Technical Report 69-12

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Acquisition, Retention, and Retraining: Training Category IV Personnel With Low Fidelity Devices

by

Douglas L. Grimsley

HumRRO Division No. 3 (Recruit Training)

June 1969

Prepared for:

Office, Chief of
Research and Development
Department of the Army

Contract DAHC 19-69-C-0018

HumRRO

The George Washington University
HUMAN RESOURCES RESEARCH OFFICE

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SUBJECT: Acquisition, Retention, and Retraining: Training Category IV Personnel With Low Fidelity Devices

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1. This report describes research on the effects of the degree of fidelity of training devices on acquisition, retention, and retraining of the ability of low mental aptitude personnel to perform as operators of a Nike-Hercules guided missile system. It also integrates new experimental findings with data from previous studies in this series.

2. This report will be of interest to military personnel concerned with training and training devices, especially for procedural tasks, and to those concerned with training and utilization of mental Category IV personnel.

FOR THE CHIEF OF RESEARCH AND DEVELOPMENT:

1 Incl
as

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Acquisition, Retention, and Retraining: Training Category IV Personnel With Low Fidelity Devices

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Technical Report 69-12
Work Unit STRANGER
Sub-Unit III

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FOREWORD

The objective of HumRRO Work Unit STRANGER is to examine and obtain a better understanding of long-term memory of motor skills. STRANGER III deals with retention and retraining of skills acquired under various simulated procedures.

The research reported here is of theoretical importance for the area of simulated training and is of practical significance from a training device requirement standpoint and from the viewpoint of efficacy of training, remembering, and retraining. The findings support the information supplied in earlier reports from STRANGER III and extend the conclusions to cover high and low aptitude trainees.

This report integrates the data from the previous studies in this series and also the existing literature on procedural tasks in general. Specific conclusions are reached concerning the efficacy of low fidelity equipment for training men to perform procedural tasks and ideas for future work are offered.

STRANGER III studies were performed during 1967 by HumRRO Division No. 3 (Recruit Training) at the Presidio of Monterey, California. Director of Research was Dr. Howard H. McFann.

Military support for the study was provided by the U.S. Army Training Center Human Research Unit. Military Chief of the Unit at the time the study was conducted was LTC David S. M :shall.

Assisting in the collection of the data were SP 4 Lynn C. Fox, SP 4 Eugene R. Brown, and SP 4 Louis E. Moore. The data analysis was performed by Mr. William H. Burckhartt.

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Meredith P. Crawford
Director
Human Resources Research Office

SUMMARY AND CONCLUSIONS

Military Problem

A number of studies have shown that the fidelity of simulators used in training for procedural tasks can be very low with no adverse effect on training. Little is known, however, about the long-term retention and reinstatement of performance following training on these low fidelity simulators. If relatively inexpensive training devices are as efficient for acquisition, retention, and reinstatement as the real equipment, their utilization could lead to greater efficiency and training economy.

Research Problem

In the first report from STRANGER III (1), which involved individual training of personnel in AFQT Mental Categories I-III, there were no differences in training time, initial performance level, amount remembered after four and six weeks, or retraining time between individuals trained on high and low fidelity devices.

The second report from STRANGER III (2) examined the effects of varying the fidelity of training devices on acquisition, retention, and reinstatement of a procedural task when group training procedures were used, and reported additional information on the efficacy of low fidelity devices for group training and retraining.

The research reported here examined the effects of varying the fidelity of training devices on acquisition, retention, and reinstatement in low aptitude trainees (as defined by the AFQT). Men in Mental Category IV were selected for study.

Method

Trainees were trained individually to operate the Section Control Indicator (SCI) console of the Nike-Hercules guided missile system during Blue (preparation) and Red (firing) Status.

The men were trained on one of three panels differing in appearance and/or functional fidelity:

(1) *Hot Panel*, a physical duplicate of the tactical panel in which all lights, meters, intercom, and other indicators functioned.

(2) *Cold Panel*, identical to Hot Panel except there was no electric power.

(3) *Reproduced Panel*, a full-size artist's representation (in color) of the Hot Panel.

Each man was tested immediately after training and approximately four and six weeks later to see how much of the procedure he remembered; he was then retrained to criterion.

Results

Low aptitude subjects can be trained to a high level of performance on a long, complicated procedural task using only low fidelity training devices. The results indicated that Category IV men required more time to master the task than non-Category IV trainees. There were no practical differences in training time, initial performance level, amount remembered after four and six weeks, or retraining time between Category IV groups trained on high and low fidelity devices for this procedural task. These results are consistent with those of non-Category IV men, as described in the previous STRANGER III reports (1, 2), and the RINGER report (3).

Conclusions

To train men to perform procedural tasks, the fidelity of training devices can be low with no adverse effect on training time, level of proficiency, amount remembered over time, or time to retrain.

This report integrates the data from the previous studies in this series, and the existing literature on procedural tasks in general. Without exception, men could be effectively trained to perform a procedural task as well on a very simple, low fidelity reproduction as on a functional, high fidelity device. This is true regardless of whether the training is individually or group administered. Low fidelity devices, in conjunction with a list of the correct actions to be taken, can be used to effectively reinstate a high level of performance after the passage of time, regardless of the panel used for original training.

