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TIME TO FIRE: THE SEMIAUTOMATIC PISTOL VERSUS THE REVOLVER

N. William Doss

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U. S. ARMY HUMAN ENGINEERING LABORATORY
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This study analyzed the time to first-round-fired for selected personal-defense weapons and investigated associated problems. The findings reveal the revolver can be brought into action and fired significantly faster than the semiautomatic. The single-action M1911A1 can be fired as quickly from an empty-chamber condition as from a prechambered condition. The service-type holster accounts for 60 percent of the total mean time-to-fire.

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November 1976

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TIME TO FIRE THE SEMIAUTOMATIC PISTOL VERSUS THE REVOLVER

INTRODUCTION

The U.S. Army Human Engineering Laboratory (HEL) had been requested to provide information about the speeds with which different types of personal-defense weapons (PDW's) could be brought into action and fired from a stowed position. This area had been relegated to a low-priority status in the past, because pistol-effectiveness studies were being undertaken at the time. However, upon completion of one such study by HEL, it was decided to conduct a PDW Time-to-Fire Study, since the equipment and facility were operational, and the test subjects (Ss) were available and conditioned to field routine.

The task was to conduct a timed comparison between a double-action revolver stowed in a service-type holster with a retaining strap, and the M1911A1 semiautomatic service pistol (5, 8) stowed in the service holster with a full cover flap (Figure 1).

To place the test criteria in proper perspective, it is essential to realize that the models of the PDW's selected for the test are not truly representative in the human factors sense, of the entire specturm of configurations that exists in the handgun marketplace. For example; it would have been valid:

1. To test the revolver as if it were a single-action weapon and required cocking. (This way, we would know what the double-action feature contributes.)

2. To fire both weapons with a chambered round and precocked action (3).

3. To use an existing double-action semiautomatic (Smith & Wesson 9mm Model 39 or 59) in both single- and double-action mode (6).

However, the systems selected for testing are the systems in the user inventory.

METHOD

The Ss were assigned to two groups of nine Ss each. The groups were tested on alternate days. The same group assignment, but not S number, was utilized in another study during the "off" day. The test Ss were members of the 82d Airborne, MOS 11BX0, recent graduates of Advanced Infantry Training, with emphasis on machine gunnery, in good physical condition, and reasonably motivated to the HEL Pistol Program. They had just completed a pistol-effectiveness test and were familiar with correct pistol-handling and firing procedure.

The test was conducted on a secured firing range (Figure 2), instrumented for data gathering. A firing point was oriented to face three pop-up targets at a range of 10 meters, arranged in a fan of 60 degrees; the left target was 30 degrees from the center, which was 30 degrees from the right target.

The targets were E-type silhouettes on M31A1 mechanisms, which were electrically controlled from the data van. The mechanisms were connected to the data recorders for time-base purposes. None of the targets or mechanisms were visible to any test S while on the firing point.

