NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

AN ANALYSIS OF THE EFFECT OF FREQUENCY
OF TASK PERFORMANCE
ON JOB PERFORMANCE MEASUREMENT

by

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March 1990

Thesis Advisor: Laura D. Johnson

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Unclassified

security classification of this page

REPORT DOCUMENTATION PAGE

1a Report Security Classification Unclassified			1b Restrictive Markings
2a Security Classification Authority			3 Distribution Availability of Report
2b Declassification/Downgrading Schedule			Approved for public release; distribution is unlimited.
4 Performing Organization Report Number(s)			5 Monitoring Organization Report Number(s)
6a Name of Performing Organization Naval Postgraduate School	6b Office Symbol *(if applicable)* 30		7a Name of Monitoring Organization Naval Postgraduate School
6c Address *(city, state, and ZIP code)* Monterey, CA 93943-5000			7b Address *(city, state, and ZIP code)* Monterey, CA 93943-5000
8a Name of Funding Sponsoring Organization	8b Office Symbol *(if applicable)*		9 Procurement Instrument Identification Number
8c Address *(city, state, and ZIP code)*			10 Source of Funding Numbers
		Program Element No	Project No / Task No / Work Unit Accession No

11 Title *(Include security classification)* AN ANALYSIS OF THE EFFECT OF FREQUENCY OF TASK PERFORMANCE ON JOB PERFORMANCE MEASUREMENT

12 Personal Author(s) Rick L. Reece

13a Type of Report	13b Time Covered	14 Date of Report *(year, month, day)*	15 Page Count
Master's Thesis	From To	March 1990	70

16 Supplementary Notation The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

17 Cosati Codes			18 Subject Terms *(continue on reverse if necessary and identify by block number)*
Field	Group	Subgroup	~~readiness, aptitude~~, task performance, frequency, ~~recency~~, theses, aptitude readiness, Performance tests. (CP)

19 Abstract *(continue on reverse if necessary and identify by block number)*

This thesis explores the effect of frequency of performance on the Congressionally mandated Job Performance Measurement, specifically the Marine Corps' portion of the study. The initial portion of the project involved the hands-on performance testing of the infantry specialities. The purpose of this thesis is to validate the use of the general technical (GT) composite of the ASVAB test as a predictor of performance in the infantry specialty and to provide recommendations to revise training priorities. Our approach in analyzing the problem included the following. (i) computing the correlation between aptitude and performance, then investigating any degrading or moderating effect that frequency might have on this relationship, (ii) an investigation into the performance of high aptitude personnel versus low aptitude personnel across frequency categories, and (iii) the relative effect of frequency on the maintenance of proficiency in each task.

We have validated the use of the GT composite as an effective predictor for hands on performance by performing analysis of variance. An interesting result was the determination that frequency is the major predictor for performance based tasks requiring continual practice for the maintenance of skill levels. while recency is the major factor in predicting tasks that are more knowledge based and require the recall of detailed procedures. Keywords:

20 Distribution Availability of Abstract	21 Abstract Security Classification	
☒ unclassified unlimited ☐ same as report ☐ DTIC users	Unclassified	
22a Name of Responsible Individual Laura D. Johnson	22b Telephone *(include Area code)* (408) 646-5243	22c Office Symbol 55Jo

DD FORM 1473.84 MAR 83 APR edition may be used until exhausted
All other editions are obsolete

security classification of this page

Unclassified

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An Analysis of the Effect of Frequency of Task Performance
on Job Performance Measurement

by

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
March 1990

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ABSTRACT

This thesis explores the effect of frequency of performance on the Congressionally mandated Job Performance Measurement, specifically the Marine Corps' portion of the study. The initial portion of the project involved the hands-on performance testing of the infantry specialities. The purpose of this thesis is to validate the use of the general technical (GT) composite of the ASVAB test as a predictor of performance in the infantry specialty and to provide recommendations to revise training priorities. Our approach in analyzing the problem include the following: (i) computing the correlation between aptitude and performance, then investigating any degrading or moderating effect that frequency might have on this relationship, (ii) an investigation into the performance of high aptitude personnel versus low aptitude personnel across frequency categories, and (iii) the relative effect of frequency on the maintenance of proficiency in each task.

We have validated the use of the GT composite as an effective predictor for hands on performance by performing analysis of variance. An interesting result was the determination that frequency is the major predictor for performance based tasks requiring continual practice for the maintenance of skill levels, while recency is the major factor in predicting tasks that are more knowledge based and require the recall of detailed procedures.

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I. INTRODUCTION

A. BACKGROUND

Between 1976 and 1980, due to an error in the norming of the Armed Services Vocational Aptitude Battery (ASVAB), over 300,000 recruits who would have been classified as "unqualified" were admitted into the service. This was more than one out of four recruits. The Marine Corps' share of this was approximately 39,000 recruits. In March 1980, the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics) presented this information to both the House and Senate Committees on Armed Services in the Department of Defense (DoD) Manpower Overview Statement. [Ref. 1 : p. 1-3]

Concerns about the suitability of service enlistment standards prompted Congress to call for an investigation of the feasibility of measuring job performance effectively. Congress also required that measures resulting from this investigation be used to link military enlistment standards directly to job performance. The House Committee on Armed Services expressed dissatisfaction with the DoD and service levels of research activity during the initial years due to the limited effort put forth by the services. This criticism was provided in the report which accompanied the Fiscal Year 1982 Defense Authorization Act. The Committee requested a report which identified all studies and research programs underway which were aimed at improving the services' ability to predict success of individuals who enter the military, and an outline of the program for the future. During hearings for the Fiscal Year 1983 budget, the House Committee tasked the Office of the Secretary of Defense (OSD) to provide direct oversight for joint-service activities addressing the development of job performance measures and their possible linkage to enlistment standards. A National Academy of Sciences (NAS) Committee on Performance of Military Personnel was formed to serve as technical oversight for the project. The Committee also requested that OSD and the services document research progress in annual reports.

Congressional concerns focussed on the services' requirement for high enlistment standards, since there were no readily observable dire consequences and the services were still able to perform their mission with one fourth of their recruits "unqualified". As a result of this Congressional mandate, the Joint-Service Job Performance Measurement/Enlistment Standards Project (JPM) was developed. The objectives were to: (1) validate the services' enlistment standards against the Hands On Performance

Test (the hands-on test developed by the Marine Corps to meet the guidelines of the JPM); and (2) link enlistment standards to on-the-job performance. In doing this, the Services hoped to validate the ASVAB as an indicator of job performance. [Ref. 1 : p. 1-4]

B. AN EXPLANATION OF THE USE OF ASVAB

The basic instrument used by the services to select enlisted personnel is a written test called the Armed Services Vocational Aptitude Battery (ASVAB). Traditionally, the ASVAB has been validated against training success at entry level speciality schools. The Joint-Service Project was begun to examine the relationship of job performance measures with the ASVAB. The ultimate goal of this thesis will be to validate enlistment standards against actual job performance.

The ASVAB is currently the single test used by the DoD to determine the aptitude levels of applicants for the four military services. In addition, ASVAB scores are used to assign new recruits into Military Occupational Specialities (MOS). Because the ASVAB determines the qualifications for entry into a large number of skill training courses, it is designed to measure aptitude by means of ten subtests. Four of the subtests (word knowledge, paragraph comprehension, arithmetic reasoning, and numeric operations) are combined to produce the Armed Forces Qualification Test (AFQT). AFQT scores are used as the primary selection screening device and as a measure of enlisted recruit quality. [Ref. 1 : p. 1-2]

The Services combine various ASVAB subtests into Service specific composites. The composites' most important purpose is to determine eligibility for MOS assignment. The Marine Corps uses four composites: the General Technical (GT), Mechanical Maintenance (MM), Electronics Repair (EL), and the Clerical, Administrative (CL). An accurate predictor of potential job performance is essential for training success, retention of skilled personnel, and mission performance. Any deficiencies in the selection and classification system lead to increased training times and other than end of active service attrition with concomitant increases in recruiting and training costs. The failure to achieve optimal assignment of available manpower into the various occupations could also cause critical shortage of skills.

C. TEST DEVELOPMENT AND ADMINISTRATION

The Marine Corps JPM effort was designed to validate enlistment standards by carefully studying a small number of MOS's in each of the four composite categories. The results would be generalized to other MOS's in each of the composites as necessary.

In 1986-7, 2500 Marines in the infantry occupational area, which uses the GT composite, were tested. The following explanation describes the development and administration of the test.

The Individual Training Standards (ITS), developed by the Marine Corps Combat Development Center (MCCDC), were the primary source of detailed information that defined the job tasks of the infantry occupational field. Tasks were sampled from those listed in the ITS's and subjected to extensive task analysis to construct hands-on tests that could be accurately and objectively scored. Seventy-five basic infantry tasks were chosen and are listed in Appendix A along with the labels used to identify the task.

Unlike written tests in which reliable and objective scoring keys are easily applied, hands-on-testing involves a judgment of whether or not an individual performed a particular step adequately. To minimize the variance of the subjectivity involved in such judgments, the test administrators were trained for two weeks in standardized test administration procedures. Retired Marine Corps staff non-commissioned officers (SNCO's) were hired to serve as test administrators because of their experience in the infantry field, knowledge of the Marine Corps, and ability to work well with young Marines. These individuals were familiar with all the test content (unlike non-prior-service civilian test administrators) and also had no vested interest in the outcome of the testing (as would active duty in-Service personnel).

Four first-term enlistment infantry specialities were tested: rifleman (MOS 0311), machine gunner (MOS 0331), mortarman (MOS 0341) and assault man (MOS 0351). Additionly, second-term enlistment infantry leaders (MOS 0369) were also tested. Each Marine was tested for two days. One day was used for the hands-on testing and the other day for administering the written job knowledge tests and for re-administering the ASVAB. Each hands-on task required the performance of a series of steps that were scored "go" or "no-go" (either they were successful or they were not). Task scores were computed as the percent of steps correctly performed, thus task scores ranged from 0 to 100 percent. In addition to performing the task, Marines were required to provide information regarding recency (the last time the particular task was performed) and frequency (the number of times the task was performed in the last six months). An example score sheet is included in Appendix B. Table 1 on page 4 gives the coding used to record recency and frequency data. [Ref. 1 : pp. 7-2 through 7-5]

Table 1. RECENCY AND FREQUENCY CODING

Recency			Frequency	
Code	Last time task performed		Code	Number of times performed in last 6 months
1	< 1 week		1	none
2	> 1 week, < 1 month		2	1 or 2
3	> 1 month, < 6 months		3	3 to 10
4	> 6 months		4	> 10
5	never			

D. PREVIOUS EFFORT

Previous work on the JPM [Ref. 1 : p. 7-13] has concentrated on the effects of the recency of practicing a task on the performance of that task for infantry Marines. The results of the infantry study indicate that high-aptitude personnel significantly outperform low-aptitude personnel on the Hands-On Performance Test across all recency levels. Low-aptitude personnel with recent task performance (less than six months) are comparable to high-aptitude personnel with limited task performance (greater than six months). Such findings speak strongly to the need for high-aptitude personnel because training and refresher performance is not always possible in time of conflict. Potential savings in training costs may be realized as a result of employing a force of high-aptitude personnel who require less recent practice to maintain a given level of proficiency.

The previous work on recency has also identified tasks which range from stable (small correlation between recency and hands-on performance) to perishable (high correlation between recency and hands-on performance). The perishable tasks reflect skills which are degraded measureably if not practiced on a regular basis. The benefit of identifying the perishability of tasks was observing those that may deserve additional attention in the training workup cycle or immediately prior to a deployment. It also identifies tasks where performance degrades more slowly over time. This information gives the infantry commander the ability to schedule training prior to a deployment or exercise in such a way that the level of proficiency across the twelve duty areas can be improved to best utilize the pre-deployment workup time.

E. MOTIVATION BEHIND THE JPM

The primary benefit of the JPM study will be to identify aptitude levels of new recruits necessary to adequately perform actual job requirements. This will assist the Marine Corps in defending against calls for a reduction in enlistment quality. The JPM project is vital to demonstrate the need for quality personnel and to defend the requirement for pay, bonuses, advertisement, and other resources used to attract and retain high quality personnel. The services spend over two billion dollars (Fiscal Year 89 numbers) per year to recruit and retain high quality personnel. The Marine Corps' share of this is in excess of 230 million dollars, not including educational and other benefits used as incentives to get and keep top caliber people. If high aptitude cannot be shown to predict on-the-job performance, the Marine Corps could take significant cuts in the number of recruiters and in the millions of dollars spent each year in reenlistment bonuses.

Another important factor to consider is the effect on enlisted pay scales. One of the principal arguments for keeping them at current levels, or even increasing them, is that the services must compete with civilian industry for high school graduates. Without a case for high quality personnel, pay scales may not keep pace with the private sector. Additionally, if the Marine Corps cannot make a case for its own high standards, it may be forced to conform to other services standards or lose high quality personnel to other services who make a better case for high quality recruits.

In addition to quality issues, JPM is expected to provide benefits that will impact training. The results of JPM have already helped to identify certain perishable skills (i.e., skills which diminish if not performed recently). Another prospective benefit is to establish a frequency pattern for the tasks (for example, the number of times a task must be performed during a six month period to maintain proficiency). Finally, the results help to establish a performance baseline that will aid commanders in reassessing training priorities. The fundamental measure of the preparedness and effectiveness of infantry units is **readiness**, which is the ability of a unit to immediately respond to any mission which it is assigned. The most important and overriding result of JPM is hoped to be a tool to assist in the improvement of the readiness of infantry units.

II. METHODOLOGY

A. PURPOSE

The purpose of this thesis is to analyze the relationship and effect that the frequency of task performance has on the test scores of the Job Performance Measurement. Many tasks and duty areas are practiced quite frequently. For example, the assembly and disassembly of a rifle is performed at least weekly by Marines in the infantry MOS due to the need for operator maintenance (care and cleaning of the weapon). Other tasks are not performed as frequently. The duty areas of mines and first aid are not practiced as frequently because there is no overriding concern such as mechanical maintenance to cause the recurring performance of these tasks. Some areas need only be performed on a frequent enough basis to maintain familiarity and limited proficiency, while other tasks are deemed far more important and a high level of proficiency is desired, therefore these tasks are repeated far more frequently. Additionally, cost constraints impact upon the availability of ammunition and prevent the frequent live firing of some weapons.

The analysis of frequency of performance is expected to reinforce the previous results as well as show any relationship that may exist between frequency and recency. First, in the work that follows the correlation of task performance and the composite scores of the ASVAB will be examined to analyze the relative predicting ability of each of the composite scores for the infantry MOS. This will be examined further by analyzing any effect that frequency has on the aptitude-performance relationship. Finally aptitude and frequency will be regressed against task performance to determine any differences that frequency of performance may have on the performance of high and low quality personnel.

B. DESCRIPTION OF DATA

The data supplied by Headquarters, Marine Corps (HQMC) is described below. The data consists of information supplied on 1882 Marines. A data field includes information that identifies the individual Marine by MOS, test site and the date the test was conducted. Information gathered during testing comprise the largest part of the data field. Included are the overall Hands-On Test Score, which is a weighted sum of duty area scores that include some MOS specific tasks, and the Hands-On Core Score, which is the average of the sum of duty area scores common to all four MOS's (0311,

0331, 0341, 0351). Scores, recency and frequency data are given in the data field for the twelve duty areas which are listed in Table 2 below.

Table 2. DUTY AREAS INCLUDED IN THE JPM TESTING FOR INFANTRY

Communications
First Aid
Grenade Launcher
Hand Grenades
LAW (Light Antitank Assault Weapon)
Land Navigation
Mines
NBC (Nuclear, Biological and Chemical) defense
Night Vision
SAW (Squad Automatic Weapon)
Security-Intelligence
Tactical Measures

Additionally, scores, recency and frequency are provided for each of the 75 tasks listed in Appendix A. Finally pay grade, time in service (months), education status (high school graduate, non-high school graduate) are given for each individual as well as ASVAB scores for GT, MM, EL, CL and AFQT composites. The data has missing values due to the fact that two forms of the test were administered to the same unit on different dates. Some tasks were included on both forms and some were not. This step was taken to reduce the advantage Marines tested on the second day might gain by receiving test information from those that took the first test.