These results are also consistent with those of other researchers who have shown that for fixed procedural tasks–ranging from starting and stopping a tank to controlling course and depth in a submarine–fidelity is relatively unimportant in the training device.

A careful review of tasks to be taught should precede selection of training devices. Low fidelity devices may be used to considerable advantage both economically and from the viewpoint of efficacy of training, remembering, and retraining.

CONTENTS

Acquisition, Retention, and Retraining: Training Category IV Personnel With Low Fidelity Devices

INTRODUCTION

Many studies (3-10) have shown that the fidelity[1] of devices used in training men to perform procedural tasks can be very low with no adverse effect on training. For example, in a series of experiments performed under HumRRO Work Unit RINGER (3) the fidelity of devices used to train men on the Nike-Hercules missile system was varied in either a functional or appearance dimension. The results showed that the requirements for fidelity in the training device were quite low—the photographic reproduction trained men just as effectively as the device of highest fidelity. Lowering the fidelity by reducing the size of the photographic reproduction had no effect on proficiency as long as the elements were clearly visible.

Even though it has been shown that under certain circumstances fidelity is relatively unimportant in training to a specified criterion, an equally important concern is the retention of the task performance. Is material learned under low fidelity procedures retained as long as that learned under high fidelity conditions? Is a task learned on a low fidelity device retained equally well by high and low aptitude subjects? Is there a difference in reinstatement of performance between groups trained on low vs. high fidelity devices? If retention is poorer or reinstatement of performance more difficult following training on low fidelity devices, then, in the long run, high fidelity devices for training may be more economical.

The purpose of STRANGER III was to examine the effect of varying fidelity of the training device on acquisition, retention, and reinstatement of a procedural task. The results of this effort have been presented in three reports.

The first report from STRANGER III (1) extended the general conclusions obtained in RINGER (3) by providing retention and reinstatement data for subjects trained on devices of varying fidelity. Subjects were trained individually to operate the Section Control Indicator (SCI) console of the Nike-Hercules guided missile system. Three panels, differing in appearance and/or functional fidelity, were selected from those employed by RINGER: (a) Hot Panel, a physical duplicate of the tactical equipment; (b) Cold Panel, identical to the Hot Panel except none of the instruments worked; and (c) Reproduced Panel, an artist's representation of the Hot Panel.

Approximately four and six weeks later they were retested and retrained to the original level of proficiency. The results indicated that there were no differences in training time, initial performance level, amount remembered after four and six weeks, or retraining time between individuals trained on high and low fidelity devices. Of particular interest was the finding that the subjects remembered equally well even when they had not been exposed to the high fidelity device during training.

In the second report from STRANGER III (2) five different studies were performed using the equipment and the same general procedure described above.

[1]The degree to which a device resembles the tactical equipment for which it is a substitute.

All subjects were trained and tested in groups. Study I attempted to replicate the general findings reported in the first report from STRANGER III on individual training by repeating the same general experimental design but employing group training procedures. In Study II, the importance of exposure to the high fidelity equipment prior to testing for those trained on a low fidelity device was assessed. Study III was an investigation of various methods of reinstating the original level of performance after a lapse of time. The focus of Study IV was on the curve of forgetting over time. Study V was included to see whether knowledge of eventual retesting would affect retest performance.

The results can be summarized as follows:

(1) There were no significant differences in training time, initial performance level, amount remembered after four and six weeks, or retraining time between groups trained on high and those trained on low fidelity devices. These findings are in complete agreement with the results reported earlier from STRANGER III (1) and thus occur regardless of whether training is individually or group administered.

(2) Brief practice on the high fidelity device immediately after training on the low fidelity device could lead to a greater number of perfect scores by groups initially trained on a low fidelity device.

(3) A demonstration of the correct procedure or a showing of the list of correct actions plus a picture of a low fidelity panel to practice on were the most effective reinstatement procedures. Presenting the list of correct actions alone had about the same effect as no reinstatement training at all.

(4) There was no significant difference in retest performance for groups tested at four weeks compared to those tested at six weeks, though the six-week group did take more trials and more time to retrain.

(5) Subjects with advance information that they were to be retested showed no retest score advantage over subjects who had not had this information.

The purpose of this final report from STRANGER III was to examine the effects of varying the fidelity of training devices on acquisition, retention, and reinstatement in low aptitude trainees. It is particularly important that this information be available since large numbers of low aptitude personnel are now entering the military service. Under Project 100,000, for instance, 100,000 men who score at the bottom of the Armed Forces Qualification Test (AFQT) and who would formerly have been rejected from military service are now being inducted each year. Supplying adequate training equipment and the right procedures for learning are especially important to the low aptitude trainee.[1]

It is important to know whether the conclusions reached in the earlier STRANGER III reports also apply to Mental Category IV personnel. Specifically, can low fidelity equipment be used to train low aptitude trainees? Do low aptitude men learn as fast and to the same level of proficiency as those of high aptitude? Do low aptitude personnel retain the material over time as well as high aptitude trainees? These are some of the questions explored in this report.