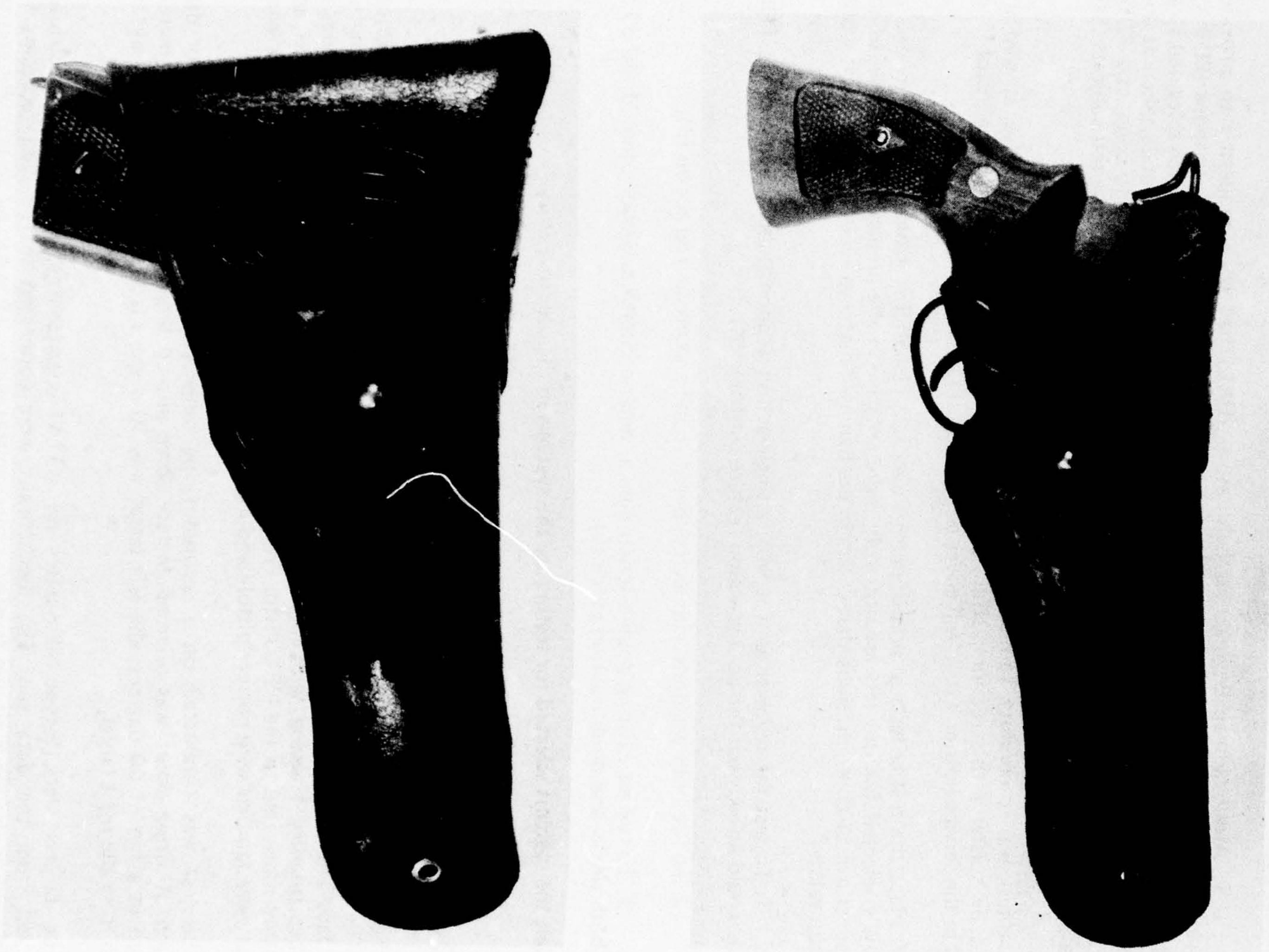

Figure 1. Test PDW's stowed in service holsters.

