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

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ABSTRACT

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

Neither method of varied training yielded transfer superior to constant training. This finding held without exception for all transfer tasks on all transfer days. A previously reported experiment had found superior initial transfer for varied training when training extended over 10 days, an interval which permitted each training task to be well mastered. In light of this, an attempt was made to account for the present results in terms of the lack of mastery of each training task and the attendant lack of skill in differentiating stimuli within and between tasks.

The findings of this and the previous report imply that training devices which provide a number of training task variations may yield initially greater transfer to operational equipment than training devices which provide only one training task. However, it is also implied that it is worthwhile to design training task variations into training devices only if sufficient training time is available to obtain more than a small amount of mastery of each variation. Otherwise, there may be no advantage of varied training.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

JACK BOLLERUD
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INTRODUCTION

The first report (2) of this series presented a portion of a larger study dealing with transfer in perceptual-motor tasks as a function of constant as compared with varied training. That report was concerned with the results of three groups given 10 days of training before being tested for transfer. The present study presents the results for three additional groups from the larger study (see Appendix A for the design of the complete experimental program). As will be explained in more detail later, these groups were given the same kinds of training and the same number of training tasks as were the 10-day groups, but were trained for only two days. Since the time spent practicing within a training day, and the total number of training tasks, was the same for the two-day and 10-day groups, the two-day groups received considerably fewer practice trials on any one training task.

The major finding with the 10-day groups was that varied training produced initially better transfer than constant training. However, it was pointed out that each of the different tasks presented to the varied training groups was well-practiced; most subjects had mastered each task before proceeding to the next task. The results of the present report will indicate whether varied training also yields superior transfer when there is the same degree of variation in training; i.e., the training tasks are exactly the same as for the 10-day groups, but when only a small amount of practice is given on each training task.

METHOD

Apparatus

The apparatus is described in detail in the first report (2), and accordingly will be described here only briefly. The apparatus permitted presentation of perceptual-motor paired-associate tasks in which the stimuli were symbols of various 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 one in. deep and one in. apart. The slots were numbered from one to 13 and arranged in a semi-circle concave to the subject. The stimuli were machine-paced, each stimulus appearing for four seconds. Each subject was instructed to make one and only one response to every stimulus. As soon as he responded by placing the lever in a slot a light flashed on above the slot which was correct for the particular stimulus being presented.

Tasks

The responses were the same for all tasks. Different sets of 13 stimuli provided the different tasks. There were available 10 training and four transfer tasks. Each training task consisted of 13 relatively 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. A more complete description of the tasks is given in the first report (2).

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 described in the report are identified as Groups I, II, and III. Group I was trained under constant conditions; Groups II and III each practiced under a different type of varied conditions during training.

In Group I each subject practiced on only one task for all trials given on both of the two training days. The 10 training tasks were assigned to subjects in the order of their appearance.

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

In Group III each subject practiced 10 different pairings of one set of stimuli (one task) with the slots. Five pairings were practiced on each of the two training days. As in Group I, each subject within a block of 10 subjects was assigned a different training task. In each of the 10 pairings of the same task, all 13 stimuli were completely re-paired with the slots and no stimulus was ever paired with the same slot more than once. Thus, whereas Group II was confronted with a different set of stimuli for each task and had to learn to associate them with the correct slots, Group III had the same set of stimuli for all 10 pairings and only had to learn new sets of S-R associations. On each training day all subjects were given 20 trials of practice, with a trial defined as one presentation of each of the 13 stimuli constituting a task. Thus, subjects in Group I practiced one training task for a total of 40 trials, whereas Groups II and III received only four trials on each of their 10 training variations (tasks or re-pairings). In Groups II and III, where five variations were practiced within each training day, there was a rest of approximately two minutes between successive variations within a day to permit adjustment of the apparatus. Group I had no such rests.

Measuring transfer

It was pointed out in the first report (2) that the data of chief interest are performance on two transfer 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 two subgroups. One subgroup is tested with the nonsense syllables on the first transfer day and H-figures on the second day. The order of tasks is reversed for the other subgroup. Thus, the transfer tasks are counterbalanced over transfer days.

