WADC TECHNICAL REPORT 54-533

TRANSFER OF TRAINING AFTER FIVE DAYS OF PRACTICE WITH ONE TASK OR WITH VARIED TASKS

CARL P. DUNCAN
BENTON J. UNDERWOOD

NORTHWESTERN UNIVERSITY

DECEMBER 1954

AERO MEDICAL LABORATORY
CONTRACT No. AF 33(616)-308
PROJECT No. 7197

WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Carpenter Litho & Prtg. Co., Springfield, O.
200 - 21 April 1955

ABSTRACT

Transfer among perceptual-motor paired-associate tasks was studied as a function of constant and varied training conditions. Over five days of training, one group practiced the same task every day (constant training), while training was varied for two other groups. One of these groups practiced 10 different tasks, two tasks each day; the other group practiced 10 different pairings of the stimuli and responses of the same task, two pairings each day. Following training, all groups were tested for transfer to four additional tasks.

Neither method of varied training yielded transfer superior to constant training. There was no exception to this finding with any of the four transfer tasks on any of the transfer days. Two previously reported experiments have presented transfer data from groups for which the training period was respectively 10 days and two days. When training extended over 10 days, varied training produced better transfer than constant training, but not when only two days of training were given. It was suggested that the difference in results between these earlier studies was due to the difference in level of mastery attained on the training tasks, the level being considerably higher with 10 days than with two days of training. The results given in the present report show that the medium level of mastery of training tasks attained during the five-day training period also did not produce superior transfer for groups given varied training.

The results of this and the earlier reports again imply that if training task variations are introduced into training devices, the number of such variations should be such as to permit attainment of a high level of mastery on each within the available training time. Otherwise, there may be no advantage in varied training.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

JACK BOLLERUD
Colonel, USAF (MC)
Chief, Aero Medical Laboratory
Directorate of Research

TABLE OF CONTENTS

	Page
Introduction	1
Method	2
Apparatus	2
Tasks	2
Conditions	2
Measuring Transfer	3
Subjects and Procedure	3
Results	4
Comparability or Groups	4
Training	4
Transfer	7
Further Transfer Tests	9
Discussion	10
Implications for the Design of Training Equipment	11
Conclusions	12
Bibliography	13
Appendix A (The Design of the Complete Experimental Program)	14
Appendix B (Summary of Data from the Training Period)	15

LIST OF FIGURES

		Page
Figure 1	Performance of Group II and Group III on four of the ten training tasks	5
Figure 2	Mean performance of Group II and Group III on all training tasks	6
Figure 3	Performance on the first transfer day, both on the nonsense-syllables task on the left, and on the H-figures task on the right	7
Figure 4	Performance on the second transfer day, both on the H-figures task on the left, and on the nonsense-syllables task on the right.	8
Figure 5	Performance on the third transfer day, both on the Gibson-figures task on the left, and on the colors task on the right	9
Figure 6	Performance on the fourth transfer day, both on the colors task on the left, and on the Gibson-figures task on the right.	10

TRANSFER OF TRAINING AFTER FIVE DAYS OF PRACTICE WITH ONE TASK OR WITH VARIED TASKS

INTRODUCTION

Two previous reports (1, 2) have presented parts of a larger study dealing with transfer of training in perceptual-motor tasks as a function of constant as compared with varied training. The first report (1) was concerned with the results of three groups from the larger study that were given 10 days of training before being tested for transfer (see Appendix A for the design of the complete experimental program). The second report (2) presented the results of another three groups which were trained in the same way as those of the first report, except that only two days of training preceded the tests for transfer. The present report will present the data for three further groups. These were also trained in the same way as those of the two earlier reports except that the training period was five days.

The major finding with the groups trained for 10 days (1) was that varied training produced better transfer than constant training. In contrast, when training continued for only two days (2), varied training yielded no better transfer than constant training. In discussing this difference in results between the two studies it was pointed out that varied training had been achieved in both studies by providing ten different training tasks. Since the number of training tasks was not reduced when the length of the training period was reduced from 10 days to two days, the two-day varied-training groups received relatively little practice on each training task. Specifically, the 10-day varied-training groups were given 21 trials, while the corresponding two-day groups were given only four trials, on each training task. The result was that the 10-day groups achieved a fairly high degree of mastery of each training task, while the two-day groups achieved only a very low level of mastery of each task. Thus, it appeared that varied training per se was not sufficient to produce superior transfer to constant training; rather, there must also be a sufficient amount of practice on each training variation to permit attainment of a level of proficiency at least higher than that reached by the two-day groups.