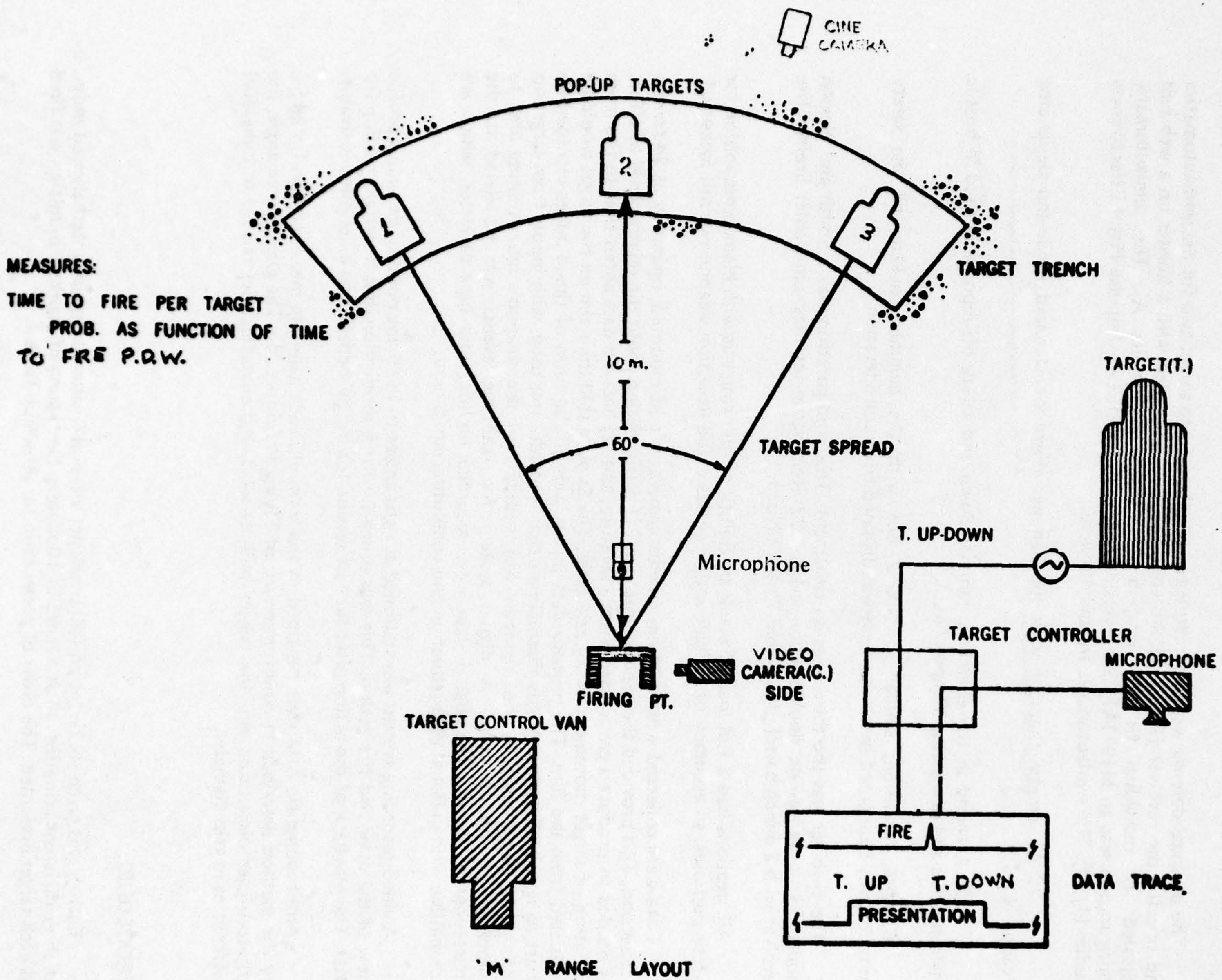

Figure 2. Diagram of pop-up range facility.

The personal-defense weapon treatments were limited to three: two for the semiautomatics and one for the revolver (Figure 3). All configurations were used with a holster on a web belt adjusted for individual fit and weapon deployment (Appendix A). The semiautomatic configuration was an M1911A1/22 conversion, as used in HEL Low-Impulse Pistol Effectiveness studies (1, 10). The semiautomatic treatments were:

1. An empty chamber with the hammer down-the standard mode-and designated Weapon No. 1.

2. A round in the chamber, hammer down and safety off-reportedly used in hostile environments-and designated Weapon No. 2.

A third condition, similar to No. 2 but with the hammer cocked and the safety on-reportedly being used in hostile areas-was dropped from consideration.

The revolver was the third weapon treatment. This configuration was a Smith and Wesson model 53, a single- or double-action caliber-.22 Remington-Jet Magnum center-fire/rim-fire revolver with a 6-inch barrel, designated Weapon No. 3.

All weapons had a full load of blank ammunition. All firing was with blank ammunition for safety purposes, so accuracy of a single-action versus a double-action weapon was not measured.

Data were collected with a 16mm cinema camera, tripod mounted, operating at 24 frames per second. This provided the experimenter with (1) information about the relative level of effort Ss needed to produce a given performance measure, and (2) back-up data about time-to-fire from initiation of target movement to muzzle blast. The Ss were told their aim on the target would be evaluated from the film. The primary data inputs were in the form of timed pulses recorded on chart paper. An Esterline-Angus thermal-pen chart recorder was used, with inputs from target-up commands (time zero). A shot detector was located near the weapon's muzzle-firing area to complete the timing cycle. A digital system for real-time events was paralleled to the chart-recorder inputs. The digital data were recorded on magnetic tape cassettes, which are compatible with in-house data-reduction and computing equipment.

A video recording system was stationed at right angles to the firing point to provide a profile view of the draw and fire action. This was primarily for S motivation and a tertiary backup for data. The playback of the action after the test session for the Ss' benefit was a definite motivator.

Anthropometric data were obtained in the form of inside handgrip measurements for all Ss, by the method described in Anthropometry of Flying Personnel (4). The grip-to-bore angle, the grip-to-trigger dimension, and the trigger pull are all design characteristics related to individual differences in grip diameter.

PROCEDURE

Each S was given six target presentations per weapon treatment, in a counterbalanced order, at three different azimuths, all at a range of 10 meters. One round of blank ammunition was fired at each target presented. The order of presentation is shown in Table 1.

Each S was given six trigger pulls per weapon treatment for practice prior to the main test.

Figure 3. M1911A1/.22 (top) and Smith & Wesson Model 53 (bottom).

TABLE 1

Time to Fire—Order of Presentation

Subject by Weapon by Target Sequence by Replication

Subject No.	Repl. No.	I		II		III	
		Wpn.	Tgt. Sq.	Wpn.	Tgt Sq.	Wpn.	Tgt. Sq.
1		1	1	2	11	3	6
2		3	2	1	12	2	7
3		2	3	3	13	1	8
4		3	4	2	14	1	9
5		1	5	3	15	2	10
6		2	6	1	1	3	11
7		2	7	3	2	1	12
8		1	8	2	3	3	13
9		3	9	1	4	2	14
10		1	15	3	8	2	1
11		2	1	1	9	3	2
12		3	2	2	10	1	3
13		3	3	1	11	2	4
14		2	4	3	12	1	5
15		1	5	2	13	3	6
16		2	6	1	14	3	7
17		3	7	2	15	1	8
18		1	8	3	1	2	9

Wpn. 1 = Auto. Empty
Wpn. 2 = Auto. Loaded
Wpn. 3 = Revolver

The complete matrix is shown as:

S		WPN.		TGT.		TRIG. PULL/TGT		REPL.	
18	x	3	x	3	x	1	x	2	= 324 Total shots fired.

