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An Experimental Review of Basic Combat Rifle Marksmanship: MARKSMAN, Phase I

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

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16. Abstract

Commanding officers in Vietnam and others have indicated that individual rifle marksmanship training needed attention. Furthermore, no comprehensive, systematic study of Army rifle marksmanship has been conducted since the Work Unit TRAINFIRE studies conducted by HumRRO in 1954. Phase I of the MARKSMAN research dealt with basic rifle marksmanship. This report describes a series of 21 experiments addressing both "what" should be taught and "how" it should be taught. A number of conclusions were reached concerning such matters as the use of automatic fire, aimed fire vs. pointing fire including Quick Fire, night firing techniques, firing positions, carry positions, aiming points, night sights, multiple targets, area targets, surprise targets, sight calibration, and other issues.

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FOREWORD

The objective of Work Unit MARKSMAN is to identify methods of improving marksmanship training. This report describes work accomplished during Phase 1, which was concerned primarily with basic rifle marksmanship.

The research is being conducted at Fort Benning, Georgia as a joint effort of the U.S. Army Infantry School and the Human Resources Research Organization (HumRRO) Division No. 4. Military support and coordination for the research is being provided by the U.S. Army Infantry Human Research Unit.

Dr. T.O. Jacobs is Director of HumRRO Division No. 4. Dr. James W. Dees was Work Unit Leader of MARKSMAN. Other HumRRO personnel engaged in the research were two associates, Mr. George J. Magner and Mr. Michael R. McCluskey, and a developmental engineer, Mr. Lyman K. Harris.

The following U.S. Army Infantry Human Research Unit personnel participated directly in the research: 1LT Marvin J. Pesek, SFC Lucien T. Brewer, SFC Herbert G. Thompson, SP5 John H. Hubbard, SP5 David D. Myer, SP5 Kevin J. O'Reilly, SP5 Allen R. Searles, SP5 David R. Sennett, and SP4 Richard G. Winslow.

Appreciation is expressed to Major General John M. Wright and Lieutenant General (then Major General) George I. Forsythe, former Commandants of the U.S. Army Infantry School, to the present Commandant, Major General Orwin C. Talbott, and Assistant Commandant, Brigadier General Sidney B. Berry for their considerable interest and assistance.

Directors of the Weapons Department, U.S. Army Infantry School, during the conduct of the research have been COL Joel M. Hollis, COL John T. Carley, and COL Jack L. Conn. The systems analyses of weapons training were conducted under the direction of LTC Freddie R. Wenck. LTC Barney K. Neal served as Chief of the Rifle Marksmanship Evaluation Study Group (RMESG) during its first year of operation, and was succeeded by the present Chief, MAJ Robert W. Faulkender. Deputy Chief of RMESG during the early stages of research was MAJ Clifton R. Franks; MAJ Peter Sharber is currently serving as Deputy. Project Officers for the individual experiments were MAJ William E. Smith III, CPT Gerry A. Harr, CPT Robert L. Newkirk, CPT Ronald S. Popp, CPT Henry D. Robertson, CPT Ronald E. Saxton, CPT Michael P. Shaver, CPT St. Elmo P. Tyner II and CPT Prentis D. Wilson.

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Meredith P. Crawford
President
Human Resources Research Organization

SUMMARY AND CONCLUSIONS

PROBLEM

Commanding officers in Vietnam, and gatherings such as the Training Centers Conference held at Fort Benning in 1968 have expressed a strong belief that individual rifle marksmanship is not as good as it could and should be. Furthermore, no comprehensive, systematic study of Army rifle marksmanship has been conducted since the Work Unit TRAINFIRE studies conducted by HumRRO in 1954.

The rifle used by infantrymen in Vietnam is considerably different from the weapon (M1) used in the TRAINFIRE studies. Compared to the M1 and also the M14, the M16 rifle is lighter in weight and uses a lighter projectile with a higher muzzle velocity, giving it a relatively flat trajectory. In addition, the weapon has an automatic capability and comparatively little recoil. The effect of these changes in the weapon must be evaluated. More importantly, however, the original TRAINFIRE studies were concerned with the utility of the general training techniques, not directed toward the determination of what marksmanship skills should be taught. Phase 1 of Project MARKSMAN is concerned primarily with basic rifle marksmanship. Although concerned with both "how" to teach and "what" to teach, the major emphasis of MARKSMAN was on "what" should be taught.

METHOD

A total of 21 experiments dealing with varied aspects of rifle marksmanship are described in summary fashion in this report and are reported individually in the appendices. The experiments were planned and administered through cooperation among three different agencies: The Human Resources Research Organization (HumRRO), the U.S. Army Infantry Human Research Unit (USAIHRU) collocated with HumRRO Divison No. 4, and the Rifle Marksmanship Evaluation Study Group (RMESG) of the Weapons Department of the U.S. Army Infantry School at Fort Benning, Georgia. In general, HumRRO had the technical responsibility for the project; the USAIHRU provided personnel and expertise in direct support of HumRRO; and the RMESG had overall administrative responsibility for the experiments and for the implementation of the results into training changes.

RESULTS

The results of the experiments conducted in Phase 1 of the MARKSMAN research are summarized in the following paragraphs.

(1) Mode of Fire. Semiautomatic fire is superior to automatic fire against single, multiple, and area targets under conditions of illumination which allow the use of the M16A1 sight. Where the conditions of illumination are insufficient to allow the use of the M16A1 sight, the automatic mode (three-round burst) is superior to the semiautomatic mode. These factors have not been studied for moving or aerial targets.

(2) Firing Technique and Sight. (a) Aimed fire is generally better than pointing fire, whether at night or in the daytime. The Quick-Fire technique is included as a method of pointing fire. (b) A special sight providing a luminescent front sight post and a rear aperture in excess of five millimeters in diameter is required for accurate, low illumination level firing. (c) The same large rear-aperture sight can be used for aimed fire against close range targets requiring a quick reaction.

(3) Firing Position. (a) Defensive positions (foxhole and bunker) are superior to offensive positions in both speed on target and accuracy. (b) Among the offensive positions, kneeling supported and kneeling are the best overall for speed and accuracy combined. (c) In the prone position, support is quite important in the daytime, but its addition makes no appreciable difference at night.

(4) Carry Position. The results are inconclusive, but there is an indication of a possible speed advantage to a modification of the British alert position as compared to the underarm carry. The British alert position is a firing position, and could only be used when there was potential, immediate enemy threat.

(5) Aiming Points. Aiming at the center of the target at distances out to 300 meters is equal in accuracy to the present adjusted aiming point system for the M16 rifle, and is simpler to teach.

(6) Sight Calibration. The prezeroing of sights, using a collimator and a three-round correction group is equal to the personal zero established by the individual shooting the weapon and offers the potential of simple training, facilitates simple battlefield and armory checks without firing the weapon, and allows a reduction of the training ammunition expenditure for zeroing.

(7) Pupil-Coach. The pupil-coach system does not have any impact upon performance. Therefore, this time could be used to better advantage.

(8) BB Gun and Tape for Night Firing. Night practice with the BB gun did not improve performance in night record fire. Also, when tape was placed along the barrel of the BB gun, night practice with the BB gun had a detrimental effect on night record fire.

(9) Wearing of Equipment During Marksmanship Training. The wearing of the helmet and web gear had no appreciable effect upon record fire scores in Basic Rifle Marksmanship. The wearing of this equipment was originally recommended by the TRAINFIRE studies in order to increase battlefield fidelity. Whether the wearing of this equipment actually increases battlefield fidelity is not readily testable.

(10) Position of Quick Fire in Training. The sequence of Quick Fire in Basic Rifle Marksmanship (early or late) had no impact upon BRM record scores. However, those individuals who had Quick-Fire training late in BRM did perform better when tested on their Quick-Fire skills than did those individuals who had the Quick-Fire training early in BRM. This could have been caused either by the recency of the training, or by some more important training factor. In any event, there are no disadvantages to having Quick Fire late in the BRM program, and there may be an advantage.

(11) Evaluation of Training Changes in Night Firing. It was determined that a 4½-hour night firing program outlined in the text was superior to the present 7-hour program.

(12) Use of Competitive Marksmen as Assistant Instructors. The present range training format does not allow sufficient time or freedom for an increase in the quality or the quantity of assistant instructors to improve marksmanship scores.

(13) Daylight Training for Night Firing. Subjects trained on night firing techniques in the daytime performed considerably better on their night record fire than did subjects trained on the same techniques for the same length of time at night

CONCLUSIONS AND IMPLICATIONS

(1) The semiautomatic mode of fire should be emphasized.

(2) A night sight with a luminescent front sight post and a large-aperture rear sight would be valuable not only for night firing but also against close range targets requiring a quick response. The large-aperture rear sight could be combined with a small-aperture, peep sight in a "flip type" arrangement.

(3) The kneeling supported and kneeling position should be emphasized in training where their use would not bring undue exposure to the infantryman. In the prone position, support should be used whenever possible in the daytime.

(4) Aimed fire is superior to pointing fire in all cases, but a special sight is required to accommodate both the low illumination level condition and the close range, quick response target.

(5) The use of special "alert" carry positions should be studied further.

(6) A center of target aiming point system is equal to the adjusted aiming point system in performance and would be easier to teach.

(7) A prezeroing of sights would simplify training, reduce training ammunition requirements by six rounds per man, and allow a simple, economical, and fast method of checking the sights of a weapon on the battlefield or in the armory without firing a round.

(8) The pupil-coach system could be eliminated without any loss in marksmanship performance, and the time spent on other training.

(9) The BB gun does not offer any advantage for night firing training at night.

(10) The wearing of the helmet and web gear during marksmanship training is of questionable value, but is not detrimental to training.

(11) If Quick Fire as a separately taught skill is continued, there may be an advantage to teaching it late in the Basic Rifle Marksmanship program.

(12) A 4½-hour night firing program outlined in the text is superior to the present 7-hour program.

(13) If an increase in the quantity or quality of the assistant instructors is contemplated as a means of improving the quality of the training, the range training format should be changed to allow the individual assistant instructors more time and freedom.

(14) Students should be taught and should practice night firing techniques in the daytime prior to night practice and record fire.

(15) The Quick-Fire technique was demonstrated to be inferior to aimed fire generally at and beyond a target distance of about 25 meters. Quick Fire was superior to aimed fire using the M16A1 sight only at target distances of about 10 meters and less. If a large-aperature rear sight is provided for targets within 50 meters, aimed fire is equal or superior to Quick Fire at every distance within that limit.

The Quick-Fire technique appears not to be the optimal solution, but the Quick-Fire situation requires a solution. Suddenly appearing targets requiring a quick response are a legitimate area of concern. A refinement of Quick Fire to accommodate these research findings would emphasize aimed fire with the precision of the aim, and therefore the time required, decreasing with decreasing target distance. At the extremely close ranges (within 10 meters) aiming might consist of looking down the barrel of the weapon.

The value of the training techniques used in Quick Fire have yet to be demonstrated. Such techniques as BB gun practice against discs thrown in the air should be studied. Those aspects of Quick Fire that have superior training merit should be maintained in a new Quick-Fire program.

The possible adoption of a night sight must be considered in any redesign of training for the Quick-Fire situation. If a large-aperture rear sight, primarily for night use, is available for daytime use within 50 meters, the techniques and training for the Quick-Fire situation will be very different from those which would otherwise be used.

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An Experimental Review of Basic Combat Rifle Marksmanship: MARKSMAN, Phase I

PROBLEM

Commanding officers in Vietnam, and groups such as the Training Centers Conference held at Fort Benning in 1968, have indicated a strong belief that individual rifle marksmanship is not as good as it could and should be. To the individual foot soldier, his marksmanship ability is not only the key skill for his job but his principal means of survival in the struggle against a similarly equipped enemy.

In spite of the overwhelming advantages of good training, probabilities in warfare assure that a few of even the best-trained men will be killed. For example, in a sudden engagement, the man who fires wildly will generally miss the target and be shot by an opponent who takes the time to align his weapon with the target. However, an occasional wild shot will hit the target, and the man who takes the time to make his shot count will be hit.

In such a situation, no skill level, regardless of how high, will ever be deemed sufficient, and no amount or quality of marksmanship training will ever be free of criticism. While complaint about rifle marksmanship is inevitable in war, it is the impression of many senior Army officers that the volume of complaint about the marksmanship of the American soldier in the Vietnam conflict exceeds what would normally be expected.

Furthermore, no comprehensive, systematic study of Army rifle marksmanship has been conducted since the TRAINFIRE studies by HumRRO in 1954. For a number of reasons, it is time for such a review. The rifle used by infantrymen in Vietnam is considerably different from the weapon (the M1) studied by HumRRO researchers under Work Unit TRAINFIRE in 1954.[1] Compared to the M1 and also the later M14, the M16 rifle is lighter weight, and uses a lighter projectile with a higher muzzle velocity, which gives it a relatively flat trajectory. In addition, the weapon has an automatic capability and comparatively little recoil. The effects—on marksmanship, tactics, and potentially on training—of these changes in the weapon need to be evaluated.

More importantly, however, the original Work Unit TRAINFIRE studies were directed primarily at the practicability of alternate methods of marksmanship training. As such, the major thrust of TRAINFIRE was in "how" the training should be conducted and the general format determined by these studies is assumed to be correct. MARKSMAN research, on the other hand, is primarily concerned with "what" should be taught, although in Phase 1 it also addresses the "how" of training.

Phase 1 is also directed primarily at Basic Rifle Marksmanship training. Advanced Rifle Marksmanship will be covered in Phase 2.

METHOD

The first phase of the MARKSMAN research was in the form of a series of experiments planned and conducted cooperatively by HumRRO and military personnel and agencies. This section of the report describes the general administrative and technical procedures used in setting up and conducting the experiments. The detailed methodology

[1] Howard H. McFann, John A. Hammes, and John E. Taylor, *TRAINFIRE I: A New Course in Basic Rifle Marksmanship*, HumRRO Technical Report 22, October 1955

is described in appendices which cover the procedure and results for the individual experiments.

The series as originally planned included 32 experiments. Results from 21 experiments are reported in this volume. Two experiments have not yet been performed because the necessary equipment has not been available. Two others served as early-stage advance runs for the revised Basic Rifle Marksmanship program and are not reported here. The remaining six experiments in the original list were essentially exploratory studies that were not designed to yield reportable results but laid the groundwork for subsequent experimentation.

COOPERATING AGENCIES

A Work Unit Leader and one additional full-time scientist were provided by HumRRO, along with a part-time engineer needed for the construction of experimental equipment. The U.S. Army Infantry Human Research Unit (USAIHRU), collocated with HumRRO Division No. 4, provided personnel for direct assistance to the Division. The level of this assistance varied with need and availability, but was generally one officer and two enlisted men at the minimum, and two officers and eight enlisted men at the maximum level.

The Rifle Marksmanship Evaluation Study Group (RMESG) is a special study group instituted by the Weapons Department of the U.S. Army Infantry School for the purpose of this research program. The group consisted of a chief, who was a lieutenant colonel or a senior major, a deputy with the rank of major, and from four to 15 other officers on extended temporary assignment. In addition, other personnel were made available for specific experiments by several agencies including the U.S. Army Infantry Board, the U.S. Army Marksmanship Training Unit, and the Ranger Department of the U.S. Army Infantry School.

WORKING ARRANGEMENTS

This project was a cooperative venture. Responsibilities for a particular job were generally accepted by the agencies best suited to handle them, although there were guiding principles as to their assignment. The Rifle Marksmanship Evaluation Study Group of the Weapons Department had the final authority on which studies would or would not be conducted. HumRRO had the technical responsibility for the design and analysis of the experiments. This does not mean that all experiment designs were written by HumRRO personnel, (although several were); many were written by RMESG personnel with HumRRO guidance and supervision.

Most of the experiments were conducted at Fort Benning, using as subjects either students entering Noncommissioned Officer Candidate School or trainees at the Basic Combat Training Center. A list of the experiments and the locations at which they were conducted is presented in Table 1.

On a number of the more intricate experiments conducted at Fort Benning, HumRRO representatives, assisted by a team furnished by the USAIHRU, supervised the technical conduct of the test and served as scorers. RMESG always provided a range safety officer and supporting NCOs, and was responsible for obtaining subjects, ammunition, and other support as needed. Several experiments, including all of those conducted at posts other than Fort Benning, were conducted exclusively by RMESG personnel with the exception of the planning and analysis stages.

Table 1

Locations of Experiments

Experiment	Location
1: Sequence of Quick-Fire Training in Basic Rifle Marksmanship Training	Fort Jackson, South Carolina Fort Gordon, Georgia Fort Lewis, Washington Fort Bliss, Texas
2: Effect of Wearing Combat Equipment During Marksmanship Training	Fort Jackson
3: Effectiveness of the Pupil-Coach in Basic Rifle Marksmanship Training	Fort Gordon
4: The Definition of the Interaction of the Firing Position, Firing Method, Firing Mode, Distance, and Type of Sights in Combat Marksmanship	Fort Benning, Georgia
5: Evaluation of the Use of Competitive Marksmen as Assistant Instructors in Basic Rifle Marksmanship	Fort Gordon
6: Effect of Additional BB Gun Training on Night Firing	Fort Jackson
7: Center of Mass vs. Adjusted Aiming Point	Fort Benning
8: Optically Produced Zero vs. Personal Zero	Fort Benning
9: Semiautomatic vs. Automatic Fire at Night	Fort Benning
10: Vision Technique, Sight, Mode, and Position for Use in Night Fire	Fort Benning
11: Use of the Tri-Lux Sight for Daytime Targets	Fort Benning
12: Tri-Lux Sight at Night	Fort Benning
13: Evaluation of Training Changes in Night Firing	Fort Jackson
14: Mode of Fire for Multiple and Area Targets	Fort Benning
15: Tracer Ammunition During Daylight Training for Night Fire	Fort Benning
16: Comparisons of New and Old Basic Rifle Marksmanship Programs	Fort Benning[a]
17: Comparison of Kneeling, Prone, Sitting, and Squatting Positions	Fort Benning
18: Evaluation of Possible Modification to Prone Positions	Fort Benning
19: Comparison of the Standard, Tri-Lux, Promethium, and Open Sights for Night Usage	Fort Benning
20: Comparison of M16A1, Tri-Lux, Open, and Promethium Sights Under Daylight Conditions	Fort Benning
21: The Effectiveness of Different Methods of Weapon Carry	Fort Benning

[a]Data for the old BRM program were gathered at Forts Gordon and Jackson; the new BRM program was administered at Fort Benning.

SELECTION OF EXPERIMENTS

Experiments were initiated by several sources including HumRRO, RMESG, and the U.S. Continental Army Command (CONARC). Except for experiments conducted in response to directives from CONARC, the experiments generally were selected according to the bases outlined in the following paragraphs.

Potential areas of study could be divided into two categories—"what" should be taught, and "how" it should be taught. Since "what" should be taught must be specified before deciding "how" it should be taught, studies in the "what" category were undertaken first.

In examining the "what" elements, a systems analysis concluded that much of combat rifle marksmanship is concerned either with firing techniques, or with the firing environment. The firing environment is divisible into five areas, while the firing techniques are single areas. Generally speaking, each experiment was concerned with at least one firing technique, and at least one of the two choices under each of the five environmental conditions.

This system is portrayed in Figure 1. The shaded cells represent illogical combinations of firing techniques and firing environment which were excluded from consideration (for example, it obviously makes little sense to calibrate the sights of a weapon at night). Five experienced HumRRO staff members were requested to rank order, without consulting one another, the 10 environmental conditions and the seven firing techniques. There was considerable agreement among the five individuals as to the order of importance; using the mode rank in each case provided a single rank ordering without any deletions or redundancies (Figure 1).

In order to determine the order of priority of the various combinations of firing techniques and firing environments, the rank order of each row and column were summed, with the lowest sum receiving the highest priority. For example, automatic vs.

Combinations of Firing Techniques and Environment as a Function of Range

Firing Technique	Firing Environment and Rank Order of Importance									
	Illumination		Target Motion		Time Pressure		Target Location		Target Definition	
	6 Night	4 Day	7 Moving	1 Stationary	3 Present	9 Absent	10 Aerial	2 Ground	5 Point	8 Area
1 Automatic vs. Semiautomatic										
2 Rapid Fire vs. Deliberate Fire							■			
3 Sighting Technique										
4 Sight Calibration (Zero)	■		■		■		■			■
5 Body and Weapon Position During Firing										
6 Aiming Point					■	■				
7 Weapon Position at the Carry										

Figure 1

semiautomatic fire was judged the most important firing technique, and stationary targets ing without any deletions or redundancies (Figure 1).

In order to determine the order of priority of the various combinations of firing techniques and firing environments, the rank order of each row and column were summed, with the lowest sum receiving the highest priority. For example, automatic vs. semiautomatic fire was judged the most important firing technique, and stationary targets the most important environment. In Figure 2, a "1" was placed in the appropriate cell to indicate that the sum of the appropriate row and column ranks showed this was the most important cell in the table.

Selection of Most Important Combination of Firing Technique and Environment

Firing Technique	Firing Environment and Rank Order of Importance									
	Illumination		Target Motion		Time Pressure		Target Location		Target Definition	
	6 Night	4 Day	7 Moving	1 Stationary	3 Present	9 Absent	10 Aerial	2 Ground	5 Point	8 Area
1 Automatic vs. Semiautomatic				1						
2 Rapid Fire vs. Deliberate Fire										
3 Sighting Technique										
4 Sight Calibration (Zero)										
5 Body and Weapon Position During Firing										
6 Aiming Point										
7 Weapon Position at the Carry										

Figure 2

In Figure 3 this process is continued. Rapid fire vs. deliberate fire is the second most important row, target location on the ground the second most important column. Where the second most important column crosses the first most important row, and where the second most important row crosses the first most important column there are combinations of firing environment and firing techniques that are second in priority. Where the second most important row and column cross each other there is a combination of environment and technique that is third in priority.

This process was continued throughout the entire tabulation. While the completed list did not automatically furnish a listing of experiments, it did furnish a reference scheme against which the potential value of a number of experiments were judged. In most instances, studies concerned with "how" to teach were conducted after the appropriate experiments concerned with "what" to teach.

Selection of Second and Third Most Important Combinations of Firing Technique and Environment

Firing Technique	Firing Environment and Rank Order of Importance									
	Illumination		Target Motion		Time Pressure		Target Location		Target Definition	
	6 Night	4 Day	7 Moving	1 Stationary	3 Present	9 Absent	10 Aerial	2 Ground	5 Point	8 Area
1 Automatic vs. Semiautomatic				1				2		
2 Rapid Fire vs. Deliberate Fire				2				3		
3 Sighting Technique										
4 Sight Calibration (Zero)										
5 Body and Weapon Position During Firing										
6 Aiming Point										
7 Weapon Position at the Carry										

Figure 3

Two selected experiments—one on moving targets and one on aerial targets—have not yet been conducted because the equipment required for them has not been available.

CRITERION MEASUREMENT

A few comments on the criterion measures taken should be of general interest. Time to first hit was probably the most useful measure taken in most of the studies. Whenever there is pressure to "get the enemy before he gets you," this criterion is certainly paramount. For this reason, the elapsed time to first hit was extremely useful in comparisons of automatic vs. semiautomatic fire and of firing techniques. The elapsed time from target presentation to target "kill" was measured electromechanically, using mercury switches on the target to close and open a circuit to an electric timer as the target was presented and automatically "killed" by the strike of the bullet.

Such measures as time per round, time per hit, and time per trigger pull were especially valuable in explaining why a particular technique was superior, or inferior, in time to first hit. They were obtained by dividing total rounds used, hits achieved, or trigger pulls made by time to first hit. The number of rounds used was obtained by counting the rounds remaining in the magazine and subtracting from the original issue. The number of trigger pulls made was obtained by a count conducted by monitors assigned on a one-to-one basis to each man on the firing line. The number of hits achieved was recorded automatically through the use of hit-sensing devices on the target.

In addition, the measures taken normally during marksmanship training were often used. These were hits, misses, and no fires. These measures were taken from standard training ranges using standard training performance measurement techniques and electromechanical equipment except for the addition of experiment monitors, and a thorough check of the equipment to see that it was operating properly.

INCORPORATION OF RESULTS INTO TRAINING

In addition to its other responsibilities, the RMESG develops programs of instruction for Basic Rifle Marksmanship incorporated into the training program at training centers throughout the United States. During the conduct of Work Unit MARKSMAN, HumRRO has furnished a written analysis and interpretation of each experiment soon after its completion. These analysis reports were the basis for the construction by the RMESG of a revised Program of Instruction in Basic Rifle Marksmanship for Basic Combat Training (BCT). In this way, the use of the results of this research was expedited.

RESEARCH CALENDAR

It was concluded at the Army Training Center Conference held at Fort Benning in December 1968 that there was a significant training problem in the area of marksmanship. In January 1969, the Weapons Department of the U.S. Army Infantry School, in cooperation with HumRRO Division No. 4 sought CONARC approval and guidance for research on combat rifle marksmanship. This approval and guidance was given in February 1969, and testing was initiated in March.

Also in February 1969, task analyses of weapons training in Basic Combat Training and in Advanced Individual Training were undertaken by the Weapons Department at their own initiative. These task analyses were valuable aids in outlining the research program. The research divided logically into two phases: Phase 1 was concerned chiefly with basic rifle marksmanship and Phase 2 will be concerned principally with advanced rifle marksmanship.

RESULTS

All experiments discussed in the text of this report are described in more detail individually in the Appendices.

DAY FIRING—SINGLE TARGETS

Mode of Fire

Mode of Fire (semiautomatic vs. automatic) was studied in Experiments 4, 11A, and 11B. Against nonmoving, single targets in the daytime, from most firing positions, the semiautomatic mode was superior to the automatic mode in both the time required for a hit and the number of trigger pulls required for a hit from 50 meters out. Within 50 meters, there was little difference between these two modes, either in time to first hit, or in trigger pulls to first hit. Within 25 meters, the automatic mode was faster than the semiautomatic mode in time to first hit ($p < .05$). Figures 4 through 7 illustrate the interaction between mode and target distance.

