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Armor Procedural Skills: Learning and Retention

C. Mazie Knerr, James H. Harris, and Bridgette K. O'Brien
Human Resources Research Organization

Paul J. Sticha
Decisions and Designs, Inc.
and
Stephen L. Goldberg
Army Research Institute

ARI Field Unit at Fort Knox, Kentucky
Training Research Laboratory

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EDGAR M. JOHNSON
Technical Director

L. NEALE COSBY
Colonel, IN
Commander

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Decisions and Designs, Inc.

Technical review by

Susan L. Burroughs
Bob G. Witmer

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A critical issue in planning military training is in estimating the requirements for initial and refresher training. The present research investigated the learning and retention of a subset of eight armor tasks selected to represent tasks that vary in length, complexity, and extent of practice in operational units. Two data collections were conducted. One collected performance data from soldiers in operational units; the other utilized soldiers attending One Station Unit Training (OSUT) in Armor Military Occupational Specialty (19E). Soldiers in the operational unit sample had been (Continued)

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out of OSUT entry training for up to 72 months. ~~Soldiers in the OSUT sample participated in a series of task learning trials for two tasks followed by a retention trial approximately four weeks later.~~ The operational unit soldiers took a one-time performance test on all eight tasks. Results were consistent with previous skill retention research. Multiple regression analysis was used to predict the slopes of the retention function for each task for the combined sample. ~~The prediction equation accounted for a large proportion of the variance when number of steps in the task, daily practice rate, and measures of complexity and interference are used as predictors of skill decay rate.~~ The results of the OSUT, unit, and combined samples support a representation of the skill retention curve in which rapid decay occurs soon after training with little change in performance for samples tested later. Key words:

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C. Mazie Knerr, James H. Harris, and Bridgette K. O'Brien
Human Resources Research Organization

Paul J. Sticha
Decisions and Designs, Inc.

and

Stephen L. Goldberg
Army Research Institute

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

Approved as technically adequate
and submitted for publication by
Harold F. O'Neil, Jr., Director
Training Research Laboratory

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

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FOREWORD

Modern armor weapon systems require soldiers to learn, retain, and be able to perform a large number of frequently complicated procedural tasks. The Army Research Institute at Fort Knox has undertaken research to improve methods for training those tasks and to estimate the requirements for training them in operational armor units.

Procedural tasks are performed in preparing tanks for operations and during combat. Their correct performance prevents unnecessary damage to equipment and helps to ensure success in combat. The present research involves a number of tasks that are initially taught in One Station Unit Training (OSUT) at the Armor Center and then performed and trained intermittently in Armor units. The purpose of the research reported here is to provide a data base showing the acquisition and retention of armor procedural skills. The data base will be used to build models of skill learning and retention that can be useful in management of training and to replicate the findings of earlier skill retention research, which demonstrated the importance of a number of variables in predicting performance over time.

The results of this project feed into a body of research in skill retention performed by the Army Research Institute. The research has implications for training designers in Army schools and for training managers in units.

EDGAR M. JOHNSON
Technical Director

ARMOR PROCEDURAL SKILLS: LEARNING AND RETENTION

EXECUTIVE SUMMARY

Requirement:

Soldiers' performance of armor procedural skills is a complex mixture of training experiences, task characteristics, individual abilities, and on-the-job performance history. The present research was performed to establish a data base for retention modeling and to replicate previous findings that identified factors affecting skill learning and retention.

Procedure:

A subset of eight armor procedural tasks trained during One Station Unit Training (OSUT) were selected to represent tasks that vary in length, complexity, and extent of practice in operational unit. Data collections were conducted using soldiers in operational armor units and soldiers attending OSUT. The operational unit sample had all completed OSUT within 72 months prior to the study. The operational unit data collection consisted of soldiers performing the eight tasks in a "round robin" fashion. Each soldier's performance was scored. If soldiers made errors, they were given varying levels of prompts sufficient to allow them to continue and eventually complete performance of the task. The OSUT data collection involved training and retention testing of soldiers who had received formal training on tasks prior to participating in the research. Each soldier performed two of the eight tasks. For each task tested, the soldier reported twice to the test site. In the first session, soldiers performed a task five times, using the same prompting procedure described above. Approximately 4 weeks after the first session, soldiers returned to perform the task one additional time.

Findings:

The percentage of task steps performed correctly was used as the primary dependent measure because none of the soldiers in the operational unit sample correctly performed three of the tasks. There were no significant correlations in the operational unit sample between task performance and months since graduation from OSUT, months since last Table VIII, or education level. For the OSUT sample, learning over the first five trials was charted as was retention between the fifth trial and the sixth trial administered 4 weeks later. The effect of learning was significant for all trials and results of analysis of variance found a significant decrease in performance for all tasks except ground guiding between trials five and six. Both the proportion of soldiers and the average percentage of steps performed correctly returned to approximately the level of the second learning trial after the retention interval. Combining the samples and using multiple regression techniques to predict the slope of the retention functions for each

task produced an equation that accounts for 94% of the variance when number of steps in the task, daily practice rate, and measures of complexity and interference are used as predictors. The results of the OSJT, unit, and combined samples support a representation of the skill retention curve in which rapid decay occurs soon after training, with little change in performance for samples tested later.

Utilization of Findings:

The results of the analysis indicated some ability to predict differences among tasks in the rate of forgetting from the number of task steps, and details about practice on the task. These findings were also consistent with earlier research that utilized similar data collection techniques. Results of the combined analysis indicate that differences in performance practices between the training standard and unit methods will result in apparent decline in performance even under conditions of frequent practice. Data collected here will be utilized in development of a model for skill learning and retention.

ARMOR PROCEDURAL SKILLS: LEARNING AND RETENTION

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ARMOR PROCEDURAL SKILLS: LEARNING AND RETENTION

INTRODUCTION

A critical issue in planning military training is estimating the requirements for initial and refresher training. For example, certain tasks that are difficult to learn or are performed infrequently require additional initial training and periodic retraining. The frequency of refresher training, then, depends on the amount of skill retention, the costs of training, and the minimum level of proficiency required for mission accomplishment.

Over 100 years of research and theoretical development indicates that skill retention depends on the level of original learning and other training considerations, individual differences, task variables, retention interval variables, and transfer among tasks. These factors have been analyzed in several comprehensive reviews that are summarized in Table 1. The reviews differ in the kinds of skills examined, research settings, focus, and time span covered. The most recent review, by Rose, McLaughlin, Felker, and Hagman (in preparation), integrated research by or for the U.S. Army Research Institute (ARI). The kinds of skills and variables in the ARI studies are the most relevant to the present research and therefore are emphasized in the following discussion of skill acquisition and retention.

Level of Original Learning and Other Training Considerations

The level of original learning is perhaps the most potent factor of determining the level of performance after periods without practice. Block and Burns (1976) analyzed 27 skill retention experiments and determined that training to a mastery level (rather than to a minimum level of skill) produced significantly more retention in 17 of the experiments and nominally (but not significantly) more in 9 other experiments.

ARI research shows that training beyond the typical Army criterion of one correct performance of the task improves retention (Goldberg, Drillings, & Dressel, 1982; Hagman, 1980b; Schendel & Hagman, 1980; Shields, Joyce, & VanWert, 1979). However, Rose et al. (in preparation) pose the following questions: How much initial training must be given? Is it cost effective? Under what conditions is it superior to refresher training? The answers appear to depend on such factors as the time available for refresher training versus the costs of initial mastery training, but definitive research has yet to be conducted.

Other factors that influence skill retention are the extent of active practice, spaced practice, and transfer of training among task clusters. Performance tests and active practice produce higher rates of skill retention than passive presentation of the material (Hagman, 1980a; Hagman, in preparation; Holmgren, Hilligoss, Swezey, & Eakins, 1979). Repetitions of the task, spaced a day apart, produce high retention even when the soldiers have to learn other tasks between repetitions of the tested tasks (Hagman, 1980c). However, spacing the repetitions 4 weeks apart does not enhance retention (Schendel & Hagman, 1980).

Table 1

Skills Retention Literature Review

	Characteristics			
Review	Time Span	Setting	Behavior Examined	Focus
Naylor & Briggs (1961)	1960s	Academic	Mostly verbal	Military, U.S. Air Force
Gardlin & Sitterley (1972)	1960s	Military	Simulation, Essential Element, Verbal	Simulators, Long-term Retention Spacecraft skills. NASA
Prophet (1976)	1960-1976	Academic & Military	Psychomotor	Long-term flight skills or complex performance
Wheaton, Rose, Fingerman, Korotkin, Holding, & Mirabella (1976)	1950-1976	Academic & Military	Verbal & Psychomotor	Initial training, Transfer of training, Device effectiveness
Annett (1977)	1885-1976	Industrial, Military & Academic	Psychomotor & Perceptual	Skill loss, areas for further research
Johnson (1978)	1860-1977	Academic	Verbal	Retention/Transfer on procedural task; cognitive style
Schendel, Shields, & Katz (1978)	1960-1977	Academic	Psychomotor	Retention over lengthy no practice intervals
Knerr, Berger, & Popelka (1980)	1960-1977	Military	Psychomotor & Communications	Sustainment of team/crew performance
Rose, McLaughlin, Felker, & Hagman (in press)	1975-1981	Army	Psychomotor	Research by and for the U.S. Army Research Institute

Individual Differences

Aptitude differences influence skill acquisition and thus indirectly influence retention. Army research demonstrates the favorable effects of general aptitude on skills in Air Defense and Field Artillery (Department of the Army, Training and Doctrine Command [TRADOC] Systems Analysis Activity [TRASANA], 1977; U.S. Army Field Artillery School, 1977). Rose et al. (in preparation) note, however, that Army research on the subject, as yet, is inconclusive.

Five ARI projects investigated the effects on skill retention of individual ability as measured by Army aptitude tests. Vineberg (1975) found a direct relationship between aptitude and performance on both initial and retention tests; however, the relationship did not hold for all tasks. Other ARI research discovered no significant relationship between aptitude and performance (Goldberg et al., 1982). Any relationship may be mediated by training methods (Dressel, 1980; Holmgren et al., 1979; Sullivan, Casey, & Hebin, 1978).

Task Variables

Schendel, Shields, and Katz (1978) succinctly state that "Procedural tasks and individual discrete motor responses are forgotten over retention intervals measured in terms of days, weeks, or months, whereas continuous movements typically show little or no forgetting over retention intervals measured in terms of months or years" (p. 5). The cognitive mechanism producing differences in retention of procedural and continuous tasks may be the extent of memorization, which is greater in procedural tasks. Most Army tasks, however, are procedural, and thus the global distinctions used to characterize tasks fail to distinguish the determinants of retention.

The differentiation of tasks into their components, skills, steps, or subtasks leads to the detailed behavioral analysis of tasks to determine their stimuli, processes, and responses. These components, or subtasks, differ in their level of retention, as shown in existing research. Rose et al. (in preparation) summarize the types of tasks that have been examined in Army skill retention research, and note that descriptive analyses of the tasks and steps have been performed post hoc. Dimensions of task steps and tasks that appear to reduce retention, and documents reporting this information include the following:

1. Difficulty or high skill demand
   - Goldberg et al. (1982)
   - Osborn, Campbell, and Harris (1979)
   - McCluskey, Hiller, Bloom, and Whitmarsh (1978)
   - Vineberg (1975)
   - Hagman (1980b & c)

2. Lack of cues from sequential steps, equipment, etc. (often the safety precautions)
   - Goldberg et al. (1982)
   - McCluskey et al. (1978)
   - Osborn et al. (1979)
   - Shields, Goldberg, and Dressel (1979)

3. Unclear to the soldier or of questionable relevance to the task
   Osborn et al. (1979)
   Shields, Goldberg, and Dressel (1979)

4. Task boundaries (first and last steps)
   Osborn et al. (1979)

5. Passive steps
   Osborn et al. (1979)

6. Training and testing differences
   Goldberg et al. (1982)
   Osborn et al. (1979)

Shields, Goldberg, and Dressel (1979) also demonstrated that longer tasks (more steps) and tasks that contained multiple subtasks were forgotten sooner than others.

Retention Interval and Differences Between School and Operational Unit

Job activities during the retention interval complicate the relationships among training, tasks, and individual variables. Performance decrements are likely after the no-practice period when soldiers transfer from school to their unit assignments. Afterward, tasks that receive on-the-job practice show increments rather than decrements in performance (TRASANA, 1977). Tasks specific to the job are practiced during normal duties while common tasks (e.g., first aid) are practiced infrequently during early months in the unit and are not retained as well. Common tasks are not retained as well as job-specific ones even if the soldiers are not assigned to a duty position for which they were trained (Osborn et al., 1979). Therefore, practice on the job does not completely explain the retention differences.

A problem in the skill retention literature is in reconciling differences in the way soldiers are taught to perform tasks in the training center (the by-the-book approach) with the way they perform the same tasks in operational units. Somewhere along the way, soldiers learn to take shortcuts, such that by the time they are tested for skill retention in their units they are no longer defining tasks the same way as the researcher, who is following the school-taught procedure. Skill retention may look poor because of these differences. Soldiers can functionally perform the task, although not by the Army-prescribed procedure. Evidence of this fact can be found in the systematic errors soldiers made in a study where safety procedures were consistently not retained (Shields, Goldberg, & Dressel, 1979).

Objectives

The effects of aptitude, task types, and initial learning on skill retention suggest the need to tailor training to enhance skill retention. If the effects, singly or in concert, were known they could be used to guide training management. For example, Rose et al. (in preparation) envision a "task performance book" for troop commanders to estimate proficiency and

training needs by task type. Recent empirical field research has investigated skill retention in several Army Military Occupational Specialties (MOS); however, the empirical research is extremely expensive, even for a few skill retention variables. The high cost of field research does not allow for empirical tests of the effects of training strategies on acquisition and retention of Army skills.

Analytical models of skill acquisition and retention offer a potential solution to training management problems. Models organize large quantities of data from empirical studies to predict the effectiveness of various training strategies. A validated model can go beyond empirical results to answer training management questions for soldiering tasks for which no data exist.

This report is part of a larger project to develop and validate mathematical models of skill acquisition and performance of procedural tasks. The objectives of the report are to present the data collected as the basis for model development, and to analyze those data to replicate previous skill retention results. In particular, the data collection method was similar to that used by Shields, Goldberg, and Dressel (1979).

METHOD

Task Selection

The population of tasks included all tasks performed in the driver, gunner, and loader positions in the M60A1 tank. These tasks vary in length, complexity, and extent of practice in the unit after initial training (One Station Unit Training [OSUT]). The following eight tasks were selected from the task population to represent high and low values on these dimensions:

1. Load an M240 Machinegun,
2. Start the M60A1 Tank Engine,
3. Stop the M60A1 Tank Engine,
4. Perform Gunner's Prepare-to-Fire Checks,
5. Perform Loader's Prepare-to-Fire Checks,
6. Engage Targets Using Precision Fire Techniques,
7. Communicate over Tactical FM Radio, and
8. Communicate Using Visual Signal Techniques.

The selection of tasks was based on a preliminary analysis of the task population. The actual length, complexity, and extent of practice were determined by behavioral analysis and analysis of questionnaire data.

Behavioral Analysis

The tasks were analyzed to determine the task elements (steps), standards, and conditions of performance. These analyses were used to develop test scenarios and score forms.

Additional behavioral analyses of the tasks covered characteristics related to learning, performance, and retention gleaned from the literature and previous research. Characteristics include subtask sequence (task elements,

connections, branches, and dependencies); cues for task element performance from the equipment, fellow crew members, etc.; products of tasks and task elements; and task characteristics related to skill acquisition and retention (feedback and interference). Project staff and noncommissioned officer (NCO) personnel who served as scorers in the data collection rated each task element on the following 14 characteristics:

1. Requires recall of knowledge,
2. Requires rule learning and using,
3. Requires guiding and steering, continuous movement,
4. Lacks cues,
5. Has stimulus-response conflict,
6. Has aversive consequences,
7. Has feedback,
8. Unit omits the step (interference),
9. Unit performs the step differently (interference),
10. Unit performs different step (interference),
11. Step not performed in similar task (interference),
12. Step not performed in emergency or in combat (interference),
13. Difficult, and
14. Critical to the overall performance of the task.