As pointed out in the first report (2), some groups are also tested on one or two additional transfer days. The Gibson figures and the colors are the tasks used on these days. When additional transfer days are run, no attempt is made to counterbalance all transfer tasks over all days.

In the present study one additional transfer day was run, three transfer days in all. Those subjects in each of the three main groups who were tested with nonsense syllables on the first transfer day and H-figures on the second day were given Gibson figures on the third day; these subjects will hereafter be called subgroups A. The remaining subjects in each major group, subgroups B, were tested with H-figures on the first transfer day, nonsense syllables on the second, and colors on the third.

Twenty trials were given on each transfer task. This represents a slight change in procedure from that used with the 10-day groups described in the first report (2). With those groups, 21 trials were given on each transfer task. In fact, the total amount of practice on any one day, whether a training or transfer day, was 21 trials for the 10-day groups and 20 trials for the present 2-day groups, regardless of the number of tasks to be practiced. Twenty trials per day were used in the present study so that subjects practicing 10 training variations within two days (Groups II and III) could be given an equal number of trials (four) on each variation. Since variation in the number of trials given on training variations is, in effect, a major variable of the experimental program, the only actual change in procedure consists of giving only 20 instead of 21 trials on the transfer tasks. Because the change in performance resulting from one trial is very small at this point in practice, no adjustment will be made in analyzing the data presented in this report.

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 two training and three transfer days were completed within a single week.

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

Comparability of groups

All six subgroups were equated on total correct responses for trials 2-4 on the first training task by eliminating a few subjects in each subgroup who had unusually high or low totals. Table I shows the final number of subjects in each subgroup and the mean total correct responses. These mean totals are similar to those reported for the 10-day groups in the first report (2), thus permitting 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	22	6.59	.53
IB	23	6.65	.51
IIA	23	6.70	.37
IIB	23	6.70	.43
IIIA	23	6.74	.62
IIIB	23	6.57	.57

Training

Since Group I was trained under constant conditions, i.e., practiced the same task for all 40 trials (20 per day) during training, we need only report their final level of performance at the end of training. On the last trial of the second training day only five of the 45 subjects in this group made any errors, i.e., made less than the maximum of 13 correct responses. Thus, it can be said that Group I had pretty well mastered their one task by the end of training.

Both Group II and Group III were given only four trials on each of their 10 training tasks, Group II having 10 different sets of stimuli, Group III having 10 different pairings of the same stimuli. Thus, it would not be expected that either of these groups would achieve much mastery of any task (see Appendix B for the raw data). However, we may inquire whether these groups showed any evidence of improvement in successive tasks during training. The most sensitive measure of improvement would be performance on the last trial (trial 4) of each training task. This measure is shown graphically in Figure 1.

