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AN EXPLORATION OF THE CONTRIBUTION OF STRIKE FEEDBACK TO COMBAT EFFECTIVENESS WITH BALL AND TRACER AMMUNITION

John L. Miles, Jr., et al

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Aberdeen Proving Ground, Maryland

May 1975

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Technical Memorandum 14-75

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John L. Miles, Jr.
David J. Ursin

May 1975
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HUMAN ENGINEERING LABORATORY

ABERDEEN PROVING GROUND, MARYLAND

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A field test was conducted in which 22 machinegunners each engaged double E-type silhouette targets at ranges from 350 to 650 meters with the M60 and Stoner machineguns during daylight with ball ammunition and the 4:1 ball:tracer mix in a test of the hypothesis that targets would be hit faster and with fewer rounds if located on strike feedback-enhancing terrain. Intervening factors precluded a clear answer to the question, but suggested that it might be of less importance than other factors. Data are analyzed for the performance measures percent targets hit, number of bursts per engagement, and score.

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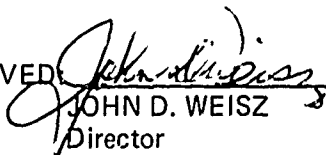
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PREFACE

The authors wish to express appreciation to the following:

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SP4 William M. Robinson of the U. S. Army Human Engineering Laboratory Infantry Team for his cheerful, reliable and thorough execution of many simultaneous (and sometimes conflicting) assignments.

CONTENTS

TABLES

AN EXPLORATION OF THE CONTRIBUTION OF STRIKE FEEDBACK TO

COMBAT EFFECTIVENESS WITH BALL AND TRACER AMMUNITION

BACKGROUND

The HEL Tracer Program

With respect to several new weapon concepts under consideration or actual development, the infantry community has needed a quantitative assessment of the effectiveness of tracer ammunition. Beginning in 1968, the Human Engineering Laboratory (HEL) undertook a program of applied research to answer the question, "What is the increase (if any) in combat effectiveness of tracer ammunition over ball ammunition in the infantry ground-to-ground role?" A three-phase program was established consisting of (1) a literature review, (2) a series of preliminary experiments to determine how certain hypothesized "major factors" influenced performance measures from which "effectiveness" was inferred, and (3) a major field test. The report of phase one (5) and several of the reports of phase two (6, 9, 10) have been published and distributed.

The Theory of Strike Feedback

This report concerns Tracer Experiment 2 (TE2), entitled "strike feedback." Data in this experiment were gathered to answer the question, "What difference in (the performance measures from which we infer) effectiveness is a function of the firer being able to see the ground impact points of his rounds?"

Although strike feedback is theoretically independent of ammunition type, it is logically addressed as part of the tracer research program because the phenomenon can be utilized for at least some of the same functions as tracer. That is, tracer supposedly provides to the gunner a visual cue as to where his rounds pass or impact with respect to the target engaged. Given that strike feedback is present (in the form of dust, movement of vegetation, or water splash), the gunner may have much the same information—at least if his rounds in fact impact around the target [1] Consequently, the effective utilization of the phenomenon of strike feedback by gunners may substantially have accounted for the consistent findings in previous tracer experiments (1, 3, 4, 6, 8, 9) that in daylight there is essentially no difference in effectiveness between ball and tracer ammunition. In all of those experiments, the existence, type and amount of strike feedback were essentially uncontrolled (despite occasionally heroic efforts to obtain control). It remains possible that, on terrain which produces no strike feedback, the gunner may be able to hit the target significantly faster and/or with fewer rounds when he fires tracer ammunition than when he fires ball. This experiment was designed to test that hypothesis.

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[1]On level terrain, rounds fired over or past the target will impact a considerable distance away from the target.

Experimental Plan

The original test plan for TE2[2] called for the hypothesis to be tested with single riflemen firing ball and tracer semiautomatically from the M14 rifle against single E-type silhouette targets on the same terrain utilized in the previous preliminary experiments. The test was to be conducted in daylight only (since the sort of strike feedback under consideration was presumed to be generally invisible at night).

The terrain previously used was Griswold Range at Fort Benning, Georgia, and it was under the operational control of the U. S. Army Infantry Board. The U. S. Army Small Arms Systems Agency, which had sponsored the tracer program, requested (15) that the U. S. Army Test and Evaluation Command (USATECOM) support Tracer Experiment 7 (TE7) to be conducted in May of 1973 at Fort Benning. USATECOM directed (16) the Infantry Board to support that experiment, and HEL requested (13) that this support be expanded to include the conduct of TE2 using the same facilities upon completion of the authorized TE7.

Two factors defeated this plan: (1) inability to secure a competent test director at that time, and (2) inability to control strike feedback on Griswold Range during the weather conditions which prevailed at that time of year.[3] It was then decided to conduct TE2 at Aberdeen Proving Ground in September of 1973. Meanwhile, the strong influence of the Squad Automatic Weapon (SAW) development program caused the original concept of TE2 to be reevaluated, and an entirely new test plan was prepared which combined TE2 (strike feedback with single riflemen) and TE5 (machinegunner in the defense).[4]

The new test plan called for single M60 machinegunners to engage double-E-type silhouette targets at nominal ranges of 350, 450, 550 and 650 meters with all ball and the 4:1 ball:tracer mix under two conditions of strike feedback. The two conditions were designated "enhanced" and "minimized" and were created on the test range by locating the minimized targets in a marshy area (Fig. 1) and by scraping the vegetation away from the enhanced targets with a bulldozer (Fig. 2). Test firing was conducted from a platform constructed atop a truck. The springs of the truck were immobilized by stakes (as shown in Fig. 3) to make the platform rigid, and the firing area was then covered with 4 inches of dirt and sodded (Fig. 4). A schematic of the range is shown in Figure 5.

Subjects in this experiment were 22 enlisted men from the 82d Airborne Division at Fort Bragg, NC. (Some relevant characteristics are stated in Appendix C, page 58.) The subjects were randomly assigned to two groups, each of which alternated, one day at a time, between participation in this experiment and in a pistol experiment conducted by HEL on a nearby range. To control for order effects within this experiment, Subject Group 1 fired its M62 tracer missions first; Subject Group 2 fired its M80 ball missions first. Each subject was assigned a number, and his sequence of target presentations in the actual test was ordered as shown in Figure 6. Each subject was scheduled to fire the test course (consisting of one engagement at each of the eight targets) once on each of 4 different days (making a total of 8 days testing time).[5]

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[2]Stated fully in (12).

[3]Control of strike feedback on that range is discussed in the report of TE7, to be published.

[4]Original test plans given in (12).

[5]For days 2, 3, and 4 the subject's sequence of target presentations was obtained by adding 1, 2 and 3 (respectively) to his assigned subject number and then entering Figure 6 with the sum.

Figure 1. Targets (center) located in marsh to minimize strike feedback.
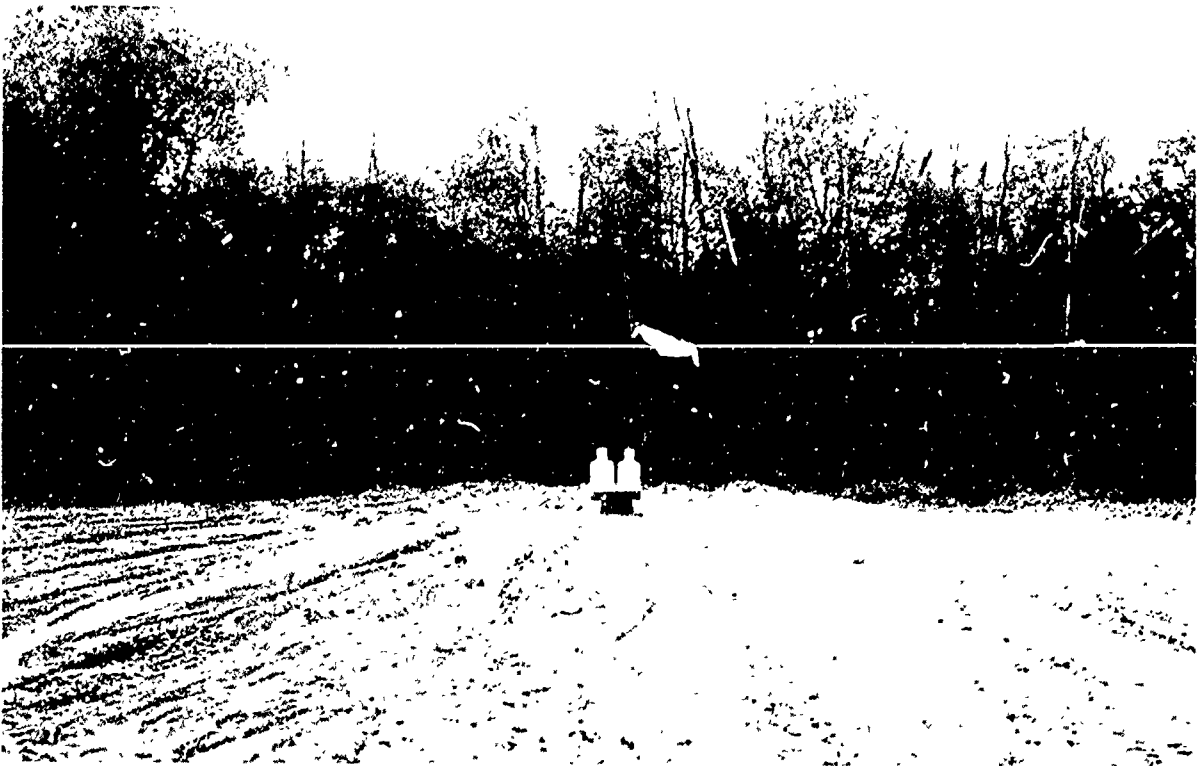
Figure 2. Target located on freshly-scraped earth to enhance strike feedback.
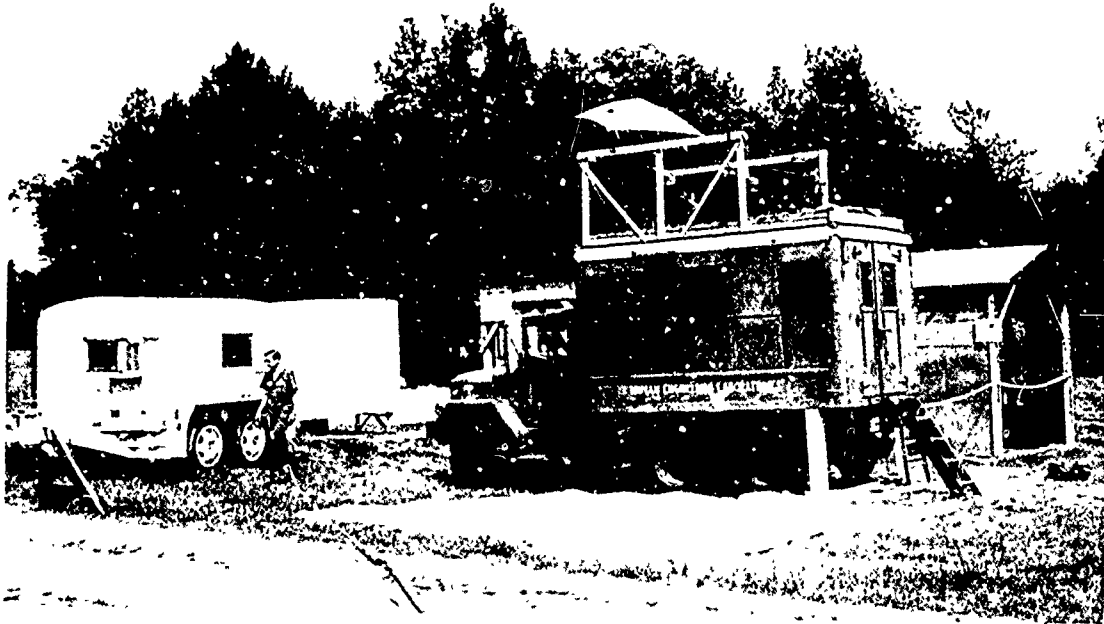
Figure 3. Gunner, assistant gunner, and safety officer in place on firing platform.

Figure 4. Gunner on firing platform during test.

CONTROL POINT

FIRING PLATFORM

350 METERS

450 METERS

550 METERS

650 METERS
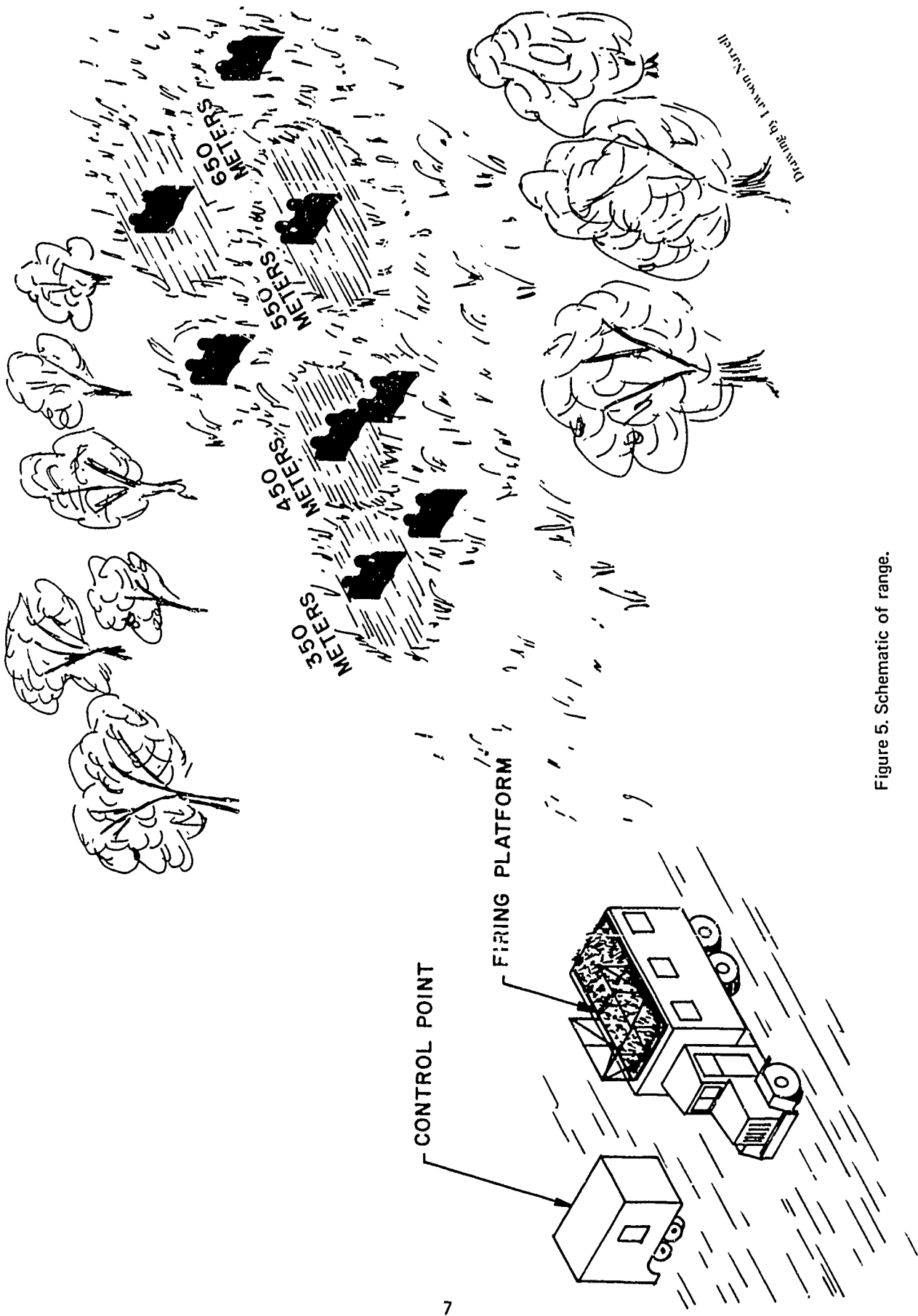
Drawing by Lawson Nurrell

Figure 5. Schematic of range.

7

S E Q U E N C E

	Morning				Afternoon			
	1	2	3	4	1	2	3	4
101/201	A	B	C	D	E	F	G	H
102/202	B	D	A	F	C	H	E	G
103/203	C	A	E	B	G	D	H	F
104/204	D	F	B	H	A	G	C	E
105/205	E	C	G	A	H	B	F	D
106/206	F	H	D	G	B	E	A	C
107/207	G	E	H	C	F	A	D	B
108/208	H	G	F	E	D	C	B	A
109/209	E	F	G	H	A	B	C	D
110/210	C	H	E	G	B	D	A	F
111/211	G	D	H	F	C	A	E	B

S U B J E C T   N U M B E R

Identification of Target

A = 550 meters, strike feedback minimized
B = 650 meters, strike feedback enhanced
C = 350 meters, strike feedback minimizeu
D = 450 meters, strike feedback enhanced
E = 650 meters, strike feedback minimized
F = 350 meters, strike feedback enhanced
G = 450 meters, strike feedback minimized
H = 550 meters, strike feedback enhanced

Figure 6. Sequence of events.

8

For each target engagement, the gunner loaded a fresh belt of 50 rounds into his weapon, assumed the tactical scenario stated in Appendix A, page 47, and when a target was raised, commenced firing until it dropped (when hit) or the firer expended all 50 rounds. At the completion of each target engagement, any unexpended rounds were removed from the weapon. In all of the 4:1 ball:tracer mixes of ammunition, the lead round in the belt of 50 was a tracer.

Performance data were gathered electronically:[6] an acoustic transducer located near the muzzle of the weapon sensed each round fired, and a target hit was sensed by momentary closure of the normally open circuit between the metal front and rear of each E-type silhouette caused each time a bullet passed through an exposed target. These and other sensings were fed to a Techni-Rite Event Recorder which transcribed them graphically and on a common time base.

The experimental variables planned for TE2 are shown in Table 1. Previously in the HEL Tracer Program, the dependent variables or performance measures used were hits/shots ratios, rate of fire and mean time to hit a target. These measures were deemed adequate for experiments in which single riflemen engaged targets with semiautomatic fire, but not wholly appropriate for a test with automatic weapons. For this experiment, we retained the measure mean time to hit and added three others:

- Percent targets hit — This measure is the quotient (x 100) of the number of targets hit divided by the total number of targets exposed.

- Number of bursts per mission — This measure is the number of trigger-pulls per mission and is roughly equivalent (in terms of the previous experiments) to the number of shots fired.