C. RELATIONSHIP BETWEEN FREQUENCY AND RECENCY

The relationship between frequency and recency will be examined initially by conducting the nonparametric Chi-square test for independence using a three by three contingency table. This test will be performed using data from all 1882 records and all 75 tasks. The association between recency and frequency will be analyzed by using the data from the 75 tasks and examining their dependence. Finally the average recency for the 75 tasks will be plotted against the average frequency for the 75 tasks to graphically illustrate any relationship that may exist.

D. APTITUDE-TASK PERFORMANCE RELATIONSHIP

The relationship between aptitude and task performance will be examined by computing a matrix of sample correlation coefficients (i.e., the correlation between the score on each task and the five composite scores) to determine the suitability of using any of the composite scores to linearly predict job performance for each task. This analysis will be summarized at the duty area level and will be graphically illustrated by a plot of the correlations of composite scores and duty area scores against duty areas for each composite score. The duty area scores will give an indication of the performance in the major categories into which the tasks can be grouped. A matrix of sample correlation coefficients of the correlation between tasks and composite scores will be computed for each of the frequency categories to determine the degrading or moderating effect of frequency on the task-aptitude relationship. The correlation found for the frequency categories will be compared to that for the overall data to give an indication of how the correlation varies by frequency of performance relative to the average correlation. This will be summarized by plotting the average correlations of all tasks against the frequency categories. The sample correlation coefficients of the correlation between task score and frequency of performance will be organized into a matrix that will identify the tasks that have a proportional return on the amount of practice invested (amount of practice reflects the performance on the task, i. e., infrequent practice results in low scores, frequent practice results in high scores) as well as show those that have less than or greater than a proportional return. The tasks will also be ranked by sample correlation coefficient to reflect how the performance of certain tasks depends on the frequency of performance.

Finally, in order to determine any difference that may exist in the hands-on performance of different quality individuals (as determined by GT score, which is used to assign personnel into the infantry specialty), the task score will be plotted against the frequency category. The quality levels that we are concerned with are listed in Table 3 on page 9.

Table 3. BREAKDOWN OF MENTAL GROUPS BY GT COMPOSITE SCORE

Mental Group	GT
I, II	> 110
IIIA	100-109
IIIB	90-99
IV	< 89

The Hands-On Test Score (HOTS) for low quality (GT < 100) personnel will be plotted against the frequency. On the same graph, the HOTS for high quality (GT ≥ 100) personnel will be plotted against the same scale of frequency. This relationship will be examined for patterns such as:

- a shift in the mean between the two quality groups,
- the frequency needed to maintain a given level of proficiency for each quality group,
- any task where an increase in frequency of performance might overcome lower mental potential,
- tasks where performance levels off (plateaus) with frequency and
- tasks where performance continues to increase (or decrease) with frequency.

E. ANALYSIS OF VARIANCE

In order to determine which factors have the most effect on task performance, analysis of variance will be performed on each task. The full scale model will consist of the task score as the dependent variable with GT score (as categorized in Table 3), recency, frequency and all possible cross products of the three as the factors which could affect task scores. We will analyze the significance of the effects of all the variables upon the individual task scores. Finally, the analysis for all 75 tasks will be analyzed to investigate any patterns that may exist.

III. FREQUENCY-RECENCY RELATIONSHIP

A. INTRODUCTION

Determining the association between frequency of performance and recency of performance is of interest as we attempt to predict task performance based in part on these factors. The interactions may give us information to determine trade offs that may be made between recency and frequency and still maintain high levels of performance.

As we analyzed the four frequency categories and the five recency categories, a reduction in the number of categories was considered obvious. The frequency categories are dependent upon the task being performed within the last six months. Recency category 4 indicated more than six months since the task was last practiced and category 5 indicated it was never practiced. These two categories should contain no entries for frequency and any entries that are included should be disregarded as erroneous since all frequency data was within six months. We have now reduced the categories to 1, 2, and 3 for recency. If the individual responds in one of these categories, then the task has been performed within six months. This allows us to remove frequency category 1 which is that the task has not been practiced within six months. The result of eliminating these values conveniently provides us with three categories each for recency and frequency.

B. ANALYSIS

The method chosen for determining the existence of any association between frequency and recency was the Chi-square test for independence [Ref. 2 : pp. 158-162]. The cell counts were arranged into a 3 x 3 contingency table as seen in Figure 1 on page 11. The test was conducted based on the null hypothesis of no association between frequency and recency.

The resulting test statistic was highly significant (< 0.001) and the null hypothesis is rejected resulting in a high confidence that there is an association between frequency and recency. In order to measure the degree of association between the two factors, the phi coefficient (ϕ) is used. With our values for the χ^2 test statistic T (6074.727), and the total sample size N (31241), we compute the phi coefficient from the following equation:

$$\phi = \sqrt{\frac{T}{N}}$$

Our value is 0.441 which indicates a significant positive association. Fleiss [Ref. 3 : pp. 41-43] arbitrarily establishes phi values less than 0.35 as no more than trivial association. Thus, this phi-value would be considered non-trivial by these standards.

EXPECTED COUNTS ARE PRINTED BELOW OBSERVED COUNTS

		TASK FREQUENCY CATEGORIES 2	3	4	TOTAL
RECENCY CATEGORIES	1	1114	988	2247	4349
		2456.47	1126.33	766.20	
	2	3846	2718	2114	8678
		4901.63	2247.49	1528.88	
	3	12686	4385	1143	18214
		10287.89	4717.18	3208.92	
	TOTAL	17646	8091	5504	31241

CHISQ =733.661 + 16.989 +2.9E+03 +
227.345 + 98.503 +223.933 +
558.998 + 23.392 +1.3E+03 = 6074.727
DF = 4

Recency (last time task performed)		Frequency (number of times performed in last 6 mos.)	
1	< 1 week	2	1 or 2
2	> 1 week, < 1 month	3	3 to 10
3	> 1 month, < 6 months	4	> 10

Figure 1. Chi-square Test for Association Between Task Frequency and Recency

The graphical representation in Figure 2 on page 12 reveals the association between frequency and recency. The horizontal axis reflects the recency (categories have been converted to months using the midpoint of each category) and the vertical axis represents the counts that appear in each cell. The three lines correspond to the frequency categories. We see that the largest occurrence is of the least frequent (category 2) and

the least recent. The number of observations decrease as we look at the more recent performance with frequency category 2. Frequency category 3 behaves in the same manner with the number of occurrences decreasing as we observe more recent performance. The category representing the most frequent performance (4) behaves differently.

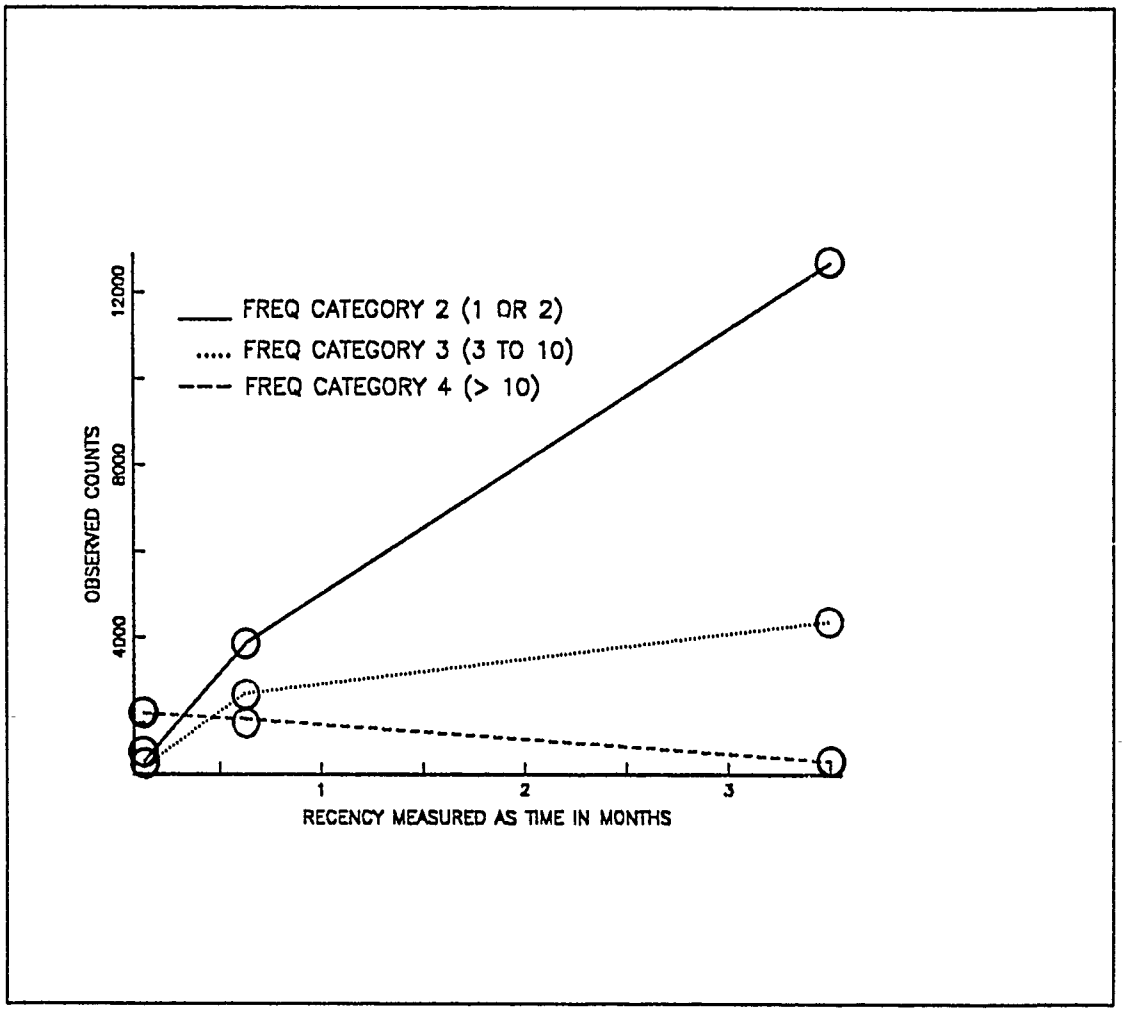


Figure 2. Graphical Representation of Observed Cells from the Chi-Square Test

As performance becomes less recent, the observations increase. This is consistent with what we would reasonably expect. The majority of tasks are not practiced on a very frequent basis. Tasks that are practiced very frequently tend to also be practiced more recently.

The final graphical representation displays a plot of the average frequency for each of the 75 tasks versus the average recency for each of the 75 tasks. The categories have

been converted into repetitions for frequency and into months for recency by using the midpoint of each category as the value for that category. Figure 3 displays the 75 data points along with a fitted line reinforcing the same relationships discussed previously. The additional information gained by this graph is the interaction between frequency and recency.

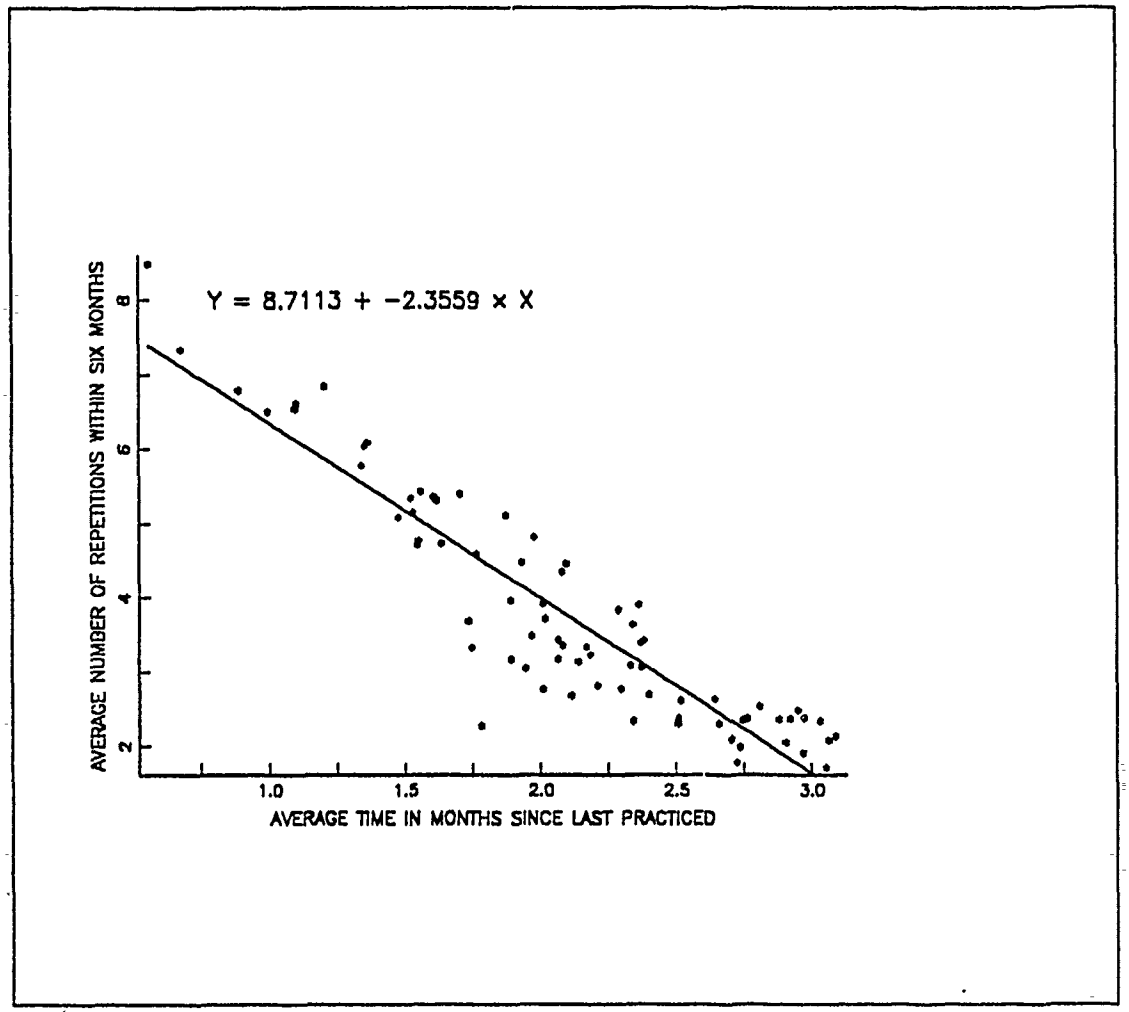


Figure 3. Average Task Frequency versus Average Task Recency

The categories representing the most frequent performance tend to be associated with categories representing the most recent performance. This seems to hold true among all tasks analyzed. The majority of the data points lie in an area of the graph representing a recency of between one and six months and a frequency one to three in-

stances. This is consistent with our analysis of the occurence of observations seen in the previous figure.

In summary, our analysis of the frequency recency relationship reveals four facts:

- A relationship exists between frequency and recency.
- The vast majority of tasks are practiced with a recency of between one month and six months and a frequency of one or two times within a six month period.
- High frequency of performance is associated with high recency of performance.
- Low frequency of performance is associated with low recency of performance.

The effects of frequency of performance on task performance will be analyzed in a later portion of this thesis. In the next chapter we will examine the relationship between aptitude and task performance.

IV. APTITUDE-TASK PERFORMANCE RELATIONSHIP

A. INTRODUCTION

As previously discussed, the GT composite score on the ASVAB test is used to assign new recruits to infantry specialities. In this chapter we investigate the effects of not only the GT composite, but also the effects of the CL,EL,MM, and AFQT composites upon task performance. This is of interest in establishing the GT composite as the proper predictor of performance in the infantry or in identifying one of the other composites as a superior predictor for infantry performance. Other aspects of interest are:

- any effect that frequency has upon the aptitude-task relationship,
- comparison of the performance of different quality individuals (based upon GT score) and
- relative comparison of the effect of frequency on task performance.

