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AUTHORITY

Human Resources Research Office ltr dtd 1 Mar 1966 [66-10] via Department of the Army

HUMAN RESEARCH UNIT NR 1
Continental Army Command
Fort Knox, Kentucky

The Effect of Flinching on M1 Rifle Marksmanship

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Staff Memorandum, March 1955
Reprinted May 1956

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BRIEF

This report summarizes two preliminary studies on the effect of flinching on marksmanship. The chief purpose of the first study was to determine whether or not the judgments of experts will serve as reliable measures of flinching; the second study was an attempt to find out the extent to which flinching affects marksmanship scores.

In both studies, flinching was rated by judges while the trainees were firing a series of live rounds interspersed with dummy rounds. The judgments of flinching were made only on dummy rounds. Marksmanship data were obtained from the live round firing, and the second study provided further marksmanship data from instructional and record known distance firing. The known distance targets were pit scored; the experimental targets were scored by a template centered on the shot group.

Interpretation of the results of both studies indicates that expert judgments will measure flinching reliably, and that flinching significantly affects marksmanship. In fact, the data suggest that about 38 per cent of the variation in trainee marksmanship scores is due to flinching. Hence the problem appears to be serious enough to show a need for research into possible methods of reducing flinch. (See page 11.)

PREFACE

The studies on the problem of flinching reported here were conducted under the general authorization given to the Human Research Units by Office, Chief of Army Field Forces, to do preliminary research on problems of possible value to the Army. The purpose of the two studies was to determine whether or not the effect of flinching on marksmanship is large enough to justify further research. The first study was conducted in May 1953; the second in March 1954. Both studies were conducted at Fort Knox, Kentucky with the cooperation of the 3d Armored Division.

In reading this report of the two studies, Table 1 may be used as a guide.

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The Effect of Flinching on M1 Rifle Marksmanship

THE FIRST STUDY

Statement of the Problem:

To determine whether or not one performance has an effect on another, it is necessary to use reliable measures of both. A reliable measure is one which can be expected to give essentially the same answer for repeated measurements of the same thing. For example, if a trainee consistently makes about the same score in known distance firing, his known distance score is a reliable measure of his firing performance. A reliable measure of marksmanship performance is readily available from target scores. (See Appendix B.) But in order to compare flinching with marksmanship performance, it is also necessary to find a reliable measure of flinching.

Hence the first study was designed primarily to test the reliability of human judgments of flinching. Human judgments have been the traditional means by which to diagnose flinching in firing shoulder weapons. If it is shown that a group of judges agree (that is, "give the same answer") in rating the degree of flinching exhibited by a number of firers, then it may be concluded that human judgments are a reliable or consistent measure of flinch. The study was also designed to yield preliminary information on the relationship of flinching to marksmanship, although it was planned to study this topic more thoroughly in future experiments.

Approach to the Problem:

Trainees and Firing Instructions. Twenty-five men were arbitrarily chosen from a basic training company before their 1000-inch instructional firing. These trainees had received twenty hours of preliminary rifle instruction, but had done no previous live firing during their Army training. It was assumed that they would become aware that their flinch behavior was

being observed, but that diverting their attention from this fact by emphasizing accuracy of marksmanship would probably increase the reliability of their flinch behavior and marksmanship performance. Therefore they were told that in this test their reactions to firing at certain types of targets would be observed. They were encouraged to try to shoot as accurately as possible and were assured that they would be able to inspect their targets after each series of rounds.

Firing and Scoring Procedure. The trainees fired on the 1000-inch rifle range, from the standing position, using the hasty sling. Two M1 rifles were used; they were thoroughly inspected and gauged, their worn parts were replaced, and they were zeroed by experienced firers. Two visibly different head-and-shoulders silhouette targets, one foot square, were used. On one, the bottom of the silhouette measured 1.8 inches; on the other, 3.6 inches. Six different sequences of live and dummy rounds (seven live rounds and three dummy rounds in each sequence) were used. Each firer fired one sequence of rounds at each target, a different sequence for each. Each sequence was observed by a pair of judges.

