>
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<td>EL</td>
<td>Electronics</td>
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<tr>
<td>SC</td>
<td>Surveillance and Communications</td>
</tr>
<tr>
<td>ST</td>
<td>Skilled Technical</td>
</tr>
<tr>
<td>GCT&lt;sup&gt;a&lt;/sup&gt;</td>
<td>General Classification Test</td>
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</tbody>
</table>

<sup>a</sup>This composite, if defined in percentile form, is referred to as the AFQT (Armed Forces Qualification Test).
**TABLE A-3**

FORMULAS FOR COMPUTING MARINE CORPS AND ARMY ASVAB 6/7 COMPOSITES

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<thead>
<tr>
<th>Formula</th>
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<td>AR + SI + SP + AD + CC</td>
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<td>FA</td>
<td>AR + GI + MK + EI + CA</td>
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<tr>
<td>MM</td>
<td>MK + SI + EI + AI + CM</td>
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<tr>
<td>GM</td>
<td>AR + GS + MC + AI</td>
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<td>GT</td>
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</tr>
<tr>
<td>EL&lt;sup&gt;a&lt;/sup&gt;</td>
<td>AR + GS + MK + EI</td>
</tr>
<tr>
<td>EL&lt;sup&gt;b&lt;/sup&gt;</td>
<td>AR + EI + MC + SI + CE</td>
</tr>
<tr>
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<td>AR + WK + MC + SP</td>
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<tr>
<td>ST</td>
<td>AR + MK + GS</td>
</tr>
<tr>
<td>OF</td>
<td>GI + AI + CA</td>
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<tr>
<td>GCT&lt;sup&gt;c&lt;/sup&gt;</td>
<td>AR + WK + SP</td>
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</tbody>
</table>

<sup>a</sup>Marine Corps only.
<sup>b</sup>Army only.
<sup>c</sup>Also called the AFQT.
<table>
<thead>
<tr>
<th>TABLE A-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORMULAS FOR COMPUTING NAVY AND AIR FORCE ASVAB 6/7 COMPOSITES</td>
</tr>
</tbody>
</table>

**Navy**

\[
\begin{align*}
G &= WK + AR \\
M^a &= WK + MC + SI \\
E &= AR + MK + EI + GS \\
C &= NO + AD + WK
\end{align*}
\]

**Air Force**

\[
\begin{align*}
M &= MC + SI + AI \\
A &= NO + AD + WK \\
G &= WK + AR \\
E &= AR + SP + EI
\end{align*}
\]

\text{aNote that this formula is incorrectly stated in the following commonly used reference: Department of Defense, DoD 1301.12M, "Directions for Scoring the Armed Services Vocational Aptitude Battery Forms 6 and 7," Unclassified, January 1976.}
APPENDIX B

EXPERIMENTAL DESIGN
APPENDIX B

EXPERIMENTAL DESIGN

The data sample on which we based our analysis consisted of 3,295 Marine Corps recruits. These recruits were given a series of aptitude tests within a few days after they arrived at the two Marine Corps Recruit Depots. Each recruit was given three tests: ASVAB 6 or 7, ASVAB 6E or 7E (AFQT part only), and AFQT 7A (a reference test). The recruits were tested in platoon-size groups of about 60 men. All recruits in a platoon were tested on the same tests in the same order. But not all platoons took the same tests in the same order. That is, the order in which the tests were given was counterbalanced so that each test was given first to a platoon as often as it was given second or third. The order of testing is shown in table B-1.1

Tests were administered by Marine Corps testing personnel. One of the authors of this report monitored the initial testing session at each recruit depot.

Because ASVAB 6 and 7 are routinely administered to all recruits who enter the recruit depots, the answer sheets for these tests were graded by Marine Corps personnel. Scores were then made available to use for analysis. Answer sheets for the ASVAB 6E/7E and AFQT 7A were optically scanned by the Marine Corps Institute, which produced on punched cards output with each response (A, B, C, or D) to each test item recorded. The responses for each item were compared with the correct answer by a computer program at the Center for Naval Analyses and the number of correct responses was recorded. In the case of the ASVAB 6/7/6E/7E tests, the number of correct responses (raw score) was the variable of interest for further analysis. For the AFQT 7A reference test, the number of correct answers was converted into a percentile score using the official AFQT 7/8 conversion shown in table B-2.

1 Note that during the data collection phase of the experiment, ASVAB 6E and 7E were called "R" and "S", respectively.
### TABLE B-1
**ORDER OF TESTING**

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<th>Ordered group</th>
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<th>Series</th>
<th>Test</th>
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<th>Test</th>
<th>Hour&lt;sup&gt;a&lt;/sup&gt;/Date</th>
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<sup>a</sup>Hour test started (for example, 0800/30 Jan)
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<th>Raw score</th>
<th>Percentile score</th>
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</table>

*Raw score is the number right minus one-third the number wrong. Omitted items are not counted as wrong.*
APPENDIX C
SAMPLE STATISTICS
APPENDIX C

SAMPLE STATISTICS

This appendix presents various statistics for the sample and sub-samples used. The information is presented in tabular form.
<table>
<thead>
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<th>Item</th>
<th>AFEES</th>
<th>Depot</th>
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<td>AFQT</td>
<td></td>
<td>41.6</td>
</tr>
</tbody>
</table>

Percentage minority: 27.7
Percentage male: 100.0
Percentage high school graduates: 53.1
Percentage Parris Island/San Diego: 50.0/50.0
Reference test (AFQT 7A) percentile score: 44.4
### TABLE C-2

SUBSAMPLE STATISTICS (unweighted)

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean values</th>
<th>Sample 1</th>
<th>Sample 2</th>
<th>Sample 3</th>
<th>Sample 4</th>
<th>Sample 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AFEES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASVAB 6/7 AFQT\textsuperscript{a}</td>
<td>45.5</td>
<td>45.5</td>
<td>45.5</td>
<td>--\textsuperscript{b}</td>
<td>45.4</td>
<td></td>
</tr>
<tr>
<td>ASVAB 6/7 Pseudo AFQT\textsuperscript{a}</td>
<td>43.8</td>
<td>43.9</td>
<td>43.8</td>
<td>--\textsuperscript{b}</td>
<td>43.9</td>
<td></td>
</tr>
<tr>
<td><strong>Depot</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASVAB 6/7 AFQT\textsuperscript{a}</td>
<td>44.6</td>
<td>44.6</td>
<td>44.6</td>
<td>44.8</td>
<td>44.1</td>
<td></td>
</tr>
<tr>
<td>ASVAB 6/7 Pseudo AFQT\textsuperscript{a}</td>
<td>43.4</td>
<td>43.4</td>
<td>43.3</td>
<td>45.0</td>
<td>43.0</td>
<td></td>
</tr>
<tr>
<td>ASVAB 6E AFQT\textsuperscript{a}</td>
<td>42.7</td>
<td>--</td>
<td>43.9</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASVAB 7E AFQT\textsuperscript{a}</td>
<td>42.7</td>
<td>--</td>
<td>41.6</td>
<td>43.7</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>AFQT 7A\textsuperscript{a}</td>
<td>44.4</td>
<td>43.8</td>
<td>44.9</td>
<td>46.6</td>
<td>45.0</td>
<td></td>
</tr>
</tbody>
</table>

Sample size: 3,295 1,634 1,660 227 2,208

\textsuperscript{a}All test scores are expressed in raw score form except the AFQT 7A, which is in percentiles.

\textsuperscript{b}This subsample took ASVAB 5 as an enlistment test when in high school.
APPENDIX D

STRATIFIED NORMALIZATION ANALYSIS
APPENDIX D

STRATIFIED NORMALIZATION ANALYSIS

Each of the data subsamples was stratified on the reference test, AFQT 7A, to simulate the traditional reference population. We stratified by weighting the individual recruits so that their AFQT 7A percentile score distribution was flat. The calculations of the weight factors for samples 1 through 5 are shown in tables D-1 through D-5.

By applying the weight factors to recruits depending on their AFQT 7A scores, we calculated weighted cumulative frequency distributions of the AFQT raw score of the test to be normalized (table D-6). These weighted cumulative distributions, when smoothed, become the unadjusted conversion tables between ASVAB AFQT raw scores and percentile scores shown in the main text; i.e., the normalization of the new test.
### Table D-1

**Calculations of Weight Factors for Sample 1**

<table>
<thead>
<tr>
<th>AFQT 7A percentile interval</th>
<th>Number observed in sample</th>
<th>Number expected in mobilization population</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>1-5</td>
<td>44</td>
<td>164.75</td>
<td>3.744</td>
</tr>
<tr>
<td>6-10</td>
<td>85</td>
<td>164.75</td>
<td>1.938</td>
</tr>
<tr>
<td>11-15</td>
<td>228</td>
<td>164.75</td>
<td>0.723</td>
</tr>
<tr>
<td>16-20</td>
<td>282</td>
<td>164.75</td>
<td>0.584</td>
</tr>
<tr>
<td>21-25</td>
<td>252</td>
<td>164.75</td>
<td>0.654</td>
</tr>
<tr>
<td>26-30</td>
<td>206</td>
<td>164.75</td>
<td>0.664</td>
</tr>
<tr>
<td>31-35</td>
<td>248</td>
<td>164.75</td>
<td>0.646</td>
</tr>
<tr>
<td>36-40</td>
<td>255</td>
<td>164.75</td>
<td>1.484</td>
</tr>
<tr>
<td>41-45</td>
<td>111</td>
<td>164.75</td>
<td>0.644</td>
</tr>
<tr>
<td>46-50</td>
<td>256</td>
<td>164.75</td>
<td>0.816</td>
</tr>
<tr>
<td>51-55</td>
<td>202</td>
<td>164.75</td>
<td>0.659</td>
</tr>
<tr>
<td>56-60</td>
<td>250</td>
<td>164.75</td>
<td>0.664</td>
</tr>
<tr>
<td>61-65</td>
<td>248</td>
<td>164.75</td>
<td>2.168</td>
</tr>
<tr>
<td>66-70</td>
<td>76</td>
<td>164.75</td>
<td>1.433</td>
</tr>
<tr>
<td>71-75</td>
<td>115</td>
<td>164.75</td>
<td>1.091</td>
</tr>
<tr>
<td>76-80</td>
<td>151</td>
<td>164.75</td>
<td>1.128</td>
</tr>
<tr>
<td>81-85</td>
<td>146</td>
<td>164.75</td>
<td>1.916</td>
</tr>
<tr>
<td>86-90</td>
<td>86</td>
<td>164.75</td>
<td>3.744</td>
</tr>
<tr>
<td>91-95</td>
<td>44</td>
<td>164.75</td>
<td>16.473</td>
</tr>
<tr>
<td>96-100</td>
<td>10</td>
<td>164.75</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Column (3) divided by column (2).
### TABLE D-2