The project staff prepared the test protocols, scorer training materials, and behavioral characteristic rating forms, and conducted data analysis in an operational unit and in Armor OSUT, both located at Fort Knox, Kentucky.

Operational Unit Data Collection

Subjects. Subjects were 120 soldiers from operational units of Fort Knox, Kentucky, who had completed the OSUT program within 72 months prior to the study. Four soldiers who graduated before 1979 were eliminated from the sample since they were beyond the target population for the research. The results, therefore, reflect the performance of the remaining 116 soldiers, who completed the OSUT program within 31 months prior to the study.

Procedure. Soldiers from the operational unit were randomly assigned to one of eight test stations. Each soldier proceeded in a "round robin" fashion to the next station until he or she had performed all of the eight tasks. At each test station, the soldier was given one opportunity to perform a task. The scorer read a set of instructions to inform the soldiers of the task and any specific conditions to consider during performance (e.g., moving or stationary targets during precision fire engagements). After reading the instructions, the scorer did not intervene during the performance of the task unless the soldier made an error.

If the soldier committed an error on a step, the scorer gave some assistance. If this degree of assistance was not sufficient to produce correct performance, the scorer gave stronger assistance, until correct performance was obtained. The following three levels of assistance were used:

Level 1 - Remind the soldier what the overall task is and tell him or her the steps performed up to that point.

Level 2 - Tell the soldier what the next step is.

Level 3 - Show the soldier how to do the step.

After demonstrating the step correctly, the soldier proceeded to the next step and continued until the task was completed.

While the soldier performed the task, the scorer recorded data on correct performance of task steps, the order in which the soldier performed the steps, the type of error committed, the level of assistance given, and the elapsed time. Questionnaires were used to collect information on each soldier's background and task-related job experience. Armed Service Vocational Aptitude Battery (ASVAB) scores and level of education were obtained from personnel records.

OSUT Data Collection

Subjects. Subjects were 471 soldiers from four OSUT companies at Fort Knox, Kentucky, in their fifth to tenth week of training.

Procedure. Testing and training trials included five acquisition trials and a retention trial, for a total of six performances by the soldier. Each soldier performed two of the eight tasks. For each task tested, the soldiers reported to the test site twice during a 12-week data collection period. In the first session, the soldier performed the task five times using the procedure described for the operational unit. Approximately 4 weeks after the first session, the soldier returned to perform the task one time. The first session coincided roughly with formal training of the task; the second session coincided roughly with the gate test for that task.

Minor changes were made in the scoresheets between the operational unit and OSUT sessions to simplify the data collection procedure or to accommodate changes in the Army's training policies. In order to ensure comparability of scores, only those performance measures common to both scoresheets were considered in measuring performance.

RESULTS

Sample Demographics

Description of the Operational Unit Sample. The soldiers had pay grades ranging from 1 to 5 with the following percentages: E-1, 6.0%; E-2, 27.6%; E-3, 34.5%; E-4, 31.0%; and E-5, 0.9%. Almost all of the soldiers in the operational unit sample had completed OSUT in 1980 or 1981 so that they were within 2 years of graduation (Figure 1).

In OSUT, approximately half of the soldiers had been in each of the Armor tracks. Until January 1982, soldiers in Armor OSUT were enrolled as either MOS 19E gunner/loader or MOS 19F driver. Since then, there has been only one basic Armor training course (19E) training a general Armor crewmember. Over 48% of the research sample had been in the driver track, and over 50% had been

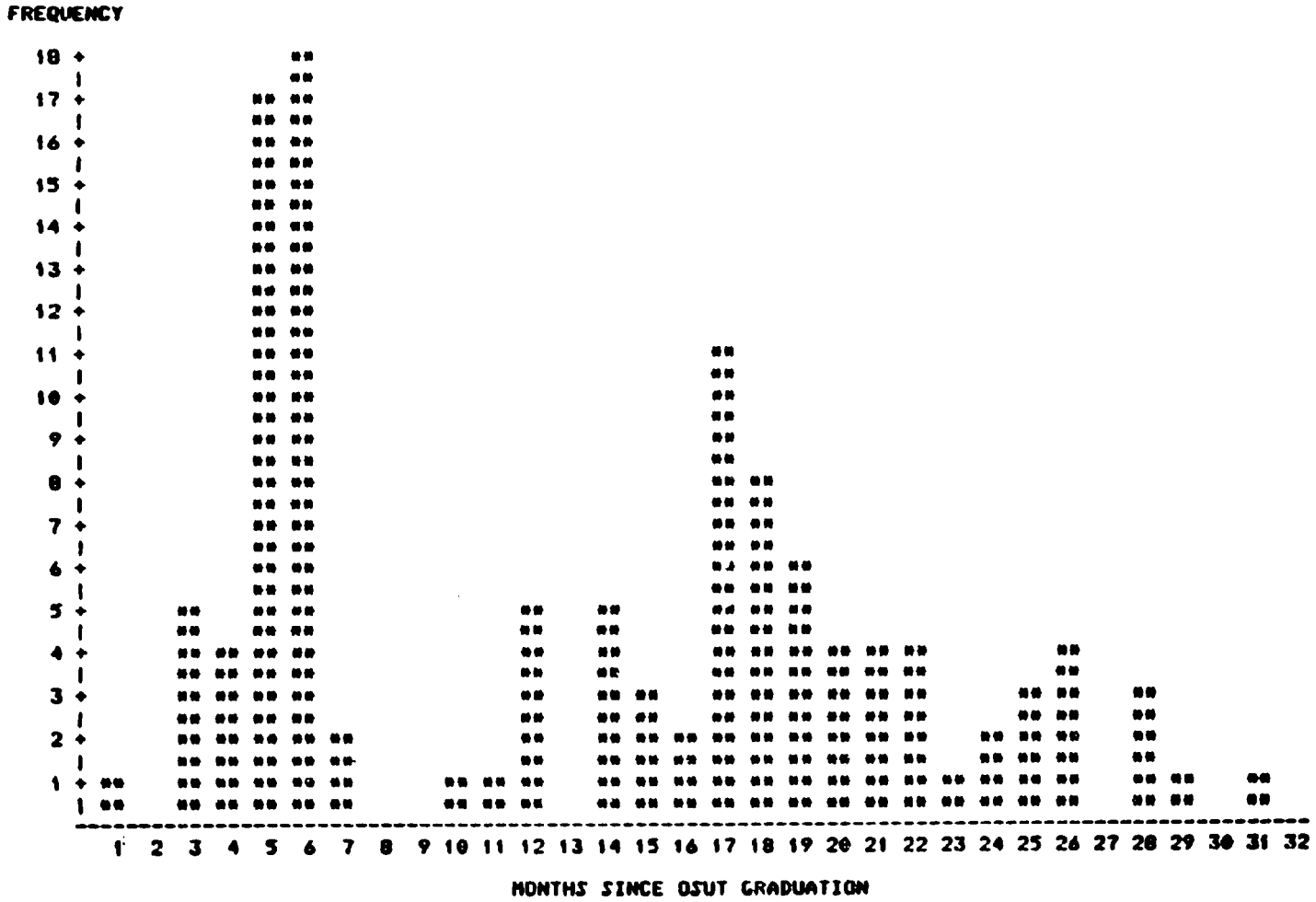


Figure 1. Distribution of number of months since OSUT graduation for operational unit sample.

in the gunner and loader track during their OSUT training. (The one remaining soldier graduated in 1982 when OSUT had no tracks.)

In their assigned posts, the soldiers held tank crew or truck driver positions, and the majority (58.8%) had the position for which they were trained in OSUT. Half had held their current duty position less than 8 months. Three-fifths of the soldiers had participated in Table VIII gunnery exercises.

Armed Forces Qualification Test (AFQT) and ASVAB results for the operational unit soldiers are shown in Table 2. The scores are similar to, but slightly lower than, the standardization population means of 50 for the AFQT and 100 for the ASVAB composites. The AFQT distribution by mental category is shown in Table 3. Approximately half of the soldiers were in category III, which contrasts with Goldberg et al. (1982) where 78.1% of the sample were in category III.

Table 2

ASVAB Results

ASVAB components	Operational unit sample[a] Mean	Operational unit sample[a] Standard deviation	OSUT sample[b] Mean	OSUT sample[b] Standard deviation
AFQT	44.06	23.11	54.69	18.60
Combat	98.67	16.18	105.88	12.88
Field Artillery	97.47	15.92	104.06	12.97
Mechanical Maintenance	98.37	17.79	105.62	13.01
General Maintenance	96.10	16.33	104.06	14.71
Clerical	95.28	16.01	100.95	13.03
General Technical	96.31	16.76	105.14	12.43
Electronics Repair	98.21	14.96	103.81	13.01
Surveillance/Communications	96.39	15.54	103.01	12.90
Skilled Technical	97.14	15.18	102.65	13.66
Operators and Food Handlers	95.70	19.41	103.54	12.69

Note: All group differences are significant by a *t*-test, $p < .001$.

[a] $N = 107$.

[b] $N = 370$.

Description of the OSUT Sample. ASVAB scores were available for 370 of 471 subjects in the OSUT sample. The AFQT and ASVAB composite results for the OSUT soldiers (shown in Table 2) indicate that soldiers' scores were higher than the standard means on all but one of the composites (Clerical) and were significantly higher than operational unit scores on the AFQT and all of the ASVAB composites. The difference may be attributable to an increase in the

enlistment standards between the time of entry of the soldiers in the two samples. The distribution of OSUT soldiers by mental category is shown in Table 4.

Table 3

Mental Category Distribution in Operational Unit

Mental category	Soldiers in unit sample	
	Number	Percent
I	3	2.7
II	24	21.4
III	49	43.8
IV	36	32.1

Table 4

Mental Category Distribution in OSUT Sample

Mental category	Soldiers in OSUT sample	
	Number	Percent
I	11	3.0
II	93	25.1
III	232	62.7
IV	34	9.2

Most of the OSUT soldiers were in the lowest Army grade, although a few had previous service, and therefore had higher grades, as follows: E-1, 86.8%; E-2, 4.7%; E-3, 6.6%; E-4, 1.7%; E-6, 0.2%.

Task Characteristics

The behavior analyses included the rating of individual task elements on 14 attributes. Ten of these attributes were used to define indices of task complexity and task interference. Components of these two indices are as follows:

- Interference

  Unit omits the step
  Unit performs step differently
  Unit performs different step
  Step not performed in similar tasks
  Step not performed in emergency or in combat

- Complexity

  Requires recall of knowledge
  Requires rule learning and using
  Lacks cues
  Has stimulus-response conflict
  Very difficult to perform

The indices combined scores on items scaled from 0 to 10, with items scored as proportions between 0 to 1. To make the ranges of these different types of items comparable, the items scored as proportions were multiplied by 10. The limits of the interference and complexity indices are -10 and 40.

Table 5 summarizes the task characteristics believed to be related to skill retention. Means over tasks for the complexity index varied from approximately 1 for Load Machinegun to over 10 for Ground Guiding; the interference index ranged from -7.88 for Load Machinegun to 2.94 for Stop the Tank Engine.

Table 5

Summary of Task Characteristics

Task	Steps	Complexity index		Interference index	
		Mean	St. dev.	Mean	St. dev.
Load Machinegun	11	1.41	4.38	-7.88	2.85
Start Tank Engine	11	4.27	2.98	-0.22	5.54
Stop Tank Engine	10	4.20	4.61	2.94	7.58
Gunner Prepare to Fire	34	4.80	2.59	-4.47	1.38
Loader Prepare to Fire	6	3.54	0.87	-5.96	5.54
Precision Fire	12	5.29	7.94	-6.25	0.72
Radio Communication	7	1.86	3.04	-4.95	5.07
Ground Guiding	20	10.15	0.49	-6.68	2.52
Index results over all tasks		5.11	4.26	-4.33	4.79

Task Experience

Task Experience in the Operational Unit Sample. The proportion of soldiers who report practicing the tasks since graduating from OSUT ranged from 37.5% (Precision Fire) to 95.5% (Ground Guiding). The three tasks reported to have over 90% of the soldiers practicing (Ground Guiding, Start Tank, and Stop Tank) also had large numbers of soldiers reporting practice more than one time per day, as well as high average practice per day, as indicated in Table 6. Since all of these tasks are trained in Armor OSUT, the date of graduation from OSUT was assumed to be the time of last practice for all soldiers who reported no practice for a particular task in the unit.

Table 6

Task Experience per Day in the Operational Unit

		Task experience				
		Times each day				Average
Task	N	0	<1	1	>1	per day
Load Machinegun	114	42	69	2	1	0.07
Start Tank Engine	110	7	26	26	51	1.80
Stop Tank Engine	108	7	27	25	49	1.79
Gunner Prepare to Fire	113	49	62	0	2	0.08
Loader Prepare to Fire	109	45	62	0	2	0.08
Precision Fire	109	70	38	0	1	0.03
Radio Communication	110	19	81	3	7	0.37
Ground Guiding	107	5	35	28	39	1.98

Task Experience in the OSUT Sample. Soldiers in the OSUT sample had just completed their initial training on the tasks when the pretest was administered for the research. The retention test for a task was timed to coincide approximately with the gate test following training in that task.

Task Performance

Soldiers in the operational unit were tested once, while soldiers in OSUT were tested six times (five acquisition trials and a retention test). No soldier in the operational unit achieved perfect performance on three of the tasks; therefore, the percentage of soldiers correctly performing the entire task had no variance for those tasks, and could not be used as a dependent variable. The number and percentage of task steps performed correctly were used as dependent measures of performance.

Task Performance in the Operational Unit Sample. The task with the highest average percentage correct (99%) was Ground Guiding, which has high levels of practice in the unit. It is a long task, as tested, but each visual signal

in the task is short (two or three steps), and thus easy to remember. Some of the signals occurred more than once in the tests; these were removed before the scores were analyzed so that the results reflect data for testing each signal one time only.

Three other tasks--Load Machinegun, Stop Tank Engine, and Radio Communication--averaged over 70% of the steps performed correctly. All three tasks are short and have high or moderate levels of practice in the unit. Load Machinegun and Radio Communication are relatively simple tasks, but Stop Tank Engine has moderate complexity.

The lowest scores occurred on the Gunner Prepare to Fire task, which is long, complex, and has low practice in the unit. Scores on the remaining tasks (Table 7) averaged from 52% (Loader Prepare to Fire) to 67% (Start Tank Engine). Scores on task steps are reported in Appendix B.

Correlations between the number of correct task steps and demographic variables were examined. For one task, Load the Machinegun, task performance correlated significantly with the number of months since last practice ($r = .20$, $p < .05$, $N = 113$). Thus, higher scores were associated with less time since the last practice of the task. No other correlations of task performance with practice, months since graduation from OSUT, months since last Table VIII, or education level were significant.

In general, there was a small, positive correlation between performance and aptitude as measured by ASVAB; five tasks had significant correlations between task performance and ASVAB scores (Table 8). Load the Machinegun, Stop Tank Engine, and Gunner Prepare to Fire task scores correlated significantly with AFQT scores. Significant correlations were obtained on ASVAB composites for Load the Machinegun, Stop Tank Engine, Gunner Prepare to Fire, Precision Fire, and Radio Communication scores. Scores on Start Tank Engine, Loader Prepare to Fire, and Ground Guiding were not related to AFQT or ASVAB composites.

