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Technical Note 7-63

A COMPARISON OF TELESCOPIC-SIGHT ACCURACY AS A FUNCTION OF MAGNIFICATION AND TIME TO FIRE

R. Bradley Randall
William J. Faccidomo

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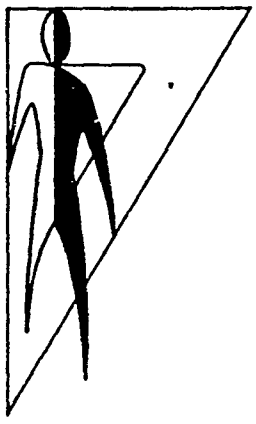
HUMAN ENGINEERING LABORATORIES



ABERDEEN PROVING GROUND,
MARYLAND

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ABSTRACT

This investigation was designed to compare the accuracy of rifles equipped with telescopic sights of high (6x, 8x) and low (2.5x, 4x) powers of magnification, when targets were presented for both short (2 seconds) and long (8 seconds) time intervals.

Twelve enlisted subjects fired a Kodiak .22 caliber magnum semiautomatic rifle equipped with a Bausch & Lomb "BALvar-8" telescopic sight.

When the measurements of marksmanship were analyzed, no significant differences were found between the various powers of magnification. Time-to-fire was a source of significant variation, with accuracy superior at the longer time interval.

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A COMPARISON OF TELESCOPIC-SIGHT ACCURACY AS A FUNCTION OF MAGNIFICATION AND TIME TO FIRE

INTRODUCTION

Modern warfare, with its increasing use of high-accuracy firearms, intensifies the need for sighting devices which reduce operator error.

A rifle locked in a machine rest will produce a shot group of a certain size about the center of impact. This dispersion is caused by many factors, some of which are inherent characteristics of the rifle; others are caused by round-to-round variations of the ammunition and ambient conditions.

Optimally, the sighting device will hold operator error to narrow limits within the normal dispersion characteristics of the rifle and its ammunition.

The telescopic sight is one of the most sophisticated devices for sighting hand-held weapons. Although it is relatively delicate, once it is sighted-in and focused for the individual user, the telescopic sight has many advantages over conventional iron sights. There is no confusion as to what constitutes a proper sight picture, and because of the target-image magnification, the user has, in effect, a much larger (or apparently closer) target to fire upon.

Because telescopic sights have many promising features, their potential military uses deserve investigation.

PURPOSE

This study's purpose is to compare the accuracy of rifles equipped with telescopic sights of variable magnification, when targets are presented for short and long time intervals.

Fig. 1. KODIAK RIFLE WITH BAUSCH & LOMB "BALvar-8" TELESCOPIC SIGHT AND ADJUSTABLE MOUNT

METHOD

Subjects

Twelve enlisted men assigned to the U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground (APG), Md., served as subjects (Ss). All Ss had fired the M-1 rifle and the M-1 carbine during military service and were generally familiar with firearms. Three of the 12 Ss held positions on the APG small-bore rifle team.

Apparatus

A Kodiak .22 caliber magnum semiautomatic rifle was equipped with a locally fabricated adaptor for a Bausch & Lomb "BALvar-8" telescopic sight and its mount (Fig. 1). The sight was continuously variable for magnification of 2.5x to 8x, with intermediate positions for 4x and 6x magnification.

All firing was conducted outdoors from a range of 25 yards. The target consisted of a 1/4" bull's-eye surrounded by three concentric circles of 7/8", 2 5/8", and 4 3/8" outside diameter. The two outer rings were 7/16" in width, the innermost 3/16"; all were painted flat black on heavy brown paper (Fig. 2).

Scoring

The measure of marksmanship used was the size of the mean radius of the shot group, in inches; i.e., the smaller the radius of the shot group, the finer the accuracy. The mean-radius method of scoring gives a measure of dispersion as well as of accuracy. For a more detailed explanation of the scoring procedure, see Karp (1).

Procedure

Before each scored run, each S was allowed to fire as many practice rounds as necessary to acquaint himself with the time interval and magnification to be tested. After practice, each S fired a total of 40 rounds for scoring purposes. Five rounds were fired in each of eight conditions: four powers of magnification (2.5x, 4x, 6x, and 8x) and two target-presentation durations (two and eight seconds). The target-presentation duration represented the time available to fire. The orders of magnification and time-to-fire were randomly established.