APPROACH TO THE RESEARCH

DEFINING THE TASK

The task and equipment used in this study are identical to those used in Work Unit RINGER (3) and earlier STRANGER III work (1, 2). Briefly, the task

[1]A detailed study of the relationship between aptitude level and training performance, using a variety of tasks from simple to complex, was made under HumRRO Work Unit SPECTRUM (11).

requires learning the responses made by an operator of an SCI panel of a Nike-Hercules guided missile system during preparation and firing status. The entire sequence consists of 92 actions, which, with their frequency of occurrence, are shown in Table 1. (The complete 92-step sequence is presented in Appendix A.)

In each step, the operator receives a signal to which he must make a specific response. The signal for an action may simply be the completion of the previous action or the action to be taken may be to monitor or wait for the next signal. Each such unit (signal and action) is considered an individual step in this procedure.

Table 1

Description and Frequency of Required Actions in a Specified Procedural Task

Action	Frequency
Operating a toggle switch	29
Operating a push-button switch	8
Operating a rotary switch	2
Operating a rheostat control	2
Operating a banana plug	1
Writing the time	3
Giving a verbal response on phone or intercom	11
Monitoring a light	18
Monitoring a sound, oral or machine originated	16
Monitoring a meter	2

SUBJECTS

Seventy-two trainees in Advanced Individual Training from the U.S. Army Training Center at Fort Ord, California were randomly assigned to the experimental conditions with 12 trainees per condition. Thirty-six subjects had AFQT scores above 30[1] (Mental Categories I-III) and 36 had scores below 30 (Mental Category IV).

TRAINING DEVICES

Subjects were trained on one of three panels which differed in appearance or functional fidelity:

(1) Hot Panel. This device is a physical duplicate of the tactical SCI. Every light, switch, meter, intercom, and telephone is functional.

(2) Cold Panel. This device is identical to the Hot Panel except that there is no electric power. Therefore, no light, meter, intercom, or telephone functions, although the switches can be operated.

(3) Reproduced Panel. This is a full-size reproduction on cardboard of the Hot Panel and is painted (in color) to resemble an illuminated Hot Panel.

CONDUCT OF THE RESEARCH

TRAINING PROCEDURES

The subjects were trained individually, with two enlisted men on the research staff serving as instructors.[2] Each instructor trained approximately the same number of subjects. All retesting was conducted by one instructor.

The subject was told that he would be trained to operate a piece of Nike-Hercules equipment. The instructor then showed a diagram of a typical Nike-Hercules site (see Appendix B) and described the function of the major pieces of

[1]These data were also published in the first report from STRANGER III (1).

[2]There were no differences between instructors on any of the variables studied ($p > .05$).

equipment. Using the particular simulator on which the subject would be trained, a demonstration talk-through of the 92-step procedure was presented.

The instructor demonstrated and described the signal for an action and the action itself, and gave a brief, simple explanation of why the action is taken. For example, the first signal is the simultaneous onset of a "Blue Status" light and sound of an alarm buzzer, and the proper action is to turn the power switch to the ON position. The explanation given was, "Turning the power switch ON provides electric power to this panel."

When the instructor had completed the 92-step procedure demonstration, the subject attempted to perform the procedure. When an error was made it was immediately corrected and the procedure continued. It was pointed out that certain sections of the procedure could be grouped together for easier learning. The instructor used verbal expressions, such as "good" and "that's right," to reinforce correct actions. (Not every action was reinforced and no attempt was made to follow an exact schedule, although reinforcement was used more frequently in the early stages of training.)

Cueing was also used when a subject hesitated to take some specific action after he had apparently recognized the signal. For example, completion of the seventh action ("Plug the Headset-Handset into Station 2") is the signal for the eighth action, which is to announce over the Headset-Handset, "Blue Status received, Section A." If, during the training, the subject completed action seven and hesitated too long in making his announcement, the instructor might say, "You plugged it in, now use it." As was the case with the verbal reinforcement, cueing was used more often in the early part of training.

A tactical SCI automatically furnishes knowledge of results to an operator after many of his actions. For example, when the Prepared button for Launcher #1 is pressed, the Red Prepared light goes out and the Green Prepared light goes on. Of the simulator training devices, only the Hot Panel provided this same knowledge of results. For the other two devices, the instructor provided the trainees this information orally. Using the example above, when the Prepared button was pressed, the instructor would say, while pointing to the proper lights, "Now this red light is off, and this green light is on."

On the Cold and Reproduced Panels the subject could only "speak" certain actions instead of actually performing them. The trainee had to verbalize that "The red light is off, and the green one now is on." Trainees on the Cold Panel actually threw the switches on the panel while Reproduced Panel trainees simply went through the motions of throwing the switches.

The training session was continuous, except for an occasional brief rest break, until the subject could perform one errorless trial or until the maximum time of three and one-half hours was reached.

