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Joseph C. Hammock, et al.

George Washington University
Human Resources Research Office

October 1954

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Training Methods Division

Staff Memorandum

A STUDY OF THE EFFECTS OF MANIFEST ANXIETY AND SITUATIONAL STRESS ON M-1 RIFLE FIRING

By Joseph C. Hammock and Albert I. Prince

October 1954

The George Washington University
HUMAN RESOURCES RESEARCH OFFICE
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THE DEPARTMENT OF THE ARMY

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BRIEF

The Problem

To determine the relation of anxiety and stress to marksmanship proficiency, and the relation of anxiety to the effects of stress on marksmanship, soldiers scoring at the extremes of a scale of manifest anxiety were test fired on the M-1 rifle under "normal" and "stress" conditions. The firing procedure for normal conditions was substantially the same as in conventional record fire. The stress condition was similar but involved a series of explosions going off successively closer to the firer during firing. False instructions were given which stated that a charge directly in front of the firer's position would be detonated eventually if the firer did not make three bullseyes in the time allotted.

Experimental Procedure

The study was carried out in two phases at Fort Bragg, N. C. In Phase I the anxiety scales were administered to the Ss. In Phase II, Ss selected on the basis of anxiety scores were tested in M-1 marksmanship. Half of the subjects fired in a normal-stress sequence of conditions and half fired in the reverse sequence. All firing was completed in one day. This design contributed two additional variables, sequence of conditions and time of day, to the two original independent variables, anxiety and stress conditions.

Dependent Variables

Marksmanship proficiency was measured in terms of both accuracy of rounds fired and rate of firing. Accuracy was scored by the conventional method and by a more precise coordinate scoring method, the latter permitting the partialing of variable and constant error components of accuracy. Variable and constant errors were determined separately for the horizontal and vertical coordinates of the target. Rate of firing and other observational data were obtained through observers who recorded certain aspects of the firing behavior of each subject.

Results

The results of the experiment indicate:

1. that men with high anxiety scores are less proficient in marksmanship than men with low anxiety scores.

2. that the relative deficiency in performance of the high anxiety group results from greater constant error and more fumbling while changing clips.

3. that greater constant error for the high anxiety group occurs significantly on the horizontal coordinate of the target only.

4. that high and low anxiety groups do not react differently to the stress situation in terms of overall proficiency or any of its components.

5. that the stress conditions result generally in decreased proficiency, the sources of which are increases in vertical constant error, vertical variable error and time to fire a clip.

6. that increases in vertical variable error resulting from the stress conditions are attributable to impairment of vision produced by dust thrown up by the explosions on the range.

7. that increases in vertical constant error and time to fire a clip resulting from the stress conditions are attributable to fear of the situation or to startle responses to the explosions (tentative).

8. that vertical constant error is increased by preliminary firing under normal or stress conditions about which no knowledge of performance is gained by the subject (tentative).

9. that frequency of firing behavior rated "very nervous," (a) is greater in the high than low anxiety group, (b) is increased by the stress conditions, and (c) is attributable to fear of the situation (b and c are tentative).

End.

INTRODUCTION

A number of investigators (1, 7, and 10) have reported recently that performance on fairly complex laboratory tasks is negatively related to manifest anxiety as measured by the Taylor Manifest Anxiety Scale, or A-Scale (8,9). The primary purpose of the present study was to determine whether this relationship would hold for a complex military skill, M-1 rifle marksmanship. This skill was selected for study for two reasons: marksmanship proficiency can be measured simply and objectively as target scores and a technique was available which permitted the introduction of stress conditions into the rifle-firing situation. The use of stress conditions would not only permit measurement of the overall effects of stress, but also would yield information on whether stress and level of manifest anxiety interact to determine performance.

The technique used for introducing stress and measuring its effect was a modification of one devised by Weislogel (11). His general procedure was to have men fire M-1 rifles at silhouette targets, first under usual record firing conditions, and immediately afterwards under "stress conditions". Stress conditions involved a series of dynamite explosions on the firing range which came closer and closer to the firing line. Each man was told that a specified number of hits would cause the explosions approaching him to cease and that he could withdraw from the firing line any time he felt his safety to be threatened. While Weislogel failed to find in a preliminary study any overall effect on marksmanship performance under the stress condition, an examination of individual scores by the present writers suggested that the subjects were reacting differentially to the stress situation and that modifications in Weislogel's procedure might bring out individual, and possibly group, effects. Consequently, bullseye rather than silhouette targets were used and a more refined scale of measurement was employed. These modifications permitted first, the scaling of accuracy for some rounds that would have missed silhouette targets, and second, an analysis of accuracy into component measures. An additional modification in Weislogel's procedure was to require all Ss to remain on the firing line throughout the series of stress explosions. It appeared reasonable to assume that Ss who withdraw are the individuals most disturbed by the threatening situation and consequently, the ones whose target scores would show the most effect of the stress conditions. It was desirable, therefore, to require all Ss to stay on the line and fire in order to get a reliable estimate of accuracy and rate of fire for the individuals who would desire to withdraw. Lastly rather than have all subjects fire first under normal and then under stress conditions, the sequence of firing conditions was reversed for half of the subjects. This change was designed to remove possible confounding effects of fatigue or warm-up from the effects of the stress conditions.

PROBLEM

The problem is one of obtaining M-1 marksmanship scores under normal and stress firing conditions for subjects who score differently on the Taylor Anxiety Scale. On the basis of the previous studies using this scale, it was hypothesized that subjects with high anxiety scores would be less proficient than those with low anxiety scores. These findings have generally been interpreted in terms of Hull's (3) theoretical conceptions which assume that increases in level of anxiety are reflected in a heightened drive level (D) which, in turn, increases the excitatory strength (E) of all the potential responses in the situation. For instances in which the Es for correct responses are considerably greater than both the Es for incorrect responses and the reaction threshold (L), increased anxiety is held to be reflected in increased proficiency. If incorrect responses are stronger than correct responses, or even if correct responses are stronger but their Es are not much advanced above L, then increases in level of anxiety are expected to be associated with decreases in proficiency.

If anxiety is found to have an effect on marksmanship it would be of interest to know whether stress also is effective, and if so, whether the effects are in the same direction. Many investigators have assumed or concluded that stress, like the anxiety variable described above, has motivating effects on behavior. If this holds, the same reasoning followed in the case of anxiety would lead to a prediction of a decrement in marksmanship proficiency when stress is introduced.

Interest in the question of whether anxiety level is a determiner of reaction to conditions of stress stems both from opinions of clinical and military observers and from current behavior theory. A prevailing opinion in clinical psychology is that anxiety is the core of neuroses and that neurotics tend to break down under stress sooner than normal persons. Furthermore, many professional military observers hold the opinion that men who don't hold up in combat can be spotted in pre-combat phases as "acting sort of queer" or "being a little off". It roughly follows from these notions that men with high levels of anxiety might be expected to lose more in marksmanship proficiency under stress than will men with low levels of anxiety.

The results will also have a bearing on current behavior theory in which there is the problem of specifying the manner in which different motivational variables combine to determine response strength. If men with high and low anxiety levels react differently to stress it would imply that anxiety and stress do not combine in a simple additive fashion.

METHOD (PHASE I)

Measures of Manifest Anxiety

Two forms of the Taylor A-Scale, modified for Army use (2), were used in the present study. Both instruments are self-description pencil and paper inventories. The simpler instrument, the True-False Inventory or TF-Anscale, has the advantage of being easily understood by nearly all Army personnel because the task merely involves marking a series of statements as either true or false. However, this very simplicity of a true-false scale enables subjects who are sensitive to possible implications of their answers to bias their responses toward giving the best impression of themselves. It has been found (2) in the case of the TF-Anscale that biasing toward favorable (low) scores is a function of level of general aptitude, the higher levels showing the most bias.

The second instrument, the Personal Check list or FC-Anscale, is a forced-choice form of the A-Scale and tends to eliminate subject bias. The scale requires the respondent to perform the fairly difficult task of selecting a statement which is most or least descriptive of himself from a pair of equally favorable statements. Unfortunately, some individuals in the lower levels of verbal ability have very unreliable forced-choice scores (2) due, presumably, to an inability to comprehend the technique. To assure a reliable and valid estimate of the level of anxiety for each man, both forms of the Anscales were administered to all Ss.

Subjects

Four hundred and nine infantry soldiers from the 325th AIR, 82nd A/B Division, Fort Bragg, N. C., were assigned as subjects. This group represented almost all of the available men in two companies. Due to the exigencies of military training it was possible to test only 379 of these Ss in Phase I. Three hundred and twenty-four of the 379 Ss were qualified parachutists and 55 were not. Four Ss were dropped from the group because their test responses were not properly marked, leaving a sample of 375.

Administration of the Anscales

Ss were tested in one day in four groups of approximately one hundred each. Fifty minutes were allowed for the FC-Anscale and thirty minutes for the TF-Anscale. There was a ten-minute break between tests and a half-hour interval between testing groups. In addition to standard test instructions Ss were told that their test scores would be seen only by research workers, that their scores would not affect their military careers, and that they could feel free to give frank answers.

METHOD (PHASE II)

Selection of Subjects for Rifle Firing

The plan of the experiment called for 75 high and 75 low anxiety Ss to fire in Phase II, and it was also desired to select an additional 16 alternates for each anxiety group. To select the high and low anxiety groups a scatter diagram was made of TF-Anscale and FC-Anscale scores for all subjects. The following two criteria were then established: (1) subjects in the high or low anxiety groups should not have a score on either scale that fell beyond the cutting score for the other group, and (2) more weight should be given to the TF-Anscale in selecting high anxiety Ss but to the FC-Anscale in selecting low anxiety Ss. This differential weighting followed from the previously cited findings (2) that TF-Anscale scores are unbiased but more reliable in the high range of Anscale scores while being confounded by bias in the low range of scores. Following these criteria the low anxiety group was selected from the men falling into the lowest 29% on the FC-Anscale and lowest 67% on TF-Anscale. The high anxiety group was selected from the highest 58% and 27% on these respective scales.