- Mission score[7] — This is the measure which we employed to integrate certain components of marksmanship related to accuracy. The score was computed for each target engagement and consisted of four components:

    a. 40% credit for hitting the target

    b. 20% credit for the number of bursts fired in the mission

    c. 20% credit for the total number of rounds fired in the mission

    d. 20% credit for burst control consistent with Army doctrine

With regard to the last component, doctrine prescribes a six-to-nine round burst as the proper sustained rate of fire for the machinegun (14, p. 297). We found during the practice sessions that the experienced machinegunners in our subject group preferred to fire three-to-four round bursts. To drive them toward performance in accordance with doctrine, we adopted the six round burst as the compromise measure of "best," and penalized subjects for firing greater or fewer rounds per burst. To motivate the gunners to increase (up to six) the number of rounds per burst they were accustomed to firing, we stressed burst control in their refresher training (Appendices A and B) and we posted conspicuously each soldier's average score after each day of firing, praised the "good" scores, and exhorted those with poorer scores to "try harder" and "do better next time."

---

[6]With a system designed by Otho C. Wolfe.

[7]Where a "mission" consists of a single target engagement.

TABLE 1

Experimental Variables in the Design of TE2

Independent Variables	Dependent Variables
Strike Feedback (Enhanced, Minimized)	Percent Targets Hit
	Mean Time to Hit
Ammunition Type (Ball, M80; Tracer, M62)	Mission Score
Gun-Target Range (350, 450, 550, 650 meters)	No. of Bursts Fired

Actual mission scores were computed by the formula:

$$S = U + G$$

where:

$$U = .2\left(1 - \frac{R}{50}\right) + \frac{.2}{B} + \left(.2 \; \frac{4 - \left|6 - \frac{R}{B}\right|}{4}\right)$$

R = Number of rounds fired in the mission

B = Number of bursts fired in the mission

G = .4 (if the target engaged was hit)

G = 0 (if the target engaged was not hit)

INTERVENING FACTORS

Effect of Weather

The range selected for this experiment was ideal for examining the effect of strike feedback. The right-hand side of the range out to about 500 meters was approximately 8 inches below the left hand side. Consequently, with the high water table at Aberdeen Proving Ground, the surface of the left side was dry (permitting scraping to enhance strike feedback) and the right side was marshy (automatically minimizing the sort of strike feedback phenomena previously discussed). Beginning at about 500 meters, the range sloped gently upward. Strike feedback was minimized at 550 and 650 meters by locating the targets amid heavy vegetation.

Coincident with the beginning of the test firing, the Aberdeen area experienced a drought of major proportions and extremely high daily temperatures. The marsh on the right of the range dried up, and strike feedback (in the form of dust clouds) could be detected all across the range. Although the dust clouds were larger and denser on the scraped areas, the original distinction between "enhanced" and "minimized" disappeared. Following a week of drought, there were several days of heavy rain. The water table rose to such an extent that the "minimized" targets produced strike feedback in the form of water splashes and the "enhanced" targets produced strike feedback in the form of easily detectable flying mud. By the end of the test, the water table and the characteristics of the terrain had returned to their normal levels.

Other Intervening Factors

Just prior to the start of the test, the U. S. Army Weapons Command requested that a 5.56mm weapon also be fired in this test. With respect to the phenomena of strike feedback, there was considerable justification for this request. The amount of strike feedback produced on a given piece of dusty terrain is presumably some function of the cross-sectional area and the kinetic energy of the projectile. Thus, if it is found that in daylight strike feedback can provide visual cues equal to or better than tracer (in terms of aiding a gunner to hit a target faster and/or with fewer rounds), caliber and muzzle velocity assume new importance. Such a finding would suggest that, at least with respect to efficiency in getting the projectile onto the target, the recent trend to smaller caliber weapons is counterproductive. Because at the time this experiment was conceived the caliber of the new Squad Automatic Weapon had not yet been decided, U.S. Army Weapons Command requested that 5.56mm ammunition also be fired on the same test bed by the same subjects. Inclusion of weapons of both calibers in this experiment would provide data on the relationships of tracer, caliber[7] and strike feedback to be used in the later trade-off determination (TOD) on SAW caliber. We acceded to the Weapons Command request, in that we scheduled two additional repetitions of the test course for each subject with the 5.56mm Stoner M63 machinegun. We did not integrate or attempt to counterbalance these repetitions in the test design primarily because our Stoner weapons were old and expected to malfunction frequently.[8]

In addition to obtaining data on a second caliber, it was also found desirable to fire some of the special "experimental white" tracer which had been conceived and built by U. S. Army Frankford Arsenal for TE7 (Tracer Composition). This particular tracer is estimated (11) to be approximately 2.5 times brighter than M62 tracer, and this test offered the first opportunity to employ it in automatic fire in a simulated tactical (defense) situation.

For the data to have been balanced according to the original plan, each of the test soldiers should have been at the right place at the right time. Nearly all were, and the spirit of enthusiastic cooperation shown by these men of the 82d Airborne Division was impressive. Nevertheless, one subject had repeated difficulty remembering to report for duty, a second had to go on sick call, and a third was involved in an automobile accident. The results of these more or less routine departures from the test firing schedule became magnified in the ultimate data analysis (as explained below).

Analysis of each subject's performance in terms of mean time to hit a target[9] showed that the times appeared normally distributed but over a surprisingly wide range (Fig. 7). Assuming that "good" military marksmen hit targets faster than "poor" military marksmen, there exists within the data gathered an unanticipatedly large performance variance as a function of individual marksmanship ability. While this was an a posteriori conclusion, its effect must nevertheless be considered in comparisons among data cells.

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[7]Which also was associated with a different projectile velocity.

[8]Our expectations were amply confirmed: In order to have a Stoner machinegun which would fire 50 consecutive rounds without a stoppage, we were, by the end of the test, forced to disassemble, clean and lubricate the weapons after each 200 rounds.

[9]In which a subject who never hit the target on a particular mission was assigned a score of 60 seconds.

SUBJECTS' OVERALL MEAN TIME IN SECONDS TO HIT A TARGET

CELL COUNTS | % REL. FREQ.
5 — 22.7
4 — 18.2
3 — 13.6
2 — 9.1
1 — 4.5
0 — 0.0

13.00 15.00 17.00 19.00 21.00 23.00 25.00 27.00 29.00 31.00

Excellent Good Fair Poor
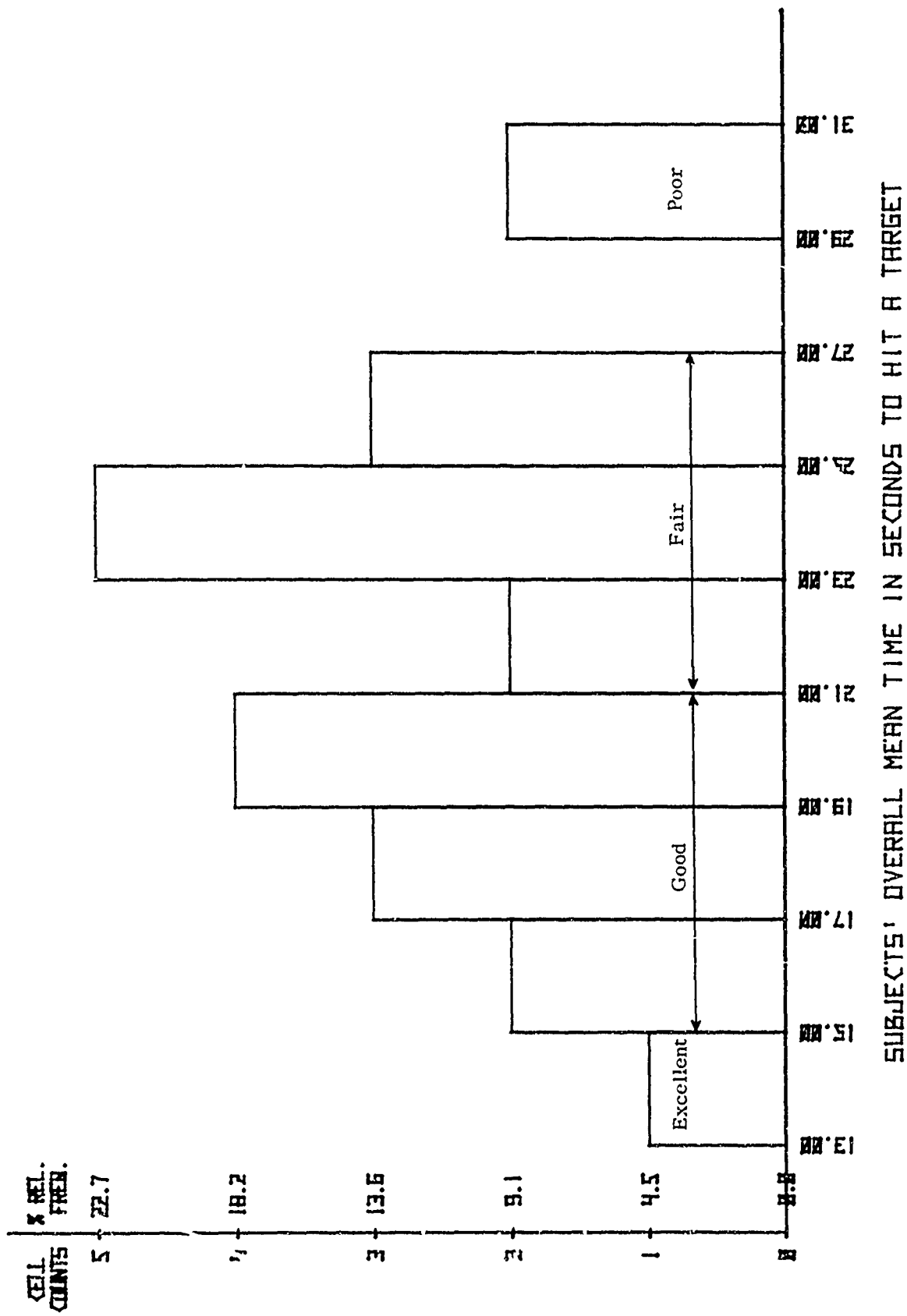
Figure 7. Distribution of marksmanship ability of subjects in Tracer Experiment 2.

A similar problem affected the daytime ambient light levels recorded during the test. The cloud cover before and after the damp portion of the test resulted in a lower than expected light level during nearly a third of the test. Actual photometric readings (which were recorded every 15 minutes during firing) ranged from 6.7×10^2 to 78.4×10^2 footcandles, with a mean of 39.3×10^2 and standard deviation of 20.9×10^2 footcandles calculated from 79 readings. The distribution of these readings is shown in Figure 8.

RESULTS

The intervening factors had a substantial effect upon the test design. Most importantly, where but two conditions of strike feedback had been postulated, there were now many. Moreover, these conditions were not merely gradations along a continuum (from no strike feedback to maximum strike feedback), but were qualitatively different as well. To bring the difficulties thereby introduced into manageable dimensions, the data were grouped by the gross condition of the terrain at the time they were gathered. The three groups were designated "dry," referring to the drought period, "normal," referring to the soil condition at the start and end of the test; and "damp," referring to the period after the heavy rain. The distribution of actual data points[10] is shown in Figure 9 (which will immediately betray to the reader the futility of conventional data analysis). Within Figure 9, the letter "M" denotes missions fired with the M60 machinegun, and the letter "S" denotes missions fired with the 5.56mm Stoner machinegun.

Notwithstanding the alterations to the identity of the "enhanced" and "minimized" categories of strike feedback, analyses of variance were run on the four dependent variables listed in Table 1 in accordance with the original experimental design. Summaries of these analyses are given in Table 2 for the M60 machinegun and in Table 3 for the Stoner machinegun. Subclass means for both sets of analyses are shown in Tables 1E, 1F, 1G and 1H respectively. For the variable "mean time to hit," the imbalance in the data caused by the fact that 101 of the 880 missions with the M60 and 40 of the 352 missions with the Stoner machinegun did not terminate in a hit was compensated for by conducting the analysis of variance on the means of the reciprocals of the actual times to hit.[11] Within these analyses only gun-target range was a significant main effect. This shows that, as expected, measures of goodness of marksmanship decrease as gun-target range (and the difficulty of hitting the target) increase. Within the analyses of the M60 data (Table 2) there were four interactions significant at the 95 percent level of confidence. Two were nuisance interactions,[12] and two involved relationships of potential theoretical significance—ammunition and range, and strike feedback and range. In the former, a significantly greater number of bursts was fired with tracer than with ball at the 350 and 450 meter targets; and a greater number of bursts with ball ammunition at the 550 and 650 targets. In the latter, subjects achieved higher mission scores against "enhanced" targets at all ranges except 650 meters. These interactions are interpreted below. The two significant interactions[13] within the Stoner analyses of variance (Table 3) are not of theoretical importance.

[10]Except for the experimental white tracer, which was fired during the normal and damp periods.

[11]Thus, where a mission did not terminate in a hit, the "time to hit" for that mission was assumed to be infinity, the reciprocal of which was taken to be zero.

[12]On the performance measure "percent targets hit," subject group 1 hit a higher percentage of targets with tracer ammunition and subject group 2 hit a higher percentage of targets with ball ammunition. On the performance measure "mission score," subject group two had higher scores with tracer at three of the four ranges; subject group 1 had higher scores with tracer at two of the four ranges.

[13]Subject group 1 hit a higher percentage of targets at 550 meters with ball ammunition and at 650 meters with tracer; subject group 2 hit a higher percentage of targets at 550 meters with tracer and at 650 meters with ball. Subject group 1 also hit the "enhanced" targets faster while group 2 hit the "minimized" targets faster. (This peculiarity presumably reflects the effects of the intervening factors.)
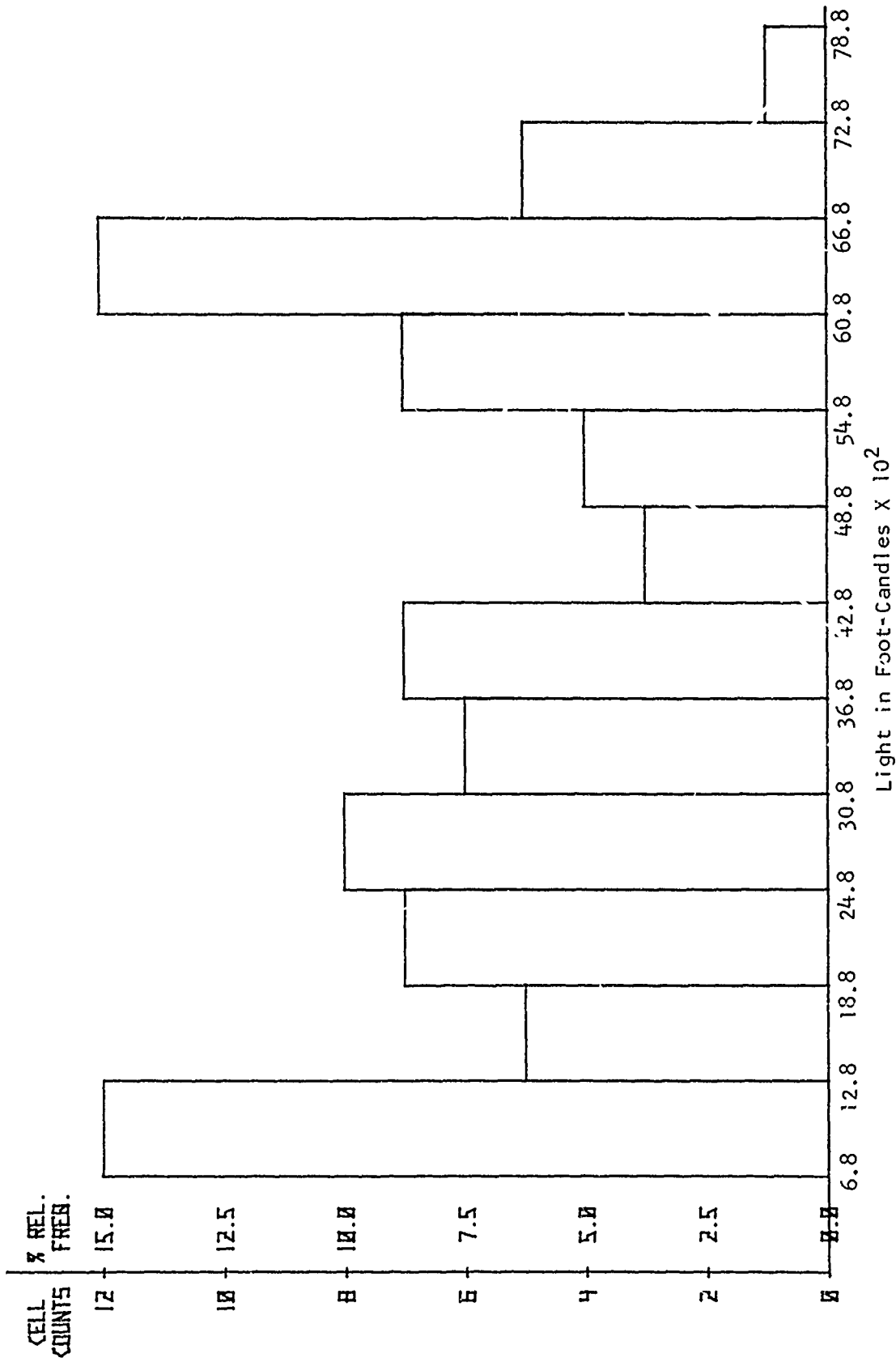
Figure 8. Distribution of ambient light readings during TE2

DRY SOIL

AMMUNITION		BALL								TRACER								
RANGE		350		450		550		650		350		450		550		650		35
STRIKE FEEDBACK		E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E
SUBJECT No	RATING																	
103	EXCELLENT	S	S	S	S	S	S	S	S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	
111	GOOD									S	S	S	S	S	S	S	S	S
211	GOOD	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S									
105	GOOD	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	
202	GOOD	M	M	M	M	M	M	M	M	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	S
104	GOOD	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	
101	GOOD	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	
102	GOOD	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	
204	GOOD	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	
203	GOOD	M	M	M	M	M	M	M	M	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	S
107	FAIR	S	S	S	S	S	S	S	S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	
210	FAIR	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S									
110	FAIR	S	S	S	S	S	S	S	S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	
207	FAIR	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M	M	M	M	M	M	M	M	
206	FAIR	M	M	M	M	M	M	M	M	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	S
208	FAIR	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M	M	M	M	M	M	M	M	
106	FAIR	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	
201	FAIR	M	M	M	M	M	M	M	M	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	S
108	FAIR	S	S	S	S	S	S	S	S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	
209	FAIR	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S									
205	POOR	M	M	M	M	M	M	M	M	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	S
109	POOR	S	S	S	S	S	S	S	S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	

Figure 9. Distribution of actual data points in Tracer Experiment 2.

