Changes in Marksmanship Trainer Performance Caused by the Relative Frequency of Simulated Laser Exposure--Mastroianni **et al.**

Human Subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Reg 50-25 on the use of volunteers in research.

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> Earlier studies have shown that marksmanship performance is degraded by the requirement to respond appropriately to the presence of simulated scanning lasers and scanning/attack laser sequences. When no-laser, scanning-laser-only, and scanning-plus-attack-laser trials are mixed in equal numbers, accuracy is best on no-laser trials, declines on scanning-laser-only trials, and is worst on scanning-plus-attack-laser trials. In this study the ratio of the three trial types was systematically mixed: one group of subjects received a high ratio of scanning-plus-attack to scanning-only and no-laser trials (4.6:2.5:1) while another group received a low proportion of laser trials (1:2.5:4.6 for scanning-plus-laser, scanning-only and no-laser trials). The high-density group showed larger decrements in performance than the low-density group on both scanning-plus-attack and scanning-only trials.

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ABSTRACT

Earlier studies have shown that marksmanship performance is degraded by the requirement to respond appropriately to the presence of simulated scanning lasers and scanning/attack laser sequences. When no-laser, scanning-laser-only, and scanning-plus-attack-laser trials are mixed in equal numbers, accuracy is best on no-laser trials, declines on scanning-laser-only trials, and is worst on scanning-plus-attack-laser trials. In this study the ratio of the three trial types was systematically mixed: one group of subjects received a high ratio of scanning-plus-attack to scanning-only and no-laser trials (4.6:2.5:1) while another group received a low proportion of laser trials (1:2.5:4.6 for scanning-plus-laser, scanning-only and no-laser trials). The high-density group showed larger decrements in performance than the low-density group on both scanning-plus-attack and scanning-only trials. Both groups of subjects showed significant improvement in performance with practice.

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INTRODUCTION

Recent research in this laboratory has shown that simulated laser exposure can affect performance on the WEAPONEER marksmanship trainer (1). When soldiers are asked to engage targets that may emit a simulated scanning beam, a scanning beam plus a simulated attack beam, or no simulated laser at all, systematic differences in performance result. Performance is best when no simulated laser interferes with the target engagement sequence and is worst when the attack laser makes the target effectively unavailable during part of the target exposure. Performance is also significantly affected when a scanning laser alone is present, even though the target is available for the full exposure duration, just as in trials with no simulated laser exposure. This effect was interpreted as a psychological effect of the simulated laser exposure, which apparently caused soldiers to change their target engagement strategy.

The study which demonstrated this effect used an experimental procedure consisting of equal numbers of no laser, scanning-laser-alone, and scanning-plus-attack-laser trials. Since it was apparently the presence of the scanning-plus-attack-laser trials that resulted in the performance change on the scanning-laser-alone trials, we reasoned that the magnitude of the effect on scanning-alone trials might be modulated by varying the proportion of scanning-plus-attack-laser trials relative to no-laser trials experienced by the soldier. If a soldier experiences a greater proportion of scanning-plus-attack trials, a change in target engagement strategy could occur, leading to a greater decrement in performance on scanning-alone trials relative to a soldier whose experience was predominantly with no-laser trials. Alternatively, soldiers might show performance improvement or even a decrement followed by an improvement.

To test this hypothesis, we conducted an experiment in which we systematically manipulated the proportion, or density, of scanning-plus-attack trials relative to no-laser and scanning-alone trials.

METHODS

Subjects: Subjects were 10 soldiers assigned to Letterman Army Institute of Research, ranging in age from 21 to 27 years. There were 9 males and 1 female in the sample. Subjects were either emmetropic or wore correction to 20/20 acuity. Subjects volunteered to participate in this experiment and were given the incentive of a three-day pass to the top 60% of the performers.

Apparatus: The apparatus used in the experiment was a modified WEAPONEER marksmanship trainer. The WEAPONEER has been described elsewhere (1, 2). It consists of an M-16A1 rifle that has been adapted to fire as part of an arcade-like training device. The infrared sighting system provides precise scoring of shots, and the device is equipped to realistically simulate the recoil and noise associated with live fire.

The apparatus was modified in the same way as reported in our earlier study (1). In addition, LED (light emitting diode) timing, target exposure control and data recording were automated using a Zenith Z-248 computer. Figure 1 shows the WEAPONEER device.

Figure 1. Line-drawing of the WEAPONEER Device.