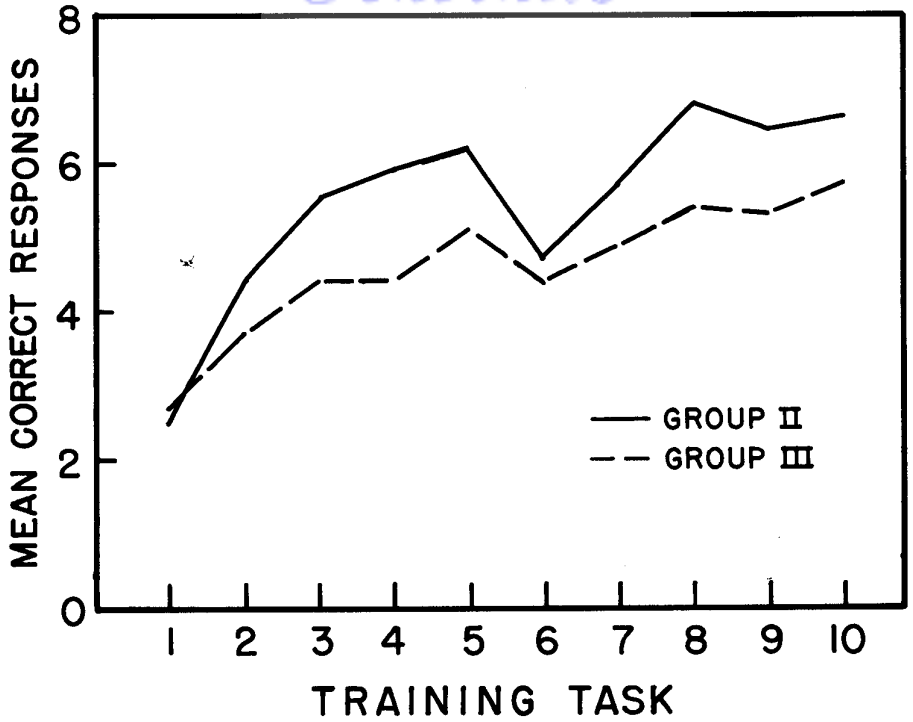

Figure 1. Mean performance of Groups II and III on the last trial (trial 4) of each training task.

It appears from Figure 1 that both groups showed a gain in performance from the first to the tenth training task. Statistically, the gain is significant; for Group II, the t-value was 9.52, and for Group III, t was 6.09. Since both of these values are significant at far beyond the 1% level, it is clear that there was considerable improvement in performance of successive tasks even with only four trials on each task.

Figure 1 also shows that Group II, practicing different tasks, performed better than Group III, practicing different pairings of the same task. The difference between the groups in mean performance on the last trial for all training tasks combined was significant at the 1% level ($t = 2.26$). The fact that Group III improved from task to task and yet gained less than Group II may be understandable when taken in connection with a study (5) which found much negative transfer when the stimuli and responses of a list of 12 paired adjectives were re-paired. In that study the first task was learned to a criterion of one errorless trial and only two seconds were allowed in which to anticipate the correct response, whereas with the present Group III only four trials were given on each task and the anticipation time was four seconds. Thus, it seems likely that Group III, although showing net improvement, suffered some interference from the successive re-pairings of the same stimuli coming in conjunction with low degrees of learning of each task and short time between tasks. Group II, with a different set of stimuli for each task, may have been better able to discriminate one task from the next.

It is also apparent from Figure 1 that both groups, but particularly Group II, showed a loss over the 24-hour rest intervening between the fifth and sixth training task. There seems no way of determining what was forgotten and how it contributed to the drop over 24 hours, but the loss may be in part a warm-up decrement. Thune (6) has also reported data showing gains within days with losses between days and interpreted the results in terms of warm-up. The smaller loss of Group III tends to support the previously advanced hypothesis (2) that, for the re-paired situation, interference between tasks decreases as time between tasks increases.

Transfer

Performance on the first transfer day is shown in Figure 2. The transfer task was nonsense syllables for the A groups, shown on the left in Figure 2, and H-figures for the B groups, shown on the right. It is obvious that differences among the groups on either transfer task are small.

Differences among the A groups were evaluated by simple analysis of variance of total correct responses over all 20 trials. The F was 1.78,