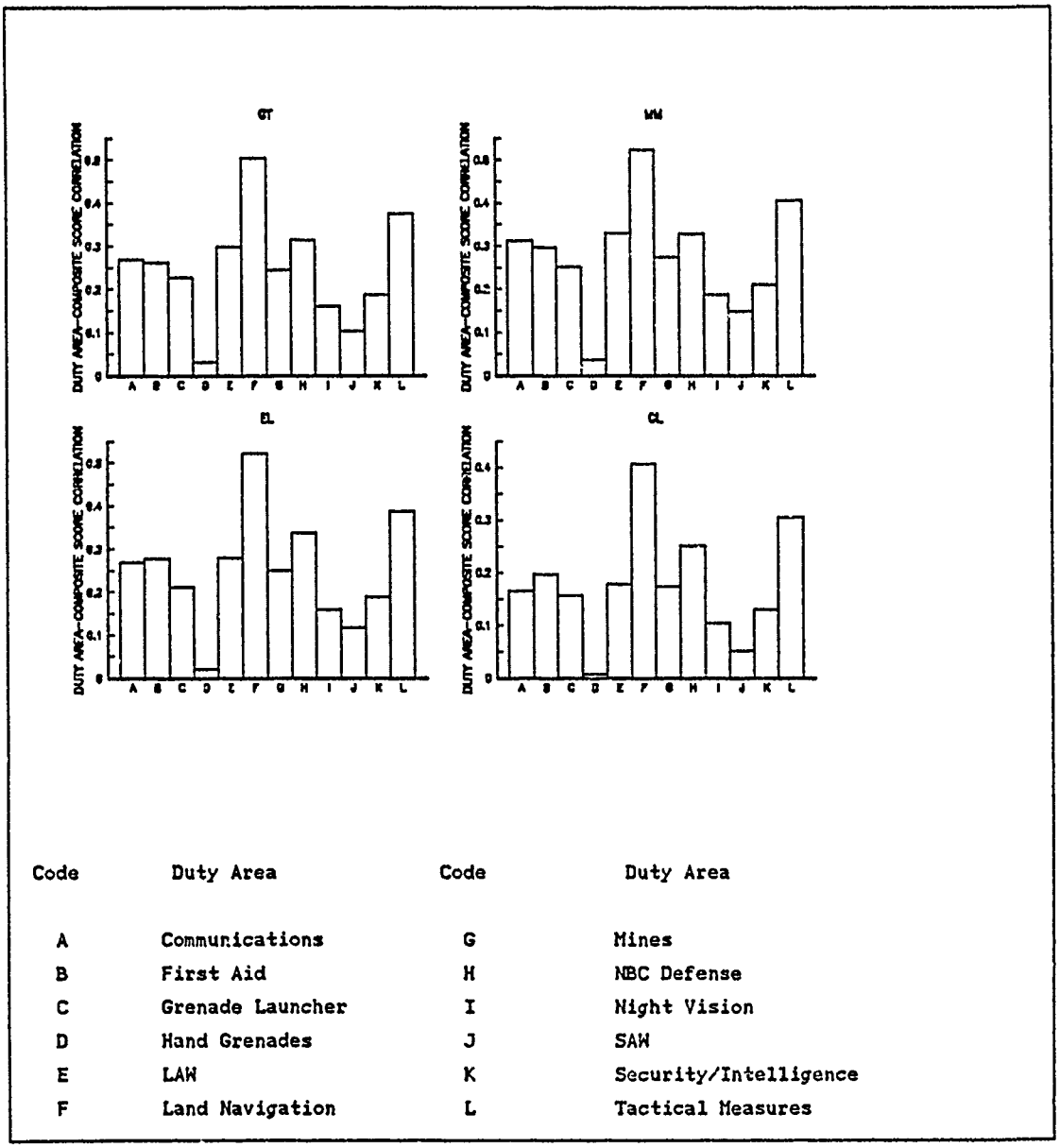
B. TASK-APTITUDE RELATIONSHIP

The method we have chosen to investigate the relationship between task performance and aptitude is the sample correlation coefficient, r. We have computed the correlations between the task score for each of the 75 tasks and the GT, EL, CL, MM, and AFQT composites. The matrix of these correlations is included as Appendix C (the description of tasks that correspond to the labels are in Appendix A). Looking at the extreme values of the correlation coefficient from the GT column, we have arbitrarily chosen two groups: those with an $r > 0.35$ and those with an $r < 0.10$. The tasks that have the higher coefficient are from the land navigation duty area and the nuclear, biological and chemical (NBC) defense duty area. These tasks rely predominantly on factual and knowledge based skills. The tasks with the lowest correlations are from all of the duty areas, but are tasks that rely more heavily on hands-on performance to demonstrate proficiency and continual practice to maintain mastery of the task. This implies that tasks with low correlations may have to be practiced more frequently to maintain skill levels. To summarize the relationship between aptitude and task performance, we have included a smaller matrix containing the sample correlation coefficients of the composites and the duty area scores. Duty area scores are a weighted average of the task scores included in the duty area. This matrix is included as Table 4 on page 16.

Table 4. CORRELATION OF DUTY AREA SCORES (WEIGHTED AVERAGE OF TASK SCORES) WITH ASVAB COMPOSITE SCORES

	GT	MM	EL	CL	AFQT
COMMUNI-CATIONS	0.26901	0.31255	0.26816	0.16601	0.22529
FIRST AID	0.26241	0.29683	0.27734	0.19657	0.23474
GRENADE LAUNCHER	0.22667	0.25222	0.21185	0.15657	0.18425
HAND GRENADES	0.03840	0.03594	0.02096	0.01646	0.02719
LAW	0.29909	0.32980	0.27857	0.17862	0.23650
LAND NAVIGA-TION	0.50401	0.52368	0.52264	0.40712	0.46512
MINES	0.24399	0.27320	0.24899	0.17369	0.21701
NBC DEFENSE	0.31452	0.32727	0.33700	0.25106	0.30743
NIGHT VISION	0.16000	0.18641	0.15945	0.10493	0.13104
SAW	0.10359	0.14835	0.11722	0.05119	0.07947
SECURITY INTEL-LIGENCE	0.18660	0.20874	0.18868	0.13038	0.17101
TACTICAL MEAS-URES	0.37600	0.40483	0.38691	0.30592	0.34936

By observing the relative magnitude of the correlations across the rows we can see that the MM composite possesses a higher correlation with duty area performance and the values of the correlations corresponding to the CL composite are the lowest. The correlations of the GT and EL composites are very close and are slightly higher than the AFQT. As we look down the columns, we find that the duty areas of land navigation, NBC defense and tactical measures have a high correlation with all composites. On the other extreme, we see that the correlation of composite scores with the duty areas of hand grenades and squad automatic weapon (SAW) are small. This observation reinforces the relationship we discovered with our analysis of the tasks. Land navigation, NBC defense and tactical measures can be classified as tasks involving intellectual skills. Hand grenades and SAW are more properly identified as physical tasks or tasks involving simple motor skills. A graphical representation of the duty area-composite matrix is included as Figure 4.



Code	Duty Area	Code	Duty Area
A	Communications	G	Mines
B	First Aid	H	NBC Defense
C	Grenade Launcher	I	Night Vision
D	Hand Grenades	J	SAW
E	LAW	K	Security/Intelligence
F	Land Navigation	L	Tactical Measures

Figure 4. Plot of Duty Area-Composite Score Correlations for each Duty Area

Each box represents one of the duty areas. The vertical axis represents a scale of correlations from Table 4. As we previously observed from the matrix of correlations, the land navigation (F), NBC defense (H), and tactical measures (L) duty areas possess relatively high correlations. This shows that high scores in these duty areas tend to occur with high scores in not only the GT composite, but in all composites. Conversely, the tendency for the hand grenades (D), night vision (I) and SAW (J) scores to be high when

composite scores are high is not very strong. For hand grenades there is almost no correlation with composite score (less than 0.04 for all composites).

Figure 4 allows us to see that all of the composites possess approximately the same ability to predict task performance in the infantry for each duty area. The CL composite is inferior to all of the other composites for all tasks. MM, EL, and GT are all effective in predicting task performance in the duty areas where intellectual skills are predominant.

C. EFFECT OF FREQUENCY ON PERFORMANCE

In order to analyze the effect that the frequency of performance has upon the task-aptitude relationship, we have followed our previous step of computing a matrix of sample correlation coefficients of each task with each of the composites. To contrast the effects of frequency, we have computed the matrices of correlation coefficients for each of the frequency categories. Due to the amount of missing data in the fourth frequency category (practiced more often than ten times within six months), we have combined it with the third frequency category (practiced three to ten times within the last six months). Therefore, in this section frequency category 3 corresponds to a task being practiced three or more times within the last six months.

To represent this relationship graphically, we have chosen to use the four plots displayed in Figure 5. The horizontal axis represents the frequency of performance measured in repetitions within the last six months. The vertical axis represents the average of the 75 correlations that we have computed for the composite that is designated for the particular graph. As we traverse each of the graphs from a frequency of having never been practiced to a frequency of having been practiced one to two times, we observe that the average correlations increase. Concentrating on the MM graph and traversing on to a repetition of more than three times, we see that the correlations decrease. The initial increase represents a greater tendency for task scores to be higher corresponding to high composite scores as the individual gains the benefit of initial practice. However in the case of MM, once the task is practiced one or two times , the occurence of having a high composite score and scoring high on task performance is shown to decrease with added practice. Therefore for MM we can infer that a frequency of performance of greater than three times within six months will help to overcome an initial deficiency in aptitude as measured by composite score. The EL graph shows a "plateauing" effect (a level of frequency at which the correlation becomes constant) when a task is practiced more than one or two times. We infer that personnel with high aptitude in the EL

composite do not gain very much advantage in task performance by continued practice. The GT and CL graphs behave similiar to each other.

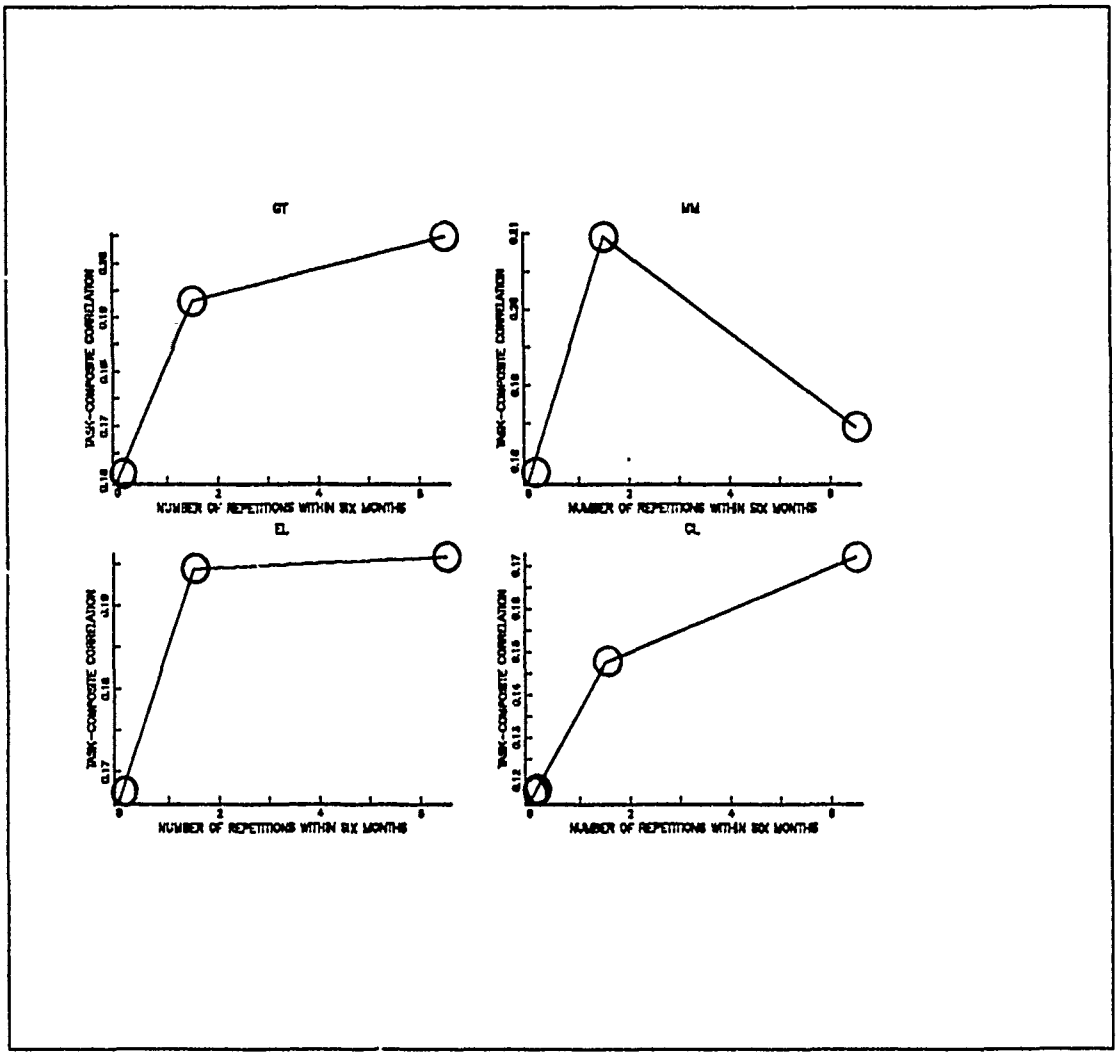


Figure 5. Effect of Frequency upon Task-Aptitude Relationship

With more practice, the correlations of composite score and task performance increase. This leads us to infer that personnel with higher aptitude are likely to demonstrate greater task performance scores with increased practice. The behavior of the MM and EL graphs indicate that frequency has a moderating effect on aptitude. The degree of this moderating effect on aptitude will be investigated in the last section of this chapter. It is interesting to note that GT, MM, and EL all have correlations that are higher (> 0.16), with only classroom instruction and no practice, than the correlation of CL (<

0.15) with two repetitions of practice. This is consistent with our analysis in the previous section where we observed that CL possessed the lowest correlation for all tasks. This observation remains true across all frequency categories. This reinforces the observation that infantry tasks are more mechanical and physical than clerical.

Our analysis of the moderating effect of frequency upon the task-aptitude relationship can be summarized with the following three points:

- frequency has a greater moderating effect on task performances that are more highly correlated with aptitude (composite score). MM and EL are moderated by frequency and the correlation of GT with task performance increases at a lesser rate with three or more repititions of practice,
- initial practice improves the task-aptitude relationship (higher aptitude helps one to assimilate the ability to perform tasks with limited practice) and
- repetitive practice (three times or more) seems to partially offset aptitude in some cases (MM and EL composites).

D. COMPARATIVE EFFECTS OF FREQUENCY ON TASK PERFORMANCE

We are interested in using our previous results to organize the tasks into a matrix form to investigate additional effects of frequency on task performance and to provide information to infantry commanders to aid in structuring the frequency of practice for these tasks. We have utilized the methods adopted by Dr. Paul Mayberry [Ref. 4 : pp. 8-13] in his analysis of the relationship between task performance and task recency. We have divided the 75 tasks into quintiles based upon the average task performance score. This is represented by the vertical partition in Figure 6. We have designated the quintile with the highest average score as the most proficient and the quintile with the lowest average score as the least proficient. The horizontal partition has been achieved by again dividing the task into quintiles, but this time using the average frequency. The quintile with the highest aver[illegible]quency has been designated most frequent and the lowest as the least frequent. The tasks that lie along the diagonal from the lower left corner to the upper right corner are tasks where there exists a proportional return in proficiency for the frequency of practice conducted on the task. The skills in the upper corner are skills which the Marine practices frequently. They include the following:

- operate PRC-77 (CR03)
- assemble PRC-77 (CR04)
- fieldstrip SAW (SL03)
- assemble SAW (SL04)
- individual movement (TL01)

- camouflage self and equipment (TL05)
- control unit movement (TM09).