Task Performance in the OSUT Sample. The effects of learning, retention, education level, and AFQT were analyzed using regression analysis. A logarithmic transformation of the performance scores over trials was used to derive scores meeting the linearity assumption of the regression model. This transformation corresponds to a learning model in which errors decrease proportionately with trials, i.e.,

$$P_{n+1}(E) = (1 - k)P_n(E),$$

where $P_n(E)$ is the probability of an error on trial n, and k is the learning rate. If $P_o(C) = p$ (i.e., p is the initial probability of a correct response), then

$$P_n(C) = 1 - (1 - k)^n (1 - p).$$

Table 7

Task Performance Summary (Operational Unit)

Task	Sample N	No. of steps	Performance on task steps: No. correct Mean	No. correct St. dev.	Mean percent correct	Minimum correct	Maximum correct
Load Machinegun	116	11	9.41	0.76	86	6	11
Start Tank Engine	116	11	7.54	1.49	67	4	11
Stop Tank Engine	111	10	7.66	1.37	77	5	10
Gunner Prepare to Fire	87	34	8.06	4.61	24	0	26
Loader Prepare to Fire	107	6	3.13	1.69	52	0	6
Precision Fire	105	12	6.72	1.48	56	3	10
Radio Communication	116	7	4.94	1.17	71	1	7
Ground Guiding	116	20	19.78	0.48	99	18	20

Table 8

Correlations Between Task Performance and ASVAB Scores in the Operational Unit Sample

ASVAB component	Task: Load Machine-gun (N=107)	Start Tank (N=107)	Stop Tank (N=104)	Gunner Prepare to Fire (N=82)	Loader Prepare to Fire (N=99)	Pre-cision Fire (N=97)	Radio Communi-cation (N=107)	Ground Guide (N=107)
AFQT	.20*	.06	.24*	.26*	-.07	.17	.09	.02
Combat	.23*	-.04	.17	.19	-.05	.17	.10	-.05
Field Artillery	.30**	.08	.15	.13	-.05	.20*	.11	-.04
Mechanical Maintenance	.19	.13	.26**	.21	-.02	.17	.20*	.02
General Maintenance	.22*	.12	.33**	.28*	-.06	.28**	.21*	.05
Clerical	.22*	-.06	.04	.07	-.09	.15	.16	-.07
General Technical	.23*	.09	.23*	.23*	-.09	.17	.15	-.03
Electronics Repair	.20*	.07	.24*	.19	-.05	.22*	.14	.08
Surveillance/ Communications	.22*	.04	.27**	.23*	-.02	.20*	.19	-.01
Skilled Technical	.23*	.06	.25*	.14	-.10	.24*	.17	-.03
Operators and Food Handlers	.17	.12	.18	.24*	-.01	.13	.20	.05

*$p < .05$.

**$p < .01$.

Thus, log $[P_n(E)]$ is a linear function of n, namely:

$$\log [P_n(E)] = n\log(1 - k) + \log(1 - p).$$

The dependent variable for the learning analysis was the logarithm of the proportion of steps performed incorrectly in trials 1 to 5. The retention analysis used the proportion of steps performed correctly in trials 5 and 6 as the dependent variable. Since only two trials are used in the retention analysis, it was not necessary to transform scores to obtain linear predictions.

The effect of learning (task performance scores increasing over trials 1 to 5) was significant for all tasks, and the analysis of variance results for the effect of forgetting (task performance scores decreasing between trials 5 and 6) was significant for all tasks except Ground Guiding. These results are shown in Table 9.

Table 9

Analysis of Variance of Performance Scores over Trials in OSUT

Task	Learning (trials 1 to 5)		Retention (trials 5 and 6)	
	F	*df*	*F*	*df*
Load Machinegun	250.45**	1,431	18.31**	1,161
Start Tank Engine	155.65**	1,358	37.72**	1,139
Stop Tank Engine	177.27**	1,413	8.85*	1,157
Gunner Prepare to Fire	929.43**	1,516	19.57**	1,194
Loader Prepare to Fire	525.93**	1,391	55.41**	1,146
Precision Fire	148.43**	1,351	45.79**	1,135
Radio Communication	212.34**	1,550	10.65*	1,206
Ground Guiding	57.29**	1,429	0.13	1,164

*$p < .01$.

**$p < .001$.

The average percentage of OSUT soldiers who performed all task steps correctly on the first trial varies from 0% (Gunner Prepare to Fire) to 31.2% (Ground Guiding). On the last learning trial (trial 5), the lowest percentage with perfect performance was 50% (Precision Fire) and the highest was 97.3% (Load Machinegun). On trial 6, administered approximately 4 weeks later, the averages varied from 10.8% (Precision Fire) to 84.8% (Ground Guiding). Results for soldiers with 100% correct performance are shown in Table 10.

Table 10

Percentage of Soldiers Performing 100% Correct (OSUT)

Task (N)	Learning trials 1	2	3	4	5	Retention trial
Load Machinegun (110)	10.9	80.0	92.7	90.9	97.3	75.0
Start Tank Engine (93)	11.8	51.6	71.0	80.6	94.2	45.5
Stop Tank Engine (120)	16.5	74.4	85.1	92.5	95.8	77.6
Gunner Prepare to Fire (124)	0.0	10.5	25.0	46.8	58.9	42.5
Loader Prepare to Fire (113)	4.4	43.4	69.0	91.2	94.6	47.0
Precision Fire (93)	4.7	26.1	33.3	51.1	50.0	10.8
Radio Communication (130)	16.2	34.6	49.2	60.8	80.8	65.5
Ground Guiding (109)	31.2	71.6	62.4	67.0	79.8	84.8

The average percentage of task steps performed correctly showed patterns of results similar to the percentage of soldiers performing correctly. Overall, scores on the first trial ranged from 19.7% average correct (for Loader Prepare to Fire) to 93.2% average correct (for Ground Guiding). All average scores were over 90% correct on trial 5. In the retention trial (trial 6), the lowest average percentage of correct steps was 84.4% (Precision Fire) and the highest was 99% (Ground Guiding). Results for average percent correct by task and trial are shown in Table 11.

Although a small percentage of soldiers performed entire tasks correctly, most performed substantial portions of the task correctly. For example, less than 5% of the soldiers executed the Precision Fire task correctly on the first trial, but on the average, over 66% of the steps were performed correctly. On trial 5, half of the soldiers performed the entire Precision Fire task, with 94% of the steps being performed correctly.

Both the proportion of soldiers and the average percentage of steps performed correctly returned to the level of the second trial after the retention interval (i.e., on trial 6). However, performance on three tasks, Gunner Prepare to Fire, Radio Communication, and Ground Guiding, remained higher than trial 2, and on one task (Precision Fire) performance on the sixth trial was lower than that on the second trial.

The effects of education level and AFQT were analyzed in the same regression analysis described above. The results indicate that level of education and AFQT scores were related to learning and retention for some of the tasks. AFQT scores were related to learning for two tasks: Precision Fire ($F[1,351] = 18.04$, $p < .001$) and Radio Communication ($F[1,550] = 25.73$, $p < .001$); and related to forgetting for two tasks: Gunner Prepare to Fire ($F[1,194] = 5.23$, $p < .05$) and Precision Fire ($F[1,135] = 9.00$, $p < .01$). Education level was related to learning for two tasks: Gunner Prepare to Fire ($F[1,156] = 6.05$, $p < .05$) and Precision Fire ($F[1,135] = 4.98$, $p < .05$); and to forgetting for Precision Fire ($F[1,135] = 4.93$, $p < .05$). Thus, for

Table 11

Percentage of Performance Measures Correc[illegible] ([illegible]UT)

Task (N)	No. of steps	Learning trials 1	2	3	4	5	Retention trial
Load Machinegun (110)	11	85.9[a] 8.5[b]	97.8 4.5	99.3 2.8	99.2 2.6	99.8 1.5	97.6 4.2
Start Tank Engine (93)	11	88.9 6.6	94.9 6.4	97.4 4.3	98.2 3.9	99.4 2.2	93.9 6.3
Stop Tank Engine (120)	10	81.5 1.5	97.1 5.4	98.6 3.5	99.2 2.6	99.6 3.0	97.6 6.0
Gunner Prepare to Fire (124)	34	33.6 23.3	86.0 11.8	93.1 7.8	95.8 7.7	98.3 2.5	91.8 15.9
Loader Prepare to Fire (113)	6	19.9 27.5	86.6 14.9	93.1 12.9	98.8 4.3	99.0 4.6	88.3 13.8
Precision Fire (93)	12	66.5 17.1	87.4 11.3	88.5 12.0	93.2 8.8	93.6 8.0	84.3 10.9
Radio Communication (130)	7	77.4 15.5	86.5 14.0	91.6 10.5	94.0 8.9	96.9 7.1	95.1 7.5
Ground Guiding (109)	20[c]	93.2 11.6	98.1 3.8	98.2 4.2	99.1 2.5	99.0 2.9	99.0 2.5

[a]Mean.

[b]Standard deviation.

[c]One ground guiding course had only 19 steps.

for the Precision Fire task, AFQT and education were related to both learning and forgetting.

Analysis of Combined Operational Unit and OSUT Samples

We combined the scores from the operational unit and OSUT samples to analyze forgetting in a cross-sectional design. Since the soldiers in the OSUT research sample received training in addition to that received by the typical soldier, we corrected the retention trial scores before using them in the combined analysis. The correction was based on the distributions of the OSUT gate test results for soldiers in the research sample (who received the additional training), and for soldiers in OSUT who were not in the research (who did not receive additional training). The proportions of soldiers performing a task correctly were converted to z-scores for research and nonresearch samples. The difference between the z-scores provided a correction factor for each task in terms of the standard deviation of the test scores. Then, the correction factor was subtracted from the scores of the research soldiers on their sixth trial. However, not all tasks were tested in the OSUT gate test. For tasks not tested, the correction factor was the average of the correction factors on the tasks that were tested. Correction factors are shown in Table 12. The first column represents the correction factor in terms of the standard deviation of the scores on the retention test. The second column portrays the actual value used to adjust the proportion of correct steps; the corrected mean score is shown in the third column.

Table 12

Correction Factors for the OSUT Retention Trial

Task	Correction factor multiple	Adjustment amount	Corrected mean (%)
Load Machinegun	-.31245	-0.013113	96.3
Start Tank Engine	-.32075	-0.020430	91.9
Stop Tank Engine	-.20990	-0.016982	95.9
Gunner Prepare to Fire	-.22780	-0.036873	88.1
Loader Prepare to Fire	-.22780	-0.031558	85.1
Precision Fire	-.13420	-0.0144656	82.9
Radio Communication	-.22780	-0.017222	93.4
Signals	-.09160	-0.002315	98.8

The performance scores and time since OSUT for the operational unit sample are reported in Table 7. Time since training was zero for the scores on trial 6 in the OSUT sample. Correlations between the percentage of steps passed (as corrected), and time since OSUT were significant for all tasks except Ground Guiding (Table 13).

Table 13

Correlation of Task Performance with Months Since OSUT in Combined Sample

Task	Correlation	Number of soldiers
Load Machinegun	-.57*	207
Start Tank Engine	-.51*	197
Stop Tank Engine	-.52*	212
Gunner Prepare to Fire	-.68*	187
Loader Prepare to Fire	-.37*	208
Precision Fire	-.56*	187
Radio Communication	-.46*	232
Ground Guiding	-.08	214

*$p < .001$.

The slope of the retention function was used as a dependent variable in a regression analysis with task length, practice per day, complexity, and interference as independent variables. The best-fitting regression model,

$$Y = -0.000484\ X_1 - 0.010449\ X_2 - 0.000717\ X_3 - 0.00189\ X_4 + C$$

where Y = the slope of the performance retention function,

X_1 = the number of steps in the task,

X_2 = the daily practice rate,

X_3 = the complexity index score, and

X_4 = the interference index score,

accounted for 94% of the variance. Regression analysis indicated the weights of task length ($F[1,3] = 11.76$, $p < .05$), practice rate ($F[1,3] = 16.85$, $p < .05$), and interference ($F[1,3] = 13.95$, $p < .05$) were significantly greater than zero. The effect of task complexity was not significant, however ($F[1,3] = 0.93$).

Similar analyses were performed assuming exponential and power decay functions. Although the results differ in detail from those reported above, the general results were the same.

Effects of Task Length, Practice, and Interference

The effects of task length, practice, and interference on forgetting are evident for some of the tasks. This section summarizes the effects for these

variables which were significant in the regression analysis on the combined sample, although they have been tabulated separately for OSUT and unit samples elsewhere (length and task performance, Tables 7 and 12; practice, Table 6; interference, Table 5).

Task Length. The longest task, Gunner Prepare to Fire, had high scores in OSUT and the lowest scores compared to other tasks in the operational unit; thus, it had high forgetting in the combined analysis. Ground Guiding, the second longest task, did not show forgetting. This task, as tested, was composed of a series of very short subtasks. Each visual signal has only two or three steps, and thus, according to the criterion of length, each signal should be easy to remember. The natural organization of the Ground Guiding task into easily remembered signals may have facilitated performance.

Three short tasks had high scores in OSUT retention and in the operational unit (Load Machinegun, Stop Tank Engine, and Radio Communication). Another short task, Loader Prepare to Fire, had one of the lower scores in both OSUT and the unit, but did not evidence much loss of performance between the two samples.

Practice. Tasks with the highest practice ratings were Ground Guiding, which did not show performance loss, and Stop Tank Engine, which also retained high scores. Tasks with low reported practice were Precision Fire, Gunner Prepare to Fire, Loader Prepare to Fire, and Load the Machinegun. Of those with low practice, Gunner Prepare to Fire had the lowest operational unit scores. Loader Prepare to Fire and Precision Fire also had low scores in the operational unit, and thus demonstrated skill loss in the combined sample analysis.

Some steps within the tasks show effects of practice in detail. In the Start Tank Engine task, for example, the steps with high scores were the ones rated as likely to be performed in the unit under ordinary circumstances. In the Stop Tank Engine task, four steps had perfect or near perfect scores (place transmission in park, release brake pedal, hold engine fuel shut-off switch on OFF position until engine stops, and turn master battery off after engine stops) and appear to represent the way soldiers perform the task rather than the by-the-book steps.

Interference. Two of the tasks with the lowest interference, Ground Guiding and Load the Machinegun, also retain the highest performance in the operational unit. Of these, Ground Guiding is the one that showed no forgetting within the OSUT sample as well. Two tasks with high interference ratings, Start Tank Engine and Stop Tank Engine, had very high OSUT scores and moderate operational unit scores, so that they showed skill loss in the combined analysis.

While the interference ratings showed significant effects, the task characteristics that describe task complexity did not. Part of the reason may be the arbitrary nature of the composite index for complexity. For example, cues had the same weight in the composite as did other variables (since the composite was unweighted). If cues were weighted highly, the Ground Guiding tasks would have been one of the simpler tasks, rather than the most complex. Since that task was retained, the overall result in the combined sample might have shown an effect of complexity.

DISCUSSION

The present research has attempted to capture the process of skill development of Armor soldiers during OSUT and the course of their task performance capability within the first 2 years in operational Armor units. Soldiers receive formal instruction and an opportunity to practice all of the tasks they are responsible for learning in OSUT. After formal training, soldiers practice tasks informally to prepare for the gate tests they must complete to graduate. The gate test is the last time they perform any given task in OSUT. Once in an operational unit, soldiers' duty positions dictate the tasks they perform frequently. Measures of task performance obtained during OSUT and in the unit provide information on the effectiveness of formal training, the contribution of the additional preparation for tests, and the course of skill development or decay in units.

Skill Acquisition and Forgetting

The first performance measure obtained from the OSUT soldiers in the research was administered soon after they had received all the formal instruction they were to be given on a task. In some cases, such as machine gun operations, this measure came after a second formal class. OSUT task performance (Tables 10 and 11) shows that formal training was effective for most tasks, since soldiers became adept in performing most steps. The number of soldiers who could complete all performance measures was low, however, generally under 20%. The acquisition of skill progressed in typical form over the five acquisition trials, and performance improvement had generally reached high levels by the fourth trial. Performance by soldiers who had not received the additional training offered in this study was estimated from gate test scores (Table 12). This performance is superior to the initial performance after formal training, and it points out that additional training is beneficial in bringing OSUT soldiers up to their gate test performance.

After the five acquisition trials, OSUT soldiers received a sixth trial after a retention interval of 4 weeks. Forgetting was significant after this short period, but became negligible over time in the operational unit. The curve had flattened out by the third month after training, when the first substantial number of soldiers was tested in the unit. The shape of the forgetting curves (Figure 2), therefore, is the classical one that has rapid skill loss at first, and a decline of rate of loss over time, thus producing a negatively accelerating curve.

The results of the OSUT, unit, and combined samples support a contention by Rose et al. (in preparation) about the impact of time sampling along the skill retention curve. Research samples tested early in the curve, during rapid decay, show large amounts of forgetting, while samples tested later do not show decay. The data from the OSUT sample were drawn from a section of the retention curve in which decay is very rapid, and hence, significant skill loss was obtained. Data from the operational unit were sampled from an area of the curve in which forgetting is very slow.