15

		NORMAL SOIL																D					
50		BALL								TRACER								BALL					
		350		450		550		650		350		450		550		650		350		450		550	
	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M
S	M,S									M	M	M	M	M	M	M	M	M	M	M	M	M	M
S	S	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M	M	M	M	M	M
										M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S						
	M									M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M	M	M	M	M	M
S	M,S	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M						
	M									M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M	M	M	M	M	M
	M									M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M	M	M	M	M	M
	M									M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M	M	M	M	M	M
	M,S									M	M	M	M	M	M	M	M						
S	M,S	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M						
S	M,S									M	M	M	M	M	M	M	M	M	M	M	M	M	M
										M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S						
S	M,S																	M	M	M	M	M	M
	M									M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S						
	M,S	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M						
	M									M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S						
	M									M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S	M	M	M	M	M	M
	M,S	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M	M		M			M
	M,S									M	M	M	M	M	M	M	M	M	M	M	M	M	M
										M,S	M,S	M,S	M,S	M,S	M,S	M,S	M,S						
	M,S	S	S	S	S	S	S	S	S	M	M	M	M	M	M	M	M						
	M,S																	M	M	M	M	M	M

	TRACER					
	450		550		650	
	E	M	E	M	E	M
	M	M	M	M	M	M
	M	M	M	M	M	M
S	M,S	M,S	M,S	M,S	M,S	M,S
S	M,S	M,S	M,S	M,S	M,S	M,S
	M	M	M	M	M	M
S	M,S	M,S	M,S	M,S	M,S	M,S
S	M,S	M,S	M,S	M,S	M,S	M,S
S	M,S	M,S	M,S	M,S	M,S	M,S
	M	M	M	M	M	M
	M	M	M	M	M	M
	M	M	M	M	M	M
	M,S	M,S	M,S	M,S	M,S	M,S
	M,S	M,S	M,S	M,S	M,S	M,S
	M	M	M	M	M	M
	M,S	M,S	M,S	M,S	M,S	M,S
	M,S	M,S	M,S	M,S	M,S	M,S
	M	M	M	M	M	M
	M	M	M	M	M	M
	M,S	M,S	M,S	M,S	M,S	M,S
	M	M	M	M	M	M

DAMP SOIL

BALL								TRACER							
350		450		550		650		350		450		550		650	
E	M	E	M	E	M	E	M	E	M	E	M	E	M	E	M
M	M	M	M	M	M	M	M								
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
M	M	M	M	M	M	M	M								
M	M	M	M	M	M	M	M								
M	M	M	M	M	M	M	M								
M	M	M	M	M	M	M	M								
M	M	M	M	M	M	M	M								
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
M	M	M	M	M	M	M	M								
M		M			M	M									
M	M	M	M	M	M	M	M								
M	M	M	M	M	M	M	M								

TABLE 2

Main Effects and Significant Interactions from Analyses of Variance of Four Dependent Variables
for the M60 Machinegun with Actual Subjects

	Percent Targets Hit			Reciprocal of Mean Time to Hit			Mission Score			No. of Bursts		
	df	ms	F	df	ms	F	df	ms	F	df	ms	F
Between Subjects												
Main Effects												
Original Groups (G)	1	.07	.90	1	.03	3.76	1	234.83	.412	1	9.07	1.26
Error (b)	20	.08		20	.01		20	570.48		20	7.21	
Within Subjects												
Main Effects												
Ammunition Type (A)	1	.05	1.03	1	.01	1.13	1	78.03	.26	1	.26	.05
Error (A)	20	.04		20	.01		20	304.74		20	4.94	
Planned Strike Feedback (S)	1	.18	3.77	1	≈.00	.04	1	358.12	1.59	1	1.31	.45
Error (S)	20	.05		20	≈.00		20	225.32		20	2.94	
Gun-Target Range (R)	3	1.24	29.01***	3	.05	27.36***	3	7293.87	35.01***	3	91.78	26.37***
Error (R)	60	.04		60	≈.00		60	208.33		60	3.48	
Significant Interactions												
(G) x (A)	1	.23	5.23*									
Error (GA)	20	.04										
(A) x (R)							3	716.10	2.77*			
Error (AR)							60	258.14				
(S) x (R)							3	573.10	3.20*			
Error (SR)							60	179.11				
(G) x (A) x (R)										3	8.34	4.15*
Error (GAR)										60	2.01	

* p < .05
** p < .01
*** p < .001

17 **Preceding page blank**

TABLE 3

Main Effects and Significant Interactions from Analyses of Variance of Four Dependent Variables
for the Stoner Machinegun with Actual Subjects

	Percent Targets Hit			Reciprocal of Mean Time to Hit			Mission Score			No. of Bursts		
	df	ms	F	df	ms	F	df	ms	F	df	ms	F
Between Subjects												
Main Effects												
Original Groups (G)	1	.01	.06	1	.02	3.21	1	68.20	.07	1	1.03	.08
Error (b)	20	.19		20	.01		20	927.48		20	12.57	
Within Subjects												
Main Effects												
Ammunition Type (A)	1	.01	.08	1	.01	2.03	1	61.55	.10	1	.48	.05
Error (A)	20	.14		20	.01		20	615.11		20	8.85	
Planned Strike Feedback (S)	1	.01	.17	1	.00	.28	1	22.51	.08	1	1.03	.14
Error (S)	20	.07		20	.00		20	300.45		20	7.11	
Gun-Target Range (R)	3	1.42	14.33***	3	.07	15.36***	3	8042.16	16.09***	3	130.13	15.63***
Error (R)	60	.10		60	.01		60	499.87		60	8.33	
Significant Interactions												
(G) x (S)	3	.16	3.23*									
Error (GS)	60	.05										
(G) x (A) x (R)				1	.03	12.07***						
Error (GAR)				20	.00							

* p < .05
** p < .01
*** p < .001

According to the original plan, analysis of the data would have stopped here. The conclusions would be that, for a single machinegunner adjusting fire on a man-size target in daylight, effectiveness of fire: (1) is approximately equivalent with ball and 4:1 ball:tracer mix; (2) decreases as gun-target range increases;[14] and (3) is not significantly affected by the existence of strike feedback. However, since we know the operational definitions of "enhanced" and "minimized" strike feedback are confounded, the third conclusion is not at this point valid. Inasmuch as strike feedback was a primary area of interest in this experiment, considerable resources had been expended in gathering these data, interest in answering the experimental question runs high, and the data inspire creative manipulation, we decided to probe further. The reader is warned that orthodoxy of method stops here.

In order to investigate the effects of real strike feedback, it was necessary to account simultaneously for the intervening effect of weather and the uneven distribution of data points (Fig. 9). The former was accomplished by reviewing the record of observations made during the test and determining when each of the "enhanced" and "minimized" targets was actually providing the named type of strike feedback. Data from missions fired on other occasions were discarded. This resulted in a much smaller set of data, but one in which the categories of strike feedback were in fact meaningful. However, what remained was unbalanced—not only with respect to the levels of the independent variables, but also with respect to the number of data points for each subject. This problem was overcome by creating "composite subjects." Instead of bits and pieces of data from 22 actual subjects, the next series of analyses of variance were run on balanced data from eight composite subjects with the M60 machinegun and five composite subjects for the Stoner machinegun. Each composite subject was created by defining within a new subroutine of Program B (17) which actual subjects' data were to be included. The definitions were based on each actual subject's numerical markmanship rating (Fig. 7), with adjacent scores being considered combinable. The one "outstanding" and the two "poor" actual marksmen (Fig. 9) were not used in the creation of composite subjects. Program B then determined the mean performance measure for each composite subject on each of the dependent variables shown in Table 1 and fed this information in the correct sort order to the analysis of variance program (2), resulting in an ANOVA sample size of 64 for the M60 and 80 for the Stoner.

Results of these analyses are shown in Tables 4 and 5 for the M60 and Stoner machineguns, respectively. Because of the lack of data for missions fired with ball ammunition against targets at 350 and 450 meters (Fig. 9), in the analyses in Table 4 the independent variable "gun-target range" considers only two levels: 550 and 650 meters. (Note: In all other analyses of variance except Table 4, this same variable has four levels.) This substantial reduction in the identity of this variable undoubtedly accounts for the fact that it was not a significant main effect in any of the ANOVAs in Table 4. Strike feedback, however, was significant in two of these analyses, with a greater percentage of targets hit and higher mission scores against the "enhanced" targets. Also significant- by its absence--was any effect attributable to ammunition type. Finally within Table 4 target hits were achieved in roughly the same time with ball ammunition at both ranges but nearly 7 seconds more slowly with tracer at 650 meters than at 550 meters.

Within Table 5, gun-target range with all four levels is significant in all analyses. Strike feedback is not, and ammunition type figured only in the time measure, where hits were achieved more quickly with tracer ammunition. Both of the significant interactions arose with respect to the targets at 650 meters: mission scores were slightly higher and fewer bursts were fired against the "minimized" targets except at the farthest range.

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[14]In some exponential function.

TABLE 4

Main Effects and Significant Interactions from Analyses of Variance of Four Dependent Variables for the M60 Machinegun with One Group of Composite Subjects

		Percent Targets Hit			Reciprocal of Mean Time to Hit			Mission Score			No. of Bursts		
		df	ms	F	df	ms	F	df	ms	F	df	ms	F
Within Subjects													
Main Effects													
Ammunition Type	(A)	1	.15	2.65	1	.00	.97	1	631.21	2.49	1	3.32	.87
Error (A)		7	.06		7	.00		7	253.35		7	3.82	
Actual Strike Feedback	(S)	1	.59	37.00***	1	.00	4.90	1	1581.81	11.85**	1	8.57	4.76
Error (S)		7	.02		7	.00		7	133.50		7	1.80	
Gun-Target Range	(R)	1	.03	.69	1	.00	1.88	1	258.29	1.71	1	8.94	3.21
Error (R)		7	.04		7	.00		7	151.41		7	2.79	
Significant Interactions													
(A) x (R)					1	.00	7.29*						
Error (AR)					7	.00							

* p < .05
** p < .01
*** p < .001

TABLE 5

Main Effects and Significant Interactions from Analyses of Variance of Four Dependent Variables for the Stoner Machinegun with One Group of Composite Subjects

		Percent Targets Hit			Reciprocal of Mean Time to Hit			Mission Score			No. of Bursts		
		df	ms	F	df	ms	F	df	ms	F	df	ms	F
Within Subjects													
Main Effects													
Ammunition Type	(A)	1	~.00	.05	1	.00	8.05*	1	12.85	.11	1	.36	.14
Error (A)		4	.01		4	.00		4	115.29		4	2.48	
Actual Strike Feedback	(S)	1	.02	.59	1	.00	.01	1	296.56	1.61	1	9.34	3.05
Error (S)		4	.03		4	.00		4	183.81		4	3.06	
Gun-Target Range	(R)	3	.23	6.96**	3	.01	9.65**	3	1560.30	9.95***	3	28.16	6.76***
Error (R)		12	.03		12	~.00		12	156.86		12	4.17	
Significant Interactions													
(S) × (R)								3	176.43	4.07*	3	4.59	6.84*
Error (SR)								12	43.36		12	.67	

* p < .05
** p < .01
*** p < .001

21

Because of the sequential, rather than the counterbalanced, way in which the subjects encountered the different weapons and ammunition types, it was not possible to test for practice and learning effects in the analyses of variance. However, particularly before comparisons of 7.62mm M60 with 5.56mm Stoner performance are made, it is necessary to have some knowledge of whether and to what extent the perfo_mance measures were affected by the subjects' learning curves. To gain this knowledge, che actual subjects' mean score for each of seven repetitions (four firing the M60 with ball and M62 tracer, and then two firing the M60 with experimental white tracer, and then two firing the Stoner machinegun with M193 ball and M196 tracer) was computed for each of six performance measures: the four given in Table 1 plus mean time between bursts .nd mean number of rounds to hit. A chi squared test was run on each of the six sets of seven means. None of the chi squared statistics was significant at the 95 percent level of confidence. While the lack of a significant chi squared does not mean that there were no order effects which might have been detected with an analysis of variance, it does remove what would otherwise have been a barrier to making comparisons among the sequentially presented variables.

The principal comparison of interest which is now modestly legitimatized is between the performance measures for the M60 machinegun and the Stoner. This comparison is shown by analyses of variance in Table 6. Within these analyses (in which strike feedback was taken in its originally planned categories), weapon type[15] was a significant main effect only in the time measure where hits were achieved more rapidly with the Stoner than with the M60. Gun target range is highly significant in all four analyses, and is involved in five of the six significant interactions. For only the second time in the analysis of all TE2 data, an interaction between ammunition and range is significant. a greater percentage of targets at 550 and 650 meters was hit wit⁺ᵇ the tracer mix than with all ball ammunition. The other significant interaction of potential theoretical importance occurred in the performance measure "number of bursts," where strike feedback interacted with weapon type[15] over range. However, inspection of the subclass means from this ANOVA shows no consistent trend.[16]

An additional useful comparison can be shown graphically, as in Figure 10,[17] by plotting percent targets hit as a function of the time the hit occurred. Figure 10 shows this relationship for the 7.62mm ball and tracer fired from the M60 machinegun at targets at all four ranges with actually enhanced and minimized strike feedback. Figure 11 gives the same information for the 5.56mm ball and tracer fired from the Stoner machinegun. Data in these two figures thus represent the values in Table 3E given in the time dimension. Inasmuch as the superiority of tracer to ball is presumed to lie at the greater gun-target ranges, similar graphs of performance were drawn for the targets at 550 and 650 meters, and are shown in Appendix D. Comparison of the performance with three types of tracer (M62, M196 and experimental white) for both actual strike feedback conditions over all ranges is given in Figure 12.

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[15]Inclusive of differences in muzzle velocity, recoil, and ammunition caliber as well as weapon configuration.

[16]At the 550 meter targets, more bursts were fired from the M60 at the minimized targets and from the Stoner at the enhanced targets, at the 650 meter targets, the relationship reversed.

[17]Data for Figures 10-12 were obtained by using the MAC option in Program A (17, p. 9).

TABLE 6

Main Effects and Significant Interactions from Analyses of Variance of Four
Dependent Variables for Actual Subjects Firing M60 and Stoner Machineguns

	Percent Targets Hit			Reciprocal of Mean Time to Hit			Mission Score			No. of Bursts		
	df	ms	F	df	ms	F	df	ms	F	df	ms	F
Between Subjects												
Main Effects												
Original Groups (G)	1	.070	.414	1	.041	6.669*	1	278.07	.320	1	8.097	.746
Error (G)	20	.168		20	.006		20	869.81		20	10.856	
Within Subjects												
Main Effects												
Weapon (W)	1	.006	.064	1	.042	7.399*	1	29.66	.047	1	.486	.055
Error (W)	20	.089		20	.006		20	628.15		20	8.916	
Ammunition Type (A)	1	.051	.583	1	.001	.291	1	139.09	.316	1	.017	.003
Error (A)	20	.088		20	.003		20	440.74		20	6.527	
Planned Strike Feedback (S)	1	.051	.795	1	$\leq$.000	.062	1	100.52	.363	1	.009	.002
Error (S)	20	.064		20	.003		20	277.20		20	5.705	
Gun-target Range (R)	3	2.654	35.616***	3	.119	33.333***	3	15183.81	38.667***	3	215.696	31.690***
Error (R)	60	.075		60	.004		60	392.68		60	6.806	
Significant Interactions												
(A) × (R)	3	.137	3.776*									
Error (AR)	60	.036										
(W) × (S) × (R)				1	.028	13.337***				3	21.498	3.080*
Error (WSR)				20	.002					60	6.980	
(G) × (W) × (S)							3	1112.13	4.573*			
Error (GWS)							60	243.18				
(G) × (W) × (A) × (R)	3	.285	4.793**									
Error (GWAR)	60	.064										
(G) × (A) × (S) × (R)	3	.252	3.648*									
Error (GASR)	60	.075										