The two targets for each trainee were scored with a transparent plastic template. Hits on the target were appropriately valued at from eight points to zero as they fell within eight concentric circles, which were inscribed on the template and which increased from half an inch to four inches in radius. The template was centered on the target in such a way as to yield a maximum score for the group of hits on that target, as shown in Figure 1. This scoring method reduced the trainee's constant error, which is normally reduced by zeroing.

Judgments of Flinching. Judgments of flinching in this study were made only on dummy rounds; for experienced riflemen agree that flinching is

SCORING PROCEDURE
(First Study)

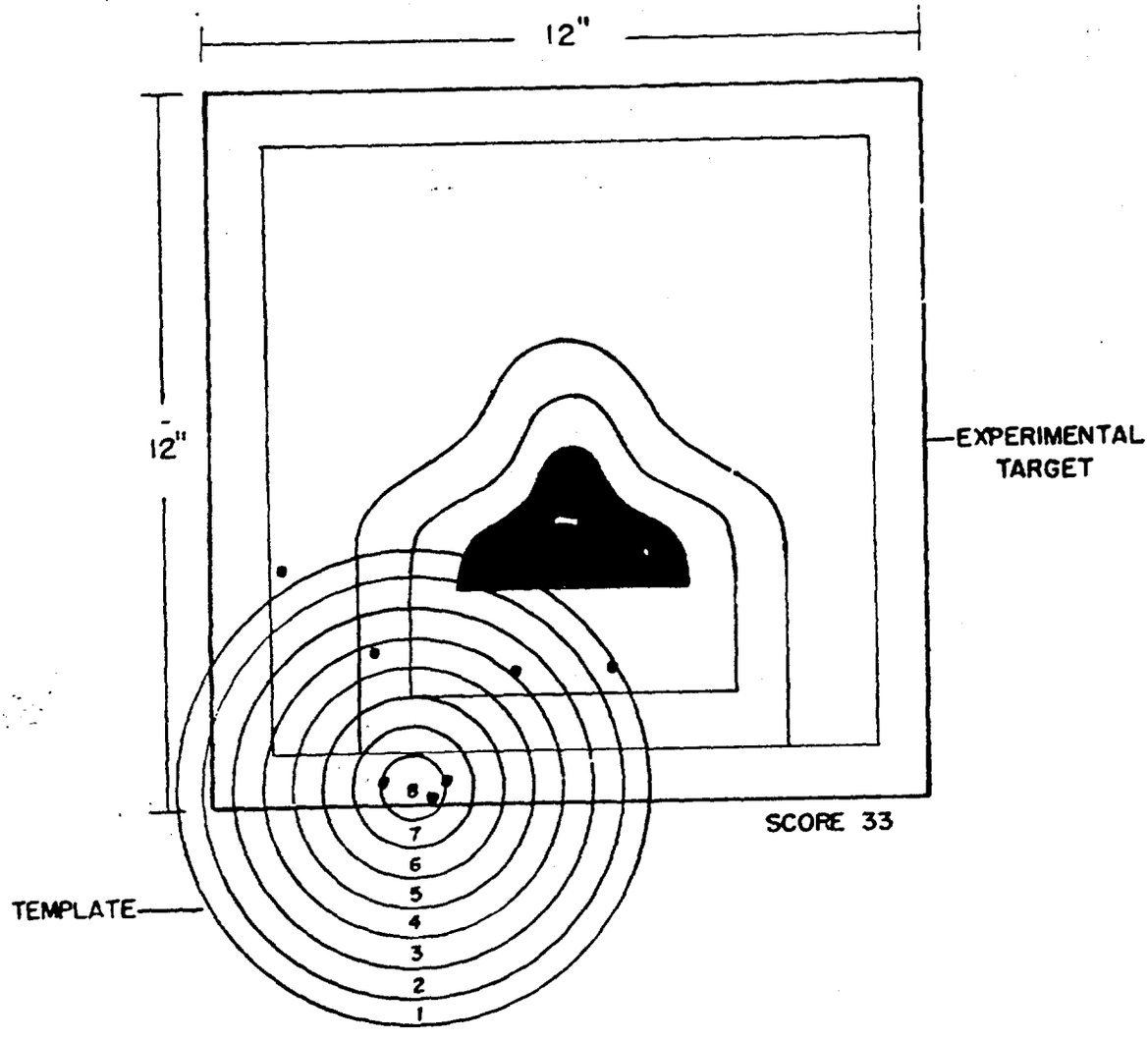

Figure 1

most easily observed when the firer pulls the trigger on an empty cartridge. Four experienced M1 rifle instructors were used as judges. Flinch behavior was rated according to five categories--from "not noticeable" to "very pronounced."[1] Although the pair of judges at each firing point made simultaneous judgments of flinch behavior, all were directed to maintain independence in their ratings throughout the study.

