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TECHNICAL REPORT 54-115

**TRANSFER OF TRAINING AFTER 10 DAYS OF PRACTICE WITH
ONE TASK OR WITH VARIED TASKS**

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NORTHWESTERN UNIVERSITY

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WRIGHT AIR DEVELOPMENT CENTER

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ONE TASK OR WITH VARIED TASKS**

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FOREWORD

This report was prepared by Northwestern University under USAF Contract No. AF33(616)-308. The contract was initiated under a project identified by Research and Development Order 694-44, "Learning and Transfer in Reference to Training Device Design." The contract was administered by the Psychology Branch of the Aero Medical Laboratory, Directorate of Research, Wright Air Development Center, with Ross L. Morgan acting as Project Engineer.

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ABSTRACT

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

On the whole, varied training yielded superior transfer to constant training. However, this result was almost entirely due to the group trained with different tasks. Specifically, the different-tasks group performed significantly better than the constant-conditions group on both tasks on the first transfer day, on one task on the second transfer day, and during the initial half of practice on one task on the third transfer day. In contrast, the group trained by daily re-pairing the stimuli and responses of the same task exhibited better transfer than the constant-conditions group on only one occasion, namely, on one task on the first transfer day. The results were accounted for primarily in terms of learning to differentiate stimuli both within and among tasks and suppression of interference.

These findings imply that training devices which provide a number of training task variations will yield greater initial transfer to operational equipment than training devices that provide only one training task. The results of the complete experimental program, of which this study is only a part, will reveal whether this conclusion is limited to the high levels of training and large number of training tasks used in this study. However, even the present findings do not imply that the greater transfer produced by a training device that provides a variety of tasks will always be sufficient to justify the cost of developing such a device. Even in those cases where superior transfer occurred after varied training, the duration of the superiority was at most three days. This is considerably less than the time that was spent in developing the training task variations.

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

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TRANSFER AFTER 10 DAYS OF PRACTICE WITH
ONE TASK OR WITH VARIED TASKS

INTRODUCTION

This paper reports a portion of a larger study dealing with transfer in perceptual-motor tasks as a function of constant as compared with varied training conditions. The basic plan consists of giving certain groups training on a single task (constant conditions), while other groups practice on several tasks all of the same class (varied conditions). After the same total amount of training, in terms of time or trials of practice, all groups are tested for transfer to new tasks. The design of the complete experimental program is presented in Appendix A.

It will be recognized that the varied training procedure used here, i.e., practice on several tasks of the same class, is the typical method used in studies of learning-how-to-learn (10). Since it is well known that subjects improve in performance when they practice a series of similar tasks, i.e., they demonstrate learning to learn, it might be expected that better transfer to a final task would result from such training than from the same total amount of practice on a single task. Certainly the assumption was implied in Harlow's (7) recommendation that variation should be introduced early and frequently in training. His recommendation was a generalization from his work on learning sets (6), although he did not actually compare transfer after training on several tasks with transfer after an equal amount of practice on one task. Such a comparison has been provided by a few studies (2, 3, 9, 13, 14), and in general they have found superior transfer for the varied-training groups. In most of these studies the groups that practiced a single task were considerably superior during training, but when tested on the transfer task their performance dropped below that of the varied-training groups, for which the transfer task was merely the last in a series.

A more analytical approach was taken by Crafts (2) in one of the most thorough investigations of the problem to date. Using card sorting, digit substitution, and typewriting, Crafts found better transfer following varied training only when there were "common elements" in the training and transfer tasks. For example, in the first card sorting experiment, subjects sorted nine packs of cards each day for five days. On each day sorting the first eight packs was defined as training; sorting the ninth pack was the transfer task. The spatial arrangement of the boxes into which the cards were sorted remained the same for the constant-training group for all eight training packs. For the varied-training group the arrangement was different for each of the eight packs. The ninth pack, the transfer task, was sorted into an arrangement which was new for both groups. The results were that the varied-training group showed no better transfer than the constant-training group.

Crafts argued that varied training yielded no better transfer because there were no elements common to both training and transfer tasks. This idea was tested in a second experiment by having cards with certain numbers on them sorted into boxes with different numbers, regardless of the spatial arrangement of the boxes. The card number corresponding to a particular box number was the same for all training and transfer tasks; this was the common element. The results supported the hypothesis; varied training produced significantly better transfer. The differences in the results of these two card-sorting experiments were duplicated in the substitution and typewriting experiments. In short, when common elements were introduced, varied training yielded superior transfer; when they were eliminated varied and constant training produced equal transfer. In no case, however, did varied training result in less transfer.

