TR-75-A1

ARI TECHNICAL REPORT

Contract DAHC 19-73-C-0057

FR-CD(C)-75-1

Determination of the Contribution of Live Firing to Weapons Proficiency

Theodore R. Powers, Michael R. McCluskey, and Donald F. Haggard
Human Resources Research Organization

G. Gary Boycan and Frederick Steinheiser, Jr.
U.S. Army Research Institute for the Behavioral and Social Sciences

HUMAN RESOURCES RESEARCH ORGANIZATION
300 North Washington Street
Alexandria, Virginia 22314

Prepared for

U.S. ARMY RESEARCH INSTITUTE for the BEHAVIORAL and SOCIAL SCIENCES
1300 Wilson Boulevard Arlington, Virginia 22209

MARCH 1975

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: HumRRO FR-CD(C)-75-1
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): DETERMINATION OF THE CONTRIBUTION OF LIVE FIRING TO WEAPONS PROFICIENCY.
5. TYPE OF REPORT & PERIOD COVERED: Final Report,
6. PERFORMING ORG. REPORT NUMBER: HumRRO-FR-CD(C)-75-1
7. AUTHOR(s): Theodore R. Powers, Michael R. McCluskey, Donald F. Haggard, G. Gary Boycan and Frederick Steinheiser, Jr.
8. CONTRACT OR GRANT NUMBER(s): DAHC19-73-C-0057
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Human Resources Research Organization (HumRRO) 300 North Washington Street Alexandria, Virginia 22314
10. PROGRAM ELEMENT PROJECT TASK AREA & WORK UNIT NUMBERS: 20762717A722
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Research Institute for the Behavioral and Social Sciences 1300 Wilson Boulevard Arlington, Virginia 22209
12. REPORT DATE: Mar[redacted]75
13. NUMBER OF PAGES: 69
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): 68p.
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report)

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
18. SUPPLEMENTARY NOTES

Research performed by HumRRO Central Division (Fort Knox and Fort Benning) and HumRRO Western Division (Fort Bliss).

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Armor training	Live firing	Training
Artillery training	Motivation	Training devices
Dry firing	Simulation	Weapons
Field tests	Subcaliber firing	Weapon systems
		0509

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Two field tests were conducted to identify the contribution of live firing to weapons proficiency for two large-caliber weapon systems, the M60A1 tank and the 105mm howitzer. Fifty-six crews were involved in each test. The tank test dealt with the gunner's work with stationary and moving targets, and compared results from four experimental training methods using varying amounts of live firing and a training simulator. The artillery test dealt with a six-man crew firing at stationary targets, and compared

(Continued) next page

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified 405 260 LB

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. *(Continued)*

cont

results from training with varying amounts of live firing together with a simulator and dry firing. Each crew was given a live-fire criterion test, as well as paper-and-pencil measures. In both field tests, there were no statistically significant differences between training methods in the proficiency level of the trainees on the live-fire test. The attitude surveys showed some differences in the way in which trainees tended to view the various training methods.

DETERMINATION OF THE CONTRIBUTION OF LIVE FIRING TO WEAPONS PROFICIENCY

Brief

Requirement:

To determine the contribution of live firing to weapons proficiency for two large-caliber weapons systems (M60A1 Tank and 105mm Howitzer).

Procedure:

This research was accomplished in three phases. In the first phase a survey was conducted of Army weapons training and weapons training devices. The second phase involved conducting job analyses on four candidate weapons systems in order to identify critical skills and procedures. In the third phase, two field tests were conducted in order to identify the contribution of live firing to weapons proficiency.

The first field test was held at Fort Knox and involved 56 tank crews. Each crew was assigned to one of four experimental training conditions. Upon completion of the training, all crews were administered a live-fire criterion test, along with a battery of paper-and-pencil tests. The second field test was conducted at Fort Sill and involved 56 howitzer crews. Each crew was assigned to one of seven experimental training conditions. Upon completion of the training, all crews were administered a live-fire criterion test, along with a battery of paper-and-pencil tests.

Research on these two weapons systems was conducted in order to gain an initial insight into the significant factors associated with various training modes. The tank weapons system basically involved an individual gunnery task that had tracking performance as a significant variable in target engagement. The artillery system involved a six-man crew who fired the weapon at stationary targets.

In the tank training, a comparison was made with varying amounts of live firing and a tank weapons training simulator (SIMFIRE). In the artillery training, the comparison involved varying amounts of live firing together with a simulator (M 31) and dry firing (the live-firing procedure without live ammunition). Various statistical analyses were conducted on these data in order to identify any differences between the various training methods.

Findings:

Armor Field Test

(1) There were no statistical differences on the live-fire criterion test between experimental groups.

(2) On the paper-and-pencil tests, the results indicated that the simulation used (SIMFIRE) did not provide either realism or interest for the trainees.

Artillery Field Test

(1) There were no statistical differences on the live-fire criterion test between experimental groups.

(2) On the paper-and-pencil tests, some of the results indicated that live firing was more interesting to the trainees and was the preferred method of training.

Utilization of Findings:

These are the initial findings on the contribution of live firing to weapons proficiency for large-caliber weapons. Whenever decisions are made concerning the substitution of simulated training techniques for live-firing instruction, these findings should be considered.

PREFACE

This report presents the results of a study of the contribution of live firing to weapons proficiency for two large-caliber weapons systems. The research was performed by the Human Resources Research Organization under contract to the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI).

The two preliminary phases of the project involved a survey of current weapons training and the conduct of four job analyses for candidate weapons systems. The final phase of the project involved two field tests. The first of these tests was held in May 1974, at Fort Knox, Kentucky, and involved the M60A1 tank as the test weapon. The second test was held in September 1974, at Fort Sill, Oklahoma, with the 105mm Howitzer (M102) serving as the test weapon. This report discusses the results of these two field tests.

The ARI Contracting Officer is Roy F. Wyne. Dr. Frank Harris served as the original Contracting Officer's Technical Representative (COTR) and actively participated in the early planning and decision making. G. Gary Boycan, the current COTR, Dr. Frederick Steinheiser, Jr., and Dr. Angelo Mirabella of ARI made significant inputs to the field test plans and to the draft final report.

The research was performed by Theodore R. Powers, Project Director, Michael R. McCluskey, Deputy Project Director, Dr. T.O. Jacobs, Dr. Joseph A. Olmstead, Chester I. Christie, Jeffery L. Maxey, George J. Magner, Fred K. Cleary, and Ray E. Ball of HumRRO Division No. 4 (now part of the HumRRO Central Division) at Fort Benning, Georgia; Dr. Donald F. Haggard, Richard E. O'Brien, and Richard D. Healy of HumRRO Division No. 2 (now part of the HumRRO Central Division) at Fort Knox, Kentucky; and Dr. Paul G. Whitmore and Leo C. Benson of HumRRO Western Division (Fort Bliss, Texas, Office).

During the project, Dr. T.O. Jacobs and Dr. Donald F. Haggard were Directors of HumRRO Divisions 4 and 2, respectively. Dr. Wallace W. Prophet is the current Director of HumRRO Central Division. Dr. Howard H. McFann is the Director of the Western Division.

Military support was provided by the U.S. Army Infantry Human Research Unit at Fort Benning, commanded by LTC Robert G. Matheson; the U.S. Army Armor Human Research Unit at Fort Knox, commanded by LTC Willis G. Pratt; and the U.S. Army Air Defense Human Research Unit at Fort Bliss, commanded by LTC F.D. Lawler.

Direct support of the field tests was provided by the U.S. Army Armor Center and School at Fort Knox and the U.S. Army Artillery Center and School at Fort Sill, Oklahoma.

TABLE OF CONTENTS

List of Illustrations

List of Tables

Determination of the Contribution of Live Firing to Weapons Proficiency

Chapter 1

INTRODUCTION

The objective of the research reported here was to determine the contribution of live firing to weapons proficiency for two large-caliber weapons systems. This project consisted of three phases. During the first phase, a survey was made of Army weapons training and weapons training devices. The results of this survey have been previously reported.[1] For the second phase of the project, task analyses were accomplished on selected weapons systems—the M60A1 Tank, the 81mm Mortar, the 155mm Howitzer (SP), and the 105mm Howitzer (M102). The results of this work have also been previously reported.[2]

As a result of the preliminary research accomplished during Phases 1 and 2, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) identified the M60A1 Tank and the 105mm Howitzer (M102) as the test weapons to be used in determining the contribution of live firing to weapons proficiency. These two weapons were selected so that initial information could be developed on the contribution of live firing to training for large-caliber weapons systems. Since ammunition costs for the large-caliber systems are extremely high, the results could be used as preliminary guidance for cost reduction. In addition, the research would generate information about an Artillery system with its requirements for crew training, and an Armor system that involves an individual gunner task.

Two separate field tests were conducted during the third phase of this project. In May 1974, a test was held at Fort Knox, Kentucky, involving 56 tank crews. In September 1974, a test was held at Fort Sill, Oklahoma, involving 56 howitzer crews. This report will discuss these field tests and will trace the development of the field test plans, the conduct of the field tests, the analysis of the results, and the implications of these results.

MILITARY PROBLEM

Traditionally, training in the use of military weapons has been conducted by lecture, demonstrations, and practice in live firing the actual weapons on ranges possessing the necessary area requirements. These ranges are generally similar to the combat environments in which the weapons would be used. However, numerous factors place serious constraints on the use of live firing.

For example, the availability of suitable ranges is decreasing. Ranges for the larger missile systems are currently located only in the southwestern section of the United States. Range availability is rapidly decreasing in Europe and the Far East, and stringent limitations are placed on the types of weapons that may be fired because of safety factors and the encroachment of civilian populations.

[1] Staff, HumRRO Division No. 4. "A Survey of Army Weapons Training and Weapons Training Devices," Interim Report IR-D4-73-13, September 1973.

[2] Staff, HumRRO Division No. 4. "Task Analyses of Three Selected Weapons Systems," Interim Report IR-D4-74-8, March 1974.

Furthermore, costs incidental to live firing place constraints on training effectiveness. Costs are incurred in relation to such factors as: (a) terrain for ranges; (b) maintenance of ranges, target arrays, and aerial targets; (c) transportation costs and maintenance of prime movers; (d) barrel life on larger weapon systems; (e) ammunition cost, especially when the weapon system may be the ammunition as is the case with missiles; and (f) support personnel associated with target acquisition, communications, safety, and meteorological data.

All of these considerations place serious constraints on the use of live firing in weapons training. Accordingly, efforts are being made to perfect techniques and devices that will enable development of weapons proficiency with a minimum, or at least optimum, use of live firing practice. Dry firing (executing the procedures for live firing without the use of live ammunition), miniature ranges using subcaliber weapons, and various training devices have been partially successful, as will be discussed in the next section. Numerous other training devices and techniques are currently under development.

The previously mentioned constraints on the use of live firing, as well as the present and potential developments in training devices, make it important to know the precise value of live firing to weapons proficiency. It is also important to determine whether required proficiency levels can be achieved through more extensive use of new training techniques and devices, or through substitution, in whole or in part, of the techniques and devices for live firing in weapons training.

RELEVANT LITERATURE

A literature survey was conducted that revealed numerous studies of simulators and the transfer of training from these devices (Prophet and Boyd, 1970; Grimsley, 1969; Cox, *et al.*, 1965; Blaiwes and Regan, 1970; Dougherty, Houston, and Nicklas, 1957; Caro, 1970a, b; Isley, 1968; Newton, 1959).[1] Most of these studies, however, examined the effectiveness of aircraft flight simulators for training pilots in certain flight procedures. These studies are related to the current project only in a general sense, with the possible exception of missile training where tasks are also highly proceduralized.

[1] Wallace W. Prophet, and H. Alton Boyd. *Device-Task Fidelity and Transfer of Training: Aircraft Cockpit Procedures Training*, HumRRO Technical Report 70-10, July 1970.

Douglas L. Grimsley. *Acquisition, Retention, and Retraining: Effects of High and Low Fidelity in Training Devices*, HumRRO Technical Report 69-1, February 1969.

John A. Cox, Robert O. Wood, Jr., Lynn M. Boren, and H. Walter Thorne. *Functional and Appearance Fidelity of Training Devices for Fixed-Procedures Tasks*, HumRRO Technical Report 65-4, June 1965.

Arthur S. Blaiwes, and James J. Regan. *An Integrated Approach to the Study of Learning Retention, and Transfer—A Key Issue in Training Device Research and Development*, Technical Report NAVTRADEVCEN IH-178, Naval Training Device Center, Orlando, Florida, August 1970.

Dora J. Dougherty, Robert C. Houston, and Douglass R. Nicklas. *Transfer of Training in Flight Procedures From Selected Ground Training Devices to the Aircraft*, Technical Report NAVTRADEVCEN 71-16-16, Naval Training Device Center, Port Washington, New York, September 1957.

Paul W. Caro. *Adaptive Training—An Application to Flight Simulation*, HumRRO Professional Paper 5-70, March 1970a.

Paul W. Caro. *Equipment-Device Task Commonality Analysis and Transfer of Training*, HumRRO Technical Report 70-7, June 1970b.

Robert N. Isley. *Inflight Performance After Zero, Ten, or Twenty Hours of Synthetic Instrument Flight Training*, HumRRO Professional Paper 23-68, June 1968.

John M. Newton. *Training Effectiveness as a Function of Simulator Complexity*, Technical Report NAVTRADEVCEN 458-1, U.S. Naval Training Device Center, Port Washington, New York, September 1959.

Another group of investigations which dealt with many of the current weapons and training devices (Stearn and Hayek, 1969; Kotras and Harris, 1967; Heatherington, 1972; Brundiek, 1972; Williams, *et al.*, 1973; Hayes, 1972; Moline, 1971; Gregory and Tibuni, 1972)[1] were oriented primarily toward engineering and reliability tests of the equipment. These studies, therefore, did not include determination of the effectiveness of training or training devices, or any information on weapons firing proficiency.

The current interest in training methods is specifically oriented toward determining the effect of various combinations of live firing, dry firing, subcaliber firing, and simulated firing on the end-of-training proficiency levels. Unfortunately, only a few directly relevant studies have been identified.

In 1955, Porter, Baerman, and Reddan[2] investigated the effects of subcaliber firing exercises during training on 90mm tank gunner proficiency. The experiment was conducted with a total of 80 subjects who were randomly assigned to one of two training method groups, a control group (Army Training Test [ATT] method) and a subcaliber group (experimental method). The normal 10-week training cycle consisted of a non-firing preliminary phase, a subcaliber firing phase, and a 90mm firing phase. The two groups received exactly the same training during the first two phases but different training during subsequent phases. The criterion test, which consisted of 12 rounds of 90mm ammunition, was given to both groups. An analysis of the criterion test scores indicated that there were no significant differences between the groups. The results of the test demonstrate that subcaliber firing may be substituted for 90mm firing without reducing gunner proficiency as measured by the criterion test.

[1] V.K. Stearn, and Joseph G. Hayek. *Comparison Test of Howitzer, Medium, Self-Propelled, Full-Tracked, 144-MM, M109*, Final Report, 26 February—13 May 1969, Aberdeen Proving Ground, Maryland, June 1969. AD-902 799L.

Edward C. Kotras, and John W. Harris. *Comparison Test of Howitzer, Heavy, Self-Propelled, Full-Tracked, 8-inch, M110*, Final Report, 8 November 1966—11 May 1967, Aberdeen Proving Ground, Maryland, July 1967. AD-903 172L

Billy W. Heatherington. *Test Evaluation Report TOW Weapon System Qualification Test Program for the XM-70 Training Set Blast Simulators*, Technical Report 1 August—22 September 1972, Test and Evaluation Directorate, Army Missile Command, Redstone Arsenal, Alabama, November 1972. AD-908 664L.

Hans Brundiek. *Military Potential Test of Subcaliber Training Device for M16A1 Rifle. Final Letter Report*, Report APG-MT-4089 (Sponsor: U.S. Army Small Arms Systems Agency), Aberdeen Proving Ground, Maryland, June 1972. AD-900 623L.

W. L. Williams, Jr. *et al. An Analysis of the Redeye System With Some Suggestions for Training*, HumRRO Research Memorandum, December 1961. AD-379 523.