Procedure: Each subject participated in three experimental sessions and was permitted to zero the rifle on the 25-m zero target prior to all sessions. During the first session, subjects were presented with two 45-shot sequences of random target presentations. In each sequence the three targets were presented 15 times each in randomized order. The 100-m target was presented for 2 seconds (s), and both 250-m targets (high and low contrast) were presented for 4 s. The fifteen target presentations for each target were composed of 5 presentations of each trial type; trial type was also randomized.

The three trial types used were the same as reported in Mastroianni et al. (1); these were no-laser, scanning-laser-alone, and scanning-plus-attack-laser trials. The simulated laser scenario was achieved by mounting LED's on the silhouette targets in the WEAPONEER. Figure 2 shows the temporal pattern of LED illumination for each trial type. Subjects were instructed that while the scanning laser (green LED) was on (Type-2 trials), they were free to engage the target, but that the scanning laser might or might not "find them." If it did find them, an attack laser would be trained on them, (simulated by the red LED in Type-3 trials) during which they were prohibited from engaging or looking at the target.

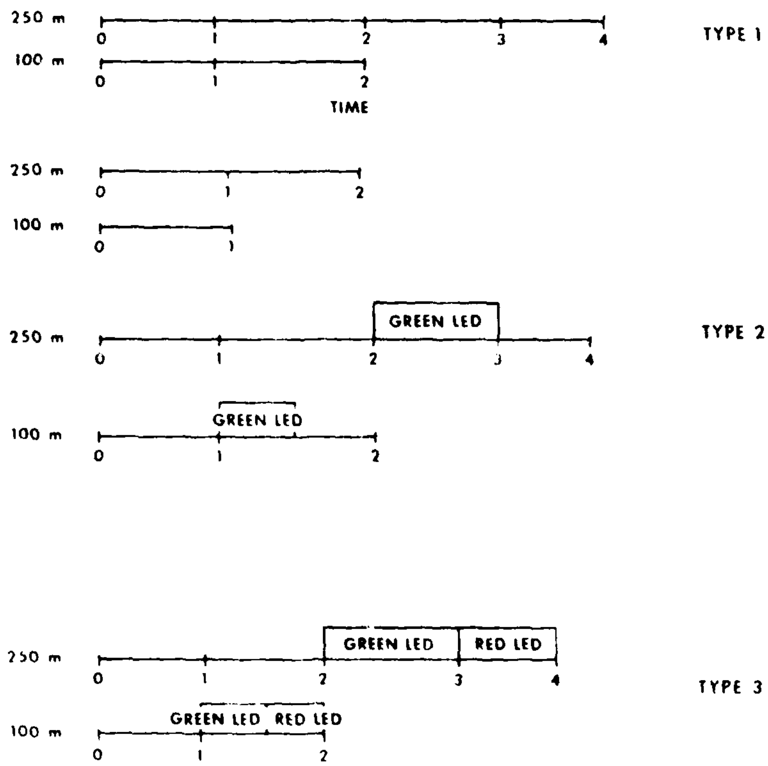

Figure 2. Diagram Showing Temporal Relations of LED Illimination and Target Exposure.

After completion of the first session (which was used as a practice session), subjects were scheduled for two additional sessions which occurred 4 days later, one session in the morning and one session in the afternoon. The subjects were divided into two groups of approximately equal ability. This was accomplished by rank-ordering all ten scores (total number of targets hit) and then alternately assigning successive individuals to the two groups. The mean baseline performance of the two groups so formed was nearly equal; however, a few reassignments were made to make the means and the standard deviations of the scores of the two groups as similar as possible.

During the second and third experimental sessions, the two groups were required to complete a total of four 45-shot sequences. These sessions differed from the baseline sessions in that the ratio of trial types was varied for the two groups; in the baseline sessions, all subjects were exposed to equal ratios of the three trial types.

Group One (the high-density laser group) was presented with 24 Type-1 (no laser) trials, 8 presentations of each target; 45 Type-2 (scanning alone) trials, 15 presentations of each target; and 111 Type-3 (scanning plus attack) trials, 37 presentations of each target. Group Two was presented with 111 Type-1 trials, 37 presentations of each target; 45 Type-2 trials, 15 presentations of each target; and 24 Type-3 trials, 8 presentations of each target. For both groups, a total of 180 trials was used. The order of target/trial type presentation was randomized for each subject with the restrictions discussed above. After completion of each 45-shot series, subjects were given feedback on their performance and allowed a few minutes to rest. At the conclusion of the experiment subjects were thanked for their participation and told that they would be notified, in a few days, of whether or not they had been awarded a pass.