Results:

The results of the first study were interpreted to show that expert judgments may be used as a reliable measure of flinching. The six ratings of each trainee's flinch behavior made by the first pair of judges were added and the six made by the second pair likewise added. Statistical procedures were then used to compute the relationship between the two totals for each trainee. A correlation coefficient of 0.00 would have shown no reliability at all; a coefficient of 1.00 would have shown the judges to be in complete agreement for each trainee. The coefficient obtained was .84; hence the reliability of expert judgments appears to be high enough to warrant their use as a reliable measure of flinching.

The data for the study also suggest a strong relationship between flinching and marksmanship. The correlation coefficient between the total flinch ratings for each trainee and the total marksmanship scores for each trainee was -.48 (the negative sign indicating that low flinchers tend to be good marksmen, and vice versa).

The statistical basis for these statements is shown in Appendix A.

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[1] See Appendix D.

The Second Study

Statement of the Problem:

The primary purpose of this study was to investigate the effect of flinching on marksmanship. It was also designed to obtain further information on the reliability of expert judgments as a measure of flinch behavior.

Approach to the Problem:

The Experimental Plan. The over-all plan of this study provided for four days of firing, as outlined in Table 1. The first and last days' firing (eight days apart), referred to here as the Flinch Test and the Flinch Retest, were conducted especially for the purpose of this study. The intervening two days of firing were the conventional known distance instructional and record firing. Judgments of flinching were made only on the Flinch Test and the Flinch Retest, but marksmanship scores were taken on all four firing days.

Table 1
Condensed Description of the Studies

The First Study (25 trainees)

12 judgments of flinching; 4 judges	14 rounds fired; scored by template	two silhouette targets at 1000-inch range

Chronological Chart of the Second Study (68 Trainees)

Flinch Test (Tuesday)	16 judgments of flinching;	24 rounds fired; scored by template	four targets--circle, plus sign, diamond, square--at 100 yards
Known Distance Instructional Firing (Friday)	no flinch judgments	66 rounds fired; pit scored	standard known distance targets
Known Distance Record Firing (Saturday)	no flinch judgments	50 rounds fired; pit scored	standard known distance targets
Flinch Retest (Wednesday)	16 judgments of flinching; 8 judges	24 rounds fired; scored by template	four targets--circle, plus sign, diamond, square--at 100 yards

Trainees and Firing Instructions. Sixty-eight men were arbitrarily chosen from a basic combat training company before their 1000-inch instruc-

tional firing.[2] These trainees had received 36 hours of preliminary rifle instruction, but had done no previous live firing during their training. They were told that during the test their reactions to firing at certain types of targets would be observed, and that therefore they should try to shoot as accurately as possible. Although it was inconvenient in these tests to allow the trainees to examine their targets after a series of rounds (as the trainees of the first study were allowed to do), they were assured that their scores would be posted on the company bulletin board as soon as possible after the test.

Firing and Scoring Procedure. In the Flinch Test and the Flinch Retest, the trainees fired from the 100-yard line of a known distance range in the standing position, using the hasty sling. Six M1 rifles were used; they had been thoroughly inspected and gauged, their worn parts had been replaced, and they had been zeroed by experienced firers. Four visibly different targets were used. One contained a conventional bullseye only, ten inches in diameter. The symbols used as bullseyes on the other targets--a plus sign, a square, a diamond--were of similar apparent size. Each type of bullseye was stenciled in black on heavy cardboard targets six feet square. Ten different sequences of live and dummy rounds (six live rounds and two dummy rounds in each sequence) were used. Instead of being loaded singly as for the first study, these rounds were prepared in standard eight-round clips. Each firer fired one sequence of live and dummy rounds at each target, a different sequence for each. The four targets for each trainee were scored, as they were in the first study, by using a trans-