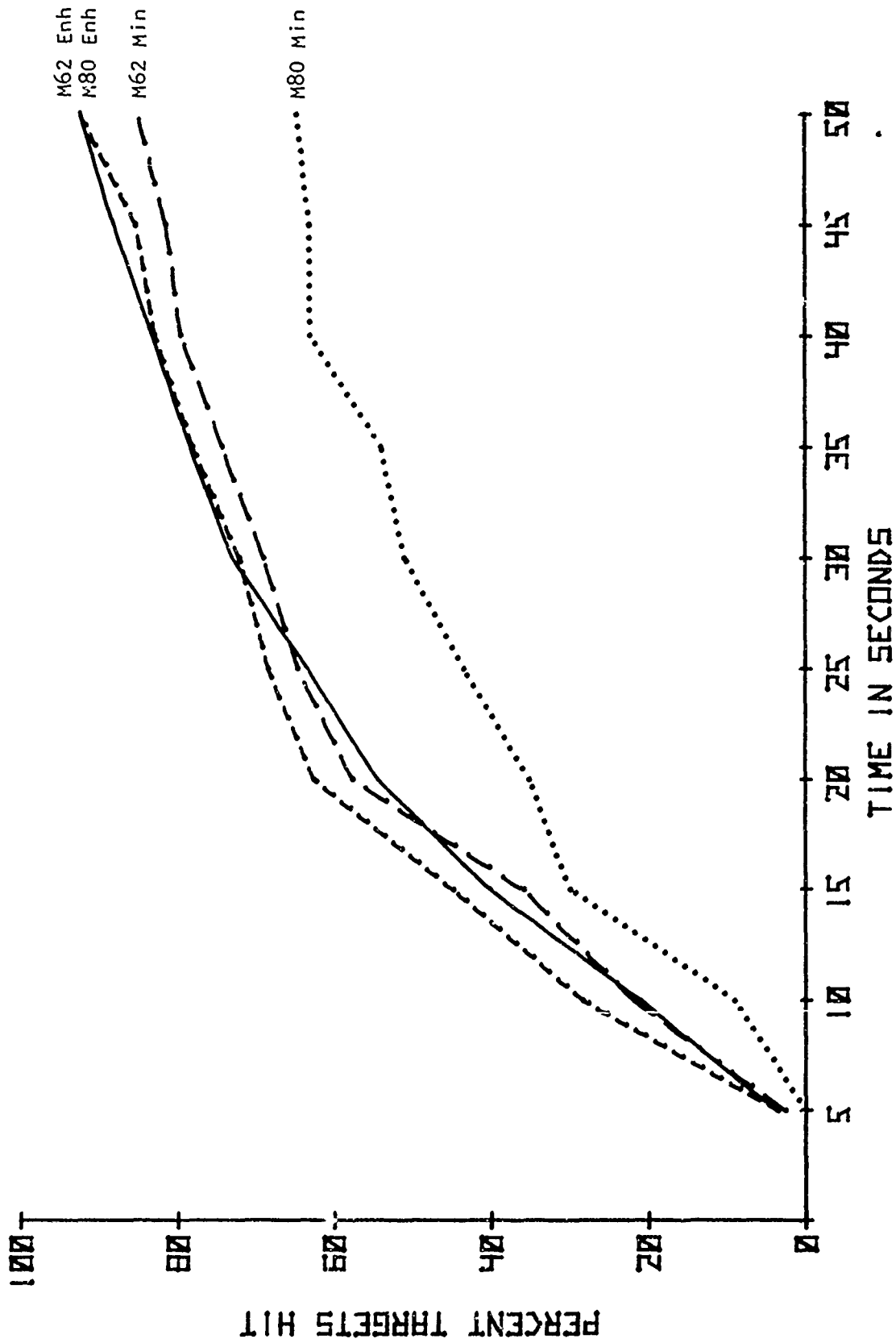* p < .05
** p < .01
*** p < .001

23

Figure 10. Comparison of 7.62mm standard ammunition over all ranges against targets with enhanced and minimized strike feedback
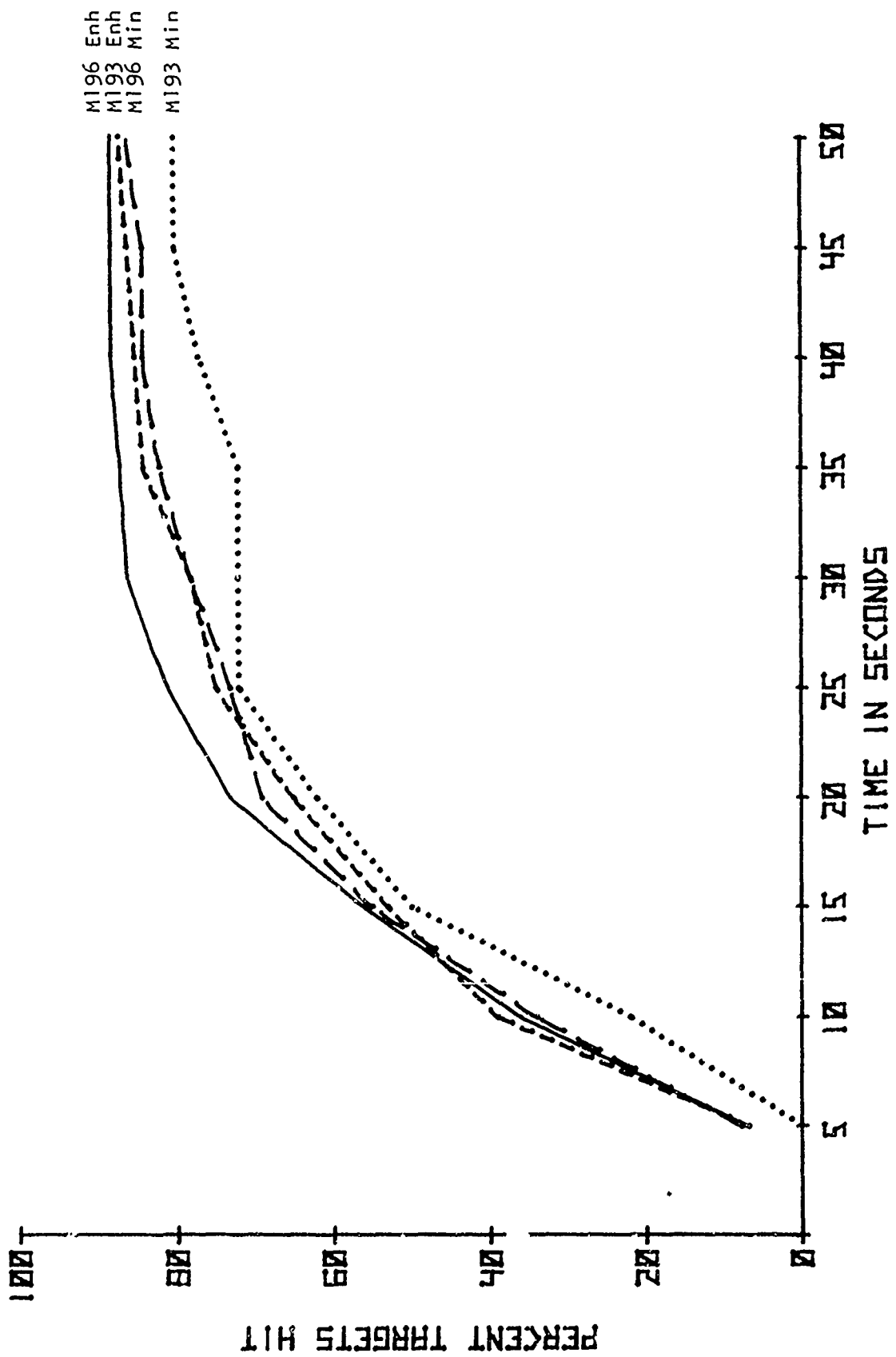
24

Figure 11. Comparison of 5.56mm standard ammunition over all ranges against targets with enhanced and minimized strike feedback
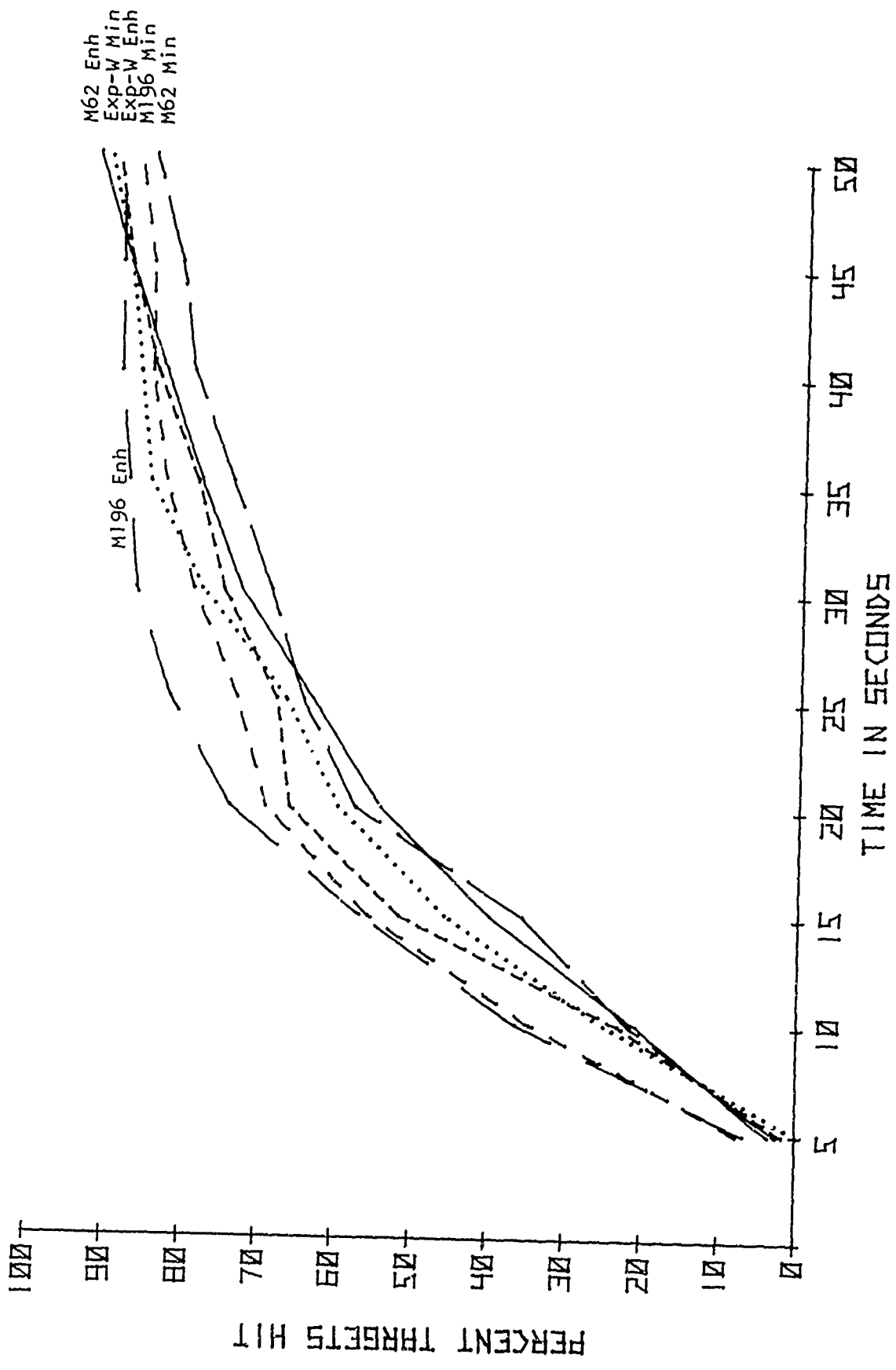
25

Figure 12. Comparison of performance of three types of tracer over all ranges against targets with enhanced and minimized strike feedback

DISCUSSION

Of all the possible results of this experiment, the one which most concerned us was that shown in Figure 13. Here--purely hypothetically--is shown that (1) "effectiveness" (in terms of hitting the greatest number of targets in the least time) is greater with 7.62mm M62 (bigger and brighter) tracer than with the 5.56mm M196, but (2) there is an interaction with strike feedback in which the larger and heavier 7.62mm ball rounds fired against "enhanced" targets provide visual cues nearly as effective as the 7.62mm tracer itself and slightly more effective than the smaller 5.56mm tracer. Such findings could have a potential impact on those present Army research programs concerned with developing small caliber weapons.

Thus, a comparison of the results of this experiment with the hypothetical data was a primary concern. The distribution of data points (Fig. 9) and the resulting small sample sizes (Figs. 1D-4D) attained in this experiment severely limit the validity of such a comparison. Nevertheless, and with the reservations noted, we can observe that in both Figures 10 and 11 ball ammunition fired against the minimized targets resulted in the least effectiveness. Moreover, hits tended to be slightly faster against targets with strike feedback enhanced. Table 4 and Appendix E show that, with 7.62mm ammunition, a significantly greater percentage of enhanced targets was hit than minimized targets. Table 5, however, does not show this effect with 5.56mm ammunition. Were the data better distributed so that comprehensive analysis of actual subjects' performance could have been made, these findings could be interpreted as being uncomfortably similar to the hypothetical data in Figure 13. Given that the findings here were based instead on specially selected samples of irregularly distributed data, we do   . ..ch that conclusion sanguinarily.

Interpretation of the two theoretically and statistically significant interactions in Table 2 is troublesome: Regardless of the identity of certain other independent variables (affected by the intervention of the factors previously described), tracer ammunition was still tracer, and distance was still distance. The most inviting interpretation of the interaction in which fewer bursts were fired with 7.62mm 4:1 ball:tracer ammunition than with 7.62mm ball ammunition alone at the 550 and 650 meter targets is that the gunners were able to use the visual cues provided by the tracers and adjust fire onto and hit the targets more efficiently. However, we also calculated for those targets the average number of bursts per mission of the missions which ended in a hit. While there were more hit missions with the 7.62mm tracer mix than with ball ammunition alone (145 vs. 133), the mean number of bursts for each ammunition type over targets at both ranges was 3.4. Thus, what the interaction is probably showing is that when the gunners failed to hit the target, they continued firing until they ran out of ammunition (just as they were instructed to do—Appendix A, page 48). The question remains why, if there were more "hit" missions with tracer, ammunition type was not a significant main effect in any of the analyses in Table 2. This question might have been answered by the appearance of the same interaction in Table 6 this time on the performance measure "percent targets hit." This appealing answer is that ammunition type was not a main effect because, in daylight, at ranges out to 450 meters, gunners are not able to use tracer to increase the effectiveness of their fire; but beyond that range, their ability becomes demonstrable. Hence, the ANOVA, in its precision, shows ammunition type significant only in combination with gun-target range. This answer is too pat. It leaves unexplained why the ammunition-range interaction, if real —

● does not occur on the same performance measures in Tables 2 and 3 (which, taken together, are analyses of the same data), and

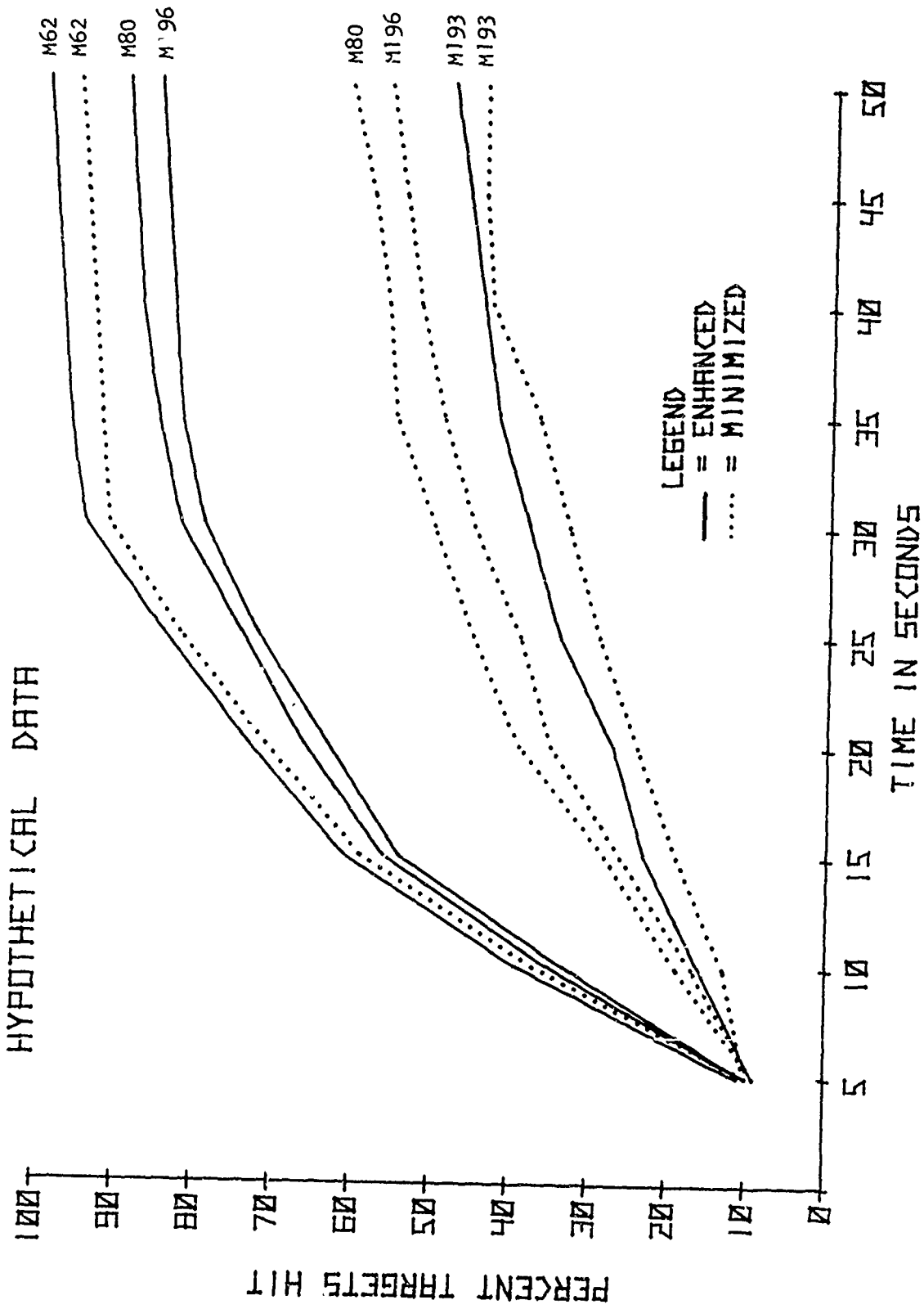● does not occur at all in the performance measure "mission score."

HYPOTHETICAL DATA

Figure 13. Hypothetical set of performance curves for two types of ammunition in two calibers against targets with enhanced and minimized strike feedback.

28

The second important interaction in Table 2 showed subjects achieving higher mission scores against the enhanced targets except at 650 meters. Its most obvious interpretation is that the strike feedback levels allegedly represented were "enhanced" and "minimized" in name only--with the intervening factors effectively destroying their identities and resulting in the conclusion that no actual relationship among real dimensions has been disclosed. However, the same interaction shows up again in Table 5--this time among real levels of strike feedback. Inspections of the subclass means of both of those analyses of variance cloud rather than clarify the picture: in the analysis involving the confounded levels of strike feedback, scores were lower against the minimized targets except at 650 meters. In the analysis involving the real levels of strike feedback, scores were higher against the minimized levels of strike feedback but with a substantial drop in scores at 650 meters against both types of targets. The interaction between real strike feedback and range occurred again in Table 5 on the performance measure "number of bursts." Here, the subclass means showed substantial change only at 650 meters, but with the fewest number of bursts being fired against the minimized--not the enhanced--targets.

Perhaps the best explanation for all of these interactions is the one we offer for the weapon — strike feedback — range interaction in Table 6: the fact that it flip-flops atheoretically suggests that it is an artifact of the distribution of data (Fig. 9), and should be regarded as noise.

Within Table 4 there is also an interaction of interest: as gun-target range increased, subjects took more time with the tracer mix than with all ball ammunition. Perhaps the extra time was spent trying to observe the tracers and in subsequent mental processes involved in selecting a new point of aim (quite contrary to the performance of the combat veterans in TE1 [6, p. 24]). If so, the extra time was non-productive: there was no concomitant increase in accuracy.

To the reader who is still with us it should be apparent that the data collected in this experiment are inadequately distributed to answer the question as originally postulated. Our sincere regret for this circumstance is, upon reflection, tempered somewhat by the realization that a more fundamental question may have been answered.

To put the horse before the cart, how often does strike feedback exist? At least a partial list of the conditions which influence its existence includes:

1. Ambient light level: No matter how great or precise the amount of strike feedback, it cannot be used by a gunner unless he can see it. Therefore, the target area must have some amount of light. Although we have not measured--and therefore will not predict--the amount of light required, it seems not unreasonable to speculate that it is in excess of 100 foot-candles. Thus, depending on the time of year, in approximately 50 percent of any 24-hour period, strike feedback will not be visible to the naked eye. This period of invisibility may, of course, be reduced by providing night vision devices to the gunner or artificial lighting for the target area.

2. Terrain configuration: Ideal advantage of strike feedback is achieved when the gunner fires down on the target. Thus, a round impacting immediately behind the target can be detected (vs. a round passing a target on level terrain and impacting hundreds of meters beyond due to its reduced velocity and the pull of gravity). Of course gunners can be trained to aim below the target and "walk" the rounds into the target (as in the experiment conducted in 3); however, this method of fire tends to waste ammunition and is thought to be considerably less efficient than aimed fire (3, p. 21).

3. Soil condition: The phenomenon of strike feedback can be generated only on certain kinds of terrain. That which is marshy or wooded or composed of moist clay (to name a few) does not produce strike feedback.