RESULTS

The dependent measure used in this experiment was the hit, miss or late score generated by WEAPONEER for each shot. (Late shots were counted as misses.) These scores were used to compute a percent hit score for each subject in each condition of the experiment. The data were then entered into *t*-tests or ANOVAs as appropriate.

An ANOVA was conducted on the percent-hit scores for the 180 trials in the experimental sessions. One between-group factor (trial type ratio) and two within-subject factors (trial type and target) were analyzed. Appendix 1 summarizes this analysis of variance. As expected, there was a significant effect of trial type ($F(2, 16) = 17.6$, $p < .001$), target ($F(2, 16) = 15.9$, $p < .002$, the target-by-trial-type interaction ($F(4, 32) = 3.2$, $p < .03$), and a marginally significant target-by-trial-type-by-group interaction ($F(4, 32) = 2.6$, $p < .056$). Figure 3 shows the mean percent hits for these data. The particularly poor performance on the 100-m target for scanning-plus-attack (Type 3) trials is explained by the extremely short (1.5 s) response time allowed the subjects on these trials. The automatic data recording equipment used in this study allowed more accurate documentation of this performance than in our other study (1), in which these data were recorded manually. Post-hoc Least Significant Difference Tests showed that, for the high-density laser group, performance on each trial type was significantly different from both other trial types: no-laser performance was better than scanning-only performance, which was better than scanning-plus-attack-laser trial performance. For the low-density laser group, no-laser performance was better than scanning-plus-attack-laser performance, and scanning-alone performance was higher than scanning-plus-attack performance, but there was not a significant difference between no-laser performance and scanning-alone performance. In general, performance on the 100-m target was better than performance on the two 250-m targets.

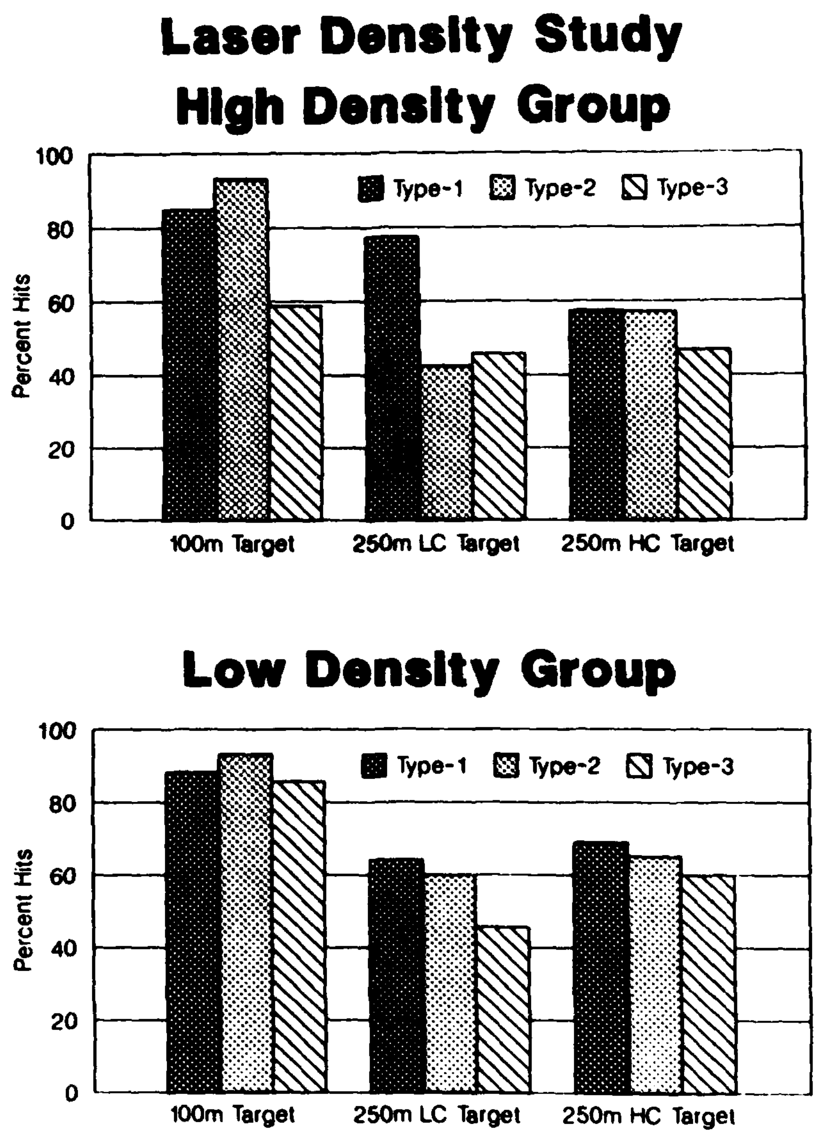

Figure 3. Histogram Showing Mean Percent Hits for Both Groups on All Targets for All Trial Types.