[2]In this study the trainees did not fire the 1000-inch instructional course (50 rounds). Instead, they fired 24 rounds for the Flinch Test and 24 rounds for the Flinch Retest. The study was conducted without interfering with their training schedule 1) by giving them the Flinch Test when the rest of the company was firing the 1000-inch instructional course, and 2 by giving them the Flinch Retest concurrently with their transition firing.

parent plastic template. Here, however, the hits on the target were appropriately valued at from nine points to zero as they fell within nine concentric circles, which were inscribed on the template and which increased from two to eighteen inches in radius. The template was placed on the target with its center at the apparent midpoint of the three shots forming the smallest triangle or "shot group,"[3] as shown in Figure 2.

The regularly-scheduled instructional and record known distance firing, which intervened between the Flinch Test and the Flinch Retest, furnished additional marksmanship data for the study. To score as accurately as possible, Unit personnel took data directly from the targets. Firing was conducted in the usual manner, except that line coaching by cadre was limited to enforcing safety precautions, giving assistance in zeroing, and reducing stoppages; the "coach and pupil" method was not used in instructional firing.

Judgments of Flinching. In the second study, judgments of flinch behavior were made only during the Flinch Test and the Flinch Retest, and, as in the first study, only on dummy rounds.[4] For the specific purposes of the study, all the judges had several hours of informal individual training in making flinch judgments under the supervision of weapons training personnel. Each judge was directed to develop his own individual method of diagnosing flinching and to continue his own training until he was satisfied that he

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[3]The problem of placing the template on the target in such a position as to yield an estimate of the highest possible score for that target was simplified during this study. It was found that placing the template in the apparent center of the three shots which formed the "tightest shot group" yielded a score equivalent to that obtained by the method used in the first study. The correlation between the scores obtained by the two methods, using the 50 targets of the first study, was .98. (A correlation of 1.00 would mean that the methods give identical results.)

[4]The judges were one staff member of the Unit, and seven enlisted personnel assigned to the Unit as research assistants. The enlisted personnel had received M1 rifle instruction in their own Army basic training within the previous nine months; the staff member had received no formal rifle instruction since his Army service in World War II.

SCORING PROCEDURE
(Second Study)