During the firing portion of the test, the Ss were instructed to "Stand ready (on the firing line)-when you see the target, draw your weapon, cock it if necessary; aim, using both hands, and fire as soon as possible."

All of the firers wore earmuff-type protectors to preclude the possibility of hearing loss and minimize any tendency to flinch or momentarily "freeze" on the trigger pull (Figures 4 and 5).

RESULTS

Several things become readily apparent by the end of the first test session. All Ss required two separate arm motions to draw the weapon from the holster: sequentially, opening the flap and drawing out the weapon. The body also had to make a twist to the right followed by a thrust back to the left, without overreacting and going past the center position. The experimenter feels that twisting the torso to the left while extending the arm/weapon combination, accounts for the faster time to draw and fire to left and to the center than to the right, which was true for all weapon conditions, although not statistically significant (Appendix B).

In terms of total time to fire, the revolver was significantly faster than either semiautomatic condition, although there was no significant difference in times to draw the weapons from their holsters.

The semiautomatic empty (Weapon 1) was slightly faster than the semiautomatic loaded (Weapon 2).

For a review of the order of events when firing all weapon conditions, see Appendix C.

The task of cocking the hammer to fire Weapon 2 was hindered by the spur above the grip-safety under the hammer. The Ss frequently tired to cock the spur instead of the hammer when under the stress of quick fire.

When attempting to "fan" the hammer with the left hand, Ss often gouged the rear sight into the heels of their hands. The Ss had been instructed to "use both hands" to draw and fire the weapon in the manner he found most effective.

There were occasions when Ss missed the hammer altogether by either method.

Figure 6 shows the percentage of the S population firing any test PDW as a function of time.

The probability of firing weapon configuration 1, 2, or 3, as a function of time, is presented in Figure 7.

Test results indicate the dexterous task of placing a revolver or a semiautomatic pistol into action are essentially the same, with minor holster differences; their exclusive difference is the need to charge the semiautomatic. This loading subtask could be assumed to be negated by

Figure 4. Firing sequence for a semiautomatic pistol from a stowed position.

Figure 5. Firing sequence for a revolver from a stowed position.