4. Weather: Precipitation, fog and haze will reduce detection of strike feedback even on terrain on which it is otherwise obtainable.

5. Absence of conflicting visual cues: Given conditions favorable to strike feedback in factors 1 to 4 above, if two gunners engage the same target simultaneously, will the strike feedback from one gunner's impacting projectiles confuse or mislead the other gunner? A previous experiment implies that the answer is yes and the amount of confusion is significant (4, p. 21).

Ignoring for the moment that there may be other factors which should be added to the above list, how often on a battlefield do favorable strike feedback conditions exist? Although we cannot directly answer the question, we think our experience in conducting this experiment may be relevant. Strike feedback is about as predictable as the weather and nearly as fortuitous. It is a shaky basis for doctrine. The concern that smaller caliber weapons will place our soldiers at a disadvantage by denying them an important technique for fire control becomes inconsequential. Given the validity of that conclusion, the data in Tables 1E, 1F, 1G and 1H are also valid.

The experimental white tracer was fired at the end of the 7.62mm missions and before the 5.56mm missions. Consequently, in comparing tracer performance we have a potential order effect unaccounted for. However, the data (both those gathered here and in TE7) show that, in daylight, subjects performed approximately the same with the experimental white tracer as with the standard types. Although there is a band of performance of varying width (Fig. 12), there is no clear evidence from this test that any one of the three types of tracer is superior in a 4:1 mix with ball.

The "systematic peculiarity" noted previously (7, p. 32) in the data collected in the HEL tracer tests appeared again here. In the post-test interview (Appendix C, page 60), subjects recited with nearly 4.1 assurance that they "hit more targets" with the tracer mix than with all ball ammunition, and they believed with 10:1 fervor that the Army should continue to have tracer for machineguns. Once again,[18] the performance data show essentially equal effectiveness between ball and tracer in daylight.

CONCLUSIONS

1. Considering all of the data together and ignoring the effects of the intervening factors:

- The 4:1 ball:tracer mix fired from the 7.62mm and 5.56mm machineguns against pop-up targets at ranges from 350 to 650 meters is no more effective in daylight than ball ammunition.

- The 7.62mm M60 and the 5.56mm Stoner machineguns are of roughly equal effectiveness in engaging pop-up targets at ranges out to 650 meters in daylight.

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[18]As in (6, 8, and 9).

2. Considering the effects of the intervening factors and analyzing specially selected samples of the data gathered with the M60 machinegun:

● More targets are hit when located on strike feedback-enhancing terrain than on strike feedback-minimizing terrain.

● The ratio of targets hit to targets exposed increases as a function of time least rapidly with all ball ammunition fired against targets located on strike feedback-minimizing terrain.

3. The conclusions realizable from the data are not dispositive of the question which the test was conducted to answer; but the experience of conducting it suggests that strike feedback may be of only peripheral importance among the factors contributing to the effectiveness of machinegun fire.

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APPENDIX A

OUTLINE OF M60 MACHINEGUN TRAINING

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LESSON OUTLINE

TITLE: M60 Machinegun Familiarization; Preparatory Marksmanship Training, Familiarization and Battle Sight Zero Firing.

1. <u>Lesson objective</u>: To enable the test subjects for Tracer Experiment 2 to apply the fundamentals and techniques of machine gunnery.

2. <u>Training objective</u>: As a result of this instruction, the test subjects must be able to accomplish the following task objectives:

    a. Task objective. The test subjects must become familiar with nomenclature and functioning of the M60 machinegun.

    b. Task objective. The test subject must demonstrate his ability to place effective fire on targets presented at various ranges.

    Subtask objective. The test subject must apply the integrated act of shooting, to include the correct aiming technique and steady hold factors as outlined in FM 23-67.

    c. Task objective. The test subject must be able to battle sight zero the M60 as outlined in FM 23-67.

    d. Task objective. The test subject must be able to confirm his battle sight zero at 500 meters.

3. <u>Advance assignment</u>: None.

4. <u>Introduction</u>:

    a. Subject briefing on Tracer Experiment 2.

        You will be participating as test subjects in Tracer Experiment 2 of the Human Engineering Laboratory's Tracer Program. In all, this program consists of a series of eight experiments which will ultimately tell us just how effective tracers really are in the infantry ground-to-ground role. You are already familiar with tracers, and may take them for granted. This is what most people in the Army had done for many years. No one had ever seriously questioned the effectiveness of tracer ammunition.

        Now a lot of scientists have <u>studied</u> tracers, and they have written a lot about them. But almost all of this work concerns the physical or chemical properties of the tracer element itself--not how <u>effective</u> it is. The lack of facts about tracer effectiveness has caused <u>another</u> recent problem. There is a new infantry weapon under development. It fires very small bullets, and it is very difficult to make a tracer to fit it. And so someone asked, "Can we <u>do without</u> tracer for this weapon? If so, how much of its effectiveness will be lost? If not, how much will it cost (in terms of time and money) to <u>develop</u> a tracer for this weapon? Is that cost equal to the effectiveness we would gain?" As you may have guessed, nobody can answer those questions right now.

The test in which you will be participating is Tracer Experiment 2. It is a study of how people fire and observe tracer.

First, let me familiarize you with how the ranges are laid out. The zero range is located to your left front. When we leave here, you will initially report there. The zero range is a 10-meter range with three firing points. Since there are 12 of you, we'll use the gunner and assistant gunner method and fire in four orders. You will do your zero firing from the prone supported position. When you have completed zeroing the M60, you will report to the holding area which is located to the rear of the firing line. After everyone has zeroed the M60, you will all fire a familiarization course. The course is located just forward of the zero range. When the actual test starts, you will fire at eight target presentations per day. The firing point of the test range is located on the top of the truck. The target area is to your front.

b. Safety briefing.

(1) This range is to be considered a dud area. At no time will you move forward of the firing lines.

(2) There will be no running on this range.

(3) There will be no horseplay at any time.

(4) Listen carefully to all instructions and follow them to the letter.

(5) There will be no smoking within 50 feet of the ammunition point.

(6) The ammunition point is off limits unless you are picking up your ammunition for a firing exercise.

(7) If you should observe an unsafe act, you will immediately call "Cease fire" as loudly and clearly as possible.

(8) If you feel abnormally hot or cold, chances are you are becoming a heat casuality. If this occurs, notify one of the test control personnel and we will see that you receive the appropriate care.

(9) Drink plenty of water and stay in the shade as much as possible.

c. Lesson tie in. As members of a STRAFF unit, you are all familiar with the M60 machinegun. Today we will conduct a short course to refresh you on the M60 machinegun. We will also review the fundamentals of machine gunnery and the proper way to achieve a battle sight zero and the confirmation of this zero at 500 meters.

d. Scope. During the next two hours, we will discuss the characteristics and functioning of the M60, the prone firing position with the bipod, proper sight picture and sight alignment, and obtaining of a proper battle-sight zero. We will also cover malfunctions and immediate action.

The following two hours will be devoted to each of you in obtaining a proper battle-sight zero and confirming the zero at 500 meters.

The last two hours will be spent in firing a familiarization course and then a summary of my presentation and the clearing up of any questions you might have.

5. Body:

Transition. Before you can effectively engage a target with the M60, you must be familiar with the characteristics and functioning of the weapon.

a. Characteristics and general data:

(1) The M60 is an air-cooled, gas-operated, belt-fed weapon which fires from the open-bolt position. Ammunition is fed into the weapon by use of a metallic, disintegrating, split-link belt.

(2) The weapon utilizes the 7.62mm NATO cartridge, which gives it a maximum range of 3725 meters. The maximum effective range, however, is 1100 meters.

(3) The M60 weighs 23 pounds mounted on its bipod.

(4) The cyclic rat · of fire of the M60 is in excess of 550 rounds per minute. The two rates of fire which are generally used are the sustained rate of 100 rounds per minute, and the rapid rate of 200 rounds per minute.

(5) Each gun is issued with two barrels, and, since the M60 features fixed headspace, the barrels can be changed within a matter of seconds.

(b) Nomenclature:

(1) Starting at the muzzle end of the gun is the flash suppressor, which during firing, dissipates or breaks up the flash and smoke.

(2) The bipod assembly is attached to the barrel assembly and is held in place by the flash suppressor. It consists of the bipod yoke, the bipod legs, the reinforcement ribs, the bipod feet and the bipod leg extensions plungers.

(3) To place a leg in position for firing, depress the top of the leg with the thumb (compressing the lock spring) and allow it to swing down into position until it locks into place.

(4) To raise the muzzle to a desired height, pull straight down on the foot. The part you see exposed is the bipod leg extension.

(5) To replace the bipod leg extension, depress the plunger and push the foot straight back up into the leg. It will telescope back into position.

(6) Beneath the barrel, and attached to the barrel group, is the gas system.

(7) On top of the barrel assembly is the fixed front sight, consisting of the front sight post and blade.

(8) To the rear of the front sight is the forearm assembly. On the left side of the forward part of the forearm assembly is the sling swivel. A sling is issued with each M60 machinegun.

(9) On top of the receiver is the carrying handle. It can be positioned to the right or to the left so as to be out of the gunner's line of sight.

38

(10) To the right of the carrying handle is the barrel locking lever. When firing the M60, insure that the barrel locking lever stays in the horizontal position as you see it here.

(11) Next is the conventional leaf and slide type rear sight, consisting of the range scale which is graduated in 100M increments from 300 to 1100M; the windage knob graduated in one mil increments; and the elevation knob graduated in 1/4 mil increments.

(a) To make major changes, depress the slide release assembly and move the slide up or down.

(b) To make minor changes in elevation, use the elevation knob. Each click on the elevation knob is equal to 1/4 mil, and will move the strike of the round 1/4 meter at 100 meters.

(c) The windage knob is graduated in one (1) mil increments--five to the left and five to the right of zero for a total of 10.

(d) To adjust the adjustable range scale, loosen the range scale screw and move the scale to the desired range increment. Then tighten the range scale crew.

(12) On top of the receiver is the feed cover. On the right rear of the feed cover is the feed cover latch.

(13) On the right side of the receiver is the cocking handle. When manually cocking the weapon, insure that the cocking handle is returned to its forward position. Keeping the cocking handle forward will prevent damage to parts within the receiver and injury to the gunner's hand, since the M60 fires from the open-bolt position.

(14) On the rear of the machinegun is the shoulder gun stock and the hinged shoulder rest.

Transition· The M60 machinegun is loaded, fired, unloaded, and cleared in the open-bolt position. The safety must be placed on the FIRE position before the bolt can be pulled to the rear.

c. Loading:

(1) Place the safety on the FIRE position.

(2) Pull the bolt to the rear, using the cocking handle.

(3) When the bolt is held to the rear by the sear, return the cocking handle to the forward position, and place the safety on the SAFE position.

(4) Raise the cover and insure that feedtray, receiver, and chamber are clear.

(5) Place the first round of the belt in the feedtray groove and close the cover, INSURING THAT THE ROUND REMAINS IN THE FEEDTRAY GROOVE.

d. Unloading:

Pull the bolt to the rear, place the safety on the SAFE position, and return the cocking handle to the forward position. Raise the cover and remove any ammunition or links from the feedtray.

e. Clearing the gun:

    (1) After the gun is unloaded--

        (a) The cover, feedtray, receiver, and chamber are checked to insure they are clear.

        (b) The safety is placed on the FIRE position, the trigger is pulled, and the safety is placed on the SAFE position.

    (2) The gun is clear during mechanical training instruction with the bolt forward, saf ty on the SAFE position, and the cover raised. During live fire exercises a cleaning rod is run through the bore until the end is visible in the receiver and is then removed.

f. Disassembly:

    (1) The only disassembly you will be required to perform is the removal of the barrel assembly in order to change barrels if required.

    (2) Removal of the barrel assembly

        (a) To remove the barrel assembly, raise the barrel locking lever to a vertical position and pull the barrel assembly straight forward.

        (b) To replace the barrel assembly, place the barrel assembly back in the weapon and lower the barrel locking lever to the horizontal position.

Transition: We all know that the M60 can be fired from the standing, sitting or prone position; however, for the conduct of this test, we will only be concerned with the prone position.

g. Prone firing position and grip

    (1) Gunner assumes the prone position behind the gun and raises the rear sight.

    (2) He places the hinged shoulder rest on his right shoulder.

    (3) His legs should be a comfortable distance apart and his heels should be down.

    (4) His right hand grasps the pistol grip with the index finger resting lightly on the trigger.

    (5) His left hand is placed on the cover.

    (6) With both hands, he exerts a firm steady pressure down and to the rear while aiming and firing the gun.

    (7) His cheek rests lightly against the cover or against his left hand.

    (8) His shoulders are level and his elbows are an equal distance from the receiver.

    (9) Left-handed firing is discouraged because of the ejection pattern of the gun (to the rear).

(10) While firing, take a deep breath, exhale, lay on the target, and fire. Do not exceed 10-15 second after exhaling before firing. This could cause trembling, blurring of vision, and finally missing your target.

(11) Trigger pull. Unlike most weapons, the trigger on the M60 is not squeezed to the rear. it is pulled straight to the rear and then released. This aids the gunner in controlling the number of rounds in each burst and prevents excessive wear on the sear and sear notch. To assist in obtaining a six-round burst, the gunner pulls the trigger to the rear and says, fire a bu, st of six, and then releases the trigger.

Transition. Now that we are in the proper prone firing position, we must obtain a good sight picture and sight alignment to effectively engage our target.

h. Sight alignment and sight picture:

(1) Sight alignment

(a) Center the front sight blade in the aperture of the rear sight slide.

(b) Align the top of the front sight blade even with the top of the sight slide.

(2) Show proper sight alignment on mock-up of sights.

(3) Sight picture.

Center the target over the front sight blade so that it appears to rest on top of the rear sight slide.

(4) Show proper sight alignment and sight picture on mock-up.

(5) Show improper sight alignments and sight pictures. Explain their effect on firing.

Question: Is it better to close one eye while firing or keep both eyes open while firing?

Answer: Both eyes open to assist in obtaining a clear sight picture longer and to relay on the target faster (a slight squint is acceptable).

Transition: Utilizing the proper prone position, sight picture and sight alignment. We are now ready to zero the M60.

i. Zeroing:

(1) The M60 can be zeroed at 10 meters or at 300 to 700 meters using the field zero method. We will discuss zeroing by the field method.

Question: What is zeroing?

Answer: It is the adjustment of the rear sight until the strike of the projectile coincides with the point of aim at a given range.

(a) Set the rear sight at a range of 500 meters. Align the windage index at zero windage.

(b) Fire three rounds, one round at a time without adjusting the sights. Insure that the same sight alignment and picture are used while firing each round.

(c) Adjust the rear sight to move the center of the three-round shot group to the aiming point. One click of deflection will move the strike of the bullet one centimeter. One click of elevation will move the strike of the bullet 1/4 of a centimeter. (4 clicks = 1 centimeter.)

(d) Confirm by firing one round at the original aiming point. If the round doesn't strike the point of aim, the round fired will represent the center of a three-round shot group and the appropriate adjustments will be made from that point.

(e) Talk the test subjects through a zeroing exercise using a standard machinegun target.

Transition: No weapon is completely reliable; however, gunners who are well trained in immediate action possess the capability of solving malfunctions and reducing stoppages in a timely manner.

j. Malfunctions:

A malfunction is a failure of the gun to function satisfactorily. Defective ammunition or improper operation of the gun by a crewmember is not considered a malfunction of the gun. Two of the more common malfunctions of the M60 machinegun are sluggish operation and runaway gun.

(1) Sluggish operation and corrective action. Sluggish operation of the gun usually is due to excessive friction caused by dirt or carbon, lack of proper lubrication, burred parts, or excessive loss of gas. Excessive loss of gas usually is due to a loose or missing gas port plug. Clean and lubricate the gun. Inspect thoroughly for burred parts and replace parts as necessary.

(2) Runaway gun and corrective action. A runaway gun is a gun that continues to fire after the trigger is released. It may be caused by a worn sear, worn sear notch, or short recoil (where the operating group recoils sufficiently to feed and fire but not sufficiently for the sear to engage the sear notch) caused by loss of gas or excessive carbon buildup in the operating rod tube.

(a) Immediate action. Hold the fire on the target until the feeding is stopped or the ammunition is expended. Either the gunner or assistant gunner may be able to stop the gun by-

(1) Raising the cover, thus stopping the feeding action.

(2) Twisting or breaking the belt to stop the feeding.

(3) Grasping the cocking handle firmly and pulling it to the rear to stop the bolt from going forward.

k. Stoppages:

A stoppage is any interruption in the cycle of functioning caused by faulty action of the gun or faulty ammunition. Stoppages are classified by their relationship to the cycle of functioning.

l. Immediate action:

Immediate action is the action taken to reduce the stoppage without investigating the cause. This action must be accomplished within 10 seconds, when the barrel is hot enough to cause a cookoff. Two hundred rounds fired in a 2-minute period may heat the barrel sufficiently to cause a cookoff.

(1) If a stoppage occurs, retract the cocking handle to the rear insuring that the operating rod remains to the rear.

(2) If the round is ejected, return cocking handle to forward position, relay on target and attempt to fire. If the weapon does not fire, it must be cleared and the weapon and ammunition inspected to determine the cause.

(3) If a round is not ejected, move the safety to (safe) position. Remove ammunition and links and inspect the receiver, chamber and extractor.

(4) If a round is present in the chamber, close the cover, move the safety to the fire position, and attempt to fire. If the round does not fire and the barrel is considered hot enough to cause a cookoff (200 rounds fired within 2 minutes), wait five (5) minutes with the bolt in the forward position. Remove the round, reload, relay on the target, and attempt to fire.

(5) If the immediate action steps don't correct the stoppage, the weapon must be cleared and disassembled to determine the cause of the stoppage.

m. This concludes your refresher training on the M60.

Ask for questions.

n. Summarize

(1) Characteristics

(2) Position, breathing, trigger pull

(3) Sight picture and alignment

(4) Malfunction

Sluggish gun
Runaway gun

(5) Immediate action

(6) Zeroing

o. Ten-meter firing.

(1) All test subjects report to the 10-meter zero range.

(2) All test subjects are assigned to firing orders and further assigned an M60 machinegun. Test subjects will utilize the same M60 throughout the tracer experiment.

(3) Two firing orders will be on the firing line during all firing. One order will zero the M60 and the other order will act as the assistant gunners. The remaining two firing orders will remain in the test subject holding area until called to the firing line.

(4) Each firing order conducting the zero firing will be given the following instructions:

(a) Gunner, take up a good prone position.

(b) Assistant gunner, check your gunner's position and adjust the bipod legs if required. When you are satisfied with his position, stand to the rear of the gunner.

(c) Assistant gunner, move to the ammunition point and pick up five loose rounds of M80 ball ammunition.

(d) Assistant gunner, take up the assistant gunner's position to the left of the gunner.