Ranking of High and Low Anxiety Subjects for Level of Anxiety

For the purpose of equating manifest anxiety between experimental sub-groups that were to fire at different times, it was necessary to rank order the subjects in each of the high and low anxiety groups. The following procedure was used. The cell in the scatter diagram containing the highest scores on both tests was ranked one for the high anxiety group. The remaining cells for that group were ranked in successive order, diagonally, with the cell nearest the TF-Anscale axis receiving the lowest rank in each diagonal. Conversely, the cell containing the lowest score on both tests was ranked one for the low anxiety group. The remaining cells for this group were ranked in successive order, diagonally, with the cell nearest the FC-Anscale axis receiving the lowest rank in each diagonal. This method of ranking further weighted TF-Anscale scores in the high anxiety group and FC-Anscale scores in the low anxiety group.

Assignment of Subjects to Experimental Groups

The 75 lowest ranking Ss in the high and low anxiety groups were assigned to four firing sessions for Phase II, 19 high and 19 low anxiety Ss being assigned to sessions I and III and 19 low and 18 high anxiety Ss being assigned to sessions II and IV. Assignments were made so that the sum of high anxiety ranks was approximately equal to the sum of the low group ranks for each session and so that the sums of ranks for each anxiety group were approximately equal between sessions. Subjects with ranks from 76-91 were used as alternates for each anxiety group. These Ss were assigned, in the same manner, four to each anxiety subgroup in each session. In all, twenty alternates were used to replace absentees in the execution of Phase II.

Mean Army Classification Battery, Aptitude Area-I scores of high anxiety Ss who fired in Phase II were 94.00, 96.2, 92.2, and 91.[illegible] for sessions I to IV respectively while mean Area-I scores for low anxiety Ss were 93.1, 95.1, 91.6, and 94.2 for these sessions. The mean Area-I score for all high anxiety Ss was equal to the mean for all low anxiety Ss--93.5.

Experimental Design

Table 1

Design of the Experiment

Firing Session	N	Firing Time	Sequence of Conditions: 1st Firing	Sequence of Conditions: 2nd Firing
I	19 High Anx. 19 Low Anx.	AM (0930)	Normal --->	Stress
II	18 High Anx. 19 Low Anx.	AM (1100)	Stress --->	Normal
III	19 High Anx. 19 Low Anx.	PM (1400)	Stress --->	Normal
IV	18 High Anx. 19 Low Anx.	PM (1530)	Normal --->	Stress

The complex factorial design employed is summarized in Table 1. Approximately one-quarter of each of the high and low-anxiety groups was fired in each of four firing sessions.[1] Firing conditions were counterbalanced to control for practice or fatigue effects. Two sessions, I and IV, were fired in a normal-stress sequence of conditions and two sessions, II and III, were fired in the reverse sequence (stress-normal), about 10 minutes elapsing between normal and stress firings for each session. Sessions I and II fired in the morning and sessions III and IV fired in the afternoon of the same day. The time of day variable was necessary because limited range facilities prevented all Ss firing at once or in one morning, and because of a concern that subjects firing on different days might communicate and compromise the stress technique. While each session was being fired, subjects in the other three sessions were at least five miles from the firing range.[2]

The four variables in the design involve three independent comparisons, high vs. low anxiety groups, normal-stress vs. stress-normal sequences of conditions, and morning vs. afternoon. The fourth comparison is between normal and stress firing conditions involving the same subjects. The relation of anxiety to the effect of stress on marksmanship will be indicated, of course, by the interaction term between (firing) conditions and anxiety.

---

1. Due to errors in the pit, one high anxiety S in each of sessions I and III fired at the same target under both normal and stress conditions. These Ss were dropped, leaving 18 high anxiety and 19 low anxiety Ss in each session. To simplify analyses of variance, subgroups were equated for number of Ss (18) by dropping the one S in each low anxiety subgroup who was most moderate in anxiety (highest rank).

2. For purposes of another study, sessions III and IV were retested on the Anscales in the morning and sessions I and II were retested in the afternoon.

PROCEDURE

The Firing Range and Targets

Phase II occurred on Known Distance Range #5 at Fort Bragg which contained 75 firing lanes. All firing was performed at a 200 yard range and from the prone position. Each session fired on alternate lanes, sessions I and III on odd-numbered lanes (1-75) and sessions II and IV on even-numbered lanes (2-74).

The targets used were type "A" (3' x 6') pasted on type "B" (6' x 6') targets and were mounted on standard target carriage frames. The "A" target is standard for a 200 yard range, but the larger "B" target was used to secure position information on rounds that would have missed an "A" target. All Ss received Preliminary Rifle Instruction as part of their normal training routine one or two days prior to the execution of Phase II.

Range Layout for Stress Conditions

Two half-pound charges were implanted one to two inches in the ground and five yards apart at points 80, 120, 150, 175 yards from the target in each of the 75 firing lanes. Two 1/4 pound charges were buried two to four inches in the ground 190 yards from the target in each lane. A dummy charge (including colored wires leading out of the ground) was set up one yard in front of the firing position in each lane.

During stress firing the charges were detonated successively closer to the firing line beginning ten seconds after the commence firing command. The time of detonation, in seconds from the commence firing command, was the following at each distance: 80 yards-10 seconds, 120 yards-15 seconds, 150 yards-30 seconds, 175 yards-40 seconds, and 190 yards-50 seconds.

Charges were detonated in lanes adjacent to the firing lanes, i.e., for Ss firing in odd lanes 1-75 charges were detonated in even lanes 2-74. This procedure reduced the degree to which dirt, thrown up by the explosions, might obscure the firer's vision of the target. It also decreased the possibility of a round being deflected by the dirt.

All charges were implanted but not capped in the morning prior to firing. The charges were connected in parallel and detonated by Army Engineering personnel from a point in the rear of the range.

Range Personnel

The firing procedure was directed by a range officer over a public address system. The range officer, who was stationed at a control tower in the middle-rear of the range, was assisted by two assistant range officers. A pit and two assistant pit officers supervised the pit detail. Two observers were assigned to each firer to make specific observations and to assure that proper safety precautions were taken.

Firing Procedure: Sessions I and IV

Zeroing. After the firers had assumed the prone position at their firing points and were supplied with two eight-round clips of ammunition the range officer gave SOP instructions for zeroing rifles. Ss were allowed up to fifteen rounds to obtain a reasonably centered shot pattern. Very few Ss required more than nine zeroing rounds.

Normal Firing. Immediately after the completion of zeroing Ss were given the following record firing instructions by the range officer: "This is a problem in M-1 marksmanship. Each of you has been given two clips of ammunition, one holding four rounds and one holding eight. You will fire the four round clip first and you will reload immediately with the eight round clip and continue to fire until you fire all twelve rounds. You have sixty-five seconds in which to fire the twelve rounds." Most Ss were able to fire all twelve rounds in the 65 second period.

About 10 minutes elapsed between normal and stress firing, during which time targets were changed and ammunition was reissued. Firers stayed at their firing points during this period.

Stress Firing. After record firing Ss were assembled in the rear of the range where the following points were covered in a briefing by E:

(1) Ss were correctly informed that explosions simulating artillery fire would go off closer and closer to them while they fired and that they were expected to remain on the firing line for the entire firing period.

(2) Ss were misinformed that the explosives had been found to be safe previously but that they had been doubled in size and moved closer to the firer for the present exercise, and (b) that if they fired three bullseyes the explosions in front of their firing point would cease and their targets would come down.

Immediately following the briefing Ss returned to their firing points where they were given these instructions by the range officer: "Again you have been given two clips of ammunition, one holding four rounds, and one holding eight. You will fire the four round clip first, reload immediately with the eight round clip and continue to fire until you get three bullseyes and your target comes down or until you hear the command "cease fire". Ss were again given 65 seconds to fire twelve rounds at the same range and from the same position.

Firing Procedure: Sessions II and III

Sessions II and III fired under stress conditions before normal record fire. This sequence of firing required two changes in the procedure described for sessions I and IV. First, the briefing by E was given just before Ss had completed zeroing. Second, Ss were informed during the briefing, and again by the range officer just before normal firing, that there would be no explosions during the normal firing period.