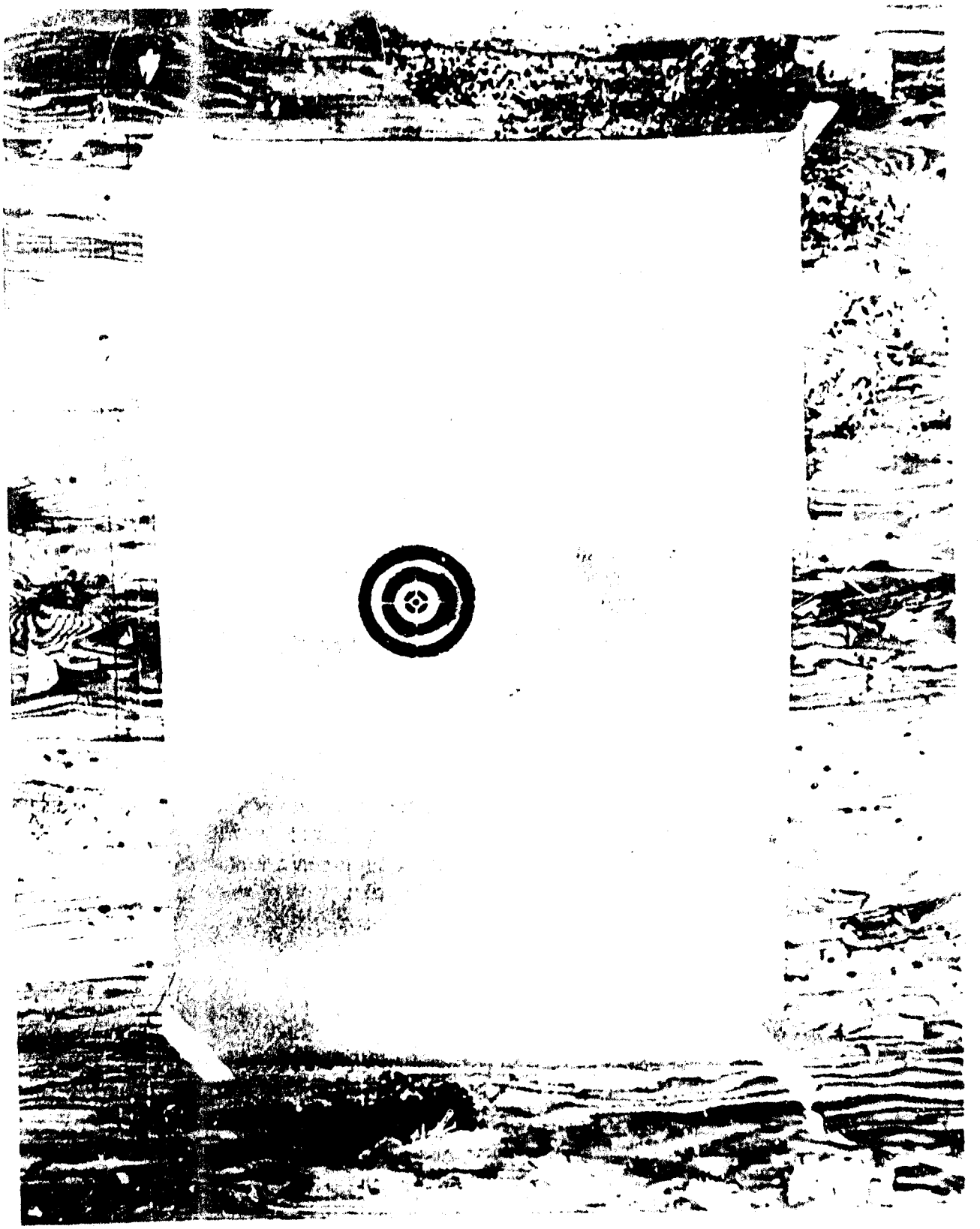

Fig. 2. TARGET MOUNTED ON VERTICAL SUPPORT

At the sound of a buzzer, the S was required to bring the rifle from a port-arms attitude to the off-hand firing position, acquire the target, and squeeze off one aimed shot before a second buzzer indicated the end of the firing period. The S would then lower the rifle to the port-arms position and wait for the next trial. In the event the S had difficulty acquiring the target (e.g., under conditions of 8x magnification at two seconds, when acquisition was most difficult) and fired hastily only to get the shot off, he was given another trial to ensure that only well-aimed shots were fired for scoring (Fig. 3, 4, and 5).