Time to first hit is probably the more important of the two criteria examined, combining both speed and accuracy. The time to first hit as a function of target distance

Mode as a Function of Time to First Hit: Experiment 4

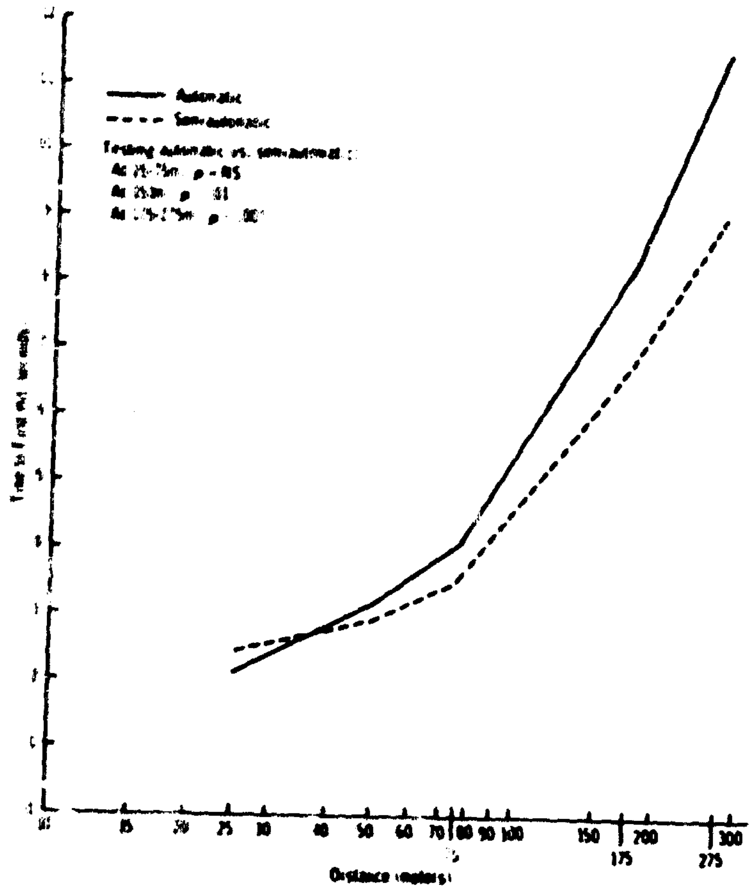

Figure 4

Mode as a Function of Time to First Hit: Experiments 11A and 11B

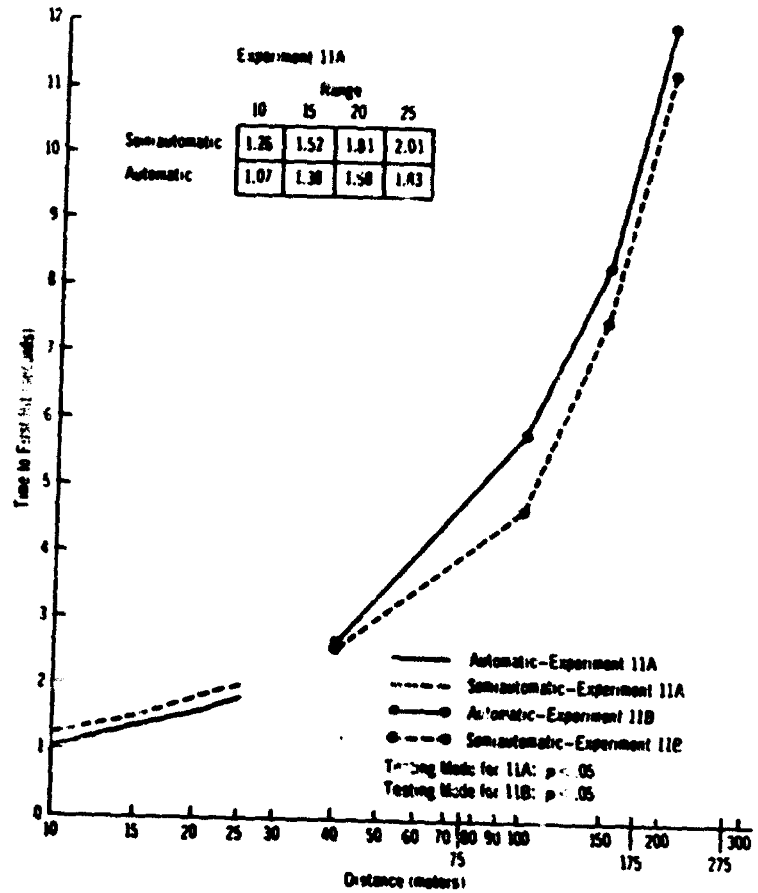

Figure 5

Mode as a Function of Trigger Pulls to First Hit: Experiment 4

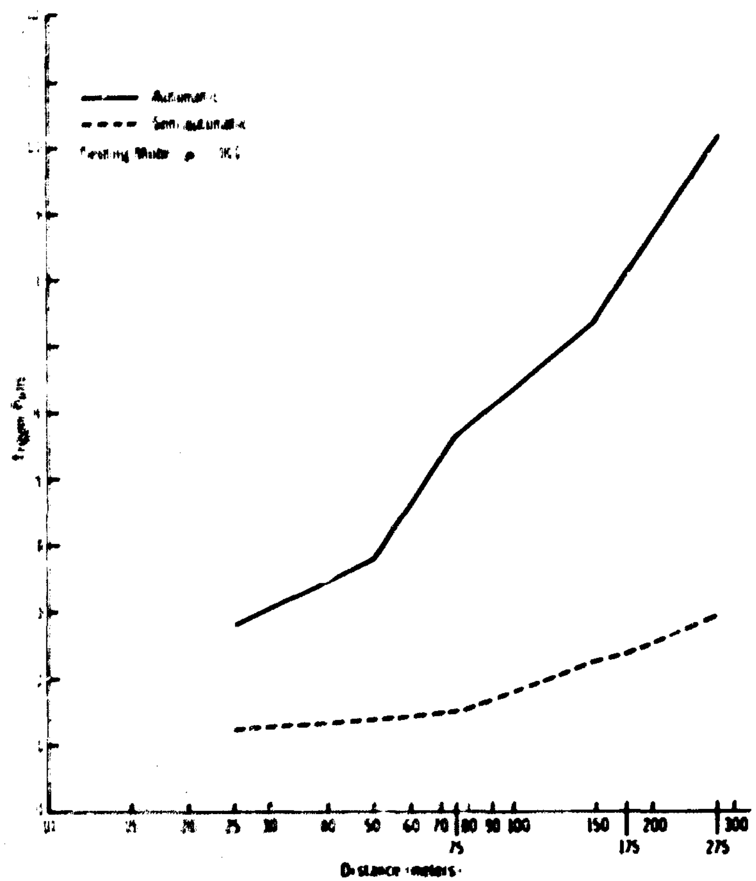

Figure 6

Mode as a Function of Trigger Pulls to First Hit: Experiments 11A and 11B

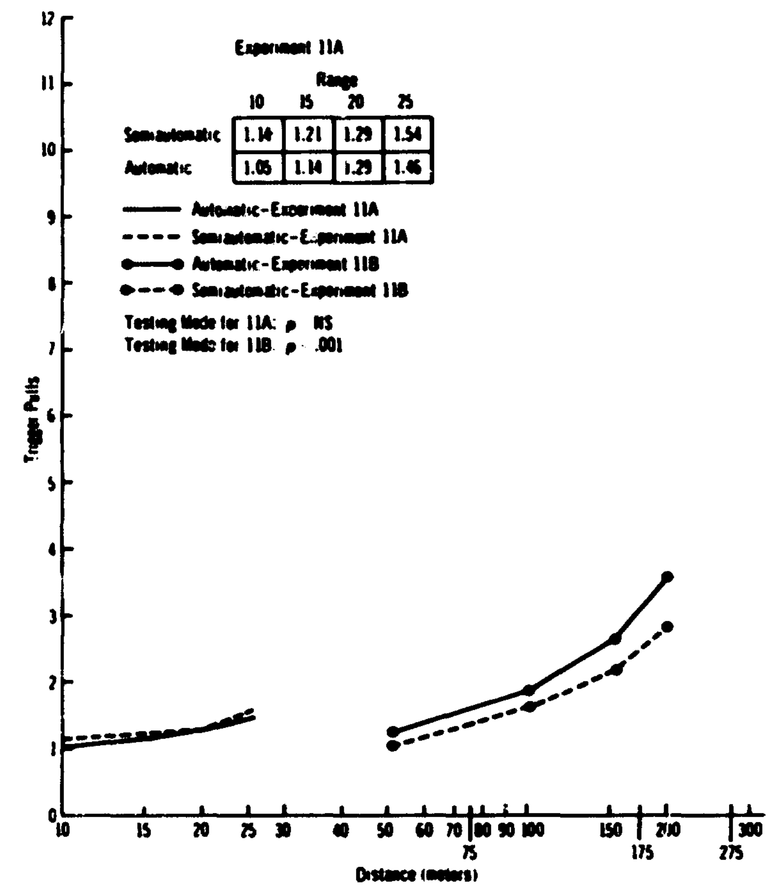

Figure 7

in Experiment 4 is plotted in Figure 4. These values are the means for the "coarse aim" technique for all of the five firing positions tested. Beyond 50 meters, the semiautomatic mode was superior in both speed and accuracy, becoming more superior with increasing distance. Within 25 meters, the automatic mode was superior in time to first hit (Figure 5) although not in trigger pulls to first hit (Figure 7). The superiority of the automatic mode of fire within 25 meters was slight, but significant ($p<.05$) (Figure 5).

Mean time to first hit data as a function of target distance for Experiments 11A and 11B is provided in Figure 5; the "aimed fire" portion of Experiment 11B was averaged across all firing positions for this graph. The differences between the positions used in Experiments 4 and 11B possibly account for some of the difference between Figures 4 and 5. Experiment 11A provided the only examination of the semi-automatic versus the automatic mode within 25 meters. The data for Experiment 11B on the same graph support the conclusion reached in Experiment 4 that semiautomatic fire is superior to automatic fire with the M16 rifle, beyond 50 meters (Figure 6).

Firing Technique and Sight

The results of Experiment 4 indicated that aimed fire might be superior to Quick Fire. The time to first hit criterion for a comparison of the Quick-Fire technique with aimed fire using the M16A1 sight is shown in Figure 8. The difference between the Quick-Fire and the aimed fire techniques was statistically significant at the 50- and 75-meter distances ($p<.001$), but not at the 25-meter distance. It was decided that a further comparison was needed, examining Quick Fire and aimed fire within 25 meters as well as corroborating the results beyond 25 meters. Experiments 11A and 11B were intended to provide this information.

Time to First Hit for Quick Fire vs. Aimed Fire Beyond 25 Meters: Experiment 4 for Semiautomatic Fire

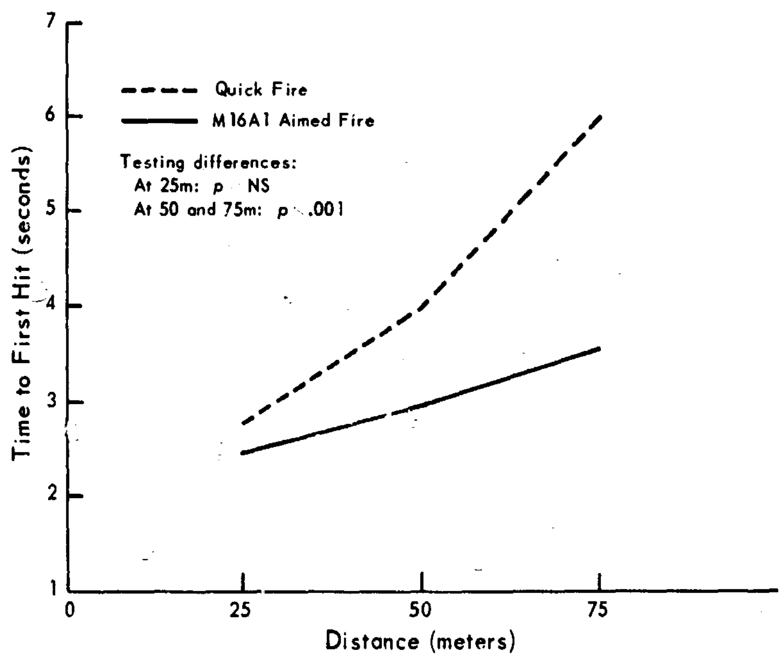

Figure 8

At about the same time, other research on night firing indicated a possible utility for a nightsight with a large rear aperture. One such nightsight, the Tri-Lux sight, is used by the British not only for night firing, but also for rapid aimed fire at close targets in the daytime. The British, in their comparison of Quick Fire with aimed fire using the Tri-Lux sight, found that aimed fire with their sight was superior to Quick Fire[2]. It was decided to include an examination of the Tri-Lux sight in Experiments 11A and 11B.

A comparison of Quick Fire with aimed fire using both the M16A1 sight and the Tri-Lux sight on the time to first hit criterion for Experiment 11A, which was concerned with ranges of 25 meters and less, is provided in Figure 9. Considering time to first hit, the M16A1 sight was inferior at 10 and 15 meters, where the Tri-Lux sight and Quick Fire were about equal. At 20 meters, the technique used made little difference. At 25 meters, aimed fire in general and the Tri-Lux sight in particular were superior. This interaction of sight and technique with distance was significant ($p<.01$). Thus, it would appear that aimed fire with a large aperture rear sight is superior to Quick Fire, and to aimed fire with the M16A1 sight within 25 meters. A trigger pulls to first hit criterion was also examined. Quick Fire was significantly inferior to aimed fire beyond 15 meters, and was never superior to aimed fire in terms of trigger pulls to first hit ($p<.001$). In Experiment 11B, there was no significant difference between the M16A1 sight and the Tri-Lux sight at 50 meters but the performance with the Tri-Lux sight deteriorated rapidly beyond that distance (Figure 10).

From the results of Experiments 11A and 11B it appeared that a large-aperture rear sight might have some value for rapid aimed fire in the daytime at targets within 50 meters. Before concluding this, it was decided to run one additional test, examining the M16A1 sight, the Tri-Lux sight, a second but smaller rear-aperture sight (Promethium) and an Open sight consisting simply of the "U" of the carrying handle. This study was conducted in Experiment 20. The time to first hit criterion for this experiment is portrayed in Figure 11, which shows that the M16A1 sight becomes superior at some

Time to First Hit for Quick Fire vs. Aimed Fire Within 25 Meters: Experiment 11A

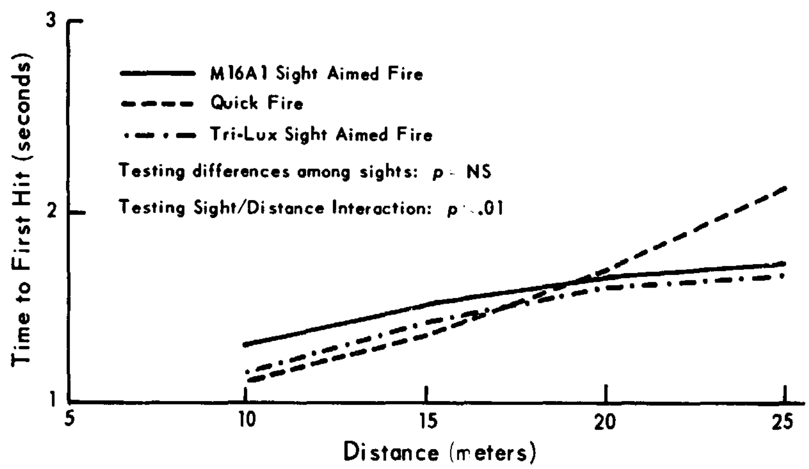

Figure 9

[2]Major D. Stopford. *An Evaluation of the Quick Kill Shooting Systems*, FARELF G (Operational Requirements and Analysis Branch), Report No. 3-69, March 1969.

Time to First Hit for M16A1 Sight vs. Tri-Lux Sight: Experiment 11B

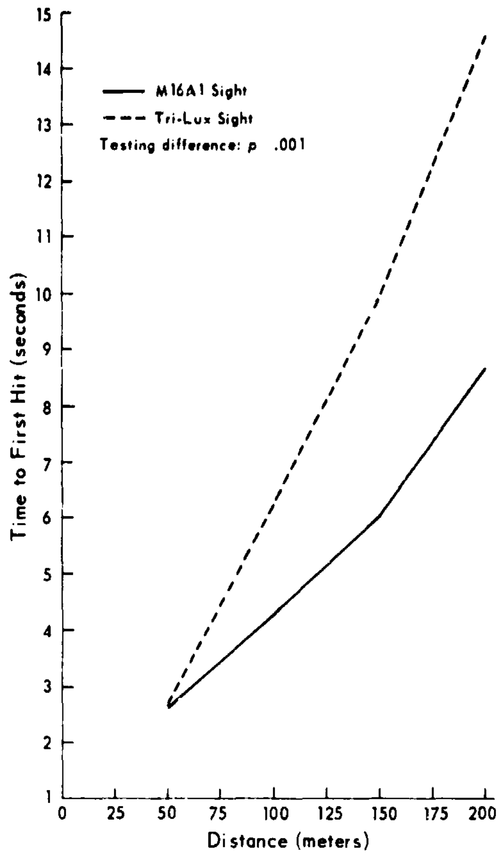

Figure 10

Time to First Hit for M16A1 vs. Tri-Lux vs. Promethium vs. Open Sights: Experiment 20

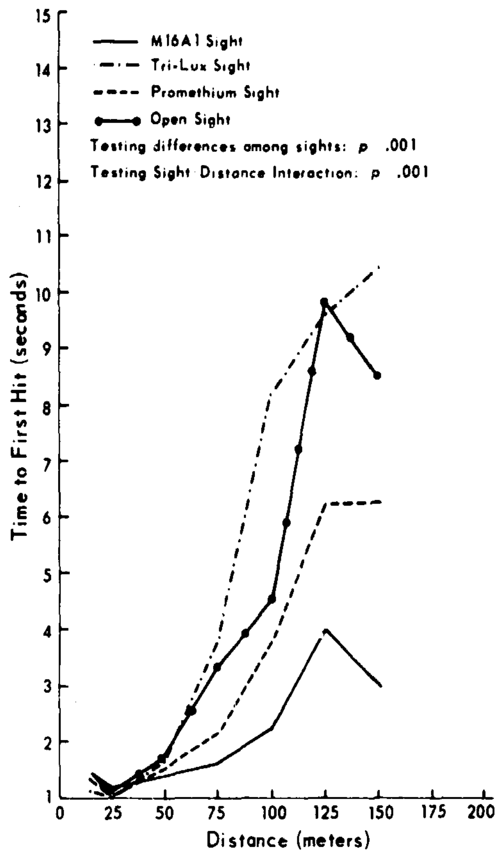

Figure 11

distance between 25 and 50 meters. This superiority increases with distance. Within 50 meters, there is little difference among the three large-aperture sights.

From the results of Experiments 4, 11A, 11B, and 20 it appears that aimed fire, particularly with a large-aperture rear sight, is superior to Quick Fire. However, the advantage of the large-aperture rear sight over the standard M16A1 sight is limited to target distances of less than 50 meters. Within 50 meters, the Promethium sight has a superior mean performance as compared with the other three sights, but its superiority over the Tri-Lux and Open sights is not significant.

Firing Position

Four experiments were conducted that included a study of firing positions. In Experiment 4, a study of the standing, kneeling supported, kneeling, prone supported, and prone positions, it was determined that the kneeling supported and kneeling positions generally yield the most rapid time to first hit. At the more distant targets (150-275 meters) prone supported was next, followed by standing, then prone. Support greatly improves performance in the prone position in both time and rounds to first hit. In Experiment 11B the prone, kneeling, and standing positions were examined and it was determined only that the standing position was inferior to both the prone and kneeling positions in terms of number of trigger pulls required to first hit.

In Experiment 17 four offensive positions, the kneeling, prone, squatting, and sitting positions, and two defensive positions, the bunker and foxhole were examined. This experiment determined that the defensive positions are generally faster and more accurate than the offensive positions. In addition, it was determined that the descending order of the offensive positions considering both speed and accuracy is: (a) Kneeling, (b) prone, (c) squatting, and (d) sitting. In Experiment 18 it was determined that a straight line, unsupported prone position is superior to the angled, unsupported prone position when firing the M16 rifle, but that body alignment made no difference when support was used.

In summary, the following findings were reported:

(1) Defensive positions (i.e., bunker and foxhole), are better than offensive positions in both speed and accuracy.
(2) Among the offensive positions, the kneeling supported and kneeling positions provide the best combination of speed and accuracy.
(3) The prone supported position provides the next best speed/accuracy combination at the greater distances (150-200 meters).
(4) The sitting and squatting positions do not offer any speed or accuracy advantages.
(5) Using the M16 rifle, a modification of the prone position to align the body with the rifle will provide a speed and accuracy advantage.

Carry Position

The two criteria for determining the best carry position for the rifle are comfort and speed on target. There are two carry positions, one that maximizes comfort when no immediate threat is perceived, and one that maximizes readiness when the possibility of an immediate threat is perceived. Only the second of these situations was considered in the conduct of this research.

In Experiment 11A, a modification of the British ready position was compared with an underarm carry position. In the modified British ready position the butt of the weapon is placed high in the shoulder pocket so that when the weapon is raised, a minimum head movement is required of the shooter. For a right-handed individual, the right-hand is on the pistol grip, the left-hand is on the stock beyond the carrying handle, and the weapon is slanted downward and to the left across the body. The British ready position was superior to the underarm carry in time to first hit, but the two positions were equal in the number of trigger pulls required to hit the target. Thus, there was no accuracy difference, but the modified British ready position was faster. In this study, the gun was always fired from the shoulder.

In order to check the possibility that the underarm position might be superior to shifting to the shoulder position for firing the weapon, this comparison was also made in Experiment 11A. Firing from the underarm position was grossly inferior to firing from the shoulder position in both speed and accuracy, even though the individual firing from the shoulder position had to raise the rifle from the underarm carry before he could fire.

Experiment 21 was a comparison of the modified British ready position with a high port position, the underarm carry, and the British ready position using a sling. No significant difference was found among these four carry positions. Since Experiment 21 failed to corroborate the results of Experiment 11A, no definite conclusions can be reached concerning the carry position.

DAY FIRING–MULTIPLE AND AREA TARGETS

Mode of Fire

In Experiments 4, 11A, and 11B it was determined that the semiautomatic mode of fire is superior in time to first hit and total number of hits as compared with the automatic mode of fire against single targets in the daytime. In Experiments 9 and 10 it was concluded that the automatic mode of fire is superior against single targets at night and in limited visibility conditions.

It was reasoned that the automatic mode of fire was superior at night because the targets were indistinct, resulting in less accurate aiming, thereby increasing the value of maximizing chance hits by the use of automatic fire; further, where the target was visible, the semiautomatic mode of fire gave a higher hit rate than the automatic mode because it was possible to re-lay the weapon for follow-up shots more rapidly in the semiautomatic mode. Multiple targets and area targets in the daytime have characteristics of both of these situations, so it was necessary to examine them in the daytime to determine which mode of fire would maximize the number of hits and the number of hits per unit time.

In Experiment 14A, the semiautomatic and automatic modes were compared at four target distances and two distribution densities for multiple targets. It was found that semiautomatic fire resulted in more hits per second than automatic fire. Furthermore, semiautomatic fire resulted in two to three times as many total hits as automatic fire, and resulted in better fire distribution as well. In addition, increasing the target density resulted in an even greater superiority for semiautomatic fire. Ammunition expenditure was held equal in both modes.

In Experiment 14B area targets were studied. In this experiment, the automatic mode, which was provided three times as much ammunition as the semiautomatic mode, achieved more total hits and more targets hit than the semiautomatic mode. In addition, the automatic mode achieved more hits per trigger pull than did the semiautomatic mode. However, the semiautomatic mode of fire still provided a faster hit rate than did automatic fire.

The first round of a three-round burst on automatic fire should be just as accurate as a single round fired using semiautomatic fire. Therefore, it is logical that when firing in three-round bursts, and provided with three times the ammunition of semiautomatic fire, the automatic mode should achieve more total hits and more hits per trigger pull than the semiautomatic mode of fire.

However, the real question is whether the occasional extra hit per trigger pull gained when using automatic fire is sufficient to compensate for the extra time required to re-lay the weapon after firing a burst in the automatic mode. Since the semiautomatic mode of fire achieved a faster hit rate per unit time than did automatic fire, it would seem that the occasional extra hits afforded by the use of automatic fire does not compensate for the extra re-lay time. In a given period of time, semiautomatic fire will provide more target hits than automatic fire. Therefore, in a situation requiring the delivery of effective fire into multiple or area targets, semiautomatic fire would be superior.

Firing Techniques, Sight, and Position

It was reasoned that the firing techniques, sights, and positions selected in the studies of single, visible targets would also very likely be selected for multiple and area targets. Therefore, these variables were held constant. Only aimed fire in the foxhole position using the M16A1 sight was investigated.

NIGHT FIRING

Mode of Fire

In Experiments 9 and 10 semiautomatic vs. automatic fire at night was studied. It was concluded in both experiments that automatic fire using the three-round burst was superior to semiautomatic fire in total number of hits, and in hits per trigger pull. In addition, it took no longer to fire a three-round burst of automatic fire than to fire a single round in the semiautomatic mode at night. The conclusion must be that in a time-critical situation at night, automatic fire using the three-round burst is more likely to achieve a hit than semiautomatic fire. However, since automatic fire uses more ammunition than semiautomatic fire, the superiority of automatic fire at night will be compromised by the additional ammunition expenditure.

Firing Technique and Sight

Experiments 10, 12, and 19 were concerned with firing techniques and sights for night firing. In Experiment 11 these variables were studied under starlight (no moon) conditions. Under these conditions no firing technique or sight tested made a significant difference. In Experiment 12, the Tri-Lux sight was compared with the M16A1 sight in both the starlight and half-moon conditions and again there was no significant difference under the starlight condition. However, under the half-moon condition the Tri-Lux was significantly superior to the M16A1 (Figures 12 and 13).

Time to First Hit for M16A1 and Tri-Lux Sights at Night: Experiment 12

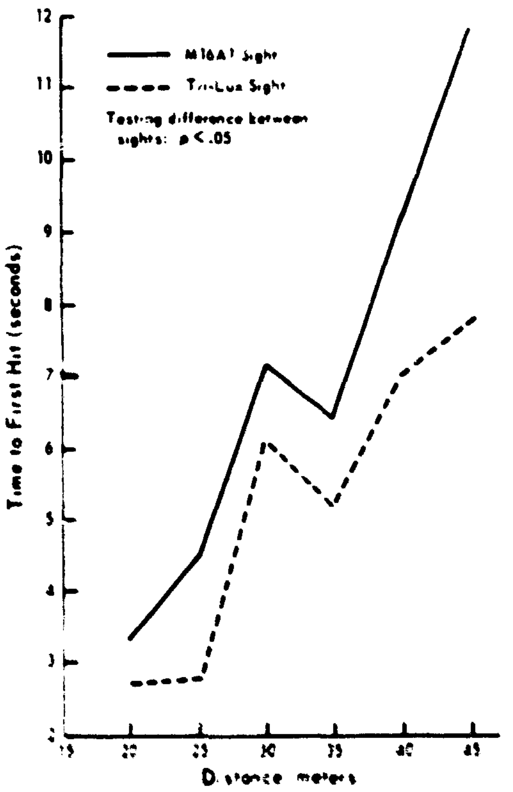

Figure 12

Number of Hits for M16A1 vs. Tri-Lux Sight Under Half-Moon Illumination: Experiment 12

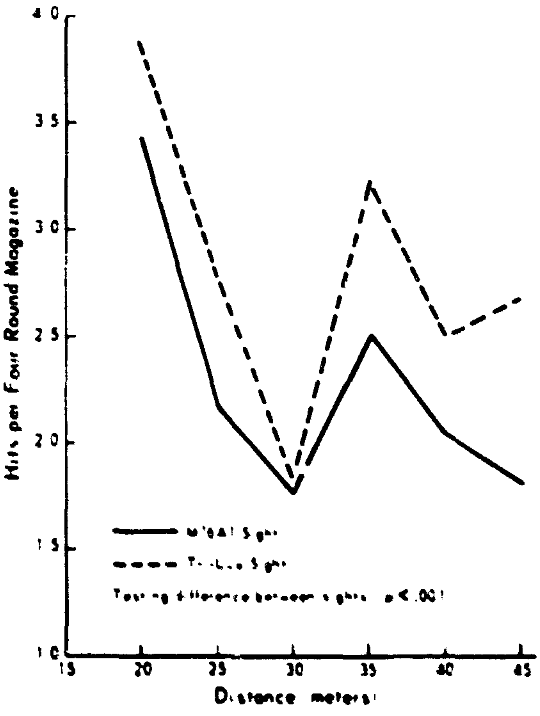

Figure 13

In Part 1 of Experiment 19 this examination was repeated under the full-moon condition with the addition of a third sight, the Promethium. The Promethium sight differs from the Tri-Lux only in the source of luminescence in the front sight post and in the size of the rear aperture. The Tri-Lux rear aperture was a circle, truncated by the carrying handle on both sides, one centimeter high and 0.75 centimeter wide. The Promethium rear sight was circular with a diameter of 0.70 centimeter; it is named for the luminescent element used in it. The Tri-Lux sight used tritium as the luminescent element in the front sight post. Both the Tri-Lux and the Promethium sights were significantly superior to the M16A1 sight, but were not significantly different from one another (Figures 14 and 15).

The second part of Experiment 19 repeated this examination under the half-moon condition with the addition of an Open sight which consisted of the Promethium front sight and no rear sight. The "U" of the carrying handle was used as the rear sight. Again, there was a significant difference among the sights, due principally to the superiority of all of the night sights relative to the standard M16A1 sight (Figures 16 and 17).

Time to First Hit for M16A1, Tri-Lux, and Promethium Sights Under Full-Moon Illumination: Experiment 19, Part 1

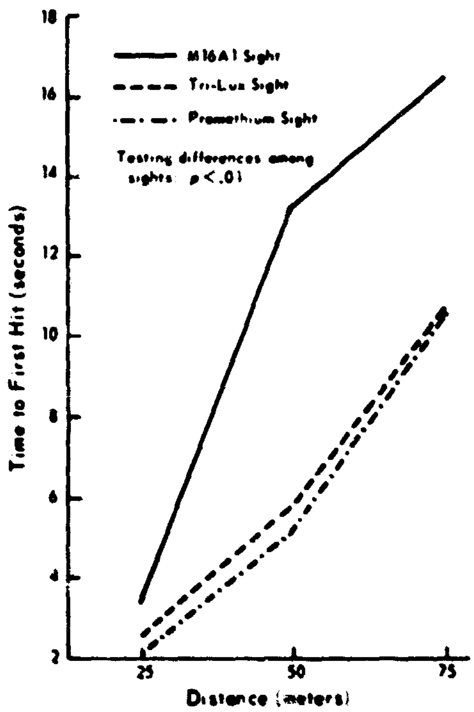

Figure 14

Total Hits for M16A1, Tri-Lux, and Promethium Sights Under Full-Moon Illumination: Experiment 19, Part 1

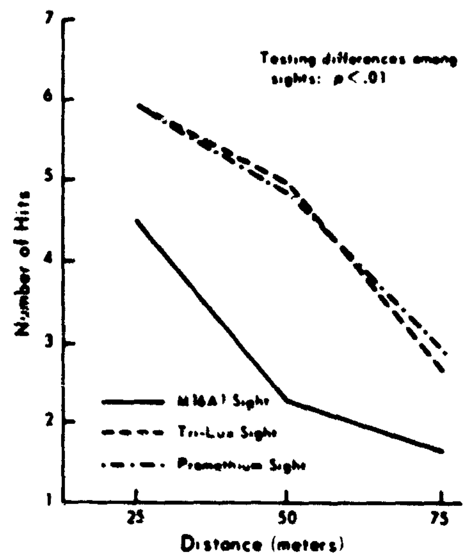

Figure 15

Time to First Hit for M16A1, Tri-Lux, Promethium, and Open Sights Under Half-Moon Illumination: Experiment 19, Part 2

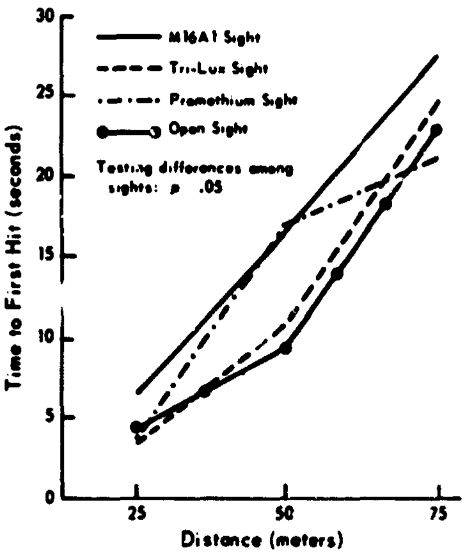

Figure 16

Total Hits for M16A1, Tri-Lux, Promethium, and Open Sights Under Half-Moon Illumination: Experiment 19, Part 2

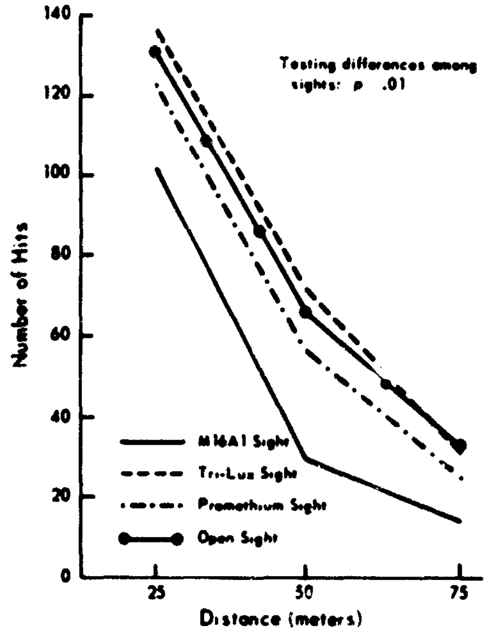

Figure 17

Firing Position

Firing position at night was studied in Experiments 6 and 9. In Experiment 6, the prone supported position was compared with the kneeling unsupported position. The prone supported was generally superior ($p<.01$). However, the kneeling unsupported position was superior to the prone position when white tape was placed longitudinally along the barrel to assist in aiming ($p<.001$). It seems likely that the use of any type of night sight would make the kneeling position superior to the prone. Without some such assistance, the prone position is superior at night.