Dependent Variables

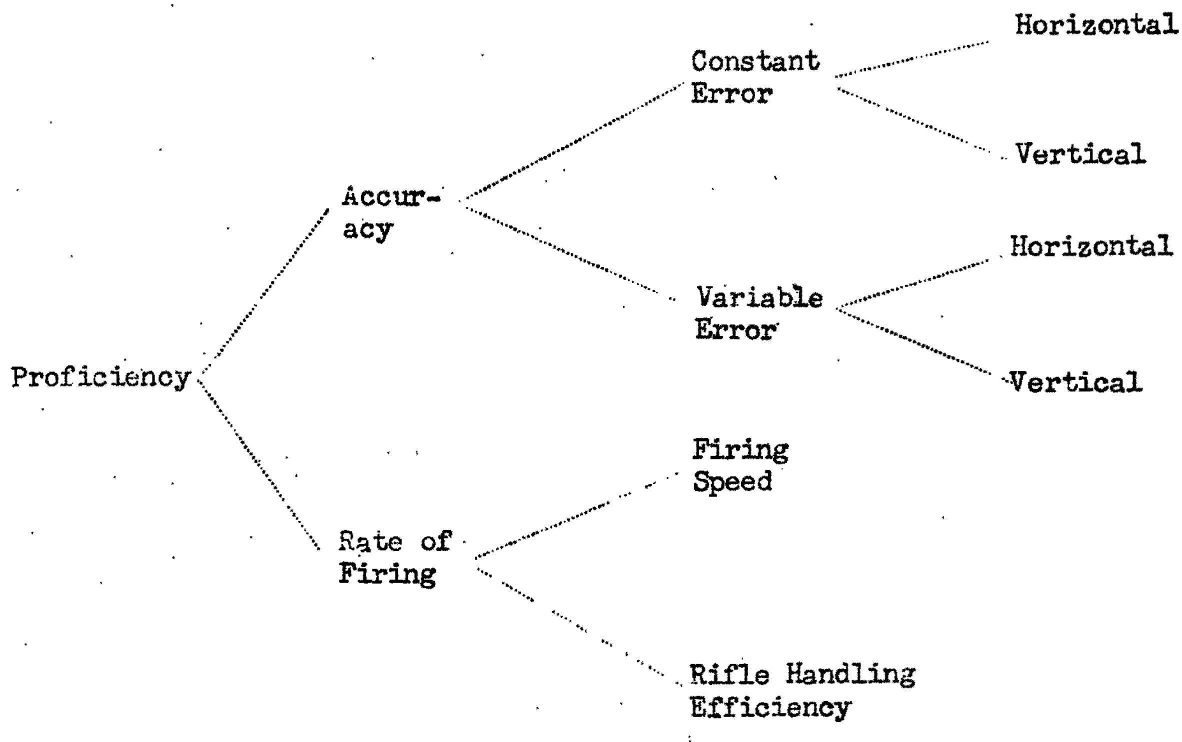

Figure I

Components of Marksmanship Proficiency

The primary dependent variable, marksmanship proficiency, was analyzed into the various component measures shown in Figure I. Proficiency, the average score for rounds available to be fired (12 in this case), is a function of accuracy and the number of rounds fired or the rate of firing. Rate of firing, in turn, is a function of the speed of firing a clip of rounds and the efficiency with which the rifle and clip are handled in changing clips and avoiding and recovering from malfunctions. Measures of firing speed and clip handling efficiency were obtained through a rater and a timer assigned to each subject. The rater checked whether the rifle jammed, the clip was fumbled, and rounds were left unfired. He also recorded the number of rounds left unfired. The timer recorded the number of seconds to fire the first round, to fire the first clip, to change clips, and to fire the second clip.

Accuracy was computed as the average target score for rounds fired only. Scores were measured in two ways: first, by the conventional scoring procedure of weighting successive concentric circles 5, 4, 3 and zero and second, by measuring in two inch units along the vertical and horizontal coordinates of the target the more exact distance of each hit from the bullseye. These coordinate measurements made possible the partitioning of accuracy (actually inaccuracy in this case) into constant error, the distance of the center of the shot-group from the bullseye, and variable error, the amount of deviation[3] of the shot-group around its own center. The constant and variable error components of accuracy were computed separately for the horizontal and vertical coordinates of the target.[4]

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3. The measure of deviation used was the standard deviation.

4. For the analysis of accuracy component scores, it was necessary to drop two Ss from each subgroup. It was felt that targets with only one or two hits provided an inadequate sample of values for estimating accuracy components for all rounds fired. No more than one target of this type was found in either condition in any subgroup and these, along with the target for the other condition for the same S, were excluded from further analysis. Finally, the S in the remaining subgroups who had the lowest number of hits for either of the conditions was dropped. This re-equated the number of cases in the subgroups (N = 16) and minimized any bias resulting from dropping the Ss above.

RESULTS AND DISCUSSION

The results of the experiment will be considered in three sections, the first of which presents analyses of both proficiency and accuracy scores. It is convenient to discuss the results for proficiency and accuracy together since they are similar in form, both resulting from conventional target scoring. The analyses of variable and constant error will be presented and discussed in the second section. These two measures of error are similar in that each is measured along horizontal and vertical coordinates on a refined equal unit scale. In the third section, analyses of rate of fire and other observational data will be considered.

Proficiency and Accuracy

Group Averages. Means and standard deviations are presented in Table 2 for proficiency and accuracy scores. These data are given for high and low anxiety sub-groups in each of the four sessions for both normal and stress conditions. An inspection of the means indicates that high anxiety groups have lower target scores than comparable low anxiety groups in every session for both proficiency and accuracy scores. The effect of the stress conditions is not as clear cut, however, as that of high anxiety. For proficiency, means are seen to be lower under stress than normal conditions in sessions I, III, and IV, but this relationship is reversed in session II. For accuracy the same results obtain except that an additional group, high anxiety subjects in session III, shows the reversed relationship. In general, it may be said that the trends in the means in Table 2 are in the direction of high anxiety and stress conditions being associated with impairment in marksmanship performance, with the former factor being more consistantly effective then the latter.

Table 2

Means and Standard Deviations for Proficiency and Accuracy
(Conventional Scoring)

			Low Anxiety				High Anxiety			
			Normal		Stress		Normal		Stress	
Session	Sequence of Conditions	Measure of Marksmanship	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
I	Normal before Stress	Proficiency	44.17	10.01	39.83	13.85	34.56	13.26	33.33	13.07
		Accuracy	44.17	10.01	41.11	12.87	36.28	13.59	34.78	13.40
II	Stress before Normal	Proficiency	38.67	17.75	39.89	16.55	30.33	19.62	30.89	14.66
		Accuracy	40.78	17.16	42.39	16.48	32.00	19.24	34.50	13.58
III	Stress before Normal	Proficiency	37.72	12.37	33.28	15.82	33.33	13.88	30.94	12.82
		Accuracy	39.00	12.73	35.17	14.57	34.44	12.79	34.67	11.71
IV	Normal before Stress	Proficiency	38.83	15.99	32.28	13.88	36.33	13.46	29.50	14.78
		Accuracy	40.06	16.99	33.72	14.77	36.50	13.40	30.00	14.30

Analysis of Variance. The results of analyses of mean differences for the proficiency and accuracy data are summarized in Table 3 as F-ratios. Complete presentations of the analyses may be found in Appendix B. The method of analysis was somewhat unorthodox in that it involved three separate analyses, one on the factors and interactions which do not involve the repeated measures for conditions (presented in the upper half of the table), a second on the overall effect of conditions (presented in the center of the table) and a third on the interactions of conditions with the other factors and interactions (presented in the lower half of the table). The first procedure utilized a factorial analysis of variance on individual's total scores for both normal and stress condition, the second used a simple t-test for repeated measures between the two conditions, and the third was an additional factorial analysis of variance on individual's relative difference scores between conditions (normal minus stress). In the case of overall effects of conditions, t-ratios were squared to obtain F-ratios comparable to those obtained from the two analyses of variance. Bartlett's test indicated that hypotheses of homogeneity of variance could be rejected only in the case of difference scores for proficiency ($p < .05$).[5]

The effects of primary interest in Table 3 are those of anxiety groups, conditions and the interaction of these two factors. Apparently, this interaction is not significant for either measure, and it may be assumed that the high and low anxiety groups did not react differentially to the stress conditions as compared to their performance under the normal conditions. As indicated by the F-ratios for the main effects of anxiety groups, the high anxiety group was significantly[6] poorer in performance under both conditions than the low anxiety group for proficiency and accuracy scores. It is also indicated that the overall detrimental effect of stress is significant for both proficiency and accuracy. However, this effect is confounded by an interaction for each measure, first, by a single interaction with time of day in the case of proficiency, and secondly, by interactions with both time of day and sequences in the case of accuracy. To determine whether differences between normal and stress conditions hold for both morning and afternoon, and for both sequences in the case of accuracy, it will be necessary to inspect and test the effects of conditions for these simpler comparisons.

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5. Recent studies by Norton (5) indicate that the degree of heterogeneity found in this case does not vitiate the use of F-ratios as indicators of significant mean differences.

6. Effects that can be expected to occur by chance less than 5% of the time ($p < .05$) will be considered to be "statistically significant" throughout the analysis.

Table 3

F-ratios for Proficiency and Accuracy
(Conventional Scoring)

Source	Marksmanship Measure: Proficiency	Marksmanship Measure: Accuracy
Anxiety Groups (High-Low)	6.48*	6.08*
Sequences of Conditions (NS-SN)	1.18	--
Time of Day (AM-PM)	--	1.64
Anxiety x Sequences	--	--
Anxiety x Time	1.43	1.12
Sequences x Time	--	--
A x S x T	--	--
Conditions (Normal-Stress)	9.87**	5.10*
Conditions x Anxiety	--	--
Conditions x Sequences	3.12	6.39*
Conditions x Time	4.38*	4.90*
C x A x S	--	--
C x A x T	--	--
C x S x T	--	--
C x A x S x T	--	--

$*p < .05$ $**p < .01$
--F less than 1.00

The specific effects of anxiety and stress conditions for each session can be seen in Figure II which is a plot of the means shown in Table 2. [7] The detrimental effect of high anxiety is immediately apparent and the lack of interaction between anxiety and conditions is observed as a tendency toward parallel lines of relationship between anxiety groups. The interactions of conditions with time of day can be seen to result from more decrement under stress in session IV than session I (normal-stress sequence sessions) and a general tendency toward relatively poorer performance under stress when compared to normal conditions for session III than for session II. In the case of session II, performance was actually poorer under normal than under stress conditions. The interaction found for accuracy between conditions and sequences obviously results from the reversed relationship of conditions in session II compared to I and the greater difference between conditions in session IV than III.

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7. It will be noted that in every instance the mean proficiency score is equal to or less than the mean accuracy score. This follows directly, of course, from the respective computational formulae which are identical unless one or more rounds are left unfired in which case this number of rounds is added to the denominator of the proficiency formula reducing the proficiency score (see page 12 and Appendix A).