RESULTS AND DISCUSSION

Since the experimenters were primarily interested in dispersion patterns rather than point value scores, the arithmetic mean center of a shot group was calculated to be its center of impact.

Table 1 presents the scores for time-to-fire intervals and powers of magnification across all 12 subjects.

TABLE 1

Mean Shot Group Size in Inches for all Subjects (N = 12)

Time	2 Seconds				8 Seconds			
Magnifications	2.5x	4x	6x	8x	2.5x	4x	6x	8x
Mean	2.66	2.36	2.75	3.45	1.53	1.38	1.76	1.52
SD	1.20	.79	1.16	.94	.84	.52	.81	.88

Fig. 3. SUBJECT IN "READY" POSITION

Fig. 4. SUBJECT IN FIRING POSITION

Fig. 5. SUBJECT FIRING ON 25-YARD RANGE

Figure 6 illustrates the interaction between time to fire and power of magnification. It was expected that performance would be poor under conditions of high magnification (8x) and short time interval (2 seconds). This assumption was proved correct. Most of the two-second interval was spent acquiring the target. The high power of magnification tended to exaggerate any movement due to tremor or poor breath control, and the S had difficulty holding on the target. The time interval was rather short, so to stay within the time limits the S had to "snap off" the shot, still somewhat uncertain of his aim. The Ss had difficulty locating the bull's-eye, apparently because of the small field of view of the sight.

It was further expected that at long time intervals (8 seconds) with high powers of magnification (8x), performance would be superior to that using lower powers of magnification. This expectation was not fully confirmed. Figure 6 shows the greatest difference in size of shot groups as a function of target-presentation duration.

An analysis of variance was performed on the data with shot-group size as a measure of marksmanship. The results appear in Table 2.

TABLE 2

Summary of Analysis of Variance

Source	df	Sum of Squares	Mean Squares	F
Time	1	38.00	38.00	90.48*
Magnification	3	1.17	.39	-
Subjects	11	39.83	3.62	-
Time x Magnification	3	7.41	2.47	82.33*
Time x Subjects	11	4.61	.42	14.00*
Magnification x Subjects	33	26.17	.79	26.33*
Time x Magnification x Subjects	33	1.09	.03	-
TOTAL	95	116.28		

* Significant at .01 level.