TESTING

Approximately five minutes after completing training, the subject was given a proficiency level test on the Hot Panel, which was considered equivalent to the tactical SCI. The trainee was told that he was to perform the 92-step procedure using the Hot Panel and that all parts of the device operated. He was cautioned to take his time and asked if there were any questions. Then the instructor operated a switch that turned on the Blue Status light and alarm buzzer and the trainee began the test.

In every case, the alternate instructor was present in the room and acted as scorer, keeping a record of the trainee's errors. Each step omitted or

taken out of sequence constituted an error. Any question about procedure asked by the trainee was answered by the instructor and an error scored for that step. If the trainee made an error which would have prevented continuance, the instructor corrected and recorded it, and the trainee continued with the test.

The trainee was told that he would be scored on accuracy only and that time was not a factor on the test. The proficiency score was the number of steps performed correctly.

RETESTING

Approximately four weeks after training (26-30 days), each subject was brought back and all were tested on the Hot Panel. The previously described testing procedure was used. After the test the instructor reviewed any errors made by the subject and pointed out the correct action.

Two weeks (14-18 days) after the first retest, a second retest was given following the same test procedure. After the test, any errors were corrected and the trainee attempted to perform the procedure correctly. Continued attempts were made until the trainee reached a criterion of 90 correct or better. Both the number of trials and time to reach criterion were recorded.

RESULTS

The mean AFQT scores for the 12 subjects in each treatment group are shown in Table 2. A comparison of aptitude scores across treatment groups indicated no differences in mean AFQT scores within the high or low aptitude groups.

The mean time to train for each treatment group, based on 12 subjects per group, is shown in Table 3. Analysis of variance performed on the data shown in Table 3 indicated that the higher aptitude trainees took significantly less time to attain criterion than did the low aptitude trainees—$\underline{F}$ (1, 66) = 28.20, $\underline{p} = < .001$. On the average, the low aptitude trainees took about 50 minutes longer to train than those of higher aptitude. This is a conservative estimate, as not all low aptitude trainees achieved the performance criterion of 90 correct responses, or better. A total of five Low AFQT subjects (one in the Hot Panel group, two in the Cold Panel group, and two in the Reproduced Panel group) failed to reach criterion. It is worthy of note that even though it took more time, the majority of Low AFQT trainees could be trained to perform this procedural task.

Table 2

AFQT Mean Scores by Treatment Group

Aptitude Group	Hot Panel	Cold Panel	Repro Panel
High-AFQT			
Mean	78.1	78.8	79.2
Low-AFQT			
Mean	18.1	16.8	17.4

Table 3

Mean Time to Criterion Scores
(Minutes)

Aptitude Group	Hot Panel	Cold Panel	Repro Panel
High-AFQT			
Mean	114.0	119.3	97.8
Low-AFQT			
Mean	153.8	160.0	164.2

The fidelity of the training panel had little effect on training time—$F(2,66) = .31$—and there was no aptitude by fidelity interaction effect—$F(2,66) = .92$.

The mean number of correct responses for each treatment group on the first retention measure taken only a few minutes after training is shown in Table 4. All retention testing was performed on the Hot Panel. Those subjects in the low aptitude group who failed to attain the performance criterion are not included in the remainder of the data summaries and analyses. In the Low AFQT group there were 11 trained on the Hot Panel, 10 on the Cold Panel, and 10 on the Repro Panel.

Unequal N analysis of variance (Winer, 12) indicated no significant differences between aptitude groups—$F(1, 61) = 2.84$. There was, however, a significant effect due to the fidelity of the training panel—$F(2, 61) = 8.51$, $p = < .001$. Those subjects trained on the Hot Panel performed better than those trained on the other panels. Inasmuch as there was a confounding of retention and transfer effects in this condition, it is not possible to state that fidelity alone had an adverse effect upon retention. Although statistically significant, the actual group differences are slight and, except for theoretical consideration, have little significance for the design of simulation devices. The aptitude by fidelity interaction effect was not significant—$F(2, 66) = .41$.

The mean number of correct responses for each treatment group on the first retest, taken four weeks after training, is recorded in Table 5. None of the main effects or the aptitude by fidelity interaction effect was significant—Aptitude: $F(1, 61) = 3.60$; Fidelity: $F(2, 61) = .01$; Aptitude by Fidelity: $F(2, 61) = .10$. Thus, it can be concluded that the treatment groups retained approximately the same number of responses over the four-week retention interval.

Table 4

Mean Number Correct on Test of Immediate Retention

Aptitude Group	Hot Panel	Cold Panel	Repro Panel
High-AFQT Mean	90.9	89.2	88.3
Low-AFQT Mean	90.5	88.0	86.5

Table 5

Mean Number of Correct Responses on Four-Week Retention Test

Aptitude Group	Hot Panel	Cold Panel	Repro Panel
High-AFQT Mean	75.7	75.0	75.0
Low-AFQT Mean	72.4	73.0	72.9

The mean scores for each treatment group for the remaining variables, the second retention measure taken six weeks after training, the time taken for retraining, and the number of trials required during retraining to attain the performance criterion are shown in Table 6. Retraining for all treatment groups was performed on the Hot Panel. Analysis of the data indicated highly significant aptitude effects on all three variables—Retest 2: $F(1, 61) = 12.09$, $p = < .001$; Time to Retrain: $F(1, 61) = 11.36$, $p = < .005$; Trials to Retrain; $F(1, 61) = 17.36$, $p = < .001$. Neither the fidelity main effect nor the aptitude by fidelity interaction for any of the variables approached significance.