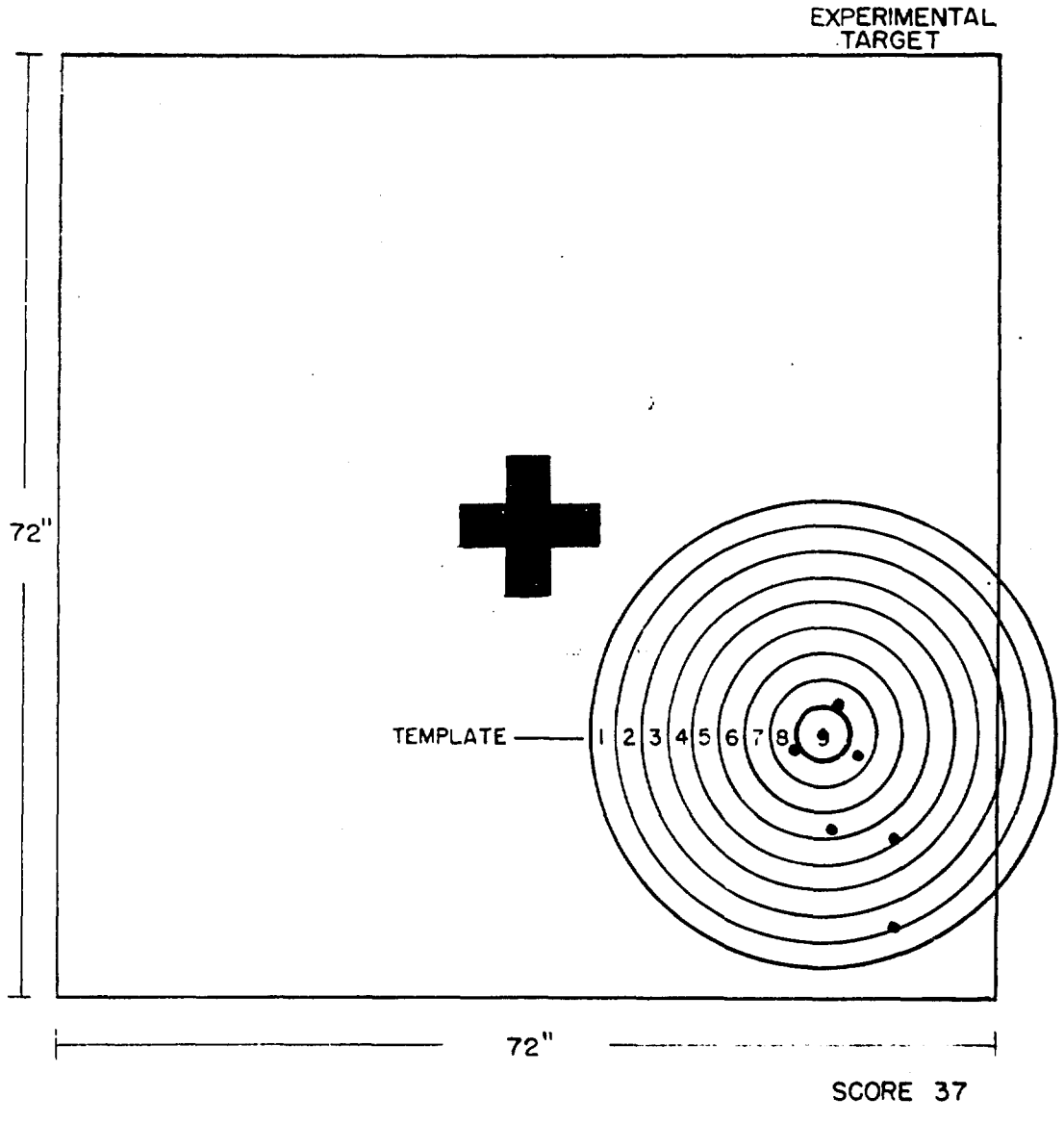

Figure 2

could distinguish degrees of flinching. Flinch behavior was rated according to five categories,[5] as in the first study, and again all judges were directed to maintain independence in their ratings throughout the study. The eight judges observed flinching in pairs during both tests.

Results:

A low relationship (-.06, statistically insignificant) was found between flinching and marksmanship for the Flinch Test. A higher relationship (-.46, statistically significant) was found between flinching and marksmanship on the Flinch Retest. Similarly, the relationships between the flinch ratings of the Flinch Test and the known distance marksmanship scores were low (instructional, -.17; record, -.18); whereas the relationships between the Flinch Retest ratings and the known distance scores were relatively high (instructional, -.37; record, -.40).

The reliability of the flinch judgments appeared to be practically the same for the Flinch Test (.78) and the Flinch Retest (.77), and sufficiently high for each test to serve as a measure of flinching.

The statistical bases for these statements is shown in Appendix B.

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[5]See Appendix D.

Discussion

Interpretation of the Results of Both Studies:

The four experienced rifle instructors who acted as judges in the first study gave somewhat more reliable judgments of flinching (r=.84) than did the eight relatively inexperienced men who acted as judges in the second study (r=.78; .77). In both studies, the trainees were observed before their first Army firing. Yet the correlation between flinching and marksmanship found in the first study (-.48) was higher than the same correlation for the Flinch Test of the second study (-.06). Whether or not the lack of experience of the judges of the second study may account for this difference,[6] the correlation between their ratings and the marksmanship scores of the Flinch Retest was high. The fact that the judgments of the Flinch Retest also correlated significantly with the marksmanship scores for instructional and record firing leads to this interpretation of the results of the studies: Flinching has a significantly harmful effect on marksmanship. In fact, statistical analysis suggets that as much as 38 per cent of the variation in trainee marksmanship scores is due to flinching, as the data in Appendix C show. An effect as large as this is assuredly serious.