Jack H. Hayes. *Initial Production Test of Redeye Moving Target Simulator (M-87)*, Final Report, Army Missile Test and Evaluation Directorate, White Sands Missile Range, New Mexico, April 1972. AD-900 913.

Michael J. Moline. *Engineering Test of CHAPARRAL Simulator/Evaluator*, Final Report, Army Missile Test and Evaluation Directorate, White Sands Missile Range, New Mexico, March 1971. AD-894 823L.

Walter Gregory, and Robert Tibuni. *Engineering Test of Training Set, Guided Missile, XM-70, for TOW Heavy Antitank/Assault Weapon System*, Final Report, TOW Report 19, Army Missile Test and Evaluation Directorate, White Sands Missile Range, New Mexico, June 1972. AD-903 948L.

[2] Vonne F. Porter, Donald J. Baerman, and John G. Reddan. *The Effect of Increased Subcaliber Substitution Training on 90mm Gunner Proficiency*, HumRRO Staff Memorandum, June 1955 (GUNNERY I). AD-480 427.

Although data were not presented, Titl (1972a,b)[1] suggested that subcaliber firing and practice with simulators would increase the effectiveness of tank gunnery training. Also related to Armor weapons training, Mierswa (1971)[2] indicated that the Conduct-Of-Fire Trainer (XM41-XM42) for the Shillelagh missile has had a favorable effect on ammunition allocations. It was previously believed that seven missiles per gunner were required for firing proficiency. With the incorporation of XM41 and XM42 trainers into weapons training, however, an acceptable level of gunner proficiency was achieved with three missiles.

Two studies examined the effectiveness of a laser training device in marksmanship training for the M16. Marshall (1972)[3] reported the results of a study conducted with basic trainees at Fort Jackson. Trainees were divided into four groups: (a) a control group, (b) a group firing ball ammunition followed by laser firing, (c) a group firing the laser followed by ball ammunition firing, and (d) a group firing all laser. Basic Rifle Marksmanship record fire scores were used as a criterion test. Although the details of the study were not provided, it was concluded that in all cases, groups using the laser did as well or better than the group using all live fire. Although the differences were small, the data also seemed to suggest that there may be some order effects when trainees fire both laser and live ammunition.

The second study of the laser training device was conducted by HumRRO Division No. 4 (now part of the Central Division) at Fort Benning (unpublished). Four groups of subjects were randomly selected from Basic Combat Training companies undergoing the field firing portion of Basic Rifle Marksmanship. The experimental groups either fired all ball ammunition, all laser, half ball and half laser, or half laser and half ball. Record fire scores were used as the criteria for evaluating the effectiveness of the laser training device. It was found that the scores obtained were not significantly increased or decreased by substituting firing with the laser training device for either 50% or 100% of the ball ammunition firing. The range of the mean scores for all four groups was 52.80 to 54.79. Also, the order of presentation of laser and ball firing, in the 50% condition, did not have a significant effect on record fire scores.

The final study reported here was related to the basic problems of determining the optimum mix of various training methods in weapons training (Norris, 1971).[4] The purpose of this study was to evaluate the effectiveness of the Redeye Launch Simulator (RELS) as a training device. Since the sample size for this study was extremely small, the data can be used only to indicate possible trends. During the firing test, four students who fired the RELS prior to Redeye firing made no performance errors in the live firing, but errors were observed in the performance of three other gunners who did not fire the RELS.

IMPLICATION FROM LITERATURE REVIEW

Only a few of the studies just described are considered adequate experimental evaluations of methods of providing weapons training with respect to the proportions of

[1] Alfred Titl. *Training With Modern Tanks: Simulators Raise Training Levels*, U.S. Army Foreign Science and Technology Center, Charlottesville, Virginia, Technical Translation FSTC-HT-23-451-72, 1972. Translation of *Soldat und Technik*, 7/1970a, West Germany, pp 382-387. AD-894 434.

Alfred Titl. *Training on Modern Tanks, Simulators Raise the Level of Training*, U.S. Army Foreign Science and Technology Center, Technical Translation FSTC-HT-23-1413-71, 17 April 1972, Translation of brochure from Krauss-Maffer, Munich, West Germany, 1970b. AD-894 699.

[2] Myles H. Mierswa. "Army Training Devices—1950-1980." *Commemorative Technical Journal* - 25th Anniversary. Naval Training Device Center, November 1971.

[3] Albert H. Marshall. "Semiconductor Laser Applications to Military Training Devices," *Proceedings of the Fifth Naval Training Device Center and Industry Conference*, February 15-17, 1972, pp. 46-49.

[4] Charles L. Norris. *Evaluation of the Deployment of a Lightweight Air Defense Weapons System (LADS); Redeye Launch Simulator (RELS)*, Field Test Report, Marine Corps Development and Education Command, Quantico, Virginia, August 1971. AD-887 159L.

subcaliber firing, simulated firing, and live firing. Based on this survey, however, it does appear that some subcaliber or simulated firing may be substituted for live firing without reducing end-of-course gunner proficiency levels.

ORGANIZATION OF THE REPORT

This report discusses two separate field tests that were held at two locations using two different test weapons. For clarity, each of these field tests is presented separately. It will be noted that there were differences between tests in some of the experimental procedures that were employed. For example, in the Armor Test there were four experimental groups. For the Artillery Test there were seven experimental groups. The tests differed on various factors for one or both of the following reasons:

(1) The Armor Test, using M60A1 Tanks, only involved the proficiency of the Gunner. Thus, test results are mainly due to the efforts of a single individual. This individual engaged both moving and stationary targets at varying distances; in addition to the initial setting of the appropriate sights and dials, a continuous tracking task was also involved.

The Artillery Test, using 105mm Howitzers (M102), involved the integrated performance of a six-man crew. Thus, these test results are due to their combined efforts, although the Chief of Section, Gunner, Assistant Gunner, and No. 1 Cannoneer were critical positions in the crew situation. The howitzer crew engaged only stationary targets at varying distances. Once the initial settings were made on the sights, dials, and bubbles, the piece was ready for firing; no tracking of targets was involved.

Thus, the first reason for differences in procedures is that there were inherent differences in the two situations that required modifications in certain experimental areas.

(2) The second reason for test differences lay in the timing of the two field studies. The Armor Test was held in May 1974, and, as with all field tests, hindsight identified several areas where improvement could have been made to the experimental procedures. The Artillery Test was conducted in September 1974, and was able to use the Armor Test's experience to refine some of the factors used at that time.

The conduct of the Armor Test will be discussed first, followed by the discussion of the Artillery Test.

Chapter 2

THE ARMOR FIELD TEST

INTRODUCTION

The Armor Test was conducted at Fort Knox, Kentucky, during a three-day period in May 1974. Before this time, detailed test-related coordinations were conducted with ARI, the Armor Human Research Unit, and the Armor Center and School. In particular, these coordinations addressed the test experimental design, troop administrative procedures, firing and range procedures, and the data collection process. The test was conducted according to this plan except for the problems noted in the following discussion.

TASK REQUIREMENTS

The objective of the Armor Field Test was to determine the contribution of live firing to weapons proficiency for a large-caliber, direct fire, weapons system. To achieve maximum experimental control, subjects were assigned to only one of the four crew positions in the tank—the Gunner position.

The gunner was required to acquire the target, sight the main tank gun by making the appropriate adjustments on the sighting instruments, and fire the gun. Thus, in the Armor Field Test, individual proficiency was the data source.

TEST RANGES

Two existing tank firing ranges at Fort Knox were used for all training and testing (see Figure 1). Live firing was conducted on the Boydston Tank Range using a 6 x 6 ft. panel target at a distance of 1200-1400 meters. Simulated firing was conducted on Steeles Tank Range using a 6 x 6 ft. panel target at a distance of 700-900 meters. This shorter range for the simulator was necessitated by the use of existing ranges and equipment. On both ranges, target panels were mounted on wheeled carts, traversing counter-clockwise around an oval track positioned at 90° to the firing line.

EQUIPMENT

Live firing was conducted from five M60A1 Tanks parked in stationary positions along the firing line of Boydston Tank Range. All tanks were bore-sighted and zeroed by the tank commander immediately before the initiation of training. A check round was fired by the tank commander each day before beginning training or testing. All live firing used HEAT-TPT ammunition from a single production lot.

Simulated firing was conducted from five M60A1 Tanks parked in stationary positions along the firing line of Steeles Tank Range. Components of the hit-kill indicator device, XM56 SIMFIRE, were mounted on each tank to require tracking lead inputs and

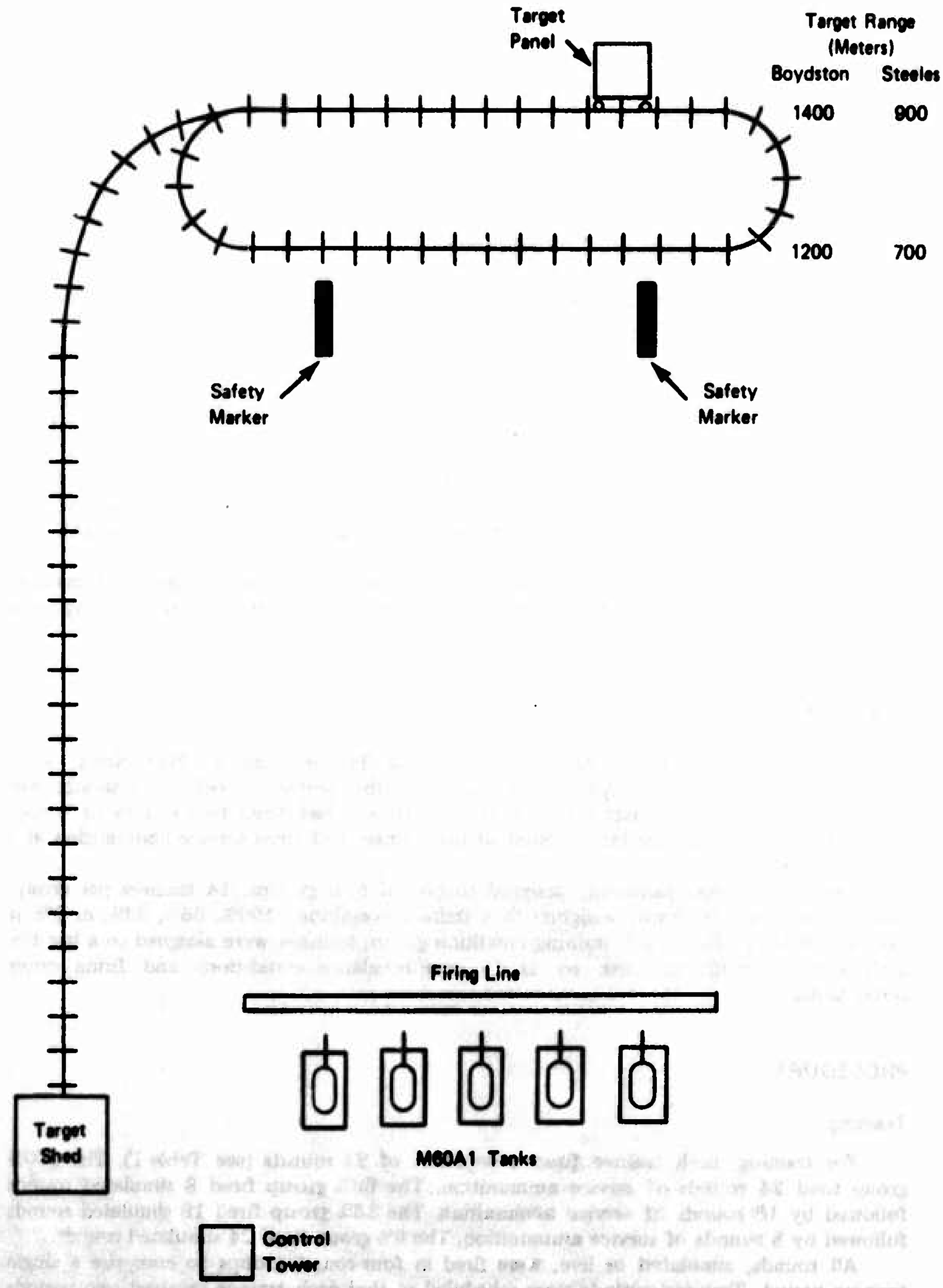

Figure 1 **– Tank Range Layout**

provide hit-miss data. The device is an electronic training aid utilizing a low-power laser beam which simulates the effects of firing the main armament of an M60 series tank. The components used consisted of:

(1) Tank Commander Remote Box—index target range and lead requirement, START button to initiate gunnery cycle.

(2) Loader Remote Box—index ammunition type.

(3) Laser Weapons Projector—projects low-power, eye-safe, laser beam aligned with gunner's primary sight reticle.

(4) Detector—mounted on target, detects projected laser beam position, discriminates 3-foot radius hit area and 9-foot radius position for miss direction.

(5) Transmitter/Receiver—radio frequency communication of hit-miss information between target and firing tank.

(6) Eyepiece—mounted on periscope, telescope, and/or rangefinder eyepieces; white indicator illuminates when weapon firing trigger is activated; pattern of four red indicators illuminates to indicate "hit" or miss direction if miss distance is within the 9-foot Detector radius. For this research eyepieces were placed on the gunner's periscope and the tank commander/instructors' rangefinder. A remote eyepiece was located in the loader's section and attached to the gunner's telescope.

All simulators were aligned by ARI-HRU engineers prior to the initiation of training, periodically check-fired by the tank commanders, and realigned by the engineers as necessary.

SUBJECTS

Fifty-six trainees from Advanced Individual Training/Armor, Fort Knox, were assigned for the research. All trainees were in the seventh week of training; had completed the subcaliber laser Tables I, II, and III; and had fired two rounds of service ammunition at a stationary target. None of the trainees had fired service ammunition at a moving target.

The trainees were randomly assigned to one of four groups, 14 trainees per group. Groups were then randomly assigned to a training condition: 100%, 66%, 33%, or 0% of live fire. Finally, within each training condition group, trainees were assigned to a live-fire tank and a simulation tank so as to counterbalance conditions and firing order across tanks.

PROCEDURE

Training

For training, each trainee fired a sequence of 24 rounds (see Table 1). The 100% group fired 24 rounds of service ammunition. The 66% group fired 8 simulated rounds followed by 16 rounds of service ammunition. The 33% group fired 16 simulated rounds followed by 8 rounds of service ammunition. The 0% group fired 24 simulated rounds.

All rounds, simulated or live, were fired in four-round groups to comprise a single training period. Training periods were scheduled so that each trainee received two periods per half day for a total of six training periods requiring 1 1/2 days of training for the groups (see Table 2). During each period the trainees fired in sequence, then rested until their turn for the next period. A turn consisted of first acting as loader and then as gunner.

Table 1

Number of Simulated and Service Rounds Fired, by Training Group

Training Group	Number of Rounds		
	Simulated	Service	Total
100%	0	24	24
66%	8	16	24
33%	16	8	24
0%	24	0	24

Table 2

Training Schedule

Training Group	Training Period[a]					
	DAY 1 - A.M.		DAY 1 - P.M.		DAY 2 - A.M.	
100%	LLLL	LLLL	LLLL	LLLL	LLLL	LLLL
66%	SSSS	SSSS	LLLL	LLLL	LLLL	LLLL
33%	SSSS	SSSS	SSSS	SSSS	LLLL	LLLL
0%	SSSS	SSSS	SSSS	SSSS	SSSS	SSSS

[a]S = Simulated Firing, L = Live Firing.

Before firing commenced, the tank commander activated all equipment and indexed the proper ammunition and target range into the computer, and, where relevant, the SIMFIRE Tank Commander Remote Box. Thus, the gunnery requirement was limited to gunner tracking—with lead—and firing.

During each training period this firing procedure was followed for each trainee (see Figure 1):

(1) The trainee laid the sight reticle, in azimuth, on the right safety marker and, in elevation, on the near segment of the target track. With the SIMFIRE device, the tank commander indexed the lead correction element.

(2) When the moving target (traversing from right to left on the far target track segment) approached the firing fan, the tank commander issued a fire command and, with SIMFIRE, depressed the START button. The loader loaded a round of ammunition, or depressed the HEAT button on the SIMFIRE Loader Remote Box, and announced "up." The trainee gunner initiated target tracking.