It is obvious from a comparison of the first and second retention test mean scores that all treatment groups benefited from the practice afforded by the four-week retention measure. It is not unreasonable to expect that the experience gained during the first retention test would not be as effective for the low

Table 6

Mean Scores for Retest 2, Retraining, and Trials to Retrain

Test	Treatment Group					
	High-AFQT			Low-AFQT		
	Hot Panel	Cold Panel	Repro Panel	Hot Panel	Cold Panel	Repro Panel
Retest 2						
Mean	82.9	83.3	83.6	78.8	79.6	78.7
Retrain (minutes)						
Mean	20.7	19.9	17.8	26.1	26.3	27.2
Trials to retrain						
Mean	2.5	2.5	2.2	3.3	3.4	3.2

as for the high aptitude groups in light of the large aptitude differences recorded during initial training on the task. Thus, little emphasis should be placed on the findings from this study of significant aptitude effects on the six-week retention and retraining measures. It is again worth noting that all but one of the low aptitude subjects were retrained to criterion in the allotted time, including those who did not achieve criterion during initial training on the task.

DISCUSSION

The findings related to the training of Mental Category IV personnel with low fidelity devices are in agreement with the results reported earlier for non-Category subjects. That is, most low aptitude subjects can be trained to a high level of performance on a long, complicated procedural task using only low fidelity training devices. They retain the performance well over time and can be retrained to a high level of performance after the passage of time.

For the high aptitude subjects, the low fidelity equipment was sufficient to train them to a high level of performance. They retained the performance well over time and could be easily retrained.

The results from the present study are in agreement with the findings reported earlier (1, 2) for individual and group training. Moreover, the results support and extend the findings reported from Work Unit RINGER (3) which employed the same training devices as the present study and a generally similar experimental procedure. The conclusions from both studies were very similar even though collected by different instructors at different times, and utilizing a different subject pool. Such a finding ensures greater generality of the conclusions reached in this report.

The present results are also consistent with those of other researchers who have shown that for fixed procedural tasks fidelity is relatively unimportant in the training device (4-10). The implications for increased efficiency with a substantial decrease in cost are clear. It has been shown, for instance, that low fidelity devices are as good as the real equipment for training men to perform the following tasks: Learning basic instrument and radio-range procedures in aircraft (6); control of the course and depth of a submarine (8); pre-start check, engine start, engine run-up, and engine shut down of aircraft (9);

preparation and firing status of a Nike-Hercules guided missile system (1); and starting and stopping procedures in a tank (5). Since the efficacy of low fidelity equipment has been demonstrated in such a wide variety of tasks, there should be a careful review of the tasks to be taught in order to employ inexpensive devices where possible.

Several points concerning the Mental Category IV subjects were obvious in the data collected in this study. First, the low aptitude personnel are a heterogeneous group, composed of men ranging in accomplishment from those who cannot read at the fifth grade level to those who have some college training. Since the data from this group are quite variable, it is difficult to characterize the "typical" or "average" Mental Category IV subject.

A second point, related to the first, is that several of the low aptitude subjects performed better in the present study than did men of higher aptitude. In fact, the fastest learning time was recorded by a low aptitude subject trained on the Cold Panel. Because of the high performance of some Mental Category IV subjects, there was overlap between the low aptitude and higher aptitude groups.

In training low aptitude subjects it became clear that most could learn the procedural task employed in this study. They took longer to reach criterion, requiring more practice than high aptitude men, but they eventually learned. The same is true for the retraining phase—they required more trials and more time but most eventually reached the criterion of at least 90 correct. Therefore it seems that the low aptitude subject can usually learn to perform a procedural task if given a greater amount of time than the higher aptitude man.

More information about learning and aptitude level is provided by research performed under HumRRO Work Unit SPECTRUM (11), which found that performance is directly related to aptitude level. This relationship was verified across a variety of tasks and also along a hierarchy of complexity varying from simple stimulus-response, through motor, verbal chaining, and multiple discrimination, to tasks having to do with the learning of principles.

In some tasks, the differences among the aptitude groups were in rate of learning only; in other tasks, the groups differed both in rate and in final levels of performance. In general, the low aptitude subjects "were slower to respond, required more training time to attain a specified criterion, needed more guidance and repetition of instruction, and were decidedly more variable as a group than the middle and high aptitude subjects" (11). The low aptitude person can learn to perform a variety of tasks, however, if the training methods have been carefully selected and organized to facilitate his assimilation of the instruction.