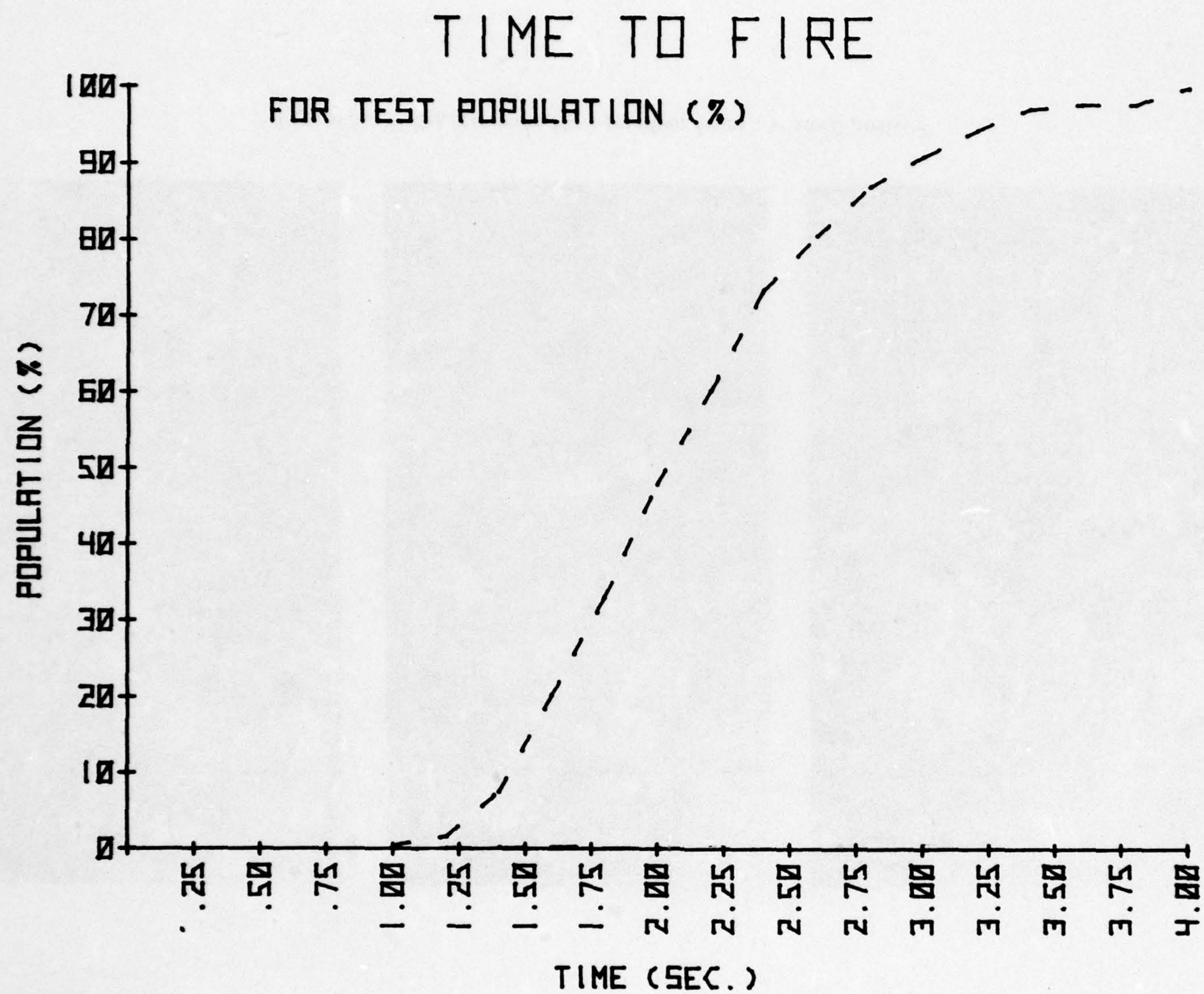

Figure 6. Cumulative times to fire for the test population.

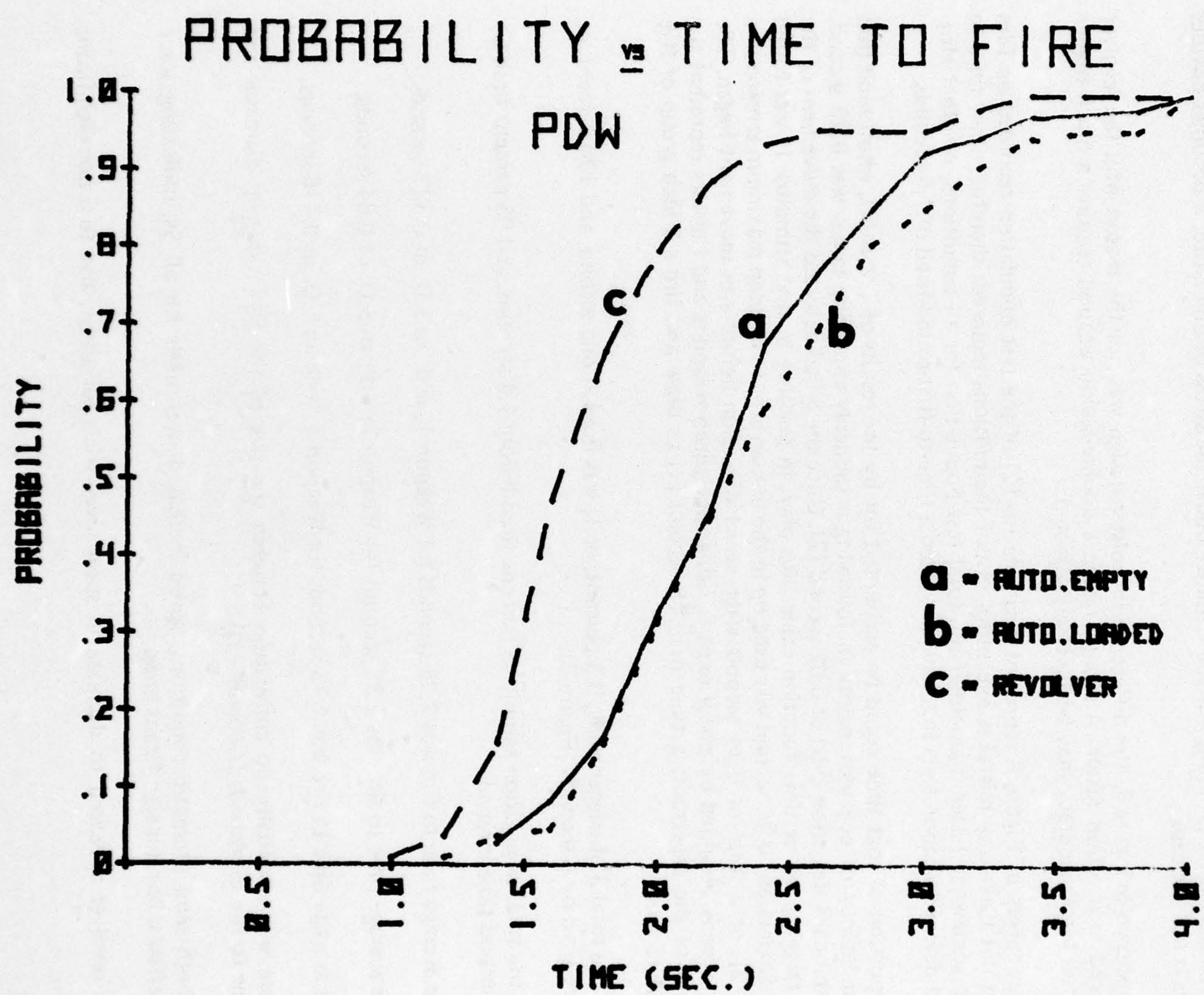

Figure 7. Cumulative times to fire a PDW, by weapons.

prechambering a round of ammunition, so the user would need only to cock the hammer of the M1911A1, thus leaving just the holster differences to deal with. However, when one observes the infantryman subjects grouping for the hammer under the stress of quick-fire, it becomes obvious that this is not the case.