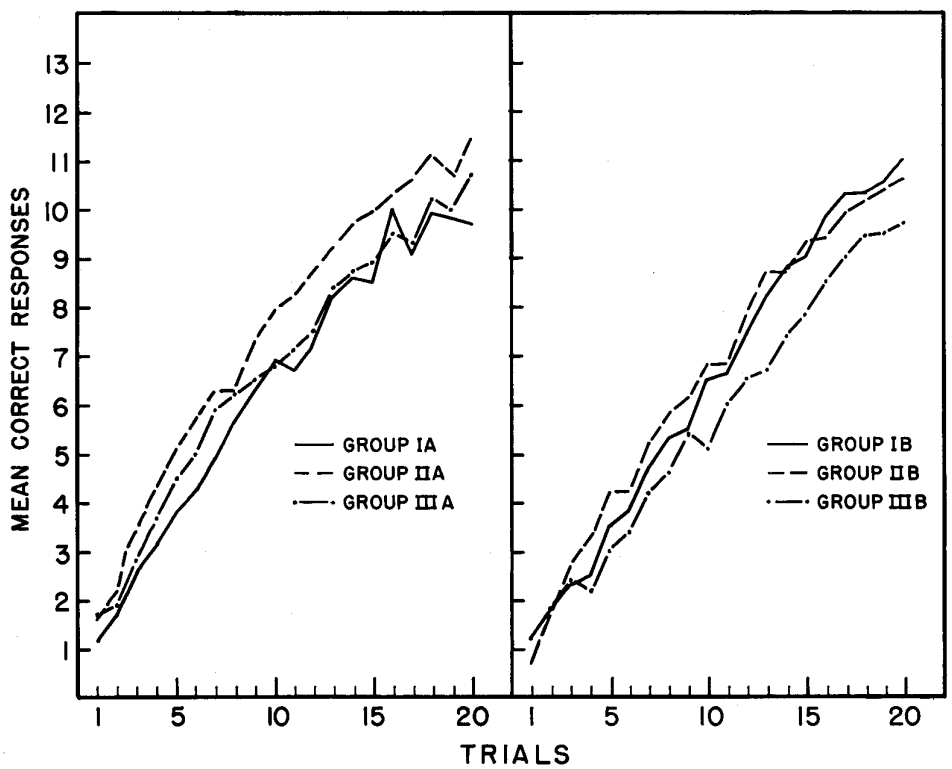

Figure 2. Performance on the first transfer day, both on the nonsense-syllables task on the left, and on the H-figures task on the right.

which, with 2 and 65 df, is not significant. The hypothesis of homogeneity of variance could not be rejected; χ^2 was 1.25. Thus, even though Figure 2 shows that Group IIA, which had been trained with 10 different tasks, performed slightly better than the other groups, the F-value indicates that there were no reliable differences in transfer among the groups tested with the nonsense-syllables task on the first transfer day.

Analysis of variance of the B groups tested on the H-figures task (on the right in Figure 2) gave an F value of 1.77, which is not significant with 2 and 66 df. The variances could be considered homogeneous; χ^2 was 2.82. All groups transfered equally well to the H-figures task on the first transfer day.

Since Figure 2 shows that both the A and B subgroups of Group II did slightly better on the whole than the corresponding subgroups of Groups I and III, the transfer tasks were combined to permit comparison of the three major groups. The F-value was 2.25, which with 2 and 134 df is not significant. Thus, there is no evidence for differences in transfer performance on the first transfer day as a result of different methods of training, even though the first transfer day should be most sensitive to such differences in training (2)