(e) Gunners, insure that your rear sight is in the up position and that the range is set at 500 meters. Disregard the deflection setting.

(Safety Officer insures that the range is clear.)

(f) Gunners, load one round of loose M80 ball ammunition. At my command, engage paster number 1 with three rounds. Insure that you obtain the same sight picture and sight alignment for each round. When you have completed firing three rounds, clear your weapon and stand to the rear of the weapon.

(Safety Officer insures that all weapons are clear.)

(g) Gunners, move downrange and check your targets.

(h) Gunners, return to the firing line and make the necessary sight adjustments.

(Safety Officer insures that the range is clear.)

(i) Gunners, at my command, fire one confirming round at your original point of aim. When you have completed firing, clear your weapon and stand to the rear of the weapon.

(j) Gunners, move downrange and check your targets. If you did not hit your point of aim, consider the last round fired as the center of your shot group and determine the necessary sight changes.

(k) Gunners, return to the firing line and make the necessary sight changes (if any). Confirmation firing continues, if required.

(l) Gunners, insure that you record the changes required to zero the M60 on the clipboard at the firing point.

(5) This procedure will continue until all firing orders have zeroed the M60.

p. Demonstration and practice firing.

(1) All test subjects report to the vicinity of the firing point that will be used for the conduct of the experiment.

(2) All test subjects receive the following briefing on the conduct of the experiment test firing:

(a) Before I tell you the details of the practice and test firing, let me review the safety rules which apply to this range:

(1) No running or horseplay.

(2) No one will go downrange.

(3) No smoking outside of the holding area.

(4) The following areas are off limits on this range: the ammo point, the control point, and the instrumented VAN.

(5) If you observe an unsafe act, stop it or call "Cease fire" if it is occurring downrange.

Are there any questions about the safety rules for this range?

(b) This range is instrumented to monitor your firing. The targets are controlled by the instrumented van and your hits will be recorded on instruments within the van. The targets are located at various ranges to your front in a sector bounded on the left by that barber pole (POINT OUT) and on the right by that barber pole (POINT OUT). There are no targets outside of the barber poles. These poles are also the safety limits of the range, so don't fire outside of them. There are no targets closer than 300 meters or farther than 700 meters. The targets are all the same size and color: 2 yellow silhouettes abreast.(SHOW SILHOUETTE TO CLASS.)

(c) You will have to do your own target detection and range estimation. If you do not see a target, do not fire.

(d) Targets will appear at various ranges. You will estimate the range to these targets and try to achieve a first burst hit on the target. If the target is at 500 meters, aim for the center of the target. If at ranges greater than 500 meters, aim at the top of the target, and if the target is less than 500 meters away, aim at the base of the target.

(e) Now, what happens if you DON'T hit the target with your initial burst?

Answer: Use adjusted aiming point method of adjustment.

First, you determine where your rounds landed with respect to the target. Then you select a new aiming point on the ground the same distance from the target as the center of impact of the initial burst--but in the opposite direction. You lay your weapon on that new aiming point and fire a 6-9 round burst. If you estimated your original miss distance correctly, you should be right on target with this burst. If not, what should you do?

Answer: Follow the same procedure:

(<u>1</u>) Determine where rounds landed with respect to the target.

(<u>2</u>) Estimate miss distance.

(<u>3</u>) Select new aiming point (same distance, opposite direction).

(<u>4</u>) Fire another 6-9 round burst.

(f) Now let's go back a minute. I said that if you did not hit the target with your first burst, you should "determine where the rounds landed with respect to the target." How do you do that?

<u>(For Group 1, days 1 and 3; Group 2, days 6 and 8)</u>

Answer: You need to look for indications on the terrain of where your rounds are striking. What are some of these indications?

(<u>1</u>) Point of impact of tracer (where the tracer changes trajectory).

(<u>2</u>) If no impact, point where tracer passes by your target.

(<u>3</u>) Dust cloud kicked up by rounds hitting the dirt near the target.

(<u>4</u>) Movement of brush or bushes near a target when struck by rounds.

<u>(For Group 1, days 5 and 7; Group 2, days 2 and 4)</u>

Since you will not have any tracer ammunition for your next two days of firing, you need to look for indications on the terrain of where your rounds are striking. What are some of these indications?

(<u>1</u>) Dust cloud kicked up by rounds hitting the dirt near the target.

(<u>2</u>) Movement of brush or bushes near a target when struck by rounds.

(g) This is the way the test will be conducted. You will be called to the firing point as either a gunner or assistant gunner. Only 1 firer at a time will be on the firing point. The M60 assigned to you will be at the firing point and your zero will already have been placed on the sights.

(h) Let me clarify the duties of both the gunner and assistant gunner:

(<u>1</u>) First, the gunner—

(<u>a</u>) You will do all firing from the prone position.

(<u>b</u>) You are responsible for placing effective fire on each target presented.

(<u>c</u>) You will clear the M60 after each target engagement and reload a new 50-round belt on order.

(d) You must detect and estimate the range to each target.

(e) You will not make any sight adjustments. If your first burst doesn't hit the target, you will use the adjusted aiming point method to place effective fire on the target.

(f) After your last target engagement, you will clear the M60 and stand to the left of the weapon.

(g) Apply immediate action in the event of a malfunction or stoppage.

(h) When you hear the command, "Cease fire," do so immediately.

(i) Be alert for any unsafe act or condition downrange or at the firing point.

(j) Do not talk to the assistant gunner once a fire mission has begun.

(2) Assistant Gunner—

(a) Pick up four 50-round linked belts from the ammo point and bring them to the firing point.

(b) Assist the gunner in obtaining a good prone position and in adjusting the bipod legs (if required).

(c) Assist the gunner in loading and clearing the M60 before and after each target engagement.

(d) Be alert for unsafe act or condition downrange or at the firing point.

(e) Assist the gunner in applying immediate action in the event of a malfunction or stoppage.

(f) Do not talk to the gunner once a fire mission has begun except to repeat the command, "Cease fire" if you hear it or to pass on emergency instructions. In particular, you are not to give the gunner any help with target detection, range estimation, or fire adjustment.

(g) Except to break the ammunition belt in case of a runaway gun, do not touch the weapon once a fire mission has begun. Are there any questions as to your duties as gunner or assistant gunner?

(i) Situation.

(1) When you arrive at the firing point, you will have the situation read to you. It goes like this:

"You are a machine gunner with a rifle platoon, assigned to a sector in a combat outpost line with the mission of deceiving the enemy as the exact location of the friendly main line of resistance. The enemy has been conducting probing operations with small patrols (up to 4 men). These patrols are not sure of your location. Consequently, should you observe a member of these patrols, you need to try to kill him with your first burst so that he would not be able to bring fire on you or report your location."

47

Load your weapon and put the safety on.

Are you ready?

Take the safety off, watch the range."

(2) When you are told to watch the range, that is your clearance to fire. When you observe a target, get a good sight picture and sight alignment and commence firing (6-9 round bursts) until the target goes down. When you have fired all of the 50-round belt or the target goes down, cease fire and clear your weapon.

(3) The same procedure will be used in firing at 4 targets in the morning and 4 in the afternoon.

Are there any questions?

(4) Now we will fire the practice experience. Each of you will engage 2 targets with up to 50 rounds each.

q. Conclusion.

You have received refresher training on the M60, obtained and recorded a battle-sight zero and fired a practice exercise with the M60. This training, along with your past experience with the M60 and tracer ammunition, should make you a valuable asset to Tracer Experiment 2.

APPENDIX B

OUTLINE OF STONER MACHINEGUN TRAINING

LESSON PLAN

TITLE· Familiarization and Zeroing of the Stoner 63 Light Machinegun

1. <u>Lesson Objective</u>: To allow the test subjects for Tracer Experiment 2 to learn the fundamentals of firing the Stoner Machinegun.

2. <u>Training Objectives</u>: As a result of this instruction, the test subjects must be able to accomplish the following task objectives:

      a. Task Objective. The test subjects must become familiar with the safe functioning of the Stoner light machinegun.

      b. Task Objective. The test subjects will be able to battle-sight zero the Stoner machinegun.

      c. Task Objective. The test subject must be able to confirm his battle-sight zero at 500 meters.

3. <u>Advance Assignment</u>: None.

<p align="center">LESSON OUTLINE</p>

I. INTRODUCTION

      During the past few weeks we have fired the M60 machinegun for the purpose of collecting data to determine if the tracer round really helps you, the gunner, hit your target. We have fired alternate days of tracer and ball ammunition and have also fired the experimental white tracer round. All of this was done to collect enough facts and data to try to make a scientific decision about the tracer round. With your help and cooperation we have been able to get ahead of the planned schedule and saw the opportunity to gather a greater amount and a greater variety of data. Therefore, the last few remaining days of firing we would like to introduce you to the Stoner 63 light machinegun. The Stoner machinegun fires the 5.56mm round which you use with your M16 rifle.

II. DESCRIPTION

      A. The Stoner 63 machinegun is a 5.56mm, belt-fed, gas-operated, air-cooled automatic weapon. The ammunition is fed into the gun by means of a disintegrating metallic link belt. The weapon fires from the open-bolt position. It has a quick-change barrel and fixed headspace. The operational energy is provided by the trapped gases from the previously fired round. So, as you can see, the basic weapon is very similar in its characteristics to the M60.

      B. <u>Sights.</u> The sights are adjustable in 1/4 mil increments in windage and elevation and are graduated on a scale from 200 to 1000 meters. The fully adjustable front sight can be zeroed to the rear sight in both windage and elevation.

<p align="center">50</p>

III. OPERATION

   A. Safety. Before discussing loading and firing of the weapon, it is necessary that all gun safety precautions are observed.

      1. Inspect the machinegun by moving the safety lever to "S" (safe).

      2. Pull the cocking handle to the rear and return the handle to its locked position.

      3. Raise the feed cover and feed tray and inspect the receiver and chamber for live ammunition.

   B. Mechanical Safety. The safety lever is located on the left side of the trigger housing group. There are three positions in which the selector lever can be set, as indicated by "S" for safe, "R" for repetitive or semiautomatic fire, and "A" for automatic. Note the position is indicated by the pointer, not the knurled lever.

   C. Loading.

      1. Check to insure the rounds are securely assembled and positioned in their push through type link.

      2. Set the selector on safe.

      3. Pull the cocking handle to the rear, locking the bolt to the rear, then return the handle to the forward, locked position.

      4. Open the feed tray and place the belt (open side of links down) on the feed tray with the first round to be fired on the feed tray slot.

      5. Close the cover insuring that the latch is secure.

   D. Firing.

      1. Place the selector to "A" (automatic).

      2. Use proper sighting, trigger pull and breathing techniques.

      3. Depress the trigger and the weapon will fire until you release the trigger or the belt is exhausted.

      4. Like the M60, when the last round has been fired, the last link will remain in the feed tray and must be removed manually.

   E. Unloading. To unload a cocked, loaded machinegun, follow this procedure:

      1. Place the selector on safe.

      2. Raise the cover and remove the belt and remaining link from the feed tray.

      3. Inspect the receiver and chamber for ammunition.

IV. STOPPAGES AND MALFUNCTIONS

A. Stoppages. We have discussed in previous instruction that stoppages are caused by dirty, worn or broken parts in the weapon or by faulty ammunition. Remember, a stoppage is an interruption of the normal cycle of operation of the gun, not a malfunction. Preventive maintenance is, of course, the best cure for stoppages. But since our training here will be limited, we want you to know what immediate action to take in case of a stoppage. Immediate action takes place in two phases:

1. To apply the first phase, immediately pull the cocking handle to the rear, return the cocking handle to the forward position, aim and fire. This should be an automatic reaction.

2. If the first phase fails, make a detailed examination of the weapon as follows:

a. Place the weapon on safe.

b. Tap the cover to insure that it is securely latched.

c. Look into the receiver as you slowly pull the cocking handle to the rear.

d. Locate the stoppage by observing, as you pull the handle back, what is in the chamber and what has been ejected.

e. Reduce the stoppage and continue to fire.

B. Hang fire or Misfire. Take the following action for hangfire or misfire:

1. Place the selector on safe.

2. Wait ten seconds, keeping the weapon pointed downrange.

3. If the round does not go off, apply immediate action just as we discussed for the stoppage.

C. Malfunctions. The malfunctions of the Stoner weapon are the same as the M60. The most common are sluggish operation and a runaway gun. We have discussed the causes and corrections for each of these malfunctions several times before. However, I will remind you of the immediate action again for a runaway gun.

1. Release the trigger and maintain a good downrange sighting.

2 Holding the pistol grip firmly, either twist the belt to break it or take the heel of your left hand and strike the rear of the belt, pushing it toward the muzzle. This will cause a break in the belt approximately five rounds from the receiver.

3. Keep the weapon under control and pointed downrange until the weapon stops firing.

V. ZEROING

A. Sights and Adjustments.

1. The Stoner machinegun is equipped with a leaf rear sight and a post front sight. As I indicated earlier, the sight is adjustable in 1/4 mil increments in windage and elevation and is graduated from 200 to 1000 meters. We will not use the front sight to zero, only the rear sight.

2. The windage adjustment is located on the left side and to the rear of the feed cover. To move the bullets point of impact on the target to the left, rotate the windage knob counterclockwise four clicks for each centimeter on the 1000-inch range target. Reverse the rotation to move the strike to the right.

3. Elevation adjustments are made from the right side of the leaf rear sight. To increase range, rotate the elevation knob counterclockwise four clicks for each centimeter on the zero target.

B. Zeroing.

1. We will shortly go to the zero range to zero the Stoner. You will follow the exact procedure for zeroing the Stoner as you did for the M60.

a. Fire three rounds to establish a shot grouping.

b. Determine the proper correction for your shot group to move it to the center of the target using four clicks per centimeter.

c. Using one round, fire until a zero is established.

VI. CONCLUSION

During the past hour, we have discussed the characteristics, general data and operational techniques of the Stoner 63 light machinegun. We also reviewed stoppages and malfunctions with respect to this weapon. Although the Stoner operates basically like the M60, I want you to remember that it is a nonstandard weapon. I want you to feel obligated to ask me anything that may be confusing to you now or even later in the training and test firing. I demand that each of you operate the weapon safely to insure that we have no accidents. Are there any questions?

APPENDIX C

SUBJECT QUESTIONNAIRE

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Tracer Experiment 2 – Pistol Experiment 5

SUBJECT QUESTIONNAIRE

INSTRUCTIONS: Please answer all questions.

PART ONE: Personal data

1. Print your name _____
                         Last   First   MI

2. Rank _____   3. SSN _____   4. MOS _____

5. How many months have you been in the U. S. Army? _____

6. To what unit/organization/station are you now assigned?

   _____

7. Have you ever participated in active combat operations against the enemy?

   ☐ Yes   ☐ No

PART TWO: Experience

1. Before you joined the U. S. Army, approximately how many times had you fired

   a. BB gun _____.

   b. rifle   _____

   c. shotgun _____

2. Approximately how much training have you had on the M60 machinegun? (Check one)

   ☐ Enough that I know well the functioning, nomenclature, care and cleaning, and
      techniques of fire.

   ☐ Enough that I am familiar with the weapon and how to shoot it.

   ☐ Only a little and I don't remember too much of that.

3. In the unit from which you came, are you assigned as a member of an M60 machinegun
crew?
                      ☐ Yes   ☐ No

4 Have you ever been assigned as a member of an M60 machinegun crew? (Do not include
BCT or AIT.)
                      ☐ Yes   ☐ No

5. Approximately how many rounds have you fired from an M60 machinegun? (Include
any firing in BCT and AIT.) _____

6. When you fire the M60 machinegun in daylight, which of the following techniques do you use? (Check as many as you personally use.)

- [ ] Keep both eyes wide open when looking through the sight.
- [ ] Squint or close one eye when looking through the sight.
- [ ] Use the sight when engaging targets at all ranges.
- [ ] Use the sight when engaging targets only at close ranges (less than 450 meters).
- [ ] Use the sight when engaging targets only at far ranges (greater than 550 meters).
- [ ] Seldom use the sight.
- [ ] Use the sight only for the initial burst on a target.
- [ ] Observe tracers through the sight.
- [ ] Raise head and observe tracers looking over or around sight.

7. If your answers to the last question don't give an adequate description of how YOU fire the M60 machinegun, please write a description of the method you use.

Summary of Questionnaire Responses from 22 Subjects

I   Part One - Personal Data

1. Distribution of Grade (Question 2)

    1 E-6,   4 E-5,   12 E-4,   4 E-3,   1 E-2

2. Distribution of Basic MOS (Question 4)

    20   11B   2   11C

3. Months in U. S. Army (Question 5)

    M = 26.8   S.D. = 23.4   N = 22

4. Combat Experience (Question 7)

    0   Combat experience   22   No combat experience

II Part Two - Experience

1. Pre-Army Weapons Firing

	Many Times	Some	Few	Never
BB gun	16	2	1	3
Rifle	12	3	6	1
Shotgun	8	2	7	5

2. Familiarity with M60 Machinegun

    14 claimed to know well the functioning, nomenclature, care and cleaning, and techniques of fire

    7   claimed to be familiar with the weapon and how to shoot it

    1   claimed only a little knowledge of the weapon

3. Present Assignment

    11 now assigned as member of M60 machinegun crew

    11 not assigned as member of M60 machinegun crew

11 Part Two - Experience (continued)

4. Previous Assignments

14 had at some time (other than BCT or AIT) been assigned as
a member of an M60 machinegun crew

8 had never been assigned as an M60 machinegun crew member

5. Experience Firing the M60 Machinegun

21 had fired between 1,000 and 25,000 rounds

1 had fired approximately 25 rounds

6. Techniques Used in Firing the M60

15 claimed they would squint or close one eye when looking
through the sight.