It should be noted that there was a significant difference attributable to the fidelity of the training device. The fact that the proficiency score five minutes after training was significantly higher for the Hot Panel group suggests that individuals will perform better immediately after training if trained on a high fidelity device. This demand for high fidelity equipment should not be urged too strongly, however, since the differences in practical terms were slight and the fidelity of training panel did not lead to statistical differences on any other variable.

The fidelity of training panel was not an important variable when retention of performance over time is considered. Subjects trained on low fidelity equipment remembered just as well after four and six weeks as subjects trained on the high fidelity device. In other words, a person remembered just as much after being trained on a picture of the equipment as he remembered following training on the equipment itself.

It seems appropriate at the close of this last report from STRANGER III to indicate some general opinions and conclusions reached by the author during preparation of these reports. The general use of simulated training and the use of simulated situations has mushroomed in the last 20 years. The wide variety of uses of the term simulation (13) supports the widespread employment of the concept. From classroom teaching situation to computer warfare, from learning to start a tank to "think tanks," the concept of simulation is being explored.

There seems to be ample evidence to show that for training men to perform many of the tasks important in the military services, low fidelity equipment is sufficient. The high caliber instructors currently using high fidelity or the real equipment could be just as successful, in many cases, with a picture or drawing of the device. The saving in initial cost, maintenance, and obsolescence could be a staggering amount. This is in addition to increased efficiency of training, since the low fidelity equipment would always be in operating condition, would not be dangerous or expensive to operate, would be suited to repeated practice on difficult aspects of training, and could be made available on a one-per-man basis. These advantages would be highly appropriate to reserve units, where it is even more difficult than in regular military services to obtain and maintain the latest in military equipment.

The areas of training in which simulation can be effectively employed are varied. For the civilian educational system such things as line drawings and simple pictures may replace expensive and often fragile models. There is some evidence for trends in this direction (14). In the military, training devices of low fidelity may be used not only to replace existing equipment, as indicated earlier, but also to prepare and train troops for the arrival of new equipment. Soldiers could be given training on additional pieces of equipment with minimum cost. For example, infantry trainees could be taught indirect fire techniques on a mortar by the use of drawings, without actually firing any shells. They could be allowed one session of "dry firing" where their accuracy is evaluated by slides showing explosions, or perhaps orally by the instructor. A simple study could evaluate the efficacy of these two feedback procedures.

CONCLUSIONS

The fidelity of training devices used to train men to perform procedural tasks can be very low with no adverse effect on time to train, level of proficiency, amount remembered over time, or time to retrain. These conclusions apply to both individual and group training situations. Furthermore, low fidelity equipment can be used for retraining by allowing practice with a list of the correct actions to be taken, plus the low fidelity device. Therefore, training device selection should be based on a careful review of the tasks to be taught in order to employ inexpensive devices where possible. These statements apply to the conclusions reached from all of the STRANGER III reports.

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LITERATURE CITED
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APPENDICES

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Appendix A

COMPLETE SEQUENCE OF PROCEDURAL TASK

Standard Blue Status Procedures

Operator is standing before the SCI, which is open but "cold." He is monitoring for Blue Status light and Alarm buzzer to sound.

SIGNAL	ACTION
1. Buzzer and Blue Status light.	1. Throw Power switch to ON. 2. Throw Panel Light switch to ON. 3. Put hand under Panel Light to check for illumination level. 4. Adjust light level with control knob. 5. Throw all four Intercom (IC) switches to ON. 6. Throw all four Launcher Power switches to ON. 7. Plug Handset-Headset (HH) set into Station 2. 8. Announce "Blue Status received, Section A" on HH set. 9. Put IC switch to TALK and hold. 10. Announce "Blue Status" on IC. 11. Check and adjust mike level while announcing. 12. Release IC switch to LISTEN. 13. Press Alarm shutoff button till buzzer stops. 14. Monitor for "All crewmen present" on IC.
2. "All crewmen present" on IC.	15. Announce "All crewmen present, Section A" on HH set. 16. Monitor for "Battle Stations" on HH set.
3. "Battle Stations" on HH set.	17. Announce "Battle Stations received, Section A" on HH set. 18. Operate IC switch. 19. Monitor for green ON DECK light. 20. Announce "Battle Stations" on IC.
4. Green ON DECK light.	21. Monitor for "Launcher prepared" on IC.
5. "Launcher #1 prepared" on IC.	22. Press PREPARED button for #1.