(3) The trainee fired one round as soon as he had established a smooth tracking lay on the target. The tank commander sensed the round, or read the SIMFIRE eyepiece return indication, and issued a second fire command. The procedure for first round firing was then repeated until a second round was fired. After firing a second round, the trainee gunner continued tracking the target until the sight reticle was in line in azimuth with the left safety marker. The time required for the target to traverse the

distance between the two safety markers was approximately three minutes. The tank commander critiqued gunner performance after the second firing. No critique was allowed during firing except to prevent suspected attempts at ambushing the target. That is, if the tank commander interpreted the gunner's tracking behavior as indicating an attempt to ambush the target, he would immediately caution the gunner.

(4) The above sequence was repeated for left-to-right target movement. However, the period after the second round firing was utilized not only to critique the gunner but also to rotate gunners and prepare for the next firing sequence.

Testing

On the third day, two test periods of eight rounds were fired by all trainees except for the 100% live-fire group. After the completion of training, but before initiation of the test periods, one trainee in the 100% live-fire group was injured. The test period data for the 100% live-fire group is thus based on the scores for 13 trainees.

All firing was with service ammunition. Firing sequence and procedure was the same as during training except that no performance critique was permitted.

Since the 0% group was transferring to a different tank system on the live-fire range, all groups were assigned to a different tank and tank commander. The procedure to change tank commanders was thought necessary in order to achieve maximum objectivity in the criterion test. This change, together with the requirement to change tanks, may have resulted in a loss of trainee proficiency related to learned characteristics of the specific tank system utilized during training. However, the loss was consistent for all groups.

Scoring

All scoring was accomplished by HumRRO and ARI-HRU personnel. Two measures were obtained for each firing: time-to-fire and hit-miss.

The time-to-fire measures spanned the period from first turret or gun movement to first firing, and from first to second firing. (While loading time was an unknown variable in each live-fire measure, rotation of loaders was assumed to average out these times across groups.) The time intervals were measured with a stopwatch and recorded on individual trainee data sheets. If a gunner did not fire one or both "rounds" during a target run, the appropriate round(s) was recorded as a "No-Fire."

For live firing, a scorer was located on the turret bustle to observe gun-turret movement when the round was fired. For simulated firings, a scorer was located in the loader's section of the turret to observe gun-turret movement and the "fire" indicator light on the remote eyepiece.

The hit-miss measure indicated whether or not a live round impacted on the 6 x 6 foot moving target panel or a simulated round had been aimed within the 3-foot Detector radius. Live-fire hits were determined by a scorer using binoculars, who was located approximately 10 feet to the side of the firing vehicle. For simulated firings, the time-to-fire scorer located inside the turret also recorded hit-miss information as presented on the remote eyepiece. Again, if a gunner did not fire one or both "rounds" during a target run, the appropriate round(s) was recorded as a "No-Fire." If the scorer could not determine the point of impact of a live firing, the round was recorded as "Lost."

During live firing an alibi was allowed only for a misfire or equipment malfunction—neither occurred. During simulated firings an alibi was allowed for simulator malfunctions or for interference from adjacent simulators.

When simulator malfunctions occurred during the first firing of a target run, the two-round sequence was immediately repeated. When simulator malfunctions occurred during the second firing, no repeat was allowed and the data were recorded as "Lost." The lost data created no major problems in subsequent statistical analyses. Most malfunctions were attributed to the Detector and resulted only in a loss of hit-miss data. However, a target malfunction during the final training period for the 0% group resulted in the loss of both time and hit data for one trainee.

Interference from adjacent simulators could result from two or more tanks firing within a two-second period, since the detector required a two-second reset period. Thus, if two or more tanks fired within that period, only the first would receive a hit-miss return. If there was not a hit-miss return, the tank commander judged whether the gunner's cross-hair had been within the 9-foot Detector radius, and if so, reran the firing.

Trainee Attitude

Immediately following the final training period, all trainees completed an anonymous confidence and attitude questionnaire (Appendices A and B).

The first part of the questionnaire consisted of a 13-item Bipolar Adjective Scale. The 13 items were designed to assess a trainee's confidence and were taken from the semantic differential confidence-despair scale developed by HumRRO under Work Unit FIGHTER (Kern 1966).[1] For each item the respondents were asked to indicate their level of confidence at some point along a seven-point scale. In this way, alternatives chosen could be weighted as to the degree of confidence expressed and mean scores could be obtained for each group.

The second part of the questionnaire contained a series of multiple choice questions designed to determine: (a) the respondent's confidence in his live-fire ability, (b) his preference for the different types of weapons training he had received, (c) his opinions regarding the relative effectiveness of the different types of training and the amount of realism provided through simulation, and (d) the interest generated through the use of simulation and live-fire methods. Each item on the questionnaire was analyzed separately since there was no basis for combining items into indicated scale areas.

Problems

During the first training day a weather problem developed, with cold rain and high winds persisting until early afternoon. Since the major consideration of the research was in the relative contribution of practice, rather than the absolute level of proficiency attained, it was decided to initiate training under these conditions rather than to reschedule. (Because of the unavailability of range facilities and personnel, rescheduling would have delayed the research approximately four months.) However, the effects of weather conditions did interact with demonstrated proficiency during the first two training periods.

For the 100% live-fire group, the first two firing periods were conducted with a ribbon-type wind target rather than with a solid panel. The target type and rain caused reduced target visibility which may have increased time-to-fire scores and decreased the number of hits. On the other hand, reduced visibility also caused the scorers to lose a larger number of shots than usual. Since lost shots are more likely with misses, due to the lack of a solid background for the tracer element, poor visibility may have reduced the relative number of misses recorded. When lost rounds were not included in the calculation of percentage hit scores, that percentage might then be inflated.

[1] Richard P. Kern. *A Conceptual Model of Behavior Under Stress, With Implications for Combat Training*, HumRRO Technical Report 66-12, June 1966.

For the simulation group, the rain and wind delayed training until the afternoon since the target receiver could not be mounted on a wind target and the target track was blocked with mud. To meet the schedules for transfer to live-fire conditions, intact groups were then run in sequence for the first two training periods: 66%, 33%, 0% groups respectively. This massed practice may have interacted with both time-to-fire and hit-miss scores.

Thus, for all groups, the first two training periods provided the scheduled tracking practice but the data for those two periods may not be accurate.

RESULTS

Design

The design of this study was a single-factor analysis of variance design. Time-to-fire and hit-miss data were collected for each trainee for each firing. For each trainee the average time score and percentage hit score was calculated for each training and test period. These calculations represent the measures used in the assessment of firing proficiency. In addition, measures reflecting trainee confidence and attitudes were collected to determine the intrinsic motivation inherent in the conduct of live firing.

For these calculations, "No-Fire" data were omitted from the time-to-fire average but were treated as a "Miss" for the hit percentage. There were very few "No-Fire" recordings, all occurring during the first training period. Firings recorded as "Lost" were omitted from both the average time-to-fire and hit percentage calculations. While very little time information was lost, quite a few of the hit-miss sensings were lost. Table 3, summarizing the number of lost rounds, indicates that this procedure may have significantly affected the data for the 100% group during the first two training periods, and for much of the simulation training. While the simulator data were lost due to equipment malfunction, the major cause of malfunction was believed to be due to target cart and Detector mountings that were fabricated for this research and not due to the simulation hardware per se.

Table 3

Number of Firings Recorded as Lost for Each Firing Period

Firing Period	Training Group[a] 100%	66%	33%	0%
Training				
1	10	4	3	6
2	15	1	2	0
3	3	3	6	2
4	1	2	3	2
5	1	0	0	1
6	0	1	0	5
Test				
1	0	1	2	0
2	0	0	0	0

[a]Periods above the dashed line (- - -) are simulator firing periods, below the dashed line are live firing periods.

Performance Measures

The average time-to-fire percentage hit scores under the live-firing conditions for all groups are shown in Figures 2 and 3, respectively.

From the figures it appears that all groups that had experienced live fire during training showed a relative loss in hit percentage when transferred to a different tank system for testing, but firing time remained relatively stable. (While this comparison could not be made for the all-simulation group, it is assumed that the same effect occurred there.) More importantly, there appears to be little difference between the groups that is consistent over the two test periods; all groups appear to be performing at approximately the same level of proficiency after the completion of training. While the study was a single-factor analysis of variance design, for the time scores a two-factor repeated-measurements analysis of variance was conducted (Winer, 1971).[1] The results are presented in Table 4. The results indicate that the final level of performance was not significantly different for the groups.

Analysis of variance tests for percentage hit scores for the test periods resulted in many *F* ratios significantly less than 1.00. This appeared to be attributable to the large ranges of average scores and to individual inconsistency over repeated measures. Non-parametric chi square tests of the number of hits were therefore calculated for all hit

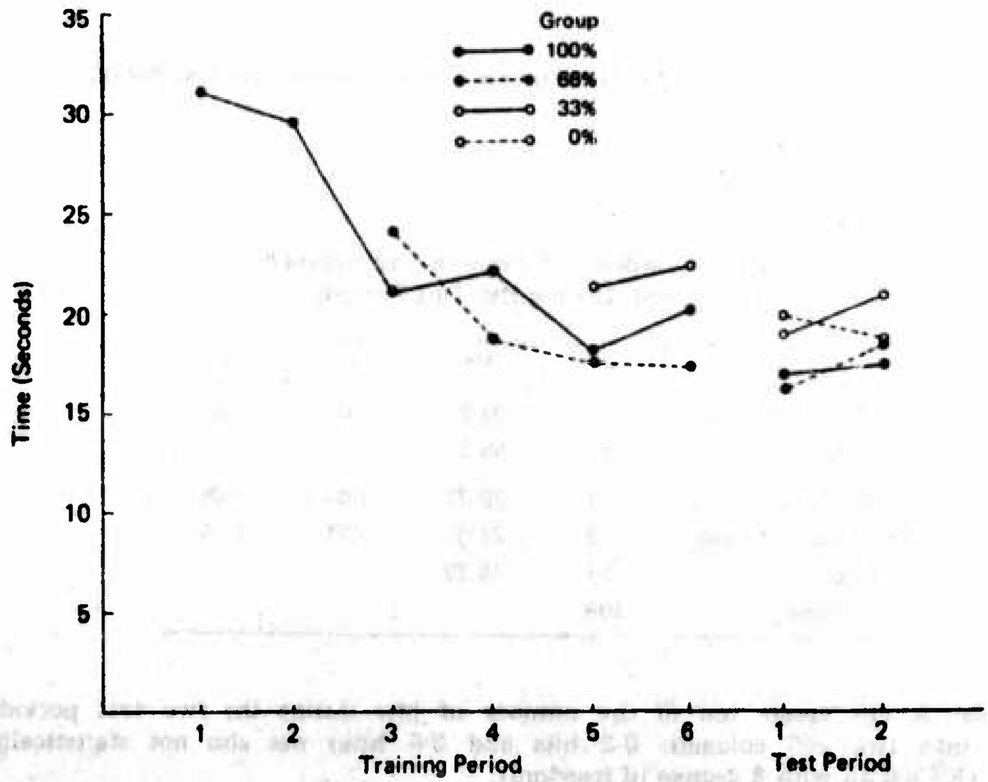

Figure 2 – **Average Time-to-Fire During Live Firing Training and Test Periods**

[1] B.J. Winer, *Statistical Principles in Experimental Design*, (2nd Ed.), McGraw-Hill, New York, 1971.

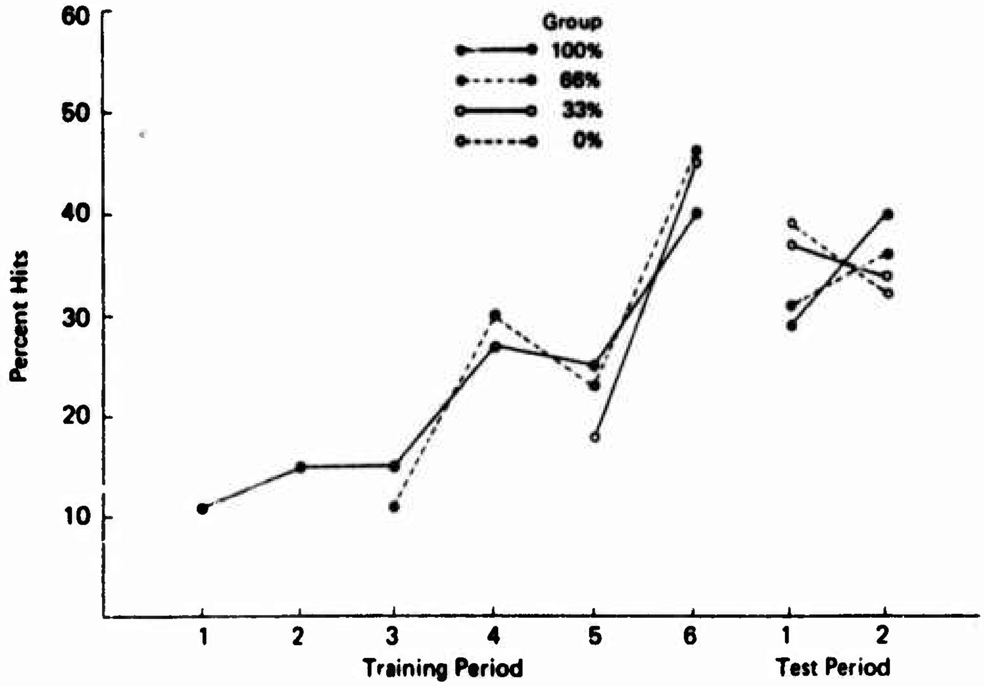

Figure 3 – **Average Percent Hits During Live Firing Training and Test Periods**

Table 4

Analysis of Variance of Time-to-Fire Scores for All Groups, During the Test Periods

Source	*df*	*MS*	*F*	*p*
Training Conditions	3	62.97	1.07	>.05
Error	51	58.87		
Test Periods	1	29.92	1.64	>.05
Conditions x Periods	3	21.97	1.21	>.05
Error	51	18.23		
Total	109			

comparisons. A chi square test of the number of hits during the two test periods (collapsed into two cell columns: 0-2 hits and 3-6 hits) was also not statistically significant ($X^2 = 0.45$ with 3 degrees of freedom).

With respect to the training curves in Figures 2 and 3, both figures indicate that following simulator practice (training period 3 for the 66% group and 5 for the 33% group) there is an initial decrement in live-fire performance relative to the group that had received continuous live-fire practice. However, after no more than four live firings (one training period), the simulator groups perform at a level at least equal to the 100% live-fire group. This finding is qualified somewhat by the performance of the 33% group with respect to firing times. As with the simulator training performances, this group appears to be consistently slower in firing than the other groups.

A single-factor analysis of variance of the time scores for period 3 and period 5 (Winer, 1971),[1] Tables 5 and 6, respectively, indicated that the initial transfer decrement was not statistically significant. Chi square tests of the number of hits for periods 3 and 5 were also not statistically significant ($X^2 = 0.67$ with 1 degree of freedom and 3.24 with 2 degrees of freedom, respectively).

Table 5

Analysis of Variance of Time-to-Fire Scores for The 100% and 66% Groups, During Training Period 3

Source	*df*	*MS*	*F*	*p*
Training Conditions	1	63.00	1.15	>.05
Error	26	54.76		
Total	27			

Table 6

Analysis of Variance of Time-to-Fire Scores for The 100%, 66%, and 33% Groups, During Training Period 5

Source	*df*	*MS*	*F*	*p*
Training Conditions	2	31.02	1.78	>.05
Error	39	17.43		
Total	41			

Thus, it would appear that gunner tracking proficiency, to the levels obtained during this research, can be attained equally well through live-firing practice or through essentially dry-fire practice, with augmented lead requirements and hit-miss indications, under the same range conditions. However, while it was not statistically significant, there appears to be a need for several rounds of live-fire practice in transition.

Consistency of Performance Across Test Trials

Because of the apparent inconsistency of performance in the testing phase across groups, as implied by *F* ratios less than 1, additional analyses were conducted on the hit-miss data from testing. These analyses were performed not to probe for differential effects due to amounts of live fire used in training, but rather to assess the consistency of performance across the first and second sets of four test trials.

The reliability of the test was measured by a test-retest procedure. Scores on the first four trials were correlated with the scores on the second set of four trials for each

[1] Winer, 1971, *op. cit.*

subject within each of the four treatment conditions. These values turned out to be -.47, -.25, -.39, and -.15 for the 100%, 66%, 33%, and 0% live-fire groups, respectively. The overall correlation, computed across all four treatment groups, was -.21.