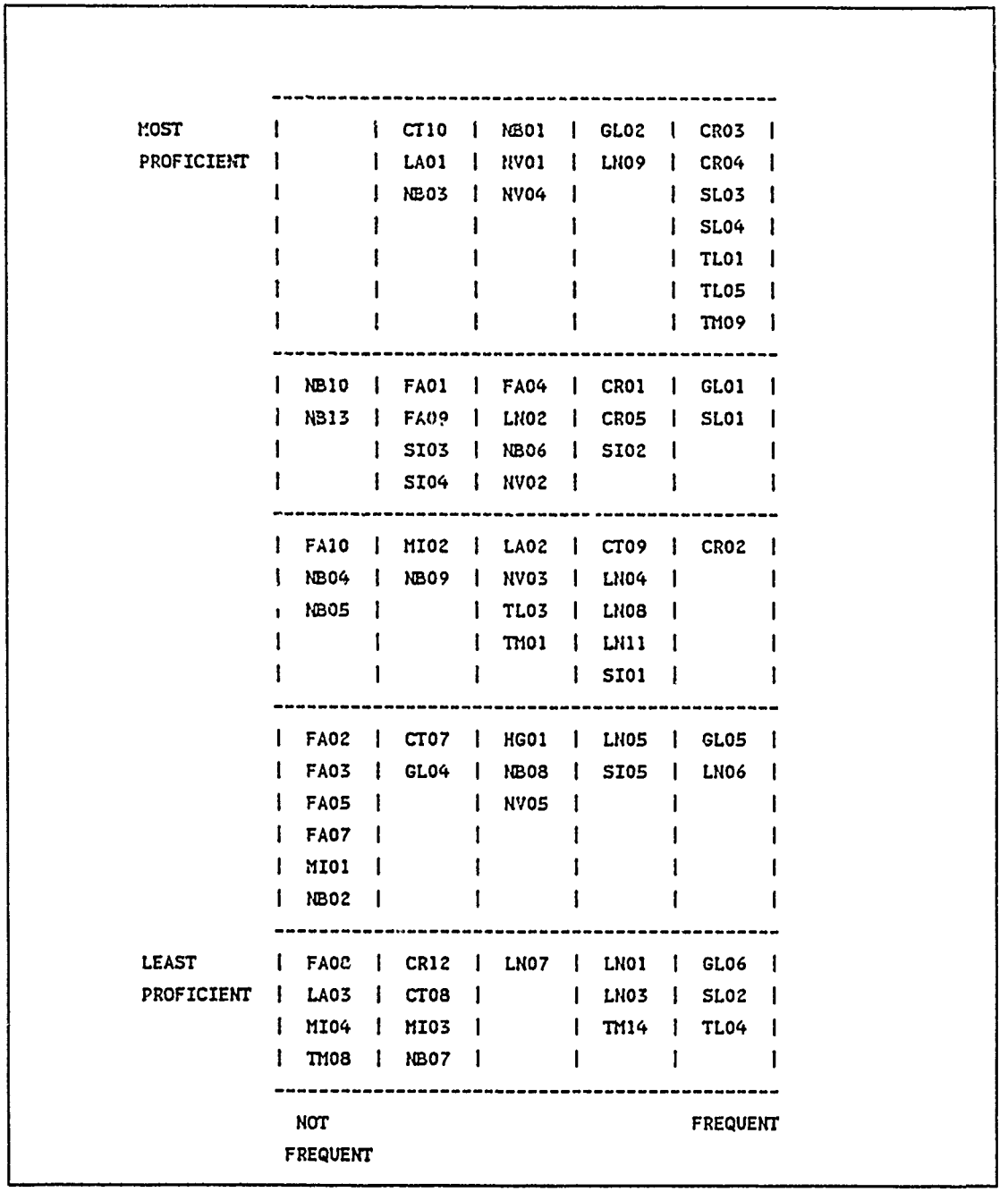


Figure 6. Comparative Relationship between Performance and Frequency

These skills are also the tasks that Marines are most proficient in. On the other extreme, the lower left hand corner represents tasks that are practiced infrequently or not at all and the proficiency of Marines is correspondingly low. These task include:

- perform chest pressure-arm lift (FA08)
- restore expended LAW (LA03)
- recover Claymore mine with tripwire (MI04)
- direct helicopter landing and takeoff (TM08).

The tasks in the upper left triangle above the diagonal include tasks where there is a greater return on task performance for frequency of practice. The tasks are practiced infrequently to regularly but Marines still demonstrate a greater than proportional score on their performance. Most of the first aid tasks lie in this area. Theses are tasks such as treat for schock and treat for abdominal wound that can be performed with a high level of proficiency with just minimal refresher training. Prepare the LAW to fire (LA01), give visual NBC alarm (NB01), and pace distance (LN02) are other examples of tasks that Marines maintain high proficiency in with little training.

The lower right triangle below the diagonal represents tasks that are practiced more frequently but offer a less than proportional return in task performance. The majority of the land navigation tasks fall into this region. The more technical and detailed tasks also are in this triangle. A sample of these tasks include:

- call for and adjust indirect fire (TM14)
- determine location by resection (LN07)
- operationally inspect SAW (SL02)
- emplace stakes for grenade launcher (GL06).

This figure reflects the current training emphasis in Marine Corps infantry units and the resultant performance. It provides a tool to reassess training priorities in terms of frequency of performance. It identifies tasks (in the upper triangle) that we can neglect in terms of frequent practice and still maintain a high level of proficiency. Tasks that do not give a proportional return on the frequency of performance are identified so that the method of training or practice may be modified or upgraded in order to increase proficiency.

Another method adopted from Mayberry [Ref. 4 : pp. 14-15] is the categorization of tasks into four groups. These categories range from stable to highly perishable as can be seen in Figure 7. The numbers in the figure are the correlations of the corresponding

task with the frequency of performance. The categories are arbitrary and are intended merely for broad generalizations.

CT08	0.04	CT07	0.09				
CT10	0.02	CT09	0.10				
FA03	0.03	FA01	0.09				
FA05	0.01	FA02	0.085				
FA07	0.02	FA04	0.083				
FA08	0.06	FA09	0.09				
GL02	0.04	GL01	0.09				
HG01	0.00	GL04	0.13				
LN09	0.07	GL05	0.13				
MI03	0.05	GL06	0.084			CR02	0.21
MI04	0.05	LA01	0.14			CR04	0.26
NB08	0.04	LN03	0.10			CR12	0.22
NB09	0.002	MI02	0.12	CR01	0.17	LN01	0.28
NB10	0.05	NB01	0.12	CR03	0.19	LN04	0.30
NB13	0.07	NB04	0.10	CR05	0.18	LN06	0.27
NV03	0.05	NB06	0.082	FA10	0.16	LN07	0.35
SI02	0.05	NV01	0.09	LA02	0.17	LN08	0.27
SI03	0.07	NV04	0.09	LA03	0.19	LN11	0.21
SI04	0.00	NV05	0.12	LN02	0.17	NB03	0.20
SI05	0.07	SL01	0.10	LN05	0.1999	NB07	0.25
TL01	0.07	SI01	0.09	MI01	0.16	NV02	0.21
TL04	0.02	TL03	0.09	NB02	0.19	SL02	0.29
TL05	0.03	TM08	0.14	NB05	0.153	SL03	0.39
TM01	0.005	TM09	0.15	TM14	0.18	SL04	0.39

STABLE	MODERATELY STABLE	SOMEWHAT PERISHABLE	PERISHABLE
(0.00-0.08)	(0.08-0.15)	(0.15-0.20)	(0.20-0.39)

Figure 7. Perishability of Task Performance with Frequency

High correlations reflect a greater effect of frequency on hands-on task performance. The tasks with high correlations are considered perishable since the skills will diminish without practice. Small correlations reflect negligible effect of frequency. Tasks with small correlations are considered stable in that the proficiency does not decrease if the skill is not practiced frequently.

Tasks in the land navigation, SAW, and commmunication (radio) duty areas were identified as perishable if not performed on a frequent basis. These are tasks that should be practiced on a more frequent basis to maintain proficiency. Tasks in the first aid, security, intelligence, tactical measures, grenade launcher, hand grenade, and communication (wire and phone) duty areas are stable tasks that only require infrequent refresher training to maintain proficiency.

The perishable tasks represent skills relying on hands-on performance and continual practice for mastery. The stable tasks involve factual and knowledge based skills and do not depend upon repeated practice to maintain proficiency. Perishable tasks that are critical to the performance of a unit's mission need frequent practice to maintain proficiency. Combining the results from Figures 6 and 7, we find a less then proportional return on the duty area of land navigation, yet it is a highly perishable skill. Although the amount of time invested may seem better applied elsewhere to obtain higher proportional performance, we must frequently practice the land navigation tasks to maintain the low level of proficiency. On the other hand, first aid gives a higher return on practice invested and the first aid tasks are stable, not depending greatly on practice. Therefore, practice for first aid should not be increased and if a unit is constrained by limited practice time, first aid tasks would be the obvious area for reduction or elimination of practice time.

E. COMPARISON OF FREQUENCY EFFECTS FOR QUALITY

Previously we discovered that frequency has a moderating effect on aptitude. In this section, we will investigate the degree of this moderating effect by analyzing the measure of aptitude in the infantry speciality, the GT composite. We conducted this portion of our analysis by first dividing our sample into categories, those with GT equal or above the mean (100) and those with GT below the mean. We then averaged the task scores by frequency category for each of the groups. Once again, due to missing data points we have combined frequency categories 3 and 4 into category 3. As before, we have converted the categories into number of repetitions by using the midpoint of each category. The graph representing the average of all tasks is displayed in Figure 8 on page 25. In this graph we see that the higher quality personnel perform better at all levels of frequency for all tasks on average. We also see that task performance improves with more practice. In order for low quality personnel to attain the level of proficiency that high quality personnel possess with no practice, they must have a frequency of at least six or more performances within six months.

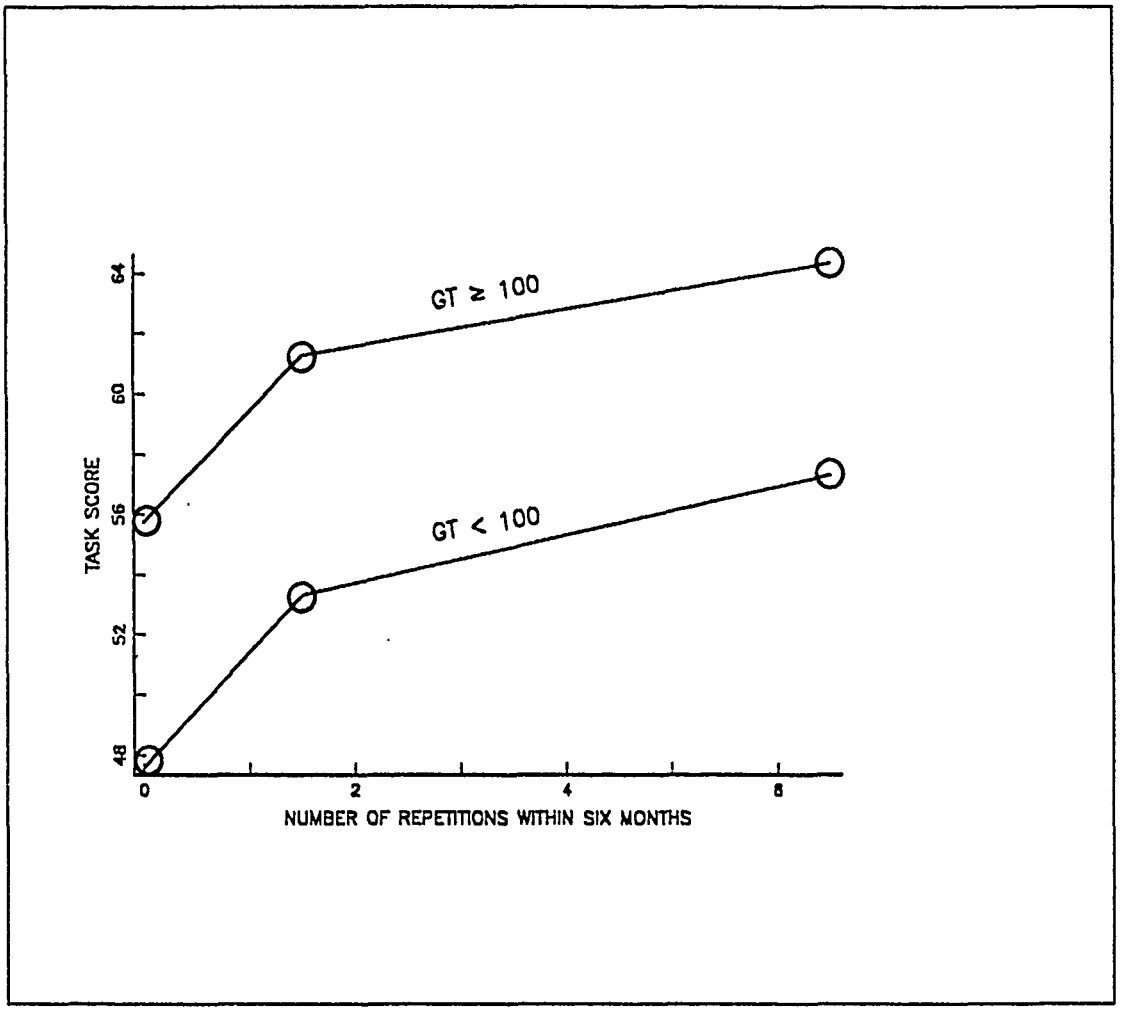


Figure 8. Comparison of Frequency Effects for Quality

In order to conduct a more complete analysis of the comparison between the two aptitude groups, it is necessary to examine the variability of test scores for each aptitude group across all frequency categories. The method we have chosen is the box plot. Box plots for all tasks are displayed in Figure 9.

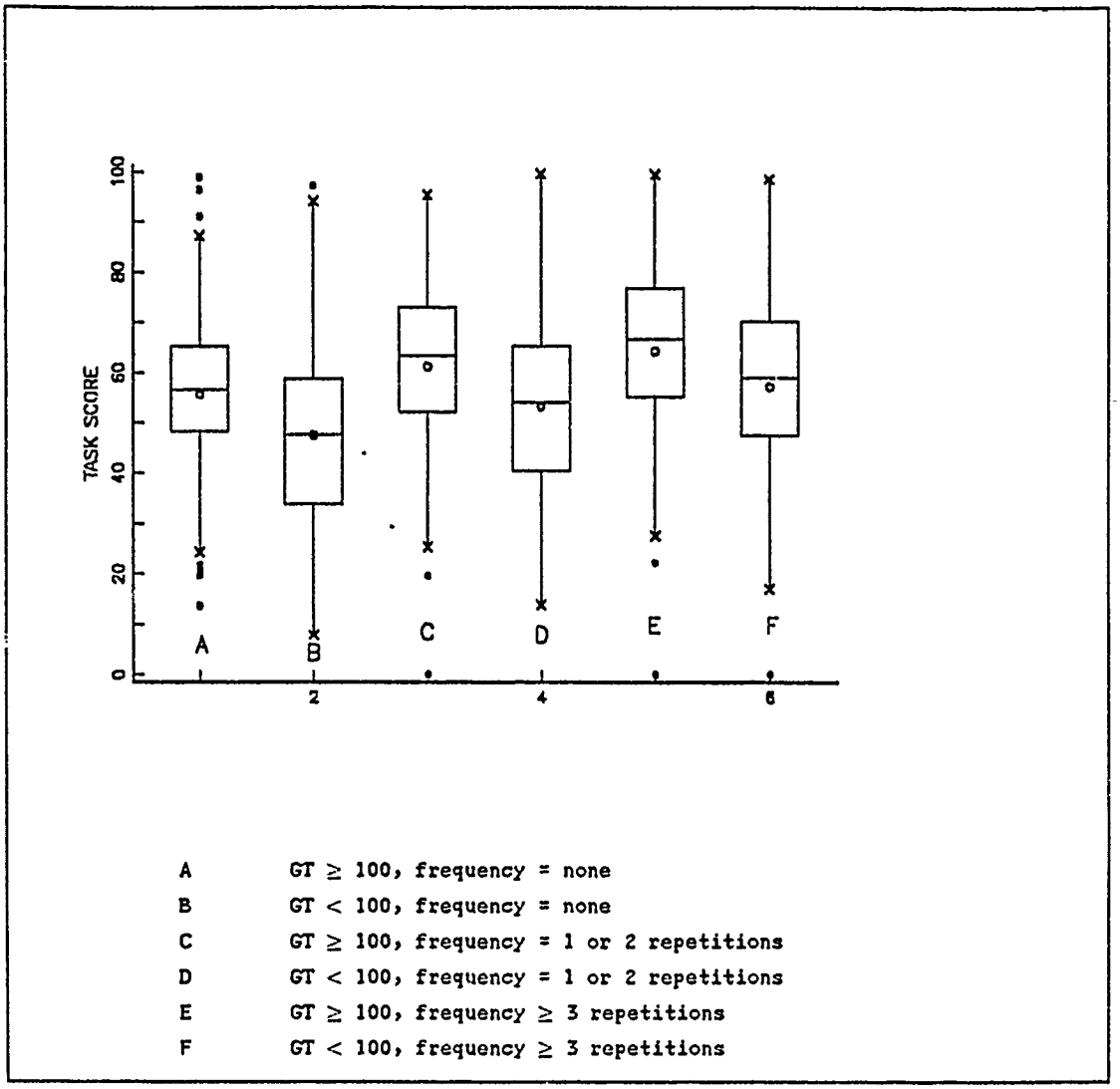


Figure 9. Box Plots of all Task Scores by Aptitude Group and Frequency of Performance

In the box plot the upper and lower quartiles of the data are portrayed by the top and bottom of a rectangle and the median is portrayed by a horizontal line segment within the rectangle. The circle in the middle is the mean. The range between the upper and lower quartiles is the interquartile range (IQR). The lines that extend from the box contain the adjacent values that are computed as follows:

- upper adjacent value = largest observation ≤ the upper quartile + 1.5xIQR, and
- lower adjacent value = smallest observation ≥ the lower quartile - 1.5xIQR. [Ref. 5 : p. 21]

Figure 9 reinforces the fact that the majority of high aptitude personnel score greater than the low aptitude personnel. We also see that the variability of scores is greater for the low aptitude personnel than for the high aptitude group across all frequency categories (as evidenced by comparing the length of the adjacent value lines). However, the variability of low aptitude scores decreases as the tasks are practiced more frequently. This representation of the overall performance on all tasks does not explain our previous finding of the moderating effect of frequency. In order to further examine this, we have analyzed each duty area using the same procedure.