12 claimed to use the sight when engaging targets at all ranges

9 claimed they would raise the head and observe tracers looking
over or around the sight

7 claimed they observed tracers through the sight

6 claimed to use the sight only for the initial burst on a target

6 claimed they kept both eyes wide open when looking through the
sight

4 claimed they would use the sight when engaging targets only
at close ranges (less than 450 meters)

4 claimed they would use the sight when engaging targets only
at far ranges (greater than 550 meters)

0 admitted they seldom used the sight

7. Voluntary description of technique of fire with M60

1 stated "I use the rear sight to frame the front sight post
and target, but don't line up front sight post and rear
sight slot after initial burst"

SUMMARY OF SUBJECT POST-TEST INTERVIEW

1. Which weapon did you prefer?   M60 - 9   Stoner - 13

2. Why?

M60 Reasons	Stoner Reasons
More reliable	Lighter: so easier to handle and can carry more ammunition
Round more powerful	
Greater range	More firepower
Doesn't squirt gas in your face (like the Stoner) so is easier to aim	Fewer parts make maintenance much easier
Better cartridge case ejection pattern	Doesn't bounce around during firing
Sights much better	Sights much better
More accurate	More accurate
Less recoil	Less recoil

3. Which of the three types of tracer was easiest to see?

    M62 - 8   White - 8   M196 - 5   No difference - 1

4. With which ammunition do you think you hit more targets?

    4:1 ball:tracer mix - 17   No difference - 4   All ball - 1

5. Do you think the Army needs tracer for machineguns?

        Yes - 20   No - 2

APPENDIX D

SUMMARIES OF PERFORMANCE AT 550 AND 650 METERS
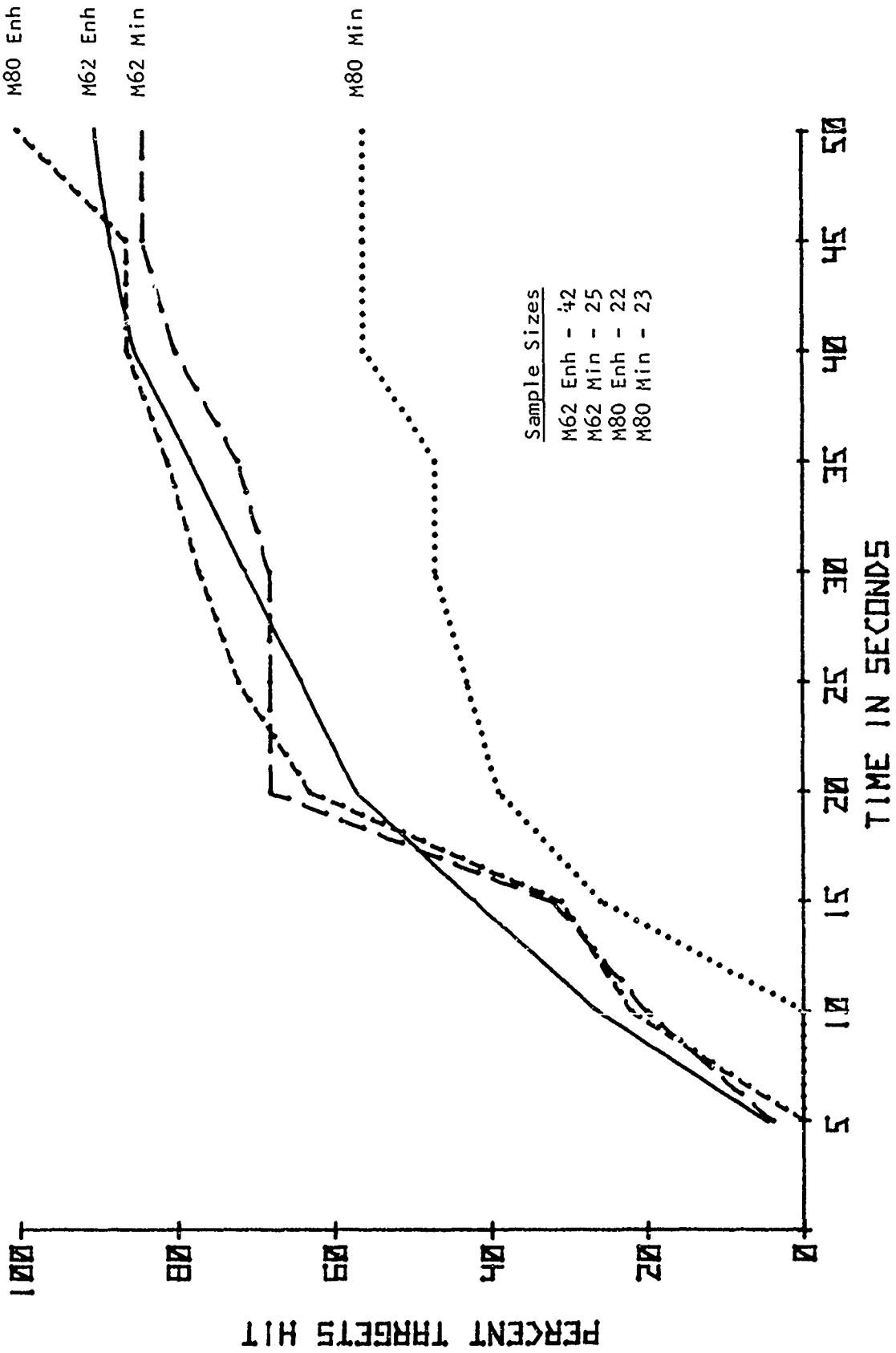
Figure 1D. Comparison of 7.62mm standard ammunition against targets at 550 meters with enhanced and minimized strike feedback

62
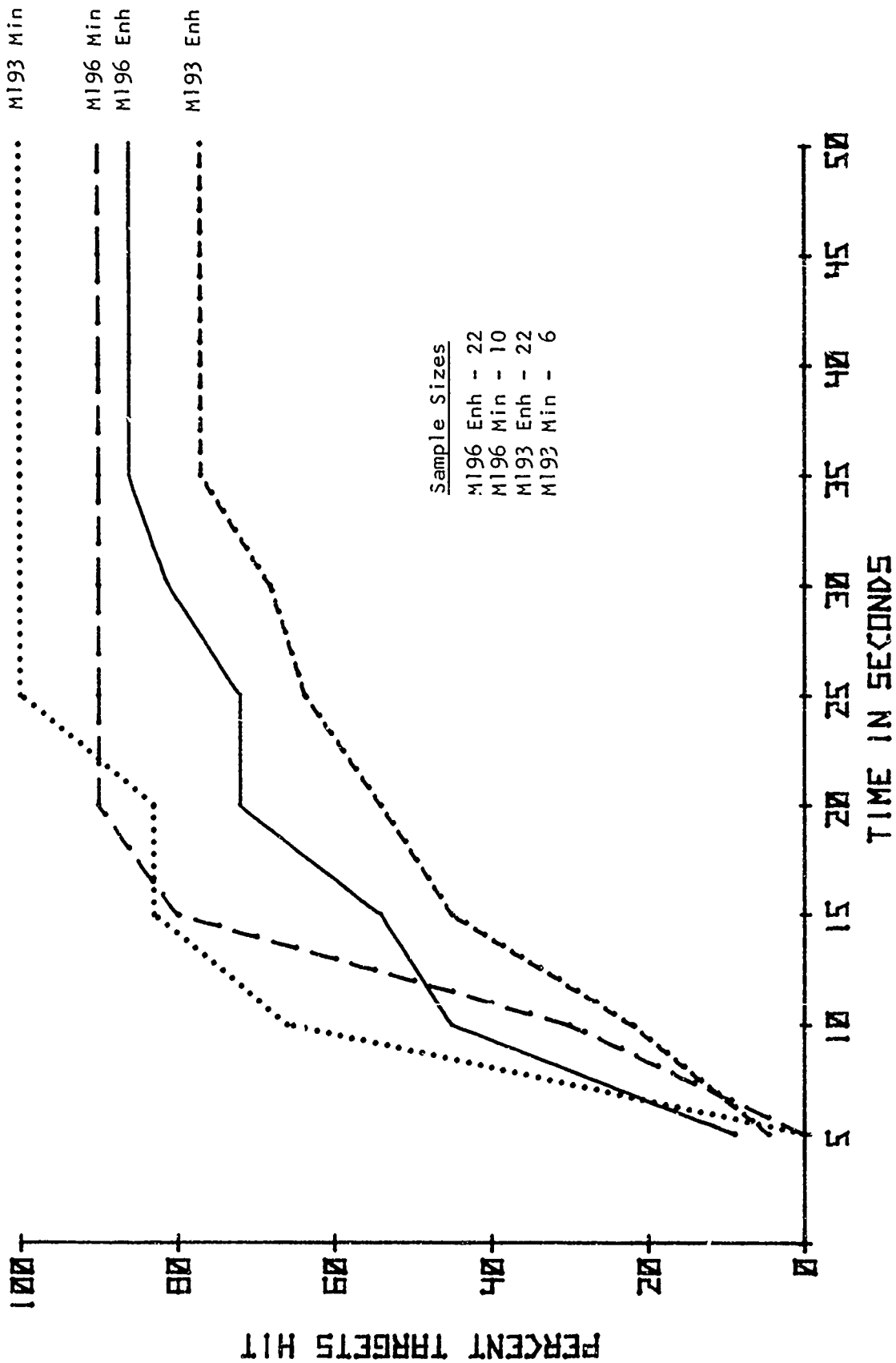
Figure 2D. Comparison of 5.56mm standard ammunition against targets at 550 meters with enhanced and minimized strike feedback

63
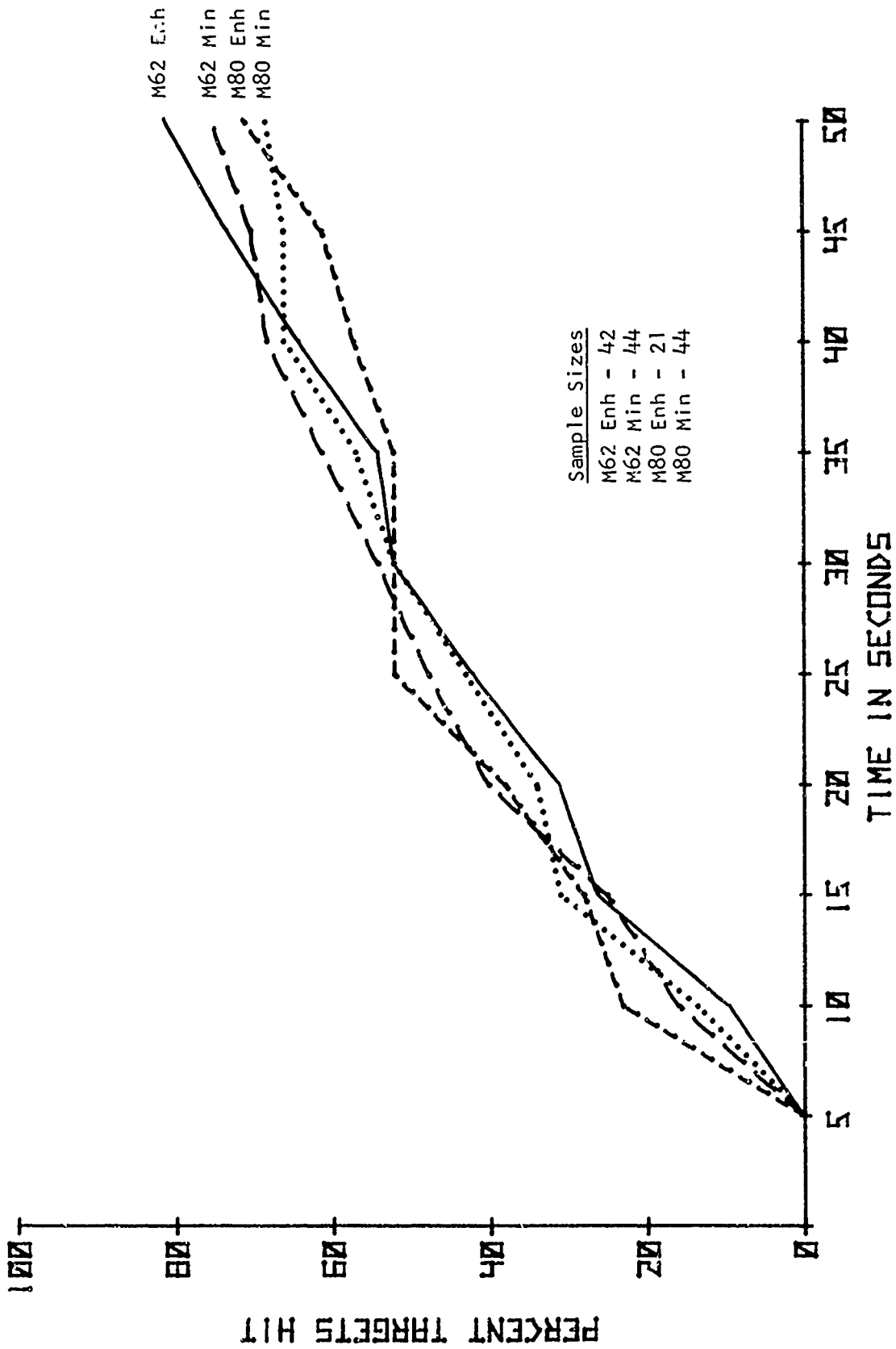
Figure 3D. Comparison of 7.62mm standard ammunition against targets at 650 meters with enhanced and minimized strike feedback

64
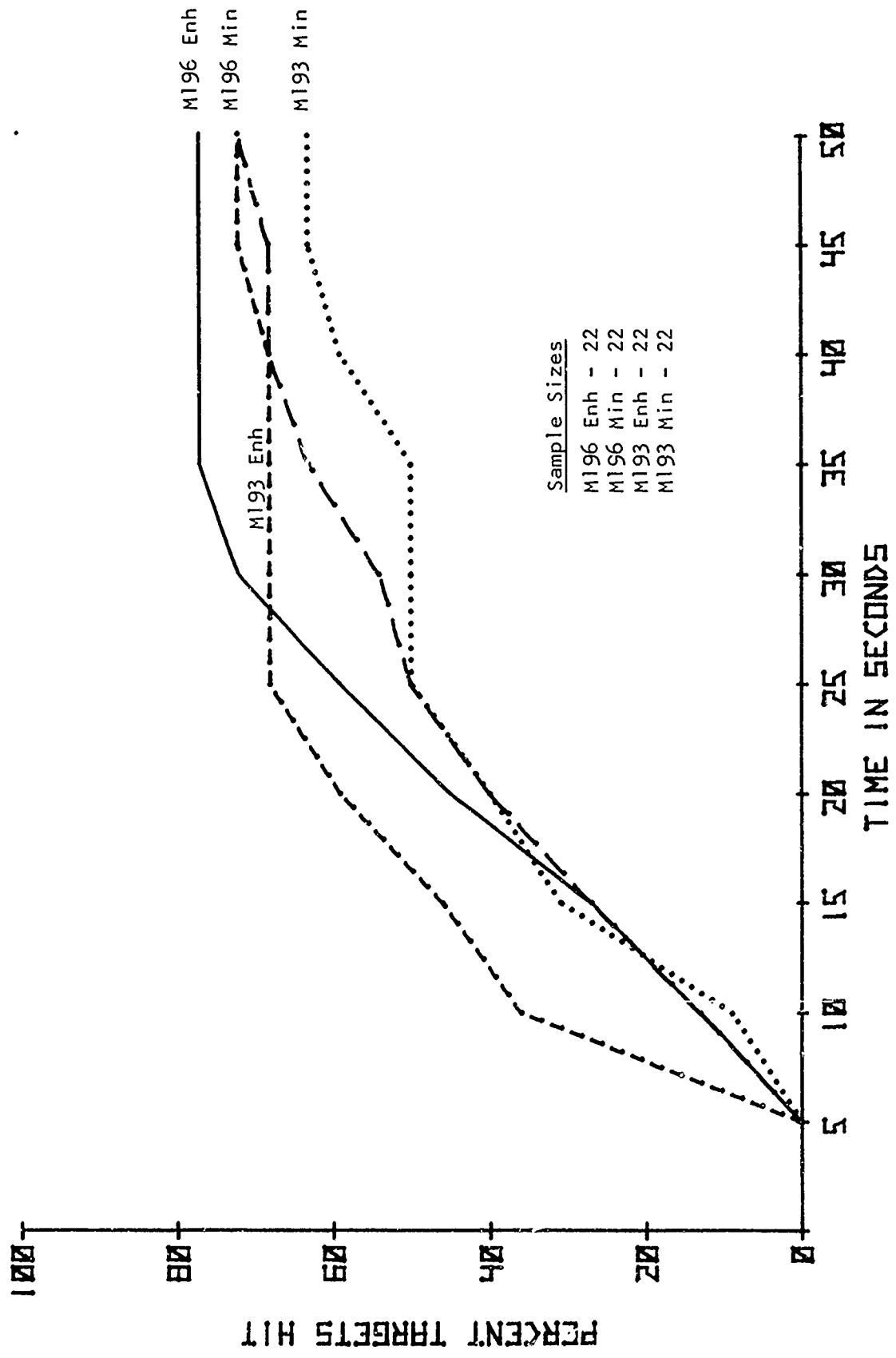
Figure 40. Comparison of 5.56mm standard ammunition against targets at 650 meters with enhanced and minimized strike feedback

APPENDIX E

DATA TABLES
PERCENT TARGETS HIT

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TABLE 1E

Percent Targets Hit by Weapon, Range, Ammunition, and the
Originally Planned Categories of Strike Feedback

Weapon	Ammunition	Planned Strike Feedback	Gun-Target Range (in meters)			
			350	450	550	650
M60	Ball M80	Enh	100	98	93	66
		Min	97	97	75	68
	Tracer M62	Enh	95	100	91	80
		Min	93	95	84	75
	White Tracer	Enh	91	100	82	86
		Min	100	91	91	81
Stoner	Ball M193	Enh	100	100	77	7^
		Min	100	100	91	64
	Tracer M196	Enh	95	95	86	77
		Min	100	95	91	72

TABLE 2E

Percent Targets Hit by Weapon, Range, Ammunition, Original
Categories of Strike Feedback and Soil Condition

Weapon	Range	Ammunition	Dry Soil Enh	Dry Soil Min	Normal Soil Enh	Normal Soil Min	Damp Soil Enh	Damp Soil Min
M60	350	Ball	100	100	*	*	100	95
		Tracer	89	95	100	91	100	100
		White	*	*	93	100	88	100
	450	Ball	95	100	*	*	100	95
		Tracer	100	95	100	96	100	100
		White	*	*	100	93	100	88
	550	Ball	100	95	*	*	86	57
		Tracer	84	84	97	87	100	50
		White	*	*	79	93	88	88
	650	Ball	71	64	*	*	61	73
		Tracer	84	68	78	78	50	100
		White	*	*	86	79	88	88
Stoner	350	Ball	100	100	100	100	*	*
		Tracer	92	100	100	100	*	*
	450	Ball	100	100	100	100	*	*
		Tracer	100	92	90	100	*	*
	550	Ball	81	88	67	100	*	*
		Tracer	83	92	90	90	*	*
	650	Ball	69	56	83	83	*	*
		Tracer	75	67	80	80	*	*

*Data not collected under this combination of conditions.

69

TABLE 3E

Percent Targets Hit by Weapon, Range, Ammunition, and
Actually Obtained Categories of Strike Feedback

Weapon	Ammunition	Actual Strike Feedback	Gun-Target Range (in meters)			
			350	450	550	650
M60	Ball M80	Enh	100	95	100	71
		Min	*	*	57	68
	Tracer M62	Enh	95	100	90	81
		Min	91	96	84	75
	White Tracer	Enh	93	100	79	86
		Min	100	93	91	82
Stoner	Ball M193	Enh	100	100	77	73
		Min	100	100	100	64
	Tracer M196	Enh	95	95	86	77
		Min	100	100	90	73

*Data not collected under this combination of conditions.