This research supports previous findings that performance decays during the interval when soldiers transfer from school to their first unit assignments

(e.g., Osborn et al., 1978; TRASANA, 1977). Although some research has shown increments in performance after the soldier is in the unit for several months (e.g., TRASANA, 1977), the present results show neither decrements nor increments in the unit. As with prior research, the measures of practice in the unit were simply ratings by the soldier; the ratings relied on memory and have untested reliability and accuracy. Soldiers in the operational unit performed at about the same level (in percentage of steps correct) as soldiers in their initial performance after formal training. The salient task steps that soldiers learn initially are the ones they are likely to retain.

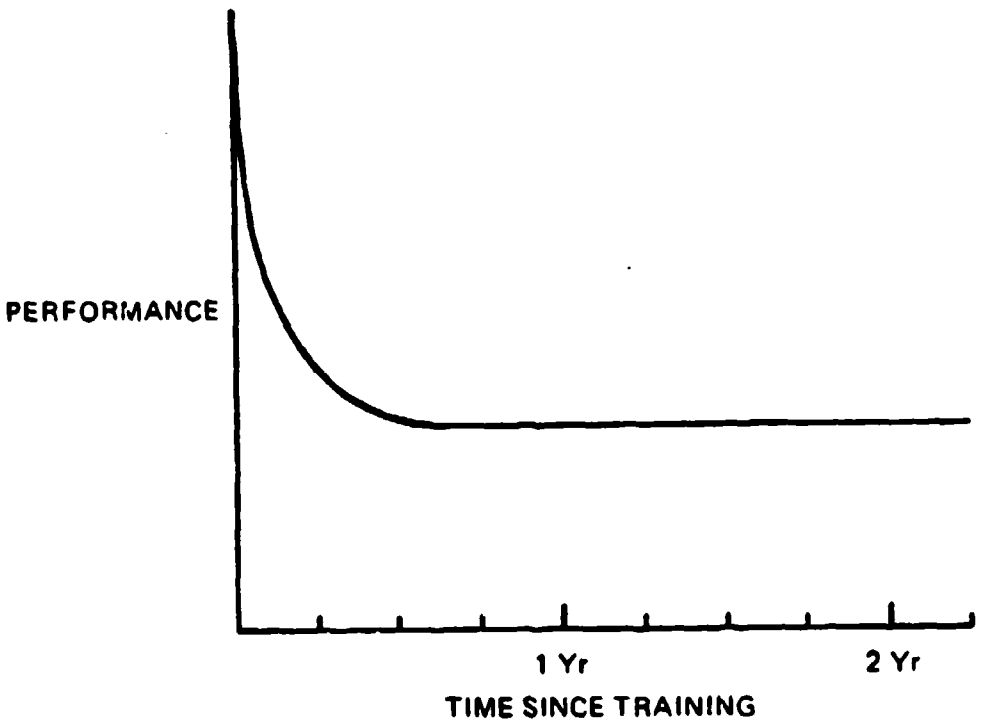


Figure 2. Hypothetical relationship between performance and time since training.

Effects of Individual Differences on Acquisition and Forgetting

Earlier ARI research showed mixed effects of aptitude on skill acquisition and retention. Results of this research showed higher retention with higher aptitude on approximately half of the tasks in the operational unit, but aptitude effects for only two tasks in the OSUT sample. Since so few tasks correlated with aptitude measures, the types of tasks or conditions under which aptitude does or does not influence acquisition and retention are unresolved.

Educational level was related to acquisition rate for only two tasks in the OSUT sample, and for only one task in the operational unit. Thus,

education did not have a strong effect in this research; this finding supports that of Goldberg et al. (1982), who found no effect from educational level. Overall, the results pertaining to aptitude and education, which were the variables investigated in the present study, corroborated previous ARI findings.

Effects of Practice, Task Length, and Interference

The effect of the extent of practice in the combined operational unit and OSUT samples indicated that practice differentiated among tasks. Tasks that were practiced more often retained high performance scores over time. One example, Ground Guiding, is a task likely to be practiced by the portion of soldiers in the operational unit who were truck drivers, as well as by the soldiers who held tank crew positions. Definitive research would need to investigate an array of common and job-specific tasks that vary systematically on the dimensions of interference, practice, and other retention variables. Alternatively, the results of the modeling in the research phases to follow this one may provide some information about retention under different conditions.

Differences among tasks in rates of forgetting were also associated with task length and interference. As demonstrated earlier by Shields, Goldberg, and Dressel (1979), tasks that are longer (have more steps) are forgotten sooner than shorter tasks. The effect of length may be the memory demand of the task. The results reported here replicate those of Shields, Goldberg, and Dressel (1979), even though the present results are based on the percentage of task steps performed correctly while those of Shields, Goldberg, and Dressel were based on the percentage of soldiers who performed the entire task correctly. Thus, even a change in the dependent variable did not degrade the effect of task length on retention.

Tasks that had more interference had higher rates of forgetting. Four sources of interference combined into the interference index were whether the step in the operational unit, as compared to the training situation, would be (1) omitted, (2) performed differently, (3) have another step substituted for it, or (4) be omitted in a similar task. Some tasks, such as Start and Stop Tank Engine, have steps that are omitted in the unit (e.g., idle the engine for a set number of minutes to cool it), and apparently these tasks are more quickly forgotten. In contrast, tasks with steps that are all performed under operational conditions, such as Load the Machinegun, are better retained. Interference theory has been cited as one of the theoretical orientations most useful in explaining forgetting (Ellis, 1979; Holding, 1965). The results of this research support that view.

Problems and Future Prospects

The results of the analysis indicate some ability to predict differences among tasks in the rate of forgetting from the number of task steps, and details about practice on the task. Given that there were only eight tasks, the ability to obtain significant results is impressive. Nevertheless, the results should not be viewed as definitive because of problems in measuring task characteristics and experience variables. Task characteristics were

measured by indices that combined several factors. With the small number of tasks used, moderate changes in the weights used to combine the factors in these indices could have a great effect on the relationship between retention and task characteristics. For example, tasks that involve greater recall from memory (a positive component of complexity) often have more and stronger performance cues (a negative component of complexity). Changes in the relative weights of these two factors in determining complexity could change the rank order of tasks on the complexity index, and hence, the overall relationship between complexity and retention.

Future research, then, should concentrate on providing refined measures of complexity, interference, and other task factors, and should relate these indices to retention on a large sample of tasks. Much of the work required is conceptual and involves the determination of appropriate factors to include in measures of complexity and interference, and proper rules for combining these factors into reliable indices. Other aspects involve increasing the sample of tasks used to test the effects of the skill components on retention.

Probably the most significant aspect of the results of the combined analysis is that it indicates that details associated with how a task is practiced influence retention. Thus, if the tasks are performed differently in the unit from the way they were trained, the soldiers' performance will look less and less like the standards set during training, and will appear to decline even at high rates of practice.

REFERENCES

Annett, J. (September 1977). Skill loss: A review of the literature and recommendation for research. Warwick, England: University of Warwick.

Block, J. H., & Burns, R. B. (1976). Mastery learning. In L. Shulman (Ed.), Review of research in education. Itasca, IL: F. E. Peacock.

Dressell, J. D. (February 1980). Mnemonically enhanced training (Working paper). Alexandria, VA: U.S. Army Research Institute.

Ellis, H. C. (1979). Transfer and retention. In M. H. Marx (Ed.), Learning: Processes. London: Macmillan.

Gardlin, G. R., & Sitterley, T. E. (June 1972). Degradation of learned skills: A review and annotated bibliography. Seattle, WA: Boeing Aerospace.

Goldberg, S. L., Drillings, M., & Dressel, J. D. (1982). Mastery training: Effect on skill retention (Technical Report 513) Alexandria, VA.: U.S. Army Research Institute.

Hagman, J. D. (January 1980a). Effects of presentation- and test-trial training on motor acquisition and retention (Technical Report 431). Alexandria, VA: U.S. Army Research Institute.

Hagman, J. D. (May 1980b). Effects of training task repetition on retention and transfer of maintenance skill (Research Report, Draft). Alexandria, VA: U.S. Army Research Institute.

Hagman, J. D. (November 1980c). Effects of training schedule and equipment variety on retention and transfer of maintenance skill (Research Report 1309). Alexandria, VA: U.S. Army Research Institute.

Hagman, J. D. Effects of presentation- and test-trial training on acquisition and retention of movement end location (Technical Report Draft) Alexandria, VA.: US Army Research Institute.

Holding, D. H. (1965). Principles of training. Oxford: Pergamon Press.

Holmgren, J. E., Hilligoss, R. E., Swezey, R. W., & Eakins, R. C. (April 1979). Training effectiveness and retention of training extension course (TEC) instruction in the combat arms (Research Report 1203). Alexandria, VA: U.S. Army Research Institute.

Johnson, S. L. (January 1978). Retention and transfer of training on a procedural task: Interaction of training strategy and cognitive style (Calspan Report No. DJ-6032-M-1). Buffalo, NY: Calspan Corp.

Knerr, C. M., Berger, D. C., & Popelka, B. A. (1980). Sustaining team performance: A systems model (Final Report). Springfield, VA: Litton Mellonics.

McCluskey, M. R., Hiller, J. H., Bloom, R. D., & Whitmarsh, P. J. (November 1978). Skill decay of sixteen common tasks for MOS 11B and 11C (Final Report, Draft). Alexandria, VA: U.S. Army Research Institute.

Osborn, W. C., Campbell, C. H., & Harris, J. H. (December 1979). The retention of tank crewman skills (Research Report 1234). Alexandria, VA: U.S. Army Research Institute.

Prophet, W. W. (October 1976). Long-term retention of flying skills: A review of the literature (HumRRO Technical Report 76-35). Alexandria, VA: Human Resources Research Organization.

Rose, A. M., McLaughlin, D. H., Felker, D. B., & Hagman, J. D. (In preparation). Retention of soldiering skills: Review of recent ARI research (Technical Report 530). Alexandria, VA: U.S. Army Research Institute.

Schendel, J. D., & Hagman, J. D. (July 1980). On sustaining procedural skills over prolonged retention intervals (Research Report 1298). Alexandria, VA: U.S. Army Research Institute.

Schendel, J. D., Shields, J. L., & Katz, M. S. (September 1978). Retention of motor skills: A review (Technical Paper 313). Alexandria, VA: U.S. Army Research Institute.

Shields, J. L., Goldberg, S. L., & Dressel, J. D. (September 1979). Retention of basic soldiering skills (Research Report 1225). Alexandria, VA: U.S. Army Research Institute.

Shields, J. L., Joyce, R. P., & VanWert, J. R. (March 1979). Chaparral skill retention (Research Report 1205). Alexandria, VA: U.S. Army Research Institute.

Sullivan, D. J., Casey, R. J., & Hebin, J. M. (October 1978). Acquisition and retention of cognitive versus perceptually oriented training materials (Technical Report Draft) Alexandria, VA: US Army Research Institute.

U.S. Army Field Artillery School. (1977). Weapon system training effectiveness analysis: The forward observer (Phase IA Baseline, Vol. 1). Fort Sill, OK: U.S. Army Field Artillery School.

U.S. Army TRADOC Systems Analysis Activity (TRASANA). (1977). REDEYE weapons system training effectiveness analysis (TRASANA Technical Report 21-77). White Sands, NM: U.S. Army TRADOC Systems Analysis Activity.

Vineberg, R. (June 1975). A study of the retention of skills and knowledge acquired in basic training (HumRRO Technical Report 75-10). Alexandria, VA: Human Resources Research Organization.

Wheaton, G. R., Rose, A. M., Fingerman, P. W., Korotkin, A. L., Holding, F. H., & Mirabella, A. (April 1976). Evaluation of the effectiveness of training devices: Literature review and preliminary model (Research Memorandum 76-6). Alexandria, VA: U.S. Army Research Institute.

APPENDIX A

SAMPLE QUESTIONNAIRES AND SCORESHEETS

BACKGROUND INFORMATION

NAME: _____ Social Security No._____
(Last) (First) (Middle)

PAY GRADE: E1_____ E2_____ E3_____

(Check one) E4_____ E5_____ E6_____

CURRENT DUTY POSITION: (1) Gunner_____ (2) Loader_____
(3) Driver_____ (4) TC _____
(5) Other_____
(Describe)

WHEN DID YOU START YOUR CURRENT DUTY POSITION? Month_____ Year_____

BATTALION: 5/33 AR_____ COMPANY: HQ_____ Platoon: 1_____
4/37 AR_____ A_____ 2_____
B_____ 3_____
C_____

WHICH ENTRY LEVEL TRAINING COURSE DID YOU ATTEND?
(1) 19E OSUT_____
(2) 19F OSUT_____
(3) Entry training in another MOS_____

WHAT OSUT TRACK DID YOU ATTEND:
(1) Driver_____
(2) Gunner/Loader_____
(3) My OSUT did not have tracks_____

WHAT WAS YOUR OSUT COMPANY?_____

WHEN DID YOU GRADUATE FROM OSUT? Month_____ Year_____

WHEN WAS YOUR LAST TABLE 8? Month_____ Year_____
Have not participated in Table 8_____

WHAT WAS YOUR CREW POSITION DURING YOUR LAST TABLE 8?
(1) Tank Commander_____ (2) Gunner_____ (3) Driver_____
(4) Loader_____ (5) No Previous Table 8_____

HOW DID YOUR CREW DO ON ITS LAST TABLE 8?
(1) Distinguished_____ (2) Qualified_____
(2) Non-qualified_____ (4) No Previous Table 8_____

WHAT POSITION DO YOU EXPECT TO HOLD DURING THE NEXT TABLE 8 YOUR CREW PARTICIPATES IN?
(1) Tank Commander_____ (2) Gunner_____
(3) Driver_____ (4) Loader_____

NAME _____

SSAN _____

UNIT _____

TASK-RELATED JOB EXPERIENCE

INSTRUCTIONS: Check YES if you have performed the task since you left OSUT or check NO if you have not performed it. If you check YES, please write the Date of the LAST Time that you performed it. Answer only one space under the Number of Times. For example, if you perform the task about two times a month, write 2 under the Month column.

SINCE YOU LEFT OSUT (not counting today) HAVE YOU:	YES	NUMBER OF TIMES a Day	a Week	a Month	a Year	DATE OF LAST TIME	NO
1. Loaded an M240 Coax Machinegun?	___	___	___	___	___	_____	___
2. Started an M60A1 Tank Engine?	___	___	___	___	___	_____	___
3. Stopped an M60A1 Tank Engine?	___	___	___	___	___	_____	___
4. Performed Gunner' Prepare-to-Fire Checks: Check Gun Controls?	___	___	___	___	___	_____	___
5. Performed Loader's Prepare-to-Fire Checks: Check Main Gun Firing Switches?	___	___	___	___	___	_____	___
6. Engaged Targets Using Precision Firing Techniques?	___	___	___	___	___	_____	___
7. Communicated Over Tactical Radio FM AN/VRC-64?	___	___	___	___	___	_____	___
8. Communicsted Using Visual, Signalling Techniques: Ground Guiding?	___	___	___	___	___	_____	___

NAME _____

SSAN _____

UNIT _____

TEST [1] [2] [3]

TRAIN [1] [2] [3]

LOAD AN M240 COAX MACHINEGUN

INSTRUCTIONS TO SOLDIER

"At this station you will demonstrate your ability to load an M240 coaxial machinegun. Assume the machinegun will be fired immediately after it is loaded. Do you understand the instructions?" (NOTE TO SCORER: If the soldier does not, read the instructions again.) "BEGIN."

PERFORMANCE MEASURES	YES	NO	PROMPTS	TIME
1. Clears the machinegun.				
a. Pulls charger handle rearward to lock bolt back.	___	___	1 2 3	
b. Places safety on S	___	___	1 2 3	
c. Raises cover	___	___	1 2 3	
d. Lifts feedtray	___	___	1 2 3	
e. Looks and feels empty chamber.	___	___	1 2 3	
f. Lowers feedtray.	___	___	1 2 3	___
2. Loads the machinegun.				
a. Places first round in feedtray with open side of belt face down.	___	___	1 2 3	
b. Pushes ammunition in feedtray until it comes in contact with cartridge stops.	___	___	1 2 3	
c. Closes cover	___	___	1 2 3	
d. Places safety in F	___	___	1 2 3	
e. Announces "UP" when machinegun loaded.	___	___	1 2 3	
			TOTAL TIME	_____

The soldier has satisfactorily completed the task if he scores a "YES" on all of the standards listed below:

STANDARDS	YES	NO
1. Completes all performance measures without assistance from scorer	___	___
2. Steps are performed in sequence.	___	___
3. Ammunition is in feedtray and doesn't pull out when jerked.	___	___
TOTAL SCORE	___	___
TOTAL TIME	_____	

REASON(S) FOR "NO" SCORE

_____

_____

NAME _____

SSAN _____

UNIT _____

TEST [1] [2] [3]

TRAIN [1] [2] [3]

START THE M60A1 TANK ENGINE

INSTRUCTIONS TO SOLDIER

"You are the driver of an M60A1 tank. You are to start the engine, assuming normal weather conditions. I will act as other crew positions when necessary. Do you understand the instructions?" (NOTE TO SCORER: If the soldier has questions, read the instructions again.) "BEGIN."