The task scores in each duty area have been averaged by frequency category. The duty areas have then been analyzed for similiarities in behavior. The first group of duty areas that we will examine are displayed in Figure 10 on the following page. These four duty areas portray approximately the same behavior as the total average of tasks from Figure 8. The higher aptitude personnel perform better at all levels of frequency and increased practice results in increased proficiency. Observing the first aid and land navigation areas, we see that the difference between the two aptitude groups remains approximately constant and, as with Figure 8, lower aptitude personnel must perform a task six or more times within six months to attain the level of proficiency demonstrated by high aptitude personnel with no practice. In the mines duty area, we see that the difference between the aptitude groups appears to increase after two repetitions of practice. Again, lower aptitude personnel must practice six or more times to attain the "no practice" level of proficiency demonstrated by high aptitude personnel. In the NBC duty area, the difference between the quality groups tends to decrease after the tasks are practiced two times. This leads us to suspect that there is a level of frequency at which the proficiency of both high and low aptitude groups approach the same value, but that level of frequency appears to be greater than six repetitions of practice.

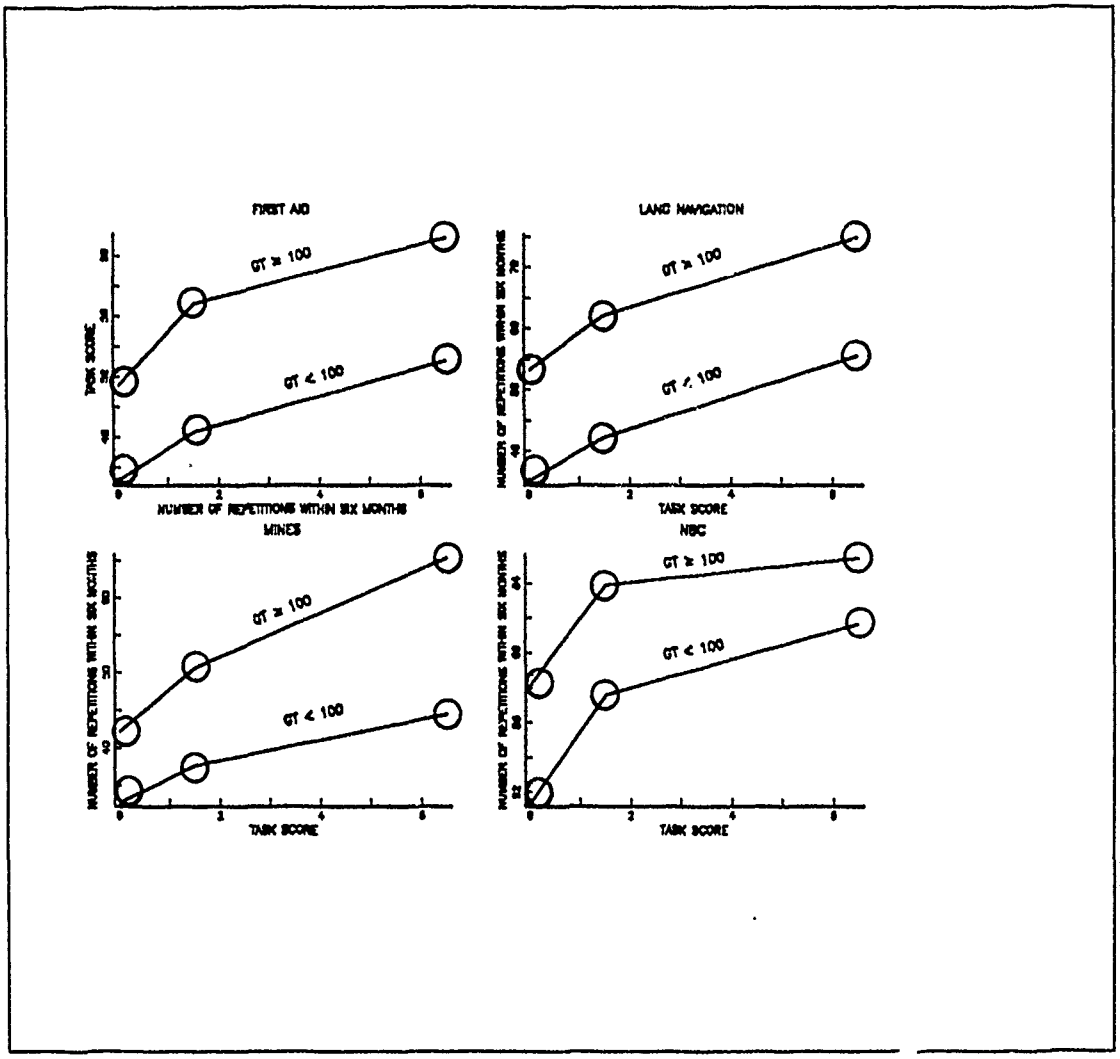


Figure 10. Increased Proficiency with Increasing Frequency

We analyzed possible reasons for the grouping of these categories and developed the following results. All of the duty areas are unique to themselves. Some of the other areas could be aggregated into broader categories (i.e., Weapons: LAW, SAW, grenade launcher), but each of the four areas in Figure 10 have very little relation to any other duty area. These four areas also do not involve the performance of mechanical skills. They primarily involve the mastery of a sequence of short exact steps that must be performed. The box plots of these duty areas are displayed in Figure 11. These plots reinforce the observation that proficiency increases as the frequency of performance increases.

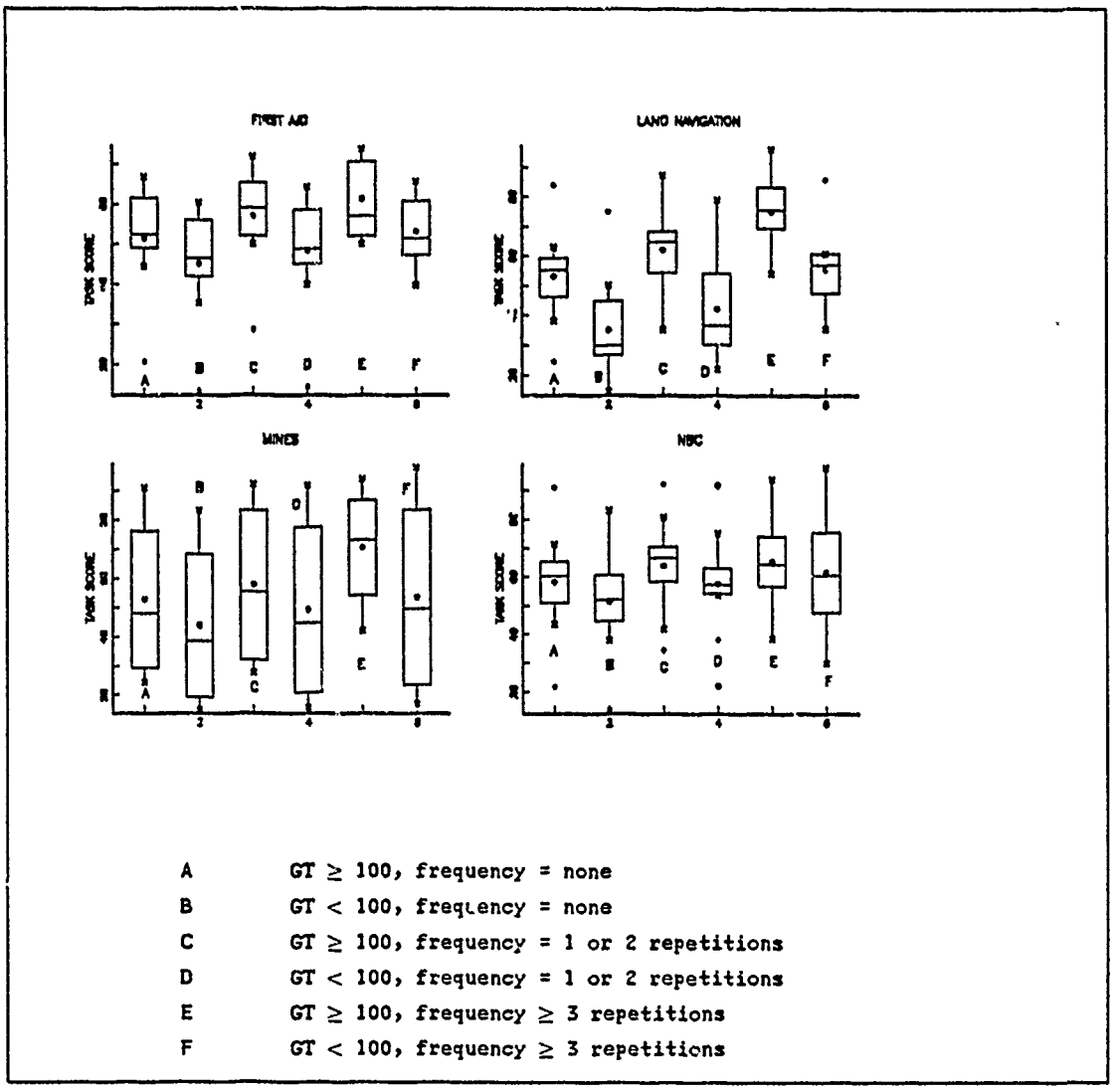


Figure 11. Box Plots of Increasing Proficiency Areas

In the first aid and land navigation areas we see that the difference between the variability of scores between aptitude groups remains approximately constant. The land navigation interquartile range (IQR) of the high aptitude group is greater in terms of score than the IQR of the low aptitude group. This clearly indicates the majority of the high aptitude group outperforms the low aptitude group across all frequency categories. Another interesting observation is that the variability of low aptitude scores in the NBC area increase greatly at a frequency of practice of three or greater times.

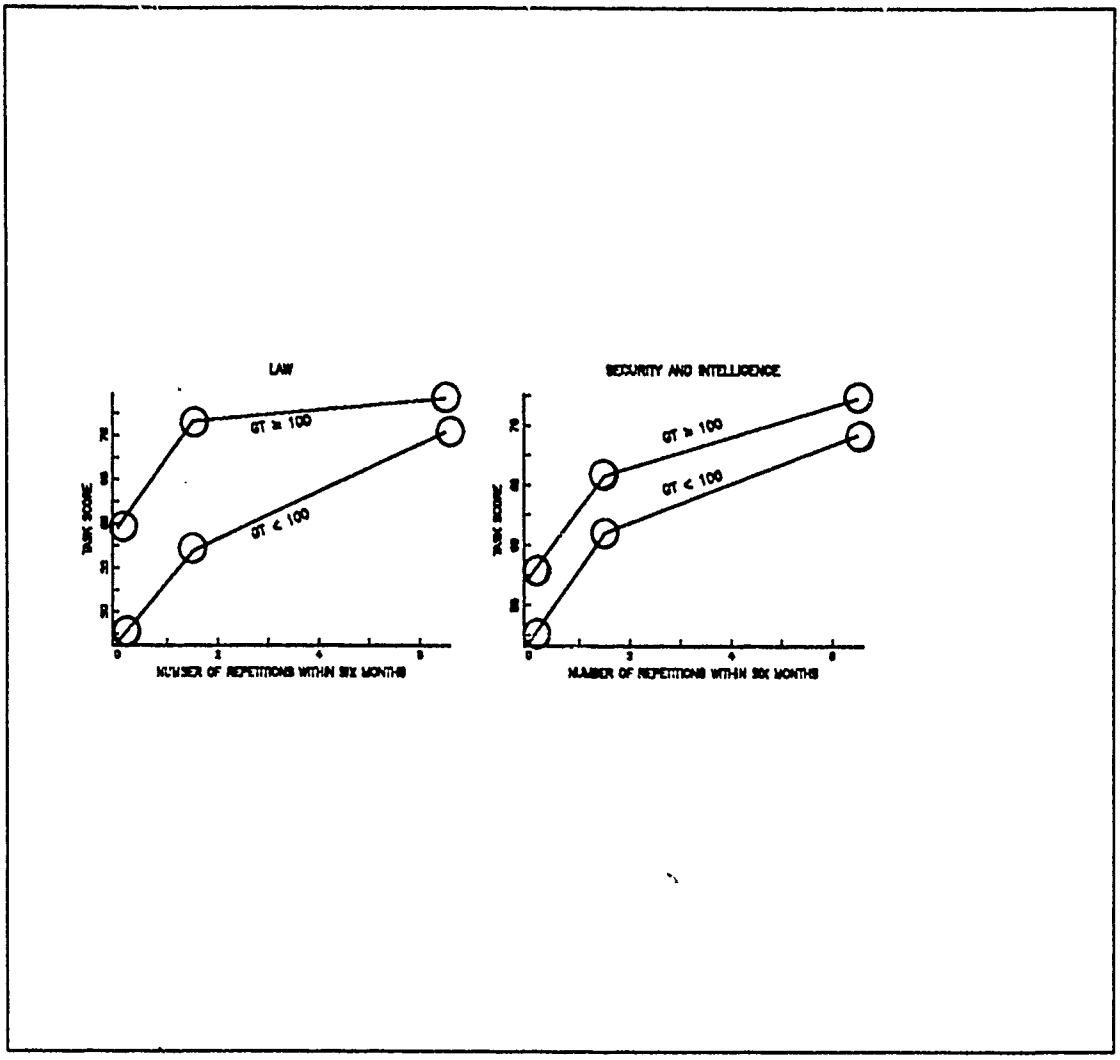
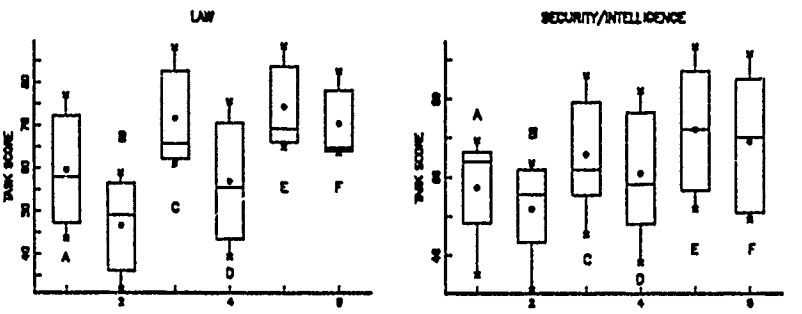


Figure 12. Decreasing Difference in Performance with Increased Frequency

The second group of tasks displayed in Figure 12 share part of the behavior of the NBC duty area. The difference between quality groups decrease as the frequency of performance increases. This is very obvious for the LAW area. After two repetitions of performance, the high aptitude group does not appear to increase in proficiency very much, but the lower aptitude group appears to increase rapidly. Not only do they appear to surpass the higher aptitude performance at a frequency level of instruction only, but they also appear to approach the level of proficiency of the higher aptitude group at a frequency level of one or two repetitions of practice. The security-intelligence area is not as obvious, but we still observe that at each frequency level the difference in per-

formance appears to become less. The lower aptitude group, with one or two repetitions of practice, appears to surpass the higher aptitude group at the point where the high aptitude group has only had instruction and no practice. With six repetitions of practice, the low aptitude group appears to surpass the performance of the high aptitude group at one or two repetitions of practice. Analyzing the reasons for these two duty areas to be grouped together, we arrived at the following results. These duty areas are comprised of tasks that are simple to perform. There are very few distracting actions that would lead the individual to perform the task incorrectly. After an initial practice or perhaps two repetitions, the tasks are practically mastered. Therefore this results in the eventual equal levels of performance from each aptitude group.