The two-day and the 10-day groups, given respectively four and 21 trials on each training variation, represent fairly well the opposite ends of the dimension of mastery of the training tasks used here. Therefore, it is not known whether superior transfer will result from varied training when each training task is practiced to a medium degree of mastery. The results with the five-day groups to be presented in this report will supply this information. During the five-day training period each of the 10 training tasks was practiced for 10 trials, thereby permitting a medium level of proficiency on each task.

METHOD

Apparatus

Since the apparatus is fully described in an earlier report (1), only a summary description will be given here. The apparatus was designed to present perceptual-motor paired-associate tasks in which the stimuli were symbols of several kinds and the responses were movements of a lever into slots. The lever was 24 in. long and pivoted at its lower end in a ball and socket joint. It could be moved into any one of 13 slots cut one inch deep and one inch apart in a steel plate. The slots were numbered from one to 13 and were arranged in a semicircle, concave to the subject. The stimuli were machine paced, each stimulus appearing for four seconds. The subjects were instructed to make only one response to each stimulus. As soon as a response was made by moving the lever into a slot, a light flashed on above the slot which was correct for the particular stimulus showing at the moment.

Tasks

The responses were the same for all tasks. The different tasks were provided by different sets of 13 stimuli. Ten training and four transfer tasks were available. Each training task consisted of 13 fairly meaningless forms. The four transfer tasks consisted of two sets of forms (H-figures and Gibson figures) not used for training, a set of nonsense syllables, and a set of patches of color. The tasks are described more completely in the first report (1).

The stimuli were mounted on tapes propelled by a drum. To prevent serial learning, the 13 stimuli in each task were mounted in 12 different orders, forming an endless belt on the tape.

Conditions

The three training conditions are identified as Groups I, II, and III. Group I was trained under constant conditions, while Groups II and III each practiced under a different type of varied conditions during training.

The Group I subjects practiced on only one task for all trials given on the five training days. The 10 training tasks were assigned to subjects in turn.

In Group II the subjects practiced all 10 training tasks, two tasks on each of the five training days. The 10 training tasks could be presented in 10 different orders which were assigned to subjects in turn. Among the 10 different orders, no task appeared more than once in each ordinal position and no task preceded or followed any other task more than once.

The Group III subjects practiced 10 different pairings of one set of stimuli (one task) with the slots. Two pairings were practiced on each training day. As in Group I, each subject within a block of 10 subjects was assigned a different set of training stimuli. In each of the 10 pairings of the same task all 13 stimuli were completely repaired with the slots and no stimulus was ever paired with the same slot more than once.

On each training day each subject was given a total of 20 practice trials, where a trial is one presentation of each of the 13 stimuli of a task. Thus, Group I subjects received 100 trials of practice on the same task during training, while Groups II and III received only 10 trials on each of their 10 training variations (tasks or re-pairings). In Groups II and III there was a rest of approximately two minutes between the two training variations within a day to permit changing from one variation to the next. Group I had no such rests.

Measuring transfer

As before (1, 2), the major transfer data are obtained on two days following the end of training. The transfer tasks presented on these days are the H figures and the nonsense syllables. In testing for transfer each main group is split into subgroups. Subgroup A is tested with the nonsense syllables on the first transfer day and H figures on the second day. For subgroup B the order of tasks is reversed. Thus, the transfer tasks are counterbalanced over days.

As indicated in the earlier reports (1, 2), some groups in the complete experimental program are also tested on one or two additional transfer days. The Gibson figures and the colors are the transfer tasks used on these days. When additional transfer days are run, no attempt is made to counterbalance all transfer tasks over all transfer days.

In the present study both additional transfer days were run, four days in all. In each major group the subjects comprising subgroup A practiced the transfer tasks in this order: nonsense syllables on the first transfer day, H figures on the second day, Gibson figures on the third day, and colors on the fourth day. Subgroups B practiced in this order: H figures, nonsense syllables, colors, and Gibson figures. Twenty trials were given on each transfer task.

Subjects and procedure

The subjects were male and female undergraduates at Northwestern University and were paid for their services. The number of subjects in each group will be given later. The five training and four transfer days were completed within two weeks.

Instructions to the subjects described the nature of the task and emphasized the making of as many correct responses as possible. The instructions also specified that it was necessary to make one and only one response each time a stimulus appeared. Thus, there is no independent error measure. The data are reported in terms of correct responses.

RESULTS

Comparability of groups

All six subgroups were equated on total correct responses for trials 2-4 of the first training task by eliminating in each subgroup those few subjects who had especially high or low totals. Table I shows the final number of subjects in each subgroup and the mean total correct responses. The mean totals in Table I are sufficiently similar to those reported in the earlier reports (1, 2) for the 10-day and 2-day groups to permit eventual comparison of these groups with the present ones.