Crafts' results make clear that varied training will yield superior transfer only under certain conditions. The present paper reports part of a larger study in which certain other conditions are investigated (see Appendix A). Specifically, the major variables of the larger study are the length of the training period and the number of training tasks. Comparisons will be made, as measured by transfer, between groups practicing a single task and groups practicing several tasks during training, with variation in both the number of training tasks and the length of the training period. In addition, two ways of providing different training tasks will be employed. The basic purpose of the study as a whole is to test for interactions between the number and kinds of training tasks and the length of the training period.

The present paper serves to report the over-all method, and the results for three groups given the longest training period. The data for these three groups were collected first.

METHOD

Apparatus

The response portion of the apparatus consisted of a lever, 24 inches long, pivoted at its lower end in a ball and socket joint. The lever could be moved into any one of 13 slots cut one inch deep and one inch apart in a steel plate. The slots were arranged in a semicircle concave to the subject. A small red jewel light was immediately above, and a microswitch immediately below, each slot. Movement of the lever into any slot depressed the microswitch and flashed on the light above the slot which was correct for the stimulus showing. Thus, the subject was informed which slot was correct immediately after each response. As a further aid to the subject, the slots were numbered one to 13, from left to right, with a large numeral printed above each slot.

The lever was always operated from a sitting position. The subject grasped the lever such that the top six inches of the lever projected above the hand; stops on the lever prevented moving the hand up or down. The top, free end of the lever entered the slot.

In the sitting position the lights and numerals above the slots were at or slightly below eye level. Immediately above the lights and numerals was the aperture of a memory drum. The drum fitted into a hole cut in a large screen which prevented the subject from seeing the experimenter or the rest of the apparatus. The view from the subject's side is shown on the left in Figure 1.

Behind the screen the experimenter faced two rows of 13 lights each. The light which was on in the top row indicated the correct slot for the stimulus showing. When the subject moved the lever into a slot, the light in the bottom row indicated which slot had been entered. Recording of correct and incorrect responses was done manually by the experimenter.

The circuits connecting the subject's and the experimenter's lights were controlled by a selector switch operated off the memory drum. Each time the drum, run by its own motor, moved forward to present a new stimulus, the selector switch moved forward simultaneously. In its new position the switch turned on the "correct" light on the experimenter's panel of 13 lights and prepared the circuits so that as soon as the subject responded the "correct" light would also appear on his panel. A set of 13 telephone jacks permitted rapid re-pairing of stimuli and slots. The experimenter's side of the apparatus is shown on the right in Figure 1.

Tasks

Since the responses were always movements of the lever into the slots, a task is defined as a set of 13 stimuli which the subject had to learn to associate with the appropriate slots. There were 10 training and four transfer tasks. Each training task consisted of 13 relatively meaningless forms. All 13



Figure 1. The apparatus: subject's view on the left, experimenter's view on the right.

forms within a task were produced by drawing elaborations on a single "theme," such as a circle, an H, etc. A different theme was used for each task. Thus, no stimulus in any task had any obvious similarity to a stimulus from another task. Because of this there was probably very little transfer between tasks resulting from stimuli in different tasks appearing similar and, by chance, being assigned to the same response. Nevertheless, over-all intertask similarity was not especially low, particularly in the training tasks where all stimuli were forms. Intratask similarity was probably high, particularly in the training tasks, although an effort was made to minimize similarity within a task while sticking to the theme.

The four transfer tasks were: (a) H figures, 13 forms built on a theme (basic figure a capital H) not used for any training task, (b) nonsense syllables of low association values and low intratask similarity, (c) Gibson figures, 13 selected from Gibson's (5) four lists, (d) colors, patches cut from 13 shades of colored paper. All training and transfer tasks, except the colors, are shown in Appendix B.

All sets of training and transfer stimuli, except the colors, were drawn and photographed on white patches about one-half inch square. These patches, as well as the color patches, were dry-mounted on tapes which had been cut to fit the memory drum.

To prevent serial learning, the 13 stimuli in each task were mounted in 12 different orders in a single vertical column on the tape. Since the tape was an endless belt, there was no particular beginning or end of a task. The stimuli were machine paced, each stimulus appearing for four sec. After every 39 stimulus presentations (three trials or three orders) a blank space on the tape appeared for four sec. during which the selector switch controlling the slot lights shifted to another bank of contacts. As a further enforcement of paired-associate learning, the tape was never started at the same blank space on successive days of practice.