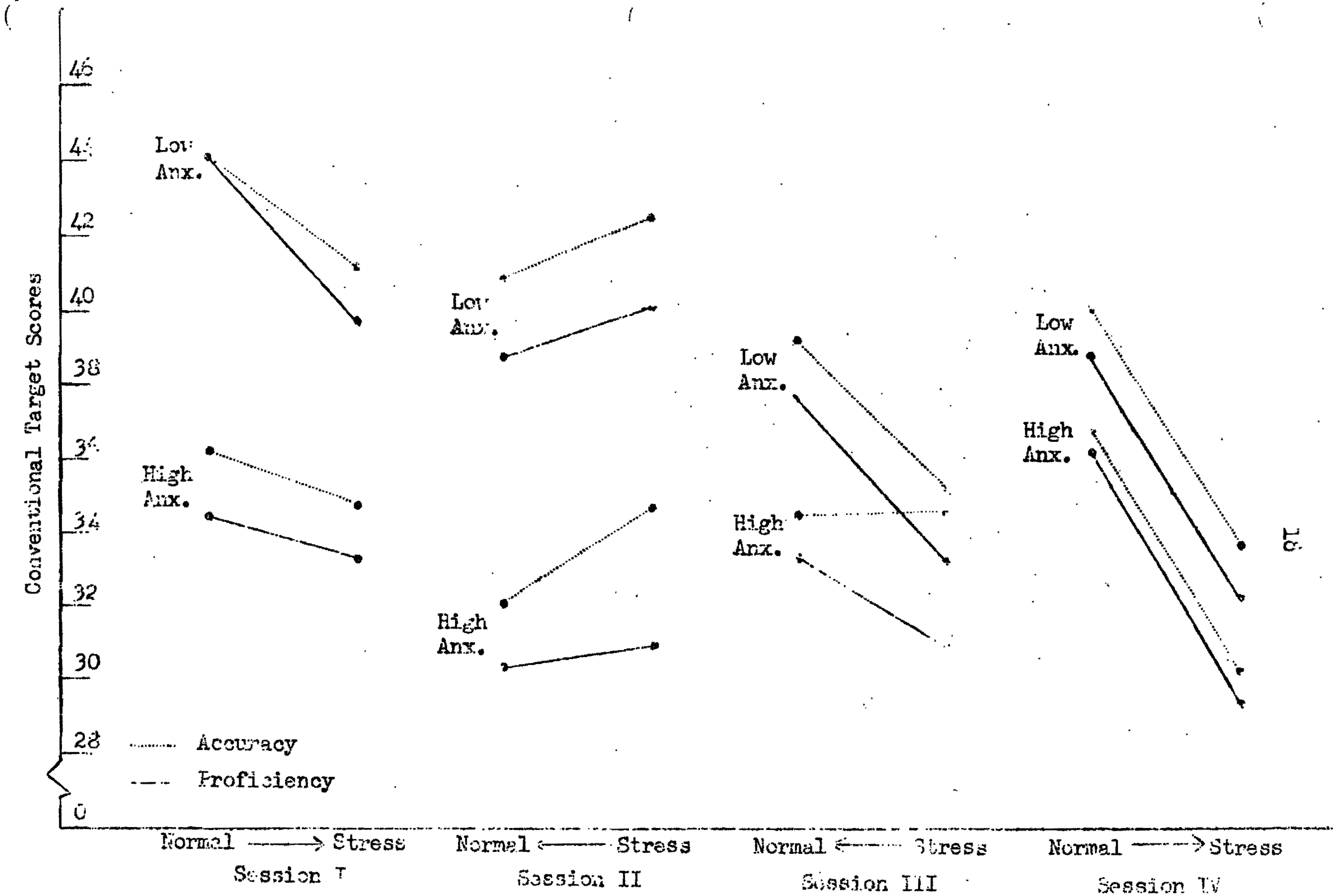

Figure II
Mean Conventional Scores for the Low and High Anxiety Subgroups of each Session under Normal and Stress Conditions

Table 4

Means by Sessions for Proficiency and Accuracy under Normal and Stress Conditions and F-ratios for Comparisons between Conditions

Session	N	Proficiency			Accuracy		
		Means		F-ratio	Means		F-ratio
		Normal	Stress		Normal	Stress	
I	36	39.37	36.58	2.28	40.23	37.95	1.82
II	36	34.50	35.39	--	36.39	38.45	1.02
III	36	35.53	32.11	3.61	36.72	34.92	--
IV	36	37.58	30.89	19.98***	38.28	31.86	18.67***

*** $p < .001$

-- indicates $F < 1.00$

The results of analyses of the differences between normal and stress scores for each session are shown in Table 4. [8] Apparently, means for normal and stress conditions differ significantly only in session IV. That is, for these measures, the present stress conditions resulted in decreased performance, relative to normal scores obtained within the same half hour, only if firing under the stress conditions followed normal firing and if firing occurred in the afternoon. The data in Table 4 would seem to suggest a second order interaction between

8. Since the conditions by time of day were the only ones for proficiency that involved conditions, these effects might have been examined for pooled morning sessions and pooled afternoon sessions. The analysis was performed for each session for convenience of presentation. It should be noted that the F-ratios for afternoon session III were actually not significant.

conditions, time of day and sequence of firing conditions. However, it has been indicated in Table 3 that this interaction term is not significant. Instead, there are separate interactions of conditions with sequences and with time of day for accuracy. For proficiency, there is only the interaction of conditions with time of day.

<u>Stress Conditions - Time of Day Interaction</u>. The interaction effect of time of day with normal-stress differences was not anticipated prior to running of the experiment, but it became apparent to the experimenter during the afternoon firing sessions. As previously indicated, the size of the available firing range precluded firing all Ss during the morning and the necessity of minimizing communication among Ss prohibited carrying out Phase II in a period longer than one day. Thus, two sessions were scheduled in the morning and two in the afternoon. The stress procedure for setting off explosions was tested on a morning previous to the experiment. The size of explosives and the depth to which they should be implanted were selected so that dirt and dust thrown up by the explosions would not impair S's visions during firing. However, the fact that an excessively hot day would cause the ground moisture to evaporate making the ground loose and dusty was not taken into account. Consequently, there was a substantial increase in the amount of dust and debris thrown up by the explosions in the afternoon producing a noticeable impairment in target vision for stress conditions.

It appears then that stress conditions have no significant detrimental effect on either proficiency or accuracy other than one of decreasing target visibility. Any effect of the stress situation toward increasing fear (or even of introducing startle) would be expected to yield a significant decrement under stress conditions in session I also. However, the effect for this session, although in the expected direction, was not significant.

<u>Stress Conditions - Sequences Interaction</u>. The explanation of the conditions by sequences interaction in accuracy scores is by no means as obvious. Literally, the interaction indicates a significantly greater difference between normal and stress accuracy (in favor of normal conditions) for the sessions (I and IV) firing in the normal-stress sequence than for those (II and III) firing in the stress-normal sequence. Another interpretation of the effect is an overall difference between average scores for first firings (normal for sessions I and IV and stress for II and III) and second firings (stress for sessions I and IV and normal for II and III).

This is made clear in the following diagram:

		Conditions	
		Normal	Stress
Sequences	N---> S	1st Firing	2nd Firing
	S---> N	2nd Firing	1st Firing

A conditions by sequences interaction for this experimental design involves a comparison of means for first and second firings irrespective of conditions or sequences. It will be recalled that no overall difference was found between sequences. A comparison of sequences for normal and stress conditions separately indicates that the difference between sequences is not significant in either case. An investigation of these differences for each session resulted in no significant comparisons but indicated, as can be seen in Figure II, that nearly all of the difference in stress scores between sequences occurs between sessions III and IV. This difference could be attributed to greater dust during stress firing in session IV. [9] On this basis a tentative hypothesis was entertained which suggested that firing first under normal conditions had no effect on subsequent firing under stress, whereas firing under the present stress condition first was detrimental to subsequent normal firing. This, obviously, was an hypothesis of "conditioned stress", assuming that inappropriate responses to the stress situation transferred to the normal situation. However, the difference between sequences for normal scores alone was also insignificant. Only the sum of the differences, on the one hand between normal scores and on the other between stress scores (the conditions by sequences interaction) was significant. Therefore, the most appropriate hypothesis states that firing a series of twelve rounds (under either conditions) under the present conditions is detrimental to firing accuracy (under either condition) about ten minutes later. This is a difficult hypothesis to develop further, first, because fatigue resulting from firing would have dissipated within ten minutes, and second, because increments due to warm-up might have been expected in this situation. (Practice effects would not have been predicted since no scores or results were relayed to the Ss until after the second firings.) The most plausible explanation is that not receiving scores following the first firing evoked some reaction (anxiety, concern, preoccupation, etc.) on the part of the

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9. Nearly two hours elapsed between the stress firings in sessions III and IV and this period was the hottest part of the day when the highest rate of moisture evaporation would be expected.

subjects which impaired performance during second firings.

Summary of Effects on Proficiency and Accuracy. In summary, it was found that high anxiety subjects had significantly poorer scores than low anxiety subjects on both proficiency and accuracy, and that scores for normal and stress conditions did not differ except for session IV (normal-stress sequence in the afternoon) in which case stress scores were significantly poorer for both proficiency and accuracy. Neither time of day nor sequence of conditions affected the scores directly. However, these factors did determine the degree of difference between normal and stress scores.[10]

Attention will be turned now to consider whether the various effects found for accuracy occur in all or only some of its components.