Use of Tracers

In Experiment 15 the use of tracers for night firing and for training for night firing was studied. While the use of tracers for night firing resulted in a considerable improvement in performance ($p<.001$), it had a detrimental effect upon night firing without tracers ($p<.01$). Therefore, it was concluded that night fire training should be conducted with tracers only if it is intended that tracers be used for night firing in combat.

The finding that use of tracers improved performance in night firing with the rifle to some extent contradicts information in a technical literature survey previously compiled by HumRRO.[3] However, that review was concerned with the use of tracers in antiaircraft firing, which is conducted against moving targets at comparatively great distances and

[3]Robert J. Foskett, E.W. Frederickson, and Robert D. Baldwin. *A Review of the Literature on Use of Tracer Observation as an Antiaircraft Firing Technique*, HumRRO Technical Report 68-11, September 1968.

usually in the daytime. The MARKSMAN results apply to night visibility conditions at comparatively short ranges and at standing targets. These situational differences probably account for the different conclusions reached in the two reports.

TRAINING CONSIDERATIONS

Aiming Points

Soldiers firing the M14 rifle with a 250-meter, battle sight zero are instructed to aim below the center of the target for any targets less than 200 meters, and to aim at the center of the target for targets beyond 200 meters. Since most combat targets are within 200 meters, this means that most combat shots are fired using the low center of target aiming technique. This adjusted aiming point technique is necessary for the M14 rifle because of its trajectory. However, the M16 rifle, with a higher muzzle velocity, has a flatter trajectory.

It seems plausible that the soldier might be able to fire at a center of target aiming point for all targets within 300 meters. This would not necessarily yield greater accuracy, but if the accuracy of the center of target technique were equal to the accuracy of the adjusted aiming technique the training could be simplified. Experiment 7 addressed this problem.

The problem was attacked in two ways. First, the projected points of impact on a man-sized target, using the M16 rifle at varying distances, and three different aiming points were calculated, based upon trajectory data furnished by the Aberdeen Proving Grounds. A "standard man" according to the Hertzberg data was used for the target projection.[1] The analysis showing the impact points obtained while the bullet was rising in its trajectory are slightly to the left of the center line, while the impact points obtained as the bullet was falling are slightly to the right of the center line. Clearly, an aiming system using either the beltbuckle or the stomach area as the aiming point will result in more hits in the chest and stomach area, and the present adjusted aiming point system will result in more hits in the lower abdomen.

An argument in favor of any of these three aiming systems could probably not be supported on the basis of these data. Similarly, the experimental evaluation of the center of mass vs. the adjusted aiming technique resulted in a conclusion of no significant difference. With no difference in hit probabilities, the choice between the aiming techniques can be made on the basis of other criteria, such as the simplicity of training obtained by using a single aiming point throughout rather than a dual system.

Prezeroed Sights

A true zero is the calibration of the sights on a weapon so that when they are aligned with the target at a specified range, and with a specified ammunition, a round fired from the weapon hits the aiming point within the margin of error for the weapon. It has been commonly believed that a weapon should not be fired with the true zero but that it should be zeroed by the individual doing the shooting. According to this philosophy, eccentricities in sight alignment would be eliminated by correcting the sight for the individual doing the firing.

There is considerable logic in opposition to this point of view. The man who consistently makes an error in sight alignment can eliminate it if the sights are zeroed

[1] H.T.E. Hertzberg and G.S. Daniels. *Anthropometry of Flying Personnel*, Aero-Medical Lab Report WADC ER 52-321, 1950.

perfectly and, through firing, he notices his error. However, when a man is allowed to introduce an error into the zeroing of his weapon, learning to correct for it becomes impossible because an accurate sight alignment will yield an inaccurate shot. Furthermore, it is more difficult to maintain a consistent sight alignment when the "correct" sight alignment is off center. Therefore, it would seem better to train a man to shoot with a weapon that is accurately zeroed before teaching him to zero the weapon. The present system of training the man to zero the weapon before training him to shoot with it would seem to ensure that the inaccuracies in sight alignment existing when the training begins will have a negative effect upon the course of the training.

Probably the main reason why trainees have not in the past been furnished accurately prezeroed weapons is the difficulty of mass producing accurate zeroes. If a weapon could be accurately prezeroed using a mechanical and/or optical device requiring a minimum amount of time and money, it would then be feasible to teach the soldier to shoot before he is taught to zero the weapon. This should make the training easier and save ammunition required for zeroing.

The optical collimator is potentially a device that could accurately prezero a weapon. The collimator is inserted into the muzzle of the weapon. Through the sights, a target is seen. When the target is centered in these sights, the alignment of the sights is parallel to the barrel of the weapon and the windage at this point is correct. The correction of a set number of clicks in elevation, or the alignment of the sights to a compensatory mark on the collimator will zero the weapon in elevation for a given range.

In Experiment 8 a collimator-produced zero was compared with the personal zero, the results indicating no significant difference in performance. However, the data did indicate that it was highly desirable to fire a single three-round shot group as a final check and correction after zeroing the weapon with a collimator. The collimator-produced zero with a three-round check was as good as the personal zero, and eliminated two-thirds of the ammunition required for zeroing. It can be used to check the zero on weapons under battlefield conditions without firing a shot.

Pupil-Coach Evaluation

The Pupil-Coach has traditionally been used as a teaching assistant during 25-meter firing in the Basic Rifle Marksmanship program. If it were shown that the pupil-coach made no significant contribution, this student time would become available for other uses. Experiment 3 addressed this problem.

One basic combat training company of 206 men was divided into two groups: One group acted as coaches and received coaching during the normal 25-meter firing exercises; the other did neither. All students received the same formal instruction, including instruction on coaching duties. The test criterion was performance in record fire 1 and 2.

The mean record fire scores were 49.1 and 49.9 for the "with coach" and the "without coach" groups respectively. Tests of significance yielded "ts" of .73, .20, and .18 for hits, misses, and no-fires respectively. With 204 degrees of freedom, none of these is significant. Apparently, whether or not a man receives coaching from a pupil-coach on his 25-meter firing has no significant effect upon his performance in record fire 1 and 2.

Use of BB Gun and Tape for Night Firing

Since both Quick Fire and night firing practices employ a pointing unaimed technique, it was reasoned that night firing with the rifle might benefit from BB gun practice to the same extent that Quick Fire in the daytime reportedly does. Also, since white tape placed along the barrel of the rifle is an accepted field expedient for night firing, it was decided to determine the effect of using it on the BB gun during practice, as well as on the service weapon during record fire.

Night practice with the BB gun without tape on the barrel had no appreciable effect upon the firing of the service weapon later. However, the same practice *with* tape had a detrimental effect upon later firing with the service weapon ($p<.05$). The use of the BB gun requires a substantial correction in elevation to account for the trajectory of the BB. The use of tape on the BB gun probably increases the ability to make this correction. Training in such an elevation correction would have a detrimental effect if transferred to the service weapon. The use of tape on the service weapon, with or without the BB gun training, had no appreciable effect upon performance.

Wearing of Equipment During Marksmanship Training

During the original TRAINFIRE research, it was suggested (although not tested) that one method of maintaining battlefield fidelity during marksmanship training would be to wear the helmet and web gear. While the use of this equipment probably does increase battlefield fidelity, it was also considered possible that it might create obstructions to learning in the early stages of marksmanship training. Experiment 2 was conducted in order to obtain some indication of the effect of wearing this equipment upon Record Fire 1 and 2.

Three conditions were studied:

(1) No helmet or web gear worn during training.
(2) No helmet or web gear worn during the first half of training.
(3) Helmet and web gear worn during the entire training period.

There was no significant difference among the three groups in terms of hits, misses, or no-fires during Record Fire 1 and 2. Apparently, wearing the equipment has no ill effect upon record fire scores. Whether it increases battlefield fidelity as originally suggested is an open question.

Sequence of Quick Fire in Training

Experiment 1 was devoted to the topic of Quick Fire in training. Later experiments have indicated that substantial changes in this training may be desirable. While the Quick-Fire situation (i.e., one in which it is necessary to fire quickly and accurately at short ranges) is certain to remain an infantry requirement, it may be feasible to eliminate many of the principles taught and training techniques used in the present Quick-Fire program. It is also possible that training for the Quick-Fire situation will be integrated with other marksmanship training. However, in the event that this training remains an isolated element of instruction, comparatively unconnected to the rest of Basic Rifle Marksmanship, the results of Experiment 1 indicating the optimal position of Quick-Fire training in the BRM program will be of value.

The sequence of Quick Fire in the BRM program (i.e., early or late in the program) did not have any significant effect upon record fire scores. However, men who had Quick Fire late in the BRM program scored significantly higher on that portion of a criterion test devoted to targets representing a Quick-Fire situation. There was nothing in the experiment to indicate why this was so. It is possible that the Quick-Fire skill deteriorates rapidly, and that the relative superiority of those trained on Quick Fire late in the regular BRM program was due to their being in a more recent position on the forgetting curve. On the other hand, it is also possible that the weapon familiarity gained from the training on aimed fire greatly assisted in the learning of Quick Fire techniques. In any event, there is no disadvantage to placing Quick Fire late in the program, and there may be a gain.

Evaluation of Training Changes in Night Firing

Prior to Work Unit MARKSMAN the night firing program was a considerably scaled-down adaptation of the program of instruction recommended after testing by HumRRO in 1954 and adopted by the Army in 1958. The program had been considerably reduced on two occasions in order to free ammunition and time for other purposes. As a result of feedback from U.S. commanders in Vietnam, the original program was reinstated. Some segments of this 7-hour program seemed of questionable value, both to the present HumRRO personnel and to the RMESG.

In Experiment 13 the relative value of four different programs was studied by deleting certain elements from the 7-hour program in varying combinations. The 7-hour program was compared with the 5-, 4½-, and 2½-hour programs. The 4½-hour program proved superior to all three of the others ($p<.001$). It consists of two hours of orientation firing, followed by one-half hour of conference and demonstration of night vision techniques, then two hours of practice and record night fire.

Use of Competitive Marksmen as Assistant Instructors

Basic Rifle Marksmanship in the U.S. Army is, of necessity, a mass production training program. The present program places a severe time limitation upon the instruction. Experiment 5 was conducted to determine whether the use of competitive marksmen rather than the present cadre as assistant instructors in the BRM program would improve marksmanship scores within the time limitations of the program. A secondary objective was to determine whether additional assistant instructors would improve training when no increase in training time was allowed.

There was no significant difference among the groups tested, either as a function of the use of experienced, competitive marksmen in place of the usual training cadre, or as a function of reducing the trainer/trainee ratio. This does not mean that experienced instructors have no value in teaching rifle marksmanship nor that the teacher/pupil ratio is of no consequence in teaching this skill. In the present program, there is only one instructor for as many as 100 men on the line.

The functions of the assistant instructors are mainly mechanical. There is neither enough time nor enough freedom for the assistant instructors to act as individual teachers. Thus, within the confines of the present program, an increase in either the quality or the quantity of assistant instructors will have little if any impact upon the quality of the instruction. Any attempt to improve the quality of the product by improving the quality and/or the quantity of the assistant instructors must begin with redesigning the format in which the instruction is given in order to allow the more experienced and/or numerous assistant instructors the time and freedom in which to operate.

Daylight Training for Night Firing

One of the most fundamental principles of learning theory is that there must be a knowledge of results in order for learning to occur. In marksmanship, this means that the man must know where the rounds that he is firing hit on and around the target in order to make corrections in his firing technique, and learn to shoot better. This becomes a serious problem at night because of the almost total elimination of visual feedback. Thus, it seems reasonable that some practice of night firing techniques in the daytime might be more beneficial than practice of the same techniques at night. Experiment 15 treated this subject.

Men trained on night firing techniques in the daytime performed considerably better on their night record fire than those trained on the same techniques for the same length of time at night ($p<.001$). This does not mean that a total elimination of night practice in favor of daylight practice would be advantageous, but it does mean that a considerable portion of the training could be held in the daytime with positive results.

Comparison of Old and New BRM Programs

The primary purpose of Experiment 16 was to furnish a "shakedown" run for the new Basic Rifle Marksmanship Program developed by the Rifle Marksmanship Evaluation Study Group.[5] However, the data derived from this trial run offer an opportunity for consideration of the total effect of the changes introduced into the program as a result of Phase 1 of the MARKSMAN research.

Comparisons of the old and the new program based upon these data must be treated with caution because:

(1) Weapons Department personnel, rather than the normal cadre, were used as instructors for the administration of the new BRM program, but the regular cadre were used in the administration of the old BRM program.

(2) The data for the old BRM program were gathered at Forts Gordon and Jackson (the only training centers which commonly used the M16 rifle at that time), while the new BRM program was administered at Fort Benning.

However, the differences between the hit probabilities achieved with the new and with the old BRM programs are sufficiently great to lend considerable support for the new program (Figures 18 and 19). Another experiment will furnish a more valid comparison. In it, the old program conducted by the regular cadre at a training center will be compared with the new program after it is installed and running.

[5] Two earlier experiments were also conducted by the MARKSMAN working group as "shakedown" runs for the new BRM program. Because of the preliminary nature of these runs, they are not reported here.

Comparison of Hit Probabilities for Old and New BRM Programs—Aimed Supported Fire: Experiment 16

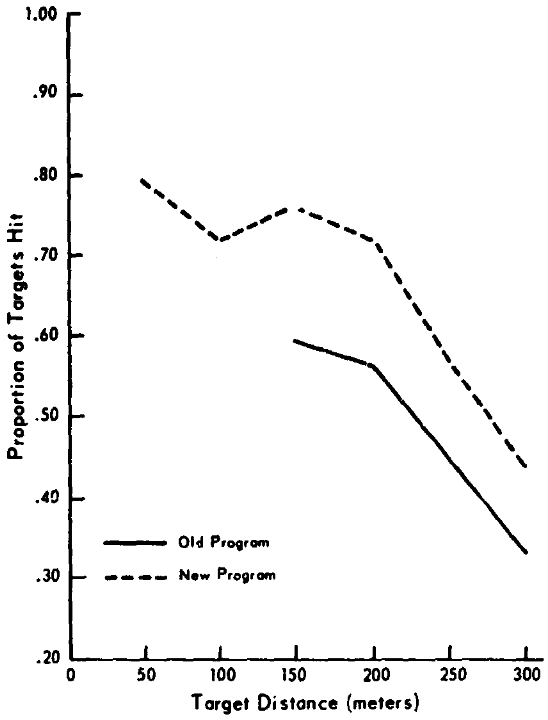

Figure 18

Comparison of Hit Probabilities for Old and New BRM Programs—Aimed Unsupported Fire: Experiment 16

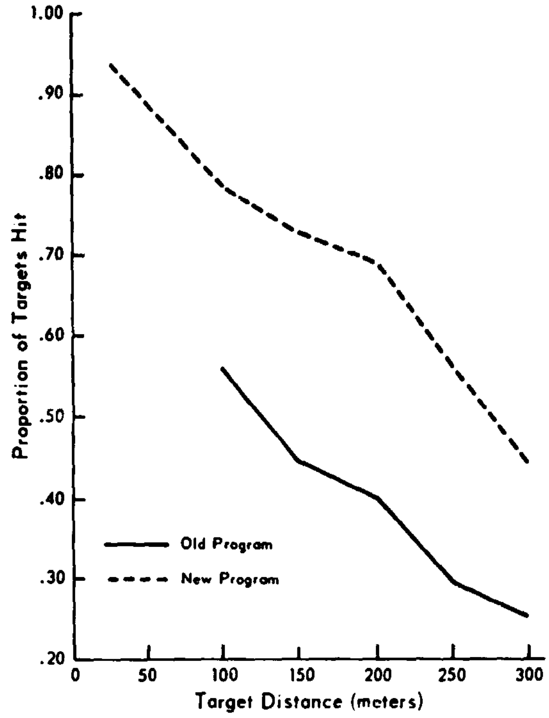

Figure 19

APPENDICES

Appendix A

EXPERIMENT 1: SEQUENCE OF QUICK-FIRE TRAINING IN BASIC RIFLE MARKSMANSHIP TRAINING

OBJECTIVE

The primary objective was to determine the proper sequencing of Quick-Fire training in the Basic Rifle Marksmanship (BRM) program. The question was "Should Quick Fire be taught early or late in BRM?"

METHOD

Subjects

Five BRM companies from Forts Jackson, Gordon, Lewis, and Bliss were selected for this experiment. The data from 2,958 men were analyzed.

Procedure

The training centers at Forts Lewis and Bliss customarily gave Quick-Fire training early in the BRM program, and at the time of this experiment were using the M14 rifle. Forts Jackson and Gordon customarily gave Quick-Fire training late in the program and used the M16 rifle. In order to eliminate any bias due to prior sequencing, the companies at each post were assigned to experimental and control groups according to the following design:

Customary Sequencing of Quick-Fire Training	Quick Fire Test	
	Early	Late
Early	A Lewis/Bliss Control	B Lewis/Bliss Experimental
Late	C Jackson/Gordon Experimental	D Jackson/Gordon Control

At each post, two BCT companies were assigned to the experimental group and two to the control group, and one was designated as a rehearsal company. The rehearsal company was used to train the cadre in the research procedure. The experimental group was the group trained in Quick Fire in a location different from the normal for that fort. This was an independent groups design.

Since the M16 rifle was not available in sufficient quantity for Forts Lewis and Bliss there was no way to completely eliminate this variable in its interactive effect. However, this should have had no impact upon the "Quick-Fire Test" main effect.

Three measures were obtained:

(1) Number of hits
(2) Number of no-fires
(3) Number of misses

Each of these three measures were obtained for:

(1) Aimed supported fire
(2) Aimed unsupported fire
(3) Quick Fire

The measures of aimed supported and aimed unsupported fire were obtained from the normal record fire in BRM. The Quick-Fire measure was obtained by the use of a special criterion test that imposed a shorter time limit.

RESULTS

Tables 1-1, 1-2, and 1-3 provide the analyses of variance tables for supported fire, unsupported fire, and Quick Fire respectively. Similarly, Table 1-4 provides the means for supported fire, unsupported fire, and Quick Fire respectively. The lack of significance in the "Quick-Fire Test" dimension for hits, misses, and no-fires for both supported fire and unsupported fire indicates that the placement of Quick-Fire training in the current BRM program in BCT has no effect upon aimed fire either in the supported or unsupported mode.

However, there was a significant difference in the "Quick-Fire Test" dimension in the Quick-Fire criterion test. Those who had Quick Fire after the regular BRM program performed better on Quick-Fire targets. While there is nothing in the experiment to indicate why this is so, it is possible that the Quick-Fire skill deteriorates rapidly, and that the relative superiority of those trained on Quick Fire late in the regular BRM program was due to their being in a more recent position on the forgetting curve. On the other hand, it is possible that the weapon familarity gained from the training on aimed fire greatly assisted in learning the Quick Fire techniques.

Table 1-1

Effects of Quick-Fire Training Sequence for Supported Fire: Analysis of Variance

Source	Number of Hits				Number of Misses				Number of No-Fires			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Quick-Fire Training Late (A)	1	0.01	<1	NS	1	6.12	1.92	NS	1	4.62	6.09	<.05
Quick-Fire Training Early (B)	1	87.92	27.71	<.001	1	193.49	60.87	.001	1	24.38	32.17	<.001
Interaction (AB)	1	0.02	<1	NS	1	6.21	1.95	NS	1	4.27	5.63	<.05
Error	2955	3.17			2955	3.18			2927	0.76		

Table 1-2

Effects of Quick-Fire Training Sequence for Unsupported Fire: Analyses of Variance

Source	Number of Hits				Number of Misses				Number of No-Fires			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Quick-Fire Training Late (A)	1	20.74	1.54	NS	1	290.90	18.51	<.001	1	12.42	3.67	NS
Quick-Fire Training Early (B)	1	979.49	72.49	<.001	1	102.61	6.53	<.05	1	1415.97	418.02	<.001
AB	1	5.28	<1	NS	1	471.55	30.01	<.001	1	70.97	20.95	<.001
Error	2981	13.51			2981	15.71			2978	3.39		

Table 1-3

Effects of Quick-Fire Training Sequence for Quick Fire: Analyses of Variance

Source	Number of Hits				Number of Misses				Number of No-Fires			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Quick-Fire Training Late (A)	1	40.34	7.50	< .01	1	26.44	6.05	.05	1	0.43	<1	NS
Quick-Fire Training Early (B)	1	8.02	1.49	NS	1	1732.01	396.26	.001	1	62.63	73.04	< .001
AB	1	75.59	14.05	< .001	1	11.14	2.55	NS	1	1.85	2.16	NS
Error	2948	5.38			2946	4.37			2943	0.86		

Table 1-4

Effects of Quick-Fire Training Sequence: Means

Customary Sequencing of Quick-Fire	Experimental Sequencing of Quick-Fire Training					
	Number of Hits		Number of Misses		Number of No-Fires	
	Early	Late	Early	Late	Early	Late
Supported Fire						
Early	3.31	3.31	4.05	4.23	0.49	0.49
Late	3.66	3.65	3.63	3.62	0.59	0.75
Unsupported Fire						
Early	8.08	8.16	11.73	10.31	0.62	0.80
Late	9.14	9.39	10.56	10.73	2.30	1.87
Quick-Fire						
Early	6.69	6.60	4.11	4.04	0.27	0.34
Late	6.47	7.03	2.70	2.38	0.61	0.59

Appendix 3

EXPERIMENT 2: EFFECT OF WEARING COMBAT EQUIPMENT DURING MARKSMANSHIP TRAINING

OBJECTIVE

In order to obtain an indication of the usefulness of wearing helmet and web gear equipment, a test of the effect upon Record Fire 1 and 2 was conducted. In the original TRAINFIRE documents, it was suggested that one means of maintaining battlefield fidelity during marksmanship training would be to have the men wear the helmet and web gear. This had not been tested. While the wearing of the equipment probably does increase battlefield fidelity, it also may create obstructions to learning in the early stages of marksmanship training. Whether the overall effect is positive or negative is an open question.

METHOD

Subjects

One-hundred-eighty-three students from two companies of troops in BCT at Fort Jackson participated.

Procedure

This was a one-dimensional, three-level test to determine whether wearing the helmet and web gear during Basic Rifle Marksmanship training had a positive effect upon training. The groups tested were:

(1) No web gear worn during training
(2) No web gear worn during the first half of training
(3) Web gear worn during the entire training period

This was an independent groups design. After the men were trained in accordance with their grouping, all of them fired for record while wearing the helmet and web gear.

RESULTS

Table 2-1 provides the analyses of variance for target hits, misses, and no fires respectively. Two men from Group 2 and four from Group 3 were eliminated at random in order to have equal numbers for the analyses. Table 2-2 provides the means for all three groups for all three criteria. There was no significant difference among the three groups for any of the three criteria.

Table 2-1

Effects of Wearing Combat Equipment During Marksmanship Training: Analyses of Variance

Source	Number of Hits				Number of Misses				Number of No-Fires			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Total	182	90.1			182	115.6			182	19.5		
Hits	2	103	1.14	NS	2	171.0	1.49	NS	2	18.0	<1	NS
Error	180	90.0			180	114.9			180	19.6		

Table 2-2

Effects of Wearing Combat Equipment During Marksmanship Training: Means

Groups	Criteria		
	Hits	Misses	No-Fires
No web gear worn during training	52.75	36.56	6.77
No web gear worn during first half of training	53.19	36.50	6.33
Web gear worn during entire training period	51.20	37.64	5.74

Appendix C

EXPERIMENT 3: EFFECTIVENESS OF THE PUPIL-COACH IN BASIC RIFLE MARKSMANSHIP TRAINING

OBJECTIVE

The primary objective of this experiment was to determine whether the pupil-coach makes a significant contribution to learning in Basic Rifle Marksmanship. The pupil-coach has been used traditionally as a teaching assistant during 25-meter firing in the BRM program. If it were to be shown that he makes no significant contribution, this student time would become available for other uses.

METHOD

Subjects

One basic combat training company of 206 men from Fort Gordon participated in the test.

Procedure

The company personnel were assigned to odd and even roster numbers. The even-roster-numbered personnel fired each of the normal 25-meter firing exercises with the assistance of a pupil-coach, and performed as pupil-coaches. The odd-roster-numbered personnel fired these exercises without a coach. All students received the same formal instructions, including instruction on coaching duties. It was explained that they were participating in a test and that only half of them would have the opportunity to act as a coach. The test criterion was performance in Record Fire 1 and 2.

RESULTS

The mean record fire scores were 49.09 for the With-Coach and 49.91 for the Without-Coach groups. Tests of significance yielded *t*s of .728, .200, and .179 for hits, misses, and no-fires, respectively. With 204 degrees of freedom, none of these is significant. Apparently, whether or not a man receives coaching from a pupil-coach on his 25-meter firing has no significant effect on his performance in Record Fire 1 and 2.

Appendix D

EXPERIMENT 4: THE DEFINITION OF THE INTERACTION OF THE FIRING POSITION, FIRING METHOD, FIRING MODE, DISTANCE, AND TYPE OF SIGHTS IN COMBAT MARKSMANSHIP

OBJECTIVE

Training in combat rifle marksmanship should be based upon a thorough knowledge of the optimal firing technique for any combat situation. The optimal technique can vary as the combat situation varies. For example, it is generally true that aimed fire is more precise than pointing, unaimed fire, but that pointing, unaimed fire has a speed advantage.

Logically, for a given target size, there should be a distance within which pointing, unaimed fire would yield a more rapid target hit, and beyond which aimed fire should yield a more rapid target hit. This experiment attempted to define that transition distance as well as the interaction of the other parameters under investigation.

METHOD

Experimental Variables

The four variables that were examined in this study, along with the levels of each, were:

A. Firing Position
  1. Prone supported
  2. Prone
  3. Kneeling supported
  4. Kneeling
  5. Standing

B. Firing Method
  1. Quick Fire
  2. Coarse aim
  3. Precision aim

C. Firing Mode
  1. Semiautomatic
  2. Automatic (three-round bursts)

D. Distance
  1. 25 meters
  2. 50 meters
  3. 75 meters
  4. 150 meters
  5. 175 meters
  6. 275 meters

All men fired all firing positions, firing modes, and designated distances. Three independent groups were required for the three firing methods. The only distinction between coarse aim and precision aim was that in coarse aim the men were told to fire as soon as the target was lined up on their sights, thereby paying less attention to the eight steady hold factors taught in marksmanship.

Subjects

Thirty subjects were used for each of the three firing methods, so that 90 men were required. Students from the Noncommissioned Officer Candidate School at Fort Benning were obtained as subjects.

Counterbalancing

Since all men were exposed to all combinations of three of the variables being studied (firing position, firing mode and distance), it was necessary that these variables be presented in a fashion that minimized any cumulative effect due to the order of presentation. The counterbalancing of four sequences of firing position and firing mode is shown in Table 4-1. Within practical limitations, distance of targets was randomized for each combination of position and mode. Also for a given mode, all of the positions were tested before the next mode was examined. Subject Number One began in Position A and Mode 1. Three target distances were presented to him once in random order. He then moved to Position B where three target distances were again presented in random order. This continued until he had fired all positions for Mode 1. He then fired Mode 2 through all positions in a similar manner.

Criteria

Three criteria were used:

(1) Time elapsed from target presentation to first hit
(2) Number of rounds fired to obtain the first hit
(3) Time per round fired

The first criterion measure is the most important, since the speed with which the enemy is hit is of primary importance. The second criterion is valuable secondary information, and the third is a good indication of ammunition usage when compared to the first two criteria.

Procedure

Each day nine different men (three from each of the three independent groups) reported to the range at 0800 hours. Each of the three-man groups received separate instruction and practice on their respective types of firing. Two hours were allocated for this instruction and zero fire. On the first day, all subjects fired the position order and mode order of Day 1 in Table 4-1. The three members of each of the independent groups fired in the same order. The order in which these groups were run was counterbalanced, again to eliminate any order effects (Table 4-2).

The experiment was run in a manner which allowed for ample rest during natural breaks. For example, on Day 1, Group 1 assumed the firing position first; they fired the semiautomatic mode first, firing the 25-, 75-, and 175-meter distances in random order for each position before proceeding to the next position. When this had been completed, they retired and the second group did the same. When all three groups had fired this combination, Group 1 moved 25 meters forward of the firing line and fired the same position order in the semiautomatic mode for the 50-, 150-, and 275-meter targets. This arrangement continued until all positions at all distances had been fired in both modes by all groups. Thus, each of three groups assumed the firing position four times. The only exception to this was the Quick-Fire group which did not fire at distances greater than 75 meters.

RESULTS

Analyses of variance were conducted on all three of the criteria for each of the six distances separately, yielding a total of 18 analyses. The conclusions drawn from these analyses are summarized in Table 4-3. The analysis of variance tables themselves are given as Tables 4-4 through 4-6. Means for the time to first hit, time per round, and rounds per target criteria are presented in Tables 4-7 through 4-9.

Quick Fire yields a significantly slower time to first hit than aimed fire at all but the 25 meter distance. At the 25 meter distance, Quick Fire was slower than aimed fire, but not significantly so. This was true in spite of the fact that Quick Fire is faster than aimed fire in time per round at all three distances tested. Thus, subjects using the Quick Fire firing method fired more rapidly with fewer hits per round, using more ammunition with less results at all ranges tested. At the intermediate ranges (150 and 175 meters), coarse aim was faster in time per round than precision aim, but was not significantly faster in time to first hit, and it did not use significantly more ammunition. Therefore, this finding is of little functional significance.

Semiautomatic fire yields a significantly faster time to first hit than automatic fire from some distance within 150 meters to all distances beyond. At no distance is automatic fire superior in time to first hit to semiautomatic fire. Naturally, automatic fire uses more ammunition with a faster time per round than semiautomatic fire.