Conditions

In this report the results for three training conditions will be presented. Group I was trained under constant conditions; Group II and III each practiced under a different type of varied conditions during training. In Group I each subject practiced on one task throughout all 10 training days. The 10 training tasks were assigned to subjects in turn. In Group II each subject practiced all 10 training tasks, one task per day. For each subject the task to be practiced each day was determined by a 10 x 10 Latin square in which subjects were represented by rows; within each block of 10 subjects no task was assigned to more than one subject on any day. In Group III each subject practiced 10 different pairings of one set of stimuli with the slots (one task). As in Group I, each subject within a block of 10 subjects was assigned a different training task. The stimuli and slots were completely re-paired before practice began each day. In these 10 re-pairings no stimulus was ever paired with the same slot more than once. Thus, whereas Group II was confronted with a different set of stimuli every day and had to learn to pair them with the correct slots, Group III saw the same stimuli every day and only had to learn a new set of S-R associations.

Twenty-one trials were given each day. Since the pacing was fairly slow (each stimulus appearing four sec.), no rests were given other than the four-sec. blank after 29 stimuli, or three trials.

Measuring transfer.

In this and in future reports 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 of the three main groups is split into two subgroups. One subgroup is tested with the nonsense syllables on the first transfer day and the H-figures on the second day. The order of tasks is reversed for the other subgroup. Thus the transfer tasks are counterbalanced over days.

When the schedule of experimentation permits, one or two additional transfer days are run. 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 both additional transfer days were run, making a total of four transfer days. 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 transfer day were given Gibson figures and colors on the third and fourth transfer days respectively; these subjects will hereafter be called subgroups A. The remaining subjects, subgroups B, went through the transfer tasks in the order: H-figures, nonsense syllables, colors, Gibson figures. Twenty-one 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 subjects worked a five-day week, thus, the 10 days of training required two weeks, and transfer was tested on the first four days of the third week.

Instructions to the subjects described the nature of the task and emphasized making as many correct responses as possible. The instructions were given every day to all subjects since conditions changed every day for Groups II and III, and since the repeated emphasis on making correct responses was intended to counteract possible carelessness in Group I late in training.

The instructions also specified that it was necessary to make a response every 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 on the first training task (correct responses on trial 1 would be largely chance).

These trials were used because in a later report comparisons will be made between the present groups and others given only four trials on the first training task. Since the groups in this study were actually given 21 trials on the first task, equating on total of trials 2-4 could be checked against total of all trials.

The original number of subjects in each subgroup ranged from 20 to 23. Those with unusually high or low totals on trials 2-4 were eliminated. Table 1 shows the resultant number of subjects in each subgroup and the mean totals both for trials 2-4 and for all trials. Equating on trials 2-4 yielded mean totals for all trials that did not differ significantly; the largest t-value, that between Groups IA and IB, was 1.03.

TABLE 1

Comparability of subgroups at two stages of practice on the first training task, indexed by mean total correct responses

Group	N	Trials 2-4		All trials	
		Mean	σ_M	Mean	σ_M
IA	19	6.69	.57	131.58	12.74
IB	18	6.83	.74	147.22	8.37
IIA	19	6.63	.69	138.47	8.77
IIB	17	6.88	.68	142.35	8.06
IIIA	18	6.89	.69	132.94	10.40
IIIB	18	6.72	.44	134.94	11.43

Training

Little need be said concerning performance of Group I during training, since these subjects practiced the same task for 10 days. By the end of the third day (63 trials) only three of the 37 subjects in this group were still making one or two errors per trial. No subject made more than an occasional error after the fourth day.

Both Group II (a new set of stimuli every day) and Group III (the same stimuli re-paired every day) showed learning to learn in typical fashion; intertask improvement was rapid at first, with gradually decreasing gains. Figure 2 shows performance of both Groups II and III on four of the 10 training days. (The data for all training days for Groups II and III are given in Appendix C.) It may be seen that most of the learning-to-learn transfer in both groups occurred by Day 7, although slight gains continued even through Day 10. While only a few subjects achieved errorless performance (13 correct responses per trial) on the later trials of Day 1, by Day 10 such performance was essentially characteristic of all subjects in both groups. In Figure 2 the means, based on 36 subjects, run from 12.8 to 12.9 correct responses on the last few trials of Day 10.