Components of Accuracy

Group Averages. As described on page 12 accuracy was partitioned into variable and constant error and each of these measures was determined along both horizontal (x) and vertical (y) coordinates of the target. This procedure yielded four components of accuracy--variable error on the horizontal (Vx) and vertical (Vy) coordinates and constant error on these coordinates (Cx and Cy). Means and standard deviations for the four component measures are reported in Table 5 for each sub-group.[11] A graphical presentation of the means is given in Figure III. A superiority of the low anxiety groups over the high anxiety groups is seen to be fairly consistent. Out of 32 possible comparisons, 28 show superior performance for low anxiety groups. In terms of magnitude of difference, it is clear that constant error is more effective in differentiating groups and that Cx is more effective than Cy. The effects of stress conditions, sequence of conditions, and time of day are not as consistent in terms of direction of mean differences as is the effect of anxiety.

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10. In the usual record firing procedure, an individual is permitted to refire if his rifle jams. Consequently, rounds left unfired due to jamming are not counted against him, as is true for the present measure of proficiency. (In the usual procedure rounds not fired due to slowness of firing are counted against the man.) This accommodation for jammed rifles is not possible in an experiment of the present type. Therefore, neither the present proficiency nor accuracy score is identical with typical record firing scores. For this reason, all of the analyses were also run on a third type of score which is quite similar to record firing scores. It consists of an individual's proficiency score, unless his rifle jammed, in which case it is his accuracy score. The results for this score were essentially the same as were those for proficiency.

11. For these measures N=16. See the rationale for discarding subjects on page 8.

Table 5

Means and Standard Deviations for Variable and Constant Errors
(Coordinate Scoring*)

Session	Target Coordinate	Low Anxiety Normal Mean	Low Anxiety Normal S. D.	Low Anxiety Stress Mean	Low Anxiety Stress S. D.	High Anxiety Normal Mean	High Anxiety Normal S. D.	High Anxiety Stress Mean	High Anxiety Stress S. D.
				Constant Error					
I	Horiz. (C_x)	2.14	1.81	2.26	1.98	3.49	2.17	3.78	2.52
	Vert. (C_y)	2.66	2.30	3.36	2.06	2.91	2.00	3.51	1.98
II	Horiz. (C_x)	2.38	2.95	2.26	1.92	3.74	3.34	2.87	2.30
	Vert. (C_y)	2.97	2.98	3.10	3.61	4.02	3.80	3.78	3.05
III	Horiz. (C_x)	2.36	2.45	3.47	2.99	3.59	3.20	3.39	2.82
	Vert. (C_y)	2.49	2.95	2.92	1.84	3.01	2.44	3.35	1.97
IV	Horiz. (C_x)	2.14	1.49	1.98	3.23	3.28	2.00	4.03	2.61
	Vert. (C_y)	1.83	1.36	4.03	2.85	2.96	2.29	4.08	3.54
				Variable Error					
I	Horiz. (V_x)	2.64	.75	2.83	1.16	3.42	1.35	2.98	1.24
	Vert. (V_y)	2.83	1.06	2.83	1.34	3.23	1.04	2.92	.85
II	Horiz. (V_x)	3.16	2.52	3.34	2.02	3.40	1.59	3.16	.84
	Vert. (V_y)	2.76	1.21	2.84	.95	3.10	1.13	3.19	1.03
III	Horiz. (V_x)	3.49	1.39	3.64	1.68	3.49	1.20	4.29	2.35
	Vert. (V_y)	3.41	1.14	4.33	1.76	3.21	1.23	3.83	1.35
IV	Horiz. (V_x)	3.14	1.16	3.63	1.27	3.52	1.38	3.74	1.29
	Vert. (V_y)	3.34	1.58	3.39	.91	3.48	1.06	4.31	1.55

*Contrary to the conventional scoring scale, high scores on the coordinate scoring scale used to measure variable and constant error indicate more error and, consequently, less effectiveness.

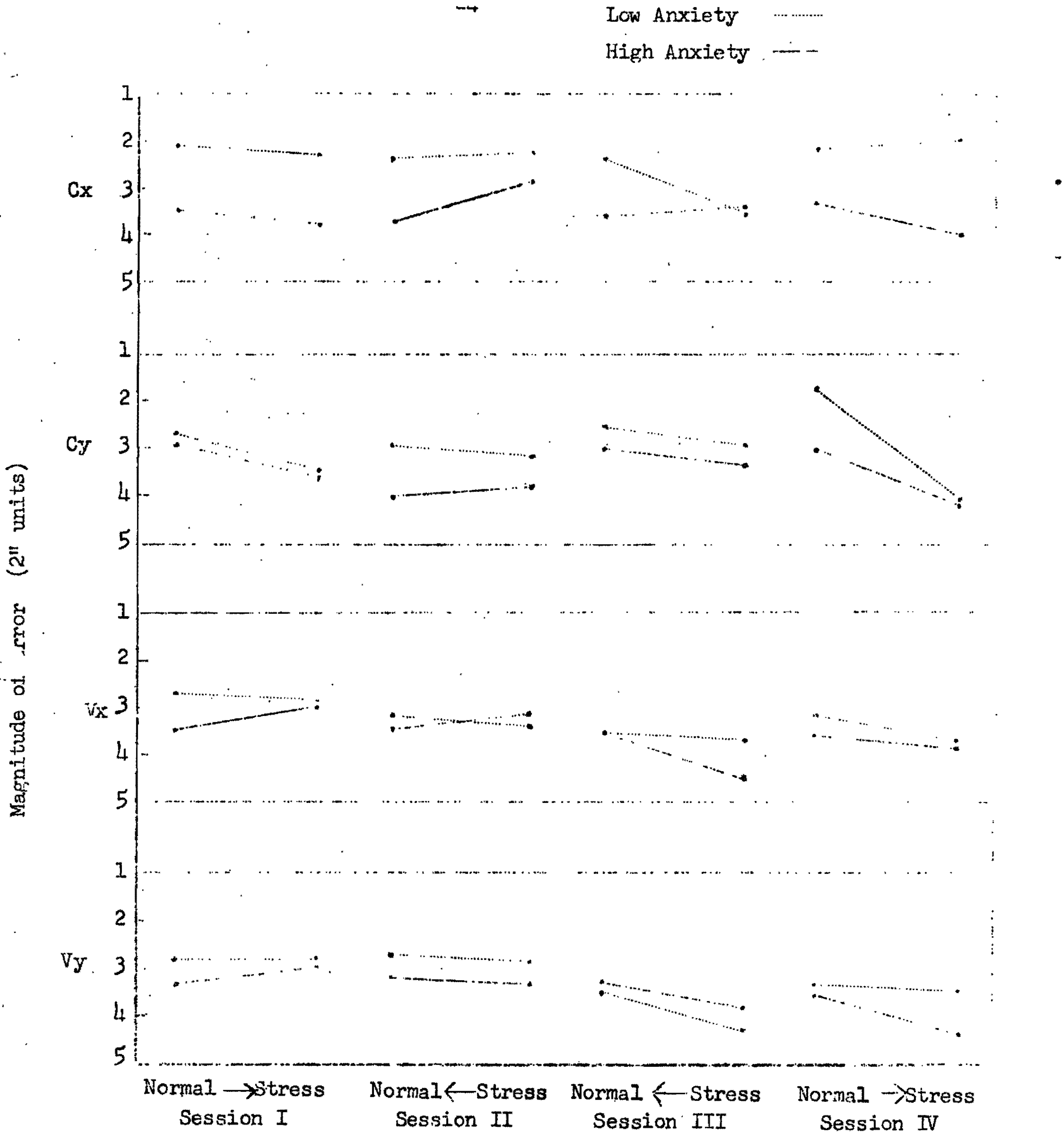

Figure III
Sub-group Means for Components of Accuracy
under Normal and Stress Conditions

Analysis of Variance. The statistical significance of overall mean differences may be seen in Table 6 which presents F-ratios for analyses of variance on all four component measures. The complete analyses for each measure may be found in Appendix B. Note that Table 6 is arranged, as was Table 3, to show in the upper half of the table the effects which are independent of conditions and in the lower half the various interactions with conditions. The overall comparisons between conditions, computed as squared t-tests are again shown in the center of the table. It is obvious that none of the effects found for accuracy in Table 3 is significant for all four component measures. The detrimental effect of high anxiety is significant for Cx only, while the main effect of stress conditions is significant for only Vy and Cy. The conditions by time of day interaction is significant only for Vy, and the conditions by sequences interaction is significant only for Cy. On the other hand, it appears that a main effect of time of day, which was not significant for the total accuracy measure, is significant for both Vx and Vy. Each of the significant effects will be considered separately, first, in terms of any confounded influences and, second, with reference to a meaningful interpretation.

The significant detrimental effect of high anxiety on accuracy was found to be non-confounded and this holds for Cx. The main effect of time of day on Vx is also non-confounded. However, for this analysis, the hypothesis of homogeneity of variance can be rejected at the .01 level, heterogeneity being quite extreme. Consequently, a conclusion concerning the detrimental effect of time of day on both normal and stress scores for horizontal variable error (Vx) is merely suggested for further investigation. The significant main effects on Vy of time of day (poorer in the afternoon) and conditions (poorer under stress) are both confounded by a significant interaction of these two factors. An analysis which removes the effect of this interaction will be shown in Table 7. Before going on, however, it should be noted further in Table 6 that the significant detrimental effect of stress conditions on Cy is confounded by an interaction of conditions with sequences. A breakdown of this effect to eliminate the interaction will be presented in Table 8.