70

APPENDIX F

DATA TABLES
MEAN TIME TO FIRST HIT

TABLE 1F

Mean Time in Seconds to Hit* by Weapon, Ammunition, Range and the Originally Planned Categories of Strike Feedback

Gun - Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters Mean	350 meters S.D.	350 meters N	450 meters Mean	450 meters S.D.	450 meters N	550 meters Mean	550 meters S.D.	550 meters N	650 meters Mean	650 meters S.D.	650 meters N
M 60	Ball	Enh	13.74	9.67	44	14.73	11.78	43	20.22	14.46	41	21.42	14.88	29
		Min	12.55	7.29	43	16.88	13.14	43	23.88	13.70	33	20.97	12.48	30
	Tracer	Enh	16.45	9.72	42	19.81	12.33	44	18.76	11.88	40	26.67	15.40	35
		Min	15.00	9.77	41	17.03	14.87	42	18.77	11.75	37	22.05	13.70	37
	White	Enh	17.52	13.99	20	16.34	9.64	22	19.39	9.72	18	12.52	5.18	19
		Min	15.61	11.30	22	14.87	7.18	20	15.84	9.32	20	23.61	16.29	18
Stoner	Ball	Enh	14.19	9.85	22	15.08	11.43	22	15.72	8.85	17	14.13	9.04	16
		Min	11.88	5.70	22	14.87	8.66	22	12.64	6.78	20	20.27	1.05	14
	Tracer	Enh	9.71	5.05	21	13.52	7.39	21	11.94	7.54	19	18.08	7.76	17
		Min	11.46	6.65	22	9.24	4.42	21	13.29	6.00	20	21.44	12.78	16

*given a hit

72

TABLE 2F

Mean Time in Seconds to Hit[*] by Weapon, Ammunition, Range and Original
Categories of Strike Feedback for the "Dry" Soil Condition

Gun - Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters			450 meters			550 meters			650 meters		
			Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
M 60	Ball	Enh	17.83	12.40	21	15.68	13.18	20	22.73	15.72	22	22.64	16.94	15
		Min	14.62	6.34	22	19.04	14.58	22	26.96	15.46	20	20.97	11.00	14
	Tracer	Enh	15.35	9.85	17	20.67	13.64	19	19.13	12.58	16	25.06	12.20	16
		Min	14.79	12.72	18	13.51	8.76	18	20.23	13.85	16	21.90	13.39	13
	White	Enh	**	**		**	**		**	**		**	**	
		Min	**	**		**	**		**	**		**	**	
Stoner	Ball	Enh	14.53	10.82	16	16.03	13.03	16	14.01	7.99	13	15.09	10.21	11
		Min	11.94	6.24	16	14.77	9.75	16	13.65	7.17	14	20.08	12.47	9
	Tracer	Enh	11.39	4.77	11	11.58	4.92	12	11.56	7.21	10	17.36	6.54	9
		Min	9.90	4.32	12	9.36	4.90	11	15.42	7.02	11	23.58	15.27	8

[*]Given a hit

[**]Data not collected under this combination of conditions.

TABLE 3F

Mean Time in Seconds to Hit [*] by Weapon, Ammunition, Range and Original Categories of Strike Feedback for the "Normal" Soil Condition

			Gun – Target Range											
			350 meters			450 meters			550 meters			650 meters		
Weapon	Ammunition Type	Strike Feedback	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
M 60	Ball	Enh	**			**			**			**		
		Min	**			**			**			**		
	Tracer	Enh	17.24	10.10	23	19.25	11.41	23	18.72	11.93	22	27.04	18.49	18
		Min	14.92	7.85	21	20.35	18.56	22	18.22	10.01	20	21.99	14.11	18
	White	Enh	19.85	15.75	13	17.19	10.50	14	19.38	10.99	11	13.61	6.00	12
		Min	17.48	11.75	14	16.09	6.33	13	17.59	9.61	13	23.90	20.50	11
Stoner	Ball	Enh	13.28	7.42	6	12.55	5.37	6	21.30	10.39	4	12.00	6.14	5
		Min	11.72	4.46	6	15.15	5.49	6	10.27	5.60	6	20.62	9.27	5
	Tracer	Enh	7.85	4.92	10	16.12	9.49	9	12.36	8.31	9	18.90	9.35	8
		Min	13.32	8.57	10	9.10	4.09	10	10.68	3.16	9	19.31	10.33	8

[*]Given a hit

[**]Data not collected under this combination of conditions.

74

TABLE 4F

Mean Time in Seconds to Hit* by Weapon, Ammunition, Range and Original Categories of Strike Feedback for the "Damp" Soil Condition

Gun - Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters Mean	S.D.	N	450 meters Mean	S.D.	N	550 meters Mean	S.D.	N	650 meters Mean	S.D.	N
M 60	Ball	Enh	10.01	3.53	23	13.91	10.65	23	17.31	12.63	19	20.11	12.81	14
		Min	10.39	7.72	21	14.61	11.35	21	19.15	9.04	13	20.96	14.02	16
	Tracer	Enh	16.80	6.51	2	17.95	17.32	2	16.25	11.38	2	29.80	.00	1
		Min	17.70	7.07	2	12.20	3.25	2	6.60	.00	1	23.60	21.50	2
	White	Enh	13.19	9.49	7	14.85	8.36	8	19.37	8.16	7	10.66	2.85	7
		Min	12.34	10.35	8	12.61	8.59	7	12.59	8.45	7	23.14	7.18	7
Stoner	Ball	Enh	**			**			**			**		
		Min	**			**			**			**		
	Tracer	Enh	**			**			**			**		
		Min	**			**			**			**		

*Given a hit

**Data not collected under this combination of conditions.

75

TABLE 5F

Mean Time in Seconds to Hit* by Weapon, Ammunition, Range
and Actually Obtained Categories of Strike Feedback

Gun - Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters			450 meters			550 meters			650 meters		
			Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
M 60	Ball	Enh	17.83	12.40	21	15.68	13.18	20	22.73	15.72	22	22.64	16.94	15
		Min	**			**			19.15	9.04	13	20.97	12.48	30
	Tracer	Enh	16.44	9.91	40	19.89	12.33	42	18.90	12.04	38	26.58	15.62	34
		Min	14.92	7.85	21	20.35	18.56	22	17.66	10.08	21	22.05	13.70	33
	White	Enh	19.85	15.75	13	17.19	10.50	14	19.38	10.99	11	13.61	6.00	12
		Min	17.48	11.75	14	16.09	6.33	13	15.84	9.32	20	23.61	16.29	18
Stoner	Ball	Enh	14.19	9.85	22	15.08	11.43	22	15.72	8.85	17	14.13	9.04	16
		Min	11.72	4.46	6	15.15	5.49	6	10.27	5.60	6	20.27	11.05	14
	Tracer	Enh	9.71	5.5	21	13.52	7.39	21	11.94	7.54	13	18.08	7.76	17
		Min	13.32	8.57	10	9.10	4.09	10	10.68	3.16	9	21.44	12.78	16

*Given a hit

**Data not collected under this combination of conditions

76

APPENDIX G

DATA TABLES
MISSION SCORES

TABLE 1G

Mean Mission Score by Weapon, Ammunition, Range and the
Originally Planned Categories of Strike Feedback

Gun - Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters			450 meters			550 meters			650 meters		
			Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
M 60	Ball	Enh	81	9	44	81	14	44	74	18	44	56	29	44
		Min	81	14	44	80	15	44	59	25	44	59	31	44
	Tracer	Enh	77	16	44	78	11	44	75	22	44	61	24	44
		Min	77	20	44	78	17	44	69	25	44	63	29	44
	White	Enh	77	21	22	81	9	22	70	24	22	75	24	22
		Min	83	11	22	77	21	22	78	22	22	68	27	22
Stoner	Ball	Enh	80	13	22	79	12	22	64	28	22	64	31	22
		Min	81	7	22	77	11	22	76	23	22	54	28	22
	Tracer	Enh	79	18	22	75	18	22	74	24	22	60	25	22
		Min	80	10	22	81	17	22	74	22	22	57	28	22

78

TABLE 2G

Mean Mission Score by Weapon, Ammunition, Range and Original
Categories of Strike Feedback for the "Dry" Soil Condition

Gun - Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters Mean	S.D.	N	450 meters Mean	S.D.	N	550 meters Mean	S.D.	N	650 meters Mean	S.D.	N
M 60	Ball	Enh	78	11	21	78	17	21	76	12	22	58	30	22
		Min	79	9	22	78	12	22	68	16	21	55	32	21
	Tracer	Enh	75	21	19	80	11	19	71	27	19	64	20	19
		Min	80	20	19	81	18	19	70	26	19	60	30	19
	White	Enh	*			*			*			*		
		Min	*			*			*			*		
Stoner	Ball	Enh	78	14	15	76	12	16	66	26	16	59	30	16
		Min	79	7	16	77	12	16	72	26	16	49	29	16
	Tracer	Enh	74	21	12	80	11	12	74	28	12	60	27	12
		Min	82	10	12	77	21	12	70	20	12	54	30	12

*Data not collected under this combination of conditions

79

TABLE 3G

Mean Mission Score by Weapon, Ammunition, Range and Original
Categories of Strike Feedback for the "Normal" Soil Condition

Gun - Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters			450 meters			550 meters			650 meters		
			Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
M 6G	Ball	Enh	*			*			*			*		
		Min	*			*			*			*		
	Tracer	Enh	79	11	23	75	11	23	77	18	23	60	26	23
		Min	74	21	23	75	17	23	69	23	23	65	29	23
	White	Enh	78	20	14	82	10	14	69	28	14	75	26	14
		Min	81	12	14	77	19	14	79	22	14	69	30	14
Stoner	Ball	Enh	85	10	6	86	9	6	58	34	6	76	32	6
		Min	85	8	6	78	6	6	87	9	6	67	26	6
	Tracer	Enh	85	10	10	69	23	10	74	22	10	61	25	10
		Min	77	9	10	84	8	10	77	24	10	62	25	10

*Data not collected under this combination of conditions.

80

TABLE 4G

Mean Mission Score by Weapon, Ammunition, Range and Original
Categories of Strike Feedback for the "Damp" Soil Condition

Gun – Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters			450 meters			550 meters			650 meters		
			Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
M 60	Ball	Enh	84	7	23	83	11	23	72	23	22	54	29	23
		Min	83	17	22	81	17	22	51	28	23	63	31	22
	Tracer	Enh	75	14	2	80	19	2	80	25	2	45	47	2
		Min	76	13	2	85	0	2	57	57	2	72	28	2
	White	Enh	75	24	8	80	9	8	72	15	8	76	24	8
		Min	86	9	8	76	24	8	76	25	8	67	21	8
Stoner	Ball	Enh	*	*		*	*		*	*		*	*	
		Min	*	*		*	*		*	*		*	*	
	Tracer	Enh	*	*		*	*		*	*		*	*	
		Min	*	*		*	*		*	*		*	*	

*Data not collected under this combination of conditions.

81

TABLE 5G

Mean Mission Score by Weapon, Ammunition, Range and
Actually Obtained Categories of Strike Feedback

Gun - Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters			450 meters			550 meters			650 meters		
			Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
M 60	Ball	Enh	78	11	21	78	17	21	76	12	22	58	30	21
		Min	*			*			51	28	23	59	31	44
	Tracer	Enh	77	16	42	77	11	42	74	22	42	62	23	42
		Min	74	21	23	75	17	23	68	25	25	63	29	44
	White	Enh	78	20	14	82	10	14	69	28	14	75	26	14
		Min	81	12	14	77	19	14	78	22	22	68	27	22
Stoner	Ball	Enh	80	13	22	79	12	22	64	28	22	64	31	22
		Min	85	8	6	78	6	6	87	9	6	54	29	22
	Tracer	Enh	79	18	22	75	18	22	74	25	22	60	25	22
		Min	77	9	10	84	8	10	77	24	10	57	28	22

*Data not collected under this combination of conditions.

82

APPENDIX H

DATA TABLES
NUMBER OF BURSTS FIRED

TABLE 1H

Mean Number of Bursts Fired Per Mission by Weapon, Ammunition, Range and the Originally Planned Categories of Strike Feedback

Gun - Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters			450 meters			550 meters			650 meters		
			Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
M 60	Ball	Enh	2.46	1.61	44	2.61	2.14	44	3.55	2.52	44	5.32	3.36	44
		Min	2.48	1.79	44	2.89	1.96	44	5.14	2.91	44	5.00	3.52	44
	Tracer	Enh	3.16	2.20	44	3.43	2.14	44	3.34	2.33	44	5.27	3.14	44
		Min	3.02	2.12	44	3.11	2.59	44	4.07	3.08	44	4.43	2.97	44
	White	Enh	3.14	2.42	22	2.59	1.44	22	3.50	2.56	22	2.68	2.17	22
		Min	2.41	1.65	22	2.77	2.02	22	2.91	2.29	22	3.91	2.54	22
Stoner	Ball	Enh	3.23	2.88	22	2.91	2.18	22	4.41	2.87	22	4.55	3.57	22
		Min	2.32	1.21	22	3.23	2.00	22	3.00	2.71	22	5.86	3.48	22
	Tracer	Enh	2.82	2.44	22	3.41	2.72	22	3.14	2.64	22	5.18	2.91	22
		Min	2.55	1.60	22	2.32	2.01	22	3.46	2.77	22	6.05	3.77	22

84

TABLE 2H

Mean Number of Bursts Fired Per Mission by Weapon, Ammunition, Range and the
Originally Planned Categories of Strike Feedback for the "Dry" Soil Condition

Gun - Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters			450 meters			550 meters			650 meters		
			Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
M 60	Ball	Enh	2.91	2.05	21	2.71	2.61	21	3.32	2.51	22	5.24	3.75	21
		Min	2.55	1.47	22	3.00	1.89	22	4.71	2.92	21	5.64	4.11	22
	Tracer	Enh	3.21	2.42	19	3.05	1.84	19	3.42	2.29	19	4.68	2.26	19
		Min	2.53	1.74	19	2.63	2.01	19	3.84	2.52	19	4.42	2.85	19
	White	Enh	*			*			*			*		
		Min	*			*			*			*		
Stoner	Ball	Enh	3.63	3.18	16	3.50	2.28	16	4.31	3.07	16	5.06	3.42	16
		Min	2.56	1.26	16	3.44	2.19	16	3.56	2.92	16	6.31	3.36	16
	Tracer	Enh	3.58	2.91	12	2.75	1.71	12	3.08	2.47	12	5.42	2.78	12
		Min	2.17	1.12	12	2.75	2.53	12	4.00	2.59	12	6.42	3.73	12

*Data not gathered under this combination of conditions.

TABLE 3H

Mean Number of Bursts Fired Per Mission by Weapon, Ammunition, Range and the
Originally Planned Categories of Strike Feedback for the "Normal" Soil Condition

Gun - Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters			450 meters			550 meters			650 meters		
			Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
M 60	Ball	Enh	*			*			*			*		
		Min	*			*			*			*		
	Tracer	Enh	3.13	3.14	23	3.78	2.35	23	3.35	2.46	23	5.83	3.77	23
		Min	3.44	2.41	23	3.61	3.04	23	4.30	3.55	23	4.57	3.16	23
	White	Enh	2.93	2.27	14	2.57	1.56	14	3.71	3.05	14	2.64	2.17	14
		Min	2.57	1.65	14	2.57	1.65	14	2.79	2.12	14	3.57	2.90	14
Stoner	Ball	Enh	2.17	1.60	6	1.33	.52	6	4.67	2.50	6	3.17	3.92	6
		Min	1.67	.82	6	2.67	1.37	6	1.50	1.23	6	4.67	3.83	6
	Tracer	Enh	1.90	1.37	10	4.20	3.52	10	3.20	2.97	10	4.90	3.18	10
		Min	3.00	2.00	10	1.80	1.03	10	2.80	2.97	10	5.60	3.99	10

*Data not collected under this combination of conditions.

TABLE 4H

Mean Number of Bursts Fired Per Mission by Weapon, Ammunition, Range and the Originally Planned Categories of Strike Feedback for the "Damp" Soil Condition

Gun - Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters Mean	350 meters S.D.	350 meters N	450 meters Mean	450 meters S.D.	450 meters N	550 meters Mean	550 meters S.D.	550 meters N	650 meters Mean	650 meters S.D.	650 meters N
M 60	Ball	Enh	2.04	.93	23	2.52	1.65	23	3.77	2.56	22	5.39	3.04	23
		Min	2.41	2.89	22	2.77	2.07	22	5.48	2.92	23	4.36	2.75	22
	Tracer	Enh	3.00	1.41	2	3.00	2.83	2	2.50	2.12	2	4.50	2.12	2
		Min	3.00	1.41	2	2.00	.00	2	3.50	3.54	2	3.00	3.16	2
	White	Enh	3.50	2.78	8	2.63	1.30	8	3.13	1.46	8	2.75	2.32	8
		Min	2.13	1.73	8	3.13	2.64	8	3.13	2.70	8	4.50	1.77	8
Stoner	Ball	Enh	*			*			*			*		
		Min	*			*			*			*		
	Tracer	Enh	*			*			*			*		
		Min	*			*			*			*		

*Data not collected under this combination of conditions.

87

TABLE 5H

Mean Number of Bursts Fired Per Mission by Weapon, Ammunition, Range
and the Actually Obtained Categories of Strike Feedback

Gun – Target Range

Weapon	Ammunition Type	Strike Feedback	350 meters			450 meters			550 meters			650 meters		
			Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
M 60	Ball	Enh	2.91	2.05	21	2.71	2.61	21	3.32	2.51	22	5.24	3.75	21
		Min	*			*			5.48	2.92	23	5.00	3.52	44
	Tracer	Enh	3.17	2.24	42	3.45	2.14	42	3.38	2.36	42	5.31	3.20	42
		Min	3.44	2.41	23	3.61	3.04	23	4.24	3.48	25	4.43	2.97	44
	White	Enh	2.93	2.27	14	2.57	1.56	14	3.71	3.05	14	2.64	2.17	14
		Min	2.57	1.65	14	2.57	1.65	14	2.9i	2.29	22	3.91	2.54	22
Stoner	Ball	Enh	3.23	2.89	22	2.91	2.18	22	4.41	2.87	22	4.55	3.57	22
		Min	1.67	.82	6	2.68	1.37	6	1.50	1.23	6	5.86	3.48	22
	Tracer	Enh	2.82	2.44	22	3.41	2.72	22	3.14	2.64	22	5.18	2.91	22
		Min	3.00	2.00	10	1.80	1.03	10	2.80	2.97	10	6.05	3.77	22

*Data not collected under this combination of conditions.

88