The kneeling supported position generally yields a more rapid time to first hit out to approximately 200 meters. Beyond 200 meters the prone supported position appears to yield a more rapid target kill. The kneeling and the prone supported positions are approximately equal in ammunition expenditure per target kill.

Table 4-1

Counterbalancing of Four Sequences of Firing Position and Mode[a]

Day	Firing Position Order	Firing Mode Order
1	a b c d e	1 2
2	e d c b a	1 2
3	c b a e d	1 2
4	d e a b c	1 2
5	a b c d e	2 1
6	e d c b a	2 1
7	c b a e d	2 1
8	d e a b c	2 1
9	a b c d e	1 2
10	e d c b a	2 1

[a]Firing Position
a. Prone supported
b. Prone
c. Kneeling supported
d. Kneeling
e. Standing

Firing Mode
1. Semiautomatic
2. Two or three round burst

Table 4-2

Counterbalancing of Group Firing Order[a]

Day	Group Firing Order
1	1 2 3
2	1 3 2
3	2 1 3
4	2 3 1
5	3 1 2
6	3 2 1
7	1 2 3
8	3 2 1
9	1 2 3
10	3 2 1

[a]Firing Method:
1. Quick Fire
2. Coarse aim
3. Precision aim

Table 4-3

Summary of Tests of Significance for Conclusions, by Range [a]

Conclusions	Range (Meters)					
	25	50	75	150	175	275
1. Kneeling supported position yields most rapid time to first hit.	.001	NS	.05	.001	.05	CI
2. Quick Fire yields slower time to first hit than aimed fire.	NS	.001	.001	NA	NA	NA
3. Semiautomatic yields faster time to first hit than automatic.	NS	NS	NS	.01	.001	.001
4. Prone supported position yields fastest time to first hit.	CI	CI	CI	CI	CI	.01
5. Quick Fire faster in time per round, with coarse aim second.	.001	.001	.001	NA	NA	NA
6. Kneeling supported or unsupported gives faster time per round (supported usually faster).	.001	.05	.05	.01	NS	CI
7. Coarse aim faster than precision aim in time per round.	CI	CI	CI	.01	.01	NS
8. On semiautomatic, standing yields faster time per round; on automatic, kneeling supported does.	CI	CI	CI	CI	CI	.05
9. Automatic uses more ammunition and yields faster time per round than semiautomatic.	.001	.001	.001	.001	.001	.001
10. Quick Fire uses more ammunition than aimed fire.	.001	.001	.001	NA	NA	NA
11. Quick Fire uses proportionately more ammunition on automatic than do aimed fire methods.	.01	CI	CI	NA	NA	NA
12. Kneeling position uses less ammunition.	.05	CI	NS	.01	NS	CI
13. Prone supported position uses less ammunition, with kneeling supported second.	CI	.01	NS	CI	NS	.001
14. There is a proportionately smaller penalty for using automatic with Quick Fire than aimed fire. However, Quick Fire on automatic still uses more ammunition than aimed fire.	CI	.05	.01	NA	NA	NA

[a]On semiautomatic only: NS = Not significant
NA = Not applicable
CI = Contraindicated by another conclusion

Table 4-4

Time to First Hit by Range: Analyses of Variance

Range/Source	*df*	MS	*F*	*p*
25 Meters				
Between Subjects Analysis				
Method (A)	2	18.10	1.77	NS
Error (A)	87	10.24		
Within Subjects Analysis				
Mode (B)	1	3.07	1.21	NS
Position (C)	4	11.61	4.68	<.001
AB	2	2.20	<1	NS
AC	8	3.26	1.32	NS
BC	4	4.60	1.61	NS
ABC	8	5.55	1.95	NS
Error (B + AB)	87	2.52		
Error (C + AC)	348	2.48		
Error (BC + ABC)	348	2.85		
50 Meters				
Between Subjects Analysis				
Method (A)	2	110.93	8.40	<.001
Error (A)	87	13.20		
Within Subjects Analysis				
Mode (B)	1	0.35	<1	NS
Position (C)	4	9.70	1.86	NS
AB	2	7.93	<1	NS
AC	8	4.27	<1	NS
BC	4	2.57	<1	NS
ABC	8	8.65	1.85	NS
Error (B + AB)	87	9.65		
Error (C + AC)	348	5.16		
Error (BC + ABC)	348	4.68		
75 Meters				
Between Subjects Analysis				
Method (A)	2	507.54	13.67	<.001
Error (A)	87	37.14		
Within Subjects Analysis				
Mode (B)	1	59.55	3.85	NS
Position (C)	4	13.53	1.13	NS
AB	2	6.88	<1	NS
AC	8	7.26	<1	NS
BC	4	24.85	2.46	<.05
ABC	8	7.53	<1	NS
Error (B + AB)	87	15.47		
Error (C + AC)	348	11.96		
Error (BC + ABC)	348	10.11		

Continued

Table 4-4 *(Continued)*

Time to First Hit by Range: Analysis of Variance

Range/Source	*df*	MS	*F*	*p*
150 Meters				
Between Subjects Analysis				
Method (A)	1	251.81	3.97	NS
Error (A)	58	63.38		
Within Subjects Analysis				
Mode (B)	1	387.05	10.34	<.01
Position (C)	4	336.68	9.82	<.001
AB	1	11.07	<1	NS
AC	4	23.03	<1	NS
BC	7	18.23	<1	NS
ABC	4	55.35	2.15	NS
Error (B + AB)	58	37.42		
Error (C + AC)	232	34.30		
Error (BC + ABC)	232	25.80		
175 Meters				
Between Subjects Analysis				
Method (A)	1	11.18	<1	NS
Error (A)	58	66.14		
Within Subjects Analysis				
Mode (B)	1	423.53	15.85	<.001
Position (C)	4	83.47	3.15	<.05
AB	1	4.45	<1	NS
AC	4	25.54	<1	NS
BC	4	30.68	1.01	NS
ABC	4	9.57	<1	NS
Error (B + AB)	58	26.73		
Error (C + AC)	232	26.51		
Error (BC + ABC)	232	30.40		
275 Meters				
Between Subjects Analysis				
Method (A)	1	116.87	1.21	NS
Error (A)	58	96.43		
Within Subjects Analysis				
Mode (B)	1	865.92	16.00	<.001
Position (C)	4	204.05	4.30	<.01
AB	1	6.41	<1	NS
AC	4	24.23	<1	NS
BC	4	34.21	<1	NS
ABC	4	30.59	<1	NS
Error (B + AB)	58	54.13		
Error (C + AC)	232	47.42		
Error (BC + ABC)	232	44.93		

Table 4-5

Time per Round, by Range: Analyses of Variance

Range/Source	*df*	MS	*F*	*p*
25 Meters				
Between Subjects Analysis				
Method (A)	2	6.93	9.94	<.001
Error (A)	87	0.70		
Within Subjects Analysis				
Mode (B)	1	252.56	608.24	<.001
Position (C)	4	1.15	4.63	<.001
AB	2	1.42	3.42	<.05
AC	8	0.46	1.85	NS
BC	4	0.16	<1	NS
ABC	8	0.16	<1	NS
Error (B + AB)	87	0.42		
Error (C + AC)	348	0.25		
Error (BC + ABC)	348	0.21		
50 Meters				
Between Subjects Analysis				
Method (A)	2	21.97	19.23	<.001
Error (A)	87	1.14		
Within Subjects Analysis				
Mode (B)	1	290.41	548.24	<.001
Position (C)	4	0.59	2.38	<.05
AB	2	10.12	19.11	<.001
AC	8	0.43	1.77	NS
BC	4	0.20	<1	NS
ABC	8	0.24	1.05	NS
Error (B + AB)	87	0.53		
Error (C + AC)	348	0.25		
Error (B + ABC)	348	0.23		
75 Meters				
Between Subjects Analysis				
Method (A)	2	31.15	26.17	<.001
Error (A)	87	1.19		
Within Subjects Analysis				
Mode (B)	1	379.13	696.61	<.001
Position (C)	4	0.64	2.84	<.05
AB	2	5.44	10.00	<.001
AC	8	0.16	<1	NS
BC	4	0.71	2.58	<.05
ABC	8	0.24	<1	NS
Error (B + AB)	87	0.54		
Error (C + AC)	348	0.22		
Error (BC + ABC)	348	0.28		

(Continued)

Table 4-5 *(Continued)*

Time per Round, by Range: Analyses of Variance

Range/Source	*df*	MS	*F*	*p*
150 Meters				
Between Subjects Analysis				
Method (A)	1	32.10	9.77	<.01
Error (A)	58	3.29		
Within Subjects Analysis				
Mode (B)	1	562.70	447.86	<.001
Position (C)	4	2.18	4.13	<.01
AB	1	8.8	6.97	<.05
AC	4	0.15	<1	NS
BC	4	0.99	2.03	NS
ABC	4	0.25	<1	NS
Error (B + AB)	58	1.26		
Error (C + AC)	232	0.53		
Error (BC + ABC)	232	0.49		
175 Meters				
Between Subjects Analysis				
Method (A)	1	13.37	7.44	<.01
Error (A)	58	1.80		
Within Subjects Analysis				
Mode (B)	1	514.37	616.42	<.001
Position (C)	4	0.87	1.54	NS
AB	1	2.88	3.45	NS
AC	4	1.22	2.17	NS
BC	4	1.20	2.38	<.05
ABC	4	0.49	<1	NS
Error (B + AB)	58	0.83		
Error (C + AC)	232	0.56		
Error (BC + ABC)	232	0.50		
275 Meters				
Between Subjects Analysis				
Method (A)	1	13.39	3.05	NS
Error (A)	58	4.39		
Within Subjects Analysis				
Mode (B)	1	624.97	321.43	<.001
Position (C)	4	0.45	<1	NS
AB	1	7.11	3.66	NS
AC	4	1.20	2.40	<.05
BC	4	0.49	<1	NS
ABC	4	0.34	<1	NS
Error (B + AB)	58	1.94		
Error (C + AC)	232	0.50		
Error (BC + ABC)	232	0.52		

Table 4-6

Rounds to First Hit, by Range: Analyses of Variance

Range/Source	*df*	MS	*F*	*p*
25 Meters				
Between Subjects Analysis				
Method (A)	2	76.09	14.70	<.001
Error (A)	87	5.13		
Within Subjects Analysis				
Mode (B)	1	814.15	371.26	<.001
Position (C)	4	5.11	2.45	<.05
AB	2	15.02	6.85	<.01
AC	8	2.68	1.29	NS
BC	4	5.63	2.60	<.05
ABC	8	5.46	2.52	<.01
Error (B + AB)	87	2.19		
Error (C + AC)	348	2.08		
Error (BC + ABC)	348	2.17		
50 Meters				
Between Subjects Analysis				
Method (A)	2	333.79	31.10	<.001
Error (A)	87	10.73		
Within Subjects Analysis				
Mode (B)	1	1334.68	195.74	<.001
Position (C)	4	17.12	4.23	<.01
AB	2	29.14	4.27	<.05
AC	8	6.02	1.49	NS
BC	4	6.19	1.51	NS
ABC	8	6.28	1.54	NS
Error (B + AB)	87	6.82		
Error (C + AC)	348	4.05		
Error (BC + ABC)	348	4.09		
75 Meters				
Between Subjects Analysis				
Method (A)	2	812.71	33.29	<.001
Error (A)	87	24.41		
Within Subjects Analysis				
Mode (B)	1	2809.00	182.16	<.001
Position (C)	4	1.61	<1	NS
AB	2	75.01	4.86	<.01
AC	8	4.32	<1	NS
BC	4	3.33	<1	NS
ABC	8	6.74	<1	NS
Error (B + AB)	87	15.42		
Error (C + AC)	348	8.61		
Error (BC + ABC)	348	7.74		

(Continued)

Table 4-6 *(Continued)*

Rounds to First Hit, by Range: Analyses of Variance

Range/Source	*df*	MS	*F*	*p*
150 Meters				
Between Subjects Analysis				
Method (A)	1	0.96	<1	NS
Error (A)	58	21.59		
Within Subjects Analysis				
Mode (B)	1	4150.14	230.67	<.001
Position (C)	4	55.69	3.88	<.01
AB	1	2.16	<1	NS
AC	4	23.43	1.63	NS
BC	4	15.14	1.22	NS
ABC	4	34.25	2.76	<.05
Error (B + AB)	58	17.99		
Error (C + AC)	232	14.34		
Error (BC + ABC)	232	12.41		
175 Meters				
Between Subjects Analysis				
Method (A)	1	29.93	1.05	NS
Error (A)	58	28.42		
Within Subjects Analysis				
Mode (B)	1	4537.50	197.60	<.001
Position (C)	4	27.29	2.09	NS
AB	1	6.83	<1	NS
AC	4	5.44	<1	NS
BC	4	10.71	<1	NS
ABC	4	5.86	<1	NS
Error (B + AB)	58	22.96		
Error (C + AC)	232	13.05		
Error (BC + ABC)	232	14.15		
275 Meters				
Between Subjects Analysis				
Method (A)	1	17.34	<1	NS
Error (A)	58	30.49		
Within Subjects Analysis				
Mode (B)	1	7518.96	319.30	<.001
Position (C)	4	83.83	5.12	<.001
AB	1	5.23	<1	NS
AC	4	10.59	<1	NS
BC	4	23.12	1.35	NS
ABC	4	11.61	<1	NS
Error (B + AB)	58	23.55		
Error (C + AC)	232	16.38		
Error (BC + ABC)	232	17.16		

Table 4-7

Time to First Hit, by Firing Position, Method, and Mode
(seconds)

Position	Quick Fire		Coarse Aim		Precision Aim	
	Semiautomatic	Automatic	Semiautomatic	Automatic	Semiautomatic	Automatic
Standing						
25-75 meters	4.06	4.71	3.05	3.28	3.04	3.16
150-275 meters	NA	NA	8.30	8.92	8.96	9.71
Kneeling Supported						
25-75 meters	3.63	4.42	3.52	3.79	2.81	2.86
150-275 meters	NA	NA	5.95	8.01	6.99	8.71
Kneeling						
25-75 meters	4.04	4.25	2.82	3.10	3.02	3.28
150-275 meters	NA	NA	6.55	9.31	7.67	8.81
Prone-Supported						
25-75 meters	5.15	4.08	3.26	3.36	3.31	3.34
150-275	NA	NA	6.85	8.67	7.33	9.58
Prone						
25-75 meters	4.56	4.37	3.02	2.94	3.09	3.23
150-275 meters	NA	NA	8.13	9.95	9.29	13.30

Table 4-8

Time per Round, by Firing Position, Method, and Mode
(seconds)

Position	Quick Fire		Coarse Aim		Precision Aim	
	Semiautomatic	Automatic	Semiautomatic	Automatic	Semiautomatic	Automatic
Standing						
25-75 meters	1.63	.71	2.13	.86	2.34	.83
150-275 meters	NA	NA	2.83	1.07	3.55	1.23
Kneeling Supported						
25-75 meters	1.65	.79	2.04	.81	2.23	.96
150-275 meters	NA	NA	2.87	1.15	3.24	1.25
Kneeling						
25-75 meters	1.53	.68	2.09	.96	2.25	1.00
150-275 meters	NA	NA	2.74	1.06	3.39	1.31
Prone Supported						
25-75 meters	1.69	.76	2.28	.98	2.25	1.06
150-275 meters	NA	NA	3.08	1.28	3.45	1.33
Prone						
25-75 meters	1.62	.77	2.19	.95	2.44	1.01
150-275 meters	NA	NA	2.90	1.15	3.55	1.36

Table 4-9

Rounds per Hit, by Firing Position, Method, and Mode

Position	Quick Fire		Coarse Aim		Precision Aim	
	Semiautomatic	Automatic	Semiautomatic	Automatic	Semiautomatic	Automatic
Standing						
25-75 meters	2.70	6.71	1.42	4.00	1.36	3.71
150-275 meters	NA	NA	2.84	9.09	2.67	8.39
Kneeling Supported						
25-75 meters	2.26	5.87	1.37	3.78	1.24	3.21
150-275 meters	NA	NA	2.39	8.28	2.14	7.37
Kneeling						
25-75 meters	2.58	5.96	1.34	3.47	1.35	3.70
150-275 meters	NA	NA	2.30	8.83	2.18	7.49
Prone Supported						
25-75 meters	2.87	5.39	1.40	3.78	1.36	3.34
150-275 meters	NA	NA	2.24	7.58	2.16	7.44
Prone						
25-75 meters	2.66	6.03	1.38	3.51	1.21	3.36
150-275 meters	NA	NA	2.75	8.94	2.67	10.39

Appendix E

EXPERIMENT 5: EVALUATION OF THE USE OF COMPETITIVE MARKSMEN AS ASSISTANT INSTRUCTORS IN BASIC RIFLE MARKSMANSHIP

OBJECTIVE

Basic rifle marksmanship in the U.S. Army is, of necessity, a mass-production training program. The present program places a severe time limitation upon the instruction. The objective of this experiment was to determine whether the use of competitive marksmen rather than the cadre, as at present, as assistant instructors in the BRM program would improve marksmanship within the time limitations of the program. A secondary objective was to determine whether additional assistant instructors would improve training when no increase in training time was allowed.

METHOD

Experimental Variables

This was an independent groups design. The variables studied in this experiment were:

A. Assistant Instructors (AI)
   1. Competitive marksmen
   2. Company cadre

B. Ratio of AIs to Trainees
   1. 1/15
   2. 1/10
   3. 1/5

Subjects

Three basic trainee companies, of 200 men each, from Fort Gordon were used as subjects. The division of these three companies into experimental groups is presented in Table 5-1. Since the number of groups for each trainer/trainee ratio was held constant, the numbers of men in each group were different.

Procedures

The experiment was conducted during periods 5 through 10 and period 15 of BRM according to Army Subject Schedule 23-71.[1] The following regulations were established for the conduct of the test:

(1) The groups having competitive marksmen as trainers all fired from the left-hand side of the range. Those having company cadre trainers all fired from the right-hand side of the range.

[1] Department of the Army, *Rifle Marksmanship*, Army Subject Schedule (ASubjScd) 23-71, Washington, 20 October 1966, (with Changes 1, 2, and 3).

(2) Five competitive marksmen and five company cadre were used as assistant instructors. Within these two groups, the assistant instructors were rotated so that the same subgroup was taught by the same assistant instructor once every five periods.

(3) There were 100 firing points on the range. Each company was divided into two firing orders, and each firing order contained one-half of that company's allotment of each subgroup, making a total of six firing orders.

(4) All lecturing instruction was presented by the Army Training Center Committee Group.

RESULTS

These data were amenable to a two-by-three-way analysis of variance with independent groups having proportional but unequal numbers of subjects per group. Three such analyses would have been required, one each for the hits, miss, and no-fire criteria. However, since analysis time was at a premium, the number of subjects was reduced to 50 per group by the random elimination of subjects from the larger groups. An analysis of variance was then conducted on the hit criterion. The summary table for that analysis is given in Table 5-2, while the means are presented in Table 5-3. It was concluded that, under the pressure of the time restrictions imposed by the present BRM course, neither an increase in the experience of the assistant instructors nor an increase in their number had a significant impact upon marksmanship scores.

Table 5-1

Number of Experimental Groups per Company

Trainee Company	Assistant Instructors					
	Competitive Marksmen			Company Cadre		
	Trainer-Trainee Ratio			Trainer-Trainee Ratio		
	1/15	1/10	1/5	1/15	1/10	1/5
1	4	2	4	4	2	4
2	4	2	4	4	2	4
3	2	6	2	2	6	2

Table 5-2

Effects of Use of Assistant Instructors:
Analysis of Variance

Source	*df*	*MS*	*F*	*p*
Trainer-Trainee Ratio	2	37.81	<1	NS
Instructors	1	36.75	<1	NS
Interaction	2	18.56	<1	NS
Error	289	76.96		

Table 5-3

Effects of Use of Assistant Instructors:
Group Means for Hits

Trainer-Trainee Ratio	Assistant Instructors	
	Marksmanship Training Unit (MTU)	Cadre
1/15	40.14	39.36
1/10	41.48	40.06
1/5	39.66	39.86

Appendix F

EXPERIMENT 6: EFFECT OF ADDITIONAL BB GUN TRAINING ON NIGHT FIRING

OBJECTIVES

The primary objective of this experiment was to assess the value of providing a one-hour, night practice period with the standard air rifle at miniature ground targets prior to night record fire. The effect of placing white tape longitudinally along the barrel as a field-expedient visual aid, and the relative merit of the kneeling unsupported and prone supported positions were also studied.

METHOD

Experimental Variables

This was a three-dimensional, two-by-two-by-two, independent groups design. The three dimensions and treatments within each were:

A. Tape
  1. Present
  2. Absent

B. Position
  1. Kneeling unsupported
  2. Prone supported

C. Extra BB Gun Practice
  1. Present
  2. Absent

Subjects

The members of one BCT company (192 trainees) from the Infantry Training Center at Fort Jackson were used as subjects. This provided 24 men for each of the eight combinations of experiment conditions.

Procedures

This experiment was conducted completely within Basic Rifle Marksmanship Period 20 according to training text 23-71-1, with these modifications:

(1) The class on principles and techniques used during periods of limited visibility was taught during daylight hours immediately preceding night firing.

(2) Those men who received extra BB gun training were allowed to practice with the BB gun for one hour, using no more than eight magazines of 30 BBs each. This practical exercise was conducted after the end of evening nautical twilight. The air rifle firing was conducted using standard, miniature ground targets at ranges of five meters or less, as the limit of visibility dictated.

In order to assist the firer in determining the effectiveness of his shots, a piece of wood was placed immediately beneath the targets in such a manner that a low shot produced a clearly audible sound. The standard targets were small metal silhouettes that produced a distinctly different sound when struck by a BB.

(3) The service weapon night firing was conducted immediately following the air rifle refresher. E-type silhouette targets at 25- and 50-meter ranges were used. The targets were painted flat black to increase their contrast with the ambient environment. The experiment was conducted on a standard, night firing range with 100 firing points. Half of the men fired in each of two firing orders.

The eight experiment groups were equally represented in both of the firing orders. Those who had received BB gun practice with tape on the barrel on the BB gun fired the service weapon with tape on its barrel. Half of those who did not receive any extra BB gun training fired the service weapon with the tape placed on the barrel, and half fired without the tape. The tape used was white, one-half inch wide, and ran from the base of the carrying handle to the top of the front sight on the M16 rifle. The test was conducted on a moonless night. Each man fired eight rounds for practice and eight rounds for record at each target.

RESULTS

The analyses of variance summary for the total hits at the 25- and 50-meter targets are presented in Table 6-1. The mean number of hits at the 50-meter target are shown in Table 6-2.

Apparently at 25 meters the target is sufficiently easy to hit that none of the variables have an appreciable effect. The following comments apply only to the 50-meter distance:

(1) The prone position was generally the more effective of the two positions tested. It should be remembered, however, that the prone position was supported, whereas the kneeling position was unsupported. Thus, the position difference could be due either to the difference between the two positions, or to the difference in the use of support.

(2) The kneeling position without tape was more effective than the prone supported position with tape. The prone supported position without tape was more effective than the kneeling position with tape. The use of tape was not in itself significant.

(3) Since the group that received additional BB gun practice without the tape was superior to those who received the practice with tape, and since those who did not receive the BB gun practice but used the tape during record fire were superior to those who did not receive the BB gun practice and did not use the tape in the record fire, it appears that night training with the BB gun is best conducted without the tape, but is of little value in any event.

In the absence of night training with a BB gun, the use of tape on the service weapon improves performance. By way of explanation, the use of the BB gun requires a substantial correction in elevation to account for the trajectory of the BB. The use of tape on the BB gun probably increases the ability to make this correction. Training in such an elevation correction would have a detrimental effect if transferred to the service weapon. However, if the tape is not used in the early BB gun practice, its use with the service weapon is an effective field expedient.

Apparently, night firing with the BB gun is of no benefit. The use of tape on the BB gun then becomes a moot question. On the other hand, although it is apparent that night practice with the tape on the BB gun is detrimental to performance, it is probable that the use of tape on the service weapon at night is of some assistance, at least in the kneeling position.

Table 6-1

Effects of BB Gun Practice at Night on Total Hits, by Range: Analyses of Variance

Range/Source	*df*	*MS*	*F*	*p*
25 Meters				
Tape (A)	1	14.63	2.40	NS
Position (B)	1	1.17	<1	NS
BB Gun Practice (C)	1	2.76	<1	NS
AB	1	9.63	1.58	NS
AC	1	22.01	3.62	NS
BC	1	10.55	1.73	NS
ABC	1	0.63	<1	NS
Error	184	6.08		
50 Meters				
Tape (A)	1	7.93	2.92	NS
Position (B)	1	29.30	10.78	<.01
BB Gun Practice (C)	1	9.63	3.54	NS
AB	1	45.05	16.58	<.001
AC	1	11.51	4.23	<.05
BC	1	4.38	<1	NS
ABC	1	59.53	21.90	<.001
Error	184	2.72		

Table 6-2

Effects of BB Gun Practice at Night: Mean Hits at 50 Meters

Position	Extra BB Practice at Night		No Practice	
	Received Practice			
	Used Tape	No Tape	Used Tape	No Tape
Kneeling Unsupported	3.12	3.79	3.46	3.00
Prone Supported	2.25	4.04	3.74	3.95

Appendix G

EXPERIMENT 7: CENTER OF MASS VS. ADJUSTED AIMING POINT

OBJECTIVE

Soldiers firing the M14 rifle with a 250 meter battle sight zero are instructed to aim below the center of mass for any targets less than 200 meters, and to aim at the center of mass for targets beyond 200 meters. Since most combat targets are within 200 meters, this means that most combat shots are fired aiming at the low center of mass. This adjusted aiming point technique is necessary for the M14 rifle because of the trajectory of that weapon. However, the M16 rifle, with a higher muzzle velocity, has a flatter trajectory. It seems plausible that the soldier might be able to fire at a center of mass aiming point for all targets within 300 meters.

METHOD

Approach

This problem was attacked in two ways. First, trajectory data on the M16 rifle, obtained from the Aberdeen Proving Ground, were plotted to ascertain the point of impact predicted by the trajectory on a man-size target at each of 11 distances ranging from approximately 25 to 300 meters. Second, an experiment was conducted to determine whether the use of either of these aiming systems would make any difference in firing ability as measured by performance on a record fire course.

It was recognized that the men would be very resistant to continuing to use an aiming point that they knew would cause them to miss the target. Therefore it was expected that the majority would, consciously or subconsciously, readjust their aiming point so that they would hit the target. However, since the determination of no significant difference would allow the choice of the simpler of the two aiming techniques, and since this would lend concrete support to the result of a theoretical analysis, the experiment was conducted.

Experimental Variables

Five variables were examined:

- A. Aiming Technique
  - 1. Center of mass
  - 2. Adjusted aiming point
- B. Weapon
  - 1. M14
  - 2. M16
- C. Target Size
  - 1. F silhouette
  - 2. E silhouette
  - 3. M silhouette

D. Target Distance
   1. 25 meters
   2. 50 meters
   3. 75 meters
   4. 150 meters
   5. 175 meters
   6. 275 meters
   7. 300 meters

E. Position
   1. Standing supported
   2. Kneeling supported
   3. Prone supported

Independent groups of subjects were used for the four combinations of aiming technique and weapon. All other variables were repeated across subjects.

Subjects

A total of 96 students entering the Noncommissioned Officer Candidate School at Fort Benning were used as subjects.

Apparatus

The equipment used in Experiment 4 was used for this study. In addition, F-, E-, and M-type silhouettes were situated on a three-lane range, as shown in Table 7-1. Three firing lanes were used. Two firing lines, one at the zero and one at the 25-meter point, were used to reduce the total number of targets required.

Procedure

An outline of the experiment is presented in Table 7-2. The three types of silhouettes were positioned on the three firing lanes in such a way that a man firing the three lanes in succession would fire all combinations of silhouette and range. The subjects fired in three-man orders. Position, subject number, and type silhouette were counterbalanced. The counterbalancing of Order 1 on Day 1 is given in Table 7-3. This general counterbalancing procedure was followed throughout. The order of presentation of range was randomized. In addition, the second firing line was fired first every other day.

RESULTS

It was concluded, from the data, that there probably would be no significant difference in the most important experimental dimension—aiming technique. The primary interest in the other variables concerned their interaction with aiming technique. It was decided to compute only a single analysis of variance on one target distance to verify the visual conclusion of no significant differences. This analysis of variance for the 25-meter distance is given in Table 7-4. The mean number of hits at 25 meters, by target and weapon, and by position and aim technique, is shown in Tables 7-5 and 7-6. Although there are significant differences between the M14 and M16 rifles and among the three positions tested, there was no significant difference between the two aiming techniques, or in any of the interactions of the other variables with aiming technique.

Table 7-1

Placement of Silhouettes on Range

Distances (meters)		Targets		
Firing Line 1	Firing Line 2	Lane 1	Lane 2	Lane 3
300	275	F	E	M
175	150	M	F	E
75	50	E	M	F
25		F	E	M

Table 7-2

Outline of Experiment

Order Number	Firing Line	Method of Aiming	Weapon	Ranges (meters)	Number of Targets
1	1	Center	M16	25, 75, 175, 300	36
2	1	Adjusted	M16	25, 75, 175, 300	36
3	1	Center	M14	25, 75, 175, 300	36
4	1	Adjusted	M14	25, 75, 175, 300	36
5	2	Center	M16	50, 150, 275	27
6	2	Adjusted	M16	50, 150, 275	27
7	2	Center	M14	50, 150, 275	27
8	2	Adjusted	M14	50, 150, 275	27

Table 7-3

Example of Sequence of Firing for Days 1 and 5[a]

Order Number	Subjects	Firing Line	Position	Range (meters)	Subject and Type of Target		
					Lane 1	Lane 2	Lane 3
1	1-3	1st	A	25	1F	2E	3M
				75	1E	2M	3F
				175	1M	2F	3E
				300	1F	2E	3M
			B	25	1F	2E	3M
				75	1E	2M	3F
				175	1M	2F	3E
				300	1F	2E	3M
			C	25	1F	2E	3M
				75	1E	2M	3F
				175	1M	2F	3E
				300	1F	2E	3M

[a]Sequence of Orders Varied Daily.