**CALCULATION OF WEIGHT FACTORS FOR SAMPLE 2**

<table>
<thead>
<tr>
<th>AFQT 'A percentile interval</th>
<th>Number observed in sample</th>
<th>Number expected in mobilization population</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>1-5</td>
<td>23</td>
<td>81.7</td>
<td>3.552</td>
</tr>
<tr>
<td>6-10</td>
<td>51</td>
<td>81.7</td>
<td>1.602</td>
</tr>
<tr>
<td>11-15</td>
<td>106</td>
<td>81.7</td>
<td>0.771</td>
</tr>
<tr>
<td>16-20</td>
<td>149</td>
<td>81.7</td>
<td>0.548</td>
</tr>
<tr>
<td>21-25</td>
<td>129</td>
<td>81.7</td>
<td>0.633</td>
</tr>
<tr>
<td>26-30</td>
<td>92</td>
<td>81.7</td>
<td>0.888</td>
</tr>
<tr>
<td>31-35</td>
<td>130</td>
<td>81.7</td>
<td>0.628</td>
</tr>
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<td>36-40</td>
<td>120</td>
<td>81.7</td>
<td>0.681</td>
</tr>
<tr>
<td>41-45</td>
<td>52</td>
<td>81.7</td>
<td>1.571</td>
</tr>
<tr>
<td>46-50</td>
<td>125</td>
<td>81.7</td>
<td>0.654</td>
</tr>
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<td>51-55</td>
<td>116</td>
<td>81.7</td>
<td>0.704</td>
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<tr>
<td>56-60</td>
<td>114</td>
<td>81.7</td>
<td>0.717</td>
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<tr>
<td>61-65</td>
<td>128</td>
<td>81.7</td>
<td>0.638</td>
</tr>
<tr>
<td>66-70</td>
<td>37</td>
<td>81.7</td>
<td>2.208</td>
</tr>
<tr>
<td>71-75</td>
<td>66</td>
<td>81.7</td>
<td>1.258</td>
</tr>
<tr>
<td>76-80</td>
<td>62</td>
<td>81.7</td>
<td>1.318</td>
</tr>
<tr>
<td>81-85</td>
<td>77</td>
<td>81.7</td>
<td>1.061</td>
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<td>81.7</td>
<td>2.476</td>
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<tr>
<td>91-95</td>
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<td>4.300</td>
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<td>96-100</td>
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<td>16.340</td>
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<td>Total</td>
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<td>1,634</td>
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</tr>
</tbody>
</table>

<sup>a</sup>Column (3) divided by column (2).
**TABLE D-3**

**CALCULATION OF WEIGHT FACTORS FOR SAMPLE 3**

<table>
<thead>
<tr>
<th>AFQT 7A percentile interval</th>
<th>Number observed in sample</th>
<th>Number expected in mobilization population</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>21</td>
<td>83.0</td>
<td>3.952</td>
</tr>
<tr>
<td>6-10</td>
<td>34</td>
<td>83.0</td>
<td>2.441</td>
</tr>
<tr>
<td>11-15</td>
<td>122</td>
<td>83.0</td>
<td>0.680</td>
</tr>
<tr>
<td>16-20</td>
<td>153</td>
<td>83.0</td>
<td>0.624</td>
</tr>
<tr>
<td>21-25</td>
<td>123</td>
<td>83.0</td>
<td>0.675</td>
</tr>
<tr>
<td>26-30</td>
<td>114</td>
<td>83.0</td>
<td>0.728</td>
</tr>
<tr>
<td>31-35</td>
<td>118</td>
<td>83.0</td>
<td>0.703</td>
</tr>
<tr>
<td>36-40</td>
<td>155</td>
<td>83.0</td>
<td>0.615</td>
</tr>
<tr>
<td>41-45</td>
<td>59</td>
<td>83.0</td>
<td>1.407</td>
</tr>
<tr>
<td>46-50</td>
<td>131</td>
<td>83.0</td>
<td>0.634</td>
</tr>
<tr>
<td>51-55</td>
<td>85</td>
<td>83.0</td>
<td>0.976</td>
</tr>
<tr>
<td>56-60</td>
<td>136</td>
<td>83.0</td>
<td>0.610</td>
</tr>
<tr>
<td>61-65</td>
<td>120</td>
<td>83.0</td>
<td>0.692</td>
</tr>
<tr>
<td>66-70</td>
<td>39</td>
<td>83.0</td>
<td>2.128</td>
</tr>
<tr>
<td>71-75</td>
<td>49</td>
<td>83.0</td>
<td>1.694</td>
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<td>83.0</td>
<td>1.203</td>
</tr>
<tr>
<td>86-90</td>
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<td>83.0</td>
<td>1.566</td>
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<tr>
<td>91-95</td>
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<td>83.0</td>
<td>3.320</td>
</tr>
<tr>
<td>96-100</td>
<td>5</td>
<td>83.0</td>
<td>16.600</td>
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<td>1,660</td>
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</tr>
</tbody>
</table>

<sup>a</sup>Column (3) divided by column (2).
### Table D-4

**Calculation of Weight Factors for Sample 4**

<table>
<thead>
<tr>
<th>AFQT 7A percentile interval</th>
<th>Number observed in sample</th>
<th>Number expected in mobilization population</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>8</td>
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<td>11-20</td>
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<td>41-50</td>
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<td>22.7</td>
<td>0.597</td>
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<td>51-60</td>
<td>23</td>
<td>22.7</td>
<td>0.987</td>
</tr>
<tr>
<td>61-70</td>
<td>25</td>
<td>22.7</td>
<td>0.908</td>
</tr>
<tr>
<td>71-80</td>
<td>18</td>
<td>22.7</td>
<td>1.261</td>
</tr>
<tr>
<td>81-90</td>
<td>21</td>
<td>22.7</td>
<td>1.081</td>
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<td>91-100</td>
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<td>7.567</td>
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<td>Total</td>
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<td>227</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Column (3) divided by column (2).

### Table E-5

**Calculation of Weight Factors for Sample 5**

<table>
<thead>
<tr>
<th>AFQT 7A percentile interval</th>
<th>Number observed in sample</th>
<th>Number expected in mobilization population</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>29</td>
<td>110.4</td>
<td>1.807</td>
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<tr>
<td>6-10</td>
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</tr>
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<td>152</td>
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<td>169</td>
<td>110.4</td>
<td>0.655</td>
</tr>
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<td>21-25</td>
<td>171</td>
<td>110.4</td>
<td>0.646</td>
</tr>
<tr>
<td>26-30</td>
<td>157</td>
<td>110.4</td>
<td>0.806</td>
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<tr>
<td>31-35</td>
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</tr>
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<td>110.4</td>
<td>0.800</td>
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</tr>
<tr>
<td>71-75</td>
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<td>110.4</td>
<td>1.314</td>
</tr>
<tr>
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<td>110.4</td>
<td>1.032</td>
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<td>110.4</td>
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<td>110.4</td>
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<td>110.4</td>
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<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Column (3) divided by column (2).
## TABLE D-6

**STRATIFIED CUMULATIVE FREQUENCY DISTRIBUTION OF RAW ASVAB AFQT SCORES**

<table>
<thead>
<tr>
<th>Raw AFQT score</th>
<th>Cumulative frequency</th>
<th>Sample 1, form 6/7</th>
<th>Sample 2, form 6E</th>
<th>Sample 3, form 7E</th>
<th>Sample 4, form 6/7</th>
<th>Sample 5, form 6/7</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 15</td>
<td>0.4</td>
<td>0.4</td>
<td>1.5</td>
<td>0.0</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>16 - 17</td>
<td>0.7</td>
<td>0.6</td>
<td>2.9</td>
<td>0.0</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
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<td>1.2</td>
<td>3.6</td>
<td>0.4</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1.7</td>
<td>1.5</td>
<td>4.6</td>
<td>1.7</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>2.2</td>
<td>2.1</td>
<td>4.9</td>
<td>1.7</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
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<td>3.0</td>
<td>5.6</td>
<td>4.6</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>3.2</td>
<td>4.1</td>
<td>7.1</td>
<td>4.6</td>
<td>3.4</td>
<td></td>
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<td>8.2</td>
<td>5.4</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>4.7</td>
<td>5.9</td>
<td>9.6</td>
<td>6.2</td>
<td>5.2</td>
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<td>8.2</td>
<td>11.8</td>
<td>7.3</td>
<td>6.9</td>
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<tr>
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<td>9.2</td>
<td>13.1</td>
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<td>10.8</td>
<td>15.2</td>
<td>9.1</td>
<td>9.2</td>
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D-6
APPENDIX E

UNSTRATIFIED GRAPHICAL EQUATING
APPENDIX E

UNSTRATIFIED GRAPHICAL EQUATING

In this appendix we describe the direct equating of scores on the AFQT part of ASVAB 6/7, ASVAB 6E, and ASVAB 7E to the percentile score of the reference test (AFQT 7A). The data of samples 2, 3, and 5 are used as is; i.e., the samples were not stratified on a reference test.

The procedure is illustrated in figure E-1. Cumulative percentages of the ASVAB 6E AFQT raw score and the reference test percentile score were graphed as shown. Scores on the two tests are considered to be equivalent if they are obtained by the same cumulative percentage of the sample. For example, a raw score of 30 on the ASVAB 6E AFQT was made by a cumulative 11 percent of the sample. A cumulative 11 percent of the sample also achieved the 15th percentile score on the reference test. By the definition of equivalent scores we equate a raw score of 30 on the ASVAB 6E AFQT to the 15th percentile. We used this procedure throughout the score range. (See table E-1 for results.)

In much the same way we equated ASVAB 7E AFQT and ASVAB 6/7 AFQT, as shown in figures E-2 and E-3. The results of these equations are also tabulated in table E-1.

A comparison of the results of the unstratified graphical equating with those from the stratified equating (appendix D) are shown for each form of ASVAB AFQT in figures E-4, E-5, and E-6. In general, the stratified procedure results in harder norms in the low percentiles and easier norms in the upper percentiles.
FIG. E-1: UNSTRATIFIED GRAPHICAL EQUATING FOR ASVAB 6E AFQT
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**SUMMARY OF UNSTRATIFIED GRAPHICAL EQUATING RESULTS**

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**Notes:**

- Before converting to percentiles, two points are added to the raw ASVAB score.
- Before converting to percentiles, three points are added to the raw ASVAB score.
FIG. E-2: UNSTRATIFIED GRAPHICAL EQUATING FOR ASVAB 7E AFQT
FIG. E-3: UNSTRATIFIED GRAPHICAL EQUATING FOR ASVAB 6/7 AFQT
FIG. E-4: COMPARISON OF STRATIFIED AND UNSTRATIFIED NORMS FOR ASVAB 6E AFQT
FIG. E-5: COMPARISON OF STRATIFIED AND UNSTRATIFIED NORMS FOR ASVAB 7E AFQT
FIG. E-6: COMPARISON OF STRATIFIED AND UNSTRATIFIED NORMS FOR ASVAB 6/7 AFQT
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</tr>
</tbody>
</table>

**UNCLASSIFIED**

CNS-1152
APPENDIX F

EFFECTS OF COACHING ON NORMALIZATION
APPENDIX F
EFFECTS OF COACHING ON NORMALIZATION

If recruits in the samples were coached on any of the tests used in the normalization analysis, the normalization will be biased. The effect of coaching is illustrated in figure F-1. If recruits are coached on the new test, then their raw score on the new test would be artificially high, and the curve in figure F-1 would shift to the right (in the direction of harder norms). If recruits were coached on the reference test, then they would score unexpectedly high on the reference test for a given raw score on the next test. In this case the normalization curve would shift to the left in the direction of easier norms. This appendix examines the effect of coaching on the normalization results of our analysis.

Recruits were more likely to be coached on ASVAB 6/7 than on other tests used in this analysis. The reference test as well as ASVAB 6E/7E were not being used when we collected data; hence there would be no motivation to coach the recruits on these test forms.

Comparing scattergrams of AFQT scores from ASVAB with scores on the reference test gives some perspective on effects of coaching. Figures F-2 and F-3 show these scattergrams for ASVAB 6E/7E. These figures show the relationship expected when recruits are not coached. Figure F-4 shows a similar plot for ASVAB 6/7 sample from
FIG. F-2: SCATTERGRAM OF ASVAB 6E AFQT SCORES VERSUS REFERENCE TEST SCORES
FIG. F-3: SCATTERGRAM OF ASVAB 7E AFQT SCORES VERSUS REFERENCE TEST SCORES

P-3
FIG. F-4: SCATTERGRAM OF ASVAB 6/7 AFQT SCORES FROM AFEES TESTING VERSUS REFERENCE TEST SCORES
AFEES testing when coaching on ASVAB might be expected. This figure shows some indication of an excess number of cases in the upper left corner, which may indicate some coaching on ASVAB 6/7.