There was a considerable effect of experience on performance. Figure 4 shows mean percent hits arranged across targets for the baseline trials (90 trials, all subjects included) and for the 180 experimental trials considered separately for each group. This presentation clearly shows the overall improvement in performance from the baseline to the experimental trials and also the tendency for performance on Type-2 trials to improve for the high-density group with more practice. Even after 180 trials, though, a measurable difference in performance between the two groups was seen for these trials. Mean percent hits were also tabulated separately

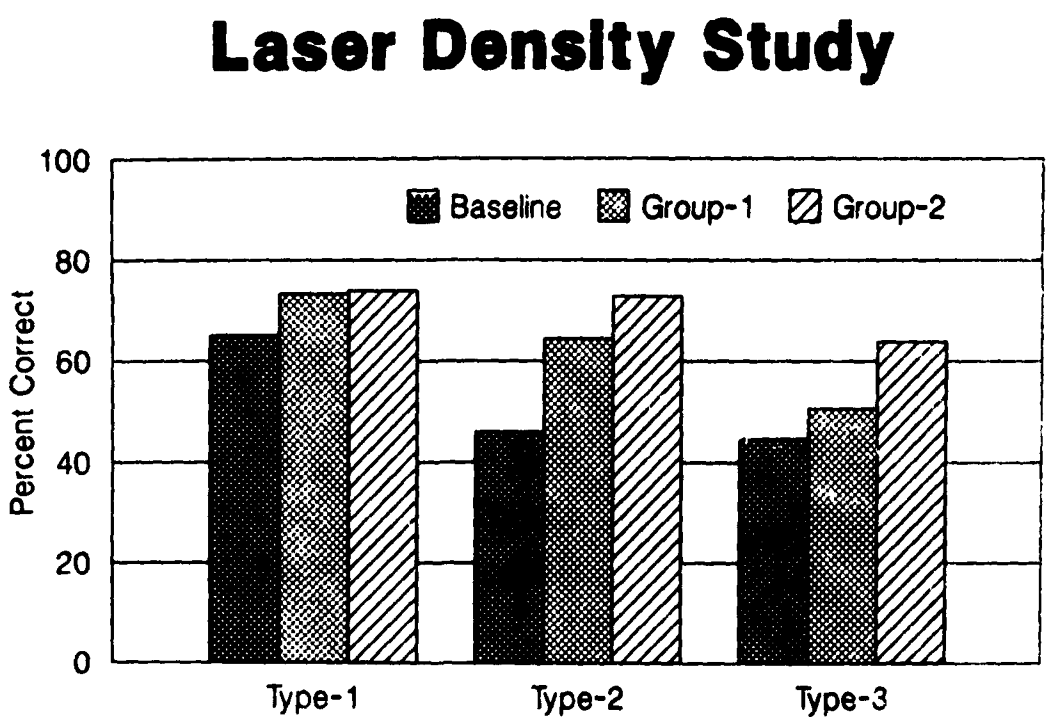

Figure 4. Histogram Showing Mean Percent Hits for Both Groups Together (Baseline nd Separately Arranged Across Targets.

for the first 90 trials and the last 90 trials of the experimental sessions. As can be seen in Figure 5, performance in the latter 90 trials was considerably better than in the first part of the session. A higher percentage of hits was scored for all three trial types by both groups over the last 90 trials, as compared to their performance on the first 90 trials. The improvement was most marked on Type-3 trials, where performance improved by nearly one third for each group. Despite these improvements, the subjects in the high-density laser group continued to perform worse than the subjects who received relatively few Type-3 trials, and by approximately the same amount. Moreover, the difference in performance on Type-2 trials between the two groups was much less after 180 trials than after the first 90 trials. This was accounted for mainly by an improvement on Type-2 trials by the high-density laser group. Extended practice thus seems to diminish the observed psychological effect.