Table 7-4

Effects of Aiming Point Techniques on Number of Hits at 25 Meters: Analyses of Variance

Source	*df*	*MS*	*F*	*p*
Between Subjects	95			
Aiming technique (A)	1	3.01	<1	NS
Weapon (B)	1	176.95	43.05	<.01
AB	1	0.19	<1	NS
Error AB	92	4.11		
Within Subjects	768			
Target size (C)	2	29.96	16.93	<.01
AC	2	0.20	<1	NS
BC	2	5.44	3.07	<.05
ABC	2	0.24	<1	NS
Error C	184	1.77		
Position (D)	2	11.19	13.01	<.01
AD	2	2.51	2.92	NS
BD	2	5.63	6.55	<.01
ABD	2	1.19	1.38	NS
Error D	184	0.86		
CD	4	1.60	2.46	<.05
ACD	4	0.41	<1	NS
BCD	4	1.42	2.18	NS
ABCD	4	1.57	2.42	<.05
Error CD	368	0.65		

Table 7-5

Mean Number of Hits, By Target and Weapon
(25 meter distance only)

Weapon	Target			Mean
	F	E	M	
M14	4.37	5.23	4.60	4.73
M16	5.40	5.82	5.70	5.64
Mean	4.88	5.52	5.15	5.19

Table 7-6

Mean Number of Hits, By Position and Aiming Technique
(25 meter distance only)

Aiming Technique	Position			Mean
	Standing Supported	Kneeling Supported	Prone Supported	
Center of Mass	5.48	5.16	5.10	5.25
Adjusted Aiming Point	5.26	5.26	4.86	5.13
Mean	5.37	5.21	4.98	5.19

Appendix H

EXPERIMENT 8: OPTICALLY PRODUCED ZERO VS. PERSONAL ZERO

OBJECTIVE

The objective of this experiment was to compare a collimator produced zero with the personal zero. A true zero is the calibration of the sights on a weapon so that when they are aligned with a target at a specified range, with a specified ammunition, the round fired hits the aiming point within the margin of error for the weapon. It has been commonly believed that a weapon should not be fired with a true zero, but should be zeroed by the individual doing the shooting. According to this philosophy, the individual eccentricities in sight alignment would be eliminated by correcting the sight for the individual doing the firing.

There is considerable logic in opposition to this point of view. The man who consistently makes an error in sight alignment can eliminate this error if the sights are zeroed perfectly and, through firing, he notices his error. However, when a man is allowed to introduce an error into the zeroing of his weapon, learning to correct for this error becomes impossible because an accurate sight alignment will yield an inaccurate shot. It is more difficult to maintain a consistent sight alignment when the "correct" sight alignment is off center. Therefore, it would seem better to train a man to shoot with a weapon that is accurately zeroed before teaching the man to zero the weapon. The present system of training the man to zero the weapon before training him to shoot with it would seem to insure that inaccuracies in sight alignment existing when the training begins will have a negative effect upon the course of the training.

Probably the main reason why trainees have not been furnished accurately prezeroed weapons in the past is the difficulty of mass producing accurate zeros. If a weapon could be accurately prezeroed using a mechanical and/or optical device requiring a minimum amount of time and money, it would then be feasible to teach the soldier to shoot before he is taught to zero the weapon. This should make the training easier and save in ammunition required for zeroing. The optical collimator is potentially such a device. The collimator is inserted into the muzzle of the weapon. Looking through the sights, a target is seen. In centering this target in these sights, the alignment of the sights is parallel to the barrel of the weapon. The windage at this point is correct. The correction of a set number of clicks in elevation, or the alignment of the sights to a compensatory mark on the collimator will zero the weapon in elevation for a given range.

METHOD

Experimental Variables

This was a two-dimensional experiment design with these variables:

A. Type of Zero
   1. Personal zero
   2. Collimator zero with three-round correction
   3. Collimator zero alone

B. Distance
   1. 50 meters
   2. 100 meters
   3. 150 meters
   4. 200 meters

Subjects

Two tests were run. One test used 12 shooters obtained from the U.S. Army Marksmanship Training Unit as subjects, and was a subjects-by-treatment design. The second test used 54 men from the Noncommissioned Officer Candidate School at Fort Benning. This was an independent groups design.

Procedure

The test was a simple comparison of the record fire scores achieved on the standard, basic rifle marksmanship, record fire II course. Those men firing the personal zero determined their own 250 meter battle sight zero by firing the standard zeroing technique as defined in paragraph 18 of Field Manual 23 71.[1] These subjects were allowed nine rounds to zero their weapons. All collimator zeroed weapons were zeroed by the individual doing the firing with supervision from Army Marksmanship Training Unit personnel. In those cases where the final three-round shot group was allowed for correction, the individual shooters fired their own shot groups.

"E" type silhouettes were used as targets, with the center of mass used as the aiming point. The "L" sight was not used since no targets beyond 300 meters were encountered. The presentation of the target distances was randomized. For the men from the Marksmanship Training Unit, all target distances were fired for a given zeroing of the weapon before going on to a weapon with a different zero.

Each of the MTU subjects was assigned to one of the following presentation orders:

1. a c b
2. b a c
3. c b a

These subjects fired all of the conditions in one day. After completing the firing of the first weapon, each order retired. Thus, the orders were rotated through the firing line three times, once for each zero. Two days were required for this phase of the experiment. Six men fired at a time. Eight firing lanes were used. As each six-man order returned to the firing line for their second and third presentation, each man shifted one space to the right. Each six-man order was composed of three pairs of men firing different weapon zeros on a given firing presentation. The subjects zeroed their weapons in the order in which they were fired.

Three days were used to fire the NCOC students in the experiment. Six subjects per day fired each of the three experiment conditions for a total of 18 subjects per day in the experiment. Six firing lanes were used. Two subjects for each of the three experiment groups were on line simultaneously. As this was an independent groups design, each subject fired only one of the zero conditions.

Both the MTU and NCOC subjects received verbal instruction on zeroing procedures. Experienced coaches from the Marksmanship Training Unit supervised the zeroing of the weapons. All subjects fired in the semiautomatic mode, using the M16 rifle.

[1] Department of the Army. *Rifle Marksmanship*, Field Manual (FM) 23-71, Washington, December 1966.

RESULTS

The mean number of hits on 9 target exposures for the Marksmanship Training Unit (MTU) subjects and the Noncommissioned Officer Candidates (NCOC) subjects, are presented in Tables 8-1 and 8-2 respectively. Within the two subject groups, analyses of variance were conducted separately on the hit data for each of the four distances. Summaries of the analyses of variance for the MTU personnel are provided in Table 8-3. The same information for the NCOC students is presented in Table 8-4. None of the analyses of the NCOC subjects was significant. For the MTU subjects, the 150- and 200-meter distances achieved statistical significance ($p<.01$ and $p<.05$ respectively), due primarily to the inferiority of the collimator zero when the three-round correction was not fired. Apparently, the collimator-produced zero is equal, but not superior to, the standard personal zero when three rounds are allowed for a final correction.

Table 8-1

Mean Number of Hits on Nine Target Exposures for MTU Subjects, by Type of Zero

Distance (Meters)	Experimental Group			
	Personal Zero	Collimator Zero with Three Rounds	Collimator Zero	Mean
50	8.92	8.92	9.00	8.94
100	8.58	8.83	8.00	8.47
150	8.33	8.50	5.00	7.28
200	6.25	7.58	3.83	5.89
Mean	8.02	8.46	6.46	7.65

Table 8-2

Mean Number of Hits on Nine Target Exposures for NCOC Subjects, by Type of Zero

Distance (Meters)	Experimental Group			
	Personal Zero	Collimator Zero with Three Rounds	Collimator Zero	Mean
50	8.67	8.78	8.50	8.65
100	7.39	7.22	6.80	7.17
150	6.50	5.44	5.17	5.70
200	4.44	5.17	3.89	4.50
Mean	6.75	6.65	6.11	6.50

Table 8-3

Effects of Type of Zero on MTU Subjects, by Range: Analyses of Variance

Range/Source	*df*	*MS*	*F*	*p*
50 Meters				
Subjects	11	0.05		
Treatments (A)	2	0.03	<1	NS
Error	22	0.06		
100 Meters				
Subjects	11	0.94		
Treatment (A)	2	2.19	1.84	NS
Error	22	1.19		
150 Meters				
Subjects	11	6.35		
Treatments (A)	2	46.78	8.74	<.01
Error	22	5.35		
200 Meters				
Subjects	11	3.84		
Treatments (A)	2	43.36	5.59	<.05
Error	22	7.76		

Table 8-4

Effects of Type of Zero on NCOC Subjects, by Range: Analyses of Variance

Range/Source	*df*	*MS*	*F*	*p*
50 Meters				
Treatments (A)	2	0.35	<1	NS
Days (B)	1	0.91	2.08	NS
Error	48	0.44		
100 Meters				
Treatments (A)	2	1.17	<1	NS
Days (B)	1	0.02	<1	NS
Error	48	3.45		
150 Meters				
Treatments (A)	2	8.91	1.53	NS
Days (B)	1	8.96	1.54	NS
Error	48	5.81		
200 Meters				
Treatments (A)	2	7.39	1.65	NS
Days (B)	1	0.46	<1	NS
Error	48	4.47		

Appendix I

EXPERIMENT 9: SEMIAUTOMATIC VS. AUTOMATIC FIRE AT NIGHT

OBJECTIVE

In Experiment 4 it was concluded that semiautomatic fire was superior to automatic fire against visible point targets in the daytime. It was considered possible that this might be reversed against visible point targets at night. At night and under other limited visibility conditions, the target is sufficiently indistinct and the alignment of the sights is sufficiently difficult that simply increasing the dispersion and number of rounds fired by using automatic fire could increase the probability of a hit.

Informal contacts with the U.S. Army Infantry Board provided assurance that their recent study had established the three-round burst as the optimal burst size for automatic fire with the M16 rifle, so this study of automatic fire was limited to the three-round burst. However, although three rounds is the ideal, the actual average burst size varies considerably from one individual to another.

METHOD

Experimental Variables

This was an incomplete factorial subjects-by-treatments design, studying four dimensions:

- A. Mode of Fire
  1. Semiautomatic
  2. Automatic
- B. Distance
  1. 25 meters
  2. 50 meters
  3. 75 meters
- C. Muzzle Flash
  1. Silhouette (Non-flashing)
  2. Flashing
- D. Position
  1. Prone
  2. Prone supported
  3. Prone with bipod

Those combinations of B and C which were examined are:

- A. 25-meter silhouette
- B. 50-meter silhouette
- C. 50-meter flashing
- D. 75-meter flashing

Two combinations of variables B and C were not examined. The illumination level was starlight (no moon).

Subjects

Subjects were 48 entering students from the Noncommissioned Officer Candidate School at Fort Benning.

Apparatus

Three firing lanes were used. "E" type silhouettes were placed at 25 and 75 meters. Flashers were positioned at about breastplate height on the 75-meter silhouettes. The XM31 flashing target display was used.[1] Two firing lines were used. At the zero-point firing line, the men fired at the 25-meter silhouette and the 75-meter flashing targets. At a second firing line, 25 meters down range, the men fired at the 75-meter target in both the flashing and non-flashing modes. This provided a 50-meter flashing and a 50-meter non-flashing target.

Procedure

A counterbalancing of the order or presentation of the firing mode, firing position, and firing line is presented in Table 9-1. The order of target presentation was randomized. Each man fired twice, once for each mode. While on the firing line he fired at both targets before changing positions and fired from all three positions before changing firing lines. After firing at all targets in all positions from both firing lines in one mode of fire the subjects retired from the firing line. He was recalled to the firing line to fire the second mode in all combinations of all of the conditions in the same order as before except that the targets were randomized. Twelve subjects are shown in Table 9-1 because 12 are required for complete counterbalancing. Three men were on the firing line at a time, and fired in succession according to the combination of conditions designated for each.

RESULTS

Time to first hit and time per round proved to be meaningless criteria because of the large number of cases where the subject never hit the target on a given combination of conditions. The chi square statistic was used to analyze total hits. As indicated in Table 9-2, the automatic mode of fire achieved more hits than did the semiautomatic mode ($p < .001$). In addition, the automatic mode was proportionately better at the closer target ($p < .01$). The majority of the subjects did not achieve a hit with a full magazine (6 rounds of semiautomatic and 18 rounds for automatic) at the 75 meter flashing target. Similarly, the majority firing in the semiautomatic mode did not achieve a hit at the 50-meter silhouette and flashing targets.

It would appear that the automatic mode is superior to the semiautomatic mode for firing out to 50 meters. The only possible criticism of this is that the semiautomatic mode was limited to one-third of the ammunition allotted to the automatic mode. Had the semiautomatic mode been allotted the same amount of ammunition as the automatic mode, those individuals firing the semiautomatic mode could have continued to fire for some time after those firing the automatic mode would have been out of ammunition.

An examination of the results for the 50 meter silhouette and 50 meter flashing targets shows that the flashing target is easier to hit ($p < .01$). There was no significant difference among the three firing positions. Table 9-3 provides the mean number of bursts and rounds of ammunition used as a function of target and mode. From this it can

[1] Federal stock number 6920-678-8478.

be seen that the mean number of bursts on automatic was no more than the mean number of rounds on semiautomatic.

The mean time per round on semiautomatic, and per burst on automatic are presented in Table 9-4. Automatic fire achieved more hits than semiautomatic fire while requiring no more trigger pulls and no more time per trigger pull (Tables 9-2, 9-3, 9-4). The conclusion must be that in a time critical situation at night, automatic fire using the three round burst is more likely to achieve a hit than semiautomatic fire.

Naturally, automatic fire requires more ammunition than does semiautomatic fire. The special conditions of this study preclude using the ammunition expenditure for this study as a guide to ammunition requirements in combat. However, Table 9-5 furnishes the mean number of bursts, ammunition expended per target, and burst size for automatic fire. The mean burst size used in the study was 2.82 rounds per burst. It is probably safe to say that using a three-round burst of automatic fire at night, the rate of ammunition expenditure will probably be about 2.8 times what it would be with semiautomatic fire. However, the number of hits will also be substantially greater using automatic fire.

Table 9-1

Counterbalancing of Firing Mode, Firing Position, and Firing Line

Subject	Firing Mode	Firing Position	Firing Line
1	a b	a b c	a b
2	a b	a c b	a b
3	a b	b a c	a b
4	b a	b c a	a b
5	b a	c a b	a b
6	b a	c b a	a b
7	a b	a b c	b a
8	a b	a c b	b a
9	a b	b a c	b a
10	b a	b c a	b a
11	b a	c a b	b a
12	b a	c b a	b a

Table 9-2

Probability of Hit for a Given Magazine of Ammunition[a]

Target	Mode of Fire	
	Semiautomatic	Automatic
25-Meter Silhouette	.84	.97
50-Meter Silhouette	.31	.51
50-Meter Flashing	.29	.69
75-Meter Flashing	.21	.28

Testing: Semiautomatic vs. Automatic $X^2 = 22.02$ $df = 1$ $p < .001$
Testing: Mode/Target Interaction $X^2 = 12.00$ $df = 3$ $p < .01$
Testing: 50-Meter Flashing vs. Silhouette $X^2 = 8.32$ $df = 1$ $p < .01$

[a]Because the analysis is based on hits, and individuals had more than one hit, chi square (X^2), which assumes independence of observations, is technically not completely valid. In this instance, the effects of violating the independence assumption are of no consequence since they lead to a conservative statistical test.

Table 9-3

Mean Number of Bursts and Rounds of Ammunition Used as a Function of Target and Mode

Target	Mode of Fire		
	Semiautomatic	Rounds on Automatic	Bursts on Automatic
25-Meter Silhouette	2.59	5.70	1.99
50-Meter Silhouette	5.15	13.20	4.67
50-Meter Flashing	5.13	11.60	4.18
75-Meter Flashing	5.40	15.60	5.54

Table 9-4

Mean Time Per Round on Semiautomatic and Per Burst on Automatic
(seconds)

Target	Mode of Fire	
	Semiautomatic	Automatic
25-Meter Silhouette	3.36	3.53
50-Meter Silhouette	4.04	3.86
50-Meter Flashing	3.60	3.54
75-Meter Flashing	3.70	3.82

Table 9-5

Mean Number of Bursts, Ammunition Expended per Target, and Burst Size for Automatic Fire

Target	Mean Number of Bursts	Mean Number of Rounds	Mean Burst Size
25-Meter Silhouette	1.99	5.70	2.87
50-Meter Silhouette	4.67	13.20	2.82
50-Meter Flashing	4.18	11.60	2.78
75-Meter Flashing	5.54	15.60	2.82

Appendix J

EXPERIMENT 10: VISION TECHNIQUE, SIGHT, MODE, AND POSITION FOR USE IN NIGHT FIRE

OBJECTIVE

The primary objective of this study was to determine whether the British night firing system, including the Tri-Lux sight, is superior to the American night firing system. A secondary objective was to determine whether semiautomatic or automatic fire is superior at night.

The British system of night firing is an aiming technique that relies upon a large-aperture rear sight, and a luminous front sight. The American system of night fire is an unaimed, pointing technique that does not use the sights at all.

METHOD

Experimental Variables

The following variables, along with the levels listed, were examined:

- A. Night Vision Technique
  1. Off-center alignment
  2. Direct alignment
- B. Sight
  1. Tri-Lux
  2. Tri-Lux front sight with standard rear sight
  3. Standard sight (M16A1)
- C. Mode
  1. Semiautomatic
  2. Automatic (3-round bursts)
- D. Distance
  1. 25 meters
  2. 50 meters
- E. Position
  1. Prone supported
  2. Kneeling supported

This was a mixed-model analysis of variance design. Variables A and B required independent groups. Variables C, D, and E were repeated across subjects. Thus, a total of six independent groups were required for the 2 by 3 combinations of vision technique and sight. The off-center night vision technique consisted of aligning the sights in elevation with the target while the target was positioned about five degrees to one side of the line of sight. Once sight alignment was achieved, the rifle was moved into alignment with the target and the round was fired. This technique is a part of the British night firing system. The direct alignment is the normal method of sight alignment.

Subjects

With six groups, using 18 men per group, a total of 108 were required. These men were members of an entering class of the Noncommissioned Officer Candidate School, Fort Benning.

Apparatus

There were three firing lanes with "E"-type targets positioned at 25 and 50 meters. The targets were controlled from a tower located at the rear of the firing line. The M16 rifle was used. The Tri-Lux sight uses a slightly radioactive luminescent element (tritium) in the front sight post. The rear aperture is a circle, truncated on the sides by the carrying handle. The inside dimensions of the rear aperture are 1.00 and 0.75 centimeters for height and width respectively.

Procedure

The six combinations of vision technique and sight provided six separate groups (firing orders) for record fire. The target ranges were randomly presented. The counterbalancing of the firing position and firing mode is as follows:

Day	Position Order		Mode Order	
1	1	2	1	2
2	2	1	1	2
3	1	2	2	1
4	2	1	2	1
5	1	2	1	2
6	2	1	2	1

All three positions were fired before the firing mode was changed. The practice session, fired before record fire, was identical to the record session except that the ammunition allotment was 4 and 12 rounds per target presentation for semiautomatic and automatic fire respectively rather than 6 and 18 rounds and only one of the two target distances available was presented for each combination of the experimental variables. The selection of this target was randomized.

The men reported to the range at 1800 hours where they were assigned to groups and given the additional training in their assigned techniques. Practice firing commenced at 1900 hours. Record firing commenced at 2000 hours, and was completed by 0100 hours. When a target was hit, it was presented again, and continued to be presented until the subject had expended his magazine of ammunition. Two criteria were obtained—time to first hit, and total number of hits.

RESULTS

There were so many cases where the men did not hit a target at all, that the time to first hit criterion is suspect, and therefore is not reported. Table 10-1 provides the analyses of variance for the hits per first four trigger pulls for 25 and 50 meters respectively. Table 10-2 provides the means for the combinations of mode and position for the 25 and 50 meter distances respectively.

This experiment furnishes conclusive evidence for the superiority of the automatic mode for night fire ($p < .001$), and for the superiority of the prone position as compared to the kneeling position when firing in the automatic mode at night at the longer ranges ($p < .001$). In the semiautomatic mode, there was no difference between the two positions. Neither the vision technique, nor the sight produced significant differences. The most plausible explanation is that the "no moonlight" condition did not provide sufficient illumination to make the target visible. A target that is not readily visible will not be hit frequently with rifle fire regardless of the sight or vision technique used. It was concluded that an additional test was needed to determine the effect of more illumination.

Table 10-1

Effects of Vision Technique, Sight, Mode, and Position on Hits per First Four Trigger Pulls: Analyses of Variance

Range/Source	*df*	*MS*	*F*	*p*
25 Meters				
Between Subjects Analysis				
Vision Technique (A)	1	4.90	1.75	NS
Sight (B)	2	6.78	2.43	NS
Test Night (C)	5	6.20	2.20	NS
AB	2	0.45	<1	NS
AC	5	3.34	1.20	NS
BC	10	2.53	<1	NS
ABC	10	2.85	1.02	NS
Error	72	2.79		
Within Subjects Analysis				
Mode (D)	1	33.33	21.49	<.001
Position (E)	1	5.79	3.73	NS
DE	1	2.68	1.73	NS
AD	1	0.01	<1	NS
AE	1	0.59	<1	NS
BD	2	0.03	<1	NS
BE	2	1.23	<1	NS
CD	5	0.59	<1	NS
CE	5	1.13	<1	NS
Pooled Error	305	1.55		
50 Meters				
Between Subjects Analysis				
Vision Technique (A)	1	0.39	<1	NS
Sight (B)	2	0.88	<1	NS
Test Night (C)	5	0.85	<1	NS
AB	2	0.11	<1	NS
AC	5	1.67	1.20	NS
BC	10	0.85	<1	NS
ABC	10	1.37	<1	NS
Error	72	1.40		
Within Subjects Analysis				
Mode (D)	1	11.67	18.31	<.001
Position (E)	1	0.52	<1	NS
DE	1	12.86	20.18	<.001
AD	1	0.00	<1	NS
AE	1	0.52	<1	NS
BD	2	0.54	<1	NS
BE	2	0.77	1.20	NS
CD	5	0.41	<1	NS
CE	5	0.63	<1	NS
Pooled Error	305	0.64		

Table 10-2

Mean Hits per First Four Trigger Pulls for Mode, Position, and Range

Range/Position	Mode		Mean
	Semiautomatic	Automatic	
25 Meters			
Prone	1.97	2.64	2.31
Kneeling	1.85	2.25	2.05
Mean	1.91	2.44	2.18
50 Meters			
Prone	0.46	0.87	0.67
Kneeling	0.47	0.72	0.60
Mean	0.47	0.80	0.63

Appendix K

EXPERIMENT 11: USE OF THE TRI-LUX SIGHT FOR DAYTIME TARGETS

OBJECTIVE

In Experiment 10 of this series, the Tri-Lux sight was found to be valuable for night firing. In Experiment 4, aimed fire was demonstrated to be superior to Quick Fire (pointing unaimed fire) at all ranges from 25 meters out, in the daytime. The British have concluded that aimed fire, in the daytime using their Tri-Lux sight, is superior to Quick Fire.[1] The British also recommend an "on the shoulder" ready position.

Experiment 11 has five objectives:

(1) Among the three shooting techniques—Quick Fire, aimed fire with the standard sight, and aimed fire with the Tri-Lux sight—which is best at ranges within 25 meters in the daytime where time is critical?

(2) Beyond 25 meters, how far out is the Tri-Lux sight superior or equal to the standard sight in time to first hit?

(3) Of the two carry positions—the underarm and a modification of the British ready position—which allows the more rapid time to first hit when firing from the shoulder position?

(4) Within what range (if any) does the underarm firing position yield a more rapid time to first hit?

(5) Within what range (if any) does automatic fire provide a more rapid time to first hit?

These questions were addressed in two separate experiments (11A and 11B).

EXPERIMENT 11A

METHOD

Experimental Variables

The following variables, along with the levels listed, were examined:

A. Firing Techniques
   1. Quick Fire
   2. Aimed fire with Tri-Lux sight
   3. Aimed fire with M16A1 sight

B. Weapon Carry Position
   1. Underarm
   2. Modification of British ready position

C. Mode of Fire
   1. Semiautomatic
   2. Automatic

[1] Major D. Stopford. *An Evaluation of the Quick Kill Shooting System*, FARELF F (Operational Requirements and Analysis Branch), Report No. 3-69, March 1969.

C. Mode of Fire
   1. Semiautomatic
   2. Automatic
D. Range
   1. 10 meters
   2. 15 meters
   3. 20 meters
   4. 25 meters

In the modified British ready position, the butt of the weapon is placed high in the shoulder pocket so that when the weapon is raised a minimum head movement is required. For a right-handed individual, the right hand is on the pistol grip, the left is on the stock beyond the carrying handle, and the weapon is slanted downward and to the left across the body.

Subjects

Twenty-four students entering the Noncommissioned Officer Candidate (NCOC) School at Fort Benning participated.

Apparatus

One firing lane was used with four firing lines five meters apart and seven "E" type targets positioned alternately on the right and left of the firer at five-meter intervals. The M16 rifle was used.

Procedure

The counterbalancing of the order of presentation of the variables is given in Tables 11A-1 and 11A-2. Table 11A-1 lists the seven combinations of firing technique and carry position. Table 11A-2 provides the order in which each subject fired the seven combinations of firing technique and carry position, and the order in which he fired the two modes. For example, Subject No. 1 first fired using the pointing underarm technique, beginning from the underarm position in the semiautomatic mode. He next fired the same combination in the automatic mode. He then fired using the pointing, shoulder technique, beginning from the underarm position in the semiautomatic mode, and so forth. The target ranges were presented randomly.

The men received preliminary instruction in the techniques examined and then were given a practice firing course described in Table 11A-3. To complete each firing exercise, the individual loaded his weapon and walked cautiously down the firing lane approximately five meters. At this point, one of four possible targets was raised (targets were offset slightly to the right and left at ranges from 10 to 25 meters). The subject engaged the target as rapidly as possible, employing his assigned firing technique, and firing until the target was hit or the ammunition was expended. The subject then changed magazines and again moved forward, repeating the procedure until he had fired from each of the four firing lines. Thus, although the lane included seven targets, only four of them (from 10 to 25 meters) were used at any given time.

RESULTS

Table 11A-4 gives the analysis of variance for the number of trigger pulls to first hit. Tables 11A-5 and 11A-6 provide means for the number of trigger pulls to first hit for various combinations of conditions. Table 11A-7 shows the analysis of variance for the time to first hit criterion. Tables 11A-8 and 11A-9 provide means for this criterion for various combinations of experimental conditions. The results can be summarized as follows:

(1) In terms of trigger pulls, Quick Fire is inferior to aimed fire beyond 15 meters, and is never superior to aimed fire.

(2) Considering time to first hit the M16A1 sight is inferior at 10 and 15 meters where the Tri-Lux sight and Quick Fire are about equal. At 20 meters, the technique used makes little difference. At 25 meters, aimed fire in general and the Tri-Lux sight in particular are superior.

(3) The British ready position is superior (in time to first hit) to the underarm carry, but the two positions are equal in the required number of trigger pulls.

(4) Automatic fire is slightly faster than semiautomatic fire in time to first hit within 25 meters. There is no difference between the two modes in the number of trigger pulls required to hit the target.

Table 11A-10 gives the analysis of variance for the number of trigger pulls to first hit for the second experiment. This was a comparison of the underarm and the shoulder firing positions for pointing unaimed fire. Table 11A-11 provides means for various combinations of experimental conditions. Tables 11A-12 and 11A-13 provide similar information for the mean time to first hit criterion. An examination of these tables shows that the underarm firing position is inferior to the shoulder firing positions in trigger pulls to first hit, and equal in time to first hit. This is based upon a comparison of the underarm firing position with the Quick Fire data of Experiment 1. Since Quick Fire itself was inferior to aimed fire, especially with the British sight, there is no doubt about the underarm firing position being inferior to the shoulder firing position.

EXPERIMENT 11B

METHOD

Experimental Variables

The following variables, along with the levels listed, were examined:

A. Firing Techniques
   1. Aimed fire with the conventional M16A1 sight
   2. Aimed fire with the Tri-Lux sight

B. Mode of Fire
   1. Semiautomatic
   2. Automatic

C. Position
   1. Prone
   2. Kneeling
   3. Standing

D. Distance
   1. 50 meters
   2. 100 meters
   3. 150 meters
   4. 200 meters

Subjects

Twenty-four students entering the Noncommissioned Officer Candidate School at Fort Benning participated.

Apparatus

Two points from a standard, basic rifle marksmanship, record fire course were used in this study. The M16 rifle was used.

Procedure

The subjects received a preliminary course of instruction in the two firing techniques and then completed a practice firing course; this course is outlined in Table 11B-1. The men then fired the record course. The order of presentation of the target distance was randomized. The orders of presentation for the other variables are given in Table 11B-2. Each man fired all four ranges before changing positions; fired all three positions before changing mode; and fired both modes before changing firing techniques. Each man was issued one 6-round magazine for each target engaged with semiautomatic fire, and one 18-round magazine for each target engaged with automatic fire. In each case the individual fired until the target was hit or his magazine was empty. The men used a three-round burst of automatic fire when in the automatic mode. All subjects fired all combinations of experimental conditions.

RESULTS

Tables 11B-3, -4, and -5 provide the results of the analysis of the trigger pulls to first hit criterion. Tables 11B-6, -7, and -8 provide the analysis of the time to first hit criterion. An examination of these tables shows that the Tri-Lux sight is at least equal to the standard M16 sight in time to first hit and in trigger pulls to first hit up to a range of 50 meters. By 100 meters the Tri-Lux sight is significantly inferior to the standard M16 sight ($p < .05$), and markedly inferior at 150 meters and beyond ($p < .01$). The probability figures were determined by the Tukey "A" Test.

Experiment 11A determined that the British Tri-Lux sight offered a speed/accuracy advantage at ranges from 25 meters in. Experiment 11B determined that there is no speed/accuracy disadvantage in using this sight out to a distance of 50 meters.