Table 6

F-ratios for Analyses of Variable and Constant Errors on the Horizontal(x) and Vertical(y) Coordinates

Source	Variable Error		Constant Error	
	V_x	V_y	C_x	C_y
Anxiety (High - Low)	1.55	1.17	7.79**	1.60
Sequences (NS-SN)	1.49	--	--	--
Time of Day (AM-PM)	5.44*	16.07***	--	--
Anxiety x Sequences	--	1.23	--	--
Anxiety x Time	--	--	--	--
Sequences x Time	--	--	--	--
G x S x T	--	--	--	--
Conditions (Normal Stress)	1.10	4.97*	.77	9.49**
Conditions x Anxiety	--	--	1.03	--
Conditions x Sequences	--	1.25	--	5.43*
Conditions x Time	2.22	6.44*	2.61	2.91
C x G x S	--	--	1.62	--
C x G x T	1.26	--	--	--
C x S x T	--	--	--	--
C x G x S x T	--	--	--	--

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

-- indicates $F < 1.00$

Interaction of Stress Conditions and Time of Day for Vy. Table 7 shows for Vy the effects of time of day separately for normal and stress conditions and the effects of conditions separately for morning and afternoon. F-ratios for separate mean comparisons indicate that for this measure the effect of stress exists only in the afternoon and that time of day is a significant factor only for stress firing.[12] The implications of these results are quite simple. Vertical variable error (Vy) was not affected significantly by any of the factors under study but was greatly affected by the previously mentioned dust aroused by the stress explosions in the afternoon.

Table 7

Means and F-ratios for Non-confounded Effects of Conditions and Time of Day on Vertical Variable Error (Vy)

Firing Conditions	Time of Day AM	PM	F-ratio
Normal	2.98	3.36	3.39
Stress	2.94	3.96	20.70***
F-ratio	--	9.53**	

** $p < .01$ ***$p < .001$
-indicates $F < 1.00$

12. The F-ratio of 3.39 ($p < .10$) between morning and afternoon for normal firing suggests, along with the similar inconclusive finding for Vx, that the relationship of variable error to time of day might be worth further investigation.

Interaction of Stress Conditions and Sequences for Cy. Table 8 presents the effects of conditions on vertical constant error (Cy) for each session. The interaction of conditions with sequences requires, of course, that the effect be broken down by sequences only (I and IV vs. II and III). But, it was desired to demonstrate that the influence of the stress conditions toward increasing error was significant for session I independent of session IV. It is seen in Table 8 that the mean difference between conditions for session I is significant at the .05 level. This difference is also significant in session IV but neither of the sessions firing in a stress-normal sequence (II or III) show significant differences between conditions. This analysis of Cy has two important implications for interpretation of the effects of the stress conditions. First, whereas for proficiency, accuracy, and vertical variable error (Vy) a significant performance decrement under stress was found in the afternoon only, for Cy the stress situation is significantly detrimental in session I in addition to session IV. It was observed by the experimenters that no noticeable dust was created by the stress explosions in session I (9 A.M.). Also, the analysis showed for Cy that stress effects did not interact with time of day. These facts suggest that, in the case of Cy, the performance decrement under stress conditions for sessions I and IV is not due to dust from the explosives but, instead, may be attributed to

Table 8

Means and F-ratios for Non-confounded Effects of Conditions on Vertical Constant Error (Cy)

Session	Means for Firing Conditions: Normal	Stress	F-ratio
I	2.79	3.44	5.63*
II	3.50	3.44	--
III	2.75	3.14	--
IV	2.39	4.05	12.74**

* $p < .05$ ** $p < .01$

-- indicates $F < 1.00$

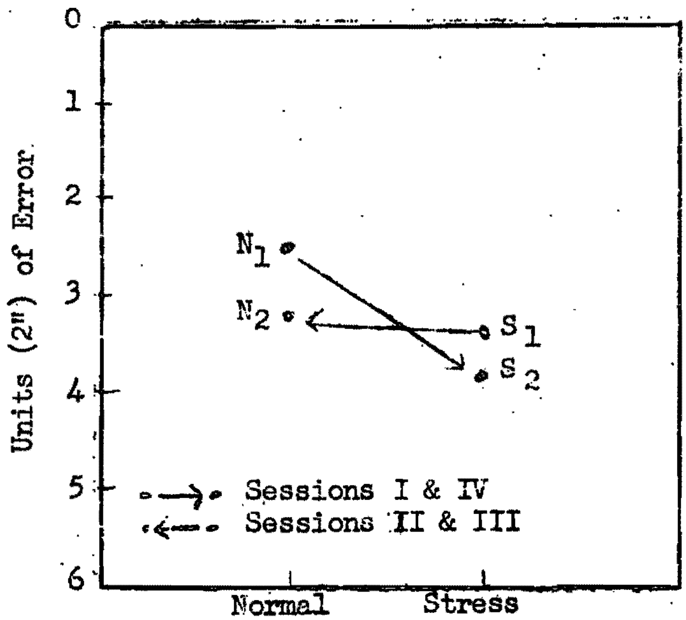

Figure IV

Normal and Stress Scores for C_y
for Each Sequence of Conditions

other factors. The hypothesis of an effect due to firing sequence, which was developed in the discussion of an analysis of accuracy scores, may be applicable for Cy also. That is, the lack of information concerning first firing scores under normal conditions resulted in impairment of second firing scores under stress conditions. However it is clear in Table 8 that the difference between first and second firing scores occurs only for the normal-stress sequence. The differences between the overall means for first and second firings were tested separately for normal or stress conditions and the differences were not significant in either case. These means are shown in Figure IV, the insignificant comparisons being between N_1 and N_2 and between S_1 and S_2. It follows then that some factor in addition to firing sequence must be responsible for the differences found between N_1 and S_2 means in Table 8. One hypothesis is that the stress conditions per se impaired performance. The effect could be attributed to startle responses to the explosions or to fear of the situation; the design doesn't permit one to differentiate between these two factors. If the stress effect alone were present it would be expected that the difference between N_1 and S_1 in Figure IV would be significant as would the difference between N_2 and S_2. Neither of these differences was found to be significant. It is concluded, therefore, that neither sequence nor stress effect is sufficient to produce a significant difference in Cy in the present experimental design, but that the significant effect of the combination of the two factors indicates the presence of both.

Rating and Timing Observations

The rating and timing observations that were recorded by the observers assigned to each subject are summarized in this section. It will be noted that each of the tables includes some data bearing on both components of rate of fire, namely, firing speed and efficiency of rifle handling.

Effect of Anxiety on Ratings. Presented in Table 9 are frequency counts of the number of Ss in each anxiety group who were checked "yes" on each of the dichotomous rating variables for which observations were made. It is seen that of the three variables related to rate of fire, only "fumbled clip" showed a significant difference between anxiety groups, the high anxiety group being observed to fumble clips more often. It is further seen that for the variable "very nervous", which has no direct relation to rate of fire, the high anxiety group was again checked more often. (It is of incidental interest that no significant relationship was found between the ratings--"fumbled clip" and "very nervous.")

Table 9

Number of Subjects in Each Anxiety Group Checked "Yes" on Each Rating Variable

Rating Variable	Low Anxiety	High Anxiety	X^2	p
Rifle Jammed	16	20	.59	--
Fumbled Clip	7	24	11.88	.001
Did Not Fire 12 Rds.	20	22	.13	--
Very Nervous	2	11	5.41	.05

Effect of Stress Conditions on Ratings. Table 10 presents comparisons between normal and stress conditions for the same rating data. Chi-square tests of association for repeated measurements on the same subjects indicate that no differences between conditions were significant for the three variables related to rate of fire. It may be noted that for the variable "did not fire all rounds", the difference approached significance (p .10) with more individuals not completing firing under the stress condition. Again it is seen that for the overall rating, "very nervous," there is a significant difference, in this case with more Ss being checked under the stress condition.

Table 10

Number of Subjects Checked "Yes" on Each Rating Variable Under Both Firing Conditions and Under One Firing Condition But Not the Other (N=144)

Rating Variable	Normal and Stress	Normal but not Stress	Stress but not Normal	X^2	P
Rifle Jammed	17	13	7	1.80	--
Fumbled Clip	4	10	15	1.00	--
Did Not Fire All Rds.	13	10	21	3.90	(.10)
Very Nervous	4	0	10	8.10	.01

Effects of Anxiety and Stress on Time to Fire. The data on time required to fire and change clips is summarized in Table 11. Median times are shown for each anxiety group under each condition and are given both for the separate intervals timed and for total time to fire. Due to the extreme skewness of the distributions, it was necessary to use a non-parametric method, the median test, for testing the significance of differences between anxiety groups and between firing conditions. No significant differences were found between anxiety groups. For comparisons between conditions there were no differences of significance in time to fire the first round or time to change clips, but time to fire each of the clips was significantly ($p < .05$) longer under the stress condition. The total time required to complete firing was also significantly ($p < .05$) longer under the stress condition.

Table 11

Median Firing Time in Seconds for Low and High Anxiety Groups under Normal and Stress Conditions

Firing Operation	Low Anxiety Normal	Low Anxiety Stress	High Anxiety Normal	High Anxiety Stress
Fire 1st Round	2	2	2	2
Fire 1st Clip (4 rds.)	9	10	8.5	10
Change Clips	10	10	10	10
Fire 2nd Clip (8 rds.)	23	24	20	25.5
Total Firing	45	50	43.5	50

The remaining measure related to rate of fire which has been considered earlier is the number of unfired rounds left in the clips when firing was halted. In fact, this is the measure that directly relates accuracy with proficiency since accuracy for an S is the ratio of his target score to the number of rounds fired while proficiency is the ratio of his target score to the sum of the number of rounds fired plus the number of rounds left unfired. The distributions of unfired rounds were markedly skewed and consequently required non-parametric statistics. It was found that no test was more appropriate than chi-square for Ss with no rounds left versus Ss with one or more rounds left and this test has already been considered in Tables 9 and 10. It will be recalled that it was determined then that no significant differences were present between either anxiety groups or firing conditions, although for the latter, slower firing under stress conditions approached significance. The total number of rounds left unfired for the normal and stress conditions respectively were 29 and 43 for the low anxiety group and 51 and 71 for the high anxiety group.

In the rating and time to fire data there was no effect of time of day or sequence of conditions present, either as a main effect or as an interaction. Also, there was no interaction present between anxiety and stress.