SIGNAL	ACTION
	23. Monitor for green #1 PREPARED and SAME light.
6. Green #1 PREPARED and SAME light on.	24. Monitor for "Launcher prepared" on IC.
7. "Launcher #2 prepared" on IC.	25. Press PREPARED button for #2.
	26. Monitor for green #2 PREPARED and SAME light.
8. Green #2 PREPARED and SAME light on.	27. Monitor for "Launcher prepared" on IC.
9. "Launcher #3 prepared" on IC.	28. Press PREPARED button for #3.
	29. Monitor for green #3 PREPARED and SAME light.
10. Green #3 PREPARED and SAME light.	30. Monitor for "Launcher prepared" on IC.
11. "Launcher #4 prepared" on IC.	31. Press PREPARED button for #4.
	32. Monitor for green #4 PREPARED and SAME light.
12. Green #4 PREPARED and SAME light on.	
	33. Monitor for "Launcher ready" on IC.
13. "Launcher #1 ready" on IC.	34. Operate IC switch.
	35. Announce "Stand clear, Launcher #1 going up" on IC.
	36. Throw Launcher Elevation (LE) switch for #1 to UP.
14. Noise on IC.	37. Monitor noise on IC till it stops.
	38. Throw LE switch for #1 to OFF.
	39. Monitor for "Launcher ready" on IC.
15. "Launcher #2 ready" on IC.	40. Operate IC switch.
	41. Announce "Stand clear, Launcher #2 going up" on IC.
	42. Throw LE switch for #2 to UP.
16. Noise on IC.	43. Monitor noise on IC till it stops.
	44. Throw LE switch for #2 to OFF.
	45. Monitor for "Launcher ready" on IC.
17. "Launcher #3 ready" on IC.	46. Operate IC switch.
	47. Announce "Stand clear, Launcher #3 going up" on IC.
	48. Throw LE switch for #3 to UP.
18. Noise on IC.	49. Monitor noise on IC till it stops.
	50. Throw LE switch for #3 to OFF.
	51. Monitor for "Launcher ready" on IC.

SIGNAL	ACTION
19. "Launcher #4 ready" on IC.	52. Operate IC switch. 53. Annbunce "Stand clear, Launcher #4 going up" on IC. 54. Throw LE switch for #4 to UP.
20. Noise on IC.	55. Monitor noise on IC till it stops. 56. Throw LE switch for #4 to OFF. 57. Wait for Section Chief.
21. Section Chief comes into revetment.	58. Throw all four IC switches to OFF.
22. Section Chief turns safety keys to FIRE.	59. Monitor for four amber LAUNCHER READY lights.
23. All four LAUNCHER READY lights on.	60. Throw Heaters and Gyros (H&G) switch for #1 to ON. 61. Record time on log. 62. Monitor for green READY TO FIRE light for #1.
24. Green READY TO FIRE light #1 on.	63. Throw DESIGNATE switch to #1 strip. 64. Press LAUNCHER DESIGNATE button. 65. Monitor for green LAUNCHER DESIGNATE light.
25. Green LAUNCHER DESIGNATE light on.	66. Press SLEW button and hold through check.
26. Smooth movement of needle full left to full right twice.	67. Throw SECTION READY switch to READY. 68. Monitor for green SECTION READY light.
27. SECTION READY green light on.	69. Wait for Section Chief to OK.
28. Section Chief says "Blue Status checks complete."	70. Announce "Blue Status checks complete, Section A" on HH set.

Standard Red Status Procedures

Operator is standing in front of open SCI. Power is on. Blue Status is on. Checks are complete. Operator is wearing Handset-Headset (HH) set and is monitoring for Red Status.

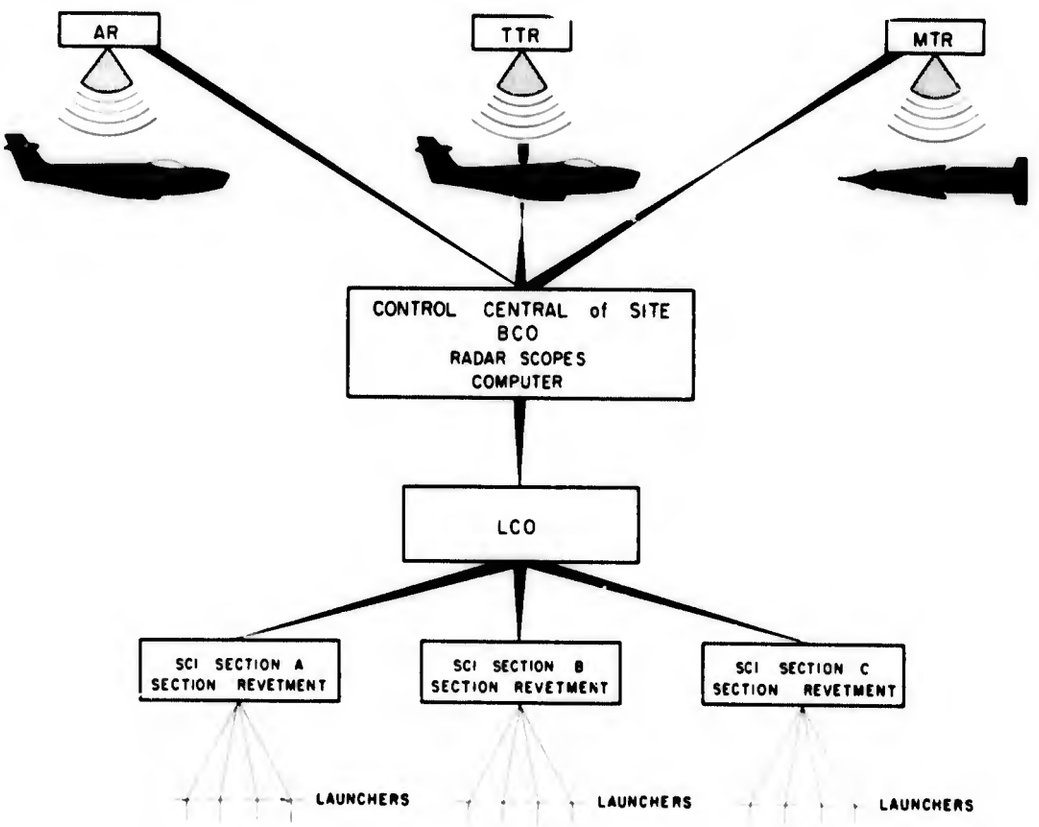
SIGNAL	ACTION
1. Red Status light on.	1. Monitor for Red Status light. 2. Announce over HH set, "Red Status received, Section A." 3. Monitor for green SELECTED light.
2. Green SELECTED light on.	4. Throw Heaters and Gyros (H&G) switch for #2 to ON. 5. Record time on log.