Table 11A-1

Combinations of Firing Technique and Carry Position

Condition Number	Firing Technique	Carry Position
1	Pointing Underarm	Underarm
2a	Pointing Shoulder	Underarm
2b	Pointing Shoulder	British
3a	Aimed Fire (M16A1 Sights)	Underarm
3b	Aimed Fire (M16A1 Sights)	British
4a	Aimed Fire (Tri-Lux Sights)	Underarm
4b	Aimed Fire (Tri-Lux Sights)	British

Table 11A-2

Counterbalancing Firing Order and Mode

Subject	Firing Order Sequence[a]	Mode Sequence
1	1 2a 3a 4a 2b 3b 4b	1 2
2	1 3a 4a 2b 3b 4b 2a	2 1
3	1 4a 2b 3b 4b 2a 3a	1 2
4	2b 3b 4b 2a 3a 4a 1	2 1
5	3b 4b 2a 3a 4a 2b 1	1 2
6	4b 2a 3a 4a 2b 3b 1	2 1

[a]See Table 11A-1.

Table 11A-3

Practice Firing Course

Condition Number	Mode	Ranges (meters)	Rounds per Target[a]	Total per Individual	Total per Order
1	Semiautomatic	10 and 20	3	6	24
1	Automatic	15 and 20	9	18	72
2	Semiautomatic	10 and 20	3	6	24
2	Automatic	15 and 25	9	18	72
2b	Semiautomatic	15 and 25	3	6	24
2b	Automatic	10 and 20	9	18	72
3a	Semiautomatic	10 and 20	3	6	24
3a	Automatic	15 and 25	9	18	72
3b	Semiautomatic	15 and 25	3	6	24
3b	Automatic	10 and 20	9	18	72
4a	Semiautomatic	10 and 20	3	6	24
4a	Automatic	15 and 25	9	18	72
4b	Semiautomatic	15 and 25	3	6	24
4b	Automatic	10 and 20	9	18	72

[a] Total per day – 672; total for 6 days – 4,032; total per day Practice and Record – 2,464; total for six days Practice and Record – 14,784. Much smaller ammunition expenditure probable since firing will stop on achieving a hit.

Table 11A-4

Effects of the Use of the Tri-Lux Sight on Trigger Pulls to First Hit: Analysis of Variance
(First Experiment of 11A)

Source	df	MS	F	p
Mode (A)	1	0.59	1.55	NS
Technique (B)	2	4.98	15.51	<.001
Carry (C)	1	0.17	<1	NS
Range (D)	3	3.40	12.26	<.001
AB	2	0.06	<1	NS
AC	1	1.39	6.40	<.05
AD	3	0.31	1.24	NS
BC	2	0.08	<1	NS
BD	6	1.73	5.36	<.001
CD	3	0.04	<1	NS
Error (A)	23	0.38		
Error (B)	46	0.32		
Error (C)	23	0.35		
Error (D)	69	0.28		
Error (AB)	46	0.20		
Error (AC)	23	0.22		
Error (AD)	69	0.25		
Error (BC)	46	0.27		
Error (BD)	138	0.32		
Error (CD)	69	0.24		
Pooled Residual	552	0.26		

Table 11A-5

Mean Trigger Pulls to First Hit for Each Technique and Distance

Technique	Distance (Meters)				Mean
	10	15	20	25	
Quick Fire	1.08	1.15	1.39	1.64	1.32
M16 Aim	1.10	1.15	1.14	1.12	1.13
British Aim	1.03	1.07	1.14	1.20	1.11
Mean	1.07	1.13	1.22	1.32	1.18

Table 11A-6

Mean Trigger Pulls to First Hit for Mode and Carry Position

Mode	Underarm	Shoulder	Mean
Semiautomatic	1.18	1.23	1.21
Automatic	1.21	1.12	1.16
Mean	1.20	1.17	1.18

Table 11A-7

Effects of the Use of the Tri-Lux Sight on Time to First Hit: Analysis of Variance
(First Experiment of 11A)

Source	*df*	*MS*	*F*	*p*
Mode (A)	1	6.74	7.71	<.05
Technique (B)	2	1.29	2.46	NS
Carry (C)	1	12.67	16.48	<.001
Distance (D)	3	24.53	58.69	<.001
AB	2	0.16	<1	NS
AC	1	1.83	5.12	<.05
AD	3	0.66	1.72	NS
BC	2	0.05	<1	NS
BD	6	1.94	3.71	<.01
CD	3	0.38	<1	NS
Error (A)	23	0.87		
Error (B)	46	0.52		
Error (C)	23	0.77		
Error (D)	69	0.41		
Error (AB)	46	0.35		
Error (AC)	23	0.36		
Error (AD)	69	0.39		
Error (BC)	46	0.37		
Error (BD)	138	0.52		
Error (CD)	69	0.44		
Pooled Residual	552	0.40		

Table 11A-8

Mean Time to First Hit by Aim Technique and Distance

Technique	Distance (Meters)				Mean
	10	15	20	25	
Quick Fire	1.10	1.36	1.65	2.13	1.56
M16 Aim	1.28	1.50	1.63	1.74	1.53
British Aim	1.12	1.40	1.60	1.68	1.45
Mean	1.16	1.42	1.62	1.85	1.51

Table 11A-9

Mean Time to First Hit by Mode and Carry Position

Mode	Underarm	Shoulder	Mean
Semiautomatic	1.65	1.52	1.59
Automatic	1.62	1.41	1.51

Table 11A-10

Effects of the Use of the Tri-Lux Sight on Trigger Pulls to First Hit: Analysis of Variance
(Second Experiment of 11A)

Source	df	MS	F	p
Mode (M)	1	0.59	<1	NS
Technique (T)	1	24.50	20.53	<.001
Distance (D)	3	16.47	17.29	<.001
Error (M)	23	1.03		
Error (T)	23	1.19		
Error (D)	69	0.95		
MT	1	3.19	3.62	NS
MD	3	1.81	2.70	NS
TD	3	1.66	1.91	NS
MTD	3	0.70	<1	NS
Error (MT)	23	0.88		
Error (MD)	69	0.69		
Error (TD)	69	0.87		
Error (MTD)	69	0.95		

Table 11A-11

Mean Trigger Pulls to First Hit, by Firing Mode/Technique and Range Combinations

Mode/Technique	Distance (Meters)				Mean
	10	15	20	25	
Semiautomatic Mode					
Underarm	1.50	1.88	2.13	2.33	1.96
Quick Fire	1.08	1.17	1.21	1.63	1.27
Mean	1.29	1.52	1.68	1.98	1.61
Automatic Mode					
Underarm	1.08	1.17	1.88	2.67	1.70
Quick Fire	1.04	1.21	1.36	1.88	1.38
Mean	1.06	1.19	1.63	2.27	1.54

Table 11A-12

Effects of the Use of the Tri-Lux Sight on Time to First Hit: Analysis of Variance
(Second Experiment of 11A)

Source	*df*	*MS*	*F*	*p*
Mode (M)	1	3.06	3.28	NS
Technique (T)	1	2.03	1.45	NS
Distance (D)	3	25.91	24.03	<.001
Error (M)	23	0.93		
Error (T)	23	1.40		
Error (D)	69	1.08		
MT	1	3.92	3.30	NS
MD	3	2.08	2.64	NS
TD	3	1.54	1.49	NS
MTD	3	0.95	<1	NS
Error (MT)	23	1.19		
Error (MD)	69	0.79		
Error (TD)	69	1.04		
Error (MTD)	69	1.10		

Table 11A-13

Mean Time to First Hit, by Mode and Distance

Mode/Technique	Distance (Meters)				Mean
	10	15	20	25	
Semiautomatic Mode					
Underarm	1.51	2.02	2.37	2.15	2.01
Quick Fire	1.18	1.45	1.65	2.39	1.67
Mean	1.34	1.73	2.01	2.27	1.84
Automatic Mode					
Underarm	0.89	1.30	1.83	2.50	1.64
Quick Fire	1.13	1.41	1.66	2.55	1.69
Mean	1.01	2.72	1.75	2.53	1.66

Table 11B-1

Practice Firing

Technique	Mode	Positions	Ranges (meters) (One Range per Position)	Target Presented	Rounds per Target	Total Rounds per Individual
1	Semiautomatic	a, b, c	100, 150, 200	3	3	9
2	Semiautomatic	a, b, c	50, 100, 150	3	3	9
1	Automatic	a, b, c	50, 100, 200	3	9	27
2	Automatic	a, b, c	50, 150, 200	3	9	27

Table 11B-2

Record Fire

Subject	Firing Technique Sequence	Mode Order	Position Order
1	1 2	1 2	a b c
2	1 2	2 1	c a b
3	2 1	1 2	b c a
4	2 1	2 1	a c b
5	1 2	1 2	b a c
6	2 1	2 1	c b a

Table 11B-3

Effects of the Use of the Tri-Lux Sight on Trigger Pulls to First Hit: Analysis of Variance

Source	*df*	*MS*	*F*	*p*
Sights (A)	1	230.23	67.73	<.001
Mode (B)	1	41.63	16.27	<.001
Position (C)	2	10.90	4.69	<.05
Distance (D)	3	228.31	99.92	<.001
Error (A)	23	3.40		
Error (B)	23	2.56		
Error (C)	46	2.32		
Error (D)	69	2.29		
AB	1	0.95	<1	NS
AC	2	1.75	<1	NS
AD	3	33.34	20.06	<.001
BC	2	1.18	<1	NS
BD	3	5.05	3.62	<.05
CD	6	1.41	<1	NS
Error (AB)	23	4.58		
Error (AC)	46	2.11		
Error (AD)	69	1.66		
Error (BC)	48	3.06		
Error (BD)	69	1.39		
Error (CD)	138	2.38		
ABC	2	2.42	1.14	NS
ABD	3	0.55	<1	NS
ACD	6	2.16	1.13	NS
BCD	6	3.82	1.74	NS
ABCD	6	2.09	<1	NS
Error (ABC)	46	2.13		
Error (ABD)	69	1.83		
Error (ACD)	138	1.91		
Error (BCD)	138	2.19		
Error (ABCD)	138	2.16		

Table 11B-4

Mean Trigger Pulls to First Hit, by Aim Technique and Distance

Technique	Distance (Meters)				Mean
	50	100	150	200	
M16 Aim	1.08	1.43	1.80	2.37	1.69
British Aim	1.18	2.06	2.97	4.50	2.56
Mean	1.13	1.74	2.38	3.21	2.12

Table 11B-5

Mean Trigger Pulls to First Hit, by Mode and Firing Position

Mode	Firing Position			Mean
	Prone	Kneeling	Standing	
Semiautomatic	1.73	1.95	2.10	1.93
Automatic	2.21	2.21	2.50	2.31
Mean	1.97	2.08	2.30	2.12

Table 11B-6

Effects of the Use of the Tri-Lux Sight on Time to First Hit: Analysis of Variance
(Experiment 11B)

Source	*df*	*MS*	*F*	*p*
Mode (M)	1	135.98	4.39	<.05
Technique (T)	1	2,519.91	49.09	<.001
Position (P)	2	33.89	1.08	NS
Distance (D)	3	4,297.23	79.58	<.001
Error (M)	23	30.98		
Error (T)	23	51.33		
Error (P)	46	31.45		
Error (D)	69	54.00		
MT	1	56.63	<1	NS
MP	2	98.77	1.61	NS
MD	3	13.80	<1	NS
TP	2	87.61	2.47	NS
TD	3	461.15	19.31	<.001
PD	6	19.84	<1	NS
Error (MT)	23	94.07		
Error (MP)	46	61.25		
Error (MD)	69	35.14		
Error (TP)	46	35.48		
Error (TD)	69	23.88		
Error (PD)	138	32.93		
MTP	2	16.75	<1	NS
MTD	3	65.19	2.20	NS
MPD	6	90.77	2.33	<.05
TPD	6	57.62	1.83	NS
MTPD	6	9.94	<1	NS
Error (MTP)	46	18.38		
Error (MTD)	69	29.60		
Error (MPD)	138	38.98		
Error (TPD)	138	31.51		
Error (MTPD)	138	31.55		

Table 11B-7

Mean Time to First Hit, by Sight Technique

Technique	Distance (Meters)				Mean
	50	100	150	200	
M16A1 Sight	2.60	4.28	6.07	8.68	5.41
British Sight	2.65	6.24	9.97	14.62	8.37
Mean	2.62	5.26	8.02	11.65	6.89

Table 11B-8

Mean Time to First Hit, by Firing Position

Mode	Firing Position			Mean
	Prone	Kneeling	Standing	
Semiautomatic	5.89	6.72	7.03	6.55
Automatic	7.71	6.57	7.42	7.23
Mean	6.80	6.64	7.22	6.89

Appendix L

EXPERIMENT 12: TRI-LUX SIGHT AT NIGHT

OBJECTIVE

Experiment 10 compared the British and the American night firing systems under starlight conditions. A significant difference in mean performance between the Tri-Lux and M16A1 sights was not obtained. The following possible explanations were given: (1) too little training on the British sight, (2) the use of an independent groups design, and (3) an illumination level so low as to render the targets invisible, thus negating the effectiveness of any sight. In the belief that the last of these three possibilities was the most probable, it was decided to run an additional test to determine whether increasing the illumination level would increase the difference between the two sights.

METHOD

Experimental Variables

The following variables, along with the levels listed, were examined:

- A. Firing Techniques
  1. Pointing technique
  2. Aiming technique using the Tri-Lux sight
- B. Distance
  1. 15 meters
  2. 20 meters
  3. 25 meters
  4. 30 meters
  5. 35 meters
  6. 40 meters
- C. Illumination Level
  1. Starlight
  2. Half-moonlight

When the subjects were using the pointing technique, their weapons were equipped with the M16A1 sight. They were instructed to use this sight if they found it to be an advantage—otherwise they were to use the pointing technique.

Subjects

Twenty-four students entering the Noncommissioned Officer Candidate School at Fort Benning participated.

Apparatus

A single firing lane was used. Six "E"-type targets were arranged from 15 to 40 meters down range at 5-meter intervals. The targets were randomly presented and "killed" upon being hit. The M16 rifle was used.

Procedure

Procedurally, this study was conducted as two separate experiments. While an attempt was made to use the same subjects under both illumination conditions, eight of the 24 men were assigned conflicting duty on the evening that the second illumination condition was run. Because substitutions were made, illumination conditions were analyzed as separate experiments.

Twenty-four men reported to the firing range and received instruction on the use of night vision techniques and in the firing techniques to be tested. They then fired the record course for practice in the daytime. On the following evening, under starlight conditions, they returned to the range and were assigned to two groups of 12 for counterbalancing purposes. One group was tested on the pointing technique first, while the other was tested on the Tri-Lux sight first; all subjects fired both conditions. The presentation of distance was randomized. All subjects fired in the semiautomatic mode. If a man hit the target in less than four rounds, the target was presented again until the subject had fired four rounds at that target.

Four nights later, the 24 subjects again reported to the range. These men, including the eight substitutes, fired for record under half-moonlight condition without further practice.

RESULTS

Two criteria were examined—total hits, and time to first hit. The time to first hit criterion was invalidated for the starlight condition because of the large number of cases where no hit was obtained. Table 12-1 gives the analysis of variance of the total hit criterion under the starlight condition. Table 12-2 furnishes the mean number of hits per four-round magazine under the starlight condition. Tables 12-3 through 12-6 furnish the analyses of variance tables and tables of means for both criteria under the half-moonlight condition.

Under the starlight condition, the difference between the sighting techniques was not significant in spite of the additional training. Thus it would seem that the choice of experiment design and the amount of training in the original experiment were not central to the outcome. On the other hand, Tables 12-3 through 12-6 show a marked superiority for the Tri-Lux sight over the pointing, unaimed technique under a half-moonlight condition of illumination. The illumination level appears to be the critical element in the utilization of a night sight.

The added precision of sight alignment obtained by using the smaller rear aperture on the M16 sight is bound to assist in achieving greater accuracy than would be obtained with the large aperture Tri-Lux sight where the illumination is sufficient for the use of a small aperture sight. However, the large rear aperture sight can be used at a much lower level of illumination, thus providing the benefits of aimed fire at illumination levels where it would otherwise not be available. In short, while the M16A1 sight is probably more accurate when the illumination level is sufficient to permit its use, the Tri-Lux sight is usable at a much lower level of illumination, and no sight is effective if the target cannot be seen.

Table 12-1

Effects of the Use of the Tri-Lux Sight on Hits per Four-Round Magazine—Starlight: Analysis of Variance

Source	*df*	*MS*	*F*	*p*
Distance (A)	5	22.65	21.37	<.01
Technique (B)	1	0.78	<1	NS
AB	5	0.08	<1	NS
Error (A)	115	1.06		
Error (B)	23	1.59		
Error (AB)	115	0.70		

Table 12-2

Mean Number of Hits per Four-Round Magazine—Starlight

Technique	Distance (Meters)						Mean
	15	20	25	30	35	40	
Pointing	1.92	1.88	1.12	0.33	0.58	0.46	1.05
Tri-Lux	2.00	1.83	1.33	0.46	0.71	0.58	1.15
Mean	1.96	1.85	1.22	0.40	0.64	0.52	1.10

Table 12-3

Effects of the Use of the Tri-Lux Sight on Hits per Four-Round Magazine—Half-Moonlight: Analysis of Variance

Source	*df*	*MS*	*F*	*p*
Distance (A)	5	21.33	22.77	<.001
Technique (B)	1	26.28	15.99	<.001
AB	5	1.91	2.08	NS
Error (A)	115	0.94		
Error (B)	23	1.64		
Error (AB)	115	0.92		

Table 12-4

Effects of the Use of the Tri-Lux Sight on Time to First Hit—Half-Moonlight: Analysis of Variance

Source	df	MS	F	p
Distance (A)	5	322.07	18.57	<.001
Technique (B)	1	234.58	6.10	<.05
AB	5	18.90	1.21	NS
Error (A)	115	17.34		
Error (B)	23	38.43		
Error (AB)	115	15.63		

Table 12-5

Hits per Four-Round Magazine—Half Moonlight

Technique	Distance (Meters)						Mean
	20	25	30	35	40	45	
Pointing	3.42	2.16	1.76	2.50	2.04	1.38	2.21
Tri-Lux	3.88	2.79	1.83	3.21	2.50	2.67	2.67
Mean	3.64	2.48	1.70	2.85	2.23	2.02	2.51

Table 12-6

Time to First Hit—Half-Moonlight

Technique	Distance (Meters)						Mean
	20	25	30	35	40	45	
M16A1	3.35	4.50	7.14	6.43	9.27	11.83	7.09
Tri-Lux	2.70	2.80	6.16	5.26	7.05	7.05	5.28
Mean	3.03	3.65	6.65	5.85	8.16	9.78	6.19

Appendix M

EXPERIMENT 13: EVALUATION OF TRAINING CHANGES IN NIGHT FIRING

OBJECTIVE

Prior to Work Unit MARKSMAN the night firing program was a scaled-down adaptation of the program of instructions recommended after testing by HumRRO and adopted by the Army in 1954. The program had been considerably reduced on two occasions in order to free ammunition and time for other purposes. As a result of feedback from U.S. commanders in Vietnam, the original program was reinstated. Certain segments of this program seemed worthy of further investigation. The purpose of this experiment was to study the relative value of four different programs obtained by the deletion of certain elements from the present program.

METHOD

Experimental Variables

The four selected programs and the content of each, are:

- A. Seven-Hour Program
    1. Orientation firing (2 hours)
    2. Day corrective firing (2½ hours)
        - a. Conference and demonstration of Quick Fire and Pointing Fire (½ hour)
        - b. Air rifle firing (1 hour)
        - c. Service rifle, day corrective firing (1 hour)
    3. Night practice and record firing (2½ hours)
        - a. Conference and demonstration of night vision techniques (½ hour)
        - b. Practice and record night fire (2 hours)
- B. 5-Hour Program
    1. Day corrective firing (2½ hours)
        - a. Conference and demonstration of Quick Fire and Pointing Techniques (½ hour)
        - b. Air rifle firing (1 hour)
        - c. Service rifle, day corrective firing (1 hour)
    2. Night practice and record firing (2½ hours)
        - a. Conference and demonstration of night vision techniques (½ hour)
        - b. Practice and record night fire (2 hours)
- C. 4½-Hour Program
    1. Orientation firing (2 hours)
    2. Night practice and record fire (2½ hours)
        - a. Conference and demonstration of night vision techniques (½ hour)
        - b. Practice and record night fire (2 hours)

D. 2½-Hour Program
   1. Conference and demonstration of night vision, Quick Fire, and Pointing Techniques (½ hour)
   2. Practice and record night firing (2 hours)

Subjects

Subjects were 1,496 Basic Combat trainees from Fort Jackson.

Apparatus

A standard, night record fire range was used. The M16 rifle was used.

Procedure

Four separate BCT companies were divided into four equal groups. Each of the groups was trained under one of the previously explained programs of instruction. This was accomplished by deleting discrete portions of the instruction for each group as follows:

A. Group A received all of the present BRM night firing program including Periods 20, 21, and 22 without change.

B. Group B did not attend Period 20, but attended Periods 21 and 22 without change.

C. Group C did not attend Period 21, but attended Periods 20 and 22 without change.

D. Group D did not attend BRM Periods 20 and 21. Group D received all the instruction of Period 22 except the standard, 12-round zero exercise. Instead of the zero exercise, Group D fired six practice rounds per man at each of the 25 and 50 meter targets prior to conducting record fire.

Each of the four Basic Combat Training companies fired on a different night. However, each company had equal representation for all of the four groups being studied. The record fire exercises were conducted on moonless nights.

RESULTS

The analysis of variance and the means for the number of hits in night record fire are presented in Tables 13-1 and 13-2. These tables show that the best record fire performance was obtained in Program C, which only required four and one-half hours of training time. It is equally obvious that Program D is inferior. Program D is the one that was used prior to the reinstatement of the HumRRO-suggested seven-hour program.

Table 13-1

Effects of Training Changes on Number of Hits: Analysis of Variance

Source	*df*	*MS*	*F*	*p*
Distance (A)	1	533.05	66.74	<.001
Programs (B)	3	45.54	5.70	<.001
AB	3	7.67	<1	NS
Error	1488	7.99		

Table 13-2

Mean Number of Hits, by Training Program and Distance

Program	Target Distance (meters)		Mean
		50	
A–7 hours	5.84	4.34	5.09
B–5 hours	5.48	4.61	5.04
C–4½ hours	5.86	4.80	5.33
D–2½ hours	5.18	3.82	4.50
Mean	5.59	4.39	4.99

Appendix N

EXPERIMENT 14: MODE OF FIRE FOR MULTIPLE AND AREA TARGETS

OBJECTIVE

Experiments 4, 11A and 11B determined that the semiautomatic mode of fire is superior in time to first hit and total number of hits as compared with the automatic mode of fire against single targets in the daytime. From experiments 9 and 10 it was concluded that the automatic mode of fire is superior against single targets at night and under limited visibility conditions. It was reasoned that the automatic mode of fire was superior at night because the targets were indistinct, resulting in less accurate aiming, thereby increasing the value of maximizing chance hits by the use of automatic fire. It was further reasoned that where the target was visible, the semiautomatic mode of fire gave as high or higher hit probability per trigger pull as the automatic mode did, and it was possible to re-lay the weapon for followup shots more rapidly in the semiautomatic mode. Multiple targets and area targets in the daytime have characteristics of both of these situations. It was therefore necessary to examine multiple and area targets in the daytime to determine which mode of fire would maximize the number of hits and the number of hits per unit time.

EXPERIMENT 14A: MULTIPLE TARGETS

METHOD

Experimental Variables

The following variables along with the levels listed were examined:

A. Target Arrays
   1. "E"-type silhouette targets spaced 2.5 meters apart laterally and in depth
   2. "E"-type silhouette targets spaced 5 meters apart laterally and in depth

B. Mode of Fire
   1. Semiautomatic
   2. Automatic

C. Target Distance
   1. 75 meters
   2. 150 meters
   3. 225 meters
   4. 300 meters

The foxhole firing position was used throughout the experiment. Two magazines of 15 rounds were fired at each target array per range in each mode of fire.

Subjects

Twenty-four students entering the Noncommissioned Officer Candidate Course at Fort Benning participated.

Apparatus

There were two firing lanes, each consisting of two firing points. The first firing line had target arrays at ranges of 75 and 225 meters. The second firing line was located 75 meters to the rear of the first line and consisted of the same target arrays at distances of 150 and 300 meters. The new target arrays consisted of four E-type silhouette targets. The more distant target arrays (225 and 300 meters) consisted of five E-type silhouette targets. Each silhouette target was wired to feed hit data into an M40 hit indicator device. The M16 rifle was used. Two 15-round magazines were used for each combination of target distance, and mode. A total of 240 rounds were fired for record for each man.

Procedure

The men received a briefing on the test and on concentrated fire techniques, and were allowed to zero their weapons. They then fired the practice exercise as shown in Table 14-1. Only selected combinations of firing point mode and range were used for practice. The subjects fired in pairs (e.g. A & B, C & D). Each subject fired one 15-round magazine at each of the four ranges, for a total of 60 rounds of practice firing per student. Record fire was conducted on the sequences indicated below on days 1, 3, and 5:

Day	Sequence of Distance (Meters)	Mode Sequence
1	75, 225, 155, 300	Semiautomatic, Automatic
3	150, 300, 75, 25	Automatic, Semiautomatic
5	225, 75, 150, 300	Semiautomatic, Automatic

Experiment 14A alternated with Experiment 14B. Experiment 14A was conducted on Days 1, 3, and 5. Experiment 14B was conducted on days 2, 4, and 6. Eight men were conducted through the experiment on each of the three days. Each group of eight received the range and mode sequence given above according to the day on which they participated in the experiment. Within each group of eight, the firing point and firing line were organized as follows:

Subject	Firing Point	Firing Line
A C E G	1, 2	1
	4, 3	2
B D F H	2, 1	1
	3, 4	2

Using these tables to arrive at the order of firing, on Day 1, Subject A began at Firing Point 1 on Firing Line 1, while B began on Firing Point 2 on Firing Line 1. Both men fired in the semiautomatic mode first at the 75 and then at the 225 meter targets. Both then retired until the other six men had fired their first sequence. Then A and B returned to Firing Line 2 in order to fire the 150 and 300 meter targets on semiautomatic. Subject A fired from Firing Point 4; B fired from Firing Point 3. Subjects A and B returned to the firing line twice again, firing the indicated combinations in the automatic mode.

RESULTS

Tables 14A-2 through 14A-4 summarize the analyses of variance for three criteria according to an examination of short-range targets (75 and 150 meters) and long-range targets (225 and 300 meters). Table 14A-5 furnishes the mean number of hits, mean number of targets hit, and mean number of hits per second for both of the array dispersions, at both the short-range and long-range targets. Table 14A-6 furnishes the mean number of hits, mean targets hit and mean number of hits per second for both modes of fire, for both the short- and long-range targets. Tables 14A-7, 14A-8, and 14A-9 furnish the means for the interactions that were statistically significant. From an examination of these tables, the following conclusions can be reached:

(1) The more dense target array resulted in more hits and more targets hit than the less dense target array, but the number of hits per second was not significantly different.

(2) The seimautomatic mode of fire resulted in more hits per second, yielded two to three times as many hits as the automatic mode of fire, using two 15 round magazines, and resulted in more targets being hit than did automatic fire.

(3) The semiautomatic mode of fire is not only generally superior to the automatic mode of fire, but the superiority is enhanced by a more dense target array.

(4) The greater the target distance, the greater the competitive advantage of semiautomatic fire over automatic fire.

EXPERIMENT 14B: AREA TARGETS

METHOD

Experimental Variables

Experiment 14A was an examination of the relative effectiveness of semiautomatic and automatic fire against area targets. The variables examined were the same as variables B and C of Experiment 14A, that is, firing mode and target distance. The same levels of both variables were used.

Subject

The same 24 men used in Experiment 14A were used. Experiment 14B was conducted on Days 2, 4, and 6 of Experiment 14, using the subjects used in Experiment 14A on the previous day.

Apparatus

The range configuration was identical to that used in Experiment 14A except that instead of arrays of single targets at two distances, 12 one-square meter panels were arrayed side-by-side at the near target distance, and 20 one-square meter panels were arrayed side-by-side at the more distant target distance. Light brush and other camouflage was placed in front of the target panels. The M16 rifle was used. Hit data was fed into an M40 hit indicator device so as to record hits for each separate panel section as well as total hits. A stopwatch was used to determine the time required to expend the ammunition.

Procedure

The students received instruction on distributed fire techniques and fired the practice exercise given in Table 14B-1. As in Experiment 14A, only selected combinations of mode and distance were practiced. In practice, each man had one 12-round magazine for each presentation in the semiautomatic mode, and one 20-round magazine for each target presentation in the automatic mode, for a total of 64 rounds. Record fire was conducted on the sequences indicated below on Days 2, 4, and 6:

Day	Sequence of Distance (Meters)	Mode Sequence
2	300 150 75 225	Automatic, Semiautomatic
4	225 75 300 150	Semiautomatic, Automatic
6	300 150 225 75	Automatic, Semiautomatic

Eight men were conducted through the experiment on each of the three days. Each group of eight received the range and mode sequence given above according to the day on which they participated in the experiment. Within each group of eight, the firing point and firing line were organized as follows:

Subject	Firing Point	Firing Line
A C E F	1,2	1
	4,3	2
B D F H	3,4	1
	3,4	2

These tables may be used to line up the order of firing in the same manner as used in Experiment 14A. Twelve-round magazines were used for the 12-meter wide panel targets, 20-round for the 20-meter wide targets. Two magazines were issued for each target presentation using semiautomatic fire, six for each presentation using automatic fire. When firing in the automatic mode, the subjects were instructed to fire in 3-round bursts.

RESULTS

Tables 14B-2 through 14B-4 summarize the analyses of variance for three criteria according to an examination of short-range targets (75 and 150 meters) and long-range targets (225 and 300 meters). Table 14B-5 provides the mean performance for all three criteria for both modes at both the near and far distances. Tables 14B-6 and 14B-7 give the means for the mode-distance interaction for the combinations of criteria and range at which the interaction was statistically significant.