A similar plot for ASVAB 6/7 scores from recruit depot testing is shown in figure F-5. (This is the data from which the normalization of ASVAB 6/7 is deduced.) In figure F-5, there also seems to be an excess of cases in the upper left corner, again indicating that some recruits in this sample may have been coached. Although the effect of coaching does not appear to be large, this appendix examines it in some detail.

In order to examine the coaching effect, we use an internal consistency check developed (reference F-1) for detecting coaching on ASVAB. Enlistment in the Marine Corps is determined only by performance on subtests that make up the AFQT part of ASVAB; hence, we expect coaching will focus on this part. Reference F-1 shows that scores on the AFQT part of ASVAB can be predicted with reasonable accuracy from the non-AF(yr parts of ASVAB. Comparing scores on the AFQT part (on which coaching may have occurred) with predicted AFQT scores (from a part of the ASVAB on which coaching is unlikely) provides some measure of the amount of coaching that occurs. The predicted AFQT is calculated from an equation taken from reference F-1:

$$\text{Predicted AFQT} = 10.15 + 0.816 \times (GI+GS+MC+MK).$$

The difference in AFQT and predicted AFQT is calculated as

$$\Delta = AFQT - \text{predicted AFQT}.$$

An illustration of the expected distribution of $\Delta$ is shown in figure F-6. In a sample containing recruits who have not been coached, the distribution is expected to be symmetric about zero. If recruits are coached on the AFQT part of ASVAB but not on the parts from which the predicted AFQT is calculated, then the values of $\Delta$ tend to be positive. The positive excess can be estimated by folding the $\Delta$ distribution about zero and subtracting the negative side from the positive side. We use the resulting excess positive group as an estimate of the cases of coaching.

The estimation technique just discussed was applied to ASVAB 6/7 scores from AFEES testing; results are given in table F-1. We estimated that 16.2 percent of the recruits were coached. We applied the same methodology to ASVAB 6/7 scores from testing at recruit depots. The results are given in table E-2 and indicate that 14.6 percent of the sample still retains effects of coaching.
FIG. F-5: SCATTERGRAM OF ASVAB 6/7 AFQT SCORES FROM RECRUIT DEPOT TESTING VERSUS REFERENCE TEST SCORES
when retested at recruit depots. This latter result is somewhat surprising because we anticipated that the recruits would not have retained the effects of coaching for the 1-to-6-month period that elapsed between testing at AFEES and at recruit depots.\footnote{Identical methodologies applied to larger samples of Marine Corps recruits enlisting during 1977 and 1978 have typically yielded estimates of a 3 percent coaching effect on tests taken at recruit depots. The sample used in this report was collected in February, March, and April 1979, and may be atypical in the sense that fewer of the recruits may have been in delayed entry programs; hence, only a short period of time may have elapsed between testing at AFEES and testing at recruit depots. If so, this could explain the unexpectedly high retention of coached material.}

Because it appears that some of the scores on the ASVAB 6/7 tests at recruit depots are inflated by coaching, we next address the issue of what effect this has on the normalization results. Because the coaching could only affect ASVAB 6/7 scores, we focused on the data in sample 5. In doing so we removed from sample 5 those recruits who were thought to have been coached. Then we recalculated the normalization of ASVAB 6/7. Comparing the normalization before and after removal of the suspect cases gives some indication of the effect of coaching on the norming results.

\[ \Delta (\text{AFEES AFQT-predicted AFEES AFQT}) \]

**FIG. F-6: ILLUSTRATION OF USE OF \( \Delta \) DISTRIBUTION TO ESTIMATE AMOUNT OF COACHING**
TABLE F-1
ESTIMATION OF AMOUNT OF COACHING IN AFEES TEST SCORES
FROM SAMPLE 5

<table>
<thead>
<tr>
<th>Δ interval</th>
<th>Positive half of Δ distribution</th>
<th>Negative half of Δ distribution</th>
<th>Excess positive</th>
</tr>
</thead>
<tbody>
<tr>
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<td>199</td>
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<td>124</td>
<td>-11</td>
</tr>
<tr>
<td>3</td>
<td>115</td>
<td>90</td>
<td>25</td>
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<tr>
<td>4</td>
<td>123</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>≥20</td>
<td>11</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

Total 1,333 975 358\(^a\)

\(^a\)Of 2,208 recruits, 358 were coached, which is 16.2 percent.

Referring to figure F-6 and to table F-1, we see that if we excluded from the sample those cases with a large Δ from AFEES testing, we can expect to have removed a significant percentage of the contamination due to coaching. Normalization would then be carried out using scores from recruit depot testing as always. Accordingly, we formed two subsamples from sample 5—one consisting of all cases with Δ from AFEES testing < 10, and the second with Δ from AFEES testing < 0.0. In the first case we estimated that we removed 100 percent of the coached cases along with 50 percent of the noncoached cases.
TABLE F-2

ESTIMATION OF AMOUNT OF COACHING IN DEPOT TEST SCORES
FROM SAMPLE 5

<table>
<thead>
<tr>
<th>Interval</th>
<th>Positive half of A distribution</th>
<th>Negative half of A distribution</th>
<th>Excess positive</th>
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<tbody>
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<td>20</td>
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<td>1</td>
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</tr>
<tr>
<td>≥20</td>
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<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Total 1,315 993 322

Of 2,208 recruits, 322 were coached, which is 14.6 percent.

Weight factors were calculated to stratify the subsamples on the reference test and thereby simulate the mobilization population. These calculations are shown in tables F-3 and F-4.

The weight factors from tables F-3 and F-4 were applied to the subsamples. The resulting stratified cumulative frequencies of ASVAB 6/7 scores are shown in table F-5. For the case of $\Delta < 10$
(40 percent of coached cases removed), the subsample agrees well with the full sample. In the case of $\Delta < 0$ (100 percent of coached cases removed), the agreement is not perfect but subjectively quite close. The distributions are plotted in figure F-7.

**TABLE F-3**

**CALCULATION OF WEIGHT FACTORS FOR $\Delta < 10$**

<table>
<thead>
<tr>
<th>Reference test percentile interval</th>
<th>Number observed in sample</th>
<th>Number expected in mobilization population</th>
<th>Weight factor$^a$</th>
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</thead>
<tbody>
<tr>
<td>1-5</td>
<td>22</td>
<td>98.5</td>
<td>4.48</td>
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<td>.79</td>
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<td>.71</td>
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<td>.64</td>
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<td>.66</td>
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</tr>
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<td>98.5</td>
<td>1.70</td>
</tr>
<tr>
<td>91-95</td>
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<td>3.40</td>
</tr>
<tr>
<td>96-100</td>
<td>9</td>
<td>98.5</td>
<td>10.94</td>
</tr>
</tbody>
</table>

1,970 1,970

$^a$Column (3) divided by column (2).

From table F-1 we see that restricting the sample to $\Delta < 10$ excludes 143 of the estimated 358 coached cases.
TABLE F-4

CALCULATION OF WEIGHT FACTORS FOR Δ < 0

<table>
<thead>
<tr>
<th>AFQT 7A percentile interval (1)</th>
<th>Number observed in sample (2)</th>
<th>Number expected in mobilization population (3)</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt; (4)</th>
</tr>
</thead>
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<tr>
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<td>6.59</td>
</tr>
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<td>.67</td>
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</tr>
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</tr>
</tbody>
</table>

<sup>a</sup>Column (3) divided by column (2).

A chi-squared test (reference F-2) for the homogeneity of the frequency distributions that make up table F-5 is shown in table F-6. The result of the test shows that the probability of observing differences this large by chance in parallel samples is quite large.

This analysis found that all forms of ASVAB can use the same conversion table. It has been argued that our results for forms 6/7 are biased by test compromise and that if this effect were removed then ASVAB 6/7 would have a markedly different norming.
<table>
<thead>
<tr>
<th>Raw score</th>
<th>All (2,208 cases)</th>
<th>( \Delta &lt; 10 ) (1,968 cases)</th>
<th>( \Delta &lt; 0 ) (924 cases)</th>
</tr>
</thead>
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<td>0.7</td>
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FIG. F-7: COMPARISON OF NORMALIZATION OF ASVAB 6/7 AFQT FROM FULL SAMPLE 5 AND FROM A SUBSAMPLE FROM WHICH RECRUITS SUSPECTED OF BEING COACHED ARE REMOVED
### TABLE F-6

**GROUPED DISTRIBUTIONS FOR HOMOGENEITY TEST**

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<thead>
<tr>
<th>ASVAB 6/7 AFQT interval (raw score) (1)</th>
<th>Number of cases</th>
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<th></th>
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<td></td>
<td>All (2)</td>
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<td>Δ&lt;0 (4)</td>
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<td>8</td>
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<td>20-22</td>
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<tr>
<td>26-28</td>
<td>60</td>
<td>52</td>
<td>14</td>
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<tr>
<td>29-31</td>
<td>114</td>
<td>104</td>
<td>71</td>
</tr>
<tr>
<td>32-34</td>
<td>144</td>
<td>126</td>
<td>55</td>
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<td>35-37</td>
<td>154</td>
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<td>38-40</td>
<td>182</td>
<td>171</td>
<td>81</td>
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<tr>
<td>41-43</td>
<td>177</td>
<td>158</td>
<td>73</td>
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<td>44-46</td>
<td>201</td>
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<td>100</td>
<td>45</td>
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<td>Total</td>
<td>2,206</td>
<td>1,968</td>
<td>924</td>
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</table>

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**Notes:**

- Chi-squared for a comparison of columns (2) and (3) is 2.8 for 17 degrees of freedom. The probability of differences this large by chance is about 1.00.
- Chi-squared for a comparison of columns (2) and (4) is 17.1 for 17 degrees of freedom. The probability of differences this large by chance is about 0.45.
- Does not sum to sample total of 2,208 due to rounding of weighted frequency.
curve than ASVAB 6E or 7E. Since June 1979, ASVAB 6/7 and ASVAB 6E/7E have all been used at AFEES, and it is reasonable to assume that by now all are equally compromised. If our ASVAB 6/7 norms are seriously in error relative to our results for ASVAB 6E/7E then one would expect that mean ASVAB test scores at AFEES would be similar for ASVAB 6/7 and ASVAB 6E/7E, when the latter were first introduced in June 1979 and to diverge later as all forms become equally compromised. An examination of recent data for Marine Corps recruits on ASVAB tests administered at AFEES does not show this divergence (table F-7). We believe this observation strengthens our contention that there is no significant bias in our ASVAB 6/7 norming results due to test compromise.

**TABLE F-7**

**COMPARISON OF MEAN SCORES FROM COMPROMISED AND UNCOMPROMISED ASVAB FORMS**

<table>
<thead>
<tr>
<th>Period tested at AFEES</th>
<th>ASVAB 6/7</th>
<th>ASVAB 6E/7E</th>
</tr>
</thead>
<tbody>
<tr>
<td>June-September 1979</td>
<td>53.8 ± 0.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>53.8 ± 0.4&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>October-December 1979</td>
<td>55.8 ± 0.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>54.8 ± 0.5&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Sample contains 6,887 Marine Corps recruits.
<sup>b</sup>Sample contains 1,755 Marine Corps recruits.
<sup>c</sup>Sample contains 2,391 Marine Corps recruits.
<sup>d</sup>Sample contains 1,096 Marine Corps recruits.

1 ASVAB 6/7 had been used for about 2 years when our data set was collected and was certainly compromised. ASVAB 6E/7E were not in use and were not compromised at that time.