A	GT ≥ 100, frequency = none
B	GT < 100, frequency = none
C	GT ≥ 100, frequency = 1 or 2 repetitions
D	GT < 100, frequency = 1 or 2 repetitions
E	GT ≥ 100, frequency ≥ 3 repetitions
F	GT < 100, frequency ≥ 3 repetitions

Figure 13. Box Plots for Areas with Decreasing Differences

The box plots of these two areas are included as Figure 13. These plots reinforce the observation of decreasing difference between aptitude groups as frequency increases. At a frequency of three or greater repetitions, the IQR of both groups are much closer in size and location. Thus not only do the mean scores tend to approach the same value but the variability also tends toward equal values.

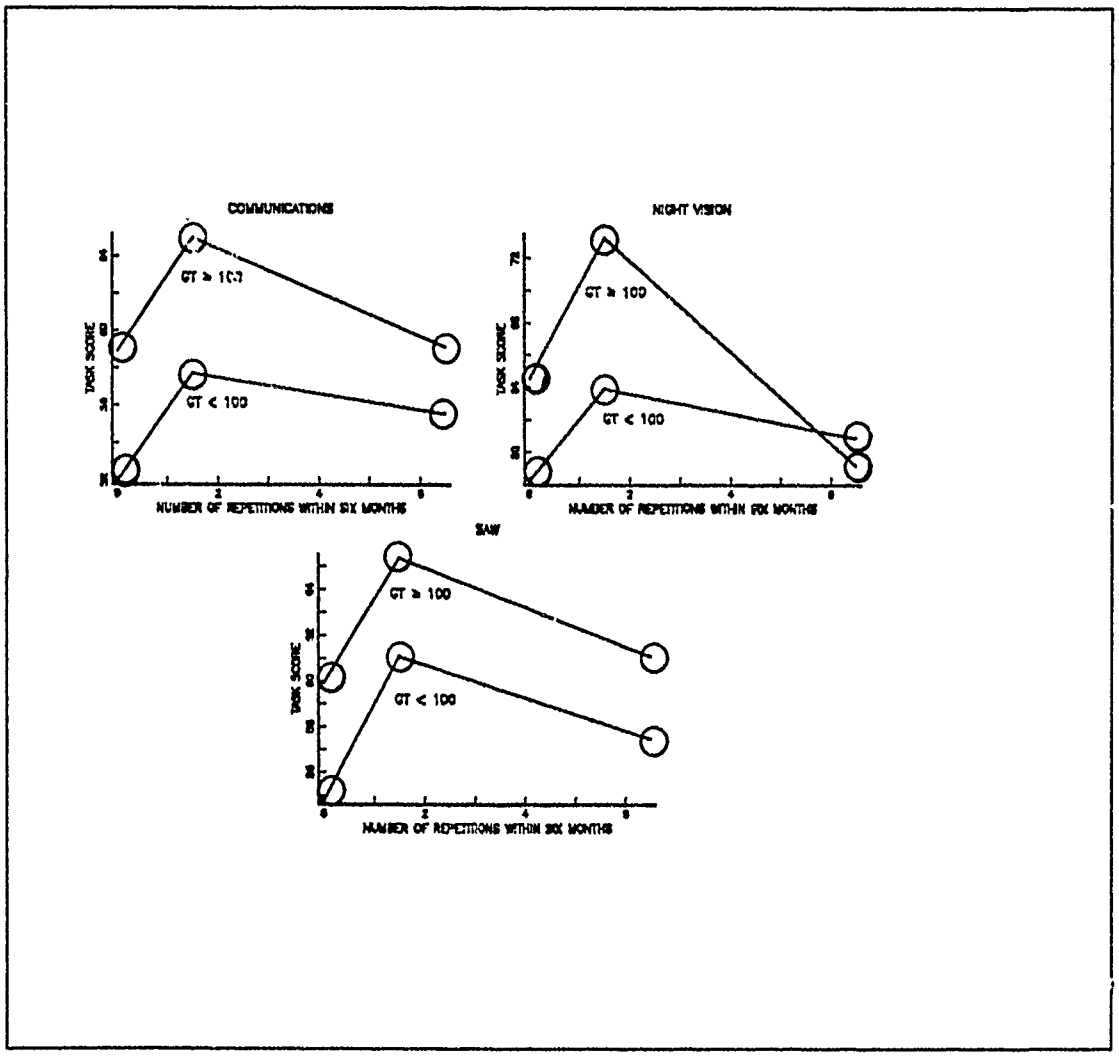
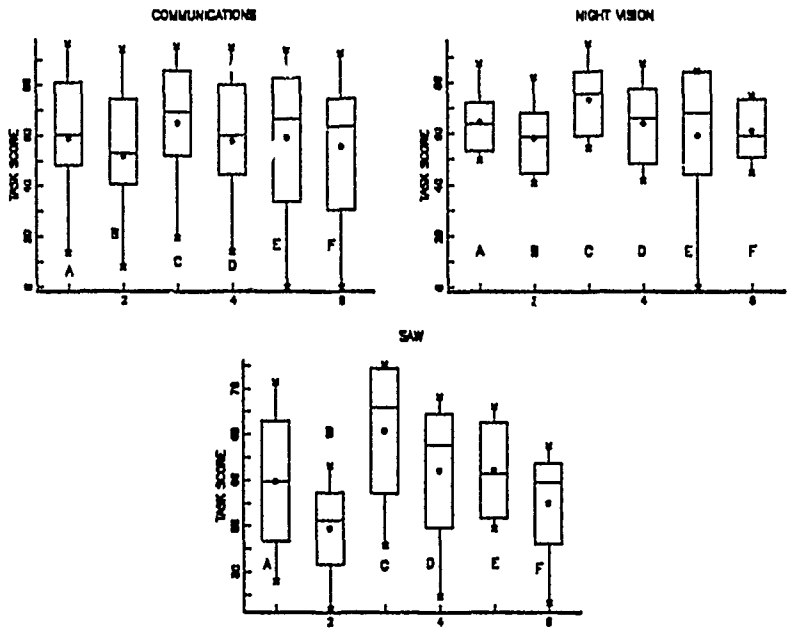


Figure 14. Declining Performance with Increasing Frequency

Figure 14 portrays a unique relationship. Performance actually declines after two repetitions of performance. In the night vision duty area the performance of high aptitude personnel actually declines below the level of low aptitude personnel at a fre-

quency of six or more repetitions. Analyzing the common characteristics of the three areas, we have found that they involve tasks that are predominantly mechanical or involve operating a mechanical device. After initially practicing these tasks one or two times, a high level of confidence has been attained by the individual. Repeated repetitions do not add to the individual's base of knowledge and he may become disinterested in performing the task. We surmise that the decreasing proficiency is due to the lack of concentration in performing a mundane task that the individual already feels he has mastered. Figure 15 contains the box plots of the duty areas with declining performance. Previously we found that performance began to decline after one or two repetitions of practice. In the box plot we see that in most cases the data are skewed toward low



A	GT ≥ 100, frequency = none
B	GT < 100, frequency = none
C	GT ≥ 100, frequency = 1 or 2 repetitions
D	GT < 100, frequency = 1 or 2 repetitions
E	GT ≥ 100, frequency ≥ 3 repetitions
F	GT < 100, frequency ≥ 3 repetitions

Figure 15. Box Plots of Areas with Declining Performance

values. The majority of scores appear to have leveled off as is evidenced by the values of the median and the IQR. The low scores appear to have pulled the average down. Our previous observation of the lack of concentration is still valid because the IQR is not increasing as the frequency increases and even demonstrates a slight downward trend.

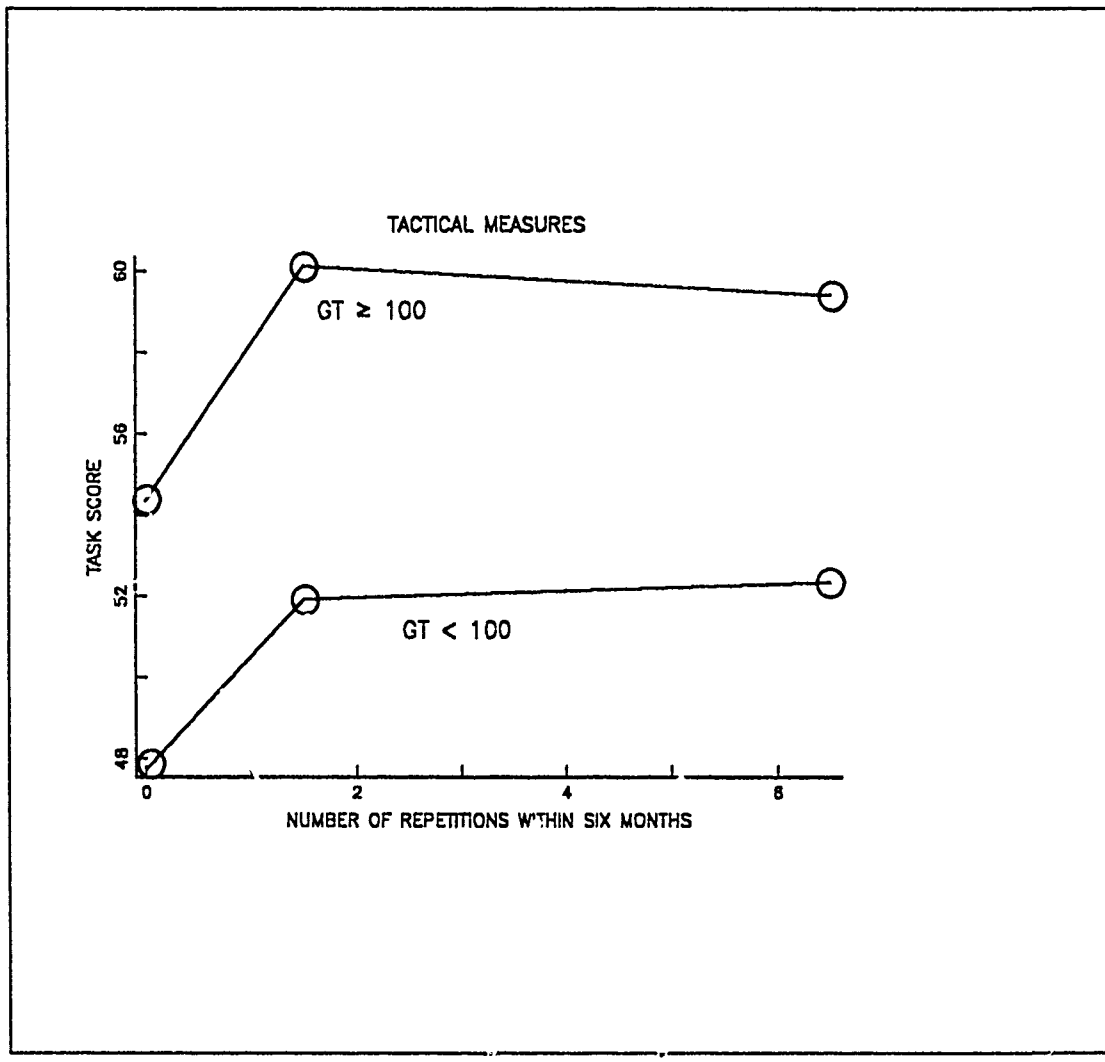
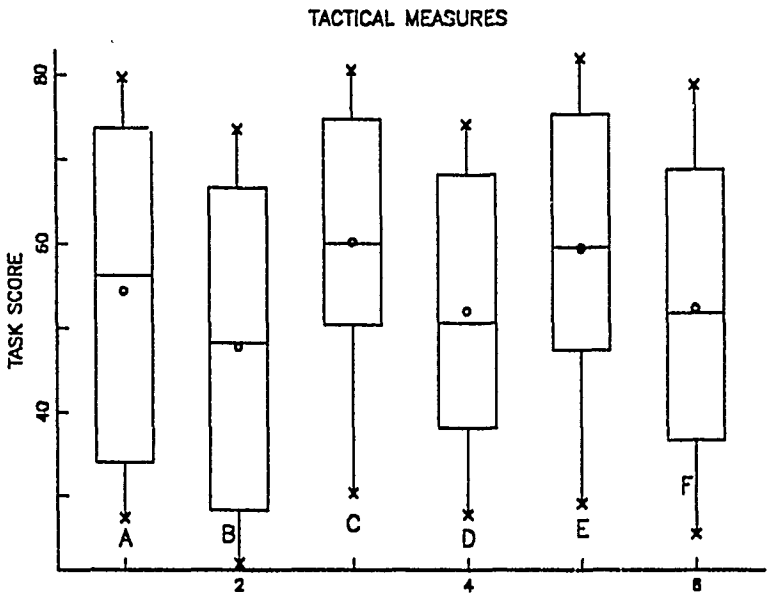


Figure 16. Plateauing of Task Performance with Increased Frequency

Figure 16 very clearly illustrates the "plateauing" effect that we described previously. After two repetitions of performance, both aptitude groups tend to have reached their plateau of performance. It is interesting to note that with a large amount of practice (six

or more times), the lower aptitude group has not reached the level of proficiency demonstrated by the higher aptitude group with no practice. Tactical measures consist of tasks that require judgement. The fundamentals must be applied to different situations in varying ways. Therefore, it primarily involves factual and knowledge based performance. The box plot of tactical measures is contained in Figure 17. The IQR of each aptitude group at a frequency of three or more repetitions of practice is approximately equal to its preceding IQR at a frequency of one or two repetitions of practice,



A	GT ≥ 100, frequency = none
B	GT < 100, frequency = none
C	GT ≥ 100, frequency = 1 or 2 repetitions
D	GT < 100, frequency = 1 or 2 repetitions
E	GT ≥ 100, frequency ≥ 3 repetitions
F	GT < 100, frequency ≥ 3 repetitions

Figure 17. Box Plots of Plateauing Duty Area

reinforcing the observation of a plateauing effect. The IQR of the high aptitude group is slightly higher and slightly smaller than the low aptitude group, especially when the

tasks are practiced more frequently. Thus with more frequent practice the majority of high aptitude personnel tend to score higher than the majority of low aptitude personnel.

Figure 18 displays a unique phenomenom. In the grenade launcher area, the performance of the high aptitude group decreases drastically with one or two repetitions. In the hand grenade area, the low aptitude area exhibits similiar behavior. The common characteristic is that obviously both areas involve grenades, but most importantly these are the two duty areas that are the most dangerous.