In the automatic mode, the man was allowed three times as much ammunition. This was done in order to equate the number of trigger pulls in automatic and semiautomatic fire, rather than the number of rounds of ammunition.

The following conclusions can be reached:

(1) For targets within 150 meters, the automatic mode yields more total hits within a sector and within one meter of the ground than does semiautomatic fire, given an equal number of trigger pulls.

(2) Within 150 meters, automatic fire provides at least one hit in a larger number of areas of a sector within one meter of the ground, than does semiautomatic fire, given an equal number of trigger pulls.

(3) Out to at least 300 meters, the semiautomatic mode of fire provides a faster rate of hits per unit time for an area target within one meter of the ground than does automatic fire.

(4) The hits per trigger pull advantage of automatic fire decreases with increasing target distance, and is no longer a significant advantage at 225 meters.

(5) The hits per unit time advantage of semiautomatic fire decreases somewhat with increasing distance, but is still significant at 300 meters.

The crucial criterion in this study was the number of hits per unit time. When men were firing in the automatic mode of fire, they were given three times as much ammunition in order to accomodate the three-round burst. Thus, the subjects were firing at a much more rapid rate in the automatic mode than in the semiautomatic mode. The majority of the second and third rounds in the three-round bursts did not strike the target. Thus, when using the semiautomatic mode, the man achieved a much higher hit probability per round fired than when using the automatic mode. However, since the automatic mode receives the benefit of three times as much ammunition, and since the first round of a three-round burst should be as accurate as semiautomatic fire, it is logical that the automatic mode should achieve a greater number of hits and greater number of targets hit than the semiautomatic mode. This should occur even if a second or third round hits the target only occasionally.

However, the real question is whether the occasional extra hit per trigger pull is sufficient to compensate for the extra time that is required to re-lay the weapon after firing the automatic mode. From these data, it is apparent that the occasional extra hits afforded by the use of automatic fire does not compensate for the extra re-lay time. In fact, the semiautomatic mode yields a faster hit rate than the automatic mode. Thus, in an engagement lasting a specific time, the semiautomatic mode would result in more target hits than would the automatic mode.

Table 14A-1

Practice Exercise, With Multiple Targets

Firing Line	Subjects	Firing Point	Mode Order	Range	Number of Rounds
1	A C E G	1	Semiautomatic	75	15
		2	Automatic	225	15
	B D F H	2	Semiautomatic	75	15
		1	Automatic	225	15
2	A C E G	4	Automatic	150	15
		3	Semiautomatic	300	15
	B D F H	3	Automatic	150	15
		4	Semiautomatic	300	15

Table 14A-2

Effects of Mode of Fire for Multiple Targets on Number of Hits, by Range: Analyses of Variance

Source	Short Range				Long Range			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Array (A)	1	96.33	18.36	<.001	1	109.51	14.40	<.001
Mode (B)	1	6,721.33	309.70	<.001	1	2,443.88	118.70	<.001
Distance (C)	1	1,692.19	135.94	<.001	1	503.76	24.69	<.001
AB	1	7.52	2.75	NS	1	84.01	12.97	<.005
AC	1	16.33	1.30	NS	1	19.38	2.34	NS
BC	1	36.75	4.47	<.05	1	170.63	18.62	<.001
ABC	1	0.02	<1	NS	1	0.05	<1	NS
Error (A)	23	5.25			23	7.60		
Error (B)	23	21.70			23	20.59		
Error (C)	23	12.45			23	20.40		
Error (AB)	23	2.74			23	6.47		
Error (AC)	23	12.57			23	8.26		
Error (BC)	23	8.23			23	9.16		
Error (ABC)	23	8.65			23	4.30		

Table 14A-3

Effects of Mode of Fire for Multiple Targets on Number of Targets Hit, by Range: Analyses of Variance

Source	Short Range				Long Range			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Array (A)	1	1.02	4.95	<.05	1	3.00	3.44	<.05
Mode (B)	1	15.19	46.16	<.001	1	168.75	120.36	<.001
Distance (C)	1	8.33	22.70	<.001	1	10.08	8.94	<.01
AB	1	0.02	<1	NS	1	0.33	<1	NS
AC	1	0.08	<1	NS	1	0.08	<1	NS
BC	1	4.08	14.07	<.005	1	0.75	<1	NS
ABC	1	0.33	1.41	NS	1	3.00	2.87	NS
Error (A)	23	0.21			23	0.87		
Error (B)	23	0.33			23	1.40		
Error (C)	23	0.37			23	1.13		
Error (AB)	23	0.21			23	1.40		
Error (AC)	23	0.42			23	0.89		
Error (BC)	23	0.29			23	1.16		
Error (ABC)	23	0.24			23	1.04		

Table 14A-4

Effects of Mode of Fire for Multiple Targets on Number of Hits per Second, by Range, for Multiple Targets: Analyses of Variance

Source	Short Range				Long Range			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Array (A)	1	0.004	4.00	NS	1	0.000	<1	NS
Mode (B)	1	0.054	54.00	<.001	1	0.000	<1	NS
Distance (C)	1	0.019	19.00	<.001	1	0.002	<1	NS
AB	1	0.000	<1	NS	1	0.007	1.40	NS
AC	1	0.000	<1	NS	1	0.004	<1	NS
BC	1	0.003	—	—	1	0.001	<1	NS
ABC	1	0.000	<1	NS	1	0.014	2.00	NS
Error (A)	23	0.001			23	0.004		
Error (B)	23	0.001			23	0.007		
Error (C)	23	0.001			23	0.006		
Error (AB)	23	0.001			23	0.005		
Error (AC)	23	0.001			23	0.007		
Error (BC)	23	0.000			23	0.005		
Error (ABC)	23	0.001			23	0.007		

Table 14A-5

Means for Array Dispersion, for Multiple Targets[a]

Criterion	Array Dispersion—Short Range			Array Dispersion—Long Range		
	2.5 Meters		5.0 Meters	2.5 Meters		5.0 Meters
Number of Hits	14.47	*	13.05	7.38	*	5.86
Targets Hit	3.73	**	3.58	3.21	**	2.96
Hits per Second	0.12		0.08	0.08		0.08

[a] * indicates interaction is significant at the $p < .001$ level; **, $p < .05$.

Table 14A-6

Means for Mode of Fire, for Multiple Targets[a]

Criterion	Short Range			Long Range		
	Semiautomatic		Automatic	Semiautomatic		Automatic
Number of Hits	19.68	*	7.84	10.19	*	3.05
Targets Hit	3.94	*	3.38	4.02	*	2.15
Hits per Second	0.10	*	0.13	0.08		0.08

[a] * indicates interaction is significant at the $p < .001$ level.

Table 14A-7

Means for Array-Mode Interaction at Long-Range Targets for Hit Criterion
(Multiple Targets)

Array	Mode	
	Semiautomatic	Automatic
2.5 Meters	11.60	3.15
5.0 Meters	8.77	2.96

Table 14A-8

Means for Mode-Distance Interaction for Hit Criterion
(Multiple Targets)

Mode	Short Range Target Distance		Long Range Target Distance	
	Near (75 meters)	Far (150 meters)	Near (225 meters)	Far (300 meters)
Semiautomatic	23.08	16.27	12.75	7.62
Automatic	10.38	5.31	3.73	2.38

Table 14A-9

Means for Mode-Distance Criterion at
Short Range for Number of Targets Criterion
(Multiple Targets)

Mode	Distance	
	Near (75 meters)	Far (150 meters)
Semiautomatic	4.00	3.88
Automatic	3.73	3.02

Table 14B-1

Practice Exercise for Area Targets

Firing Line	Subjects	Firing Point	Mode Order	Distance Order	Number of Rounds
1	A C E G	1	Semiautomatic	225 75	12 20
	B D F H	2	Semiautomatic	225 75	12 20
2	A C E G	4	Automatic	300 150	20 12
	B D F H	3	Automatic	300 150	20 12

Table 14B-2

Effects of Mode of Fire for Area Targets on Number of Hits, by Range: Analyses of Variance

Source	Short Range				Long Range			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Mode (B)	1	1,086.76	30.11	<.001	1	40.04	<1	NS
Range (C)	1	195.51	5.43	<.05	1	560.67	9.60	<.005
BC	1	207.09	8.23	<.01	1	26.04	<1	NS
Error (B)	23	36.09			23	45.80		
Error (C)	23	36.01			23	58.43		
Error (BC)	23	25.16			23	35.67		

Table 14B-3

Effects of Mode of Fire for Area Targets on Number of Targets Hit, by Range: Analyses of Variance

Source	Short Range				Long Range			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Mode (B)	1	27.09	10.18	<.005	1	12.04	1.54	NS
Range (C)	1	8.76	2.94	<.10	1	51.04	5.51	<.05
BC	1	0.01	<1	NS	1	2.67	<1	NS
Error (B)	23	2.66			23	7.82		
Error (C)	23	2.98			23	9.26		
Error (BC)	23	2.49			23	3.71		

Table 14B-4

Effects of Modes of Fire for Area Targets on Number of Targets Hit per Second, by Range: Analyses of Variance

Source	Short Range				Long Range			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Mode (B)	1	0.767	85.22	<.001	1	0.523	130.75	<.001
Range (C)	1	0.091	15.17	<.001	1	0.028	7.00	<.05
BC	1	0.0[illegible]9	7.25	<.05	1	0.013	13.00	<.005
Error (B)	23	0.009			23	0.004		
Error (C)	23	0.006			23	0.004		
Error (BC)	23	0.004			23	0.001		

Table 14B-5

Means for Mode at Near and Far Distances for All Three Criteria
(Area Targets)

Criterion	Target Distance					
	75 and 150 Meters			225 and 300 Meters		
	Semiautomatic		Automatic	Semiautomatic		Automatic
Total Hits	13.96	*	20.69	18.85		20.15
Number of Targets Hit	8.04	**	9.10	11.94		11.23
Hits per Second	0.34	*	0.16	0.22	*	0.19

*indicates interaction is significant at the $p < .001$ level; **, $p < .005$.

Table 14B-6

Means for Mode-Distance Interaction[a] for Hit Criterion at Near Distances
(Area Targets)

Mode	Distance	
	75 Meters	150 Meters
Semiautomatic	13.92	14.00
Automatic	25.58	17.79

[a]Statistically significant ($p < .01$ level).

Table 14B-7

Means for Mode-Distance Interactions for Hit per Second Criterion[a]

Mode	Distance			
	Near Targets**		Far Targets*	
	75 Meters	150 Meters	225 Meters	300 Meters
Semiautomatic	0.39	0.29	0.36	0.32
Automatic	0.18	0.15	0.12	0.11

[a]* indicates interaction is significant at the $p < .005$ level. **, $p < .05$.

Appendix O

EXPERIMENT 15: TRACER AMMUNITION DURING DAYLIGHT TRAINING FOR NIGHT FIRE

OBJECTIVE

The primary objective of this experiment was to determine the value of training with tracer ammunition, at night and in the daytime. Based on results of informal testing conducted at the U.S. Army Training Center at Fort Polk, it was hypothesized that the use of tracer ammunition in night firing exercises might increase learning on the part of basic trainees. Such improvement could result because the firer can observe the tracer round as it passes either through or near the target and is therefore able to more effectively adjust his fire on the target. Thus, it is possible that practice in the daytime, using the pointing technique, would improve the night record fire.

METHOD

Experimental Variables

The following variables, along with the levels listed, were examined:

- A. Practice Illumination
  1. Daylight
  2. Night
- B. Use of Tracers in Training
  1. Trained with tracers
  2. Trained without tracers
- C. Use of Tracers in Record Fire
  1. Fired with tracers
  2. Fired without tracers
- D. Distance
  1. 25 meters
  2. 50 meters

Subjects

Two Basic Combat Training companies at Fort Benning participated.

Apparatus

A standard, night fire record range was used. New targets for each subject were spaced at least six meters apart. The M16 rifle was used.

Procedure

The two Basic Combat Training companies fired for record on different nights. Each company was subdivided into eight groups corresponding to these eight experimental conditions:

(1) Received training as outlined in TT 23-71-1 during Periods 21 and 22 including tracer training and all tracer firing.

(2) Received the same training as Group 1, except that the 20 rounds of record fire in Period 22 were conducted with ball ammunition.

(3) Received training as outlined in TT 23-71-1 in Periods 21 and 22 except for the 20 rounds for record fire in Period 22 were conducted with tracer ammunition.

(4) Received training as outlined in TT 23-71-1 for Periods 21 and 22.

(5) Received firing as outlined in TT 23-71-1 except that they were instructed on the use of tracer ammunition, and all firing with the service weapon was done during darkness using tracer ammunition.

(6) Received the same firing as Group 5 except that the 20 rounds of record fire in Period 22 were conducted with ball ammunition.

(7) Received training as outlined in TT 23-71-1 except all firing with the service weapon was done during darkness using ball ammunition, except during Period 22 (record fire) when tracer ammunition was used.

(8) Received training as outlined in TT 23-71-1 except all service weapons firing in Period 21 was conducted during darkness.

Hits were scored by counting the holes in the targets. All men fired in the semiautomatic mode.

RESULTS

The analyses of variance for total hits at 25 and 50 meters respectively are given in Table 15-1. The mean numbers of hits are given in Tables 15-2 and 15-3. An examination of these tables leads to the following conclusions:

(1) Night firing performance inproves considerably when tracers are used.

(2) Night firing practice should be conducted with tracers if, and only if, it is intended that they be used for night firing.

(3) Daytime practice for night firing is superior to night practice.

All these conclusions are commonsense-type statements, with the possible exception of the third. It might seem strange that day practice would be more useful for night firing than night practice would be. However, Statement (3) does not mean that the elimination of all night practice would be desirable. When firing in the daytime using night techniques, the strike of the bullet can be seen. This is not true at night. Apparently at this point in the instruction, the knowledge of results that is obtained from seeing the strike of the bullet in the daytime more than offsets the disadvantages of practicing in an unreal situation.

Table 15-1

Effects of Use of Tracer Ammunition During Daylight Training for Night Fire on Total Hits, by Range: Analyses of Variance

Range/Source	*df*	*MS*	*F*	*p*
25 Meters				
Practice Illumination (A)	1	187.64	23.82	<.001
Tracer Training (B)	1	3.89	<1	NS
Tracer Record (C)	1	825.34	104.78	<.001
AB	1	6.28	<1	NS
AC	1	10.57	1.34	NS
BC	1	45.82	5.82	<.05
ABC	1	0.64	<1	NS
Error	344	7.88		
50 Meters				
Practice Illumination (A)	1	9.56	1.34	NS
Tracer Training (B)	1	0.28	<1	NS
Tracer Record (C)	1	269.50	37.72	<.001
AB	1	2.92	<1	NS
AC	1	3.28	<1	NS
BC	1	70.92	9.93	<.01
ABC	1	0.18	<1	NS
Error	344	7.14		

Table 15-2

Mean Number of Hits With Practice in Daylight and at Night, at 25 Meters

Training	Record Fire		Mean
	With Tracer	Without Tracer	
Practice in Daylight			
With Tracer	8.52	7.59	8.06
Without Tracer	7.77	6.48	7.12
Mean	8.15	7.03	7.59
Practice at Night			
With Tracer	5.00	3.55	4.27
Without Tracer	5.86	3.70	4.78
Mean	5.43	3.62	4.53

Table 15-3

Mean Number of Hits With Practice in Daylight and at Night, at 50 Meters

Training	Record Fire		Mean
	With Tracer	Without Tracer	
Practice in Daylight			
With Tracer	4.11	4.11	4.11
Without Tracer	3.41	3.14	3.27
Mean	3.76	3.62	3.69
Practice at Night			
With Tracer	1.61	1.32	1.47
Without Tracer	2.80	2.05	2.42
Mean	2.20	1.68	1.94

Appendix P

EXPERIMENT 16: COMPARISONS OF NEW AND OLD BASIC RIFLE MARKSMANSHIP PROGRAMS

OBJECTIVE

Before any new program is implemented, a "trial run" is needed, serving two purposes: First, it compares the new and old programs before the new program replaces the old; second, it allows an opportunity for a "shakedown" of the new program. Experiment 16 was conducted to accomplish these two purposes.

METHOD

Subjects

One company of 147 basic trainees from the U.S. Army Training Center at Fort Benning were conducted through the new program. The base data used to represent the old program were the mean performances of all of the personnel of the eight training companies who participated in Experiment 1 at Forts Gordon and Jackson.

Apparatus and Procedure

All men fired with the M16 rifle. A comparison of the old BRM program with the new program prepared by the Rifle Marksmanship Evaluation Study Group is provided in Table 16-1. Additional information concerning the old program is available in Field Manual 23-71, August 1969, while the new program is described in greater detail in Draft Subject Schedule 23-72, January 1970.

The new program was administered by personnel of the Weapons Department of the Infantry School. Having the program administered by the normal teaching cadre would have assured a more valid comparison between the old and the new programs. However, a second goal of this experiment was to provide a "shakedown" of the instruction, and those writing the program were in a better position to make the necessary adjustments seeing the difficulties first hand.

RESULTS

Since the new program differs from the old in terms of the number and type of targets, a statistical comparison between the two programs cannot be made without running a separate criterion test. However, in Figures 16-1 and 16-2 the hit probabilities for the old and new BRM programs for aimed supported fire and aimed unsupported fire are compared. It is highly unlikely that proportional differences of this magnitude could be due to chance.

Table 16-1

Comparison of BRM Programs

Period	New Program			Old Program		
	Instruction	Rounds	Hours	Instruction	Rounds	Hours
1	Orientation and Mechanical Training	0	4	Orientation	0	1
22	Introduction to Marksmanship Training	9	4	Mechanical Training	0	4
3	Preparatory Marksmanship	0	4	Introduction to Marksmanship	0	2
4	Preparatory Marksmanship	27	4	Preparatory Marksmanship	9	4
5	Preparatory Marks-manship Training	27	4	Preparatory Marksmanship	0	2
6	25-Meter Firing	36	4	25-Meter Firing and Target Detection	21	6
7	Introduction to Field Firing	36	4	25-Meter Firing and Target Detection	31	7
8	Field Fire and Target Detection	24	4	25-Meter Firing and Refire Zero	21	4
9	Field Fire and Target Detection	36	4	Field Firing and 25-Meter Firing	66	8
10	Field Fire and Target Detection	36	4	Field Firing and Target Detection	36	4
11	Field Fire and Target Detection	36	4	Field Firing and Target Detection	36	4
12	Field Fire, Target Box and Rapid Magazine Change	36	4	Field Firing	36	3
13	Record Fire I and Aerial Target Engagement	40	4	Field Firing and Target Detection	40	4
14	Air Rifle Training	600 BBs	3	Quick Fire	0	3
15	Transition to M16A1 With Ribs	40	4	Quick Fire	60	4
16	Remedial Firing (Field) and Target Detection	36	4	Field Firing and 25-Meter Firing	50	4
17	Field Fire (Remedial) Target Detection	36	4	Field Firing and Target Detection	36	4

Continued

Table 16-1 *(Continued)*

Comparison of BRM Programs

Period	New Program			Old Program		
	Instruction	Rounds	Hours	Instruction	Rounds	Hours
18	Record Fire II and Aerial Target Engagement	40	4	Record Fire I and Target Detection	56	4
19	25-Meter Automatic Firing	36	2	Record Fire II and Target Detection	40	4
20	Automatic Fire, 25-Meter Range	30	2	Night Fire Orientation	20	2
21	Night Firing	32	3	Night Firing	32	2½
22	Night Corrective Firing (Daytime)	72	3	Night Firing	32	2½
23	Night Record Firing	72	3			
Total		755	84		625	83

Comparison of Hit Probabilities for Old and New BRM Programs—Aimed Supported Fire: Experiment 16

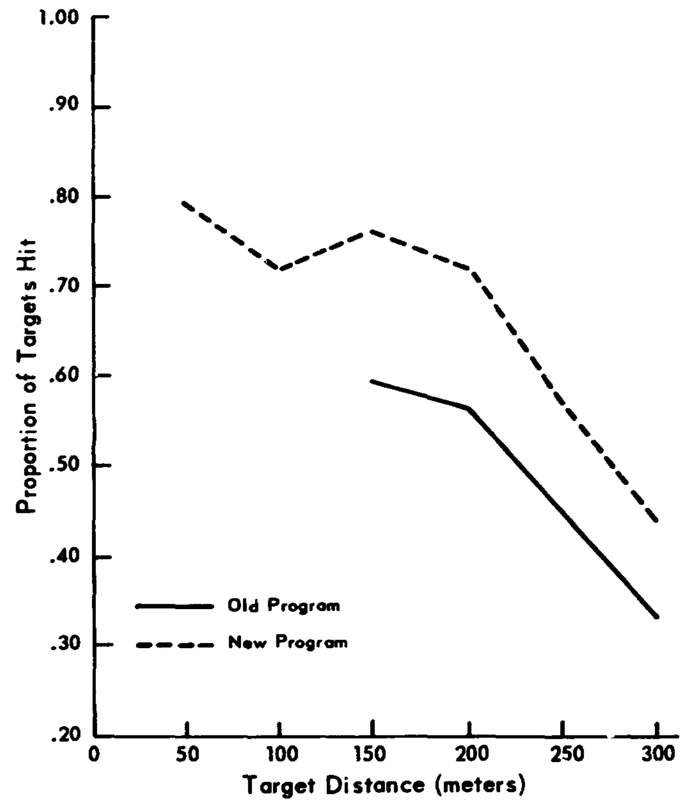

Figure 16-1

Comparison of Hit Probabilities for Old and New BRM Programs—Aimed Unsupported Fire: Experiment 16

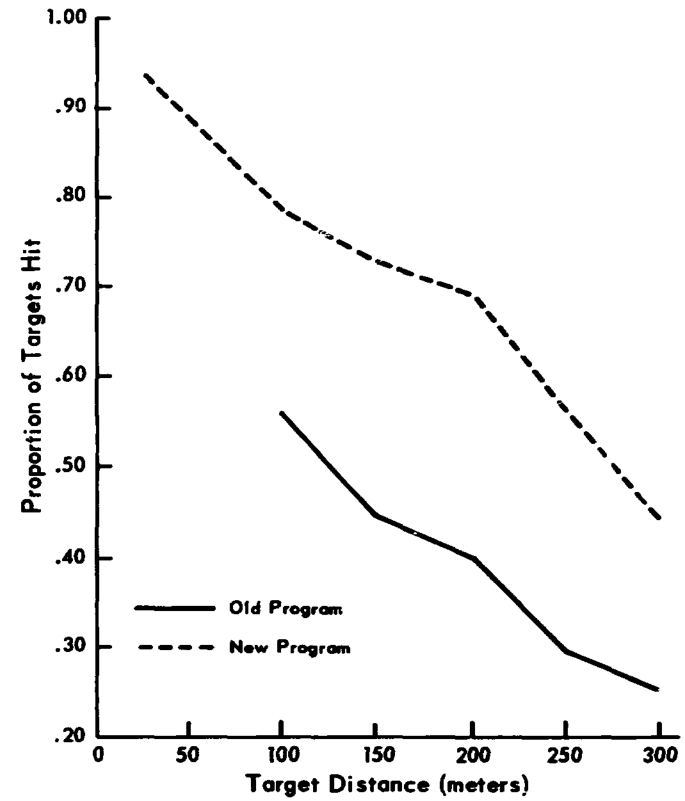

Figure 16-2

Appendix Q

EXPERIMENT 17: COMPARISON OF KNEELING, PRONE, SITTING, AND SQUATTING POSITIONS

OBJECTIVE

The objective of this experiment was to conduct a simple study of the effects of firing range (distance) and firing position on the number of hits obtained and the time required to fire.

METHOD

Experimental Variables

The following variables, along with the levels listed were examined:

A. Range
  1. 75 meters
  2. 175 meters
  3. 300 meters

B. Offensive Position
  1. Kneeling
  2. Squatting
  3. Prone
  4. Sitting

C. Defensive Position
  1. Foxhole
  2. Bunker

Subjects

Twenty-four students entering the Noncommissioned Officer Candidate School at Fort Benning, Georgia participated.

Apparatus

The 75-, 175- and 300-meter targets from three adjacent lanes of a standard, BRM field fire range were used. The M16 rifle was used.

Procedure

The men were taken to a standard BRM, 25-meter range for preliminary instructions and the confirming of their zero. Although the weapons had been prezeroed by a mechanical device, the men were given the opportunity to confirm the zero for each weapon. They were then transported to the field fire range to fire for record, and divided into two groups of 12. Since all had qualified with the M16 rifle and had received instruction in all positions in their BRM and AIT programs, no further practice was given.

During record fire, each man loaded an 18-round magazine and prepared to fire in the position described by the tower operator. When instructed to fire from an offensive position, the men were told that upon observing the target, they were to assume the prescribed firing position and engage the target in the shortest possible time. For offensive targets, the firer always began in the standing position. The firer was allowed only one round per target presentation, regardless of whether he obtained a hit. Each man engaged a 75-, 175- and a 300-meter target from each position.

The order of the presentation of range was randomized. The man was located on the middle of the three lanes. The lane in which the target was presented was randomized to increase the number of potential targets in each situation. The counterbalancing of the position sequence and target sequence by order is shown in Table 17-1; four counterbalancing orders were used.

The two defensive positions were examined at the same time, and identically except that the individuals assumed the position prior to the presentation of the targets.

Time to fire, measured from target presentation and number of hits were the measures obtained. All men fired in the semiautomatic mode.

RESULTS

The analyses of variance are given in Tables 17-2, 17-5, and 17-8. The mean numbers of hits and the mean times to fire are given in Tables 17-3, 17-4, 17-6, 17-7, 17-9 and 17-10. Both firing range and firing position had a significant effect on the number of hits obtained. A significant difference in performance was not obtained between the kneeling and the prone firing positions in total hits. However, all other positions were significantly different from each other in terms of the number of hits obtained. The rank order of superiority of the firing positions in total hits with the best ranked first, was:

(1) Bunker
(2) Foxhole
(3) Prone and kneeling
(4) Squatting
(5) Sitting

Among the offensive firing positions, the kneeling configuration was found to be significantly faster in firing than the other three positions tested. Thus, although the prone position is as accurate as the kneeling position, and both are superior to the squatting and sitting positions in accuracy, the kneeling position is superior to all three of the other offensive positions in time to fire. There was no significant difference between the two defensive positions (bunker and foxhole) in time to fire.

Considering both hit and time data, the bunker position appeared to be superior to the foxhole position, while the rank order of superiority for the offensive positions was:

(1) Kneeling
(2) Prone
(3) Squatting
(4) Sitting

Table 17-1

Counterbalancing of Variables

Order	Position Sequence	Distance Sequence (meters)
A	Foxhole	175 300 75
	Bunker	175 300 75
	Prone	75 300 175
	Sitting	75 300 175
	Kneeling	300 175 75
	Squatting	300 75 175
B	Squatting	175 300 75
	Kneeling	75 300 175
	Sitting	75 175 300
	Prone	75 175 300
	Bunker	300 175 75
	Foxhole	175 300 75
C	Sitting	75 300 175
	Kneeling	300 75 175
	Squatting	175 300 75
	Foxhole	300 175 75
	Bunker	75 175 300
	Prone	75 175 300
D	Prone	300 175 75
	Bunker	75 300 175
	Foxhole	75 175 300
	Squatting	300 75 175
	Kneeling	300 175 75
	Sitting	175 300 75

Table 17-2

Effects of Firing Position on Hits: Analysis of Variance

Source of Variation	*df*	*MS*	*F*	*p*
Range (A)	2	128.01	145.47	<.01
Position (B)	5	24.80	30.24	<.01
AB	10	0.82	1.06	NS
Error (A)	446	0.88		
Error (B)	115	0.82		
Error (AB)	230	0.77		

Table 17-3

Mean Number of Hits, by Range

Range (meters)	Mean Number of Hits
75	2.72
175	2.65
300	1.05

Table 17-4

Mean Number of Hits, by Position

Position	Mean Number of Hits
Bunker	2.94
Foxhole	2.79
Prone	1.94
Kneeling	1.89
Squatting	1.72
Sitting	1.53

Table 17-5

Effects of Offensive Positions on Time to Fire: Analysis of Variance

Source of Variation	*df*	*MS*	*F*	*p*
Range (A)	2	341.43	89.61	<.01
Position (B)	3	56.54	10.13	<.01
AB	6	3.63	1.92	NS
Error (A)	46	3.81		
Error (B)	69	5.58		
Error (AB)	138	1.89		

Table 17-6

Mean Time to Fire, by Range, For Offensive Positions

Range (meters)	Mean Time to Fire
75	5.39
175	5.74
300	6.32

Table 17-7

Mean Time to Fire, by Position, For Offensive Positions

Position	Mean Time to Fire
Kneeling	5.51
Squatting	5.81
Prone	5.96
Sitting	5.99

Table 17-8

Effects of Defensive Positions on Time to Fire: Analysis of Variance

Source of Variation	*df*	*MS*	*F*	*p*
Range (A)	2	142.07	60.52	<.01
Position (B)	1	7.11	3.61	NS
AB	2	11.55	8.62	<.01
Error (A)	46	2.43		
Error (B)	23	1.97		
Error (AB)	46	1.34		

Table 17-9

Mean Time to Fire, by Range, For Defensive Positions

Range (meters)	Mean Time to Fire
75	3.13
175	3.58
300	4.01

Table 17-10

Mean Time to Fire, by Position and Range, for Defensive Positions

Position	Range (meters)	Mean Time to Fire
Foxhole	75	2.95
	175	3.65
	300	3.96
Bunker	75	3.31
	175	3.52
	300	4.06

Appendix R

EXPERIMENT 18: EVALUATION OF POSSIBLE MODIFICATION TO PRONE POSITIONS

OBJECTIVE

The objective of this experiment was to determine the relative superiority of the angled and straight line variations of the prone and prone supported firing positions. BRM trainees are presently taught that the optimum angle formed by the firer's body and the line of sight of the rifle in the prone/prone supported firing position, using the M14 Rifle, is approximately 30°. In Field Manual 23-9, paragraph 25 c, it is stated that a straight line firing position is the most stable for the M16 rifle. No data comparing the positions were available. All other things being equal, the straight line firing position would be more desirable than the angled position, because a smaller percentage of the firer's body would be exposed to hostile fire.