2 In testimony before the House Armed Services Military Personnel Subcommittee, a recruiter stated that there wasn't a test devised "that I couldn't compromise in three months." (Navy Times, 7 June 1976). Other recruiters have given even shorter estimates of the time required.
Based on data in this appendix, we conclude that there are some cases in sample 5 that are probably distorted by coaching but that these do not seem to have had a significant effect on the normalization results for ASVAB 6/7.
REFERENCES

F-1 Center for Naval Analyses, Study 1115, "An Analysis of the Normalization and Verification of the Armed Services Vocational Aptitude Battery (ASVAB) Forms 6 and 7," by William H. Sims, Unclassified, Apr 1978

APPENDIX G

EQUIVALENCE OF RESULTS FROM DIFFERENT LOCATIONS
APPENDIX G

EQUIVALENCE OF RESULTS FROM DIFFERENT LOCATIONS

As part of our quality control procedure in testing recruits, one of the authors visited the two test sites for a few days when data were first collected. Each test site appeared to be conducting the testing correctly. In this appendix we examine the data to determine if there is any difference in the normalization results between the two test sites that might indicate that at some time during the testing one of the sites may have deviated from the proper procedure.

We used the data from sample 5 to look for a location effect. It was broken into two subsamples—those recruits tested at Parris Island and those tested at San Diego. Separate weight factors were calculated for each subsample to stratify them on the reference test. These calculations are shown in tables G-1 and G-2.

Using the weight factors in tables G-1 and G-2, we stratified the subsamples and made cumulative frequency distributions of the ASVAB 6/7 AFQT score, as shown in table G-3. We then ran a chi-squared test for the homogeneity of the two frequency distributions, as illustrated in table G-4. We found a chi-squared of 24.1 for 17 degrees of freedom, which indicates that the probability of differences that large occurring by change is about 0.12. There is, therefore, no compelling reason to doubt that the two test sites followed the same procedures throughout the data collection phase of the study.
**TABLE G-1**  
CALCULATION OF WEIGHT FACTORS FOR PARRIS ISLAND SUBSAMPLE

<table>
<thead>
<tr>
<th>Reference test percentile interval (1)</th>
<th>Number observed in sample (2)</th>
<th>Number expected in mobilization population (3)</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt; (4)</th>
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</thead>
<tbody>
<tr>
<td>1-5</td>
<td>16</td>
<td>52.8</td>
<td>3.300</td>
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<td>6-10</td>
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<td>80</td>
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<tr>
<td>16-20</td>
<td>86</td>
<td>52.8</td>
<td>0.614</td>
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<tr>
<td>21-25</td>
<td>90</td>
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<td>0.587</td>
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Total 1,056

<sup>a</sup>Column (3) divided by column (2).
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<tr>
<th>Reference test percentile interval (1)</th>
<th>Number observed in sample (2)</th>
<th>Number expected in mobilization population (3)</th>
<th>Weight factor(^a) (4)</th>
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\(^a\) Column (3) divided by column (2).
**TABLE G-3**

**TESTING LOCATION EFFECT**

*(sample 5)*

<table>
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<th>ASVAB 6/7 AFQT raw score</th>
<th>Cumulative frequency</th>
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TABLE G-4

GROUPED DISTRIBUTIONS FOR HOMOGENEITY TEST\(^{a}\)
(Sample 5)

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<th>ASVAB 6/7 AFQT (raw score)</th>
<th>Frequency</th>
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<th></th>
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<tr>
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<td>92</td>
<td>89</td>
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</tr>
<tr>
<td>41-43</td>
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<td>98</td>
<td></td>
</tr>
<tr>
<td>44-46</td>
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<td>99</td>
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<td>100</td>
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<td>75</td>
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<td></td>
</tr>
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<td>78</td>
<td>94</td>
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<td>56-58</td>
<td>52</td>
<td>65</td>
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</tr>
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<td>59-61</td>
<td>81</td>
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<td>62-64</td>
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</tr>
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<td>65-67</td>
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<td>58</td>
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</tr>
<tr>
<td>68-70</td>
<td>24</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,055(^{b})</strong></td>
<td><strong>1,155(^{c})</strong></td>
<td></td>
</tr>
</tbody>
</table>

\(^{a}\)Chi-squared is 24.1 with 17 degrees of freedom. The probability of differences this large by chance is about 0.12.

\(^{b}\)Does not sum to 1,056 due to rounding of weighted frequencies.

\(^{c}\)Does not sum to 1,152 due to rounding of weighted frequencies.
APPENDIX H

EFFECT OF TEST FATIGUE
This appendix looks at the effect of test fatigue on scores from the three-test series. The series consisted of AFQT-7A (1 hour), AFQT from ASVAB 6E/7E (1 hour), and the entire ASVAB 6/7 (3 hours). Breaks were given between testing sessions, and in some cases, the testing was spread over 2 days. Nonetheless, it is reasonable to think that fatigue may have contributed to lower test scores on the last test in the series and that this may have biased the normalization results. The counterbalanced design described in appendix B tends to reduce this possible source of bias. However, in this appendix we briefly examine the data to see if test fatigue biases norming results.

We examined a subsample of sample 5 that contained recruits who took the reference test and ASVAB 6/7 either first or second in the three-test series. We assumed these recruits would not suffer as much test fatigue as the average recruit in sample 5. We stratified the low-fatigue subsample on the reference test as shown in table H-1. Table H-2 shows the resulting cumulative frequency distribution of ASVAB 6/7 AFQT scores compared to those of the full sample 5. A test for the homogeneity of the low-fatigue subsample and sample 5 (see table H-3) indicated that the probability of observing differences that large by chance was about 0.04. Hence, we cannot reject with high confidence the hypothesis that the two samples are parallel. The practical consequences of any test fatigue effect, if any, is not large (table H-2).
### Table II-1

**Calculation of Weight Factors for Low-Fatigue Subsample**

<table>
<thead>
<tr>
<th>Reference test percentile interval (1)</th>
<th>Number observed in sample (2)</th>
<th>Number expected in mobilization population (3)</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt; (4)</th>
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<tbody>
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<td>35.15</td>
<td>0.703</td>
</tr>
<tr>
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<td>55</td>
<td>35.15</td>
<td>0.639</td>
</tr>
<tr>
<td>21-25</td>
<td>54</td>
<td>35.15</td>
<td>0.651</td>
</tr>
<tr>
<td>26-30</td>
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<td>49</td>
<td>35.15</td>
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<td>35.15</td>
<td>0.703</td>
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<td>0.676</td>
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<td>1.674</td>
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<td>96-100</td>
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<tr>
<td>Total</td>
<td>703</td>
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</tr>
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</table>

<sup>a</sup>Column (3) divided by column (2).
TABLE H-2

TEST FATIGUE EFFECTS
(Sample 5)

<table>
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<tr>
<th>ASVAB 6/7 AFQT raw score</th>
<th>Cumulative frequency</th>
<th>Full sample</th>
<th>Low-fatigue group</th>
</tr>
</thead>
<tbody>
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</tr>
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<td>18-19</td>
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<td>99.9</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
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</tr>
</tbody>
</table>
## TABLE II-3
GROUPED DISTRIBUTIONS FOR HOMOGENEITY TEST\(^a\)
(sample 5)

<table>
<thead>
<tr>
<th>ASVAB 6/7 AFQT interval (raw score) ((1))</th>
<th>Frequency</th>
<th>Full sample ((2))</th>
<th>Low-fatigue group ((3))</th>
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<tbody>
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<td>0-19</td>
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<td>7</td>
<td></td>
</tr>
<tr>
<td>20-22</td>
<td>30</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>23-25</td>
<td>57</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>26-28</td>
<td>60</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>29-31</td>
<td>114</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>32-34</td>
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<td>42</td>
<td></td>
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<td>35-37</td>
<td>154</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>38-40</td>
<td>182</td>
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<td>41-43</td>
<td>177</td>
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<td></td>
</tr>
<tr>
<td>44-46</td>
<td>201</td>
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<tr>
<td>47-49</td>
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<td>50-52</td>
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<td>171</td>
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<td>56-58</td>
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<td>59-61</td>
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<td>68-70</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>2,206</strong></td>
<td><strong>704</strong></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Chi-squared is 28.7 for 17 degrees of freedom. The probability of differences this large by chance is about 0.04.

\(^b\) Does not sum to 2,208 due to rounding weighted frequencies.

\(^c\) Does not sum to 703 due to rounding weighted frequencies.
APPENDIX I

EFFECTS OF PRESELECTION ON NORMALIZATION
APPENDIX I

EFFECTS OF PRESELECTION ON NORMALIZATION

Another possible source of bias is preselection. Ideally, the sample used for normalization should contain individuals with a wide range of mental aptitudes. In fact, because we had to use Marine Corps recruits for this analysis rather than applicants, those who made low scores on the ASVAB given at AFEES would have been rejected for military service and would not be present in our sample. Figure I-1 illustrates preselection. This appendix examines the extent to which preselection biases normalization results based on scores obtained by retesting the recruits at recruit depots.

The Marine Corps requires recruits to score a minimum of the 21st percentile on the AFQT part of ASVAB. Additional restrictions on the GT (general technical) composite correspond approximately to the 25th percentile for high school graduates and the 40th percentile for non-high school graduates.
To examine the preselection effect, we used sample 1 data and made successively more restrictive cuts on the AFQT score recruits made at AFEES. If further restrictions significantly change the normalization results, then we may infer that the original restriction at AFEES may have biased our normalization. Cuts on sample 1 were made to exclude cases scoring at or below the 30th, 40th, or 50th percentile on the ASVAB 6/7 AFQT at AFEES. The full sample 1 corresponds to a restriction at the 20th percentile. We then stratified the resulting subsamples on the reference tests using the weight factors shown in tables I-1, I-2, and I-3.

The cumulative frequencies of ASVAB 6/7 AFQT scores based on recruit depot testing are shown in table I-4. The results for restrictions at the 20th, 40th, and 50th percentiles are graphed and shown in figure I-2. The higher the restriction, the more the lower end of the normalization curve moves toward harder norms. The bias does not seem to be large until the restriction removes all cases below the 50th percentile. Nonetheless, the bias does seem to exist for less restrictive cuts and extends to at least the 50th percentile on the resulting normalization.

These data do not allow us to quantify the bias, but it seems reasonable to conclude that a bias exists and that although it appears to be small, it is not negligible.
TABLE I-1

CALCULATION OF WEIGHT FACTORS FOR AFEES AFQT > 30th PERCENTILE

<table>
<thead>
<tr>
<th>AFQT 7A percentile interval</th>
<th>Number observed in sample (2)</th>
<th>Number expected in mobilization population (3)</th>
<th>Weight factor(^a) (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>39</td>
<td>160.05</td>
<td>4.104</td>
</tr>
<tr>
<td>6-10</td>
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<td>2.354</td>
</tr>
<tr>
<td>11-15</td>
<td>206</td>
<td>160.05</td>
<td>0.777</td>
</tr>
<tr>
<td>16-20</td>
<td>262</td>
<td>160.05</td>
<td>0.611</td>
</tr>
<tr>
<td>21-25</td>
<td>240</td>
<td>160.05</td>
<td>0.667</td>
</tr>
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<td>0.804</td>
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<td>160.05</td>
<td>0.653</td>
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<tr>
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<td>252</td>
<td>160.05</td>
<td>0.635</td>
</tr>
<tr>
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<td>111</td>
<td>160.05</td>
<td>1.442</td>
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<td>0.633</td>
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<td>201</td>
<td>160.05</td>
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</tr>
<tr>
<td>56-60</td>
<td>249</td>
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<td>0.643</td>
</tr>
<tr>
<td>61-65</td>
<td>248</td>
<td>160.05</td>
<td>0.645</td>
</tr>
<tr>
<td>66-70</td>
<td>76</td>
<td>160.05</td>
<td>2.106</td>
</tr>
<tr>
<td>71-75</td>
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</tr>
<tr>
<td>86-90</td>
<td>86</td>
<td>160.05</td>
<td>1.861</td>
</tr>
<tr>
<td>91-95</td>
<td>44</td>
<td>160.05</td>
<td>3.638</td>
</tr>
<tr>
<td>96-100</td>
<td>10</td>
<td>160.05</td>
<td>16.005</td>
</tr>
</tbody>
</table>