As shown in Figure 8, the difference in holster design was not the reason why the revolver was placed into action faster. Although faster, a double-action weapon requires a much higher trigger-pull force; accuracy may be adversely affected.

The curves in Figure 8 represent a sample (n=12) of the test population recorded on film who did not make any mistakes executing any of the motions required; therefore their time to fire was somewhat faster than either the total test population for all conditions, or other HEL personal-defense weapon tests that have indicated a time-to-first-round-fired of 1.5 seconds.

A portion of that time could be accounted for by the results of Travis (9), who found that the mean latency of eye movements in following a suddenly-appearing target was 0.20 second, with a standard deviation (SD) of 0.02 second (2). Once the S had detected the movement of the pop-up target, another time function came into play, in reacting to that stimulus. It was found that approximately 0.04 second was used up in the human arm to develop maximum tension in a muscle (2), or a total of 0.24 second after visual detection before arm movement began. The extreme speeds obtained by pistol experts using specialized weapons and holsters represent the other end of the spectrum: a time of 0.45 second (7) to draw and fire a 2-inch group of five rounds at 15 feet.

Of the total 324 trigger pulls, 0.3 percent, or 1, was fired at one second; and 100 percent, or 324, were fired by 4 seconds (Figure 7).

Of the total population sample, 5 percent fired before 1.4 seconds, and 95 percent fired by the 3.2-second time interval.

The average time to fire was 2.25 seconds for Weapon 1, with an S.D. of 0.527 seconds.

The average time to fire was 2.36 seconds for Weapon 2, with an S.D. of 0.64 seconds.

The average time to fire was 1.73 seconds for Weapon 3, with an S.D. of 0.446 seconds.

There was essentially no correlation between the size of the S's inside-grip diameter and mean time to fire in seconds (Appendix D).

In both semiautomatic conditions, speed increased over trials for all Ss, indicating some learning effects, but not significant ones.

The revolver appeared to decrease in speed over trials for all Ss, also to a non-significant degree.

CONCLUSIONS

Infantryman subjects were able to draw and fire the revolver against surprise targets significantly faster than with either semiautomatic weapon.