General Implications

Summary of Significant Findings. Because data bearing on numerous relationships between independent and dependent variables were provided by the experiment and considered in the analysis of results, Table 12 is presented to summarize and to focus the reader's attention upon those relationships that were found to be statistically significant.

Effects on Proficiency. It is seen that proficiency (the overall measure of marksmanship when an S is presented the task of placing a given number of rounds in the target bullseye in a time limit) was found to be impaired, first, by high anxiety and second, by dust created by the stress condition explosions. As shown in Table 12, these two factors impair proficiency primarily through detrimental effects on the accuracy component of proficiency. It was found that dust had no noticeable effect on the second component of proficiency, rate of fire, and, although high anxiety tended to decrease this measure, the difference between anxiety groups was not significant.

Anxiety Effects on Accuracy Components. The negative relationship between anxiety scores and total accuracy indicates that rounds fired by the high anxiety subjects tended to pass through the plane of the target at greater distances from the bullseye than was the case for the low anxiety subjects. The nature of this difference between anxiety groups was delimited by the finding that this effect is significant for only one of the components of accuracy, namely, horizontal constant error (C_x). Although the group differences for the other three components are in the expected direction, and would contribute to the total effect on accuracy, they are not significant and it cannot be concluded that anxiety affects either variable error (V_x, V_y) or vertical constant error (C_y). This finding with respect to variable error may be of particular interest to those experimenters using the Taylor A-Scale to test implications of Hull's theoretical system. Spence [13] has suggested that variable error in the rifle firing situation may be a measure of the oscillation ($_sO_r$) factor in Hull's system. And it would be expected from Hull's position, which states that $_sO_r$ is independent of motivational variables, that high and low anxiety groups would not differ significantly on variable error. This was the finding in the present experiment. It is suggested that the use of variable error in marksmanship and in other perceptual-motor tasks may in the future provide a useful technique for studying $_sO_r$ in human behavior.

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13. Personal communication.

Table 12

Significant Relationships in the Experiment
(all effects are detrimental to performance)

Factors	Dependent Variables									
	Proficiency	Accuracy					Rate of Fire			Rated Nervousness
		Total	Variable Error V_x	Variable Error V_y	Constant Error C_x	Constant Error C_y	Total	Clip Fumbling	Firing Speed	
Anxiety Scores	x	x			x			x		x
Visual Impairment Due to Dust	x	x		x						
Startle or Fear						(x)*			(x)	(x)
Previous Firing with results unknown to S						(x)				

* ( ) indicates tentative interpretation

The reason for high anxiety being associated with constant error on the horizontal coordinate of the target (C_x) but not on the vertical coordinate (C_y) is not apparent. It should be made clear that a significant difference between groups on constant error does not imply a difference in a specific direction. This implication is precluded by the definition of constant error, which is the absolute distance from the center of a subject's shot group to the center of the bullseye. For example, shot groups centering 3.2 units above the bullseye have the same vertical constant error (C_y) as shot groups centering 3.2 units below the bullseye. In fact, the relative (directional) difference between anxiety groups, which is not reported, was found to be insignificant. The difference between anxiety groups on C_x indicates, therefore, only that high anxiety Ss had shot groups in which the average mean deviation from the bullseye center was greater, on the average, than these values for low anxiety Ss.

The question remains as to why the anxiety groups differed in this respect on the horizontal but not on the vertical axis of the target. Relative to the fairly warranted positions, first that anxiety is a drive (D) variable (8), and second, that drive and habit strengths multiply to determine performance (3), at least one of the following two conditions is implied by the finding in question: (a) that while the hierarchy and absolute strengths of right and wrong habits are about the same for the two anxiety groups they differ between C_x and C_y, and (b) that while C_x and C_y are about equal in this manner, they both differ between the two anxiety groups. Unfortunately, sufficient information is not available to reject one of these alternatives. It may be noted that C_x is the variable which is affected by windage, suggesting that wind might somehow account for the finding that anxiety group differences were found for C_x but not C_y. The effect could not be a direct one, however, since low and high anxiety groups fired at the same time. On the other hand, wind could have been indirectly responsible for this difference at the time of zeroing rifles and making corrections in the sights for windage. If it is supposed that high anxiety Ss were less accurate than low anxiety Ss in zeroing their rifles horizontally to compensate for windage but that the groups did not differ in accuracy at the simpler task of zeroing vertically to prepare for the standard range distance, the results obtained would have been expected. This hypothesis might be checked by comparing C_x for high and low anxiety Ss both on self-zeroed and bench-zeroed rifles. For a non-standard range distance, self-zeroed rifles might be expected to yield a high-low anxiety difference for C_y also. An alternative but less specific hypothesis is that high anxiety Ss were more concerned with the explosions during firing and either glanced horizontally more frequently at the lines of explosions or attended more to left-right peripheral vision. Consequently, horizontal accuracy in keeping the sights and bullseye aligned was impaired for this group.

Other Effects of Anxiety. The other variables related to anxiety scores were clip fumbling and ratings of nervousness. Both relationships were found to be positive and are in line with current clinical and theoretical notions as to the nature of anxious behavior. Studies (4, 6) of the effect of stress or situational anxiety on the accuracy and speed components of performance have reported that this factor decreases accuracy (increases errors) while increasing speed. This state of affairs may account for the present finding of a difference in clip fumbling (errors) between anxiety groups and no difference in speed of changing clips; faster movements by the high anxiety group compensated for more inappropriate movements. However, the speed of firing a clip was not significantly related to anxiety scores. To account for this in terms of the above notions, it would be necessary to hypothesize more inappropriate responses between the aiming of each round on the part of the high anxiety group that counteract the faster speed of movement in this group. There is some evidence for a difference between anxiety groups for appropriateness of responses during firing of the clips. More high anxiety Ss were judged to be "very nervous" by observers and these ratings were found to be unrelated to instances of clip fumbling. Since times to change and to fire clips were also not related to anxiety, it is assumed that the behavioral differences reflected in the ratings of nervousness occurred primarily during actual firing.

Effect of Dust on Variable Error. The impairment in accuracy attributed to dust in the afternoon stress conditions was found to occur significantly on vertical variable error (V_y) only. It is easily seen that the effects of dust in impairing vision would be at random with respect to direction and would not produce constant errors. It is not as apparent why the increase in random error would appear on the vertical axis (V_y) alone. One hypothesis is that the rifle, during the aiming and trigger pulling procedure, varied over a wider range vertically than horizontally. This results from the standard procedure of moving the rifle vertically in the act of lining up sight and targets. Reduction of fine discriminability by the dust would, by producing random errors along the vertical axis, increase V_y.

Stress Effects. The detrimental effect of stress conditions on C_y, firing speed, and nervousness have been attributed to startle or fear because they did not increase as dust effects increased. Each of the relationships are to be treated as tentative, however, for various reasons. First, it was found that the effect on C_y was contingent upon the normal-stress sequence of conditions and the conclusion of a startle or fear effects was closely tied to the conclusion of an impairing effect of firing second. It is considered that both of these relationships should be verified before any effort is made to develop their implications. Why these effects would be on C_y only is not clear. Slower firing under stress conditions is, on the surface, contradictory to the studies (4, 6), last cited. However, the best hypothesis for this effect is that Ss anticipated the next explosions and held their fire momentarily until the blast was over. It is also conceivable that startle responses increased the time required to get set for firing the next round. Since the effect did not increase with the presence of dust, it cannot be attributed to that factor. It is also quite tentative that the stress conditions aroused fear which was observed by the raters. The significant association between the stress condition and ratings of nervousness is confounded because the raters were aware of the change in situations from normal to stress conditions and, on this basis, could have "read into" the behavior of the Ss the nervousness recorded on the rating forms.

It has been stated previously that all of the twelve significant relationships shown in Table 12 indicate impairing effects of the experimental factors. It may be interesting to note finally, that, of the twenty-eight insignificant relationships only eight reverse this trend. These eight reversals were of the nature that high anxiety and dust were both associated with greater "firing speed", "startle or fear" was associated with decreased variable error on both coordinates and less clip fumbling, and "previous firing with results unknown to S" was associated with decreased variable error on both coordinates and a faster "rate of fire".

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APPENDIX A

Computational Procedure for Proficiency, Accuracy, and Components of Accuracy

Proficiency was measured using the conventional procedure of weighting each hit 5, 4, 3, or 0 according to its degree of deviation from the target center. With this procedure misses and rounds not fired are weighted zero. The total proficiency score was computed by summing the scoring weights for each of the twelve rounds available to the firer for each firing condition. It is feasible, and preferable in some cases, to compute a proficiency score as the average score per round available. The conventional summed score was used in the present case because the number of rounds available to each man was the same.

Similarly, accuracy may be computed as the average score per rounds fired. In order to make accuracy scores of the same magnitude as proficiency scores, accuracy was computed by multiplying proficiency by the ratio of rounds available to rounds fired. Using the following terms:

P = conventional proficiency,

A = conventional accuracy,

W = scoring weight for each hit,

N_A = 12 = number of rounds available for firing,

N_F = number of rounds fired,

N_H = number of hits,

The formulae for proficiency and accuracy are:

$$P = \sum W,$$

$$A = \frac{N_A}{N_F} (P) = \frac{N_A}{N_F} (\sum W).$$

N_F is computed by subtracting the number of rounds left in the clip (recorded by observer) from N_A. Therefore, N_F is necessarily equal to or less than N_A and it is obvious that accuracy will be equal to or greater than proficiency.

In addition to conventional scoring, each hit was measured for distance from the bullseye on both the horizontal and vertical axes. These measurements were made in two-inch units. This offered four advantages over conventional scoring. First, it provided eighteen rather than four scoring intervals for hits; second, it gave an indication as to direction of error for each hit; third, it permitted a partitioning of total error into the component measures--variable and constant error; and fourth, it permitted a further partitioning of both variable and constant error into horizontal and vertical factors. Variable error is defined as the standard deviation of the shot group while constant error is the distance of the center of the shot group from the bullseye.