None of these correlation coefficients was significantly different from zero ($p<.05$). These results suggest that it is not possible to predict performance on the second set of four trials from performance on the first set of four trials any more accurately than by random guessing. At best, there is simply a very slight tendency for students who did well on the first four test trials to do less well on the second set, and for students who did poorly on the first set to improve slightly on the second set.

If the test results are to be interpreted in classical psychometric terms, then the entire set of correlations (that are so close to zero) implies that the test was ineffective in discriminating among students. However, another interpretation that may be more appropriate for criterion-referenced testing is that the scores represent data from a homogeneous group of students. This latter conclusion may be put forth regardless of the absolute level of proficiency attained—the homogeneity of test scores is what precludes the valid use of classical correlational reliability.

Consistency of performance may also be viewed from a decision-making perspective. In this interpretation, consistency is examined in terms of its impact upon the usefulness of test results in classifying individuals as "Masters" (those who demonstrate an *a priori* defined minimum level of proficiency) or as "Non-Masters" (those who demonstrate less than the minimum acceptable level). In contrast to classical psychometric reliability, the issue here is the potential misclassification error associated with test length, and the relationship between such error and the established criterion level.

The following analyses were conducted in order to assess the misclassification errors that would have resulted from using different test lengths (one, two, four trials), and three levels of proficiency as the minimum criterion of mastery (25%, 50%, and 75% hit rates). The goal was to assess the accuracy of using the three different test lengths in correctly classifying people as Masters or Non-Masters, since the "true" state was obtained from the *entire* eight-trial test.

The results of these analyses are presented in Tables 7, 8, and 9. Recall that there was a total of eight test trials in the experiment. Therefore, with a criterion of 25%, a student would have to get at least two hits in order to be classified correctly as a Master. For example, the numbers in Table 7A indicate the following: (a) 18 people who got a hit on the first test trial also got at least one more hit on the remaining seven trials of the test, and so were correctly classified as Masters; (b) 25 people who did not get a hit on the first trial did get at least two hits out of the remaining seven, and so were classified as Non-Masters (NM) on the basis of their first trial scores, whereas, they really were Masters (M) on the basis of their entire eight-item score, (c) 11 people failed to get a hit on the first item and failed to get two or more hits on the remaining seven items; and (d) one person got a hit on the first trial but did not get any more hits on the subsequent seven trials. Therefore, using the 25% criterion and a one-trial test, a total of 26 students would have been misclassified, with 25 of them called Non-Masters when, in reality (on the basis of the entire eight-item test), they should have been called Masters.

A similar line of reasoning holds for Table 8, in which the criterion was changed to 50%. Hence, a total of at least four hits out of the eight trials was required in order to apply the "Mastery" classification. Using this criterion, Table 8A reveals that 21 students would be misclassified. Of the 21, nine students missed the first shot but managed to get at least four hits out of the subsequent seven trials; 12 hit the target on the first trial but failed to get a total of four or more hits on the entire eight-trial test.

If the instructor considered a hit on either the first <u>or</u> the second trial to be indicative of mastery, then a total of two hits out of eight trials would be required on the entire test to place a student in the M category for the 25% criterion; four hits out

Table 7

Classification Matrices for Three Test Lengths: Criterion =25%

Classification (8 Trials)	Number of Hits					
	First Trial (A)		First 2 Trials (B)		First 4 Trials (C)	
	M	NM	M	NM	M	NM
Master (M)	18	25	30	13	38	5
Non-Master (NM)	1	11	2	10	3	9
Misclassified	26		15		8	

Table 8

Classification Matrices for Three Test Lengths: Criterion=50%

Classification (8 Trials)	Number of Hits					
	First Trial (A)		First 2 Trials (B)		First 4 Trials (C)	
	M	NM	M	NM	M	NM
Master (M)	7	9	12	4	13	3
Non-Master (NM)	12	27	22	17	11	28
Misclassified	21		26		14	

Table 9

Classification Matrices for Three Test Lengths: Criterion=75%

Classification (8 Trials)	Number of Hits					
	First Trial (A)		First 2 Trials (B)		First 4 Trials (C)	
	M	NM	M	NM	M	NM
Master (M)	0	1	0	1	0	1
Non-Master (NM)	20	34	33	21	4	50
Misclassified	21		34		5	

of the eight trials for the 50% criterion, and six hits out of eight trials for the 75% criterion. Using this two-trial decision rule, a total of 15 subjects were misclassified with the 25% criterion, 26 with the 50% criterion, and 34 with the 75% criterion. Thus, increasing the stringency of the criterion will not necessarily lead to fewer misclassification errors, if the initial rule for mastery (*e.g.*, one hit out of the first two trials) is fairly lenient.

The total number of misclassifications is greater with all three criteria on the basis of only the first trial, than on the basis of four trials (26 vs. 8, 21 vs. 14, and 21 vs. 5). Under the 25% criterion, only one hit out of the first four trials was required to call a person a Master (M), the 50% criterion required two hits out of the first four, and the 75% criterion required three hits out of the first four. Thus, subject to economic and other practical constraints and regardless of the established criterion, more test items are preferable to fewer items.

Although it might seem obvious that increasing the stringency of the criterion would lead to fewer misclassification errors, such is not the case. Note that there were 26, 21, and 21 such misclassifications for the three criteria on the basis of one trial data, and 8, 14, and 5 misclassifications on the basis of four trial data. Many more students were classified as Masters under the easier 25% criterion (43) than under the stricter 75% criterion (1). Since the number of "true Masters" in any population is determined by the criterion score, it follows that an easier criterion will classify many students as Masters (on the basis of one-, two-, or four-trial data), whereas a strict criterion will classify many as Non-Masters. For example, only 12 students were classified as NM in Table 7A, whereas 54 were so classified in Table 9A. The essential point is that misclassification errors are a function of both the *a priori* criterion for mastery, and the proficiency of the subject population.

The value of this kind of an approach is that it allows the decision-maker to easily compare a variety of data analyses, and to determine which analysis best fits the constraints under which he's operating and the characteristics of the student population. By comparing the various outcomes, he can strike a balance between the number of students who pass, the cost of retraining, the risks of advancing incompetent students, and the required job performance standards.

Trainee Confidence and Attitudes

The seven categories on the Bipolar Adjective Scale were weighted sequentially from least to most—1.0 to 7.0—for each adjective pair. Average ratings for each training condition group were then calculated for each pair and are presented in Figure 4. The average of these ratings for each training condition group is 6.0 for the 100% live-fire group, 5.3 for the 66% group, 5.9 for the 33% group, and 5.5 for the 0% group. Chi square tests for each adjective pair were not statistically significant.

It appears that all training groups evidence high assuredness toward firing the M60A1 in combat, even though they differed greatly in the amount of actual firing they had received. Simulated firing did not appear to result in a lesser level of assuredness. However, it is interesting to note that, while the differences were not statistically significant, there is a fair spread of responses on the skilled-unskilled, successful-failure, and safe-doomed pairs. Also, the 100% group shows the most assuredness in each of these pairs, with the difference being fairly clear-cut on the safe-doomed pair. Thus, there is an indication that actual weapon firing may lead to greater assuredness and feelings of safety with the weapon system than will simulated firings.

The responses to the opinion questionnaire are presented in Table 10. For discussion, the separate questions have been grouped under assumed content areas although these areas are only for convenience in discussion and do not represent empirically validated differences in question content. Since there appeared to be a high level of

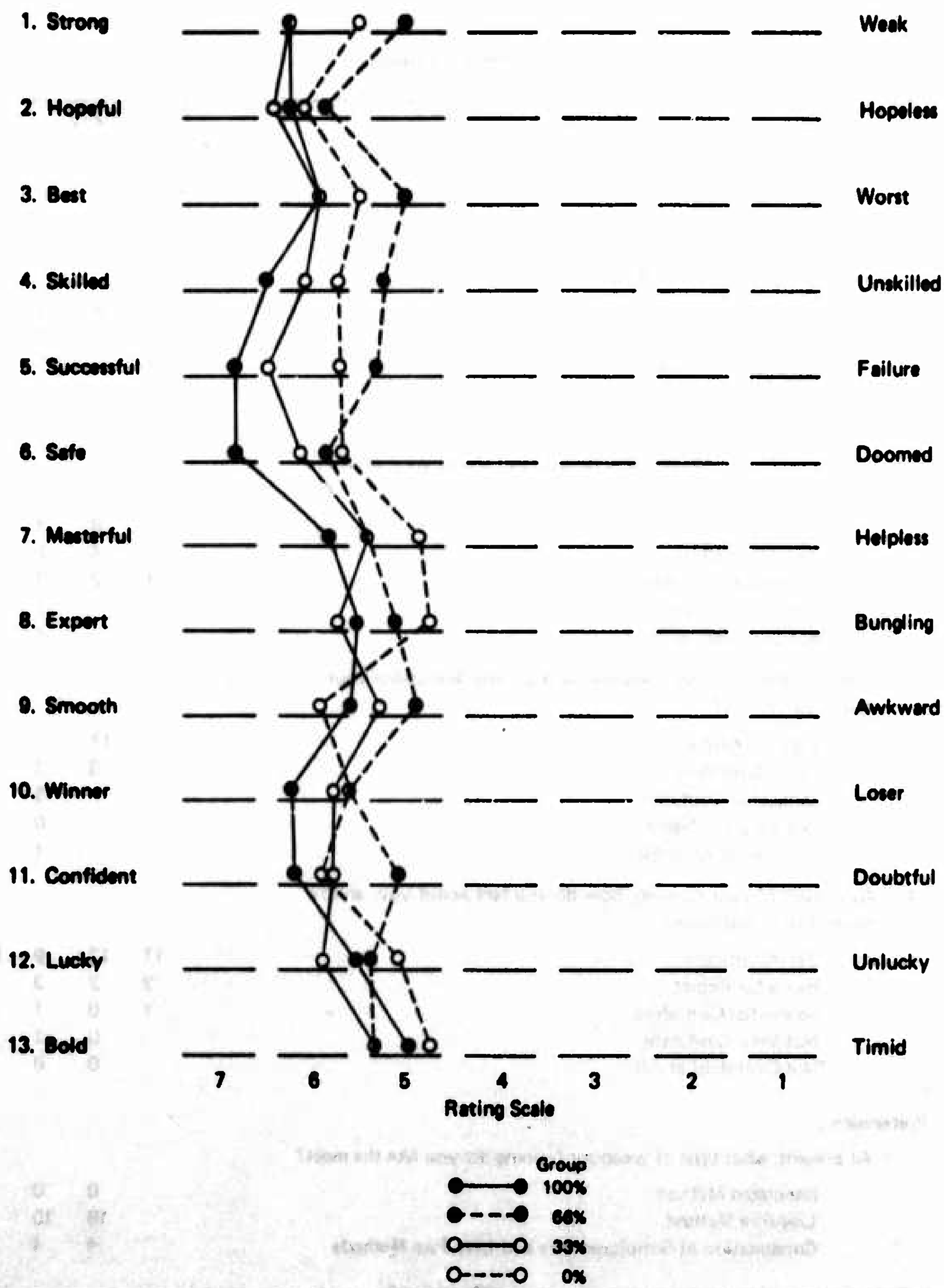

Figure 4 – **Bipolar Adjective Scale**

Table 10

Trainee Opinions

Attitude	Training Group 0%	33%	66%	100%
Confidence				
1. At the present time, how do you feel about participating in a live-fire exercise with the M60A1?				
Very Confident	11	8	9	9
Fairly Confident	2	6	1	3
Somewhat Confident	1		2	0
Not Very Confident			2	0
Not Confident at All			0	0
2. After simulated exercises, how do you feel about your ability to live fire?				
Very Confident	10	8	4	
Fairly Confident	3	4	2	
Somewhat Confident	1	2	2	
Not Very Confident			2	
Not Confident at All			4	
3. After live-fire practical exercises, how do you feel about your ability to live fire?				
Very Confident		11	7	7
Fairly Confident		3	3	5
Somewhat Confident			3	0
Not Very Confident			0	0
Not Confident at All			1	0
4. As a result of your training, how do you feel about your ability to use live ammunition?				
Very Confident	11	12	9	11
Fairly Confident	2	2	3	0
Somewhat Confident	1	0	1	1
Not Very Confident		0	1	0
Not Confident at All		0	0	0
Preference				
5. At present, what type of weapons training do you like the most?				
Simulated Method		0	0	
Live-Fire Method		10	10	
Combination of Simulated Fire and Live-Fire Methods		4	4	

(Continued)

Table 10 *(Continued)*

Trainee Opinions

Attitude	Training Group			
	0%	33%	66%	100%
Preference *(Continued)*				
6. At present, what type of weapons training do you like the least?				
Simulated Method		10	12	
Live-Fire Method		1	2	
Combination of Simulated Fire and Live-Fire Methods		2	0	
8. If you had your choice, how often would you like to train using the simulated fire method?				
Very Frequently	3	2	0	
Frequently	3	2	0	
Sometimes	4	6	5	
Infrequently	1	1	3	
Very Infrequently	3	3	6	
9. If you had your choice, how often would you like to train using the live-fire method?				
Very Frequently		7	8	7
Frequently		7	3	5
Sometimes			2	0
Infrequently			1	0
Very Infrequently			0	1
Effectiveness				
7. At the present time, what type of weapons training is most helpful in achieving a high level of firing proficiency?				
Simulated Fire Method		1	0	
Live-Fire Method		10	13	
Combination of Simulated Fire and Live-Fire Methods		3	1	
10. At present, how helpful do you feel simulated fire training is in increasing your firing proficiency?				
Very Helpful	6	7	1	
Fairly Helpful	6	3	1	
Somewhat Helpful	2	3	2	
Not Very Helpful	0	1	5	
Not Helpful at All	0	0	5	
11. At present, how helpful do you feel live-firing training is in increasing your firing proficiency?				
Very Helpful		9	9	10
Fairly Helpful		4	3	3
Somewhat Helpful		1	1	0
Not Very Helpful		0	1	0
Not Helpful at All		0	0	0

(Continued)

Table 10 *(Continued)*

Trainee Opinions

Attitude	Training Group			
	0%	33%	66%	100%
Realism				
12. In your opinion, how realistic is simulated fire training?				
Very Realistic	3	3	1	
Fairly Realistic	4	3	0	
Neutral	5	3	1	
Not Very Realistic	1	4	5	
Not Realistic at All	1	1	7	
Interest				
13. How interesting was your training using the simulated fire method?				
Very Interesting	5	4	2	
Fairly Interesting	5	3	2	
Somewhat Interesting	1	4	0	
Not Very Interesting	3	3	5	
Not Interesting at All		0	5	
14. How interesting was your training using the live-fire method?				
Very Interesting		14	10	10
Fairly Interesting		0	3	2
Somewhat Interesting		0	1	0
Not Very Interesting		0	0	1
Not Interesting at All		0	0	0

agreement among groups, with most responses clustering within a single category, the distribution of responses did not allow for valid statistical analyses of differences between training conditions.

Examination of the overall trends indicates two prominent factors. First, responses to the various aspects of simulation appear to be directly related to the proportion of simulation training received. Second, however, there is an overall tendency for some trainees in the 66% group to express negative opinions. Since the latter factor seems to have occurred on the Bipolar Adjective Scale (Figure 4) there may be a tendency for some individuals in this group to rate on a lower scale; if this is the case it could spuriously heighten the appearance of a trend across the three simulation groups.

All groups appear to be highly confident of their ability at the end of training. However, all groups that had received some live-fire practice strongly support a preference for that type of practice, with little desire for a combined method or, if combined, for very much simulated practice. Part of this preference may be due to the anticipation for live firing that is built into the preliminary gunnery exercises. However, actual experience with live fire does not appear to significantly decrease the preference. Also, live-fire *effectiveness* is viewed as much greater than that of simulated firing even though the two groups that had received the most simulated training thought that it had been helpful in increasing their firing proficiency.

Two problems with the simulation used appear to be that realism was not perceived to be very high and, possibly on that basis, it did not appear to hold trainees' interest.