Total 3,201 3,201

\(^a\) Column (3) divided by column (2).
### TABLE 1-2

**CALCULATION OF WEIGHT FACTORS FOR AFEES AFQT > 40th PERCENTILE**

<table>
<thead>
<tr>
<th>AFQT 7A percentile interval</th>
<th>Number observed in sample</th>
<th>Number expected in mobilization population</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
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<td>11-15</td>
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<tr>
<td>21-25</td>
<td>183</td>
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<td>0.654</td>
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<td>41-45</td>
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<td>1.365</td>
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<tr>
<td>46-50</td>
<td>238</td>
<td>143.3</td>
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<td>71-75</td>
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<td>143.3</td>
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<td>143.3</td>
<td>0.988</td>
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<td>86-90</td>
<td>86</td>
<td>143.3</td>
<td>1.666</td>
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<td>91-95</td>
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<td>96-100</td>
<td>10</td>
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<sup>a</sup>Column (3) divided by column (2).
### Table 1-3

**Calculation of Weight Factors for AFEES AFQT > 50th Percentile**

<table>
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<tr>
<th>AFQT 7A percentile interval</th>
<th>Number observed in sample</th>
<th>Number expected in mobilization population</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
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<tr>
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<td>12</td>
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<td>7.650</td>
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<tr>
<td>6-10</td>
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<td>11-15</td>
<td>44</td>
<td>91.8</td>
<td>2.086</td>
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<tr>
<td>16-20</td>
<td>53</td>
<td>91.8</td>
<td>1.732</td>
</tr>
<tr>
<td>21-25</td>
<td>67</td>
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<sup>a</sup>Column (3) divided by column (2).
### Table 1-4

**Cumulative Frequency of ASVAB 6/7 AFQT for Various Restrictions on AFQT Score at AFEES**

<table>
<thead>
<tr>
<th>ASVAB 6/7 AFQT raw score</th>
<th>Cumulative frequency of ASVAB 6/7 AFQT</th>
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</thead>
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<tr>
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<tr>
<td>14-15</td>
<td>0.4</td>
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<td>16-17</td>
<td>0.7</td>
</tr>
<tr>
<td>18-19</td>
<td>1.2</td>
</tr>
<tr>
<td>20</td>
<td>1.7</td>
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<td>22</td>
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<tr>
<td>23</td>
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<td>8.4</td>
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<tr>
<td>69</td>
<td>99.9</td>
</tr>
<tr>
<td>70</td>
<td>100.0</td>
</tr>
</tbody>
</table>
FIG. I-2: EFFECT OF PRESELECTION AT AFEES ON NORMALIZATION RESULTS
APPENDIX J

ADJUSTMENTS FOR EFFECTS OF SAMPLE TRUNCATION ON STRATIFIED NORMING RESULTS
APPENDIX J

ADJUSTMENTS FOR EFFECTS OF SAMPLE TRUNCATION ON STRATIFIED NORMING RESULTS

In this appendix we use a full-range data set to examine the effect of sample truncation on norming results from the stratification method. First, we applied the stratification method to the full-range data and obtained a normalization curve. Then, we truncated the sample to closely simulate the truncation in the CNA sample and obtained a second normalization curve. The difference in the two curves is the effect of truncation and could be used to correct for the effects of truncation on the CNA normalization curve.

The full-range data set obtained from DoD consisted of results from administering two tests to each of a sample of applicants for enlistment at AFEES. The CNA data set consisted of a test given at AFEES on which the sample was truncated, followed by two tests given to the truncated sample once they arrived at the Marine Corps Recruit Depots (MCRD). Hence, we need to simulate the effects of a three-test system using data from only two tests.

This simulation can be done by using the Pseudo AFQT developed by reference J-1. Reference J-1 finds that in addition to the AFQT test embodied in the ASVAB there is also a Pseudo AFQT. The Pseudo AFQT can be constructed from parts of the ASVAB that do not make up the AFQT and, hence, can be viewed as a separate test. However, it has a very high correlation with the AFQT and may be considered a good proxy. The Pseudo AFQT is defined as

\[ \text{Pseudo AFQT} = \text{GI} + \text{GS} + \text{MC} + \text{MK}. \]

It may be used to accurately predict an alternative AFQT score for each applicant. We then truncated the full-range sample on the predicted AFQT score to simulate the truncation of the CNA data set. The AFQT score and the reference test experience incidental selection similar to that occurring in the CNA data set. The ASVAB is then normed using these incidentally selected variables and compared with those from the nontruncated full-range data set. The procedure is illustrated in figure J-1.

The Pseudo AFQT and AFQT were equated by the equipercentile method using the full-range data sample. The details are given in annex J-1. In figure J-2 we show distribution of AFQT and the AFQT.

\^1The correlation between the Pseudo AFQT and AFQT in the full-range data set is 0.87.
CNA 6E sample (truncated by preselection)

- Direct selection
- Incidental selection
- Incidental selection

ASVAB AFQT (6/7) AFEES
ASVAB AFQT (6E) (MCRD)
Reference test (MCRD)

Real data simulation (DOD full-range sample)

- Direct selection
- Incidental selection
- Incidental selection

Predicted ASVAB AFQT (AFEES)
ASVAB AFQT (6E) (AFEES)
Reference test (AFEES)

FIG. J-1: ILLUSTRATION OF REAL DATA SIMULATION OF SAMPLE TRUNCATION
FIG. J-2: COMPARISON OF DISTRIBUTION IN ACTUAL AND PREDICTED AFQT FROM DOD FULL-RANGE SAMPLE
predicted from the Pseudo AFQT. The two distributions are very similar, which indicates that we have successfully created a three-test system from two tests.

The next step was to simulate in the full-range sample the truncation of AFLES. This was accomplished by determining weights "A" such that when applied to the individuals in the DoD sample, the resulting distribution in predicted AFQT (figure J-3d) is identical to that of the AFQT taken at AFLES in the CNA sample (figure J-3a). The calculation of these weights is shown in annex J-2. When these weights are applied to the individuals in the DoD data sample the cross-hatched areas in figure J-3 are removed. In this manner, the effects of both direct and incidental selection are simulated. The truncated distributions of the relevant test scores from the DoD sample closely approximate those from the CNA sample (figure J-3), which suggests that we have closely simulated the truncation of the CNA sample.

Means and correlation coefficients from the truncated CNA sample and the truncated DoD sample are compared (table J-1). The mean values are very comparable, indicating that our simulation is satisfactory. The correlation coefficients for the DoD data are somewhat higher than those for the CNA data. We believe the essential element is that the three coefficients from each CNA data set have the same relative size as the three from each DoD data set. Because the relative size of coefficients from both data sets were similar, we concluded that our simulation adequately replicated the truncation effect.

We next stratified the truncated DoD sample on the reference test and formed a cumulative frequency distribution of the scores of the test to be normed. We did this by a set of "B" weights calculated in annex J-3. These weights, applied in conjunction with the "A" weights from annex J-2, produced a stratified sample within the truncated DoD data set. The resulting cumulative frequency distribution of ASVAB 6E AFQT scores is shown in table J-2. Also shown in table J-2 is the distribution of the same variable from the full-range DoD sample stratified using the weights calculated in annex J-1. The difference in the two distributions is the result of the truncation effect. Similar results were obtained for the ASVAB 7E and ASVAB 6/7 samples and are shown in tables J-3 and J-4. The normed curves for both the full-range and truncated DoD samples are shown in figure J-4, J-5, and J-6. In each case there is a

The full-range DoD distribution was scaled to equal the truncated DoD distribution above the 30th percentile. The "dots" in figure J-3 represent the scaled full-range distribution.
FIG. J-3: COMPARISON OF TRUNCATED CNA DATA AND TRUNCATED DOD DATA FOR THE ASVAB 6E SAMPLE
<table>
<thead>
<tr>
<th>Sample</th>
<th>ASVAB form</th>
<th>Correlation coefficient&lt;sup&gt;a&lt;/sup&gt; between:</th>
<th>Mean value of distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Directly selected AFQT and indirectly selected reference test</td>
<td>Directly selected AFQT</td>
</tr>
<tr>
<td>CNA truncated</td>
<td>6E</td>
<td>0.75</td>
<td>45.5</td>
</tr>
<tr>
<td>at AFEES on AFQT</td>
<td>7E</td>
<td>0.75</td>
<td>45.5</td>
</tr>
<tr>
<td></td>
<td>6/7</td>
<td>0.76</td>
<td>45.4</td>
</tr>
<tr>
<td>DoD truncated</td>
<td>6E</td>
<td>0.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>45.6</td>
</tr>
<tr>
<td>on predicted AFQT</td>
<td>7E</td>
<td>0.81&lt;sup&gt;b&lt;/sup&gt;</td>
<td>45.6</td>
</tr>
<tr>
<td></td>
<td>6/7</td>
<td>0.79&lt;sup&gt;b&lt;/sup&gt;</td>
<td>45.3</td>
</tr>
</tbody>
</table>

<sup>a</sup>All coefficients are from unstratified data.

<sup>b</sup>The directly selected AFQT for the DoD sample is the predicted AFQT.
### Table J-2

**Calculation of Truncation Adjustment for ASVAB 6E AFQT**

<table>
<thead>
<tr>
<th>ASVAB 6E raw score (1)</th>
<th>Cumulative percentage</th>
<th>DoD&lt;sup&gt;a&lt;/sup&gt;</th>
<th>DoD&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Adjustment&lt;sup&gt;c&lt;/sup&gt; for truncation (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>full-range sample (2)</td>
<td>truncated sample (3)</td>
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<td></td>
</tr>
<tr>
<td>15</td>
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<td>.3</td>
<td>.3</td>
<td></td>
</tr>
<tr>
<td>16</td>
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<td>.5</td>
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<tr>
<td>17</td>
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<td>.9</td>
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<td>1.2</td>
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<td>3.1</td>
<td>3.1</td>
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<td>7.3</td>
<td>3.8</td>
<td>3.5</td>
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<tr>
<td>26</td>
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<td>4.2</td>
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<td>12.7</td>
<td>4.5</td>
<td></td>
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<tr>
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*<sup>a</sup>DoD sample weighted by weights in Table J-1-2.*

*<sup>b</sup>DoD sample weighted by "double weights" (viz., weight "A" and weight "B") from Table J-2-1 and J-2-2.*

*<sup>c</sup>Column (3) minus column (2).*
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*a* Dod sample weighted by weights in Table J-1-2.

*b* Dod sample weighted by "double weights" (viz., weight "A" and weight "B") from Table J-2-3 and J-3-3.

*c* Column (3) minus column (2).
### TABLE J-4

**CALCULATION OF TRUNCATION ADJUSTMENT FOR ASVAB 6/7 AFQT**

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a DOJa sample weighted by weights in table J-1-2.

b DOBb sample weighted by "double weights" (viz., weight "A" and weight "B") from table J-2-3 and J-3-1.

c Column (3) minus column (2).
FIG. J-4: EFFECT OF SIMULATED TRUNCATION ON NORMING RESULTS FOR DOD ASVAB 6E SAMPLE
FIG. J-5: EFFECT OF SIMULATED TRUNCATION ON NORMING RESULTS FOR DOD ASVAB 7E SAMPLE
FIG. J-6: EFFECT OF SIMULATED TRUNCATION ON NORMING RESULTS FOR DOD ASVAB 6/7 SAMPLE

J-12
bias toward harder norms in the low percentiles and a bias toward easier norms in the higher percentiles. The maximum extent of the bias appears to be about 5 percentile points near the 20th percentile.
REFERENCE

J-1 Center for Naval Analyses, Study 1115, "An Analysis of the Normalization and Verification of the Armed Services Vocational Aptitude Battery (ASVAB) Forms 6 and 7," by William H. Sims, Unclassified, Apr 1978
ANNEX J-1

EQUIPERCENTILE TABLES FOR PREDICTED AFQT

Equipercentile tables were constructed from the DoD sample to equate ASVAB AFQT scores with Pseudo AFQT scores. Reference J-1 indicated that the Pseudo AFQT is an excellent predictor of AFQT scores.