The Present Status of the Problem of Flinching:

These two studies show that a serious problem exists. The question is: What can be done? Army rifle instructors, who have long been aware of

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[6]Possibly the discrepancy between these two correlations may have another explanation: Firing for the first study was done 1000 inches (about 28 yards) from the target; firing for the Flinch Test and the Flinch Retest of the second study was done 100 yards from the target. A rough estimate of a trainee's marksmanship could therefore be made (during the first study only) by observing his target from the firing line. If this information influenced flinch judgments (though the judges were cautioned on this point), the correlation for the first study is misleadingly high. (If the correlation obtained in the Flinch Test of the second study were shown by future research to be the more valid correlation, then comparing it to the significant correlation found in the Flinch Retest would suggest that the flinch response becomes stronger with continued firing.)

flinching as a problem, have accepted the idea of a gradual trigger squeeze as an antidote. Yet all the trainees of this study, on whose marksmanship scores flinching appears to have exerted a large effect, received standard training on trigger squeeze in their preliminary marksmanship training.[7] Furthermore, the experimental evaluation of a special trigger squeeze exercise developed at Fort Dix, New Jersey showed that increased emphasis on trigger squeeze did not raise marksmanship scores.[8]

What Is Flinch? Probably one reason why attempts to reduce flinching have been ineffective is that the problem has not yet been clearly defined. Flinching, as measured during these experiments, was that which in the opinion of judges constituted flinching. Although these judgments were shown to be reliable, and although on the basis of these judgments a significant relationship was found to exist between flinching and marksmanship, the exact nature of flinch is no better understood. The fact that rifle instructors prefer to judge flinching when dummy rounds (instead of live rounds) are used is good evidence that much of the behavior on which their judgment is based is behavior which has taken place after the hammer has been tripped. One ordnance expert states that barrel movement from the instant of detonation until the round has reached the muzzle of the weapon has a neglibile effect on accuracy. Movement of the weapon after the round has left the

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[7] An interesting comment on trigger squeeze training may be found in an unpublished article by Lt. Col. Edward E. Cruise, The Armored School, Fort Knox, Kentucky, "What's Wrong with Our Marksmanship?": "Field Manual 23-5 very correctly states, 'Your attention must be divorced from the trigger finger. This finger works automatically when you are well trained. Then you can concentrate all your attention on the correct sight picture.' But throughout preliminary marksmanship we exhort men to 'Squeeze, squeeze, squeeze.' Inevitably attention is diverted to the trigger, men become tense as a sprinter waiting for the starter's gun, and involuntarily flinch."

[8] W. H. Denenberg and F. J. McGuigan, Evaluation of a Special Live-Firing Trigger-Squeeze Exercise, Technical Report 6 (Washington: Human Resources Research Office, May 1954).

muzzle is of course irrelevant. Thus it appears impressive that judgments made largely on the basis of post-firing behavior can have any reliable relationship to marksmanship, since only anticipatory movements (those made before tripping the hammer) change the orientation of the rifle barrel and thus the trajectory of the bullet.[9] The flinch may be defined as some movement on the part of the firer which upsets the alignment of the rifle on the target before the hammer falls.

What Causes Flinching? One guess might be that flinching is due to a fear felt by the trainee. Thus the extent to which he regards the weapon with dread, associates it with unpleasantness, or has been frightened by a similar instrument in the past, would tend to make him a flincher. Though this opinion may contain some truth, another seems to be more appropriate. The common response to loud noises, such as the report of the M1 rifle, is called the startle response. C. T. Morgan states:[10]

> ...the startle pattern...consists of closing the eyes, head movement, raising and bringing forward of the shoulders, abduction of the upper arms, bending of the elbows, pronation of the lower arms, clenching of the fists, forward movement of the trunk, contraction of the abdomen, and bending at the knees. This pattern appears at about four months of age and continues without significant modification into adulthood.

But how can a response that one makes after a loud noise affect his marksmanship? J. Dollard and N. E. Miller[11] describe the process by which this response comes to be made before the loud noise occurs:

> A rifleman pulls the trigger of his gun and then hears a loud report which elicits blinking of the eyes and a startle response

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[9] It is plausible, though, that firers whose after-firing movements are most marked are also those who are most apt to make movements before they fire; hence it is also plausible that observing after-firing movements, which are more easily detected, is an indirect way of getting information about before-firing movements.