Thus, it appears as though the use of simulation during varying proportions of firing practice did not affect the trainee's confidence in his ability to fire live ammunition. However, neither did it provide for a relative degree of realism or interest that would lead to trainee acceptance of simulation as a desirable or intrinsically motivating method of training.

CONCLUSIONS

Again it should be noted that the implications of this research should be restricted to the fairly pure conditions of firing practice under which it was conducted. The drop in performance from the training periods to the criterion test is provocative, but not understood at this time. Generalizations to methods which include other instructional techniques would be very tenuous particularly regarding the absolute levels of gunner proficiency attainable through a given number of live or simulated firings. However, this restriction should not apply to the results regarding the individual or relative effects of the methods used.

Conclusions resulting from the Armor Field Test are as follows:

(1) Simulated firings can be substituted on a one-for-one basis for live firings (over the proficiency levels attained during this research) to attain the same level of gunner tracking proficiency. However, some short transition to live fire may be required.

(2) The simulation used did not provide intrinsic motivation. Both realism and interest were judged very low by the trainees. Thus, the major motivating aspect of the simulated training appeared to result from the monitoring capability that the time and hit-miss indications provided for the Tank Command/Instructor. To be maximally effective, particularly for unmonitored individual gunner practice in a unit, more realistic gunnery exercises, providing intrinsic motivation through both realism and challenge, would have to be developed.

(3) Time-to-fire and hit-miss measures appear to include factors other than pure gunner tracking proficiency during service firing, and these factors do not appear to be consistent over early gunnery periods. For the time-to-fire measure, these factors, such as loading time, soon stabilize. For the hit-miss measures, the inconsistency, possibly caused by both weapon system error and gunner response to blast effects, continues over at least the number of firings provided during this research (32). Thus, while simulator performance was consistent on both measures, its use as a predictor of live-fire performance would be limited to the time measure.

Chapter 3

THE ARTILLERY FIELD TEST

INTRODUCTION

The Artillery Test was conducted at Fort Sill, Oklahoma, during a three-week period in September 1974. Prior to this time, a detailed field test plan had been developed by HumRRO in cooperation with ARI, the Infantry Human Research Unit, and the Artillery Center and School. This plan specified the experimental design, the troop administrative procedures, the fire commands, and the data collection forms. The test was conducted according to this plan with no major deviations being required either for weather or for administrative conditions.

TASK REQUIREMENTS

The objective of the Artillery Field Test was to determine the contribution of live firing to weapons proficiency for a large-caliber, indirect fire, weapons system. Since the firing of the 105mm Howitzer is a crew requirement, all six positions were manned by test subjects.

The Chief of Section received the fire command from the Project Officer and supervised all activities involved in the firing of the gun. Specifically, he verified that the piece was ready for action by checking settings, supervised the safety aspects of the firing, and gave the command to fire. The gunner set the announced fire command deflection on the appropriate dials and sights and layed the howitzer for direction. The assistant gunner placed the announced quadrant value on the sight scale, helped level the appropriate bubbles, and when the command to fire was given, fired the howitzer by pulling the lanyard.

The previously discussed tasks occurred both sequentially and simultaneously according to specific and detailed training procedures developed by the Artillery School. Concurrently, with this work, the other three crew members were conducting the following tasks.

The No. 1 cannoneer was required to push home each round as it was loaded and to clean and inspect the breach block and chamber between rounds. The No. 2 cannoneer handled the round and screwed in and set the appropriate fuze. The No. 3 cannoneer was responsible for securing the powder, verifying that the number of charges was correct, and passing the powder to the gun position.

Thus, unlike the Armor Field Test, the data from the Artillery Field Test were generated as a result of crew performance and are a measure of crew proficiency.

TEST CONDITIONS

Existing firing ranges were utilized during the entire test. The impact areas for both of these firing points were quite large and the 105mm rounds generally fell between 3000-4000 meters from the firing line. For the M31 subcaliber device, the 14.5mm rounds impacted 300-400 meters from the firing line. During the criterion test, forward observers were positioned at two different locations to spot rounds as they impacted and measure the angular error from the expected point of impact. With respect to the center of the impact area, the two observer positions were separated by approximately 60 degrees.

EQUIPMENT

All gun crews used the M102 towed howitzer throughout the test. The maximum number of howitzers required at any one time was 11. The M31 breech-mounted subcaliber device was used for all simulated firing conditions during training. Six of these devices, with an allocation of 14.5mm ammunition, were required. The total amount of ammunition used during the test was as follows:

105mm HE, Point Detonating Fuze:		
A.	Familiarization	32
B.	Training	480
C.	Testing	1,120
105mm HE, Time Fuze:		
A.	Training	240
B.	Testing	560
14.5mm rounds for M31 subcaliber device:		
A.	Training	480

FIRE MISSIONS

The firing of tube artillery weapons is controlled by fire missions. These missions contain highly proceduralized fire commands which indicate the actions required of each member of the gun crew. The commands are developed through the combined efforts of the forward observer (FO) and the fire direction center (FDC).

In this test, the M102 crews did not use FOs or an FDC except where necessary to satisfy safety and data recording requirements. These two elements of the fire team (FO and FDC) contribute to the errors in firing performance for a specific weapon. It would be very difficult, if not impossible, to separate these sources of variance from the variance directly attributable to the performance of the gun crew. For the present test, the FO and FDC were eliminated from the firing missions through the use of preplanned fire commands. These commands were based on calculations concerning where the rounds should land if the commands were properly executed. This approach provided a more direct examination of the performance of individual gun crews.

All preplanned fire commands were developed prior to the test by personnel in the S3 division of Field Artillery School Brigade at Fort Sill. The commands were intended to be representative of the most typical missions given to an M102 crew. Preplanned fire commands were developed for a total of 18 different targets. Five rounds were fired at each target before the fire command included the next target. During training, all crews, except those using the M31 device, were given the same fire commands and, therefore, fired on the same targets. It was necessary to develop fire commands for six different targets for the simulator training groups. During the criterion test, all gun crews followed the same fire commands for another group of six targets. Over the entire test period, each crew engaged a total of 12 targets.

SUBJECTS

A total of 336 subjects were used in the study. These subjects were randomly assigned to six-man gun crews. Samples were drawn from three different Advanced Individual Training (AIT) classes to obtain the 56 crews required for the design. Since three successive AIT classes were utilized, the sample size from each class corresponds to the number of crews used during each week of the test:

Week 1	21 crews
Week 2	21 crews
Week 3	14 crews
Total	56 crews

The samples from each class were taken in multiples of seven. This permitted an even distribution of each class over the seven experimental groups. Therefore, any differences that may have existed between AIT classes were balanced across all groups.

The AIT students served as subjects in the field test following the second week of MOS Technical Training of the Cannoneer (Army Subject Schedule No. 6-13A10). At this time, the students were at a fairly low point on the learning curve with respect to howitzer weapons training. During the first two weeks of AIT, the students received two field training exercises which involved live firing. These exercises, however, were primarily for familiarization and did not contribute substantially to weapons firing proficiency.

EXPERIMENTAL DESIGN

The experimental design for the field test consisted of a two-factor between-subjects design with a control group. The two experimental variables were (a) the amount of live firing and (b) the types of synthetic training. The crews that served in the control group received all live fire during training. The experimental design (Winer, 1962, pp. 263-267),[1] with eight crews in each condition, follows:

		Amount of Live Fire			
		2/3	1/3	0	
Synthetic Methods	Dry	A 8 crews	C 8 crews	E 8 crews	Control 8 crews
	Simulator	B 8 crews	D 8 crews	F 8 crews	

EXPERIMENTAL GROUPS

During the field test, each gun crew received 30 training trials and 30 test trials. For two of the experimental groups that did not receive any live firing during training, each gun crew received two trials of live firing prior to the criterion test. Table 11 indicates the total number of trials and types of firing practice that were administered to each gun crew in a given experimental group.

[1] B.J. Winer. *Statistical Principles in Experimental Design*, McGraw-Hill, New York, 1962.

Table 11

Trials and Types of Firing Practice, by Experimental Group

Experimental Group	Familiarization Trials	Number of Trials			Criterion Test Trials
		Dry Firing	Simulator Firing	Live Firing	
Control				30	30
A		10		20	30
B			10	20	30
C		20		10	30
D			20	10	30
E	2	30			30
F	2		30		30

DAILY SCHEDULES

A training and testing schedule was developed for each day of the field test. For each individual trial, the schedule indicated the experimental group, crew number, type of firing, and type of fuze. During the first two weeks of the test, the seven groups were divided between morning and afternoon training or testing. To control for the possible effects that time of day might have on performance, the orders for training and testing were counterbalanced across the three-week period.

PROCEDURE

Questionnaire Administration

At the beginning of each week of the test, all subjects were assembled in the unit area for administration of the Intrinsic Motivation Scale before going to the firing range. The verbal instructions included a general explanation of the test, a description of the different types of training, and the requirement for honest opinions.

The second administration of questionnaires was conducted before the live-fire criterion test. All subjects completed the Intrinsic Motivation Scale, the Task Team Motivation Scale, and the Attitude Toward Training Scale. The first and second administrations required approximately 15 and 40 minutes, respectively.

Instructions to the Trainers

Before the first week of the test, all instructors were given a briefing on their responsibilities and the purpose of the test. They were told to do everything possible to maximize the effectiveness of each type of training (dry, simulated, or live firing). During the training trials, they were encouraged to provide whatever feedback and training they considered necessary, and to generally conduct the exercise as they normally would in the AIT. Feedback and training were not permitted during the criterion test except when necessary for safety reasons. The importance of maintaining the individual members of the crew in the same position throughout the week was also stressed. Finally, they were briefed on the data collection forms and their responsibilities for collecting and recording information.

During all training and testing, each gun crew was controlled by one instructor. Each instructor trained or tested two gun crews per day. To eliminate possible instructor bias during the criterion test, all instructors were given crews that had been trained by another instructor.

Establishment of Firing Lines

At the beginning of each day of training or testing, the howitzers were moved to the firing line. It was the responsibility of each gun crew to emplace the howitzer, organize ammunition and equipment, test and align fire control equipment, and lay the howitzer for direction. Safety officers then checked each weapon with survey equipment to insure that the orientation was within the firing fan. Approximately one hour was required for the entire process. The crews scheduled for the afternoon removed the howitzers from the firing line and returned them to the unit area.

When the weapons were initially moved to the firing line, they were divided into three groups with as much separation as possible between the groups. All the crews within a given group received the same type of training, either dry, simulated, or live. This separation was not necessary during the criterion test since all crews were using live fire and received the same fire commands.

Training Conditions

The weapons training for M102 consisted of combinations of four different types of instruction. The training for all gun crews was conducted over a two-day period. All crews received crew drill and 30 training trials which were some combination of dry, simulated, and live firing. Crew drill and the first 10 trials were conducted on the first day and the remaining 20 trials were completed on the second day. The instructors were permitted to complete the required instruction at their own pace. Since some training methods, such as dry fire, could be conducted faster than others, there were differences in the amount of time required for training. The total amount of training time per crew each day was generally between one and two hours. The various training conditions are described in the following paragraphs. All training exercises were patterned as closely as possible to the current AIT instruction.

Crew Drill. The first part of the training for all crews consisted of crew drill on the M102. Since a large part of AIT is oriented toward the individual, these drills were necessary to insure that each crew could, in fact, function as a howitzer crew. The amount of time required for this training was determined by each instructor. In general, each individual was briefed on the duties of his crew position, and then crew exercises were conducted until the instructor was satisfied that the crew could function effectively as an integrated team.

Dry Fire. The dry fire training included all tasks required to fire the weapon without actually firing live ammunition. Dummy rounds were used in this training, and it was possible to practice setting time fuzes and simulate other aspects of ammunition preparation and handling. The fire commands were followed by the crew as if live ammunition were being used.

Simulated Fire. The simulated fire training exercises were completed with the breech-mounted M31 14.5mm subcaliber device in the M102. Due to the type ammunition used with this device, it was not possible to effectively simulate most of the ammunition preparation and handling activities. The Chief of Section, gunner, and assistant gunner, however, performed the same tasks that would be required with live ammunition.

Live Fire. The live fire training was conducted in the same manner as the current AIT practical exercises. All members of the crew received the appropriate practice on all required tasks.

Criterion Test

Since 16 of the gun crews in the study had not fired any live ammunition at the time of the criterion test, each of these crews fired two rounds of service ammunition for familiarization before the test. The total ammunition requirement for this firing was 32 rounds.

The criterion test consisted of 30 rounds of 105mm ammunition for each of the 56 gun crews. Preplanned fire commands were used for six different targets and all crews were given the same fire commands. After five rounds were fired on a target, the next command was given.

During training, all crews were preparing to fire and firing simultaneously. For the criterion test, however, the howitzers were fired individually at 10-second intervals. The successive firing was necessary to permit the forward observers to spot and record the impact of each round.

Performance Measures

A wide variety of performance measures were developed to evaluate the level of proficiency of the gun crews acquired from the various experimental training methods. Table 12 lists the performance and indicates when the information was collected. An "X" means that the type of information specified was collected under that particular condition.

Table 12

Performance Measures for Artillery Gun Crews

Type of Information	Experimental Conditions[a]					
	Before Training	Training: Dry Fire	Training: Simulated Fire	Training: Live Fire	After Training	Criterion Test
Bubble Accuracy		X	X	X		X
Dial Setting Accuracy		X	X	X		X
Sight Picture Accuracy		X	X	X		X
Fuze Setting Accuracy		X		X		X
Response Time		X	X	X		X
Shot Fall Placement						X
Procedural Checklist						X
Safety Checklist						X
Intrinsic Motivation Scale	X				X	
Team Task Motivation Scale					X	
Attitude Toward Training Scale					X	

[a]X indicates that information was collected under this condition.

Response time for this study was defined as the interval between the announcement of the last element of the fire command and the call of "set" by the assistant gunner. When the assistant gunner called "set," all tasks had been completed except the pulling of the lanyard. Each instructor measured this time interval with a stopwatch and recorded it on the data collection form.

After the time had been recorded, the instructor collected the following information from the howitzer before firing. These three measures and the response time constitute the most reliable and valid measure of gun crew proficiency: (a) accuracy of center on pitch and cross-level bubbles, (b) accuracy of quadrant and deflection dial settings, and (c) accuracy of sight picture.

The time fuze on the projectile was set during the timed interval. Therefore, it was necessary for the instructor to observe this setting during the performance without stopping the crew.

The procedural and safety checklists were developed following a detailed task analysis of the crew positions for the M102. The task analysis provided the basis for identifying various critical tasks and procedures in gun crew performance. These tasks and procedures were then sorted into checklists for specific crew members. Each instructor completed the procedural checklist after Trials 1, 6, 12, 18, 24, and 30, and the safety checklist following Trials 2, 7, 13, 19, 25, and 30.

Since the experimental groups contained different amounts of dry, simulated, and live firing, it was expected there might be differences between the groups in terms of crew precision, communications, and coordination between crew members.

The Team Task Motivation Scale is a 24-item inventory designed to measure the extent to which an individual is team-task motivated. A high score on this inventory reflected a team-oriented disposition, while a low score reflected a self-oriented disposition.

For this study, "intrinsic motivation" translates into a matter of attitudes and, especially, confidence. Accordingly, study of this factor involved the measurement of attitudes toward firing the weapon, the degree of job satisfaction, and confidence in ability to fire the weapon. The purpose of the questionnaire was to determine the differences in attitudes generated by the three techniques of training (live, dry, simulated) and the extent to which a correlation existed between "intrinsic motivation" and weapon proficiency. Rating scales were developed on which subjects rated various aspects of attitudes to firing the weapon and their confidence in their ability to fire the weapon adequately. Before the beginning of firing training, all subjects were required to complete a questionnaire containing the rating scales. They again completed the questionnaire after firing training and before the criterion test.

RESULTS

Design

The design for this study was a 2 X 3 factorial design with a control group. The factors addressed by the design were: (a) Synthetic Method of Training (Dry Fire or Simulated Fire) and (b) Amount of Live-Fire Training (None, 1/3, or 2/3 Live-Fire Training). The control condition represented a training treatment consisting of 100% live firing. Due to the relatively small sample size for each cell in the design (N=8), it was decided to employ an .05 significance level to assess the results of the various statistical tests conducted on the test data. The impact of this decision for the study was that for any statistical test to result in a significant finding, the probability value associated with any computed statistics had to meet or exceed a probability value of .05.