Table I

Mean total correct responses on trials 2-4 of the first training task

Group	N	Mean	σ_M
IA	23	6.70	.70
IB	23	6.74	.57
IIA	22	6.45	.72
IIB	23	6.82	.82
IIIA	22	6.82	.73
IIIB	23	6.39	.71

Training

Since Group I was trained on the same task for all five days of training, i.e., practiced under constant conditions, we shall report only the final level of performance of these subjects at the end of training. On the last (5th) day of training Group I made a total of only 25 errors in 12,000 responses (46 subjects, 20 trials each, 13 responses per trial). Thus, this group had thoroughly mastered its one task by the end of training.

Both Groups II and III practiced 10 variations (tasks or re-pairings) during training. We shall present graphically some of the data from the training period for these groups to indicate the degree to which they improved in performing successive variations i.e., showed learning to learn. (See Appendix B for the mean correct responses on all trials on all training variations given Groups II and III.) Figure 1 shows performance of both groups on four of the 10 training variations on all of the 10 trials given on each variation. It is clear that both groups showed considerable learning to learn from Task 1 to Task 10. This would be expected since in an earlier study (2) it was reported that some learning to learn takes place with only four trials on each training task.

In Figure 1, Group II shows little improvement from Task 4 to Task 7. The reason for this may be seen in Figure 2, which shows the mean performance on all 10 training tasks for both Groups II and III. The curve for Group II shows that, with two tasks per day, the gain from the first to

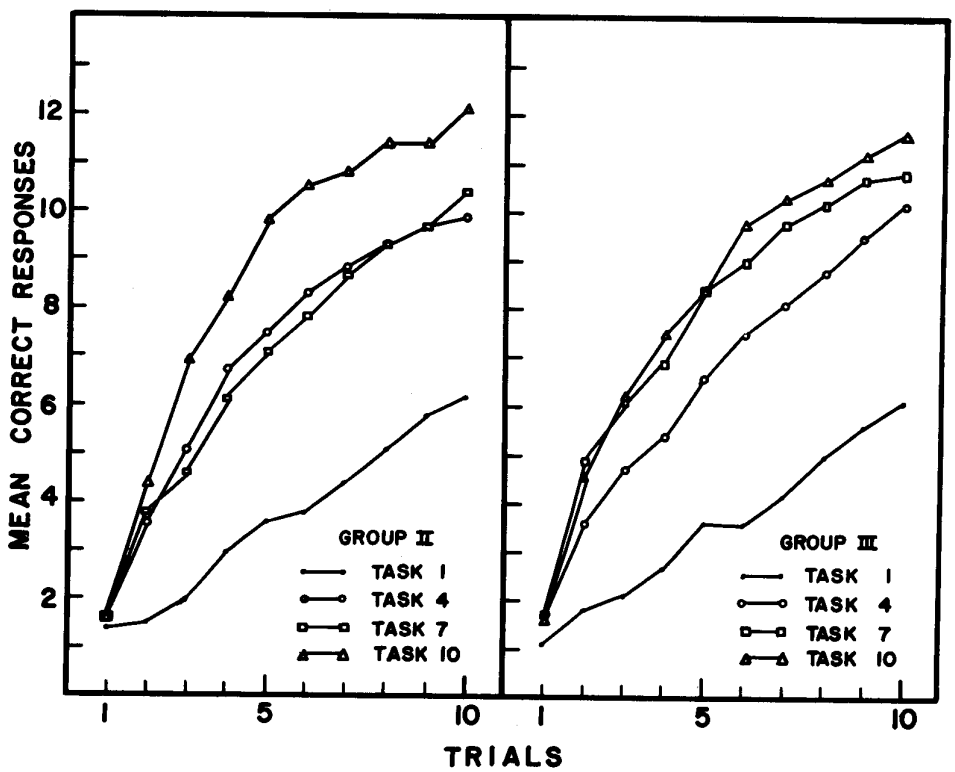

Figure 1. Performance of Group II and Group III on four of 10 training tasks.