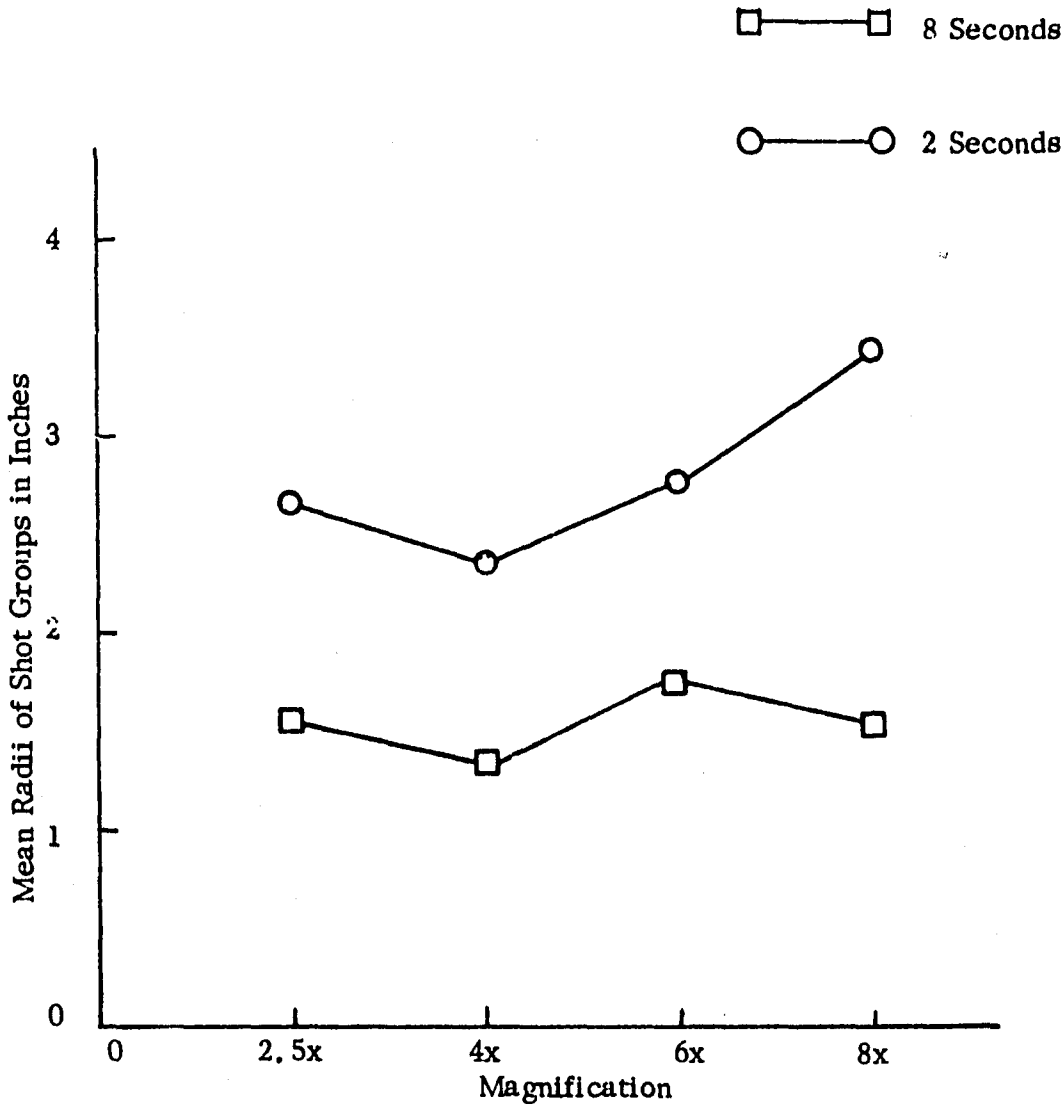

Fig. 6. MEAN SHOT GROUP SIZE AS A FUNCTION OF MAGNIFICATION AND TIME TO FIRE

It can be seen that the F for powers of magnification was not significant. The F value for time-to-fire intervals (two and eight seconds) was significant at the .01 level. The F values for the interactions -- time x magnification, time x subjects, and magnification x subjects -- were significant at the .01 level.

It is possible that the F values obtained for the interactions time x subjects and magnification x subjects derived from individual differences among the Ss tested. The ability of the Ss ranged from an apparent low value -- according to military marksmanship ratings -- to a proved high value (as evidenced by positions on the small-bore rifle team), so large differences were to be expected.

The 4x power of magnification gave the best results in terms of shot-group size at both time intervals (Fig. 6), but it has been noted that the F value for powers of magnification was not significant. It is possible that the comparatively short range (25 yards) was responsible in part for obscuring any differences attributed to magnification. Another possible factor was the rather large target used.

SUMMARY

This investigation was undertaken to compare the accuracy of rifles equipped with telescopic sights of high (6x, 8x) and low (2.5x, 4x) powers of magnification, when targets were presented for both short (2 seconds) and long (8 seconds) time intervals.

Each of the 12 Ss fired five rounds at each of eight sight-target conditions from a Kodiak .22 caliber magnum semiautomatic rifle equipped with a Bausch & Lomb "BALvar-8" telescopic sight and adjustable mount. The sight was adjustable to powers of 2.5x, 4x, 6x, and 8x magnification. The Ss fired single shots during each of the two time intervals at all four powers of magnification.

When the measurements of marksmanship were analyzed, no significant differences were found between the various powers of magnification. Time-to-fire was a source of significant variance, with accuracy superior at the longer time interval.

RECOMMENDATIONS

1. Significant differences were found between the two time-to-fire intervals. An investigation should be made of accuracy of firing at time intervals with a maximum spread of four seconds, e.g., 2 and 4, 2 and 6, 4 and 6, 4 and 8, and 6 and 8 seconds.

2. The effect of a unity-powered sight should be tested, to determine if an advantage might be realized by using a telescopic sight without the introduction of target-image magnification.

3. The effect of using a smaller-diameter bull's-eye, or greater firing distances, should be investigated. At greater distances, any differences among various powers of magnification might become more readily apparent.

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