The data from the Artillery Field Test are extensive and complex. The following sources of information supplied quantitative data to the project:

(1) Bubble Settings on Howitzer
(2) Dial Settings on Howitzer
(3) Sight Settings on Howitzer
(4) Fuze Settings on Shell

(5) Response Times
(6) Shot Fall Placement in Impact Area
(7) Procedural Checklists for Crews
(8) Safety Checklists for Crews
(9) Intrinsic Motivation Scale
(10) Team Task Motivation Scale
(11) Attitude Toward Training Scale

Performance Measures

Bubble, Dial, Sight, and Fuze Settings for All Groups

The major source of data during the Artillery criterion tests involved the recording of the bubble, dial, sight, and fuze settings by trial and crew. The data collection sheet used is shown in Appendix C. Response time, which was also recorded on that sheet, was considered to be on a separate continuum and the analysis of time will be discussed separately.

A series of analyses of variance was conducted, presented in Appendix D (Tables D1-D9). For the combined bubble, dial, sight, and fuze setting data, a 7 X 4 repeated measurements analysis of variance was accomplished. Table D-1 presents the results of this analysis. The F for Treatments was not significant although the F for Measures was significant at the .05 level of confidence. This preliminary analysis indicated that (a) there was no statistical difference in the demonstrated proficiency as a function of the various experimental treatments and (b) the different quantitative measures used to determine proficiency were differentially sensitive.

These findings are illustrated in Figures 5, 6, 7, and 8, showing the differential sensitivity in the measures.

Bubble, Dial, Sight, and Fuze Settings for Three Groups

Although the previous finding indicated that there were no differences in proficiency among the seven training treatments, it was decided to conduct a separate analysis on the three "pure" training groups—that is, the all live-fire trained group, the all dry-fire trained group, and the all simulator trained group.

A 3 X 4 repeated measurements analysis of variance was conducted on the data for these treatments. The results of this analysis are presented in Table D-2. The results duplicate the previous finding with no statistical differences found among training treatments, but a significant difference found between measures.

Sight Settings for All Groups

In order to further assess the impact of the single performance measures on training treatments, a separate analysis was conducted on each of the measures. A 2 X 3 factorial analysis with a control group was conducted on the sight settings data. The results of these analyses are shown in Table D-3. These results indicate that for the setting of sights, the all live-fire group (control group) was significantly more proficient than any of the other groups. The results also show that the interaction between synthetic methods and live fire was significant. Since the analyses of the other performance measures were negative, the basis for this result is not clear. Neither main effects nor the interaction were significant at the acceptable statistical level ($p<.05$).

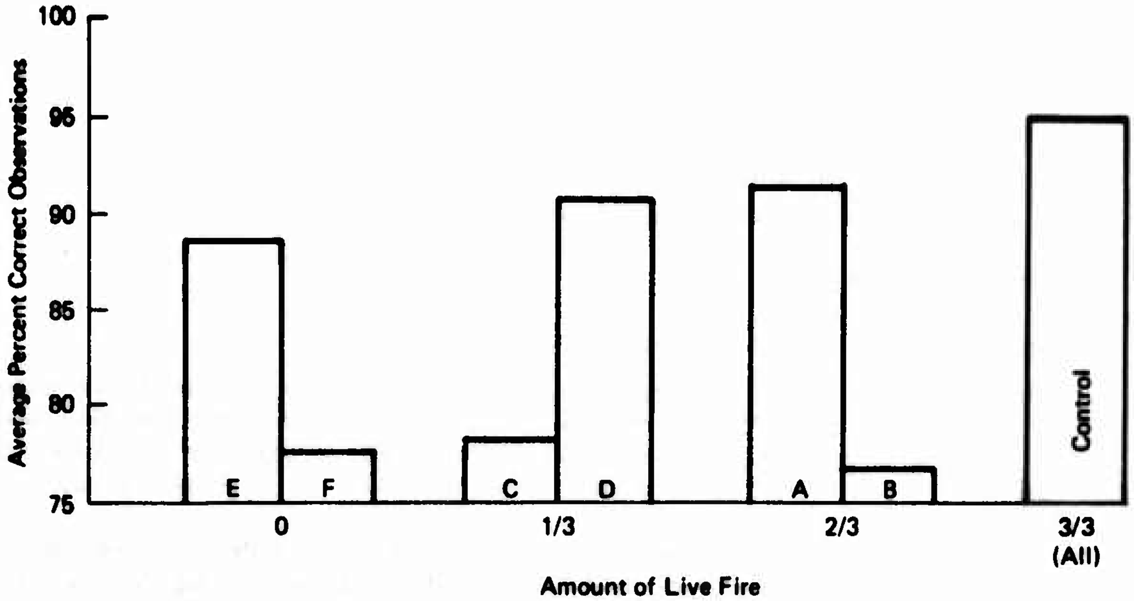

Figure 5 – **Average Proficiency Level for Sight Settings for All Groups**

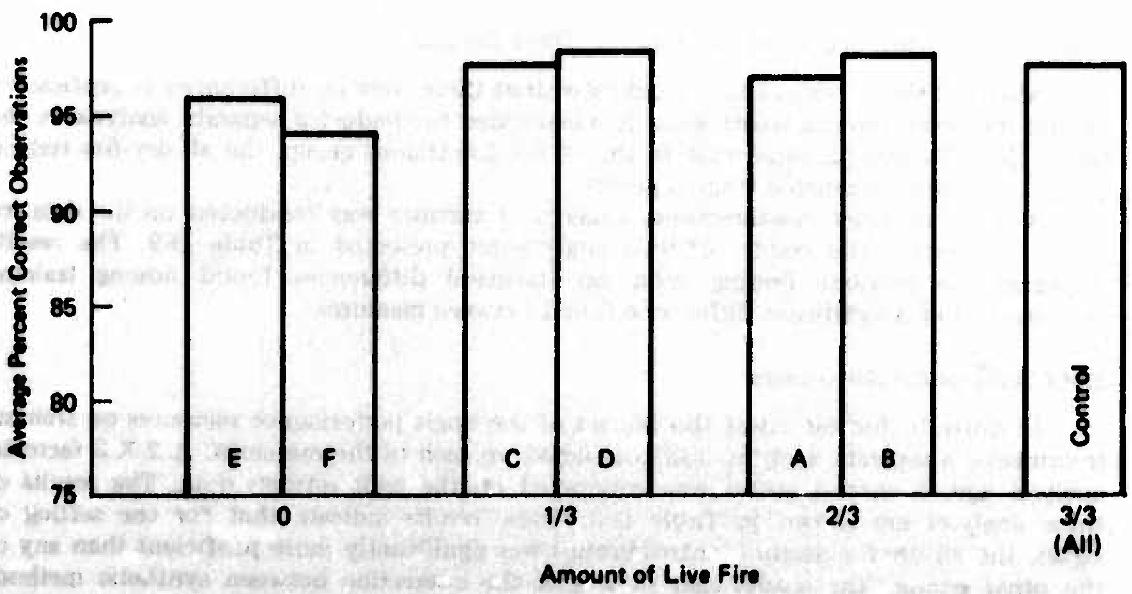

Figure 6 – **Average Proficiency Level for Dial Settings for All Groups**

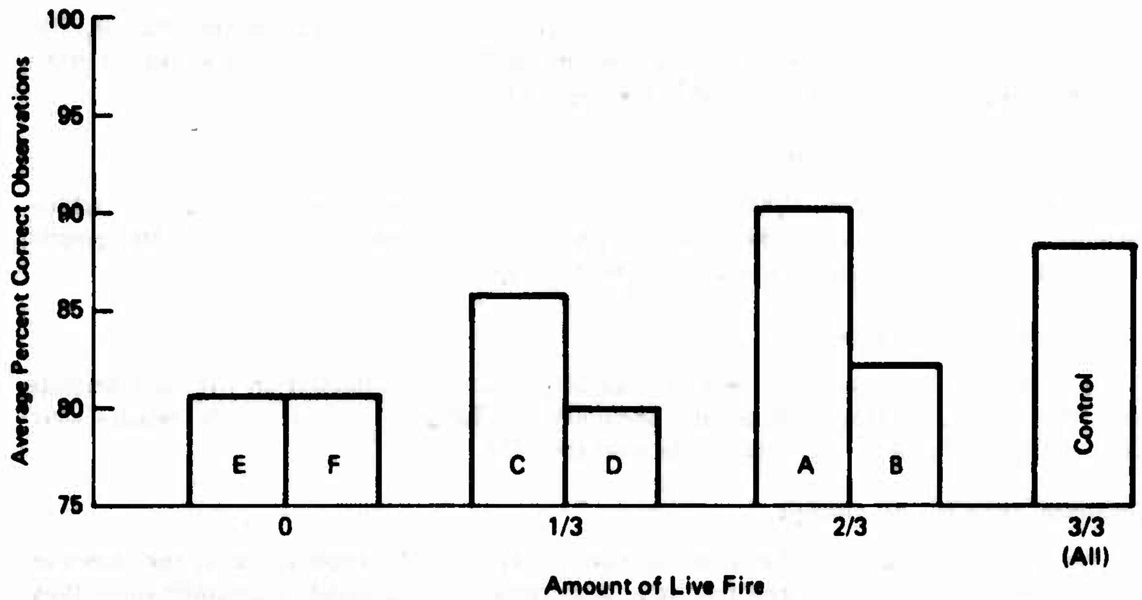

Figure 7 – **Average Proficiency Level for Fuze Settings for All Groups**

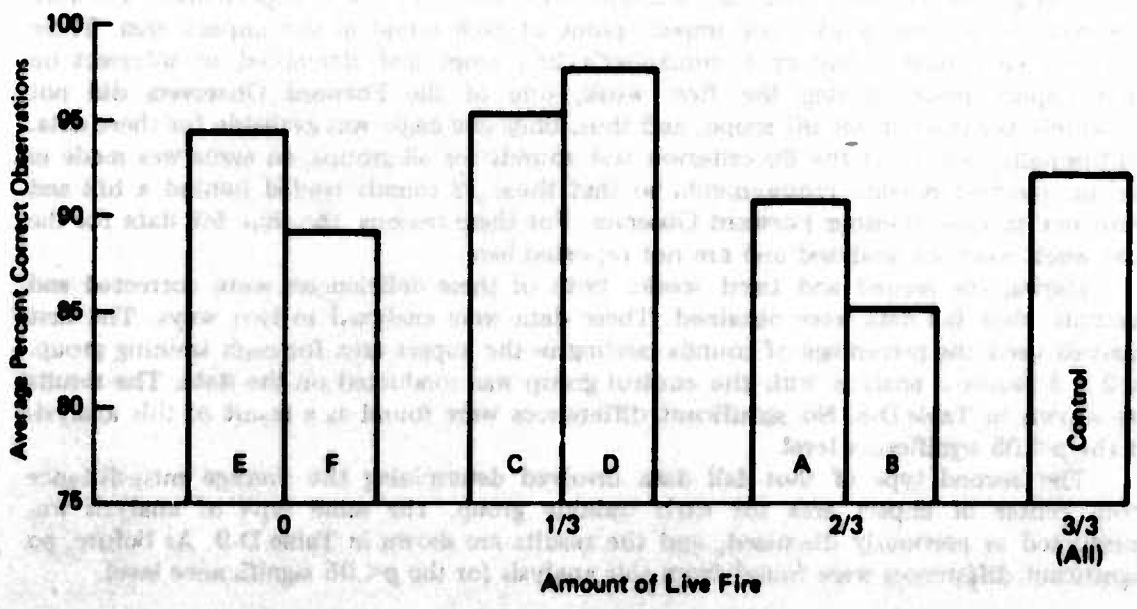

Figure 8 – **Average Proficiency Level for Bubble Settings for All Groups**

Dial Settings for All Groups

A 2 X 3 factorial analysis with a control group was conducted on the dial settings data. The results of this analysis are presented in Table D-4. None of the results were statistically significant at the acceptable level ($p<.05$).

Bubble Settings for All Groups

A 2 X 3 factorial analysis with a control group was conducted on the bubble settings data. The results of this analysis are shown in Table D-5. None of the results were statistically significant at the acceptable level ($p<.05$).

Fuze Settings for All Groups

A 2 X 3 factorial analysis with a control group was conducted on the fuze settings data. The results of this analysis are presented in Table D-6. None of the results were statistically significant at the acceptable level ($p<.05$).

Response Time for All Groups

Although recorded on the form shown in Appendix C, together with the previous four performance measures, the response time data were analyzed separately since they reflected a different scale of measure. These data indicated the time which elapsed from the issuance of the verbal mission order by the controller to the time the assistant gunner was ready to pull the firing lanyard. A 2 X 3 factorial analysis with a control group was conducted on these data. The results of this analysis are shown in Table D-7. These results indicate that neither of the main effects was significant. However, the interaction was found to be significant ($p<.05$). The basis for this result is unclear.

Analysis of Shot Fall Data

During the criterion test an attempt was made by two experienced Forward Observers to accurately plot the impact point of each round in the impact area. These observers each used a Battery Commander's (BC) scope and attempted to intersect on each impact point. During the first week, one of the Forward Observers did not accurately pre-position his BC scope, and thus, only one angle was available for these data. Additionally, for 12 of the 30 criterion test rounds for all groups, an error was made in the pre-planned mission requirements so that these 12 rounds landed behind a hill and were not in view of either Forward Observer. For these reasons, the shot fall data for the first week were not analyzed and are not reported here.

During the second and third weeks, both of these deficiencies were corrected and accurate shot fall data were obtained. These data were analyzed in two ways. The first analysis used the percentage of rounds landing in the impact area for each training group. A 2 X 3 factorial analysis with the control group was conducted on the data. The results are shown in Table D-8. No significant differences were found as a result of this analysis at the $p<.05$ significance level.

The second type of shot fall data involved determining the average miss-distance from center of impact area for each training group. The same type of analysis was conducted as previously discussed, and the results are shown in Table D-9. As before, no significant differences were found from this analysis for the $p<.05$ significance level.

Procedural and Safety Checklists

During the criterion tests, Procedural and Safety Checklists were completed for each crew on every sixth trial. These checklists are shown in Appendices E and F.

The results of an analysis of these data for the Procedural Checklists are shown in Table 13. Several observations can be made concerning these data. First, there is a remarkably high proficiency (exceeding 92%) shown for all jobs in all groups. Second, Table 13 clearly illustrates that there is no significant response pattern by either job or experimental group within the procedural requirements of the Criterion Test.

Table 13

Percent Correct Responses for Procedural Checklist, by Job and Group

Job	Group						
	A	B	C	D	E	F	Control
Chief of Section	96.5	98.6	95.8	96.5	97.2	97.9	97.2
Gunner	97.2	92.4	94.5	97.9	97.9	97.9	95.8
Assistant Gunner	96.9	100.	99.0	96.9	97.4	99.5	99.5
No. 1 Cannoneer	97.4	100.	91.2	100.	96.9	99.0	91.7
No. 2 Cannoneer	94.8	93.8	99.0	95.8	94.8	97.9	96.9
No. 3 Cannoneer	100.	100.	100.	97.9	99.3	99.3	97.9
Overall	97.1	97.5	96.6	97.5	97.3	98.6	96.5

The results for the Safety Checklists are shown in Table 14. Again, except in two experimental groups for the Chief of Section job, all scores exceed 91% in proficiency. Although there is a wider range of responses than was exhibited for the Procedural Checklists, there is no apparent pattern by either job or experimental group.

Table 14

Percent Correct Responses for Safety Checklist, by Job and Group

Job	Group						
	A	B	C	D	E	F	Control
Chief of Section	95.4	97.9	90.8	99.6	99.2	85.8	85.8
Gunner	93.1	95.1	92.9	99.3	97.2	96.5	95.1
Assistant Gunner	97.9	95.8	95.8	100.	100.	97.9	97.9
No. 1 Cannoneer	95.8	97.9	100.	100.	97.9	100.	100.
Overall	95.6	97.2	94.9	99.7	98.6	95.1	94.7

Paper-and-Pencil Attitude Tests

The foregoing results constitute the data that were directly taken from the performance of the experimental groups during the training and criterion portions of the field test. In addition to these data, three categories of paper-and-pencil tests were used to measure various psychological phenomena.