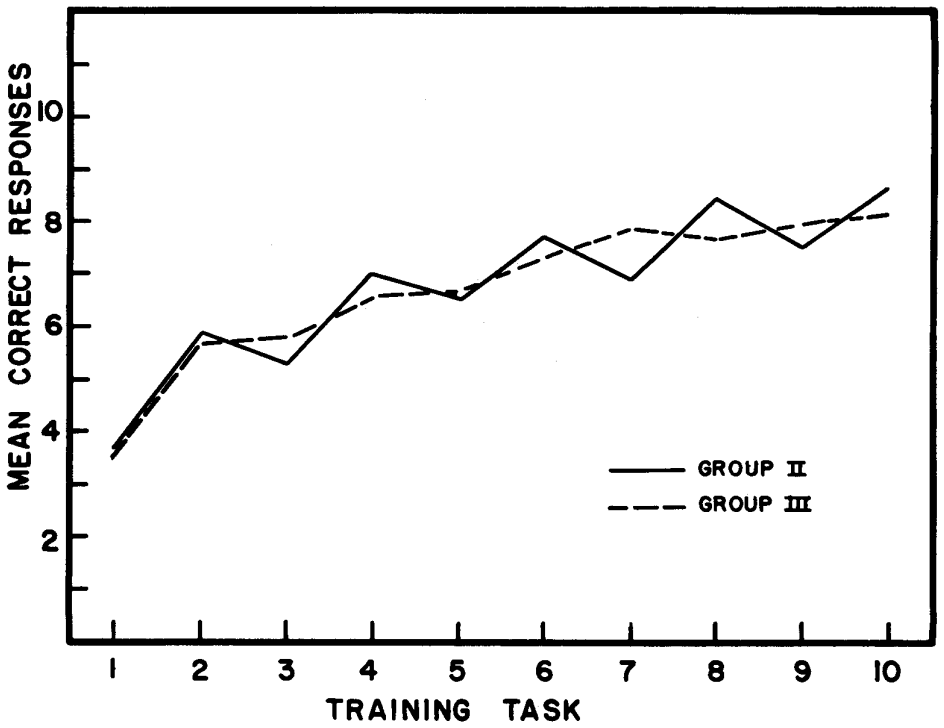

Figure 2. Mean performance of Group II and Group III on all training tasks.

the second task within a day was partly offset by a loss between days. Thus, the second task on the second day (Task 4) was performed nearly as well as the first task on the fourth day (Task 7). The sharp improvement within days has been called "warm-up" by Thune (4). Warm-up is presumably to be distinguished from the gradual improvement over days (learning to learn).

In contrast to the sawtooth curve shown by Group II in Figure 2, the progress of Group III is relatively smooth. This may be due to a combination of the opposing influences of warm-up and of interference. It is known (3) that re-pairing the stimuli and responses of the same task produces considerable interference when the intertask interval is short, e.g., two minutes, but not when the interval is 24 hours. In fact, with 24-hour intervals, intertask gains may be even greater with re-paired tasks than with tasks having different stimuli (1). Thus, in the present Group III, warm-up would facilitate performance on the second task of each day while loss of warm-up would depress performance on the first task. Intertask interference would depress performance on the second task within a day while forgetting of interference over 24 hours would facilitate performance on the first task. One difficulty with testing

such an interpretation is that warm-up is an essentially unanalyzed, descriptive concept, in contrast to interference which can sometimes be measured independently of performance in terms of correct responses.

Transfer

Performance on the first transfer day is shown in Figure 3. The transfer task was nonsense syllables for the A groups, shown on the left in Figure 3, and H figures for the B groups, shown on the right. It is clear that differences among the groups on either transfer task are small.