METHOD

Experimental Variables

The following variables, along with the levels listed, were examined:

- A. Mode
  1. Semiautomatic
  2. Automatic (three-round burst)
- B. Position
  1. Angled (30 Degrees)
  2. Straight line
- C. Support
  1. Prone supported
  2. Prone unsupported
- D. Distance
  1. 75 meters
  2. 175 meters
  3. 300 meters

Subjects

Twenty-four students entering the Noncommissioned Officer Candidate School at Fort Benning participated in the experiment.

Apparatus

The 75-, 175-, and 300-meter targets from a single lane of a standard BRM field fire range were used. The M16 rifle was used.

Procedure

The subjects fired one at a time and each man came to the firing line twice. The first time he fired all combinations of position, support and distance in one of the two modes. He then retired from the firing line and waited while all the others fired their first order. When all the men had fired their first order they were returned to the firing line one at a time to fire the same combinations of position, support, and target distance for the other mode of fire. There were four different counterbalancing groups, as shown in Table 18-1, six men in each group. The study took two days, and three men from each of the four counterbalancing groups participated on each day. The study was conducted in December 1969 at Fort Benning.

RESULTS

The analyses of variance and the means for various combinations of the variables for the number of trigger pulls required to first hit and the time to first hit are presented in Tables 18-2 through 18-5. The conclusions of this experiment, as illustrated in the tables, are:

(1) The straight line unsupported position is superior to the angled unsupported position in both trigger pulls and time to first hit. There was no difference between the straight line and the angled position when support was used.
(2) Semiautomatic fire is superior to automatic fire in both number of trigger pulls and time to first hit.
(3) Supported fire is superior to unsupported fire in both trigger pulls to first hit and time to first hit.

In summary, the straight line position is superior when no support is available. Support is preferable when available. When support is used, the choice of straight line vs. angled body position is irrelevant. The semiautomatic mode is superior to the automatic mode of fire.

Table 18-1

Counterbalancing of Variables

Group	Mode-Position-Support Sequence	Target Distance Sequence (meters)		
A	Semiautomatic-Angled-Prone	75	175	300
	Semiautomatic-Angled-Prone Supported	175	300	75
	Semiautomatic-Straight-Prone	300	75	175
	Semiautomatic-Straight-Prone Supported	75	300	175
	Automatic-Angled-Prone	175	75	300
	Automatic-Angled-Prone Supported	300	175	75
	Automatic Straight-Prone	175	300	75
	Automatic-Straight-Prone Supported	75	175	300
B	Automatic-Straight-Prone Supported	75	175	300
	Automatic-Straight-Prone	175	300	75
	Automatic-Angled-Prone Supported	300	75	175
	Automatic-Angled-Prone	75	300	175
	Semiautomatic-Straight-Prone-Supported	175	75	300
	Semiautomatic-Straight-Prone	300	175	75
	Semiautomatic-Angled-Prone Supported	175	300	75
	Semiautomatic-Angled-Prone	75	175	300
C	Automatic-Angled-Prone	75	175	300
	Automatic-Angled-Prone Supported	175	300	75
	Automatic-Straight-Prone	300	75	175
	Automatic-Straight-Prone Supported	75	300	175
	Semiautomatic-Angled-Prone	175	75	300
	Semiautomatic-Angled-Prone Supported	300	175	75
	Semiautomatic-Straight-Prone	175	300	75
	Semiautomatic-Straight-Prone Supported	75	175	300
D	Semiautomatic-Straight-Prone Supported	75	175	300
	Semiautomatic-Straight-Prone	175	300	75
	Semiautomatic-Angled-Prone Supported	300	75	175
	Semiautomatic-Angled-Prone	75	300	175
	Automatic-Straight-Prone Supported	175	75	300
	Automatic-Straight-Prone	300	175	75
	Automatic-Angled-Prone Supported	175	300	75
	Automatic-Angled-Prone	75	175	300

Table 18-2

Effects of Modifications to Prone Positions on Trigger Pulls to First Hit: Analysis of Variance

Source of Variation	*df*	*MS*	*F*	*p*
Mode (A)	1	38.03	21.01	<.01
Position (B)	1	2.51	3.54	NS
Support (C)	1	42.25	20.31	<.01
Distance (D)	2	210.51	169.77	<.01
AB	1	0.44	<1	NS
AC	1	18.06	22.86	<.01
AD	2	4.74	3.25	<.05
BC	1	7.11	7.26	<.05
BD	2	0.84	<1	NS
CD	2	3.17	1.98	NS
ABC	1	0.01	<1	NS
ABD	2	0.24	<1	NS
ACD	2	0.33	<1	NS
BCD	2	1.62	2.03	NS
ABCD	2	0.13	<1	NS
Error (A)	23	1.81		
Error (B)	23	0.71		
Error (C)	23	2.08		
Error (D)	46	1.24		
Error (AB)	23	1.33		
Error (AC)	23	0.79		
Error (AD)	46	1.46		
Error (BC)	23	0.98		
Error (BD)	46	0.95		
Error (CD)	46	1.60		
Error (ABC)	23	1.36		
Error (ABD)	46	1.32		
Error (ACD)	46	1.20		
Error (BCD)	46	0.80		
Error (ABCD)	46	1.30		

Table 18-3

Mean Number of Trigger Pulls Required for Various Treatment Conditions

Treatment Condition	Mean Number of Pulls
Semiautomatic	2.13
Automatic	2.64
Supported	2.11
Unsupported	2.66
Range	
75 Meters	1.74
175 Meters	1.82
300 Meters	3.59
Supported	
Semiautomatic	2.03
Automatic	2.19
Straight Line	2.16
30°	2.07
Unsupported	
Semiautomatic	2.22
Automatic	3.09
Straight Line	2.48
30°	2.83

Table 18-4

Effects of Modifications to Prone Positions on Time to First Hit: Analysis of Variance

Source of Variation	*df*	*MS*	*F*	*p*
Mode (A)	1	1,898.78	70.04	<.01
Position (B)	1	120.82	4.52	<.05
Support (C)	1	1,153.73	21.89	<.01
Distance (D)	2	7,525.67	205.39	<.01
AB	1	0.95	<1	NS
AC	1	20.25	<1	NS
AD	2	935.18	28.71	<.01
BC	1	350.31	8.36	<.01
BD	2	38.76	1.86	NS
CD	2	26.76	1.01	NS
ABC	1	73.11	2.65	NS
ABD	2	10.98	<1	NS
ACD	2	24.61	<1	NS
BCD	2	8.80	<1	NS
ABCD	2	86.06	2.60	NS
Error (A)	23	27.11		
Error (B)	23	26.72		
Error (C)	23	52.71		
Error (D)	46	36.64		
Error (AB)	23	40.68		
Error (AC)	23	23.29		
Error (AD)	46	32.57		
Error (BC)	23	41.91		
Error (BD)	46	20.82		
Error (CD)	46	26.62		
Error (ABC)	23	27.60		
Error (ABD)	46	34.93		
Error (ACD)	46	31.22		
Error (BCD)	46	20.57		
Error (ABCD)	46	33.08		

Table 18-5

Mean Time to First Hit for Various Treatment Conditions

Treatment Condition	Mean Time to First Hit
Semiautomatic	8.45
Automatic	12.08
30°	10.72
Straight Line	9.81
Supported	8.85
Unsupported	11.68
Range	
75 Meters	6.09
175 Meters	7.24
300 Meters	17.46
Supported	
Straight Line	9.17
30°	8.53
Unsupported	
Straight Line	10.44
30°	12.92

Appendix S

EXPERIMENT 19: COMPARISON OF THE STANDARD, TRI-LUX, PROMETHIUM, AND OPEN SIGHTS FOR NIGHT USAGE

OBJECTIVE

The purpose of this study was to compare the effectiveness of various night sights under half- and full-moon conditions. Previous tests have not examined the different sights under the increased illumination obtained with a full moon, or the use of the Promethium and Open night sights.

METHOD

Experimental Variables

The following variables, along with the levels listed, were examined:

Part 1 - Full Moon

A. Sight
   1. Standard M16A1
   2. Tri-Lux
   3. Promethium

B. Distance
   1. 25 meters
   2. 50 meters
   3. 75 meters

Part 2 - Half Moon

A. Sight
   1. Standard M16A1
   2. Tri-Lux
   3. Promethium
   4. Open

B. Distance
   1. 25 meters
   2. 50 meters
   3. 75 meters

The data for both parts of the experiment were analyzed using a Lindquist treatments-by-subjects design. Two analyses were conducted for each phase with variables A and B as within-subject factors. The criteria of performance measures used for the analyses of each phase were the total number of hits and the time, in seconds, required to obtain the first hit.

Subjects

Forty-eight members of a class of the Noncommissioned Officer Candidate School at Fort Benning participated in this study, 24 under the full-moon condition of Part 1, and 24 in Part 2, the half-moon condition.

Apparatus

One firing lane was used with three targets placed in a staggered configuration in front of the firer at ranges of 25, 50, and 75 meters. Each target was equipped with a microswitch that started a clock when the target appeared and stopped it when the target was hit. The clock was capable of measuring the response time to the nearest hundredth of a second. The test was conducted with the M16 rifle using the M16A1, Tri-Lux, Open, and Promethium sights. The Tri-Lux sight is described in Experiment 10. The Promethium sight was similar to the Tri-Lux, except that Promethium was used as the luminescent element. The rear aperture was circular with an inside diameter of 0.70 centimeter. The Open sight was simply the "U" of the carrying handle without a sight.

Procedure

On the afternoon of the test, the men were instructed briefly on the proper use of the different night sights, then given a total of 18 rounds each for practice firing. After being instructed on the range configuration, the location of targets, and the procedure to follow on the firing line, each firer was moved to the firing line and requested to assume a good prone supported position. The man was then given a six-round magazine and told to "watch your lane." The firer was instructed to fire six rounds at each target when it appeared, always using the semiautomatic mode of fire. The time required to obtain the first hit and the total number of hits were both recorded.

Each man followed this procedure until he had fired at all targets with all sights, using a six-round clip, under each experimental condition. The order of firing with each type of sight was counterbalanced and the targets at the various ranges appeared in random sequence. The record firing for Part 2, which was the half-moon condition, was conducted three weeks after the record firing for Part 1.

RESULTS

Part I

Number of Hits. This analysis indicated that the type of sight employed had a significant effect on the number of hits obtained ($p<.01$). When this effect was examined further with the Tukey A procedure, it was determined that the Tri-Lux and Promethium sights obtained significantly more hits than did the Standard sight ($p<.01$). The means for the number of hits were 2.79, 4.51, and 4.58 for the Standard, Tri-Lux, and Promethium sights, respectively. The analysis also indicated that all firing ranges were significantly different from each other with respect to the number of hits obtained ($p<.01$). The means were 5.47 at 25 meters, 4.03 at 50 meters, and 2.39 at 75 meters. When Tukey's test was applied to the significant Sight by Distance interaction, many significant differences were obtained ($p<.01$). Those relevant to the experimental objectives were: (a) Tri-Lux and Promethium vs. Standard (25 meters), (b) Tri-Lux and Promethium vs. Standard (50 meters), and (c) Promethium vs. Standard (75 meters). The analysis of variance summary is presented in Table 19-1 and the Sight by Distance interaction is represented in Figure 19-1.

Time to First Hit. The time analysis indicated that both sight and distance significantly affected the amount of time required to obtain the first hit ($p<.01$). Tukey's test indicated that significantly more time was required for the first hit with the Standard sight (11.02 seconds) than was necessary with either the Tri-Lux (6.33 seconds) or the Promethium (5.94 seconds) sight ($p<.01$)

All the firing ranges were found to be significantly different from each other with respect to the amount of time required to obtain a hit ($p<.01$). The mean times required were 2.65 seconds at 25 meters, 8.01 seconds at 50 meters, and 12.64 seconds at 75 meters. Using Tukey's test, the Sight-by-Distance interaction indicated that the Tri-Lux and Promethium sights required significantly less time to record the first hit at 50 meters ($p<.01$) and also at 75 meters ($p<.05$) than was necessary for the Standard sight. The summary for the analysis of variance is shown in Table 19-1 and the Sight by Distance interaction is plotted in Figure 19-2.

Part 2

Number of Hits. This analysis indicated that both weapon sight and firing range had a significant effect on the total number of hits recorded ($p<.01$). The mean numbers of hits obtained with each of the weapon sights were: Standard, 2.01; Tri-Lux, 3.33; Promethium, 2.83; and Open, 3.19. Wher the Tukey A procedure was applied to these means, the Standard sight was found to be significantly inferior to the other three sights tested ($p<.01$). The means for each of the firing ranges were 5.14 at 25 meters, 2.32 at 50 meters, and 1.07 at 75 meters. Tukey's test indicated that these means were all significantly different from each other ($p<.01$). A summary of the analysis of variance is given in Table 19-2.

Time to First Hit. Weapon sight ($p<.05$) and target distance ($p<.01$) both had a significant effect on the amount of time required to obtain the first hit. The mean time required to obtain a hit with each of the sights was 16.94 seconds for the Standard, 12.85 for the Tri-Lux, 13.92 for the Promethium, and 12.13 with the Open sight. It was determined by Tukey's test that the significance of this main effect was due to a significant difference between the Standard and Open sights ($p<.05$). All target distances were significantly different from each other with respect to the amount of time required to record the first hit ($p<.01$). The analysis of variance summary table is presented in Table 19-2.

DISCUSSION

Under full-moon illumination, the Tri-Lux and Promethium sights were found to be significantly superior to the Standard M16A1 rifle sight with respect to the total number of hits obtained and the amount of time required to record the first hit. Although no significant differences were obtained between the Tri-Lux and Promethium sights, the Promethium sight resulted in significantly more hits than were achieved with the Stnadard sight at the 75-meter range, but no difference was obtained between the Tri-Lux and Standard sights at this range. The Tri-Lux and Promethium sights were both significantly faster in obtaining the first hit than was the Standard sight at the 50-meter range ($p<.01$) and also at the 75-meter range ($p<.05$).

The Tri-Lux, Promethium, and Open sights all obtained significantly more hits than the Standard sight under half-moon illumination. The Open sight was found to be significantly faster than the Standard sight in scoring the first hit, but this was the only significant time difference obtained between sights for the half-moon condition.

The differences between sights tend to be reduced or eliminated as target distance increases and as the amount of illumination decreases. The differences between sights in the form of Sight by Distance interaction effects that were present in Part 1 were lost under the reduced illumination of the half-moon condition. The over-all effects of reducing the illumination from a full to a half-moon condition appear to approximately double the amount of time required to score the first hit and to reduce the number of hits obtained by about one-third.

In general, the Tri-Lux, Promethium, and Open sights were found to be superior to the Standard sight for night firing in terms of the number of hits recorded and the amount of time required to obtain the first hit. Although no significant differences were obtained between the Tri-Lux, Promethium, and Open sights, one set of treatment conditions favored the Promethium sight and the Open sight was found to be faster under the half-moon condition. A more definitive statement concerning the best sight could probably be made if data were available on the effectiveness of the Open sight under full-moon illumination.

Sight by Distance Interaction *(Mean Number of Hits)*

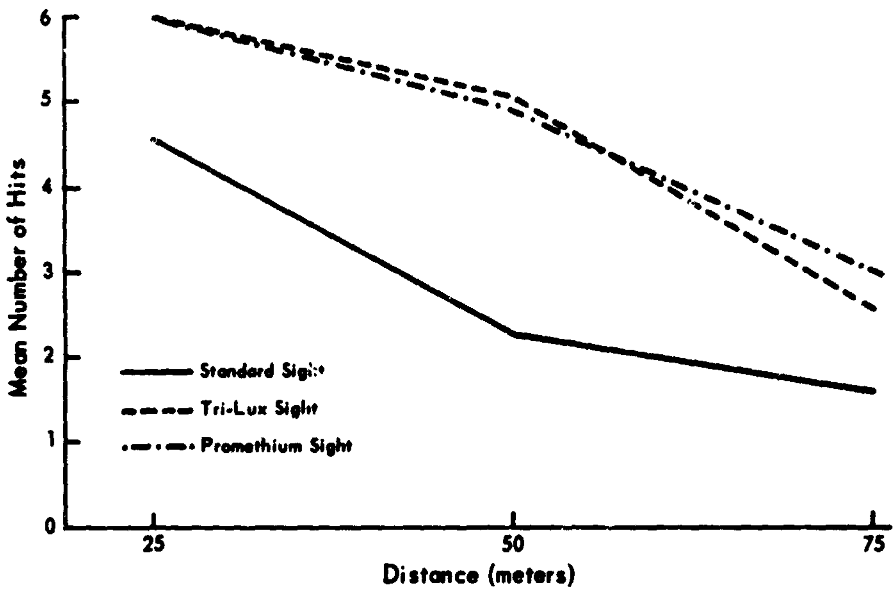

Figure 19-1

Sight by Distance Interaction *(Mean Time)*

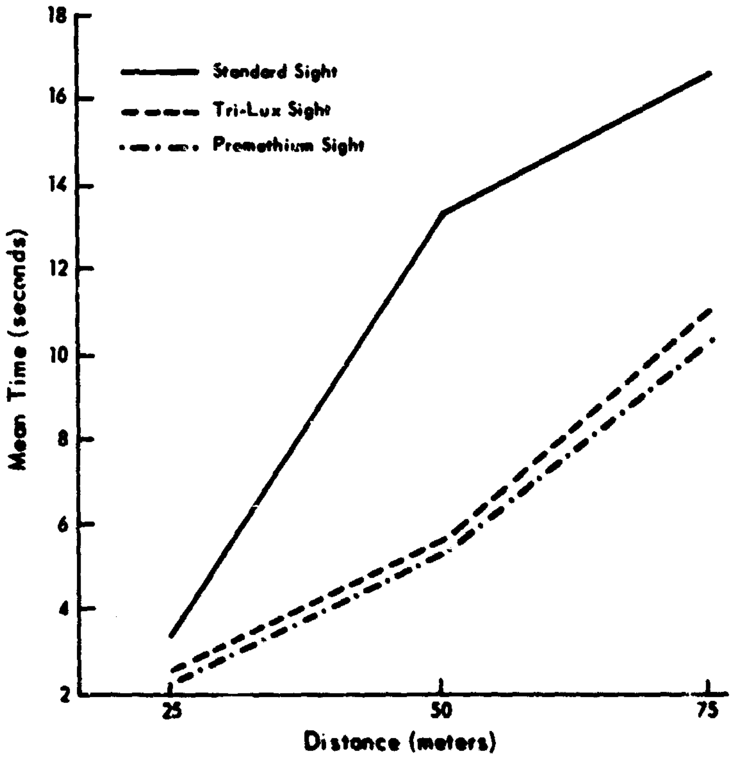

Figure 19-2

Table 19-1

Effects of Various Night Sights on Total Number of Hits and Time to First Hit, Part I: Analyses of Variance

Source	Number of Hits				Time to First Hit			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Sight (A)	2	74.17	26.12	<.01	2	575.38	9.85	<.01
Distance (B)	2	171.35	87.87	<.01	2	1,801.47	29.23	<.01
AB	4	5.40	4.29	<.01	4	94.12	2.64	<.05
Error (A)	46	2.84			46	58.43		
Error (B)	46	1.95			46	45.92		
Error (AB)	92	1.26			92	35.71		

Table 19-2

Effects of Various Night Sights on Total Number of Hits and Time to First Hit, Part 2: Analyses of Variance

Source	Number of Hits				Time to First Hit			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Sight (A)	3	25.24	10.93	<.01	3	323.37	2.97	<.05
Distance (B)	2	415.63	230.91	<.01	2	9,202.69	91.82	<.01
AB	6	1.30	<1	NS	6	143.62	2.04	NS
Error (A)	69	2.31			69	108.83		
Error (B)	46	1.80			46	100.23		
Error (AB)	138	1.74			138	70.50		

Appendix T

EXPERIMENT 20: COMPARISON OF M16A1, TRI-LUX, OPEN, AND PROMETHIUM SIGHTS UNDER DAYLIGHT CONDITIONS

OBJECTIVE

It was concluded from Subexperiments 11A and 11B that the Tri-Lux sight has a speed/accuracy advantage within 25-meter target distance, and that there is no disadvantage to its continued use to a distance of 50 meters. Beyond 50 meters, the Tri-Lux sight became increasingly inferior to the standard M16A1 sight.

The Tri-Lux sight has an extremely large rear aperture (1.00 x 0.75 cm) that increases the capability for fast, coarse aim at near targets. However, it makes more accurate aim at more distant targets difficult. The Promethium sight is an already developed night sight, similar to the Tri-Lux, except that a different luminous element is used and the rear aperture is smaller, but still quite large (.070 cm in diameter). It was reasoned that this smaller, but still large rear aperture might provide a better compromise between the requirements of coarse aim for near targets, and the requirements for precision aim at more distant targets, thus providing a larger safety zone beyond which it would be necessary to change to a smaller peep sight.

METHOD

Experimental Variables

The following variables, along with the levels listed were examined:

A. Sights
   1. Standard M16A1
   2. Tri-Lux
   3. Promethium
   4. Open

B. Range
   1. 15 meters
   2. 25 meters
   3. 50 meters
   4. 75 meters
   5. 100 meters
   6. 125 meters
   7. 150 meters

All subjects fired the M16 rifle, from the kneeling position, in the semiautomatic mode of fire.

Subjects

Thirty-two students entering the Noncommissioned Officer Candidate School at Fort Benning participated as subjects.

Apparatus

A single firing lane with seven pop-up "E"-type silhouette targets positioned in a staggered configuration to the left and right at ranges from 15 to 150 meters were used. A microswitch on each target actuated an electric clock as the target was raised, and stopped the clock when the target was "killed." The clock measured to the nearest hundredth of a second. The M16 rifle was used.

Procedure

Before the test, the firer was briefed on the range configuration, location of targets, and procedures on the firing line. To complete each exercise, the firer moved to the firing line and assumed a good kneeling supported position. He was then handed a six-round magazine and instructed to "watch your lane." When the target appeared the man fired at it until a hit was obtained or until he had fired all six rounds. The time from target presentation to target hit, and the total number of trigger pulls to target hit was recorded by a scorekeeper. The seven targets were presented in random order, and the order of presentation of the four sights was counterbalanced as shown in Table 20-1. Each man took his position on the firing line three times. In each case he fired using one sight, at all target distances.

Before firing for record, the experiment sequence was conducted for practice. The practice was identical to record fire except that only a three-round magazine was used for each target, and only the 15, 75, and 150 meter targets were used. The experiment required three days. Eleven subjects were conducted through the experiment on each of the first two days. Ten subjects were conducted through on the third day.

RESULTS

Summaries of the analyses of variance on the number of trigger pulls and the time required to hit the target are provided in Table 20-2. Summaries of the means for all the sight/distance combinations for both of these criteria are given in Table 20-3. The difference among the four sights was quite significant ($p<.001$). The principal cause for this significance was the overall superiority of the M16A1 sight, considering both criteria. However, the interaction between the type of sight used and the target distance was also significant ($p<.001$).

In the case of the time to first hit, the significance of this interaction was due primarily to the comparative speed of the large rear-aperture sight, and to a lesser extent to the open sight at the 15- and 25-meter targets (Table 20-3). In terms of trigger pulls to first hit, all of the sights were about equal within 50 meters, but the large rear-aperture sights became increasingly inferior with increasing distance.

These results tend to support the results of Subtest 11A and 11B which concluded that a large rear-aperture sight would decrease the time required to hit a target in the daytime out to a distance of about 50 meters. Beyond 50 meters, the more precise alignment made possible by the smaller aperture of the M16A1 sight is required.

Table 20-1

Counterbalancing and Randomization of Variables

Order	Subject (N = 32)	Sight Sequence	Target Sequence (*meters*)
A	1,5,9,13,17,21,25,29	Standard	12,125,50,75,25,100,150
		Tri-Lux	100,25,50,150,75,15,125
		Promethium	75,100,125,15,25,150,50
		Open	125,50,100,75,150,25,15
B	2,6,10,14,18,22,26,30	Open	25,125,150,50,15,100,75
		Promethium	15,100,75,150,125,50,25
		Tri-Lux	100,125,25,75,15,150,50
		Standard	15,125,25,150,100,75,50
C	3,7,11,15,19,23,27,31	Tri-Lux	125,75,50,150,100,25,15
		Standard	150,25,50,100,125,75,15
		Open	15,25,150,50,125,75,100
		Promethium	75,50,15,150,25,125,100
D	4,8,12,16,20,24,28,32	Promethium	15,150,50,25,100,125,75
		Open	125,15,150,100,25,75,50
		Standard	125,15,50,100,150,75,25
		Tri-Lux	75,100,125,25,50,150,15

Table 20-2

Effects of Various Sights, in Daylight, on Trigger Pulls and Time to First Hit: Analyses of Variance

Source	Trigger Pulls				Time			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Sight (A)	3	42.38	28.77	<.001	3	390.61	38.71	<.001
Distance (B)	6	71.00	56.71	<.001	6	942.42	72.83	<.001
AB	18	7.03	6.10	<.001	18	72.63	5.64	<.001
Error (A)	93	1.47			93	10.09		
Error (B)	186	1.25			186	12.94		
Error (AB)	558	1.15			558	12.88		

Table 20-3

Mean Number of Trigger Pulls and Time (in seconds) to First Hit, by Sight and Distance

Sight	Distance (Meters) 15	25	50	75	100	125	150	Mean
Trigger Pulls								
M16A1	1.03	1.03	1.06	1.06	1.12	1.66	1.34	1.22
Tri-Lux	1.03	1.03	1.06	1.84	3.19	3.50	3.63	2.25
Promethium	1.03	1.00	1.12	1.28	1.66	2.50	2.31	1.61
Open	1.12	1.00	1.12	1.72	2.03	3.44	3.06	1.99
Mean	1.05	1.02	1.09	1.48	2.00	2.77	2.58	1.71
Time to First Hit *(seconds)*								
M16A1	1.43	1.14	1.42	1.61	2.26	3.93	3.01	2.11
Tri-Lux	1.15	1.06	1.62	3.65	8.24	9.63	10.49	5.12
Promethium	1.33	1.00	1.57	2.11	3.77	6.23	6.28	3.18
Open	1.43	1.10	1.74	3.29	4.56	9.85	8.50	4.35
Mean	1.34	1.07	1.59	2.66	4.71	7.41	7.07	3.69

Appendix U

EXPERIMENT 21: THE EFFECTIVENESS OF DIFFERENT METHODS OF WEAPON CARRY

OBJECTIVE

The purpose of this study was to confirm the hit probabilities and engagement times obtained during Subexperiment 11B for different weapon carries. The results of this previous test indicated that the modified British alert position (without sling) was superior to the underarm carry (in time to first round hit) up to a distance of 25 meters. The present study was an attempt to replicate this result and also to include comparisons of the modified British alert (with sling) and high port methods of weapon carry.

METHOD

Experimental Variables

The following variables, along with the levels listed, were examined:

A. Weapon Carry
   1. High port
   2. British alert with sling
   3. Underarm
   4. British alert without sling

B. Firing Distance
   1. 10 meters
   2. 25 meters
   3. 50 meters
   4. 75 meters

The data were analyzed using a Lindquist treatments-by-subjects design. Two analyses were conducted with variables A and B as within-subjects factors. The criteria or performance measures used for these analyses were the number of trigger pulls and the time, in seconds, required to obtain the first hit.

Subjects

A total of 60 men participated in this phase of the test which was conducted over a two-day period at Fort Benning. They were a cross-section of Noncommissioned Officer Candidates.

Apparatus

One firing lane was used with four targets placed in front of the firer at ranges of 10, 25, 50, and 75 meters. Each target was equipped with a microswitch which started a clock when the target appeared and stopped it when the target was hit. All firing was conducted in the semiautomatic mode with the M16A1 rifle.

Procedure

All men were given range orientation, a safety briefing, and practice firing. Before each trial, the firers were instructed on what technique to employ while carrying the weapon, either the modified British alert position (with or without sling), the position of high port, or the underarm carry.

At the beginning of each move-out phase for each of the carrying positions, the firer was provided with one magazine containing eight rounds. The man loaded his weapon and advanced approximately five meters. When the firer reached a predetermined point, one of four targets appeared and the firer engaged the target as rapidly as he could identify it, using his assigned firing technique. The firer had instructions to continue engaging the target until a hit was recorded and the target disappeared or until his ammunition had been expended. All four targets and weapon carries were used during the practice firing. For the record firing, the order in which the subjects used the various weapon carries was counterbalanced and target range was administered in random sequence.

A scorekeeper followed the subject down the firing lane and recorded the number of trigger pulls required to hit the target, and the control tower operator who raised the appropriate targets recorded the time to first hit from a timing device in the tower.

RESULTS

Target distance was the only significant ($p<.01$ for both analyses) variable obtained for either the analysis of the number of trigger pulls required for a hit or the amount of time required to obtain the first hit. In general, the number of trigger pulls and the amount of time required for a hit increased with increasing target distance. The analysis of variance summaries are presented in Table 21-1.

DISCUSSION

Since this study did not replicate or confirm the results of Subexperiment 11B, the conclusions drawn from the previous test should be regarded with extreme caution. The significant differences obtained with Subexperiment 11B probably should be considered chance occurrences and the results of the present test should be regarded as the most reliable since a larger number of men participated (N=60 vs. N=24).

Table 21-1

Effects of Different Methods of Weapon Carry on Trigger Pulls and Time to First Hit: Analyses of Variance

Source	Trigger Pulls				Time			
	df	*MS*	*F*	*p*	*df*	*MS*	*F*	*p*
Carry (A)	3	0.42	1.83	NS	3	2.33	2.24	NS
Distance (B)	3	9.76	51.37	<.01	3	145.91	155.22	<.01
AB	9	0.25	1.04	NS	9	1.06	1.12	NS
Error (A)	177	0.23			177	1.04		
Error (B)	177	0.19			177	0.94		
Error (AB)	531	0.24			531	0.95		