Before each firing session identifying data were marked on each target and immediately after firing conventional scores were indicated on the targets by the pit detail. Targets were then removed from the frames and put into two stacks, one each for normal and stress conditions, and each stack of targets was rolled and tied. Later, all rolls were transported to a room equipped for the additional scoring procedure described above. Targets were then scored by unrolling one roll (about 37 targets) on the floor and weighting the edges so that the targets would remain flat. A plastic transparent template which was six feet square--the size of the target, was placed over the top target in the pile. The template was graduated in two-inch units in one direction with numerical designations increasing from bottom to top. It was first placed so that scale lines ran the width of the target. In this way, the distance of each hit from the bottom of the target (vertical scale) could be read off rapidly by one clerk. A second clerk recorded the values in one column of a data sheet. Next, the template was turned 90 degrees clockwise and the distance of each hit from the left side of the target was read and recorded in a second column on the same data sheet. When the scoring of each target was completed, the target was removed from the stack and the next target was scored in the same manner.

When all targets had been scored, the data sheet contained two columns of values for hits, one for vertical deviations from the bottom of the target, and a second for horizontal deviations from the left edge of the target. The number of rounds available (N_A) and fired (N_F) and the number of hits (N_H) were also entered on the data sheets. By subtracting N_H from N_F it was possible to compute the number of misses (N_M) for each target. It was not necessary to measure simultaneously or even to associate the vertical with the horizontal reading for the same hit. This additional information would be required only if one desired to know the correlation between horizontal and vertical errors, which was not the case in the present study.

The formulae according to which the horizontal and vertical components of variable and constant error were computed are given below.

Let:

X = horizontal unit distance of a hit from the arbitrary origin,*

Y = vertical unit distance of a hit from the arbitrary origin,

Bx = X value of the center of the target,

By = Y value of the center of the target,

Cx = constant error on the horizontal axis,

Cy = constant error on the vertical axis,

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* The arbitrary origin was the lower left corner of the target. It, of course, may be any convenient point in the plane of the target.

C = constant error in two dimensions,

Vx = variable error on the horizontal axis,

Vy = variable error on the vertical axis,

V = constant error in two dimensions,

Tx = root-mean-square of the shot group from the bullseye on the horizontal axis,

Ty = root-mean-square of the shot group from the bullseye on the vertical axis,

T = root-mean-square of the shot group from the bullseye in two dimensions.

The variables of primary interest are constant and variable error on both vertical and horizontal axes for rounds fired (C_{Fx}, C_{Fy}, V_{Fx}, and V_{Fy}). To obtain these measures it was necessary first to compute the squares for these measures for hits. The formulae for the latter measures are:

$$C^2_{Hx} = (\bar{X} - B_x)^2$$

$$C^2_{Hy} = (\bar{Y} - B_y)^2$$

$$V^2_{Hx} = \frac{\sum X^2 - \frac{(\sum X)^2}{N_H}}{N_H - 1},$$

$$V^2_{Hy} = \frac{\sum Y^2 - \frac{(\sum Y)^2}{N_H}}{N_H - 1}$$

The horizontal and vertical components of these measures were added (using the Pythagorean theorem) to obtain squared constant and variable errors for hits.

$$C^2_H = C^2_{Hx} + C^2_{Hy},$$

$$V^2_H = V^2_{Hx} + V^2_{Hy}.$$

Next, the mean-squares of the shot group of hits from the bullseye along the two axes were computed by the formulae:

$$T^2_{H_x} = \frac{X^2 - 2B_xX + N_H\,(B_x)^2}{N_H},$$

$$T^2_{H_y} = \frac{Y^2 - 2B_yY + N_H\,(B_y)^2}{N_H}.$$

Using the Pythagorean theorem, these values for each axis were added to obtain the mean-square of the shot group of hits from the bullseye irrespective of direction:

$$T^2_H = T^2_{Hx} + T_{Hy}.$$

In the case of misses, it was known only that they deviated sufficiently (19 or more units) from the center of the target to be off-target.* Nothing was known concerning direction of misses. Component measures, therefore, could not be adjusted separately for misses because each measure is dependent upon direction of error. It is necessary to make these adjustments indirectly and a number of indirect adjustments for misses were examined. The method which appeared to be most warranted, and which was used, involved (a) assigning the same total deviation-from-target-center value to each miss and (b) using a value

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* The target area for scorable hits was assumed to be circular with a radius of 18 units (3 feet). Since the targets were square, there were some hits in the corners of the targets that fell outside of the scorable range. Measurements were not made on these hits and they were treated as misses. A circle drawn on the scoring template clearly delineated the circular scoring area.

immediately off the target edge. Any bias involved in this method would improve scores more for individuals having either more misses or more extreme misses. The bias would tend, therefore, to decrease group differences rather than accentuate them.

The deviation-from-target-center value assigned to each miss in the present case was 20 units — two units off target. For each target this value was squared and multiplied by the number of misses, the formula being: $N_M\ (20)^2$ or $N_M\ (400)$. The mean-square around the bullseye for all rounds fired would then be equal to the sum of squares around the bullseye for hits plus the sum of squares for misses divided by the number of rounds fired:

$$T^2_F = \frac{N_H\ (T^2_H) + N_M\ (400)}{N_F} .$$

At this point, two assumptions are introduced. These are (a) that the ratio of horizontal to vertical mean-squares is the same for all rounds fired as for hits, and (b) that the ratio of squared constant to squared variable error is the same for all rounds fired as for hits. It follows from these assumptions that:

$$\frac{T^2_H}{T^2_F} = \frac{C^2_{Hx}}{C^2_{Fx}} = \frac{C^2_{Hy}}{C^2_{Fy}} = \frac{V^2_{Hx}}{V^2_{Fx}} = \frac{V^2_{Hy}}{V^2_{Fy}} .$$

Therefore the desired values for constant and variable error on each axis for all rounds fired may be computed by the following formulae:

$$C_{Fx} = \sqrt{\frac{C^2_{Hx}\ (T^2_H)}{T^2_F}} ,$$

$$C_{Fy} = \sqrt{\frac{C^2_{Hy}\ (T^2_H)}{T^2_F}}\ ,$$

$$V_{Fx} = \sqrt{\frac{V^2_{Hx}\ (T^2_H)}{T^2_F}}\ ,$$

$$V_{Fy} = \sqrt{\frac{V^2_{Hy}\ (T_H)^2}{T^2_F}}\ .$$

APPENDIX B

Degrees of Freedom and Mean Squares
for Analyses of Summed and Difference
Scores for Firing Conditions

Table B-I

Degrees of Freedom and Mean Squares for
Analyses of Conventional Proficiency and Accuracy

Source	df.	Mean Squares: Proficiency	Mean Squares: Accuracy
Conditions Summed Scores (Normal plus Stress)			
Anxiety (High A vs. Low A)	1	4678.75	4203.37
Sequences (N → S vs. S → N)	1	850.44	30.25
Times (AM vs. PM)	1	427.11	1133.45
Anxiety x Sequences	1	16.00	.11
Anxiety x Times	1	1034.69	774.69
Sequences x Times	1	245.44	210.25
A x S x T	1	.26	49.00
Within	136	721.89	691.60
Total	143		
Conditions Difference Scores (Normal minus Stress)			
Anxiety	1	40.11	98.34
Sequences	1	434.03	788.67
Times	1	608.44	604.34
Anxiety x Sequences	1	4.69	18.06
Anxiety x Times	1	1.00	8.51
Sequences x Times	1	1.36	3.06
A x S x T	1	84.03	43.34
Within	136	139.03	123.43
Total	143		

Table B-II

Degrees of Freedom and Mean Squares for Analyses of Horizontal and Vertical Variable Error

		Mean Squares	
Source	df.	Horizontal (Vx)	Vertical (Vy)
Conditions Summed Scores (Normal plus Stress)			
Anxiety (High A vs. Low A)	1	9.20	4.58
Sequences (N → S vs. S → N)	1	8.88	.23
Times (AM vs. PM)	1	32.31	63.00
Anxiety x Sequences	1	1.03	4.81
Anxiety x Times	1	.06	1.45
Sequences x Times	1	.23	.06
A x S x T	1	2.08	7.69
Within	120	5.94	3.92
Total	127		
Conditions Difference Scores (Normal minus Stress)			
Anxiety	1	.86	.06
Sequences	1	.37	2.53
Times	1	7.37	13.00
Anxiety x Sequences	1	2.62	.20
Anxiety x Times	1	4.17	1.24
Sequences x Times	1	.00	.07
A x S x T	1	1.32	5.24
Within	120	3.32	2.02
Total	127		

Table B-III

Degrees of Freedom and Mean Squares for Analyses of Horizontal and Vertical Constant Error

Source	df.	Mean Squares Horizontal (Cx)	Vertical (Cy)
Conditions Summed Scores (Normal plus Stress)			
Anxiety (High A vs. Low A)	1	145.14	36.23
Sequences (N → S vs. S → N)	1	.02	.20
Times (AM vs. PM)	1	7.65	5.32
Anxiety x Sequences	1	.02	.00
Anxiety x Times	1	3.68	2.34
Sequences x Times	1	2.79	13.07
A x S x T	1	10.55	4.93
Within	120	18.63	22.63
Total	127		
Conditions Difference Scores (Normal minus Stress)			
Anxiety	1	6.73	5.47
Sequences	1	6.00	31.30
Times	1	17.04	16.75
Anxiety x Sequences	1	10.52	1.07
Anxiety x Times	1	.34	.96
Sequences x Times	1	1.42	2.56
A x S x T	1	1.00	3.22
Within	120	6.51	5.76
Total	127		