PERFORMANCE MEASURES	YES	NO	PROMPTS	TIME
1. Sets parking brake by pushing brake pedal until pressure reaches between 750-900 psi.	___	___	1 2 3	
2. Places transmission in PARK.	___	___	1 2 3	
3. Releases brake pedal	___	___	1 2 3	
4. Closes both drain valves	___	___	1 2 3	
5. Places fuel shut-off valve handle in ON position	___	___	1 2 3	
6. Places fuel pump switch in ON position	___	___	1 2 3	
7. Asks crew if their electronic equipment is OFF	___	___	1 2 3	___
(NOTE TO SCORER: Tell soldier the electronic equipment is OFF.)				
(NOTE TO SCORER: Insure all the electronic equipment is OFF before master battery switch is turned ON.)				
8. Turns master battery switch ON	___	___	1 2 3	
9. Check fuel levels.				
a. Sets FUEL TANKS switch to position L	___	___	1 2 3	
(NOTE TO SCORER: If a soldier performs A or B, he should be given a "YES" for PM 9.)				
10. Depresses accelerator pedal	___	___	1 2 3	
11. Presses starter switch until engine starts (or up to 15 seconds, whichever comes first)	___	___	1 2 3	___

The soldier has satisfactorily completed the task if he scores a "YES" on all of the Standards listed below:

STANDARDS	YES	NO
1. Completes all performance measures without assistance from scorer.	___	___
2. Asks if electronic equipment is OFF before turning master battery switch ON.	___	___
3. Tank engine starts	___	___
4. Performs performance measures in sequence when necessary (see sequence flowchart on next page).	___	___
TOTAL SCORE	___	___
TOTAL TIME	_____	

REASON(S) FOR "NO" SCORE

_____

_____

_____

NAME _____

SSAN _____

UNIT _____

TEST [1] [2] [3]

TRAIN [1] [2] [3]

STOP THE M60A1 TANK ENGINE

INSTRUCTIONS TO SOLDIER

"You are the driver of an M60A1 tank. Assume you have driven 150 miles. You are to demonstrate the procedure for stopping the tank's engine. I will act as tank commander or gunner when necessary. Do you understand the instructions?" (NOTE TO SCORER: If the soldier has questions, read the instructions again.) "BEGIN."

PERFORMANCE MEASURES	YES	NO	PROMPTS	TIME
1. Sets parking brake by pushing brake pedal until pressure reaches between 750-900 psi.	___	___	1 2 3	
2. Places transmission in PARK.	___	___	1 2 3	
3. Releases brake pedal	___	___	1 2 3	
4. Presses accelerator so that engine idles at 1000-1200 rpm. (NOTE TO SCORER: Ask soldier how long engine should idle at this rpm.)	___	___	1 2 3	___
5. Soldier says engine idles at 1000-1200 rpm for 5 minutes (NOTE TO SCORER: Tell soldier to continue to next step.)	___	___	1 2 3	
6. Releases accelerator and idles engine at 700-750 rpm (NOTE TO SCORER: Ask soldier how long engine should idle at this rpm.)	___	___	1 2 3	
7. Soldier says engine idles at 750 rpm for 3 minutes	___	___	1 2 3	___
8. Asks Gunner and TC if their electronic equipment is OFF. (NOTE TO SCORER: Scorer tells soldier the equipment is OFF.)	___	___	1 2 3	___
9. Holds engine fuel shut-off switch in "SHUT-OFF" (Up) until engine stops.	___	___	1 2 3	
10. Turns master battery OFF, after engine stops	___	___	1 2 3	
			TOTAL TIME	_____

The soldier has satisfactorily completed the task if he scores a "YES" on all of the Standards listed below:

STANDARDS	YES	NO
1. Completes all performance measures without assistance from scorer.	___	___
2. Turns master battery switch OFF, after engine stops.	___	___
3. Performs performance measures in sequence when required.	___	___
4. Engine stops	___	___
TOTAL SCORE	___	___
TOTAL TIME	_____	

REASON(S) FOR "NO" SCORE

_____

_____

_____

NAME: _____

SSAN _____

UNIT _____

TEST [1] [2] [3]

TRAIN [1] [2] [3]

PERFORM GUNNER'S PREPARE-TO-FIRE CHECKS (CHECK GUN CONTROLS)

INSTRUCTIONS TO SOLDIER

"You are the gunner of an M60A1 tank. You are doing Prepare-to-Fire checks and have already checked the firing switches. You will perform the sequence "CHECK GUN CONTROLS" after I give you the command. The turret is in manual operation. I will act as the other crew positions when necessary. Do you understand the instructions?" (NOTE TO SCORER: If the soldier has questions, read the instructions again.) "Remember the turret must be placed into power operation before checking the azimuth indicator for accuracy or slippage." (NOTE TO SCORER: Start the training by saying "CHECK GUN CONTROL.")

PERFORMANCE MEASURES	YES	NO	PROMPTS	TIME
1. Places turret into power operation.				
a. Holds down power solenoid plunger while rotating gunner's control handle either left or right	___	___	1 2 3	
b. Holds gunner control handle in position described in (a) until zero pressure is indicated on pressure gage	___	___	1 2 3	
c. Checks hydraulic power pack oil level by removing dipstick of oil level gage	___	___	1 2 3	
d. Tells loader to unlock turret traverse lock	___	___	1 2 3	
(NOTE TO SCORER: Unlock turret lock.)				
e. Announces "POWER"	___	___	1 2 3	
(NOTE TO SCORER: Turn on master battery switch--announce "POWER ON.")				
f. Turns ELEV/TRAV power switch ON	___	___	1 2 3	
g. Squeezes magnetic brake switch while rotating gunner's power control handles to left and right	___	___	1 2 3	
h. Moves handles rearward to elevate gun, forward to lower gun, while squeezing magnetic brake switch	___	___	1 2 3	___
(NOTE TO SCORER: PM g and h may be done as listed or reversed [h then g].)				
(NOTE TO SCORER: Tell soldier TC's power control handles have been operated.)				
2. Checks azimuth indicator for accuracy.				
a. Looks through eyepiece on gunner's daylight periscope	___	___	1 2 3	
(NOTE TO SCORER: Tell soldier the aiming point.)				
b. Alines cross on aiming point using manual elevating and traversing handles	___	___	1 2 3	___
(NOTE TO SCORER: Verify soldier has alined cross on aiming point.)				
c. Sets azimuth indicator to zero.				
- Presses resetter knob	___	___	1 2 3	
- Turns resetter knob to aline middle scale pointer with inner scale pointer	___	___	1 2 3	
- Turns resetter knob moving both pointers to zero	___	___	1 2 3	
- Releases resetter knob	___	___	1 2 3	
d. Traverses turret through complete circle using manual traversing handle	___	___	1 2 3	
e. Brings aiming cross back on same aiming point	___	___	1 2 3	___
(NOTE TO SCORER: Verify the aiming cross is on original aiming point by looking through periscope.)				
f. Turns head to check that azimuth indicator middle scale pointer is within acceptable area	___	___	1 2 3	
(NOTE TO SCORER: Use scoring aid when determining if the pointer is within the acceptable area.)				
g. 1) Proceeds to next check if middle scale pointer is within acceptable area	___	___	1 2 3	
OR				
2) Notifies tank commander (TC) pointer is not within acceptable area	___	___	1 2 3	
3. Checks azimuth indicator for slippage.				
Right Side				
a. Looks through eyepiece of gunner's daylight periscope	___	___	1 2 3	
b. Uses gunner's control handles to traverse rapidly to right	___	___	1 2 3	
c. Stops turret suddenly while traversing	___	___	1 2 3	
d. Turns ELEV/TRAV power switch OFF	___	___	1 2 3	
e. Traverse turret left using manual traverse handle until cross is alined with original aiming point	___	___	1 2 3	___
(NOTE TO SCORER: Verify the aiming cross is on original aiming point by looking through periscope.)				
f. Turns head to check that azimuth indicator middle scale pointer is within acceptable area	___	___	1 2 3	
(NOTE TO SCORER: Use scoring aid when determining if the pointer is within acceptable area.)				

NAME _____

SSAN _____

UNIT _____

TEST [1] [2] [3]

TRAIN [1] [2] [3]

PERFORM GUNNER'S PREPARE-TO-FIRE CHECKS
(CHECK GUN CONTROLS)
(Cont'd.)

PERFORMANCE MEASURES	YES	NO	PROMPTS	TIME
g. 1) Proceeds to left side check if middle scale indicator pointer is within acceptable area.	___	___	1 2 3	
OR				
2) Notifies TC if both pointers are not within acceptable area	___	___	1 2 3	
h. Announces POWER.	___	___	1 2 3	
i. Turns ELEV/TRAV power switch ON.	___	___	1 2 3	
Left Side				
a. Looks through eyepiece of gunner's daylight periscope.	___	___	1 2 3	
b. Uses gunner's control handles to traverse rapidly to left.	___	___	1 2 3	
c. Stops turret suddenly while traversing	___	___	1 2 3	
d. Turns ELEV/TRAV power switch OFF	___	___	1 2 3	
e. Traverses turret right using manual-traverse handle until cross is alined with original aiming point	___	___	1 2 3	___
(NOTE TO SCORER: Verify aiming cross is on original aiming point by looking through periscope.)				
f. Turns head to check that middle scale pointer is within acceptable area. . . .	___	___	1 2 3	
(NOTE TO SCORER: Use scoring aid when determining if the pointers are within acceptable area.)				
g. 1) Stops check if pointer is within acceptable area.	___	___	1 2 3	
OR				
2) Notifies TC if pointers are not within acceptable area.	___	___	1 2 3	
			TOTAL TIME	_____

The soldier has satisfactorily completed the task if he scores a "YES" on all of the standards listed below:

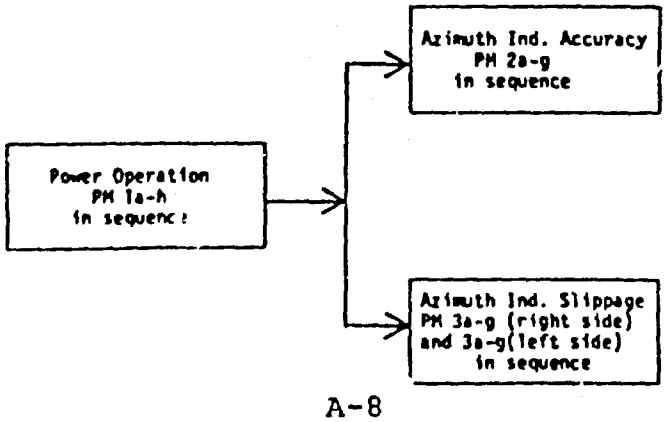
STANDARDS	YES	NO
1. Completes all performance measures	___	___
2. Announced "POWER" before turning ELEV/TRAV switch ON	___	___
3. Pointer of azimuth indicator is within range shown on scoring aid after accuracy .	___	___
4. Pointers of azimuth indicator are within range shown on scoring aid after each slippage test.	___	___
5. Cross is alined with aiming point after accuracy checks.	___	___
6. Performs performance measures in sequence when necessary (see sequence flowchart below)	___	___
TOTAL SCORE	___	___
TOTAL TIME	_____	

REASON(S) FOR "NO" SCORE

_____

_____

SEQUENCE



NAME _____

SSAN _____

UNIT _____

TEST [1] [2] [3]

TRAIN [1] [2] [3]

PERFORM LOADER'S PREPARE-TO-FIRE CHECKS
(CHECK MAIN GUN FIRING SWITCHES)

INSTRUCTIONS TO SOLDIER

"You are the loader of an M60A1 tank. You are doing the Prepare-to-Fire checks and will demonstrate the section "CHECK MAIN GUN FIRING SWITCHES." I will act as the other crew positions when necessary. Do you understand the instructions?" (NOTE TO SCORER: If the soldier has questions, read the instructions again.)

(NOTE TO SCORER: Start the training trial by saying "CHECK MAIN GUN FIRING SWITCHES.")

PERFORMANCE MEASURES	YES	NO	PROMPTS	TIME
1. Closes breech by tripping extractors with block of wood.	___	___	1 2 3	
2. Inserts circuit tester into opening between rear face of gun tube and front face of breechblock.	___	___	1 2 3	
3. Moves main gun safety switch to FIRE position.	___	___	1 2 3	
4. Announces "UP"	___	___	1 2 3	___
(NOTE TO SCORER: Turn master battery switch ON, then turn the main gun switch ON. Momentarily press the commander's control handle palm switch. Circuit tester should not light.)				
5. Tells gunner to squeeze main gun triggers.	___	___	1 2 3	
(NOTE TO SCORER: Squeeze the trigger on each handle and the trigger on manual elevation control. Rotate the manual firing handle very rapidly in a clockwise direction. Announce ON THE WAY each time you squeeze a trigger. Circuit tester should light.)				
6. Tells TC to squeeze main gun trigger	___	___	1 2 3	
(NOTE TO SCORER: Squeeze and hold override palm handle, then squeeze trigger. Announce "ON THE WAY." Circuit tester should light.)				
7. Moves main gun safety switch to SAFE	___	___	1 2 3	___
8. Tells gunner to press trigger on manual firing handle.	___	___	1 2 3	
(NOTE TO SCORER: Squeeze the trigger on manual firing handle. Announce "ON THE WAY." Turn manual firing handle very rapidly in clockwise direction. Announce "ON THE WAY." Circuit tester should not light.)				
9. Tells gunner to turn main gun OFF.	___	___	1 2 3	
10. Removes circuit tester from breechblock.	___	___	1 2 3	
			TOTAL TIME	___

STANDARD	YES	NO
1. The soldier has satisfactorily completed the task if he scores a "YES" on all of the performance measures.	___	___
2. Performs performance measure in sequence when necessary (see sequence flowchart on next page).	___	___

REASON(S) FOR "NO" SCORE

_____

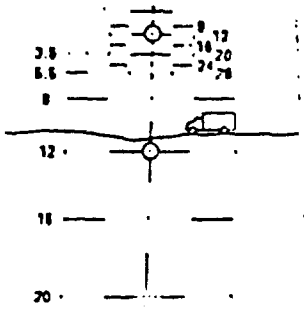
_____

_____

NAME _____
SSAN _____
UNIT _____

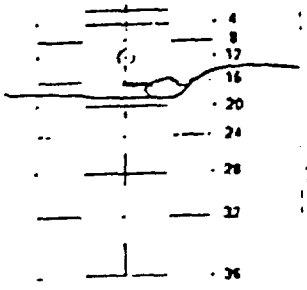
SERIES 2

Engagement 1
(Periscope damaged)
Gunner
HEP
Moving Truck
1000



	Yes	No	Prompts 1	2	3	Time
1. Turns main gun switch ON	___	___	1	2	3	
2. Indexes ammunition	___	___	1	2	3	
3. Announces IDENTIFIED	___	___	1	2	3	
NOTE: Scorer says UP						
NOTE: Scorer says FIRE						
4. Looks through correct sight	___	___	1	2	3	___
Periscope ___						
Telescope ✓						
5. Selects correct reticle	___	___	1	2	3	
Periscope ___						
SABOT/HEP ✓						
HEAT ___						
6. Lays crosshair at center of the target (with lead applied)	___	___	1	2	3	
Periscope crosshair ___						
SABOT 2000M range line, 2.5 mil lead ___						
HEP 1000M range line, 7.5 mil lead ✓						
HEAT 1800M range line, 5.0 mil lead ___						
7. Says ON THE WAY	___	___	1	2	3	___