SIGNAL	ACTION
	6. Monitor for buzzer and green FIRE, LAUNCH ORDER, and MISSILE AWAY lights.
3. Buzzer, green FIRE, LAUNCH ORDER, and MISSILE AWAY lights on.	7. Throw SECTION READY switch down (OFF).
	8. Throw LAUNCHER ELEVATION switch for #1 to DOWN.
	9. Monitor for green READY TO FIRE light on #2.
	10. Move LAUNCHER ELEVATION switch for #1 to OFF.
4. Green #2 READY TO FIRE light on.	11. Throw DESIGNATE switch to #2 strip.
	12. Press LAUNCHER DESIGNATE button.
	13. Monitor for green LAUNCHER DESIGNATE light.
5. Green LAUNCHER DESIGNATE light on.	14. Press SLEW button.
	15. Monitor SLEW METER for correct check.
6. Smooth movement of needle left to 0, right to 0, twice.	16. Throw SECTION READY switch up (ON).
	17. Monitor for green SECTION READY light.
7. Green SECTION READY light on.	18. Monitor for green SELECTED light.
8. Green SELECTED light on.	19. Throw H&G switch for #3 to ON.
	20. Record time on log.
	21. Monitor for Buzzer and green FIRE, LAUNCH ORDER, and MISSILE AWAY lights.
9. Buzzer and green FIRE, LAUNCH ORDER, and MISSILE AWAY lights on.	22. Throw SECTION READY switch down (OFF).

Appendix B

ORIENTATION TO THE NIKE HERCULES SITE AND THE SECTION CONTROL INDICATOR (SCI)

The Nike Hercules is primarily an antiaircraft missile and can be armed with a nuclear warhead. The site consists of approximately eight major pieces of equipment. The layout varies from site to site, depending on geographic conditions, and on this chart you see one example of a basic site layout. This could represent an area of several miles and the only consistency is the separation of the IFC (Integrated Fire Control) area (the upper half of the diagram) from the launching area.



Acquisition Radar (AR)

The AR operates continually as it searches the area of protection. When a target has been acquired, the AR sends azimuth and range data to the Target Tracking Radar through the computer.

Target Tracking Radar (TTR)

The TTR locks on the target and tracks it until the target is either released by the Battery Control Officer (BCO) or destroyed by the selected missile. The tracking data is fed to the computer to enable it to plot the missile course to the intercept point.

Missile Tracking Radar (MTR)

When the missile is fired the MTR controls the flight pattern and sends missile position data to the computer.

The three radars have operators constantly monitoring the display scopes.

Battery Control Officer (BCO)

The computer information is monitored by the BCO who makes the final decision whether a missile should be launched.

Launcher Control Officer (LCO)

The LCO relays the commands from the BCO to the Section Control Indicator (SCI) operators. The LCO controls 12 missiles through three SCI panels, and it is his responsibility to select a missile for firing.

Section Control Indicator (SCI)

The operator of the SCI coordinates his duties with his Section Chief and the LCO. He checks the SCI daily and maintains communication between the LCO and the launcher crew. The SCI supplies the power to the four missiles on the launchers. The SCI operator is responsible for the crewmen and the status of the missile during this procedure.

You are here to learn the SCI procedures in Blue Status and Red Status. Blue Status is the procedure taken to prepare a missile for firing, and Red Status is the actual firing procedure.

Do you have any questions?

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13. ABSTRACT

Low (AFQT Mental Category IV) aptitude subjects with no previous experience on the equipment were trained individually to operate a guided missile control panel. Three panels differing in appearance and/or functional fidelity were used. Subjects were tested immediately after training, four and six weeks later, and then retrained to the original level of proficiency. The results indicated that the higher aptitude subjects (from data presented in earlier STRANGER reports) required significantly less training time than the low aptitude subjects. For all treatment groups there were no practical differences in training time, initial performance level, amount remembered after four and six weeks, or retraining time between groups trained on high and low fidelity devices for this procedural task. Thus training device selection should be based on a careful review of the tasks to be taught in order to employ inexpensive devices where possible.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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Retention						
Retraining						
Simulation						
Training						
Training Devices						