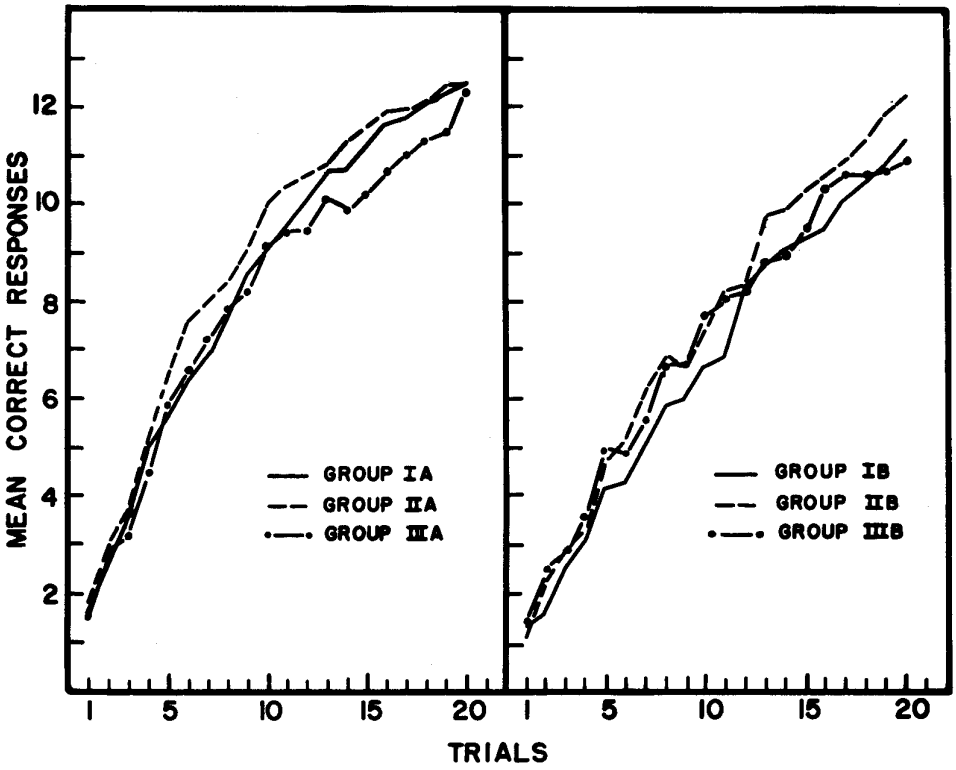

Figure 3. Performance on the first transfer day, both on the nonsense-syllables task on the left, and on the H-figures task on the right.

Simple analysis of variance on total correct responses over all 20 trials was performed to evaluate differences among the A groups. The F was 1.00, which is not significant with 2 and 64 df. The variances could be considered homogeneous; χ^2 was 4.74. Thus, even though Figure 3 shows that Group IIA (trained with 10 different tasks) performed slightly better than the other groups throughout most of practice on the nonsense syllables, the F-value indicates that there were no reliable differences in transfer among the groups tested with this task on the first transfer day.

Analysis of variance of the B groups tested on the H-figures task (on the right in Figure 3) gave an F-value of less than one, with 2 and 66 df. The variances were homogeneous; χ^2 was 2.91. Thus, all groups transferred equally well to the H-figures task on the first transfer day.

Performance on the second transfer day is shown in Figure 4. On the second transfer day the A groups, on the left in Figure 4, were tested with the H-figures task, while the B groups, on the right, were tested with nonsense syllables.

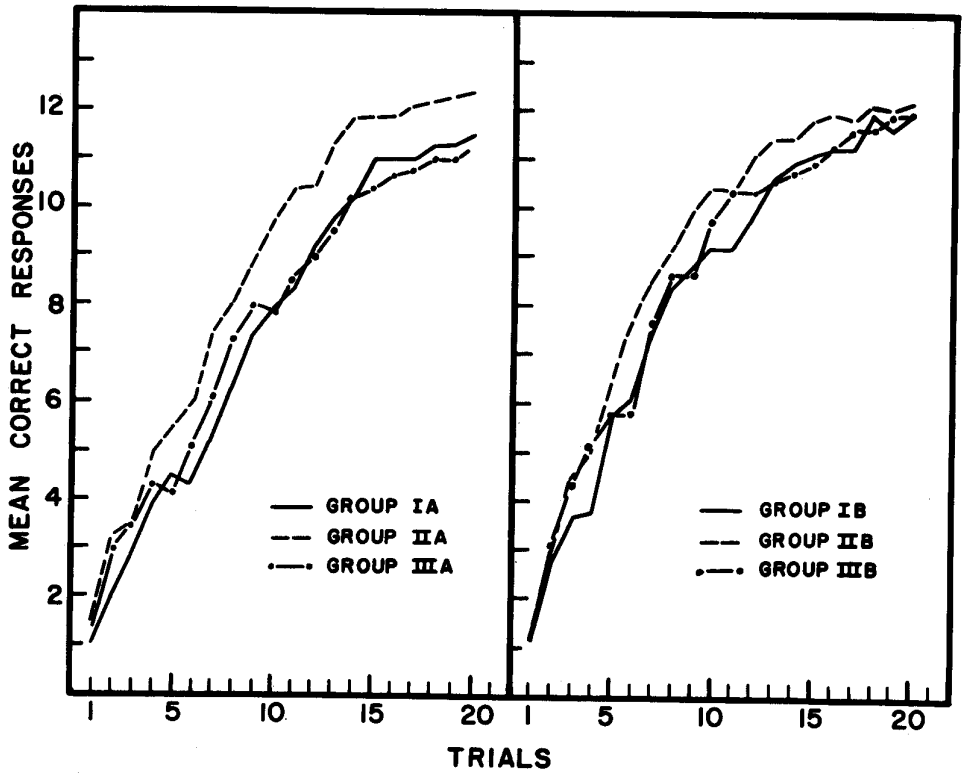

Figure 4. Performance on the second transfer day, both on the H-figures task on the left, and on the nonsense-syllables task on the right.

Analysis of variance of the A groups on the second transfer day gave F = 3.11. This is close to the value needed for significance at the 5% level with 2 and 64 df (the tabled value for 2 and 65 df is 3.14). Figure 4 shows that Group IIA performed somewhat better than the other A groups over most of the trials. However, the conclusion must be that there is no clear-cut evidence of differences in transfer among the A groups on the second transfer day.