Performance on the second transfer day is shown in Figure 3. It will be

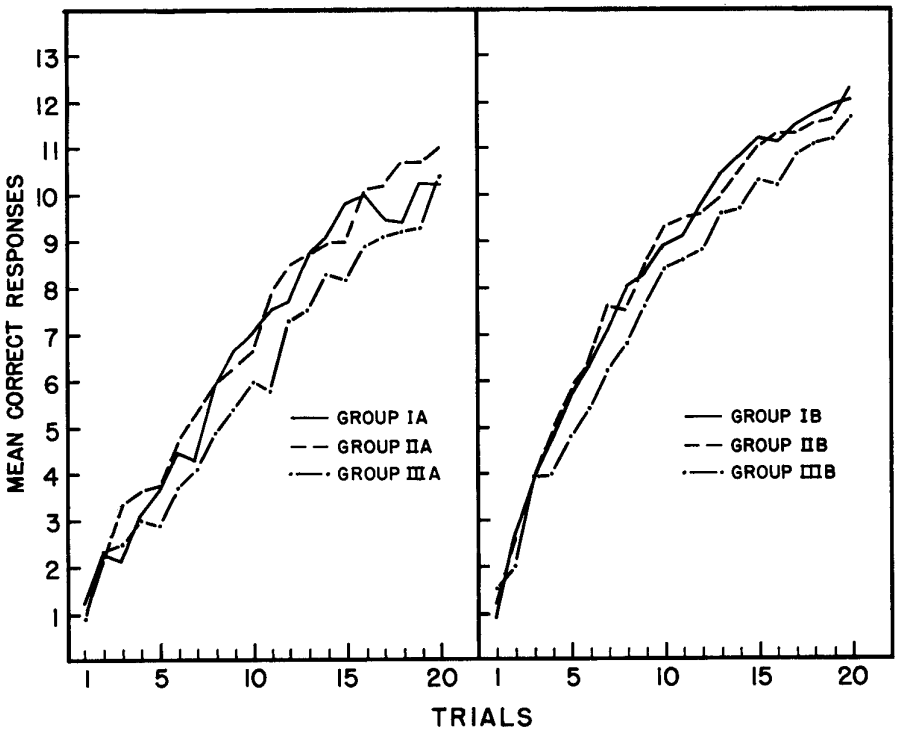

Figure 3. Performance on the second transfer day, both on the H-figures task on the left, and on the nonsense-syllables task on the right.

recalled that on the second transfer day the A groups, on the left in Figure 3, were tested with H-figures and the B groups were tested with nonsense syllables. Again, it is obvious from the curves that the differences among the groups are slight. Analysis of variance for the A groups gave an F of 1.15; for the B groups the F value was less than one. When the subgroups were combined, F was 1.82. Thus, there was no evidence for differential transfer on the second transfer day.

All three major groups showed improvement in performance from the first to the second transfer day. The mean total correct responses for Groups I, II, and III respectively were 128.29, 141.09, and 124.83 on the first transfer day, and 149.60, 152.15, and 136.43 on the second transfer day.

Further transfer tests

As noted earlier, the major data of this and future reports are obtained when transfer is tested on the first two days immediately following the end of training. However, the groups reported in this paper were also tested on a third transfer day. The transfer tasks used were Gibson figures for the A groups and colors for the B groups. The results are shown in Figure 4. There are practically no differences among the groups on either task. For the A groups, F was 1.35; for the B groups F was less than one. Obviously no test need be made on the major groups with subgroups combined.

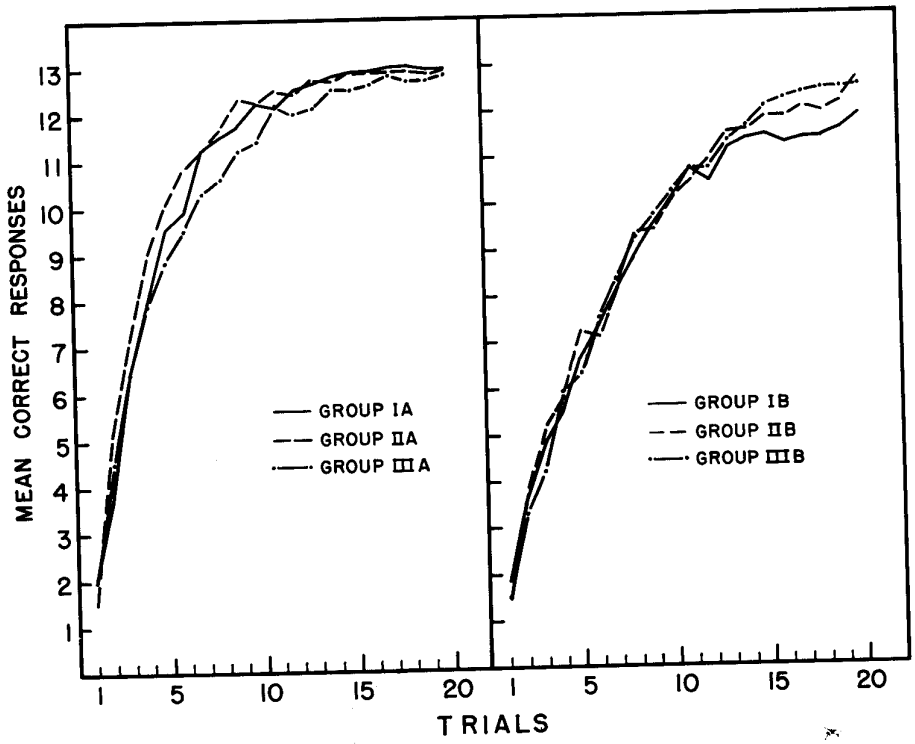

Figure 4. Performance on the third transfer day, both on the Gibson-figures task on the left, and on the colors task on the right.