Intrinsic Motivation Scale

The Intrinsic Motivation Scale (also called the Bipolar Adjective Scale) was developed to measure any intrinsic motivation that may be inherent in the actual conduct of live firing (sometimes called the Boom Phenomena). This scale, which is shown in Appendix A, consists of 13 word pairs describing points on a continuum (e.g., Bold - Timid). The scale was given to all subjects before and after training in order to identify and assess trainee attitudes about live firing.

Analysis of the overall scale scores revealed, for both the before and after training administrations, that there was no significance between group differences at the $p<.05$ significance level (see Tables D-10 and D-11).

However, there was a change in attitude toward the positive end of the scale (e.g., strong - best - safe) for all groups regardless of their training. The shift was about the same order of magnitude for all groups—approximately 1/2 to 1 scale point. Statistical analysis revealed that this shift was highly significant (t=9.77, df=55, $p<.05$).

Team Task Motivation Inventory

In order to assess whether a particular training treatment developed feelings and attitudes about team cohesiveness, a Team Task Motivation Inventory was administered to each crew upon completion of training. This questionnaire is shown in Appendix G. The Inventory, which was developed by a previous HumRRO Work Unit, had a "correct" response to each question indicating a tendency to be team oriented.

A one-way analysis of variance was performed on these data. The results of this analysis for each group are shown in Table D-12. There were no great differences in the results between groups (F=2.5, df=6, 49, $p<.05$). Thus, all of the seven training treatments seemed to impart about the same feelings of team orientation to the individual crew members.

Individual Attitudes About Various Training Treatments

Attitudes toward training were measured by a 20-item questionnaire (see Appendix B). Ten items (numbers 2-4, 5, 13-15, and 18-20) were given to the trainees only once, at the end of training. The other 10 items (numbers 1, 6-12, 16-17) were administered both before and after training to assess any attitude changes caused by the various training treatments.

The results for the items presented only once will be discussed first. Seven of these items (2, 3, 4, 5, 13, 14, 15) generally attempted to measure the trainee's feelings about his ability to use live firing, live ammunition, or the types of training. The live-fire group was compared with all other groups and none of the F tests were found to be significant.

Items 18-20 assessed the interest in the three major training treatments. The computed F was 64.9 which is significant at the .05 level. This finding seems to indicate that live firing may be more interesting to trainees than either dry firing or simulator training.

Of the items administered before and after training, numbers 1, 10-12, 16, and 17 were amenable to analysis by an F test. For the before and after training administrations, there were no significant differences at the .05 level between the control group and experimental groups' responses on any of these items (see Table D-13). Further, in only one case (item 1) was there a significant difference between the before and after training administrations for these items (see Table D-14). For item 1, the analysis showed that the average confidence level for participation in a live-fire exercise with the M102 had increased from 4.28 to 4.63, F=27.88, $p<.05$.

For items 6-9, the most frequent response to each category was determined for each item and each experimental condition, for both the before and the after training administrations. The results of this tabulation indicate that the type of weapon training liked the most, and considered most helpful, was live fire (items 6 and 8). Further, these results indicate that, overall, the dry-fire method of training was least liked and considered least helpful in achieving a high level of proficiency (see Table 15).

Table 15

Most Frequent Response to Items 6-9, by Experimental/Control Condition[a]

Condition	Response: Like Most 6 B	Like Most 6 A	Like Least 7 B	Like Least 7 A	Most Helpful 8 B	Most Helpful 8 A	Least Helpful 9 B	Least Helpful 9 A
2/3 Dry A	L	L	D	D	L	L	D	D
2/3 Sim B	L	L	C	D	L	L	S	D
1/3 Dry C	L	L	C	D	L	L	S	S
2/3 Sim D	L	L	C	D	L	L	D	D
0 Dry E	L	L	D	D	L	L	D	D
0 Sim F	L	L	S	D	L	L	D	D
Control	L	L	D	D	L	L	D	D

[a]L, Live Fire Method; D, Dry Fire Method; S, Simulated or Subcaliber Fire Method; C, Crew Drill.

DISCUSSION

The analyses of the performance measures yield a consistent conclusion. No statistically significant differences were found between the training treatments. The training with 100% live fire yielded the same level of final proficiency as did the other six training conditions which used varying percentages of live fire.

The reason that a null hypothesis could not be rejected seems to lie in the large intra-group variability. The shot-fall results, for instance, ranged from 100% of the rounds within the target area (the 100% live-fire trained group) to a low of 53% (the 100% simulator-trained crew). However, all other live-fire crews did worse than the high (100%) level score, and all other simulator crews did better than the minimal (53%) level. In effect, differences between training treatments were negated by the large differences among the treatment groups, independently of training method type.

While the precise source of the variability cannot be determined, there are several possibilities that might be considered. Since the final level of proficiency was rather high for the groups, there was probably not very much for the crews to learn, even by training on different methods. That is, given the crews' proficiency level, one method was not sufficiently easier or more difficult than any other to make it stand apart. Secondly, training trials, after the initial skill acquisition, may have served only as an indicator of errors that could have occurred randomly. Thus, the group variability exceeded the variability caused by training treatments, which implies that the differences among training treatments were slight. This is particularly true when measuring shot-fall accuracy with large-caliber weapons.

While these findings are interesting, in that no null hypothesis was rejected, it should be noted that the objective in this study of live-fire assessment was not the identification of the optimum method of gunnery training. Rather, this research has investigated the contribution of live fire to weapons proficiency. The result was that three training modes (live fire, dry fire, and use of a simulator) all yielded an acceptable level of proficiency, either in the pure state, or when mixed with varying amounts of live-fire training.

It seems reasonable to infer that the amount of live-fire training does not have to be 100%. Although no significant differences were found between the groups, it does not seem safe to conclude that live-fire training could be replaced by 100% dry fire or 100% simulation. Since the crews tended to prefer at least some live-fire experience, because it is interesting and realistic, there are strong grounds for keeping it. An operant learning perspective suggests the inclusion of some percentage of live fire as a "partial reinforcer" in any training program having a preponderance of dry firing or simulation as the major training medium. However, the identification of a specific program that maximizes all significant cost-effectiveness factors will have to be the product of additional research.

The results of the paper-and-pencil test seem to be less consistent, although tending in the same direction as the results of the performance data. The Intrinsic Motivation Scale and the Team Task Motivation Scale do not differentiate between the seven training groups. The results are the same for the Attitude Scales with the exception of seven questions dealing with interest and preference for the three basic modes of instruction. Here we find that the group trained in all live-fire instruction indicates a significantly higher level of interest and preference in their training than do the other groups. No major generalizations should be made based on only the results of these questions. However, these results may be an indication that differences in trainee attitudes may be correlated with specific types of weapon training. Since it is well established that the attitude of the soldier greatly influences his behavior when using weapons or equipment, this preliminary finding should be considered before various non-live firing training techniques are substituted for live-fire training.

It should be pointed out that the long-term effects of different types of initial training were not an objective of this research and are not known. It is conceivable that different training treatments, while not showing a difference in initial training, do have a differential effect on performance and attitudes over a long-range time frame. This is an area that needs additional research before substantial changes are made to current training methods.

CONCLUSIONS

The conclusions reported here should not be generalized to conditions that were not a direct part of this research. For example, this study measured performance during initial skill acquisition only. It did not study long-term training effects on either proficiency or attitudes. Within the context of the experiment, however, the following observations can be made:

(1) There were no statistically significant differences between the seven experimental training treatments for any of the performance measures. Thus, training to an acceptable level of performance proficiency could be given using any of the training treatments.

(2) The Team Task Motivation and Intrinsic Motivation Scales used in this study did not differentiate between training treatments. Thus, it appears that different training does not impart different orientations as measured by these two scales.

(3) Some evidence was established that live-fire training is more interesting to the trainee and is the preferred method of training. This evidence constituted a minority of the paper-and-pencil test data and, thus, should be thought of as provocative rather than definitive.

REFERENCES
AND
APPENDICES

REFERENCES

Blaiwes, Arthur S. and Regan, James J. *An Integrated Approach to the Study of Learning Retention, and Transfer—A Key Issue in Training Device Research and Development*, Technical Report NAVTRADEVCEN IH-178, Naval Training Device Center, Orlando, Florida, August 1970.

Brundiek, Hans. *Military Potential Test of Subcaliber Training Device for M16A1 Rifle. Final Letter Report*, Report APG-MT-4089 (Sponsor: U.S. Army Small Arms Systems Agency), Aberdeen Proving Ground, Maryland, June 1972. AD-900 623L.

Caro, Paul W. *Adaptive Training—An Application to Flight Simulation*, HumRRO Professional Paper 5-70, March 1970a.

Caro, Paul W. *Equipment-Device Task Commonality Analysis and Transfer of Training*, HumRRO Technical Report 70-7, June 1970b.

Cox, John A., Wood, Robert O., Jr., Boren, Lynn M., and Thorne, H. Walter. *Functional and Appearance Fidelity of Training Devices for Fixed-Procedures Tasks*, HumRRO Technical Report 65-4, June 1965.

Dougherty, Dora J., Houston, Robert C., and Nicklas, Douglass R. *Transfer of Training in Flight Procedures From Selected Ground Training Devices to the Aircraft*, Technical Report NAVTRADEVCEN 71-16-16, Naval Training Device Center, Port Washington, New York, September 1957.

Gregory, Walter and Tibuni, Robert. *Engineering Test of Training Set, Guided Missile, XM-70, for TOW Heavy Antitank/Assault Weapon System*, Final Report, TOW Report 19, Army Missile Test and Evaluation Directorate, White Sands Missile Range, New Mexico, June 1972. AD-903 948L.

Grimsley, Douglas L. *Acquisition, Retention, and Retraining: Effects of High and Low Fidelity in Training Devices*, HumRRO Technical Report 69-1, February 1969.

Hayes, Jack H. *Initial Production Test of Redeye Moving Target Simulator (M-87)*, Final Report, Army Missile Test and Evaluation Directorate, White Sands Missile Range, New Mexico, April 1972. AD-900 913.

Heatherington, Billy W. *Test Evaluation Report TOW Weapon System Qualification Test Program for the XM-70 Training Set Blast Simulators*, Technical Report, 1 August - 22 September 1972, Test and Evaluation Directorate, Army Missile Command, Redstone Arsenal, Alabama, November 1972. AD-908 664L.

Isley, Robert N. *Inflight Performance After Zero, Ten, or Twenty Hours of Synthetic Instrument Flight Training*, HumRRO Professional Paper 23-68, June 1968.

Kern, Richard P. *A Conceptual Model of Behavior Under Stress, With Implications for Combat Training*, HumRRO Technical Report 66-12, June 1966.

Kotras, Edward C. and Harris, John W. *Comparison Test of Howitzer, Heavy, Self-Propelled, Full-Tracked, 8-inch, M110*, Final Report, 8 November 1966 - 11 May 1967, Aberdeen Proving Ground, Maryland, July 1967. AD-903 172L.

Marshall, Albert H. "Semiconductor Laser Applications to Military Training Devices," *Proceedings of the Fifth Naval Training Device Center and Industry Conference*, February 15-17, 1972, pp. 46-49.

Mierswa, Myles H. "Army Training Devices - 1950-1980," *Commemorative Technical Journal - 25th Anniversary*, Naval Training Device Center, November 1971.

Moline, Michael J. *Engineering Test of CHAPARRAL Simulator/Evaluator*, Final Report, Army Missile Test and Evaluation Directorate, White Sands Missile Range, New Mexico, March 1971. AD-894 823L.

Newton, John M. *Training Effectiveness as a Function of Simulator Complexity*, Technical Report NAVTRADEVCEN 458-1, U.S. Naval Training Device Center, Port Washington, New York, September 1959.

Norris, Charles L. *Evaluation of the Deployment of a Lightweight Air Defense Weapons System (LADS); Redeye Launch Simulator (RELS)*, Field Test Report, Marine Corps Development and Education Command, Quantico, Virginia, August 1971. AD-887 159L.

Porter, Vonne F., Baerman, Donald J., and Reddan, John G. *The Effect of Increased Subcaliber Substitution Training on 90mm Gunner Proficiency*, HumRRO Staff Memorandum, June 1955. AD-480 427.

Prophet, Wallace W. and Boyd, H. Alton. *Device-Task Fidelity and Transfer of Training: Aircraft Cockpit Procedures Training*, HumRRO Technical Report 70-10, July 1970.

Staff, HumRRO Division No. 4. "A Survey of Army Weapons Training and Weapons Training Devices," Interim Report IR-D4-73-13, September 1973.

Staff, HumRRO Division No. 4. "Task Analyses of Three Selected Weapons Systems," Interim Report IR-D4-74-8, March 1974.

Stearn, V.K. and Hayek, Joseph G. *Comparison Test of Howitzer, Medium, Self-Propelled, Full-Tracked, 144-MM, M109*, Final Report, 26 February - 13 May 1969, Aberdeen Proving Ground, Maryland, June 1969. AD-902 799L.

Titl, Alfred. *Training With Modern Tanks: Simulators Raise Training Levels*, U.S. Army Foreign Science and Technology Center, Charlottesville, Virginia, Technical Translation FSTC-HT-23-451-72, 1972. Translation of *Soldat und Technik*, 7/1970a, West Germany, pp. 382-387. AD-894 434.

Titl, Alfred. *Training on Modern Tanks, Simulators Raise the Level of Training*, U.S. Army Foreign Science and Technology Center, Technical Translation FSTC-HT-23-1413-71, 17 April 1972, Translation of brochure from Krauss-Maffer, Munich, West Germany, 1970b. AD-894 699.

Williams, W.L., Jr. *et al. An Analysis of the Redeye System With Some Suggestions for Training*, HumRRO Research Memorandum, December 1961.

Winer, B.J. *Statistical Principles in Experimental Design*, McGraw-Hill, New York, 1962.

Winer, B.J. *Statistical Principles in Experimental Design* (2nd Ed.), Mc-Graw-Hill, New York, 1971.

Appendix A

INTRINSIC MOTIVATION QUESTIONNAIRE

EXPERIMENTAL GROUP ______________ CREW NUMBER ____________________

In this section, describe your feelings about firing the M102/M60A1 in combat. Place an "X" in one of the seven boxes between each pair of words. The closer the "X" is to one word of the pair means the closer that word comes to describing your feelings and is less descriptive of the other word. For example, if you feel that the word "Good" very closely describes your present know-how or skill with the M102/M60A1 in combat, then you would place an "X" in the box closest to the word "Good."

Example: BAD ☐ ☐ ☐ ☐ ☐ ☐ ☒ GOOD

Conversely, if you feel that the word "Bad" very closely describes your present know-how or skill in using the M102/M60A1 in combat, then you would place an "X" in the box closest to the word "Bad."

Example: BAD ☒ ☐ ☐ ☐ ☐ ☐ ☐ GOOD

If you think one of the words does not describe your feelings any better than the other word of the pair, then place an "X" in the mid-way box between the two words.

Example: BAD ☐ ☐ ☐ ☒ ☐ ☐ ☐ GOOD

Place only one "X" between each pair of words.

1.	WEAK	☐	☐	☐	☐	☐	☐	☐	STRONG
2.	HOPELESS	☐	☐	☐	☐	☐	☐	☐	HOPEFUL
3.	WORST	☐	☐	☐	☐	☐	☐	☐	BEST
4.	UNSKILLED	☐	☐	☐	☐	☐	☐	☐	SKILLED
5.	FAILURE	☐	☐	☐	☐	☐	☐	☐	SUCCESSFUL
6.	DOOMED	☐	☐	☐	☐	☐	☐	☐	SAFE
7.	HELPLESS	☐	☐	☐	☐	☐	☐	☐	MASTERFUL
8.	BUNGLING	☐	☐	☐	☐	☐	☐	☐	EXPERT
9.	AWKWARD	☐	☐	☐	☐	☐	☐	☐	SMOOTH
10.	LOSER	☐	☐	☐	☐	☐	☐	☐	WINNER
11.	DOUBTFUL	☐	☐	☐	☐	☐	☐	☐	CONFIDENT
12.	UNLUCKY	☐	☐	☐	☐	☐	☐	☐	LUCKY
13.	TIMID	☐	☐	☐	☐	☐	☐	☐	BOLD

Appendix B

ATTITUDES TOWARD TRAINING QUESTIONNAIRE

EXPERIMENTAL GROUP____________________ CREW NUMBER______________

The purpose of this section is to obtain your opinions about weapons training. Answer each question by placing an "X" in the blank before the word or statement that best describes your answer to the question. You must choose only one answer for each question.