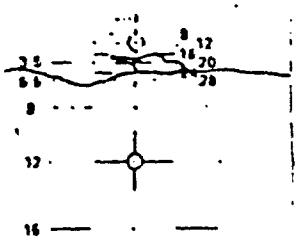
Engagement 2
(Periscope damaged)
Gunner
HEAT
Moving Tank
1800



	Yes	No	Prompts 1	2	3	Time
1. Turns main gun switch ON	___	___	1	2	3	
2. Indexes ammunition	___	___	1	2	3	
3. Announces IDENTIFIED	___	___	1	2	3	
NOTE: Scorer says UP						
NOTE: Scorer says FIRE						
4. Looks through correct sight	___	___	1	2	3	___
Periscope ___						
Telescope ✓						
5. Selects correct reticle	___	___	1	2	3	
Periscope ___						
SABOT/HEP ___						
HEAT ✓						
6. Lays crosshair at center of the target (with lead applied)	___	___	1	2	3	
Periscope crosshair ___						
SABOT 2000M range line, 2.5 mil lead ___						
HEP 1000M range line, 7.5 mil lead ___						
HEAT 1800M range line, 5.0 mil lead ✓						
7. Says ON THE WAY	___	___	1	2	3	___

NAME _____
SSAN _____
UNIT _____

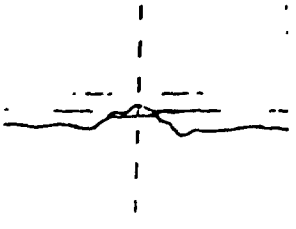
Engagement 3
(Periscope damaged)
Gunner
SABOT
Moving Tank
2000



SERIES 2

	Yes	No	Prompts 1	2	3	Time
1. Turns main gun switch ON	___	___	1	2	3	
2. Indexes ammunition	___	___	1	2	3	
3. Announces IDENTIFIED	___	___	1	2	3	
NOTE: Scorer says UP						
NOTE: Scorer says FIRE						
4. Looks through correct sight	___	___	1	2	3	___
Periscope ___						
Telescope ✓						
5. Selects correct reticle	___	___	1	2	3	
Periscope ___						
SABOT/HEP ✓						
HEAT ___						
6. Lays crosshair at center of the target (with lead applied)	___	___	1	2	3	
Periscope crosshair ___						
SABOT 2000M range line, 2.5 mil lead ✓						
HEP 1000M range line, 7.5 mil lead ___						
HEAT 1800M range line, 5.0 mil lead ___						
7. Says ON THE WAY	___	___	1	2	3	___

Engagement 4
Gunner
HEP
Truck



	Yes	No	Prompts 1	2	3	Time
1. Turns main gun switch ON	___	___	1	2	3	
2. Indexes ammunition	___	___	1	2	3	
3. Announces IDENTIFIED	___	___	1	2	3	
NOTE: Scorer says UP						
NOTE: Scorer says FIRE						
4. Looks through correct sight	___	___	1	2	3	___
Periscope ✓						
Telescope ___						
5. Selects correct reticle	___	___	1	2	3	
Periscope ✓						
SABOT/HEP ___						
HEAT ___						
6. Lays crosshair at center of the target (with lead applied)	___	___	1	2	3	
Periscope crosshair ✓						
SABOT 2000M range line, 2.5 mil lead ___						
HEP 1000M range line, 7.5 mil lead ___						
HEAT 1800M range line, 5.0 mil lead ___						
7. Says ON THE WAY	___	___	1	2	3	___

NAME _____

SSAN _____

UNIT _____

TEST [1] [2] [3]

TRAIN [1] [2] [3]

COMMUNICATE OVER TACTICAL FM RADIO AN/VRC-64

PERFORMANCE MEASURES	YES	NO	PROMPTS	TIME
1. Places CVC helmet switch in center position. . . .	___	___	1 2 3	
2. Calls net control station.	___	___	1 2 3	
3. Identifies himself before giving the messages. . .	___	___	1 2 3	
4. Tells net control station number of messages. . . .	___	___	1 2 3	
5. Tells net control station precedence of messages. . .	___	___	1 2 3	
6. Transmits Message.	___	___	1 2 3	___
7. Uses phonetic alphabet as required	___	___	1 2 3	
8. Pronounces numbers correctly	___	___	1 2 3	
9. Says OVER after Message.	___	___	1 2 3	___

STANDARDS	YES	NO
1. Each performance measure completed with a YES. . .	___	___
2. Steps are performed in sequence.	___	___

TOTAL TIME _____

INSTRUCTIONS TO SOLDIER

"At this station you will demonstrate your ability to communicate a message over a tactical FM radio AN/VRC-64. I will be the net control station. Here is the information you need to transmit the message." (NOTE TO SCORER: Hand soldier the attachment, a pencil and a sheet of paper.) "You will have two minutes to review the attachment before we begin. Do you understand the instructions?" (NOTE TO SCORER: If the soldier does not understand the instructions, reread them.) "You may review the message information now."

COURSE 2

NAME _____
SSAN _____
UNIT _____
TEST [1] [2] [3]
TRAIN [1] [2] [3]

COMMUNICATE USING VISUAL SIGNALLING TECHNIQUES: GROUND GUIDING

INSTRUCTIONS TO SOLDIER

"At this station you will be tested on your ability to ground guide a tank from the START point to the FINISH point of a driving course. The course is clearly marked for you. I will be the tank; whatever direction I am facing will be the direction the tank is facing. I am parked in the motor pool. My engine is not running. When we get to the FINISH point, assume that I won't be moving anymore today. Do you understand the instructions?" (NOTE TO SCORER: If soldier does not understand the instructions, reread them.) "BEGIN."

PERFORMANCE MEASURES	YES	NO	PROMPTS	TIME	SIGNAL GIVEN
1. Gives signal to Start Engine.				___	
a. Extends arm toward front at waist level.	___	___	1 2 3		
b. Moves arm in circular motion	___	___	1 2 3		
2. Gives signal to Move in Reverse.				___	
a. Raises both hands to shoulder level.	___	___	1 2 3		
b. Places palms to front.	___	___	1 2 3		
c. Moves hands forward and backward as if pushing vehicle away.	___	___	1 2 3		
3. Gives signal to Stop Tank Movement.				___	
a. Clasps hands	___	___	1 2 3		
b. Places hands at chin level	___	___	1 2 3		
4. Gives signal to Move Vehicle Forward.				___	
a. Positions both palms toward chest.	___	___	1 2 3		
b. Moves arms and hands backward and forward.	___	___	1 2 3		
5. Gives signal to Turn Left.				___	
a. Raises hands to shoulder level in front of body.	___	___	1 2 3		
b. Forms clenched fist of arm indicating direction turn is to be made (as seen by tank driver).	___	___	1 2 3		
c. Makes beckoning motion with other arm to bring vehicle forward	___	___	1 2 3		
6. Gives signal to Move Vehicle Forward.				___	
a. Positions both palms toward chest.	___	___	1 2 3		
b. Moves arms and hands backward and forward.	___	___	1 2 3		
7. Gives signal to Stop Tank Movement.				___	
a. Clasps hands	___	___	1 2 3		
b. Places hands at chin level	___	___	1 2 3		
8. Gives signal to Steer Neutral (Left).				___	
a. Crosses wrists at throat	___	___	1 2 3		
b. Points index finger to tank driver's left.	___	___	1 2 3		
c. Clenches fist of other hand.	___	___	1 2 3		
NOTE: If soldier gives left turn signal, tell him to give the signal for neutral steer left. Do not mark the PM "NO."					
9. Gives signal to Move Vehicle Forward.				___	
a. Positions both palms toward chest.	___	___	1 2 3		
b. Moves arms and hands backward and forward.	___	___	1 2 3		
10. Gives signal to Turn Right.				___	
a. Raises hands to shoulder level in front of body.	___	___	1 2 3		
b. Forms clenched fist of arm indicating direction turn is to be made (as seen by tank driver).	___	___	1 2 3		
c. Makes beckoning motion with other arm to bring vehicle forward	___	___	1 2 3		
11. Gives signal to Move Vehicle Forward.				___	
a. Positions both palms toward chest.	___	___	1 2 3		
b. Moves arms and hands backward and forward.	___	___	1 2 3		
12. Gives signal to Stop Tank Movement.				___	
a. Clasps hands	___	___	1 2 3		
b. Places hands at chin level	___	___	1 2 3		
13. Gives signal to Stop Engines.				___	
a. Positions right hand palm down	___	___	1 2 3		
b. Draws hand across neck in "throat cutting" motion from left to right.	___	___	1 2 3		

STANDARD	YES	NO
1. Completes each performance measure without assistance from scorer.	___	___
2. Ground guide signals given in sequence indicated	___	___
3. Correct ground guide signal given.	___	___
TOTAL TIME	_____	

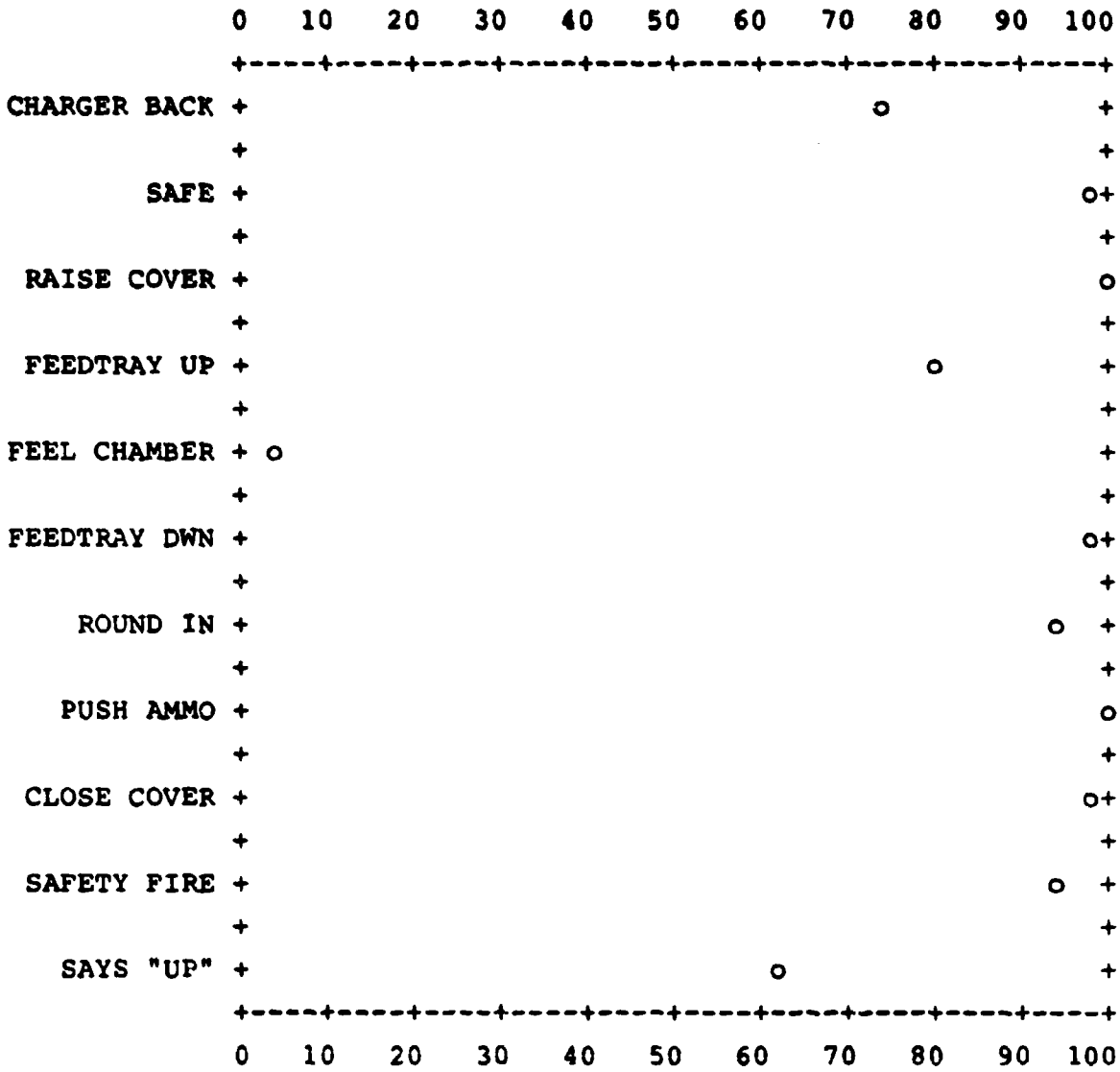
REASON(S) FOR "NO" SCORE

_____

_____

APPENDIX B

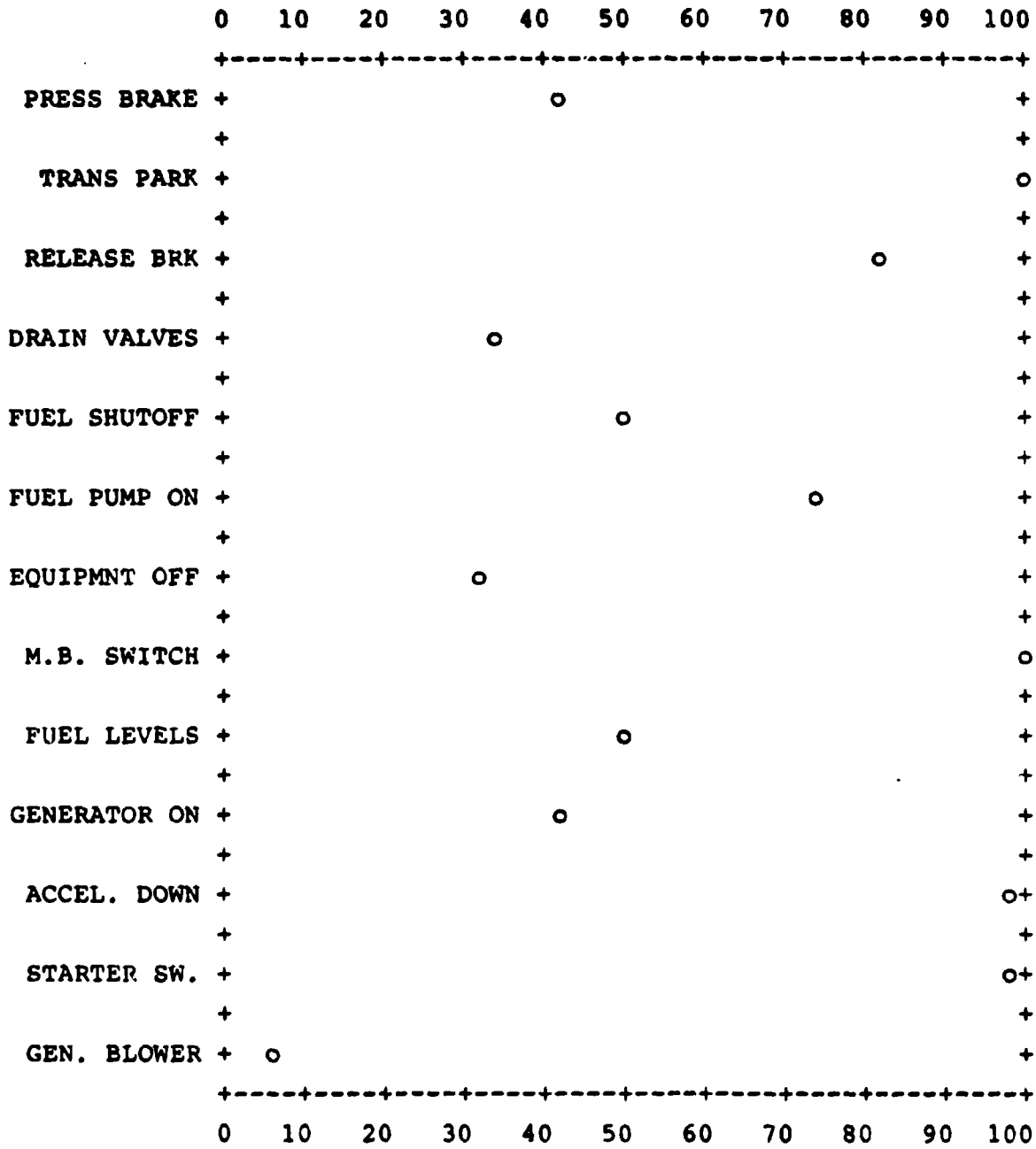
PROPORTION CORRECT BY TASK ELEMENT FOR OSUT AND OPERATIONAL UNIT SAMPLES



LOAD THE M240 MACHINEGUN
PROPORTION CORRECT BY TASK ELEMENT
IN OPERATIONAL UNIT (N=116)