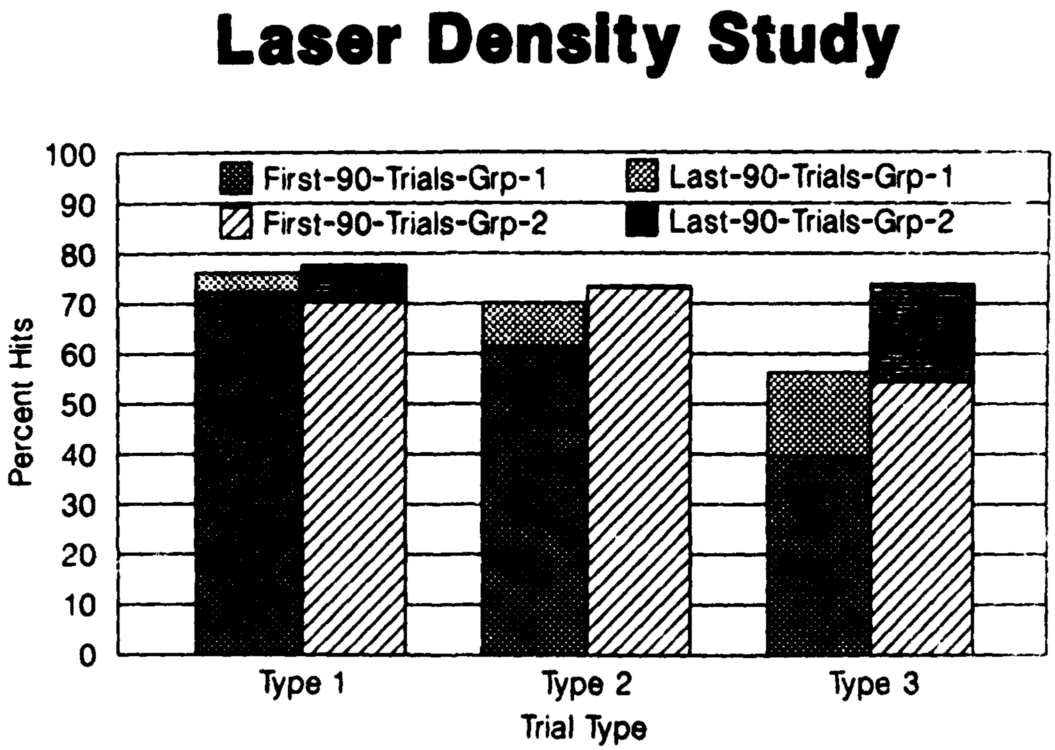

Figure 5. Stacked Histogram Showing Mean Percent Hits for Both Groups on All Trial Types for the First 90 and Last 90 Finals of the Experimental Sessions.

DISCUSSION

The hypothesis that the density of scanning-plus-attack-laser trials would affect performance on scanning-alone trials was supported in this study. It was shown that the more likely a soldier is to encounter a laser weapon, the greater the observed effect on his performance. We also showed that the magnitude of this effect diminishes as soldiers gain more experience and practice.

We interpret these findings as indicative of a change in strategy adopted by the subjects in response to the demands of the laser scenario. The presence of the scanning-plus-attack trials caused subjects to attempt to fire more quickly, resulting in decreased accuracy on scanning-plus-attack trials and (for the high-density group) scanning-alone trials. Apparently, the subjects in the high-density group made a more radical change in their strategy than did subjects in the low-density laser group.

Conclusion

These results are significant because they show that if reliable information about the parameters of potential laser use can be obtained, then predictions of performance degradation in various situations can be generated using these behavioral techniques. Moreover, training programs can be designed that will mitigate the deleterious effects of the strategy changes soldiers make in response to the presence of these weapons.

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1. Mastroianni GR, Zwick H, Stuck BE.

2. Schendel JD, Heller FH. Use of Weaponeer marksmanship trainer in predicting M16A1 rifle qualification performance. Hum Factors 1985;27:313-325.

Appendix 1

Analysis of Variance

SOURCE	DEGREES OF FREEDOM	MEAN SQUARE	F	TAIL PROB.
MEAN	1	397736.55827	371.86	.0000
GRP	1	1230.62053	1.15	.3147
ERROR	8	1069.59440		
R	2	2125.52387	17.63	
RG	2	305.46669	2.53	.1107
ERROR	16	120.58202		
S	2	7065.47347	15.92	
SG	2	214.81803	.48	.6249
ERROR	16	443.67646		
RS	4	514.31468	3.16	.0270
RSG	4	419.12487	2.57	.0565
ERROR	32	162.94254		