We calculated weight factors (tables J-1-1, J-1-2, and J-1-3) to stratify the three DoD samples on the reference test (AFQT 7A). We applied these weight factors to everyone in the DoD samples depending on their AFQT 7A score to simulate the standard mobilization population. The cumulative percentages of each sample using weighted individuals is shown in figures J-1-1, J-1-2, and J-1-3.

Raw scores on the ASVAB AFQT and Pseudo AFQT were equated by the standard graphical equipercentile method. Raw scores on the two tests were considered to be equivalent if they were obtained by the same cumulative percentage of the sample. Equivalent ASVAB AFQT and Pseudo AFQT raw scores were read directly from figures J-1-1, J-1-2, and J-1-3 and are recorded in table J-1-4.

_Pseudo AFQT = GI+GS+MC+MK, where:

GI = general information
GS = general science
MC = mechanical comprehension
MK = mathematical knowledge.
### TABLE J-1-1

**CALCULATION OF WEIGHT FACTORS FOR DoD ASVAB 6E SAMPLE**

<table>
<thead>
<tr>
<th>AFQT 7A percentile interval</th>
<th>Number observed in sample</th>
<th>Number expected in mobilization population</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt;</th>
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<sup>a</sup>Column (3) divided by column (2).
TABLE J-1-2
CALCULATION OF WEIGHT FACTORS FOR DoD ASVAB 7E SAMPLE

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<th>Number expected in mobilization population</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt;</th>
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<sup>a</sup>Column (3) divided by column (2).
TABLE J-1-3
CALCULATION OF WEIGHT FACTORS FOR DoD ASVAB 6/7 SAMPLE

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\(^a\) Column (3) divided by column (2).
FIG. J-1-1: CUMULATIVE PERCENTAGE OF STRATIFIED DOD SAMPLE ON ASVAB
6E AFQT AND PSEUDO AFQT
FIG. J-1-2: CUMULATIVE PERCENTAGE OF STRATIFIED DOD SAMPLE ON ASVAB
7E AFQT AND PSEUDO AFQT
FIG. J-1-3: CUMULATIVE PERCENTAGE OF STRATIFIED DOD SAMPLE ON ASVAB 6/7 AND PSEUDO AFQT
**TABLE J-1-4**

**EQUIPERCENTILE CONVERSION TABLE FOR PSEUDO AFQT**

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</tr>
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<td>79</td>
<td>77</td>
</tr>
<tr>
<td>72</td>
<td>80</td>
<td>80</td>
<td>78</td>
</tr>
<tr>
<td>73</td>
<td>81</td>
<td>81</td>
<td>79</td>
</tr>
<tr>
<td>74</td>
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<td>82</td>
<td>80</td>
</tr>
<tr>
<td>75</td>
<td>83</td>
<td>83</td>
<td>81</td>
</tr>
</tbody>
</table>

J-22
ANNEX J-2

CALCULATION OF "A" WEIGHTS FOR DoD DATA

The purpose of this annex is to show how to simulate the same truncation or preselection in the DoD data sample as occurred in the CNA sample. This is accomplished by calculating weights "A", which will force the distribution of predicted DoD ASVAB AFQT scores to look like those of the CNA AFEES ASVAB AFQT scores. The calculation of the weight factors is shown in tables J-2-1, J-2-2, and J-2-3. When these weights are attached to individuals in the DoD sample (as a function of their predicted ASVAB AFQT score), the resulting distribution will be identical to that of the truncated CNA ASVAB AFQT scores based on AFEES testing.
TABLE J-2-1

CALCULATION OF "A" WEIGHTS FOR DoD 6E SAMPLE

<table>
<thead>
<tr>
<th>AFQT interval (1)</th>
<th>Predicted ASVAB AFQT DoD 6E sample (2)</th>
<th>Predicted ASVAB AFQT CNA 6E sample (3)</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt; (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15</td>
<td>25</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>16-20</td>
<td>85</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>21-25</td>
<td>258</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>26-30</td>
<td>373</td>
<td>54</td>
<td>0.145</td>
</tr>
<tr>
<td>31-35</td>
<td>337</td>
<td>166</td>
<td>0.493</td>
</tr>
<tr>
<td>36-40</td>
<td>399</td>
<td>288</td>
<td>0.722</td>
</tr>
<tr>
<td>41-45</td>
<td>447</td>
<td>358</td>
<td>0.801</td>
</tr>
<tr>
<td>46-50</td>
<td>274</td>
<td>304</td>
<td>1.109</td>
</tr>
<tr>
<td>51-55</td>
<td>302</td>
<td>217</td>
<td>0.719</td>
</tr>
<tr>
<td>56-60</td>
<td>188</td>
<td>148</td>
<td>0.787</td>
</tr>
<tr>
<td>61-65</td>
<td>140</td>
<td>74</td>
<td>0.529</td>
</tr>
<tr>
<td>66-70</td>
<td>44</td>
<td>25</td>
<td>0.568</td>
</tr>
</tbody>
</table>

2,870                1,634

<sup>a</sup>Column (3) divided by column (2).
TABLE J-2-2

CALCULATION OF "A" WEIGHTS FOR DoD 7E SAMPLE

<table>
<thead>
<tr>
<th>AFQT interval (1)</th>
<th>Number of cases (unweighted)</th>
<th>Predicted ASVAB AFQT DoD 7E sample (2)</th>
<th>AFEES ASVAB AFQT CNA 7E sample (3)</th>
<th>Weight factora (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>16-20</td>
<td>104</td>
<td>0</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>21-25</td>
<td>253</td>
<td>0</td>
<td>0</td>
<td>0.000</td>
</tr>
<tr>
<td>26-30</td>
<td>309</td>
<td>45</td>
<td>0.146</td>
<td></td>
</tr>
<tr>
<td>31-35</td>
<td>331</td>
<td>163</td>
<td>0.492</td>
<td></td>
</tr>
<tr>
<td>36-40</td>
<td>320</td>
<td>305</td>
<td>0.953</td>
<td></td>
</tr>
<tr>
<td>41-45</td>
<td>367</td>
<td>383</td>
<td>1.044</td>
<td></td>
</tr>
<tr>
<td>46-50</td>
<td>320</td>
<td>304</td>
<td>0.950</td>
<td></td>
</tr>
<tr>
<td>51-55</td>
<td>276</td>
<td>215</td>
<td>0.779</td>
<td></td>
</tr>
<tr>
<td>56-60</td>
<td>142</td>
<td>127</td>
<td>0.894</td>
<td></td>
</tr>
<tr>
<td>61-65</td>
<td>130</td>
<td>89</td>
<td>0.685</td>
<td></td>
</tr>
<tr>
<td>66-70</td>
<td>75</td>
<td>29</td>
<td>0.387</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2,650</td>
<td>1,660</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

aColumn (3) divided by column (2).
<table>
<thead>
<tr>
<th>AFQT interval</th>
<th>Predicted ASVAB</th>
<th>Predicted AFQT DoD 6/7 sample</th>
<th>Predicted ASVAB</th>
<th>Predicted AFQT CNA 6/7 sample</th>
<th>Weight factor&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td></td>
</tr>
<tr>
<td>0-15</td>
<td></td>
<td>65</td>
<td>0</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>16-20</td>
<td></td>
<td>210</td>
<td>0</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>21-25</td>
<td></td>
<td>415</td>
<td>0</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>26-30</td>
<td></td>
<td>739</td>
<td>68</td>
<td>0.092</td>
<td></td>
</tr>
<tr>
<td>31-35</td>
<td></td>
<td>616</td>
<td>232</td>
<td>0.377</td>
<td></td>
</tr>
<tr>
<td>36-40</td>
<td></td>
<td>712</td>
<td>403</td>
<td>0.566</td>
<td></td>
</tr>
<tr>
<td>41-45</td>
<td></td>
<td>584</td>
<td>494</td>
<td>0.846</td>
<td></td>
</tr>
<tr>
<td>46-50</td>
<td></td>
<td>491</td>
<td>396</td>
<td>0.807</td>
<td></td>
</tr>
<tr>
<td>51-55</td>
<td></td>
<td>502</td>
<td>290</td>
<td>0.578</td>
<td></td>
</tr>
<tr>
<td>56-60</td>
<td></td>
<td>297</td>
<td>179</td>
<td>0.603</td>
<td></td>
</tr>
<tr>
<td>61-65</td>
<td></td>
<td>330</td>
<td>111</td>
<td>0.336</td>
<td></td>
</tr>
<tr>
<td>66-70</td>
<td></td>
<td>108</td>
<td>35</td>
<td>0.324</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5,069</td>
<td>2,208</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Column (3) divided by column (2).
ANNEX J-3

CALCULATION OF "B" WEIGHTS FOR DoD DATA

Annex J-2 showed that "A" weights enable us to simulate the effect of preselection in the DoD sample. This annex shows how to calculate "B" weights to stratify that truncated sample on the reference test (AFQT 7A).

The distribution of the "B" weighted sample on the reference test is given in tables J-3-1, J-3-2, and J-3-3 for the three DoD samples as is the calculation of the weights necessary to stratify the sample.
<table>
<thead>
<tr>
<th>AFQT 7A percentile interval (1)</th>
<th>Number observed in &quot;A&quot; weighted DoD 6E sample (2)</th>
<th>Number expected in mobilization population (3)</th>
<th>Weight factor (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>15.00</td>
<td>81.718</td>
<td>5.4479</td>
</tr>
<tr>
<td>6-10</td>
<td>32.20</td>
<td>81.718</td>
<td>2.5378</td>
</tr>
<tr>
<td>11-15</td>
<td>100.28</td>
<td>81.718</td>
<td>.8149</td>
</tr>
<tr>
<td>16-20</td>
<td>135.37</td>
<td>81.718</td>
<td>.6037</td>
</tr>
<tr>
<td>21-25</td>
<td>133.82</td>
<td>81.718</td>
<td>.6107</td>
</tr>
<tr>
<td>26-30</td>
<td>118.66</td>
<td>81.718</td>
<td>.6887</td>
</tr>
<tr>
<td>31-35</td>
<td>113.24</td>
<td>81.718</td>
<td>.7216</td>
</tr>
<tr>
<td>36-40</td>
<td>123.13</td>
<td>81.718</td>
<td>.6637</td>
</tr>
<tr>
<td>41-45</td>
<td>53.23</td>
<td>81.718</td>
<td>1.5352</td>
</tr>
<tr>
<td>46-50</td>
<td>132.41</td>
<td>81.718</td>
<td>.6172</td>
</tr>
<tr>
<td>51-55</td>
<td>92.91</td>
<td>81.718</td>
<td>.8795</td>
</tr>
<tr>
<td>56-60</td>
<td>130.85</td>
<td>81.718</td>
<td>.6245</td>
</tr>
<tr>
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<td>114.72</td>
<td>81.718</td>
<td>.7123</td>
</tr>
<tr>
<td>66-70</td>
<td>39.01</td>
<td>81.718</td>
<td>2.0948</td>
</tr>
<tr>
<td>71-75</td>
<td>59.03</td>
<td>81.718</td>
<td>1.3843</td>
</tr>
<tr>
<td>76-80</td>
<td>61.47</td>
<td>81.718</td>
<td>1.5294</td>
</tr>
<tr>
<td>81-85</td>
<td>79.61</td>
<td>81.718</td>
<td>1.0265</td>
</tr>
<tr>
<td>86-90</td>
<td>60.81</td>
<td>81.718</td>
<td>1.3438</td>
</tr>
<tr>
<td>91-95</td>
<td>31.50</td>
<td>81.718</td>
<td>2.5942</td>
</tr>
<tr>
<td>96-100</td>
<td>7.15</td>
<td>81.718</td>
<td>11.4291</td>
</tr>
</tbody>
</table>

Total 1,634.40 1,634.36

\(^a\)This column has fractional frequency distributions because it is the result of weighting the DoD sample by weight "A".