[10] Physiological Psychology (New York: McGraw-Hill, 1943), page 367.

[11] Personality and Psychotherapy (New York: McGraw-Hill, 1950), page 58.

> by the whole body...On subsequent occasions, the cues involved in pressing the trigger tend to elicit the blinking and the startle. These aticipatory responses are likely to occur before the gun is actually fired and to cause the bullet to swerve from its mark.

If the anticipatory startle response to the loud noise of the weapon is the primary basis of flinch behavior, it is probable that such a strong, relatively innate reaction is more or less independent of such acquired distastes as "weapon-fear."[12]

Possible Lines of Future Research:

In view of this discussion, an experimental attack on the problem of flinching might best proceed as follows:

1. Define the flinch. High speed photography of actual firing may serve to yield an objective measure of flinching.

2. Assess the causes of flinching. Determine how much the noise of the weapon, the kick of the weapon, and previous fear of the weapon influence the flinch.

3. Institute "curative" measures. A number of methods for "unlearning" an undesirable response are available for application to the problem.

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[12]After the second study, a test designed to measure anxiety was administered to the subjects. See ANSCALE, Development of an Anxiety Scale for Use in Army Training Research, Task No. 53/1.5, Training Methods Division, HumRRO. It is interesting to note that although anxiety, as measured by this test, is significantly related to marksmanship scores, it showed no significant relationship to the ratings of flinch.

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3. McGuigan, F. J., and E. F. MacCaslin. A Comparison of the Whole and Part Methods of Marksmanship Training. Staff Memorandum. Fort Knox: Human Research Unit Nr 1, May 1954.
4. Morgan, C. T. Physiological Psychology. New York: McGraw-Hill, 1943.

APPENDIX A: THE RESULTS OF THE FIRST STUDY

Reliability of Expert Judgments:

The ratings given by the first pair of judges were totaled; so were those given by the second pair of judges; the two totals were then correlated. The coefficient was adjusted, using the Spearman-Brown estimate with n=2, to represent the reliability shown by the ratings of all four judges, to yield a coefficient of .84.

Relationship Between Flinching and Marksmanship:

Each of the 25 trainees fired fourteen rounds at the targets and was rated twelve times on his flinch behavior. The reliability of the flinch judgments, given above, was .84. The reliability of the marksmanship scores,[13] estimated by correlating the template scores for the two sequences of shots, was found to be .74.

The correlation coefficient between the summed flinch ratings and the summed marksmanship scores was estimated at -.48, significant at the five per cent level of statistical significance.[14]

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[13]"Reliability of the marksmanship scores" does not refer to accuracy of scoring. The accuracy of this scoring is in little doubt, since two scorers checked each score independently. The reliability in question here is the reliability of the marksmanship performance of the trainee. The question is: Will the same group of marksmen be ranked in a similar order in two measurements of their marksmanship performance?

[14]The higher the estimated relationship, and the larger the sets of observations on which it is based, the greater may be the confidence that the estimated relationship approximates the true relationship. Here, the level of statistical significance means that the odds are about twenty to one against finding a coefficient of this size if, in fact, no relationship exist

APPENDIX B: THE RESULTS OF THE SECOND STUDY

The reliability of flinch judgments was found to be .78 for the Flinch Test, .77 for the Flinch Retest. The reliability of the marksmanship scores was estimated to be .76 for the Flinch Test and .72 for the Flinch Retest. (These reliability coefficients were obtained by the use of the analysis of variance to yield a measure of internal consistency, as shown in Table B 1). The reliability of the known distance marksmanship scores was not estimated in this study, but previous research[15] indicates that their reliability is about .64.

The correlation between the sum of the flinch ratings and the sum of the marksmanship scores for the Flinch Test was found to be -.06; for the Flinch Retest, -.46. The first of these is statistically nonsignificant; the second is significant beyond the one per cent level. The respective correlations between the Flinch Test ratings and the known distance instructional and record marksmanship scores were -.17 and -.18; those between the Flinch Retest ratings and the known distance scores were, respectively, -.37 and -.40. The correlations of the known distance scores with the Flinch Test are statistically nonsignificant; both of those with the Flinch Retest are significant beyond the one per cent level. Table B 2 shows all these relationships.