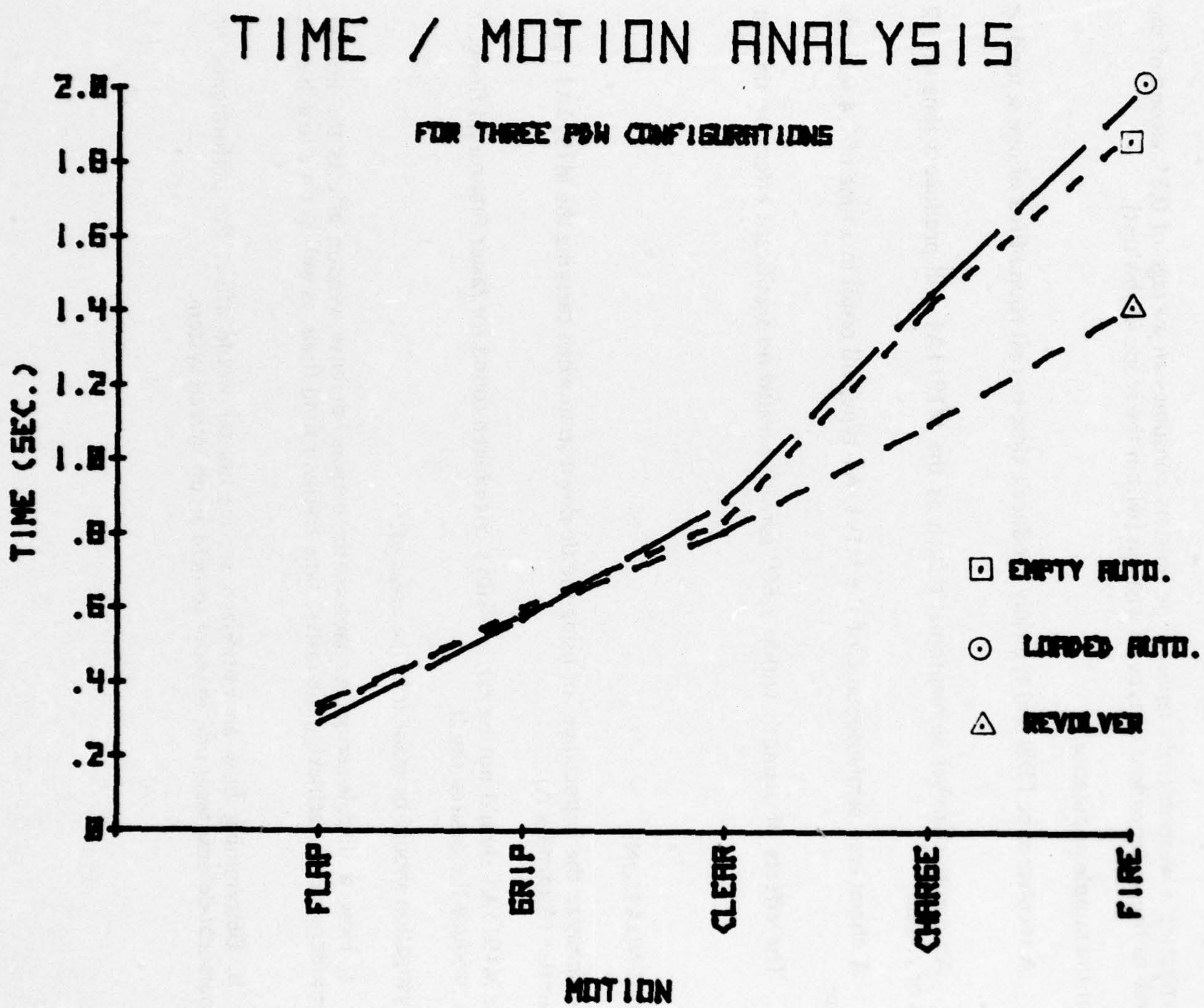

Figure 8. Time-and-motion relationship for three PDWs, by times.

The critical function affecting speed was the operational design of the weapon itself (i.e., double-versus single-action lockwork, which translates into the user cocking the hammer with the thumb(s) versus a simple trigger pull).

Extracting a weapon from service-type holsters consumes an average of 0.85 second of the total time to fire, independent of type of weapon (within the scope of this test).

For the sample population:

A revolver-type PDW will typically produce a time-to-first-round-fired of one second or longer.

An empty-chamber semiautomatic such as the M1911A1 will produce a time of 1.2 seconds or greater.

A chambered semiautomatic of the M1911A1 type will result in a time of 1.4 seconds or greater.

The effects of azimuth within a 60° spread revealed no significant effect on time to fire.

RECOMMENDATIONS

Reemphasize the importance of using the tie-down strap when carrying the M1911A1 in its service holster (Appendix A).

The M1911A1 should not be carried with a chambered round for faster first-round firing; it does not produce the desired result.

Investigation should be made into the areas of:

a. How a double-action semiautomatic personal-defense weapon affects the human factors requirements for achieving the fastest time-to-first-round-fired, as well as time to achieve a hit.

b. Determining how an optimized service holster would affect the performance of existing personal-defense weapons, in order to field an optimized system.

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APPENDIX A

HUMAN FACTORS EVALUATION OF DRAWING AND FIRING PERSONAL DEFENSE WEAPONS

The M1911A1 was used with its service holster and web belt.

The revolver was used with a holster that provided a restraining strap which fastened in the same manner and location as the M1911A1 holster. A web belt was also used with the revolver.

It became evident early in the qualifying practice that the upward forces applied to the holsters caused the weapon to hang up when the holsters rode up with the weapon. After several abortive attempts, a thin tie-down strap was added to both holsters through the eyelets provided in the lower tip or barrel end. In noncombat situations, this apparently has fallen from practice, although it has been correctly worn by personnel in hostile zones, as evident in photographs. It should be noted that the upwards force applied to the holsters by the weapons being drawn was sufficient to break packaging string and light bell-wire when the infantrymen tried them as a field expedient measure. Once the holsters were securely held in place with a thin leather thong or bootlace, the weapons could be drawn smoothly, without requiring body contortions or gymnastics of the infantrymen.

APPENDIX B

ANALYSIS OF VARIANCE

1. The representative score used for this analysis was the mean time to fire from an adjusted time zero.

2. The representative symbols chosen for the factors were:

A. TARGETS

A_1 - Left target

A_2 - Center target

A_3 - Right target

B. WEAPONS

B_1 - M1911A1 semiautomatic, empty chamber, uncocked.

B_2 - M1911A1 semiautomatic, *loaded chamber, uncocked.*

B_3 - Revolver, loaded, double-action lockwork.