Analysis of variance of the B groups on the second transfer day gave F less than one. There were no differences in transfer performance when the groups were tested with nonsense syllables on the second transfer day.

Further transfer tests

As explained earlier, the major data of this and previous reports are derived from performance on the first two transfer days. However, some groups are tested on additional transfer days, using Gibson figures and colors as the transfer tasks. With the present groups transfer was tested on two additional transfer days, four days in all.

Performance on the third transfer day is shown in Figure 5. The A groups were tested with the Gibson figures; the B group with the colors task. Neither of the analyses of variance gave significant F-values; for the A groups F was 2.09, for the B groups F was 1.34. No differences in transfer appeared on the third transfer day.

Figure 6 shows performance on the fourth transfer day. For the A groups, tested with the colors task, analysis of variance gave an F-value of 1.69 which is not significant. For the B groups, tested with the Gibson figures, F was less than one. Thus, the results on all four transfer days were consistently negative; transfer performance did not vary as a function of kind of training.

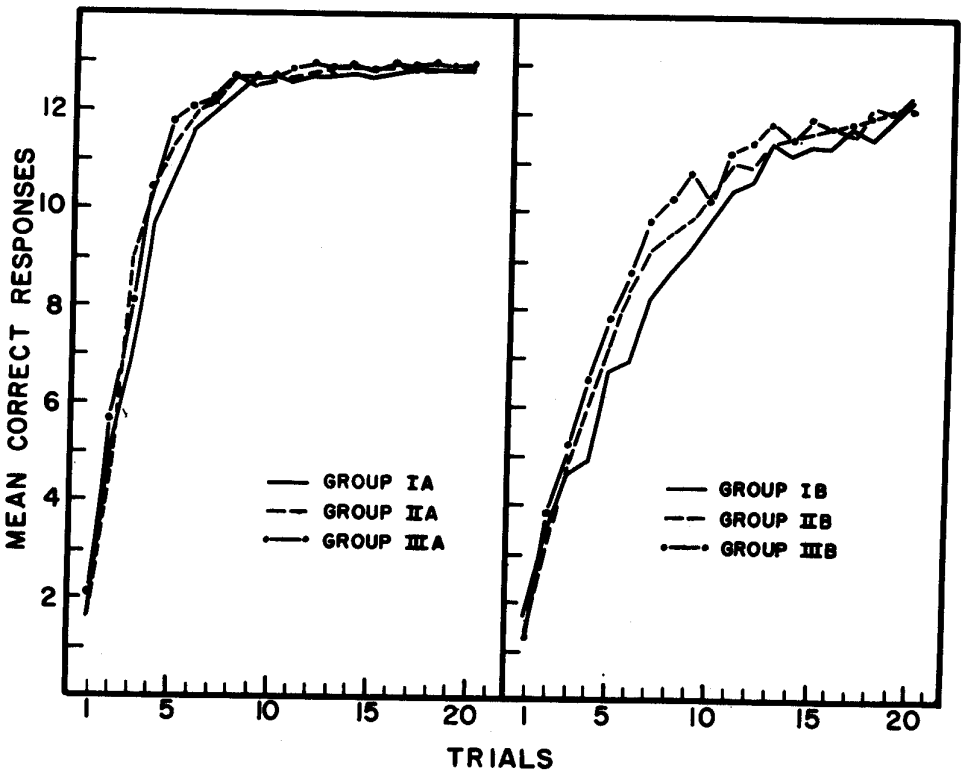

Figure 5. Performance on the third transfer day, both on the Gibson-figures task on the left, and on the colors task on the right.