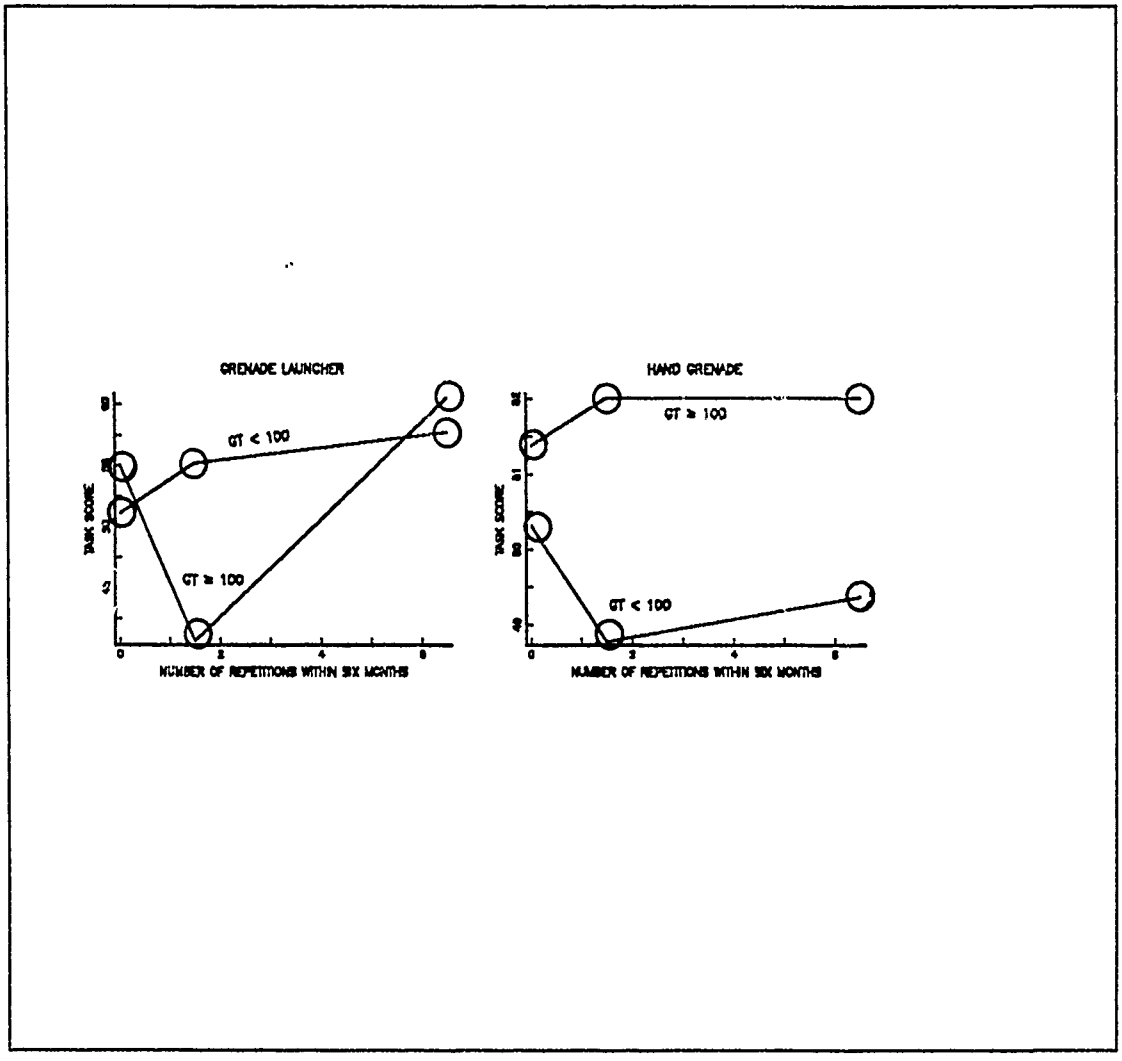
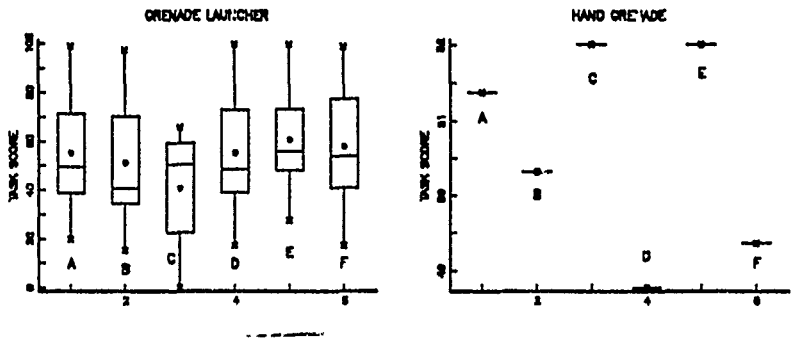


Figure 18. Decreases in Performance Corresponding to Dangerous Areas

Since the grenade launcher area consists of five tasks, we examined the average score on each of the tasks for each frequency category. Four of the five tasks exhibited in-

creasing scores as the frequency increased. One task, GL02 (prepare launcher for firing), contained the score which resulted in the average declining for frequency category two. The average score for high aptitude personnel corresponding to frequency category one was 98.89. The average score for frequency category three was 99.58. However the score for category two was 0. There were 199 personnel in this category. Due to the drastic swings in performance, we might surmise that a mistake was made in the administration of the test resulting in confusion by the personnel taking the test. We could also conclude that an error was made in the initial compilation of the data. If the GL02 scores for high aptitude personnel in frequency category two were consistent with the scores in the remaining tasks of this duty area, our plot would resemble those in Figure 10. Performance increases with frequency and the difference in scores of the aptitude groups is constant across all frequency categories. Having exhausted our ability to investigate the reasons for the extreme scores in task GL02, we continued our analysis with the assumption that the scores were correct.

The decline in performance may be due to a lack of confidence and apprehension. With only classroom instruction, the individual performs the task relatively well, but becomes more aware of the danger as he practices one or two times. With increased practice, he becomes confident in his ability to perform the task without endangering himself. The box plots of the dangerous duty areas are included in Figure 19. The high aptitude values for the grenade launcher area at a frequency of one or two repetitions of practice are skewed toward low values. At other frequency levels the high aptitude scores are skewed toward high values. We surmise that a portion of the high aptitude personnel score low due to apprehension with limited practice but overcome the fear with additional practice. The hand grenade area includes only one task. The graph is included with the grenade launcher box plot for completeness although no observations can be made about the variability.



A	GT ≥ 100, frequency = none
B	GT < 100, frequency = none
C	GT ≥ 100, frequency = 1 or 2 repetitions
D	GT < 100, frequency = 1 or 2 repetitions
E	GT ≥ 100, frequency ≥ 3 repetitions
F	GT < 100, frequency ≥ 3 repetitions

Figure 19. Box Plots of Dangerous Areas

Summarizing our analysis of the performance of different aptitude groups across the range of duty areas and frequency categories, we have discovered the following results:

- performance of high aptitude personnel is generally superior to low aptitude personnel at all levels of frequency
- The variability of the task scores of low aptitude personnel decreases as the tasks are practiced more frequently
- tasks involving short, simple nondistracting actions eventually result in equal levels of performance for both aptitude groups only with frequent amounts of practice (six or more times within six months)

- After the individual gains an initial level of skill, mundane, mechanical tasks sometimes result in his losing concentration in performing tasks. Boredom results in decreased performance. This could be combatted by making the subsequent performances more challenging (i.e., instead of disassembly of the SAW, two individuals compete in a timed race to correctly disassemble the weapon)
- In some areas, frequent performance results in proficiency reaching a plateau. Further practice does not significantly increase proficiency
- Areas involving dangerous tasks may display a decrease in performance with only initial practice. Confidence gained through additional practice helps to overcome fear and apprehension and results in improved performance.

V. ANALYSIS OF VARIANCE

A. INTRODUCTION

Our objective in this chapter is to determine the factors that predict task performance. The method we have chosen is the three-way analysis of variance (ANOVA). In designing our model, we were aware that three factors may have an impact upon task performance. Our analysis in the previous chapter revealed that aptitude, as measured by the GT composite, affected task performance. Secondly, this analysis also revealed that the frequency of performance affected task performance. The work of Mayberry [Ref. 4 : pp. 7-9] indicates that the recency of performance also affects task performance. We are interested in examining each task to determine the combination of variables that predict task performance.

B. ANALYSIS

We have conducted our analysis by computing the three-way analysis of variance for each of the 75 tasks. The factors used were GT composite score (utilizing the four mental groups that we previously discussed in Table 3 on page 9), recency category and frequency category. The three-way ANOVA analyzes the effect of each of the factors as well as all of the possible interactions. The three-way ANOVA model is listed below.

$$Task\ Score = \mu + \alpha_i + \beta_j + \zeta_k + \gamma_{jk} + \lambda_{ij} + \omega_{ik} + \psi_{ijk} + \varepsilon_{ijk}$$

where

μ is the grand mean,
α_i is the effect of the GT score,
β_j is the effect of the recency,
ζ_k is the effect of the frequency,
γ_{jk} is the interaction effect of recency and frequency,
λ_{ij} is the interaction effect of GT and recency,
ω_{ik} is the interaction effect of GT and frequency,
ψ_{ijk} is the interaction effect of GT, recency and frequency, and
ε_{ijk} is the experimental error for

i = 1, 2, 3, 4,

j = 1, 2, 3, 4, 5 and

k = 1, 2, 3, 4.

We have analyzed the results from the ANOVA and constructed Table 5 below to illustrate the frequency with which the different variables and the combinations of variables have significant effects upon task scores. These effects include both "pure" effects from each of the variables and the interactions of the variables. [Ref. 6 : p. 702-709] It is of interest to note that 73 per cent (55 of 75) of the tasks showed no significant interactions of any kind. Three of the tasks (check parts of the TA-312 telephone set, perform fireman's carry, and administer first aid for an abdominal wound) contain no significant effects from any of the variables in the three-way ANOVA. These tasks are very simple to perform and require very little mental aptitude or practice to maintain skill levels. The ANOVA tables from five of the tasks are listed as examples in Appendix D.

Table 5. THREE-WAY ANALYSIS OF VARIANCE FOR EFFECTS OF GT, RECENCY AND FREQUENCY UPON TASK SCORE

Three-Way ANOVA	
Number of Tasks	Variables which have a significant effect upon task scores
6	GT
41	GT R
3	GT F
21	GT R F
1	R
3	No Effects

Summarizing the results of the analysis of variance, we find that GT has a significant effect in all but four of the tasks. These are tasks that are fairly simple and can be performed by personnel of varied intelligence levels with only minor instruction or are tasks that are very complex. Frequency had an effect on hands-on scores in only 24 of the 75 tasks, and recency in 63 of the tasks. The measure of aptitude (GT) used by the Marine Corps to assess personnel into the infantry specialities clearly has an effect on hands-on performance in tasks involving infantry skills. GT has a significant effect on 96 percent of the tasks. The frequency and recency with which tasks are performed also

have an impact upon task performance with recency having an effect on over twice as many tasks as frequency. Analyzing the weighted duty area scores we find that recency has a greater effect than frequency in influencing area performance in all duty areas. Frequency is not significant in tasks belonging to all duty areas, but the areas in which frequency appears the least number of times are the following:

- hand grenades,
- NBC,
- SAW and
- mines.

In Figure 10 on page 28, we observed that the difference in the task score between the high and low aptitude groups in the mines duty area became greater as frequency increased. Combining this observation with the significant effects of GT and recency in the three-way ANOVA model, we can surmise that the increasing difference in performance between aptitude groups over time is due to aptitude and not frequency. Our previous analysis also revealed that the difference between aptitude groups in the duty areas of hand grenades, SAW and NBC remained relatively constant as frequency increased. Combining this result with the lack of effect of frequency in the ANOVA model, we see that aptitude and not frequency affect performance in these areas. Reviewing our analysis of the tasks from Figure 6 on page 21, we find that the tasks for which GT is not a factor in affecting task scores appear on or above the diagonal (lower left to upper right). These locations correspond to tasks that offer proportional or greater than proportional return on task performance for the frequency with which they are practiced. In Figure 7 on page 27 we also see that these tasks are either in the stable or moderately stable category.

Combining the results from Figures 6 and 7 along with our results from the analysis of variance, we can surmise that for most tasks in the infantry specialty the GT composite does have a significant effect. For those tasks where GT does not have a significant effect, the proficiency is proportional to or greater than proportional to the amount of practice invested and the skills do not diminish if not practiced frequently. Thus, those skills not depending on aptitude are generally not subject to degrading levels of proficiency if not practiced frequently.

Summarizing the effects of GT, recency and frequency as predictors of task performance, we can make the following general observations:

- recency has a significant effect on over twice as many tasks as frequency,

- GT has a significant effect on performance in the infantry specialty, and
- tasks in which GT does not have a significant effect offer proportional or greater than proportional proficiency based upon the time spent practicing the task. Additionally, these tasks are stable with regard to frequency (the skills do not diminish with infrequent practice).

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The analysis of the effect of frequency on performance of tasks in the infantry speciality reveals many areas in which the potential exists for improving the readiness of Marine Corps infantry units. Summarizing our most important observations from this thesis, we have found the relationships listed below.

1. Task-Aptitude Relationship

Tasks that are highly correlated with aptitude (i.e., high task performance occurs with personnel possessing high aptitude) tend to be factual and knowledge based skills which require recall of detailed procedures. Tasks that are not as highly correlated with aptitude (but show some correlation) tend to be oriented toward hands-on performance and require continual practice to maintain skill levels. High aptitude personnel almost always perform better regardless of the type of task. This result shows us that although the services were able to perform their mission with 25 per cent unqualified recruits, the tasks requiring knowledge based skills were probably only performed at a marginal level by the low aptitude personnel. We also suspect that these type of tasks could only be performed by low aptitude personnel with constant supervision. Extra supervision of this type is an unnecessary drain on the operational units and has a negative impact on readiness.

2. Comparative Effects of Frequency on Task Performance

Many of the knowledge based skills requiring recall of detailed procedures offer a less than proportional return of proficiency for frequency of practice. Simple tasks requiring performance of a small number of procedures have a greater than proportional return of proficiency for frequency of practice. Tasks requiring hands-on performance and continual practice to maintain skills are perishable (skills deteriorate if not practiced frequently). Tasks involving knowledge based skills are stable (do not deteriorate if not practiced frequently).

3. Comparison of Frequency Effect for Quality

High aptitude personnel perform significantly better on the hands-on tests than do the low aptitude personnel. This relationship is true across all frequency categories. Low aptitude personnel achieve the same level of proficiency as high aptitude personnel in only the tasks involving short, simple nondistracting actions. This occurs only with

frequent amounts of practice (three or greater repetitions within six months). Performance declines after two to three repetitions in most mechanical tasks (communications, night vision, and SAW). This is true for both high and low aptitude personnel. Areas involving dangerous tasks (i.e., grenades) appear to require more than two sessions of practice to overcome what we suspect is the initial fear and apprehension associated with the tasks.

4. Analysis of Variance

The GT composite has a significant effect on practical hands-on performance in the infantry specialty. Recency has a significant effect on over twice as many tasks as does frequency. Tasks which are not significantly affected by GT offer proportional or greater than proportional proficiency for the amount of practice invested. These tasks are also stable in that the skills do not deteriorate when practice is infrequent.

B. RECOMMENDATIONS

The recommendations involve two areas: scaling of the frequency survey and suggestions for practice of infantry tasks. The frequency categories were converted to a number of repetitions in our analysis in order to have a continuous scale with which to compare the continuous scale of task scores. We recommend that on future tests the frequency and recency data be taken as raw data, i.e., as is currently done, the Marines should be asked how many times they have practiced a task within six months and how recently they have practiced the task. But instead of responding with an answer in a category, the Marine should respond with the actual number. After analyzing the data, it can then be categorized.