Task Element	Trials 1	2	3	4	5	6
Charger Back	96	100	100	100	100	100
Safe	99	100	100	100	100	100
Raise Cover	85	93	95	95	100	88
Feedtray Up	100	100	100	100	100	100
Feel Chamber	57	98	99	100	100	95
Feedtray Down	98	100	99	100	100	100
Round In	100	99	99	100	100	100
Close Cover	100	100	100	99	100	100
Safety Fire	68	98	100	99	99	100
Says "Up"	41	88	99	98	100	92

LOAD THE M240 MACHINEGUN PROPORTION
CORRECT BY TASK ELEMENT IN OSUT (N=110)

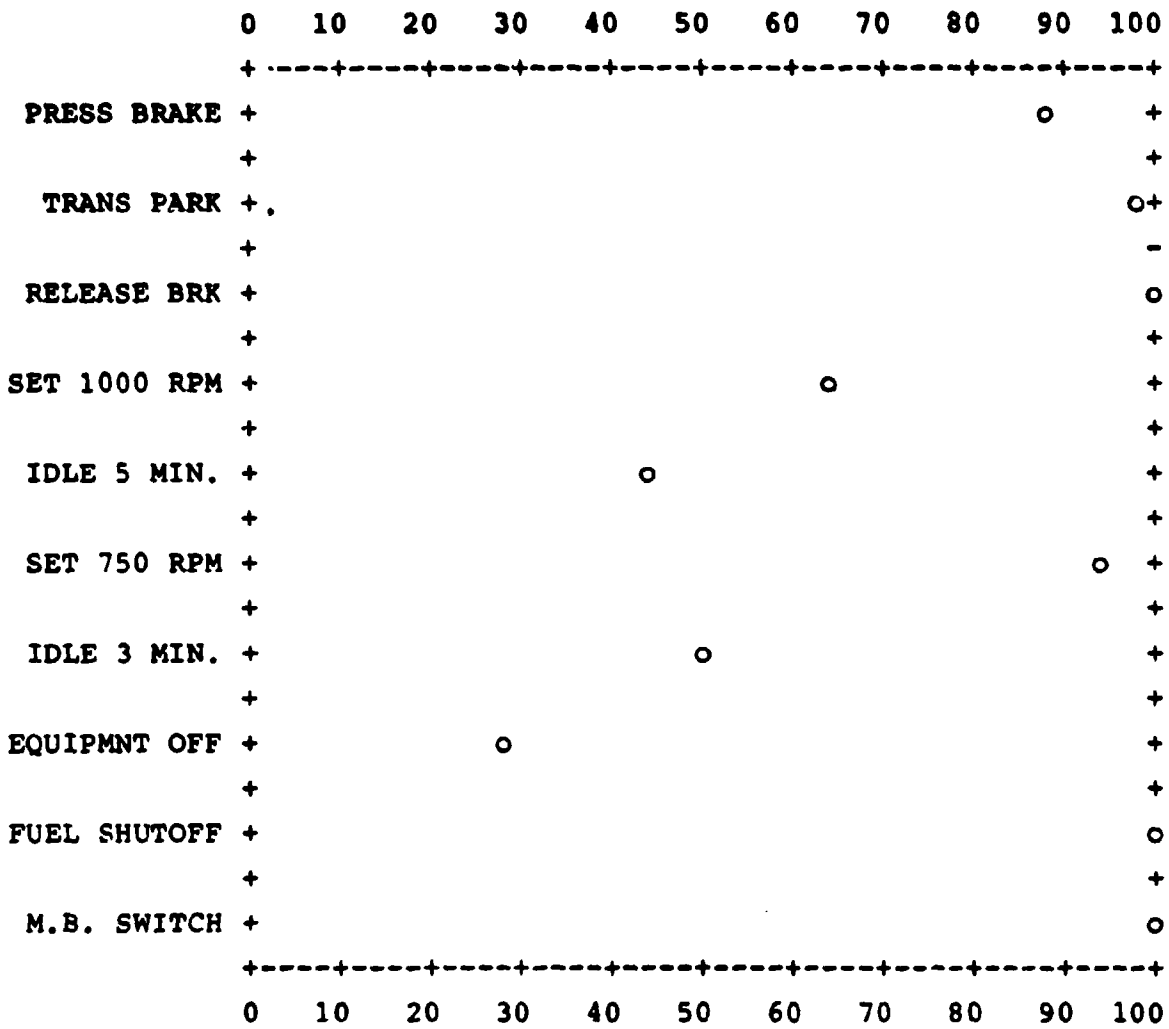


START THE M60A1 TANK ENGINE
PROPORTION CORRECT BY TASK ELEMENT
IN OPERATIONAL UNIT (N=116)

Task Element	Trials 1	2	3	4	5	6
Press Brake	98	100	100	100	100	100
Trans. Park	99	100	99	99	99	100
Release Brake	93	98	98	99	100	99
Drain Valves	90	94	100	100	100	99
Fuel Shutoff	99	100	100	100	100	100
Fuel Pump On	100	100	100	100	100	98
Equipment Off	89	99	98	99	100	99
M. B. Switch	39	74	89	93	100	62
Fuel Levels	96	99	98	100	99	95
Accl. Down	86	89	93	92	97	90
Starter	91	91	96	98	99	91

START THE M60A1 TANK ENGINE

PROPORTION CORRECT BY TASK ELEMENT IN OSUT (N=93)

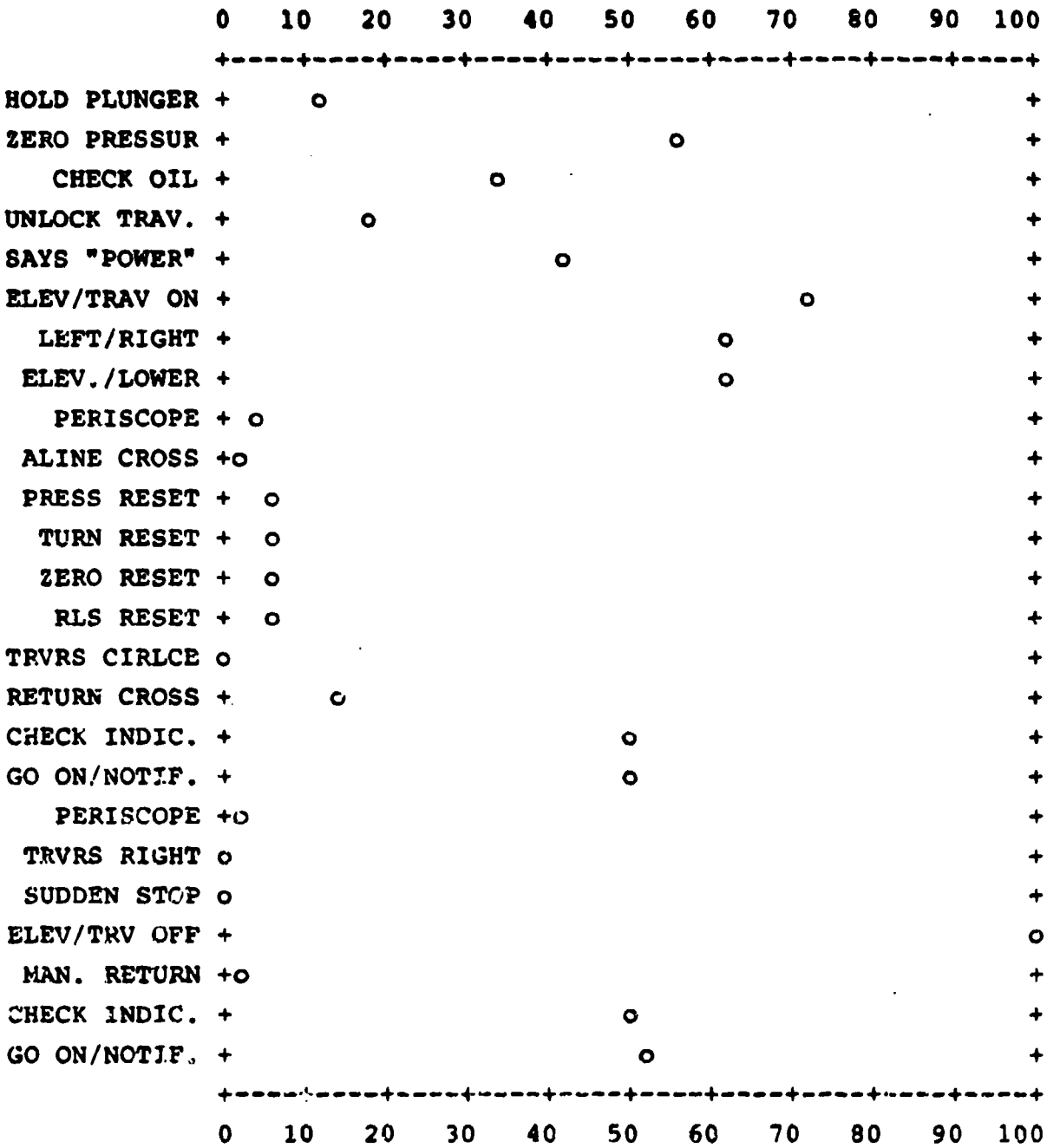


STOP THE M60A1 TANK ENGINE
PROPORTION CORRECT BY TASK ELEMENT
IN OPERATIONAL UNIT (N=116)

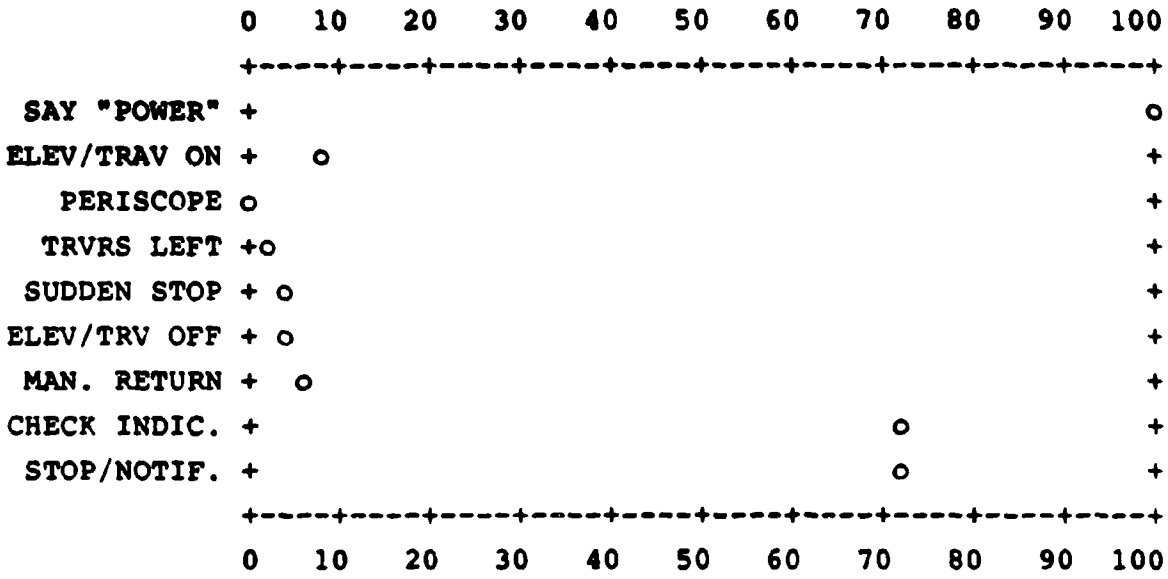
Task Element	Trials 1	2	3	4	5	6
Press Brake	97	100	100	100	100	100
Trans. Park	97	99	100	100	100	100
Release Brake	97	97	98	99	98	100
Set 1000 RPM	81	97	98	98	99	97
Idle 5 minutes	62	97	100	100	99	94
Set 750 RPM	95	99	100	100	100	99
Idle 3 minutes	78	97	99	100	100	95
Equipment Off	92	99	100	99	100	100
Fuel Shut-Off	57	92	95	98	99	94
MB Switch	60	93	95	98	100	95

TOP THE M60A1 ENGINE

PROPORTION CORRECT BY TASK ELEMMENT IN OSUT (N=120)



PERFORM GUNNER'S PREPARE-TO-FIRE CHECKS
PROPORTION CORRECT BY TASK ELEMENT
IN OPERATIONAL UNIT (N=116)



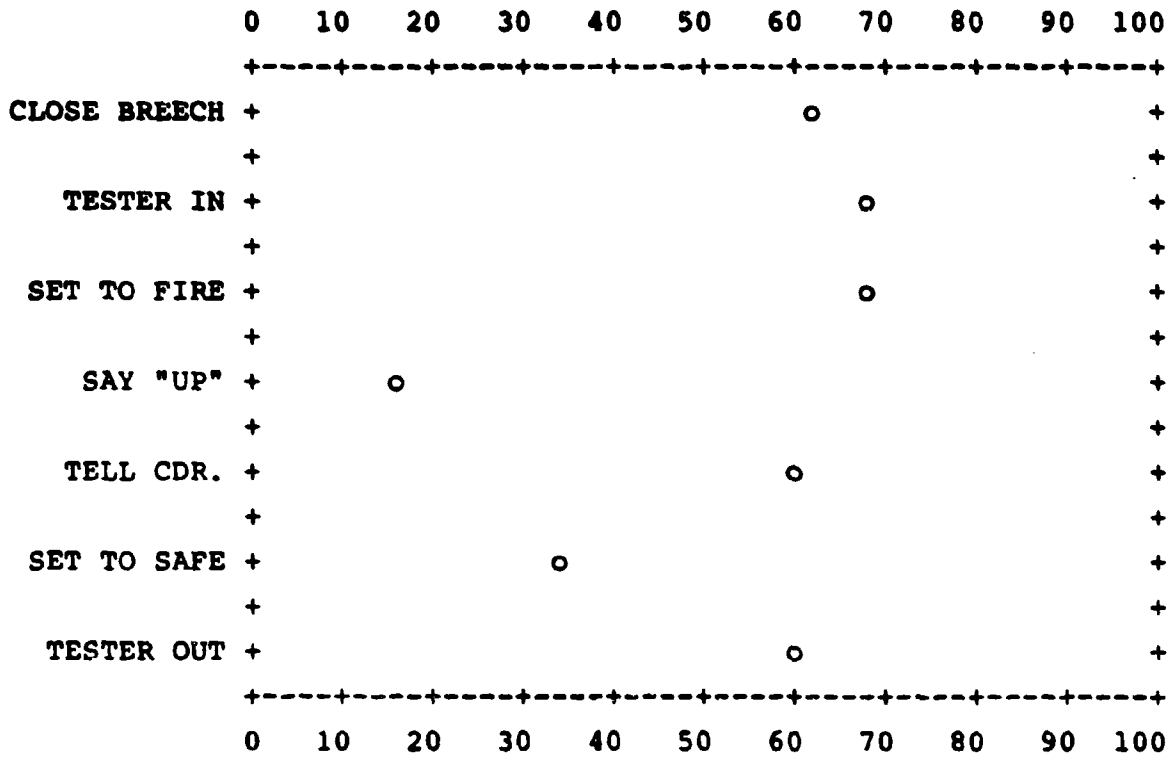
PERFORM GUNNER PREPARE-TO-FIRE CHECKS
PROPORTION CORRECT BY TASK ELEMENT
IN OPERATIONAL UNIT (N=116)
(CONTINUED)