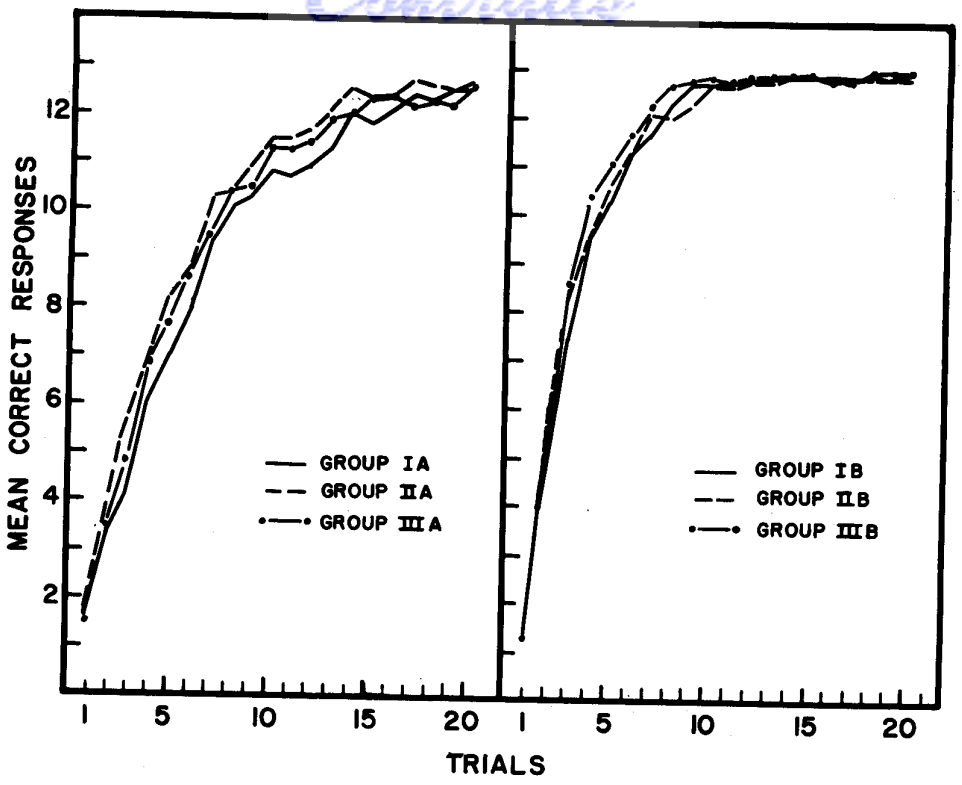

Figure 6. Performance on the fourth transfer day, both on the colors task on the left, and on the Gibson-figures task on the right.

DISCUSSION

The results are unambiguous. Varied training yielded no better transfer than constant training when the duration of the training period was five days.

We may now relate the present results with those of the two previous reports (1, 2). All three studies are directly comparable except for the length of the training period. In the first study (1) the training period was 10 days; in the second study (2) the training period was two days. Superior transfer resulting from varied training was found only in the groups trained 10 days. When, in the second study, it was found that two days of constant or varied training did not produce differential transfer, it was suggested that this may have been due to the low degree of mastery achieved on each training task by the varied training groups. If this suggestion was correct, it would follow that the superior transfer found with the groups trained 10 days under varied conditions (first report), resulted not from varied training per se, but varied training coupled with high mastery of each training variation.

This line of argument suggested the need for further information about the variable of degree of mastery of each training task (defined operationally as the amount of practice on each task). This information is made available by selecting from the overall study the three groups which were given five days of training. The 10-day groups (21 trials on each training task) and the 2-day groups (4 trials on each task) represent the extremes of the degree of mastery dimension for the tasks used. The 5-day groups of the present report (10 trials on each task) supply a point on the dimension intermediate between the two extremes. The failure of the 5-day varied training groups to perform significantly better than the corresponding constant trained groups on the transfer tasks forces the conclusion that in this situation varied training is beneficial only when coupled with high levels of mastery on the training variations.

It should be noted that the generality of this conclusion is limited by the fact that all varied training groups so far reported have practiced 10 training variations. This means that the variable of mastery of training variations has not yet been varied independently from the variable of number of training variations. Thus, without information to the contrary, it is possible that superior transfer may result from groups that satisfy the requirement of high level of mastery of each variation but that practice fewer than 10 variations. Another possibility is that differential transfer in favor of varied training groups may result from fewer training variations which are overlearned, i.e., which are practiced even beyond the high degree of mastery achieved by the 10-day groups. Information on both these questions will be available when the final report on the complete experimental program is presented.

Finally, the interpretation of the results of the first two reports (1, 2), based on learning to differentiate stimuli during training, is not refuted by the present results but neither is it strongly supported. It is, of course, possible that learning to differentiate stimuli to the extent that transfer is facilitated may require as much practice on each training task as that given the 10-day groups. Nevertheless, the complete failure to produce significantly better transfer with the present groups that were given varied training for five days does not add much support to the hypothesis that subjects trained with several tasks develop a general skill at differentiating stimuli.

IMPLICATIONS FOR THE DESIGN OF TRAINING EQUIPMENT

The implications of the present results for the design of training equipment are much the same as those stated in the second report (2) and serve to support the statements made at that time. Again it is implied that transfer to operational equipment may be facilitated by training devices which provide training variations as long as those variations are well practiced. Thus, if there is a certain amount of time available for training, training devices should be designed to provide only as many variations as can be mastered fairly thoroughly in the available time.

Again, it is worthwhile pointing out that the results to date imply that each training variation designed into a training device should be well practiced. It is not as yet known whether it is also necessary to provide several or only a few variations in the training device. The implications of this information, which will be available when the experimental program is completed, will be pointed out in the final report.