\(^b\)Column (3) divided by column (2).
### TABLE J-3-2

**CALCULATION OF "B" WEIGHTS FOR DoD 7E SAMPLE**

<table>
<thead>
<tr>
<th>AFQT 7A percentile interval (1)</th>
<th>Number(^a) observed in &quot;A&quot; weighted DoD 7E sample (2)</th>
<th>Number expected in mobilization population (3)</th>
<th>Weight factor(^b) (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>13.98</td>
<td>83.005</td>
<td>5.9374</td>
</tr>
<tr>
<td>6-10</td>
<td>30.29</td>
<td>83.005</td>
<td>2.7403</td>
</tr>
<tr>
<td>11-15</td>
<td>113.79</td>
<td>83.005</td>
<td>.7295</td>
</tr>
<tr>
<td>16-20</td>
<td>149.43</td>
<td>83.005</td>
<td>.5555</td>
</tr>
<tr>
<td>21-25</td>
<td>120.04</td>
<td>83.005</td>
<td>.6915</td>
</tr>
<tr>
<td>26-30</td>
<td>124.05</td>
<td>83.005</td>
<td>.6691</td>
</tr>
<tr>
<td>31-35</td>
<td>117.80</td>
<td>83.005</td>
<td>.7046</td>
</tr>
<tr>
<td>36-40</td>
<td>129.01</td>
<td>83.005</td>
<td>.6434</td>
</tr>
<tr>
<td>41-45</td>
<td>49.37</td>
<td>83.005</td>
<td>1.6813</td>
</tr>
<tr>
<td>46-50</td>
<td>151.11</td>
<td>83.005</td>
<td>.5493</td>
</tr>
<tr>
<td>51-55</td>
<td>87.07</td>
<td>83.005</td>
<td>.9533</td>
</tr>
<tr>
<td>56-60</td>
<td>111.65</td>
<td>83.005</td>
<td>.7434</td>
</tr>
<tr>
<td>61-65</td>
<td>113.64</td>
<td>83.005</td>
<td>.7304</td>
</tr>
<tr>
<td>66-70</td>
<td>44.07</td>
<td>83.005</td>
<td>1.8835</td>
</tr>
<tr>
<td>71-75</td>
<td>64.42</td>
<td>83.005</td>
<td>1.2885</td>
</tr>
<tr>
<td>76-80</td>
<td>76.93</td>
<td>83.005</td>
<td>1.0790</td>
</tr>
<tr>
<td>81-85</td>
<td>73.80</td>
<td>83.005</td>
<td>1.1247</td>
</tr>
<tr>
<td>86-90</td>
<td>52.91</td>
<td>83.005</td>
<td>1.5688</td>
</tr>
<tr>
<td>91-95</td>
<td>30.54</td>
<td>83.005</td>
<td>2.7179</td>
</tr>
<tr>
<td>96-100</td>
<td>6.25</td>
<td>83.005</td>
<td>13.2808</td>
</tr>
<tr>
<td>Total</td>
<td>1,660.15</td>
<td>1,660.10</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)This column has fractional frequency distributions because it is the result of weighting the DoD sample by weight "A".

\(^b\)Column (3) divided by column (2).
### TABLE J-3-3

**CALCULATION OF "B" WEIGHTS FOR DoD 6/7 SAMPLE**

<table>
<thead>
<tr>
<th>AFQT 7A percentile interval (1)</th>
<th>Number(^a) observed in &quot;A&quot; weighted DoD 6/7 sample (2)</th>
<th>Number expected in mobilization population (3)</th>
<th>Weight factor(^b) (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>16.19</td>
<td>110.43</td>
<td>6.8210</td>
</tr>
<tr>
<td>6-10</td>
<td>46.51</td>
<td>110.43</td>
<td>2.3743</td>
</tr>
<tr>
<td>11-15</td>
<td>135.23</td>
<td>110.43</td>
<td>.8166</td>
</tr>
<tr>
<td>16-20</td>
<td>185.35</td>
<td>110.43</td>
<td>.5958</td>
</tr>
<tr>
<td>21-25</td>
<td>149.38</td>
<td>110.43</td>
<td>.7393</td>
</tr>
<tr>
<td>26-30</td>
<td>172.58</td>
<td>110.43</td>
<td>.6399</td>
</tr>
<tr>
<td>31-35</td>
<td>158.87</td>
<td>110.43</td>
<td>.6951</td>
</tr>
<tr>
<td>36-40</td>
<td>169.91</td>
<td>110.43</td>
<td>.6499</td>
</tr>
<tr>
<td>41-45</td>
<td>79.69</td>
<td>110.43</td>
<td>1.3858</td>
</tr>
<tr>
<td>46-50</td>
<td>191.18</td>
<td>110.43</td>
<td>.5776</td>
</tr>
<tr>
<td>51-55</td>
<td>134.65</td>
<td>110.43</td>
<td>.8201</td>
</tr>
<tr>
<td>56-60</td>
<td>157.24</td>
<td>110.43</td>
<td>.7023</td>
</tr>
<tr>
<td>61-65</td>
<td>180.43</td>
<td>110.43</td>
<td>.6120</td>
</tr>
<tr>
<td>66-70</td>
<td>61.37</td>
<td>110.43</td>
<td>1.7994</td>
</tr>
<tr>
<td>71-75</td>
<td>88.68</td>
<td>110.43</td>
<td>1.2453</td>
</tr>
<tr>
<td>76-80</td>
<td>81.84</td>
<td>110.43</td>
<td>1.3494</td>
</tr>
<tr>
<td>81-85</td>
<td>97.34</td>
<td>110.43</td>
<td>1.1345</td>
</tr>
<tr>
<td>86-90</td>
<td>62.11</td>
<td>110.43</td>
<td>1.7780</td>
</tr>
<tr>
<td>91-95</td>
<td>33.95</td>
<td>110.43</td>
<td>3.2528</td>
</tr>
<tr>
<td>96-100</td>
<td>6.17</td>
<td>110.43</td>
<td>17.8981</td>
</tr>
</tbody>
</table>

\(^a\)This column has fractional frequency distributions because it is the result of weighting the DoD sample by weight "A".

\(^b\)Column (3) divided by column (2).
APPENDIX K

ADJUSTMENTS FOR EFFECTS OF SAMPLE TRUNCATION ON UNSTRATIFIED NORMING RESULTS
In this appendix we carry out unstratified graphical equating using the full-range DoD sample and the truncated DoD sample described in appendix J. Neither sample was stratified on the reference test.

Cumulative frequency distributions of the reference test scores and ASVAB 6E AFQT scores were graphed for the full-range sample (figure K-1) and for the truncated sample (figure K-2). Scores made by the same cumulative frequency of each sample were equated. The percentile scores equated to each ASVAB 6E AFQT raw score are shown in table K-1. Similar calculations were made for ASVAB 7E and ASVAB 6/7; these are shown in figures K-3, K-4, K-5, and K-6. The results are recorded in tables K-2 and K-3.

The difference between the norming curves for the truncated and full-range samples is very small (figures K-7, K-8, and K-9) and confined mainly to the region below the 10th percentile.

The comparison of these norming curves constructed from unstratified data with those in appendix J using stratified data indicates that using unstratified graphical equating produces much less bias in a truncated sample.
FIG. K-1: UNSTRATIFIED GRAPHICAL EQUATING FOR ASVAB 6E AFQT (DOD FULL-RANGE SAMPLE)
FIG. K-2: UNSTRATIFIED GRAPHICAL EQUATING FOR ASVAB 6E AFQT (DOD TRUNCATED SAMPLE)
### TABLE K-1

**COMPARISON OF EQUATING TECHNIQUES ON BON 6E SAMPLE**

<table>
<thead>
<tr>
<th>Percentiles</th>
<th>ASVAB 6E</th>
<th>AFQT raw score</th>
<th>Truncated sample</th>
<th>Full-range sample</th>
<th>Full-range case minus truncated case</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-15</td>
<td>14-15</td>
<td>0.0</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>16-17</td>
<td>16-17</td>
<td>1.0</td>
<td>2.0</td>
<td>1.0</td>
<td></td>
</tr>
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FIG. K-4: UNSTRATIFIED GRAPHICAL EQUATING FOR ASVAB 7E AFQT (DOD TRUNCATED SAMPLE)
FIG. K-5: UNSTRATIFIED GRAPHICAL EQUATING FOR ASVAB 6/7 AFQT (DOD FULL-RANGE SAMPLE)
FIG. K-6: UNSTRATIFIED GRAPHICAL EQUATING FOR ASVAB 6/7 AFQT (DOD TRUNCATED SAMPLE)
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FIG. K-7: COMPARISON OF ASVAB 6E NORMS FROM UNSTRATIFIED GRAPHICAL EQUATING USING FULL-RANGE DOD AND TRUNCATED DOD DATA
FIG. K-8: COMPARISON OF ASVAB 7E NORMS FROM UNSTRATIFIED GRAPHICAL EQUATING USING FULL-RANGE DOD AND TRUNCATED DOD DATA
FIG. K-9: COMPARISON OF ASVAB 6/7 NORMS FROM UNSTRATIFIED GRAPHICAL EQUATING USING FULL-RANGE DOD AND TRUNCATED DOD DATA
APPENDIX L

SMOOTHING OF FINAL CONVERSION TABLES
APPENDIX L

SMOOTHING OF FINAL CONVERSION TABLES

A summary of the results from unstratified graphical equating applied to the CNA data sample in appendix E is reproduced in table L-1. The percentiles equated to each raw score are shown for ASVAB forms 6/7, 6E, and 7E. These distributions are shown graphically (figure L-1). This figure shows that the conversion tables for ASVAB 6/7 and ASVAB 6E are very similar, which suggests that a common conversion table can be used for both forms. The curve for ASVAB 7E is displaced to the left by about two raw score points in the central region and about three raw score points in the higher and lower percentiles. It appears that a constant could be added to each applicant's ASVAB 7E score that would slide the curve to the right and enable using a common conversion table for all current forms of ASVAB.

Table L-1 shows the result of adding two and three raw score points to the ASVAB 7E AFQT raw score before converting to percentiles. As seen, either system produces a norm table for ASVAB 7E that is more closely compatible with those for ASVAB 6/7 and ASVAB 6E. Table L-1 and figure L-1 confirm that adding two points appears to be the best approach over most of the percentile range of interest.

To statistically test the compatibility of the separate norms for the three forms of ASVAB, we applied the conversion tables (table L-1) to an assumed mobilization population of the same size as our CNA subsamples and calculated the expected frequency distribution of applicants. The resulting distributions are shown in table L-2. We made a test for the homogeneity of parallel samples (table L-3). We see that the probability of observing differences as large as between ASVAB 6/7 and ASVAB 6E by chance if the two samples were parallel is about 0.07. We believe this is a good reason to use a common conversion table for ASVAB 6/7 and ASVAB 6E.