The results are clear-cut. Varied training, when crowded into the short interval of two days with the consequent low degree of mastery of each training task, yielded no better transfer than when the same interval was devoted to constant training. This finding does not support Harlow's (3) recommendation that varied training should be introduced early and frequently. In fairness it must be pointed out that Harlow based his statement on a situation where it is common to employ a great many, even hundreds of, tasks. If the present experiment were repeated with the varied-training groups receiving five training tasks per day for 10 or 20 or more days, while during the same interval the constant-conditions group practiced the same task, the transfer data might be quite different.

In the first report (2) of this series the results were reported for three groups that differed from the present groups only in that the training period occupied 10 days. The fact that varied training, particularly that of the group practicing different tasks, did yield superior transfer when 10 days were devoted to training, but did not do so when only two days of training were given, implies that the degree of mastery achieved on the several training tasks is important. The 10-day groups of the first report mastered each training task rather thoroughly in the 21 trials permitted on each task. The 2-day groups of the present report were able to achieve only a low degree of skill on each task in the four trials devoted to each. Thus, it may be tentatively concluded that superior transfer does not result from varied training per se, but rather from varied training coupled with some medium to high degree of mastery of each training variation. Further evidence on this point should result from the data to be presented in the next report in this series. That report will deal with groups given five days of training, thereby permitting ten trials on each training task for the groups given varied training.

An experiment by McAllister and Lewis (4) has some bearing on the matter of varied training and degree of mastery of training tasks. They reported two experiments, each using a different apparatus, but because the procedure and results were much the same for both experiments, they will not be referred to separately. On each apparatus it was possible to devise at least 10 somewhat different tasks, of which eight were used for training. Transfer was tested with the remaining tasks. Two groups of subjects practiced the eight training tasks over an eight-day period. One group (single-trial group) was given one trial on each of the eight tasks on each day. The other subjects (multiple-trials group) practiced on the same task (for eight trials) within a day, with a different task each day. Thus, at the end of training both groups had received not only the same total amount of practice but the same amount of practice on each training task.

The results of the McAllister and Lewis study were that the single-trial group not only eventually mastered all training tasks as well or

better than the multiple-trials group, but performed as well, and in some cases better, on the transfer tasks. This implies that if the Group II subjects of the present report (trained with 10 tasks in two days) had been permitted to return to each training task several times, and each time given only a few trials per task, their performance might well have exceeded, during both training and transfer, the corresponding group of the first report(2), who had 10 days to learn 10 tasks and mastered each task before going on to the next. Thus, a comparison of the present report with the first report suggested that varied training may be worthwhile only if each training variation is fairly well mastered. The McAllister and Lewis data further suggest that the method used in the first report to achieve high mastery of each training task, i.e., learning each task well before going on to the next, is not necessarily the best procedure. Instead, even greater variation in training than that provided by mastering in succession each of several tasks, plus high mastery of each task, can be achieved by practicing for a considerable number of trials on each of several tasks but with only a few trials at a time on each task.

It is also worthwhile noting that a recent study by Adams (1) found no transfer advantage from varied training when the conditions were such that mastery of each training problem was not achieved. One of Adams' groups practiced on the same problem throughout training while the other group practiced a series of problems. When both groups were tested for transfer to new problems, the single-problem group did as well as, and in some cases better than the multiple-problems group. His data show that the multiple-problems group did not reach as high a level of performance on any one of their training problems as did the single-problem group on their one problem. Thus, his experiment is in line with the suggestion that varied training may be advantageous only if each variation is fairly well mastered.