Our analysis of the various effects of frequency on task performance revealed problems for which we offer the suggestions that follow. Mechanical type tasks (disassembly and reassembly of weapons) must be made challenging to maintain or increase proficiency. Competitive races and identifying missing parts while performing assembly are two types of variations that could be made to combat the boredom of these mundane tasks. Dangerous tasks appear to require more than two sessions of practice in order to overcome what we suspect is the initial fear and apprehension associated with the task. Increased practice beyond this point results in increased proficiency. If commanders desire high proficiency in tasks involving the use of and maneuver with dangerous weapons and munitions, they must practice these actual tasks frequently in order to overcome fear and develop individual confidence in performing these tasks. Figure 6 is recommended as a guide in reassessing training priorities. It reveals the tasks

where we have found a greater proportional return of proficiency for the amount of practice invested. Likewise areas are noted where our practice does not pay off in a large growth of proficiency. Of course, some tasks are absolutely necessary to maintain proficiency and the sacrifice must be made despite the less then proportional return. Figure 7 is also recommended in identifying tasks where performance deteriorates if the task is not performed frequently. This will give commanders the ability to determine the frequency with which to practice individual tasks in order to achieve the highest possible state of overall readiness.

APPENDIX A. BASIC INFANTRY TASKS

Task label	Task definition
CR01	Operationally inspect PRC-77 radio
CR02	Visually inspect PRC-77 radio
CR03	Operate PRC-77 radio
CR04	Assemble PRC-77 radio
CR05	Take immediate action on PRC-77 radio
CR12	Construct field expedient antenna
CT07	Install TA-312 telephone set
CT08	Repair cut wire
CT09	Operate TA-312 telephone set
CT10	Check parts of TA-312 telephone set
FA01	Administer mouth-to-mouth resuscitation
FA02	Perform Cardiopulmonary Resuscitation (CPR)
FA03	Treat for shock
FA04	Perform fireman's carry
FA05	Administer first aid for abdominal wound
FA07	Treat amputated limb
FA08	Perform chest pressure - arm lift
FA09	Put on battle dressing
FA10	Treat sucking chest wound
GL01	Operationally inspect grenade launcher
GL02	Prepare launcher for firing
GL04	Confirm zero for grenade launcher
GL05	Maintain grenade launcher
GL06	Emplace stakes for grenade launcher

Task label	Task definition
HG01	Engage targets with hand grenade
LA01	Prepare Light Antitank Assault Weapon (LAW) to fire
LA02	Take immediate action on LAW
LA03	Restore expanded LAW
LN01	Set azimuth during night
LN02	Pace distance
LN03	Determine own location by map-terrain association
LN04	Determine azimuth from one point to another
LN05	Convert azimuth -- magnetic and grid
LN06	Determine grid coordinates
LN07	Determine location by resection
LN08	Determine location by intersection
LN09	Follow azimuth
LN11	Measure distance on map
MI01	Install Claymore mine with electronic device
MI02	Recover Claymore mine with electronic device
MI03	Install Claymore mine with tripwire
MI04	Recover Claymore mine with tripwire
NB01	Give appropriate visual Nuclear Biological Chemical (NBC) alarm
NB02	Put on and wear protective clothing
NB03	Drink while masked
NB04	Treat nerve gas casualty
NB05	Administer first aid for blistering agent
NB06	Inspect and maintain M17 mask

Task label	Task definition
NB07	Identify NATO NBC markers
NB08	React to aerial spray
NB09	Remove mask
NB10	Treat choking agent casualty
NB13	Prepare NBC-1 report
NV01	Visually inspect night vision device
NV02	Operationally inspect night vision device
NV03	Clean components of night vision device
NV04	Observe using night vision device
NV05	Collect and report information
SI01	Observe and collect information
SI02	Prepare SALUTE (Size Activity Location Unit Time Equipment) report
SI03	Perform search and safeguard procedures
SI04	Inspect and tag prisoners and equipment
SI05	Pass friendly personnel through lines
SL01	Visually inspect Squad Automatic Weapon (SAW)
SL02	Operationally inspect SAW
SL03	Fieldstrip and maintain SAW
SL04	Assemble SAW
TL01	Move individually
TL03	Perform one-man carries
TL04	Estimate range
TL05	Camouflage self and equipment
TM01	Select and establish helicopter landing zone
TM08	Direct helicopter landing and takeoff
TM09	Control unit movement when not in contact
TM14	Call for and adjust indirect fire

APPENDIX B. EXAMPLE SCORE SHEET

LN07A: Determine Location by Resection

0300

SCORESHEET

Scorer: _____ Marine: _____

Date: _____ ID: _____

Last time you did: Determine Location by Resection
< 1 wk ___ < 1 mo ___ < 6 mos ___ > 6 mos ___ Never ___

How many times have you done this task during the last six months?
None ___ 1 or 2 ___ 3 to 10 ___ > 10 ___

Say: This test covers your ability to determine your location by resection. Look at this map. You know you are located somewhere along this riverbank. You can see the watertower here (point) and the building here (point). You have determined that the grid azimuth to

the tower is 192 degrees, and that the grid azimuth to the building is 359 degrees. Now using the equipment here complete the test.

PERFORMANCE STEPS	GO	NO-GO
1. Placed protractor on the map with the 0 degree indicator pointing to the top (north) of the map, and the index point centered on the distance objects.	___	___

NOTE TO SCORER: Marine may lay off either azimuth first.

2. Drew a line from the known point through the unknown point.	___	___
3. Drew a line from the second known point until it crossed the first line	___	___
4. Lines crossed within template.	___	___

NOTE TO SCORER: Place the template on the map where the two lines cross. Score a GO in step 4 if lines cross within template.

APPENDIX C. MATRIX OF TASK-APTITUDE CORRELATIONS

Label	GT	MM	EL	CL	AFQT
CR01	0.10832	0.12799	0.12203	0.07675	0.09232
CR02	0.12649	0.13595	0.12053	0.08410	0.12497
CR03	0.18979	0.20284	0.18895	0.13654	0.15956
CR04	0.17128	0.19552	0.17603	0.10828	0.15195
CR05	0.22489	0.24171	0.22160	0.13976	0.21186
CR12	0.20076	0.24531	0.21950	0.13756	0.18043
CT07	0.20927	0.25415	0.20051	0.10544	0.15491
CT08	0.16161	0.20482	0.14616	0.09250	0.11742
CT09	0.14579	0.15788	0.12604	0.10722	0.12366
CT10	0.03774	0.05577	0.05579	-0.00068	0.02963
FA01	0.24629	0.27877	0.24838	0.15108	0.19044
FA02	0.20525	0.23096	0.22074	0.14690	0.18844
FA03	0.20850	0.21631	0.20192	0.16035	0.18635
FA04	0.06083	0.09450	0.07277	0.07942	0.05508
FA05	0.04984	0.03824	0.04501	0.06801	0.04916
FA07	0.13710	0.14470	0.15421	0.10450	0.12359
FA08	0.17750	0.22101	0.22904	0.13784	0.19725
FA09	0.12183	0.16456	0.13559	0.07909	0.10871
FA10	0.17437	0.21706	0.20478	0.12631	0.15859
GL01	0.01547	0.01871	0.00906	0.01967	0.01764
GL02	0.06360	0.08401	0.07647	0.05772	0.04586
GL04	0.14132	0.14646	0.15334	0.10274	0.12286
GL05	0.16718	0.17371	0.12911	0.09688	0.13927
GL06	0.15563	0.17012	0.13878	0.10688	0.12060
HG01	0.03840	0.03594	0.02096	0.01646	0.02719
LA01	0.27916	0.31220	0.26097	0.14970	0.22209
LA02	0.20312	0.21823	0.19611	0.14159	0.17406
LA03	0.22473	0.24165	0.21102	0.14079	0.19112

Matrix of T> \ptitude Correlations

Label	GT	MM	EL	CL	AFQT
LN01	0.24411	0.26531	0.27412	0.18962	0.24159
LN02	0.19520	0.19239	0.20324	0.17722	0.19864
LN03	0.19640	0.22673	0.18958	0.13324	0.14564
LN04	0.38065	0.40214	0.38378	0.28258	0.34538
LN05	0.25755	0.25300	0.27112	0.23532	0.26474
LN06	0.35097	0.34194	0.35703	0.28690	0.33527
LN07	0.37818	0.37943	0.41251	0.31461	0.37581
LN08	0.39786	0.40814	0.41434	0.31485	0.36665
LN09	0.08301	0.09158	0.07185	0.08257	0.08940
LN11	0.23679	0.24303	0.25588	0.19323	0.22119
MI01	0.23237	0.26860	0.24523	0.15419	0.20464
MI02	0.20120	0.22462	0.20660	0.15236	0.19461
MI03	0.27313	0.30597	0.27235	0.18485	0.22299
MI04	0.24737	0.27301	0.24607	0.16816	0.21441
NB01	0.09043	0.07364	0.09283	0.04418	0.08819
NB02	0.11544	0.12052	0.13395	0.07858	0.10264
NB03	0.17353	0.19627	0.19025	0.14128	0.15244
NB04	0.13120	0.14042	0.14406	0.10160	0.12699
NB05	0.14606	0.14494	0.16596	0.13093	0.16581
NB06	0.07509	0.11549	0.12575	0.04822	0.07097
NB07	0.24572	0.24564	0.28580	0.22423	0.26796
NB08	0.11056	0.12547	0.12711	0.09929	0.11291
NB09	0.16221	0.17204	0.15540	0.12321	0.14037
NB10	0.11302	0.13098	0.11563	0.08856	0.10223
NB13	0.42001	0.41630	0.41528	0.33164	0.41950
NV01	0.06243	0.10448	0.08172	0.06428	0.07671
NV02	0.10835	0.14073	0.11116	0.05876	0.08204
NV03	0.18035	0.18048	0.17838	0.12311	0.16725
NV04	0.09766	0.11137	0.07788	0.02346	0.06097

Matrix of Task-Aptitude Correlations

Label	GT	MM	EL	CL	AFQT
NV05	0.16091	0.15275	0.13480	0.08092	0.14698
SI01	0.07685	0.10398	0.07104	0.00898	0.04632
SI02	0.09342	0.11819	0.10075	0.04262	0.08010
SI03	0.05592	0.08626	0.07989	0.05028	0.05436
SI04	0.07211	0.11396	0.09197	0.04366	0.05447
SI05	0.14676	0.13627	0.16101	0.14036	0.17117
SL01	0.01073	0.02326	0.00317	-0.00562	0.00373
SL02	0.10835	0.11743	0.10834	0.05768	0.09781
SL03	0.20029	0.21865	0.18777	0.13689	0.18259
SL04	0.11782	0.13274	0.12288	0.09287	0.09951
TL01	0.20481	0.18233	0.18185	0.16546	0.19725
TL03	0.18326	0.19904	0.18588	0.12586	0.16998
TL04	0.09294	0.09714	0.09438	0.09803	0.09581
TL05	0.18868	0.21174	0.18360	0.12706	0.17105
TM01	0.14845	0.17480	0.16026	0.10064	0.13807
TM08	0.16776	0.20199	0.17363	0.12522	0.15890
TM09	0.16563	0.15049	0.17885	0.17208	0.16870
TM14	0.18905	0.20731	0.20058	0.15096	0.17212

APPENDIX D. SAMPLE ANOVA TABLES

CLASS	LEVELS	VALUES
GT	4	1 2 3 4
R	5	1 2 3 4 5
F	4	1 2 3 4

NUMBER OF OBSERVATIONS IN DATA SET = 1887

A. ANALYSIS FOR TASK CR01 (OPERATIONALLY INSPECT PRC-77 RADIO)

ONLY 1880 OBSERVATIONS CAN BE USED IN THIS ANALYSIS.

DEPENDENT VARIABLE: CR01

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
MODEL	56	168898.47398147	3016.04417824	2.48
ERROR	1823	2212670.34250789	1213.75224493	
CORRECTED TOTAL	1879	2381568.81648936		

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
GT	3	29513.08654251	8.11	0.0001
R1	4	86499.44516099	17.82	0.0001
GT*R1	12	15955.04854970	1.10	0.3594
F1	3	2934.94017105	0.81	0.4905
GT*F1	9	9377.53585629	0.86	0.5621
R1*F1	10	11238.96645498	0.93	0.5079
GT*R1*F1	15	13379.45124597	0.73	0.7505

B. ANALYSIS FOR TASK FA04 (PERFORM FIREMAN'S CARRY)

ONLY 936 OBSERVATIONS CAN BE USED IN THIS ANALYSIS.

DEPENDENT VARIABLE: FA04

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
MODEL	44	45612.19855318	1036.64087621	0.85
ERROR	891	1081662.46383999	1213.98705257	
CORRECTED TOTAL	935	1127274.66239316		

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
GT	3	8417.30048842	2.31	0.0748
R14	4	7427.08182711	1.53	0.1915
GT*R14	12	8911.54884272	0.61	0.8335
F14	3	4411.31375948	1.21	0.3045
GT*F14	8	8449.13216752	0.87	0.5414
R14*F14	4	2030.39817593	0.42	0.7957
GT*R14*F14	10	5965.42329199	0.49	0.8963

C. ANALYSIS FOR TASK LA01 (PREPARE LAW TO FIRE)

ONLY 1870 OBSERVATIONS CAN BE USED IN THIS ANALYSIS.

DEPENDENT VARIABLE: LA01

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
MODEL	42	336023.42130872	8000.55765021	7.81
ERROR	1827	1870828.51719395	1023.98933618	
CORRECTED TOTAL	1869	2206851.93850267		

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
GT	3	159600.52601501	51.95	0.0001
R26	4	129266.70652012	31.56	0.0001
GT*R26	12	26372.45341276	2.15	0.0120
F26	3	1331.21119839	0.43	0.7292
GT*F26	8	7533.57011437	0.92	0.4989
R26*F26	6	6697.55642327	1.09	0.3659
GT*R26*F26	6	5221.39762480	0.85	0.5314

D. ANALYSIS FOR TASK LN11 (MEASURE DISTANCE ON A MAP)

ONLY 1876 OBSERVATIONS CAN BE USED IN THIS ANALYSIS.

DEPENDENT VARIABLE: LN11

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
MODEL	53	210465.44673589	3971.04616483	4.01
ERROR	1822	1804333.95198479	990.30403512	
CORRECTED TOTAL	1875	2014799.39872068		

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
GT	3	88212.36448852	29.69	0.0001
R38	4	81240.10088754	20.51	0.0001
GT*R38	12	10101.3940858	0.85	0.5984
F38	3	6167.35296434	2.08	0.1014
GT*F38	9	7984.19153381	0.90	0.5281
R38*F38	9	4397.47719317	0.56	0.8152
GT*R38*F38	14	12342.56958214	0.89	0.5677

E. ANALYSIS FOR TASK NB09 (REMOVE MASK)

ONLY 923 OBSERVATIONS CAN BE USED IN THIS ANALYSIS.

DEPENDENT VARIABLE: NB09

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
MODEL	36	21904.58164965	608.46060138	1.36
ERROR	886	395327.79754861	446.19390243	
CORRECTED TOTAL	922	417232.37919827		

SOURCE	DF	SUM OF SQUARES	F VALUE	PR > F
GT	3	9316.32650566	6.96	0.0001
R51	4	1351.29846152	0.76	0.5536
GT*R51	12	4654.00510988	0.87	0.5785
F51	3	1224.46861887	0.91	0.4332
GT*F51	7	4415.53848435	1.41	0.1961
R51*F51	4	851.77048496	0.48	0.7525
GT*R51*F51	3	91.17398442	0.07	0.9769

LIST OF REFERENCES

1. *Report to the House Committee on Appropriations, Joint-Service Efforts to Link Enlistment Standards to Job Performance: Recruit Quality and Military Readiness,* Office of the Assistant Secretary of Defense (Force Management and Personnel), January 1989.

2. Conover, W. J. , *Practical Nonparametric Statistics,* New York; John Wiley and Sons, 1980.

3. Fleiss, Joseph L. , *Statistical Methods for Rates and Proportions,* New York; John Wiley and Sons, 1973.

4. Mayberry, Paul W. , *Performance of Basic Infantry Tasks,* Center for Naval Analyses, Alexandria, Virginia, 6 April 1989.

5. Chambers, John M. , Cleveland, William S. , Kleiner, Beat , and Tukey, Paul M., *Graphical Methods for Data Analysis,* Pacific Grove, California; Wadsworth and Brooks, 1983.

6. Duncan, A. J., *Quality Control and Industrial Statistics,* Homewood, Illinois.; Richard D. Irwin, Inc., 1986.

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