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[15] F. J. McGuigan and E. F. MacCaslin, A Comparison of the Whole and Part Methods of Marksmanship Training, Staff Memorandum (Fort Knox: Human Research Unit Nr 1, May 1954).

Table B 1

Reliability (Internal Consistency) of Flinch Ratings

FLINCH TEST

Source	df	SS	MS	F
Targets	3	577.43	192.48	38.50
Subjects	67	1538.37	22.96	4.59
T x S	201	1004.07	5.00	

$r = 1 - \frac{5.00}{22.96} = .78$

FLINCH RETEST

Source	df	SS	MS	F
Targets	3	319.18	106.39	17.02
Subjects	64	1763.56	27.56	4.41
T x S	192	1200.32	6.25	

$r = 1 - \frac{6.25}{27.56} = .77$

Reliability (Internal Consistency) of Marksmanship Scores

FLINCH TEST

Source	df	SS	MS	F
Targets	3	317.33	105.78	3.24
Subjects	67	9017.42	134.59	4.12
T x S	201	6563.92	32.66	

$r = 1 - \frac{32.66}{134.59} = .76$

FLINCH RETEST

Source	df	SS	MS	F
Targets	3	33.52	11.17	.45
Subjects	64	5606.50	87.60	3.51
T x S	192	4790.73	24.95	

$r = 1 - \frac{24.95}{87.60} = .72$

Table B 2

Relationships Between Flinch Ratings and Marksmanship Scores

Flinch Ratings	Marksmanship Scores			
	Flinch Test	Known Distance Firing		Flinch Retest
		Instructional	Record	
Flinch Test	-.06	-.17	-.18	
Flinch Retest		-.37[a]	-.40[a]	-.46[a]

[a]Statistically significant beyond the one per cent level

APPENDIX C: VARIATION IN MARKSMANSHIP SCORES DUE TO FLINCHING

The correlations found between flinching and marksmanship in these two studies were based on measures not perfectly reliable. It is therefore in order to estimate what relationship might have been found had measures of perfect reliability been used. Statistical analysis[16] shows that if such measures had been available, the correlation between flinching and marksmanship would probably have been as high as -.61 for the data of the first study, and -.62 for the data of the Flinch Retest of the second study. The square of the correlation coefficient is used to estimate the amount of variation in one variable attributable to variation in another. Thus if a correlation of about -.62 exists between flinching and marksmanship, and if it can be assumed that flinching causes poor marksmanship, it can be said that about 38 per cent of the variation in trainee marksmanship scores is due to flinching.

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[16] The specific analysis used was a correction for attenuation. The formula for this correction is: $r_c = \frac{r_{xy}}{\sqrt{r_{xx}\, r_{yy}}}$, where r_{xy} = the correlation between flinching and marksmanship in the Flinch Retest (-.46); r_{xx} = the reliability coefficient for the flinch ratings of the Flinch Retest (.77); and r_{yy} = the reliability coefficient for the marksmanship scores of the Flinch Retest (.72). Thus $r_c = \frac{-.46}{\sqrt{(.77)(.72)}} = -.62$.

APPENDIX D: FLINCH RATING SCALES FOR THE TWO STUDIES

Flinch Rating Scale: First Study

NAME OF JUDGE:_____ Point No.: 1 2

NAME OF TRAINEE:_____ No.___Trial: 1 2

RANDOM ORDER NO.: 1 2 3

		Rating				
		Not noticeable	Slight	Moderate or about average	Pronounced	Very pronounced
DUMMY ROUNDS	1st					
	2nd					
	3rd					

Flinch Rating scale: Second Study

_____

(Name) (SN) (Date)

_____Judge's Initials

Dummy Rounds	Flinch Ratings[a]				
	1	2	3	4	5
1st					
2nd					

[a]Flinch is rated on a five point scale with 1 representing neglibible flinch and 5 representing extreme flinch. Check appropriate numerical flinch rating for each dummy round.