Finally, we shall examine the results of the present study in the light of the interpretation offered for the findings of the first experiment (2). That interpretation was based on the notion that subjects may develop some skill at differentiating stimuli within and between tasks while learning a series of tasks, with the consequent lessening of interfering tendencies. This suggestion was offered as a possible explanation both for some aspects of performance during training and for the superior transfer following varied training, particularly of the group that was trained on 10 different tasks.

In relating the results of the present study to this interpretation it is only necessary to point out the probable consequences of the fact that the subjects in the varied training groups had only four trials on each training task. Since this was not enough practice to permit mastery of any task, it seems reasonable to assume that it was not enough to permit the development of much differentiation of stimuli either within or between tasks. In fact, it is known that generalizing tendencies increase during the early trials of practice (7). Poor differentiation of stimuli within and between tasks not only produces interference in learning any one task but probably also interferes with the development of skill in stimulus differentiation. In short, both from empirical and theoretical grounds it appears that varied training is advantageous only when each training variation is fairly well mastered, at least for situations in which the training variations are relatively similar to each other.

IMPLICATIONS FOR THE DESIGN OF TRAINING EQUIPMENT

Although the present program of research is devoted to the development of general principles that will have broad applicability to training equipment design, the results of this and the previous report have certain implications that may be worth considering now. It has been shown that varied training does produce superior transfer under certain conditions but not under others. These conditions have mainly to do with the amount of practice or the level of mastery of the several training variations. In the light of the findings so far, it is implied that transfer to operational equipment may be facilitated if training devices are designed to permit some variation in training. However, it is also implied that it is not worthwhile to provide variation in training equipment unless it is possible to provide a reasonable degree of practice on each training variation. Thus, with a certain amount of time available for training, training devices should be designed to provide only as many variations as can be mastered during the available time.

The preceding discussion implies that if training equipment is designed to provide varied training, several training variations will be provided. However, it is possible that only a few variations will be sufficient to yield superior transfer to constant training as long as each variation is well practiced. If so, the limitation noted above (that the number of variations introduced will be limited by the necessity to master each in the available time) is less important. If a few variations turn out to be as valuable as several variations, the design of training equipment would be simpler and the time available for training would be sufficient to master each. Information on the relative advantage of a few well-practiced variations in training will be available when the present experimental program is completed.

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 only two days were devoted to training.

2. On the basis of a comparison of the present findings with those of a previous study it was suggested that practicing 10 tasks in two days was inefficient chiefly because of the low degree of mastery achieved on each task.

3. It was suggested that designing training equipment to provide variation in training may be worthwhile only if it is possible to give sufficient practice on each training variation to permit each variation to become fairly well mastered.

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APPENDIX A

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" are those on which the previous report was based. As explained in the text, the subjects in each cell are divided into two subgroups at the time of testing for transfer. Each subgroup goes through the transfer tasks in a different order. 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 task 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	Y		X
5 different tasks			
2 different tasks			
1 task	Y		X
1 task re-paired 10 times	Y		X

APPENDIX B

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

Group II

Training task

Trial	1	2	3	4	5	6	7	8	9	10
1	1.4	1.2	1.8	1.1	1.7	1.3	2.3	1.3	2.3	.9
2	1.9	2.6	2.9	3.3	3.6	2.7	3.1	3.3	3.7	3.8
3	2.3	3.5	4.0	4.7	4.9	3.5	4.4	5.1	5.2	5.4
4	2.5	4.4	5.5	5.9	6.2	4.7	5.7	6.8	6.4	6.6

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

Group III

Training task

Trial	1	2	3	4	5	6	7	8	9	10
1	1.4	1.2	1.1	1.2	1.2	1.5	1.1	1.1	1.7	1.6
2	1.9	2.0	2.8	2.7	2.6	2.9	3.3	3.3	3.2	3.6
3	2.0	2.4	4.1	3.5	3.9	3.4	4.2	4.5	4.0	4.0
4	2.7	3.7	4.4	4.4	5.1	4.4	4.9	5.4	5.3	5.7