Task Element	Trials 1	2	3	4	5	6
Hold Plunger	19	84	97	99	100	87
Zero Pressure	40	94	100	100	100	94
Check Oil	35	93	95	98	100	97
Unlock Trav.	7	72	90	96	99	86
Say "Power"	22	66	80	90	94	79
Elev/Trav on	36	92	93	99	99	96
Left/Right	27	76	89	92	97	85
Elev/Lower	32	80	91	95	98	93
Periscope	15	77	86	94	98	90
Aline Cross	23	68	83	89	93	75
Press Reset	8	90	90	90	95	87
Turn Reset	11	98	99	99	100	96
Zero Reset	11	98	99	99	100	96
Rls Reset	30	99	99	99	99	94
Trus Circle	11	54	68	81	90	77
Return Cross	31	98	99	99	100	96
Check Indic	29	93	98	98	100	95
Go On/Notif.	46	98	99	98	100	97
Periscope	5	84	93	96	100	91
Trus Right	2	81	91	95	99	90
Sudden Stop	4	88	94	98	100	92
Elev/Trv Off	5	69	82	90	96	92
Manual Return	20	58	76	89	93	82
Check Indic	42	95	98	98	100	94
Go On/Notif.	45	92	98	98	99	96
Say "Power"	51	85	94	93	98	95
Elev/Trav On	63	90	96	98	99	97
Periscope	67	94	99	98	99	97

GUNNER PERPARE TO FIRE PROPORTION
CORRECT BY TASK ELEMENT IN OSUT (N=114)

Task Element	Trials 1	2	3	4	5	6
TRVS Left	70	93	99	98	100	96
Sudden Stop	72	94	99	98	99	97
Elev/Trv Off	67	92	95	96	99	96
Manual Return	58	87	96	97	96	92
Check Indic.	74	96	98	98	100	93
Stop/Notif.	80	96	99	98	100	95

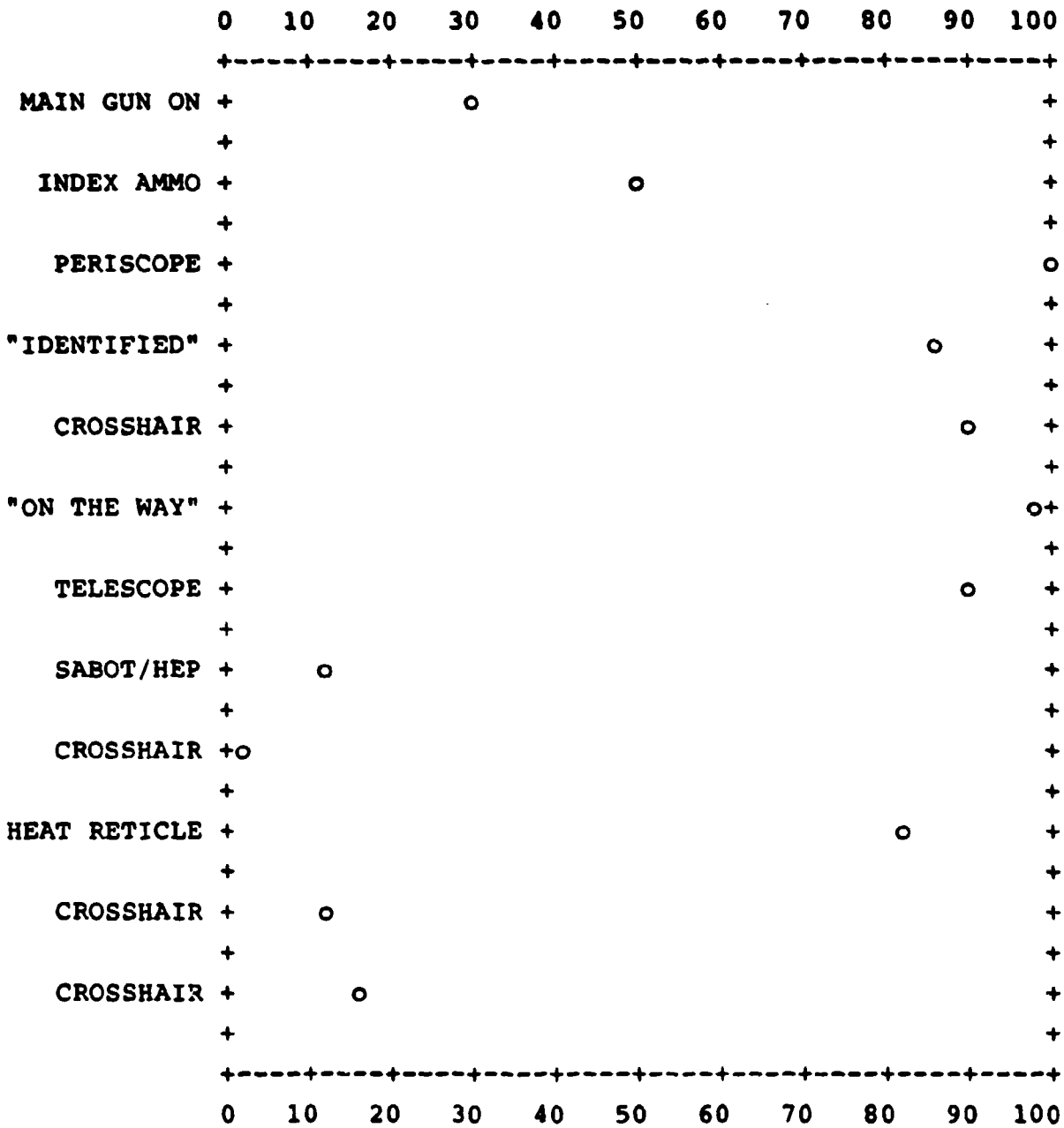
GUNNER PREPARE TO FIRE PROPORTION
CORRECT BY TASK ELEMENT IN OSUT (N=114)
(CONTINUED)



PERFORM LOADER'S PREPARE-TO-FIRE CHECKS
PROPORTION CORRECT BY TASK ELEMENT
IN OPERATIONAL UNIT (N=116)

Task Element	Trials 1	2	3	4	5	6
Close Breech	17	100	100	100	100	97
Tester In	22	98	96	98	100	95
Set to Fire	17	80	90	99	99	86
Say "Up"	26	81	91	97	99	91
Set to Safe	17	95	96	100	100	90
Tester Out	21	65	84	98	96	70

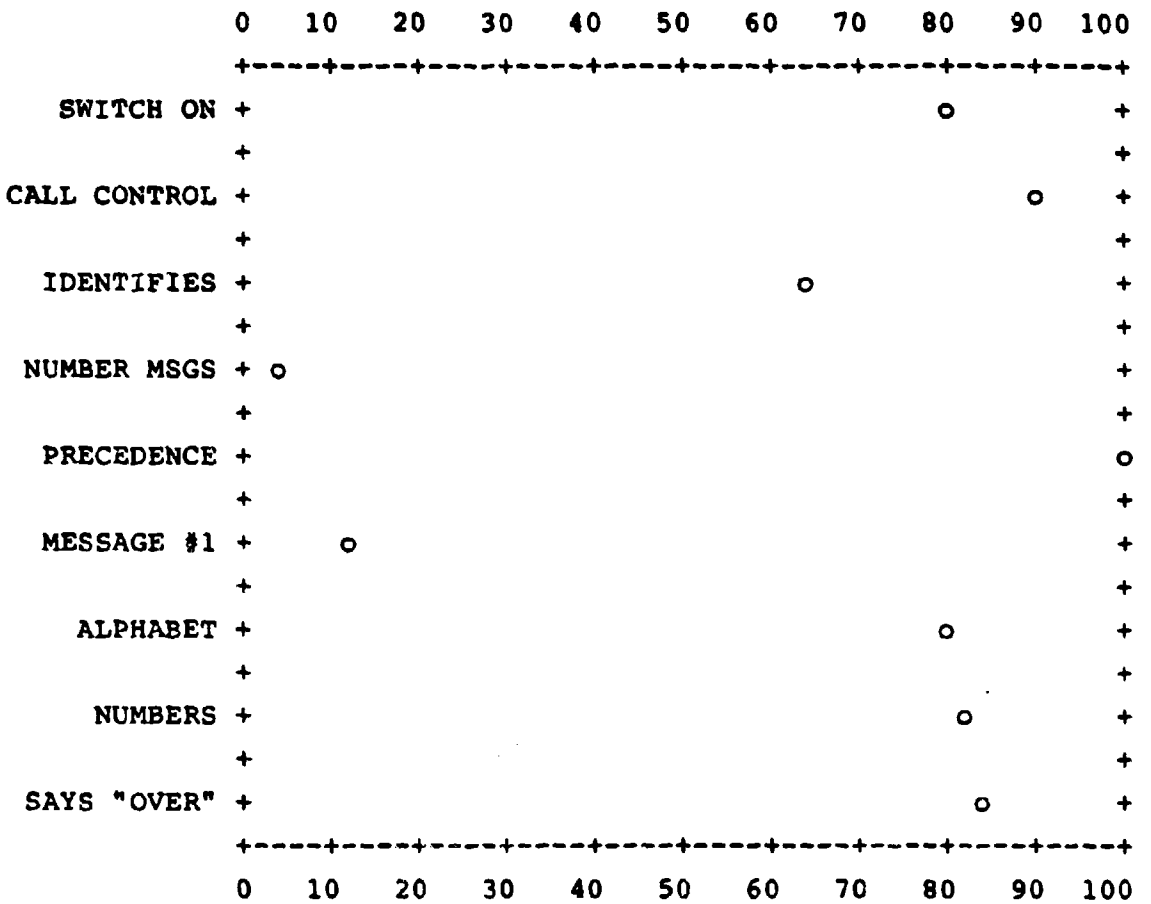
PERFORM LOADER'S PREPARE-TO-FIRE CHECKS
PROPORTION CORRECT BY TASK ELEMENT IN OSUT (N=113)



ENGAGE TARGETS USING PRECISION FIRE TECHNIQUES
PROPORTION CORRECT BY TASK ELEMENT
IN OPERATIONAL UNIT (N=116)

Task Element	Trials 1	2	3	4	5	6
Main Gun On	83	96	98	98	99	96
Index Ammo	84	99	99	99	99	98
Periscope	86	100	97	99	98	99
"Identified"	77	99	96	99	99	98
Crosshair	19	73	94	86	97	29
"On the Way"	43	91	94	97	98	87
Telescope	97	98	99	100	99	100
SABOT/HEP	66	90	86	98	98	92
Crosshair	29	51	67	80	76	65
HEAT Reticle	87	100	96	100	99	89
Crosshair	79	95	81	92	81	68
Crosshair	32	60	57	71	82	93

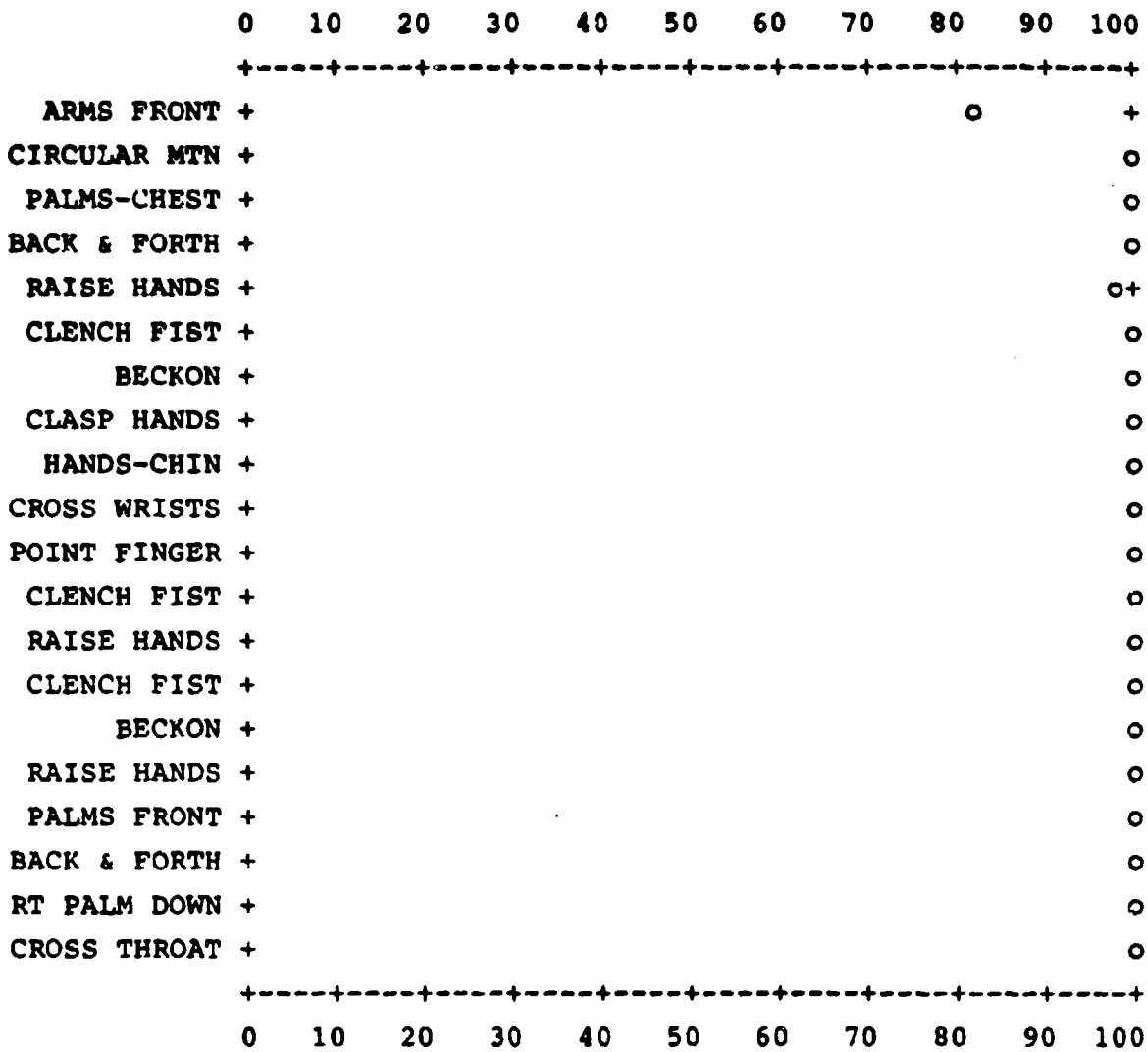
ENGAGE TARGETS USING PRECISION FIRE TECHNIQUES PROPORTION CORRECT BY TASK ELEMENTS IN OSUT (N=93)



COMMUNICATE OVER TACTICAL RM RADIO AN/VRC-64
PROPORTION CORRECT BY TASK ELEMENT
IN OPERATIONAL UNIT (N=116)

Task Element	Trials 1	2	3	4	5	6
Switch On	87	100	99	98	100	96
Call Control	77	90	90	98	98	99
Identifies	92	93	98	98	99	99
No. Messenger	69	94	94	90	95	100
Precedence	41	61	75	87	92	71
Message #1	45	66	83	92	94	97
Alphabet	67	79	83	78	96	83
Numbers	78	78	90	92	91	92
Says "Over"	97	98	98	100	100	100

COMMUNICATE OVER TACTICAL FM RADIO AN/VRC-64
PROPORTION CORRECT BY TASK ELEMENT IN OSUT (N=130)



COMMUNICATE USING VISUAL SIGNALLING TECHNIQUES
PROPORTION CORRECT BY TASK ELEMENT
IN OPERATIONAL UNIT (N=116)

Task Element	Trials 1	2	3	4	5	6
ARMS FRONT	93	97	97	99	99	100
CIRCULAR MTN	98	98	98	99	100	100
PALMS-CHEST	93	100	99	100	99	100
BACK & FORTH	95	100	98	100	99	100
RAISE HANDS	88	96	97	99	100	97
CLENCH FIST	90	93	91	94	94	98
BECKON	97	99	98	99	100	99
CLASP HANDS	90	98	99	99	98	98
HANDS-CHIN	94	100	100	99	100	97
CROSS WRISTS	78	96	95	98	97	99
POINT FINGER	90	94	97	98	97	99
CLENCH FIST	94	100	100	100	97	100
RAISE HANDS	94	97	98	99	100	97
CLENCH FIST	89	95	98	97	99	98
BECKON	97	99	98	100	100	99
RAISE HANDS	95	99	100	100	100	99
PALMS FRONT	97	100	100	100	100	100
BACK & FORTH	96	100	100	100	99	100
RT PALM DOWN	96	100	99	100	100	100
CROSS THROAT	99	100	100	100	100	100

COMMUNICATE USING VISUAL SIGNALLING TECHNIQUES
PROPORTION CORRECT BY TASK ELEMENT
IN OSUT (N=109)