Similar comparisons for ASVAB 6/7 with ASVAB 7E and with variants of form 7E made by adding two and three points are also shown in table L-3. The chance probabilities are less than 0.00, and statistically the case for using the same conversion tables for forms 6/7 and 7E is not compelling. We do see that the chi-squared value is most favorable (i.e., lowest) for the case when two points were added to the ASVAB 7E score. Referring to figure L-1, we concluded that the practical difference between forms is small if two points are added to ASVAB 7E scores before converting to percentile scores. On this basis, we believe that a common conversion table is practical and construct (table L-1) the percentile associated with each raw score for mean of the three common forms--6/7, 6E, and 7E--.
TABLE L-1

SUMMARY OF UNSTRATIFIED GRAPHICAL EQUATING RESULTS

Percentiles

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<th>ASVAB 6/7</th>
<th>ASVAB 6E</th>
<th>ASVAB 7E</th>
<th>ASVAB 7E b</th>
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aData before converting to percentiles, two points are added to the raw AFQT score.

bData before converting to percentiles, three points are added to the raw AFQT score.
FIG. L-1: COMPARISON OF NORMS FOR VARIOUS FORMS OF ASVAB
TABLE L-2

INFERRED FREQUENCY DISTRIBUTIONS FOR SEPARATE NORMS OF EACH FORM OF ASVAB

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<th>Form 6E (3)</th>
<th>Form 7E (4)</th>
<th>Form 7E\textsuperscript{a} (5)</th>
<th>Form 7E\textsuperscript{b} (6)</th>
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Sample size

Table entries for Form 6/7, Form 6E, and Form 7E are based on the assumption that 100 sample members are within the indicated interval. The sample size for each interval is the number of sample members falling within that interval.

\textsuperscript{a}Two points added to each form 7E raw AFQT score.
\textsuperscript{b}Three points added to each form 7E raw AFQT score.


TABLE L-3

TEST FOR EQUIVALENCE OF SEPARATE NORMS FOR EACH FORM OF ASVAB

<table>
<thead>
<tr>
<th>ASVAB forms compared</th>
<th>Chi-squared (^{a})</th>
<th>Degrees of freedom</th>
<th>Probability of chance difference this large</th>
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<tr>
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<td>152.3</td>
<td>17</td>
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<tr>
<td>6/7 with 7E(^b)</td>
<td>81.2</td>
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<td>6/7 with 7E(^c)</td>
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<td>17</td>
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\(^{a}\)For a test of the homogeneity of parallel samples. 
\(^{b}\)Two points added to each form 7E raw AFQT score. 
\(^{c}\)Three points added to each form 7E raw AFQT score.

In table L-4 (from appendix K) we show the estimated adjustments (based on DoD data) that would be necessary to completely remove any effects due to truncation of the CNA sample. The mean of the adjustments is also shown. The adjustments are very small (less than 1 percentile) except in the region below the 8th percentile. In the region above the 15th percentile, the adjustments are generally less than 0.5 percentile and are not consistent from form to form. This may suggest inaccuracies in estimation more than a real bias that needs an adjustment. Accordingly, we smoothed the adjustments in the region below the 15th percentile and added the adjustment to get the corrected mean percentile shown in table L-5.

The corrected mean percentiles were smoothed in two stages, as shown in table L-5. In the first stage, percentiles were rounded off to whole numbers paying attention to the need for raw scores to correspond to percentiles at critical points that separate official mental groups (16, 21, 31, 50, 65, and 93rd percentiles). The result of this partial smoothing is shown in column 5 of table L-5. Further smoothing was done to eliminate an atypical progression of scores as shown in figure L-2. In our opinion this unnatural score distribution is the result of anomalies in the official conversion table for the reference test AFQT 7A shown in figure L-3. An examination of figure L-3 discloses a number of unusual undulations in the curve. Most of these undulations were removed in the hard smoothing carried out during the graphical equating in appendix H. However, it appears from figure L-2 that one anomaly remained. We
## TABLE L-4
SUMMARY OF ADJUSTMENTS FOR TRUNCATION EFFECT ON NORMS PRODUCED BY UNSTRATIFIED GRAPHICAL EQUATING

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<th>Adjustment</th>
<th>ASVAB AFQT raw score</th>
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<th>ASVAB 7E sample</th>
<th>ASVAB 6/7 sample</th>
<th>Mean value</th>
<th>Smoothed estimate</th>
<th>Approximate percentile</th>
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*Mean value from table L-1.*
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FIG. L-2: COMPARISON OF PARTIALLY SMOOTHED AND FULLY SMOOTHED NORMS
FIG. L-3: OFFICIAL CONVERSION TABLE FOR REFERENCE TEST AFQT 7A
removed the anomaly by the smoothing shown in column 5 of table L-5 and illustrated in figure L-2. The ancestry of the resultant curve with its sharp break at the 20th percentile is apparent by examining the conversion table for the reference test shown in figure L-3.
APPENDIX M

CONVERSION TABLES FOR COMPOSITES
To avoid bias from sample stratification, we used the unstratified equipercentile equating technique to build composite conversion tables. Each composite in raw score form was equated to the ASVAB 6/7 AFQT score. This procedure is possible because of the high correlations between the AFQT score and the composite scores. The definitions of the composites are given in appendix A. We used sample 5 as the data set.

For purposes of this equating the ASVAB 6/7 AFQT score was expressed in percentiles (for Air Force composites) and Army Standard Scores (for Army and Marine Corps composites). Traditional conversion tables (annex M-1) were used to convert AFQT from percentile form to Army Standard Score form.

The resulting conversion tables are given in tables M-1 through M-6.
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A REXAMINATION OF THE NORMALIZATION OF THE ARMED SERVICES VOCAL--ETC(U)

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**TABLE M-4**

AIR FORCE CONVERSION TABLE

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*WST is GT expressed in percentile form.*
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APPENDIX N

STRATIFICATION ON ASVAB 6/7 PERCENTILE SCORE

We stratified sample 5 on ASVAB 6/7 AFQT percentiles by using the weights calculated in table N-1. Subtests were normed from this stratified sample.
### Table N-1

**Calculation of Weights to Stratify Sample 5 on ASVAB 6/7 AFQT Score**

<table>
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<th>ASVAB 6/7 AFQT Percentile</th>
<th>Observed Cases (1)</th>
<th>Expected Cases (2)</th>
<th>Weight&lt;sup&gt;a&lt;/sup&gt; (3)</th>
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<sup>a</sup>Column (3) divided by column (2).
APPENDIX O

CONVERSION TABLES FOR SUBTESTS
APPENDIX O

CONVERSION TABLES FOR SUBTESTS

To build the subtest conversion tables, we chose ASVAB 6/7 (sample 5) as a representative sample of ASVAB 6E, 7E, and 6/7. Using the weights developed in appendix N we simulated the mobilization population and obtained mean and standard deviation statistics for all subsets. These statistics are computed from the following equation for all possible scores (x) on each subtest:

\[
\text{Navy Standard Score (x)} = 50 + \frac{10(x-\bar{x})}{\sigma_x}.
\]

The resultant conversion tables for all subtests are shown in tables 0-1 through 0-4.

\[\bar{x}\] denotes mean value of y and \(\sigma_x\) denotes the standard deviation.
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<th>Raw Score</th>
<th>General Information (GI)</th>
<th>Numerical Operations (NO)</th>
<th>Attention to Detail (AD)</th>
<th>Word Knowledge (WK)</th>
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<th>Space perception (SP)</th>
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### TABLE 0-3

**ASVAB 6E/7E/6/7 SUBTEST CONVERSION TABLES**
*(in Navy Standard Score)*

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APPENDIX P

CORRELATIONS AND SAMPLE STATISTICS
APPENDIX P

CORRELATIONS AND SAMPLE STATISTICS

From sample 5 stratified on ASVAB 6/7 AFQT percentile scores in appendix M we calculated mean values, standard deviations, and correlation coefficients of ASVAB subtests and composites. Statistics for the subtests are shown in tables P-1 and P-2. Correlations for the composites are shown in table P-3. Refer to appendix A for definitions of the subtests and composites.

TABLE P-1

MEAN VALUES AND STANDARD DEVIATIONS OF ASVAB 6/7 SUBTESTS

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*Decimal points omitted.*
### TABLE P-3
CORRELATION COEFFICIENTS\(^a\) OF ASVAB COMPOSITES

|       | CO | MM | GM | CL | GT | EL | EL | SC | ST | OF | GCT | M  | A  | G  | E  | USN | USN | USN | USN |
|-------|----|----|----|----|----|----|----|----|----|----|-----|----|----|----|----|-----|-----|-----|-----|-----|
| CO    | -  | 81 | 84 | 85 | 80 | 84 | 86 | 88 | 82 | 71 | 87  | 79 | 80 | 80 | 80 | 83  | 84  | 80  | 83  | 80  |
| MN    | 81 | -  | 89 | 69 | 73 | 87 | 92 | 80 | 79 | 83 | 77  | 92 | 63 | 73 | 86 | 73  | 85  | 73  | 85  | 63  |
| GM    | 84 | 89 | -  | 80 | 86 | 92 | 92 | 92 | 90 | 84 | 87  | 92 | 72 | 86 | 88 | 86  | 91  | 92  | 72  | 92  |
| CL    | 85 | 69 | 80 | -  | 92 | 84 | 78 | 88 | 85 | 73 | 90  | 64 | 88 | 92 | 80 | 92  | 82  | 84  | 88  | 79  |
| GT    | 80 | 73 | 86 | 92 | -  | 89 | 81 | 95 | 90 | 72 | 96  | 70 | 79 | 99 | 84 | 99  | 90  | 89  | 79  | 76  |
| USMC EL | 84 | 87 | 92 | 84 | 89 | -  | 91 | 91 | 97 | 75 | 90  | 77 | 76 | 89 | 94 | 89  | 85  | 99  | 76  | 62  |
| USA EL | 86 | 92 | 92 | 78 | 81 | 91 | -  | 89 | 85 | 79 | 84  | 88 | 70 | 81 | 91 | 89  | 91  | 70  | 78  | 95  |
| SC    | 88 | 80 | 92 | 88 | 95 | 91 | 89 | -  | 90 | 74 | 99  | 80 | 78 | 95 | 93 | 95  | 93  | 91  | 78  | 82  |
| ST    | 82 | 79 | 90 | 85 | 90 | 97 | 85 | 90 | -  | 71 | 90  | 70 | 77 | 90 | 88 | 90  | 82  | 97  | 77  | 82  |
| OF    | 71 | 83 | 84 | 73 | 72 | 75 | 79 | 74 | 71 | -  | 72  | 83 | 62 | 72 | 72 | 72  | 72  | 78  | 75  | 62  |
| GCT   | 87 | 77 | 87 | 90 | 96 | 90 | 84 | 99 | 90 | 72 | -   | 73 | 78 | 96 | 92 | 90  | 90  | 78  | 78  | 78  |
| USAF M | 79 | 92 | 92 | 86 | 64 | 70 | 77 | 88 | 80 | 70 | 83 | 59 | 70 | 77 | 70 | 90  | 77  | 59  | 59  | 59  |
| USAF A | 80 | 63 | 72 | 88 | 79 | 76 | 70 | 78 | 77 | 62 | 78 | 59 | -  | 79 | 72 | 79  | 74  | 76  | 76  | 76  |
| USAF G | 80 | 73 | 86 | 92 | 99 | 89 | 81 | 95 | 90 | 72 | 96 | 70 | 79 | -  | 84 | 99  | 90  | 89  | 79  | 79  |
| USAF E | 88 | 86 | 88 | 80 | 84 | 94 | 91 | 93 | 88 | 72 | 92 | 77 | 72 | 84 | 84 | 83  | 94  | 94  | 72  | 94  |
| USN G | 80 | 73 | 86 | 92 | 99 | 89 | 81 | 95 | 90 | 72 | 96 | 70 | 79 | 99 | 84 | -   | 90  | 89  | 79  | 79  |
| USN M | 83 | 85 | 91 | 82 | 90 | 85 | 89 | 93 | 82 | 78 | 90 | 90 | 74 | 90 | 83 | 90  | -   | 85  | 74  | 74  |
| USN E | 84 | 87 | 92 | 84 | 89 | 99 | 91 | 91 | 97 | 75 | 90 | 77 | 76 | 89 | 94 | 89  | 85  | -   | 76  | 76  | 76  |
| USN C | 80 | 63 | 72 | 88 | 79 | 76 | 70 | 78 | 77 | 62 | 78 | 59 | 99 | 79 | 72 | 79  | 74  | 76  | 76  | 76  |

\(^a\)Decimal points omitted.