CONCLUSIONS

1. Variation in training provided by practicing either 10 tasks or 10 different pairings of the stimuli and responses of the same task yielded no better transfer than constant training when the length of the training period was five days.

2. The evidence again supported the conclusion that in this situation varied training yields superior transfer only when each training variation has been practiced to a high level of mastery.

3. It was again suggested that with a certain amount of time available for training, training devices should be designed to provide only as many variations as can be mastered in the available time.

BIBLIOGRAPHY

1. Duncan, C. P. & Underwood, B. J. Transfer of training after 10 days of practice with one task or with varied tasks. Wright Air Development Center, Technical Report No. 54-115, Wright-Patterson Air Force Base, 1954.

2. Duncan, C. P. & Underwood, B. J. Transfer of training after two days of practice with one task or with varied tasks. Wright Air Development Center, Technical Report No. 54-381, Wright-Patterson Air Force Base, 1954.

3. Porter, L. W. & Duncan, C. P. Negative transfer in verbal learning. J. exp. Psychol., 1953, 46, 61-64.

4. Thune, L. E. Warm-up effect as a function of level of practice in verbal learning. J. exp. Psychol., 1951, 42, 250-256.

APPENDIX A

THE DESIGN OF THE COMPLETE EXPERIMENTAL PROGRAM

The design of the training conditions for the experimental program as a whole is presented below. The three cells on which the present report is based are marked "X". The cells marked "Y" and "Z" are those on which the two previous reports are based. As explained in the text, the subjects in each cell are divided into two subgroups at the time of testing for transfer. The design is incomplete in that the type of varied training provided by different tasks, shown in the first three rows for 10, 5, and 2 different tasks, is not completely duplicated by corresponding rows for the type of varied training provided by re-pairing the stimuli and responses of one task. Since the one row for the re-paired tasks type of training indicates that the task was re-paired 10 times, this row is comparable to the row for 10 different tasks.

Type of training	Number of training days		
	10	5	2
10 different tasks	Z	X	Y
5 different tasks			
2 different tasks			
1 task	Z	X	Y
1 task re-paired 10 times	Z	X	Y

APPENDIX B

SUMMARY OF DATA FROM THE TRAINING PERIOD

Mean correct responses per trial on each of the 10 training tasks for Group II, the group trained with 10 different tasks.

	Training task									
Trial	1	2	3	4	5	6	7	8	9	10
1	1.4	1.2	1.2	1.6	2.0	1.6	1.6	2.4	2.7	1.6
2	1.5	3.1	2.4	3.6	3.5	4.1	3.8	4.7	4.0	4.4
3	2.0	4.3	3.6	5.1	4.6	5.7	4.6	6.9	5.2	6.9
4	3.0	5.4	4.9	6.7	5.2	7.3	6.1	8.7	6.4	8.2
5	3.6	5.9	4.8	7.5	6.4	8.0	7.1	9.2	7.6	9.8
6	3.8	7.0	5.8	8.3	7.6	9.0	7.8	9.7	8.8	10.5
7	4.4	7.7	7.3	8.8	8.3	10.3	8.7	10.4	9.2	10.8
8	5.1	7.9	7.0	9.3	8.7	10.4	9.3	10.5	9.9	11.4
9	5.8	8.6	7.8	9.7	9.5	10.4	9.7	10.9	10.6	11.4
10	6.2	8.6	8.5	9.9	9.9	10.9	10.4	11.5	11.4	12.1

Mean correct responses per trial on each of the 10 training tasks for Group III, the group trained by re-pairing the stimuli and responsesof the same task 10 times.

	Training task									
Trial	1	2	3	4	5	6	7	8	9	10
1	1.1	1.4	1.3	1.6	1.5	1.2	1.6	1.3	1.4	1.6
2	1.8	3.1	3.9	3.6	3.9	4.2	4.9	4.5	4.8	4.6
3	2.1	4.1	4.3	4.7	5.2	5.8	6.1	5.9	6.0	6.2
4	2.7	5.1	5.3	5.4	6.0	6.8	6.9	7.4	7.5	7.5
5	3.6	5.8	5.6	6.6	7.0	7.8	8.4	7.9	8.5	8.4
6	3.6	6.4	6.4	7.5	7.6	8.7	9.0	8.9	9.3	9.8
7	4.2	6.8	7.2	8.1	7.9	9.2	9.8	9.4	9.8	10.3
8	5.0	7.2	7.8	8.8	8.5	9.5	10.2	9.9	10.4	10.7
9	5.6	8.2	8.2	9.5	9.2	10.1	10.7	10.4	10.7	11.2
10	6.1	8.4	8.2	10.2	9.5	10.5	10.8	11.0	11.2	11.6