There are no right or wrong answers. Just place an "X" before the word or statement that best describes your feelings about the question.

1. At the present time, how do you feel about participating in a live fire exercise with the M102?

_______ Very Confident
_______ Fairly Confident
_______ Somewhat Confident
_______ Not Very Confident
_______ Not Confident at All

2. After dry fire exercises using dummy or no ammunition, how do you feel about your ability to use live ammunition?

_______ Very Confident
_______ Fairly Confident
_______ Somewhat Confident
_______ Not Very Confident
_______ Not Confident at All

3. After simulated or subcaliber firing exercises, how do you feel about your ability to live fire?

_______ Very Confident
_______ Fairly Confident
_______ Somewhat Confident
_______ Not Very Confident
_______ Not Confident at All

4. After live fire practical exercises, how do you feel about your ability to live fire?

_______ Very Confident
_______ Fairly Confident
_______ Somewhat Confident
_______ Not Very Confident
_______ Not Confident at All

5. As a result of your training, how do you feel about your ability to use live ammunition?

_______ Very Confident
_______ Fairly Confident
_______ Somewhat Confident
_______ Not Very Confident
_______ Not Confident at All

6. **At present, what type of weapons training do you like the most?**

_______ Dry Fire Method
_______ Simulated or Subcaliber Fire Method
_______ Live Fire Method
_______ Crew Drill

7. **At present, what type of weapons training do you like the least?**

_______ Dry Fire Method
_______ Simulated or Subcaliber Fire Method
_______ Live Fire Method
_______ Crew Drill

8. **In your opinion, what type of weapons training is most helpful in achieving a high level of firing proficiency?**

_______ Dry Fire Method
_______ Simulated or Subcaliber Fire Method
_______ Live Fire Method
_______ Crew Drill

9. **In your opinion, what type of weapons training is least helpful in achieving a high level of firing proficiency?**

_______ Dry Fire Method
_______ Simulated or Subcaliber Fire Method
_______ Live Fire Method
_______ Crew Drill

10. **If you had your choice, how often would you like to train using the dry fire method?**

_______ Very Frequently
_______ Frequently
_______ Sometimes
_______ Infrequently
_______ Very Infrequently

11. **If you had your choice, how often would you like to train using the simulated or subcaliber fire method?**

_______ Very Frequently
_______ Frequently
_______ Sometimes
_______ Infrequently
_______ Very Infrequently

12. **If you had your choice, how often would you like to train using the live fire method?**

_______ Very Frequently
_______ Frequently
_______ Sometimes
_______ Infrequently
_______ Very Infrequently

13. **At present, how helpful do you feel dry fire training is in increasing your firing proficiency?**

_______ Very Helpful
_______ Fairly Helpful
_______ Somewhat Helpful
_______ Not Very Helpful
_______ Not Helpful at All

14. At present, how helpful do you feel simulated or subcaliber fire training is in increasing your firing proficiency?

_______ Very Helpful
_______ Fairly Helpful
_______ Somewhat Helpful
_______ Not Very Helpful
_______ Not Helpful at All

15. At present, how helpful do you feel live fire training is in increasing your firing proficiency?

_______ Very Helpful
_______ Fairly Helpful
_______ Somewhat Helpful
_______ Not Very Helpful
_______ Not Helpful at All

16. In your opinion, how realistic is dry fire training?

_______ Very Realistic
_______ Fairly Realistic
_______ Neutral
_______ Not Very Realistic
_______ Not Realistic at All

17. In your opinion, how realistic is simulated or subcaliber fire training?

_______ Very Realistic
_______ Fairly Realistic
_______ Neutral
_______ Not Very Realistic
_______ Not Realistic at All

18. How interesting was your training using the dry fire method?

_______ Very Interesting
_______ Fairly Interesting
_______ Somewhat Interesting
_______ Not Very Interesting
_______ Not Interesting at All

19. How interesting was your training using the simulated or subcaliber fire method?

_______ Very Interesting
_______ Fairly Interesting
_______ Somewhat Interesting
_______ Not Very Interesting
_______ Not Interesting at All

20. How interesting was your training using the live fire method?

_______ Very Interesting
_______ Fairly Interesting
_______ Somewhat Interesting
_______ Not Very Interesting
_______ Not Interesting at All

Appendix C

DRAGON/LIVEFIRE DATA COLLECTION FORM FOR RESPONSES TO FIRE COMMANDS

CRITERION TEST I

EXPERIMENTAL GROUP ____________________ CREW NUMBER ____________________

Trial Number	Response Time (Seconds)	Bubbles Centered		Dial Settings Correct		Sight Picture Correct		Fuze Setting Correct	
		Yes	No	Yes	No	Yes	No	Yes	No
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

Appendix D

ANALYSES OF VARIANCE

Table D-1

Analysis of Variance of the Bubble, Dial, Sight, and Fuze Setting Data for All Experimental Treatments

Source of Variance	*df*	*MS*	*F*	*p*
Between Subjects	55			
Training Treatments (T)	6	295.08	1.26	NS
Error (Subjects Within Treatments)	49	234.87		
Within Subjects	168			
Measures (M)	3	2038.33	14.66	.05
T x M	18	147.03	1.06	NS
Error (M x Subjects Within Groups)	147	139.01		
Total	223			

Table D-2

Analysis of Variance of the Bubble, Dial, Sight, and Fuze Setting Data for the Pure Training Groups

Source of Variance	*df*	*MS*	*F*	*p*
Between Subjects	23			
Training Treatments (T)	2	506.07	2.69	NS
Error (Subjects Within Treatments)	21	187.97		
Within Subjects	72			
Measures (M)	3	765.21	6.15	.05
T x M	6	123.43	<1	NS
Error (M x Subjects Within Groups)	63	124.37		
Total	95			

Table D-3

Analysis of Variance of the Sight Setting Data

Source of Variance	df	MS	F
Control vs All Treatments	1	943.29	5.29
Synthetic Method (S)	1	238.52	1.34
Amount of Live Fire (A)	2	13.27	<1
S x A	2	777.15	4.36
Within Cell Error	49	178.23	

Table D-4

Analysis of Variance of the Dial Setting Data

Source of Variance	df	MS	F
Control vs All Treatments	1	4.29	<1
Synthetic Method (S)	1	.34	<1
Amount of Live Fire (A)	2	28.53	1.86
S x A	2	12.27	<1
Within Cell Error	49	15.31	

Table D-5

Analysis of Variance of the Bubble Setting Data

Source of Variance	df	MS	F
Control vs All Treatments	1	1.31	<1
Synthetic Method (S)	1	82.69	<1
Amount of Live Fire (A)	2	240.25	2.71
S x A	2	67.75	<1
Within Cell Error	49	88.46	

Table D-6

Analysis of Variance of the Fuze Setting Data

Source of Variance	*df*	*MS*	*F*
Control vs All Treatments	1	157.41	<1
Synthetic Methods (S)	1	252.09	<1
Amount of Live Fire (A)	2	164.59	<1
S x A	2	64.58	<1
Within Cell Error	49	369.90	

Table D-7

Analysis of Variance of the Response Time Data

Source of Variance	*df*	*MS*	*F*	*p*
Control vs All Treatments	1	2.22	<1	NS
Synthetic Methods (S)	1	22.28	<1	NS
Amount of Live Fire (A)	2	14.56	<1	NS
S x A	2	226.03	3.43	.05
Within Cell Error	49	65.82		

Table D-8

Analysis of Variance of the Percent Shotfalls Within the Impact Area

Source of Variance	*df*	*MS*	*F*
Control vs All Treatments	1	87.32	<1
Synthetic Method (S)	1	.03	<1
Amount of Live Fire (A)	2	45.54	<1
S x A	2	267.87	2.88
Within Cell Error	28	92.98	

Table D-9

Analysis of Variance of the Average Miss-Distance Shotfall Data

Source of Variance	*df*	*MS*	*F*
Control vs All Treatments	1	119.21	<1
Synthetic Method (S)	1	20.50	<1
Amount of Live Fire (A)	2	28.78	<1
S x A	2	258.38	2.05
Within Cell Error	28	125.82	

Table D-10

Analysis of Variance of the Total Pre-Training Intrinsic Motivation Scale Score

Source of Variance	*df*	*MS*	*F*
Control vs All Treatments	1	.03	<1
Synthetic Method (S)	1	.02	<1
Amount of Live Fire (A)	2	.14	1.15
S x A	2	.16	1.32
Within Cell Error	49	.12	

Table D-11

Analysis of Variance of the Total Post-Training Intrinsic Motivation Scale Score

Source of Variance	*df*	*MS*	*F*
Control vs All Treatments	1	.001	<1
Synthetic Method (S)	1	.020	<1
Amount of Live Fire (A)	2	.015	<1
S x A	2	.075	<1
Within Cell Error	49	.112	

Table D-12

Analysis of Variance of Team Task Motivation

Source of Variance	df	MS	F
Treatments	6	7.54	2.5
Error	49	3.01	
Total	55		

Table D-13

Analysis of Pre- and Post-Training Attitudes About Training, for Control vs All Experimental Groups

Item	Before Training				After Training			
		All	Control	F		All	Control	F
1	$\bar{X}$	4.30	3.89	6.00	$\bar{X}$	4.61	4.71	<1
	SD	.42	.47		SD	.40	.24	
10	$\bar{X}$	2.87	2.90	<1	$\bar{X}$	2.75	2.29	4.29
	SD	.56	.48		SD	.60	.68	
11	$\bar{X}$	3.00	3.08	<1	$\bar{X}$	3.03	2.69	4.27
	SD	.42	.48		SD	.45	.47	
12	$\bar{X}$	4.45	4.14	3.47	$\bar{X}$	4.48	4.70	1.86
	SD	.37	.73		SD	.46	.30	
16	$\bar{X}$	2.95	2.92	<1	$\bar{X}$	3.02	2.80	1.30
	SD	.48	.58		SD	.52	.46	
17	$\bar{X}$	3.18	3.28	<1	$\bar{X}$	3.30	2.95	6.01
	SD	.42	.24		SD	.37	.30	

Table D-14

Analysis of Pre- and Post-Training Attitudes About Training, for All Groups Combined

Item	Before Training		After Training		t	F^a
1	$\bar{X}$	4.24	$\bar{X}$	4.63	−5.28	27.88*
	SD	.45	SD	.38		
10	$\bar{X}$	2.88	$\bar{X}$	2.69	2.30	5.29
	SD	.56	SD	.62		
11	$\bar{X}$	3.01	$\bar{X}$	2.98	.509	<1
	SD	.43	SD	.46		
12	$\bar{X}$	4.39	$\bar{X}$	4.51	−1.69	2.86
	SD	.48	SD	.45		
16	$\bar{X}$	2.95	$\bar{X}$	2.99	− .447	<1
	SD	.49	SD	.52		
17	$\bar{X}$	3.19	$\bar{X}$	3.25	− .908	<1
	SD	.40	SD	.38		

[a]$df = 55$; * indicates $p < .05$.

Appendix E

PROCEDURAL CHECKLIST

EXPERIMENTAL GROUP ____________________ CREW NUMBER ____________________

M102 Howitzer (towed)

		Yes	No
Position:	**Chief of Section**		
1.	Verify piece is ready for action by checking settings		
2.	Indicate when piece is ready to fire by extending arm		
3.	Give command to fire by dropping arm		
Position:	**Gunner**		
1.	Set announced deflection on panoramic telescope		
2.	Lay howitzer for direction		
3.	Check that pitch and cross-level bubbles are centered		
Position:	**Assistant Gunner**		
1.	Place announced quadrant value on sight scale		
2.	Elevate or depress piece until bubble is centered		
3.	Call set when piece is laid for elevation		
4.	Fire the howitzer by pulling the lanyard		
Position:	**No. 1 Cannoneer**		
1.	Inspect, operate, and clean breech block and chamber		
2.	Inspect the powder chamber		
3.	Load the howitzer		
4.	Push round home with right fist		
Position:	**No. 2 Cannoneer**		
1.	Screws in designated fuze using authorized fuze wrench		
2.	Properly sets fuze using fuze setter		
Position:	**No. 3 Cannoneer**		
1.	Verifies the number of charge increments		
2.	Removes increments that are higher numbered than the charge commanded		
3.	Passes prepared round to No. 1 with his left hand under the cartridge case and his right hand under the projectile		

Appendix F

SAFETY CHECKLIST

EXPERIMENTAL GROUP ____________________ CREW NUMBER ____________________

M102 Howitzer (towed)

		Yes	No
Position:	**Chief of Section**		
1.	Report any defects that cause delay to XO		
2.	Conduct pre-fire checks and report errors, equipment malfunctions, and unusual incidents		
3.	Verify settings, fuse, shell, time, and check path of recoil		
4.	Check functioning of material during firing		
5.	Supervise operation during entire sequence		
Position:	**Gunner**		
1.	Identify aiming point through telescope		
2.	Test and align fire control equipment		
3.	Correct for aiming point displacement		
Position:	**Assistant Gunner**		
1.	Insure appropriate settings are on elevating quadrant		
Position:	**No. 1 Cannoneer**		
1.	Announce bore clear		

Appendix G

TEAM TASK MOTIVATION QUESTIONNAIRE

EXPERIMENTAL GROUP ____________________________ CREW NUMBER ______________

This questionnaire consists of a series of numbered questions. After you have read each question, place an "X" in the blank beside the answer that you decide is the best answer for you. If you have any questions, raise your hand and the instructor will answer it for you.

There are no correct answers to this questionnaire. Just place an "X" beside the statement that you decide is best for you.

1. If I played football, I would like to be:

   ______ The coach whose planning pays off in victory
   ______ The start quarterback

2. I would prefer to work on a committee made up of:

   ______ Hard workers
   ______ Friendly people

3. It is best to be:

   ______ An average member of the best squad in my company
   ______ The best member of an average squad

4. I like a leader who:

   ______ Gets the job done even if he is hard to get along with
   ______ Is easy to talk to and performs fairly well

5. It is most important for a leader to:

   ______ Praise individuals for doing good work
   ______ Praise units for doing good work

6. I would rather:

   ______ Be accepted as a friend by others
   ______ Help others to complete a group task

7. The best unit is the unit in which all the men:

   ______ Know each other's strengths and weaknesses
   ______ Are good friends with one another

8. Which would you prefer, assuming the same amount of money was involved:

   ______ To help plan a contest
   ______ To win a contest

9. What I like best is:

   ______ Being appreciated by my fellow squad members
   ______ Being personally satisfied with my squad's performance

10. When working in a group, I prefer to:

______ Take over as a leader whenever possible
______ Support the best man in the group for the leader position

11. I enjoy taking the lead in group discussions:

______ Only when I can help the group
______ Every chance I get

12. The greater satisfaction of soldiering is:

______ The feeling that I can do my job well
______ The friends I have made in the Army

13. My best friends in the Army are people who:

______ Are easy to get along with
______ Are better than average soldiers

14. I prefer being in a squad made up of:

______ Hard workers and good soldiers
______ Friendly, easy-going men

15. The best soldier is the man who works hardest to:

______ Improve himself as much as possible
______ Improve his unit as much as possible

16. Nothing is worse than:

______ Having your self-respect damaged
______ Failure on an important group project

17. I would like to receive more training:

______ On how to be a better member of a military team
______ On getting along better socially

18. Which would you prefer, assuming the same rewards were involved:

______ To win a rifle match
______ To be an essential member of a prize-winning platoon

19. I would like to be known as:

______ A successful person
______ A good team player

20. I prefer to work on a job that:

______ Requires each man to do his part
______ Can be done by one or two members of the group

21. Other things being equal, it is better:

______ To be the outstanding member of a group
______ To be a member of an outstanding group

22. The effectiveness of a military unit depends primarily upon:

______ Its commander's experience and knowledge
______ The desire of its members to be part of a superior unit

23. The best tank crew/artillery crew is the one in which:

_______ The men get along well together and are all skilled soldiers

_______ Most of the men are skilled soldiers and each man can predict what each other will do in a tight spot

24. In most cases, I would rather:

_______ Earn an individual citation for myself

_______ Do something that would earn a citation for my crew