3. The results of the ANOVA were:

Table 1B

Summary of Analysis of Variance

SOURCE	DF	SS	MS	F
ROWS (TGT.)	2	0.1249	0.0624	0.3146
COLS (WPN.)	2	12.2589	6.1294	30.8792
RXC	4	0.3882	0.0970	0.4889
ERROR	153	30.3701	0.1985	
TOTAL	161	43.1421		

4. It is concluded that the $\underline{F}$ value of 30.879, with df equal to 2 and 2, is significant beyond the 5 percent (.05) level. The statistical test used to determine significant differences between weapons was:

The Tukey-A (Honestly Significant Difference) Procedure for a Posteriori Testing of Ordered Means.

The representative symbols chosen for the factors were:

Ordered Means

C = 1.7328	Revolver
A = 2.2594	Auto. Empty
B = 2.3602	Auto. Loaded

TABLE 2B

Table of 0.95-Level Significant Differences

	C	A	B
C		****	
A			

The results indicate that weapon C has a 95-percent probability of being significantly different from weapon A or B.

TABLE 3B

Summary of Results of the Tukey-A Procedure: 0.95 Level

Mean-Square Error Term	= 0.1985
Studentized Range Statistic From Table	= 3.35
Computed Critical Value	= 0.35
Subjects per Group	= 18
Degrees of Freedom	=153

The statistical test was used again with the same data to determine significant differences between weapons at another significant level:

The representative symbols chosen for the factors were

Ordered Means

A = 2.2594	Auto. Empty
B = 2.3602	Auto. Loaded
C = 1.7328	Revolver

TABLE 4B

Table of 0.99-Level
Significant Differences

	C	A	B
C		****	
A			

The results indicate that weapon C has a 99-percent probability of being significantly different from weapon A or B.

TABLE 5B

Summary of Results of the
Tukey-A Procedure: 0.99 Level

Mean Square Error Term	= 0.1985
Studentized Range Statistic From Table	= 4.18
Computed Critical Value	= 0.44
Subjects per Group	= 18
Degrees of Freedom	= 153

APPENDIX C

A TASK ANALYSIS OF DRAWING AND FIRING PERSONAL-DEFENSE WEAPONS

Weapon No. 1: The S detects the target, starts to reach for holstered weapon, unfastening the flap and gripping the weapon with his right hand-the left hand is located above and in front of the drawn weapon as it starts forward to be aimed. The left hand is folded over the slide, forcing it rearward as the right hand continues its forward motion along with the receiver and grip. The instant the slide has completed its rearward travel, the left hand is quickly raised clear of the continuing forward thrust of the right hand/weapon combination. When the right arm is near full extension, the left hand is supposed to cup under the base of the grip and over the lower parts of the right hand to steady the right hand/weapon/arm combination for aiming prior to firing. Some of the Ss were firing before this was fully completed.

Weapon No. 2: Initially, the process is the same, except the left hand has only to cock the hammer, instead of forcing the slide back. It was attempted with the right hand by some Ss, but with even slower results. These abortive attempts were considered an error, and the data point a flier. It was previously though the prechambered-round condition would be the faster semiautomatic condition.

Weapon No. 3: The S begins in the same manner, with the right hand unfastening the strap; however, the basic revolver grip is displaced in a curving fashion, further away from the frame than a semiautomatic. Consequently, the protruding grip is seldom covered with a full flap, as is the case of the service holster for the M1911A1. Therefore the right hand can readily grasp revolver's unobstructed grip. This reduces the time to place the weapon into action somewhat, but not significantly. A major reduction is realized by the double-action lockwork, which requires only a trigger pull to fire (Figure 9). This results in a faster time to fire, but the greater trigger-pull force required for a double-action weapon demands increased muscle activity and may degrade accuracy.

APPENDIX D

CORRELATION OF MEAN TIME TO FIRE FOR ALL WEAPONS AND THE ANTHROPOMETRIC MEASURE OF THE Ss' INSIDE GRIP DIAMETER

Generally, the correlations, if any, between man's physical dimensions and his abilities are not considered in equipment design (11).

The coefficient of correlation was determined in order to investigate the need, if any, for changing equipment design to improve performance.

TABLE 1D

Coefficient of Correlation

	Mean	S.D.	Variance
X	2.14556	.168391	2.83556E-2
Y	2.00467	.504743	.254766

Coefficient of correlation (R) = .230136
Coefficient of determination (R^2) = 5.29624E-2
Coefficient of nondetermination (K^2) = .947038

TABLE 2D

Listing of Mean Time to Fire for all Weapons and the Anthropometric Measure of the S's Inside Grip Diameter

Inside Grip S	Diameter	Time to Fire
1	2.16	2.068
2	2.14	1.844
3	1.95	2.088
4	2.07	2.040
5	2.05	1.714
6	2.29	2.451
7	2.05	1.957
8	2.04	2.414
9	2.28	1.743
10	2.01	2.374
11	1.93	2.259
12	2.03	2.404
13	2.34	1.690
14	1.96	2.005
15	2.42	2.197
16	2.09	2.489
17	2.35	2.183
18	2.46	2.164