Comparison of the left and right sides of Figure 2 reveals that Group III showed somewhat more rapid improvement from day to day than Group II during the earlier days of training. Group III made a significantly greater gain than Group II from Day 1 to Day 6 ($t = 2.06$). This appears more clearly in Figure 3, where the two groups are compared on mean performance on all training days. The problem faced by Group II of differentiating among new stimuli every day, as well as connecting them with responses, is presumably the reason for its slower learning to learn during the first half of training. This point will be elaborated later. The groups do not differ by the end of training.

Figure 3 shows another fact worthy of remark: the sharp improvement of Group III from Day 5 to Day 6. This does not appear to be merely a chance fluctuation. The gain from Day 5 to 6 was greater, on corresponding trials, than either the gains from Days 3 to 4 or 4 to 5 on 18 out of the 21 trials. Figure 3 also shows that performance on Day 6 was the highest, although by only a fractional amount, of any achieved during training. With regard to this finding, it may be noted that a weekend (72 hrs. rest) intervened between Days 5 and 6, whereas all other intertask intervals were 24 hr. The suggestion is that the longer intertask interval permitted greater forgetting of factors counteracting positive intertask transfer. This point will be brought up again in later discussion.

Comparison of Day 1 with Day 10 in Figures 2 and 3 shows that considerable learning to learn occurred during training. One way of expressing this improvement quantitatively is in terms of the change, from Day 1 to Day 10, in probability that a correct response would occur on the trial immediately following the trial in which it was first made correctly. The maximum possible number of such occurrences was 468 (13 responses x 36 subjects) in Group II, the group on which the probability index was computed. There were 175 such immediately-repeated correct responses on Day 1, and 309 on Day 10. Thus, the probability that a response would be correct on the trial following its first correct occurrence was .37 on Day 1, and .66 on Day 10. Even this difference does not adequately express the amount of learning to learn that took place, since on Day 10 cases of two consecutive correct responses occurred earlier in practice, and were followed by fewer subsequent errors, than on Day 1.

Transfer

Analysis of the transfer data showed that there were rather important differences in performance as a function of the particular task being used to measure transfer. Therefore, for any one transfer day the results will be reported separately for the two tasks used on that day.

Performance on the first transfer day is shown in Figure 4. The transfer task was nonsense syllables for the A groups, shown on the left in Figure 4, and H-figures for the B groups, on the right of Figure 4. By inspection, the curves show differences between the constant condition groups (Groups IA and IB) and the corresponding varied training groups, especially for those groups that practiced on 10 different tasks during training (Groups IIA and IIB). A possible differential effect of the two transfer tasks is also indicated, particularly on those subjects who practiced re-pairings of the same stimuli and responses during training (Groups IIIA and IIB).

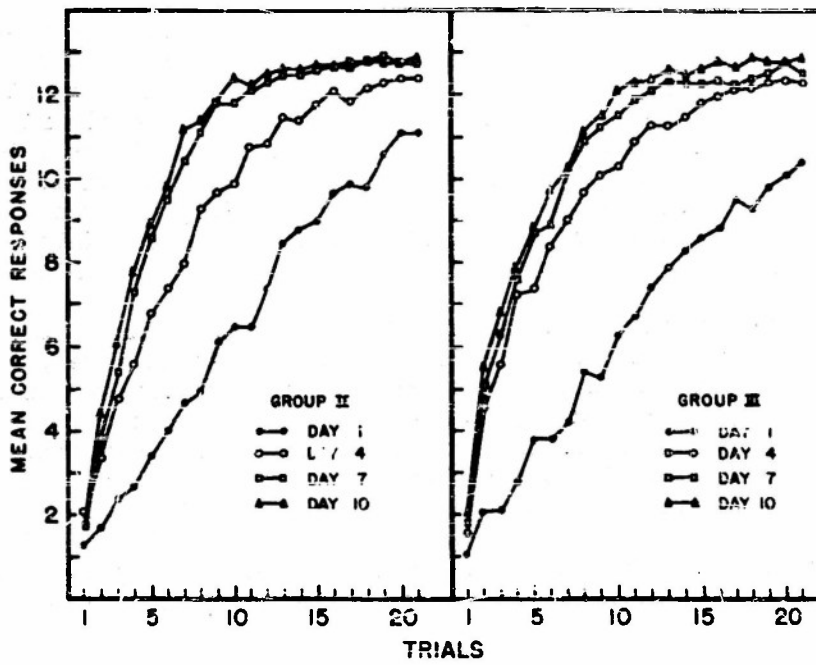


Fig. 2. Performance of Group II, on the left, and Group III, on the right, on four of the 10 training days

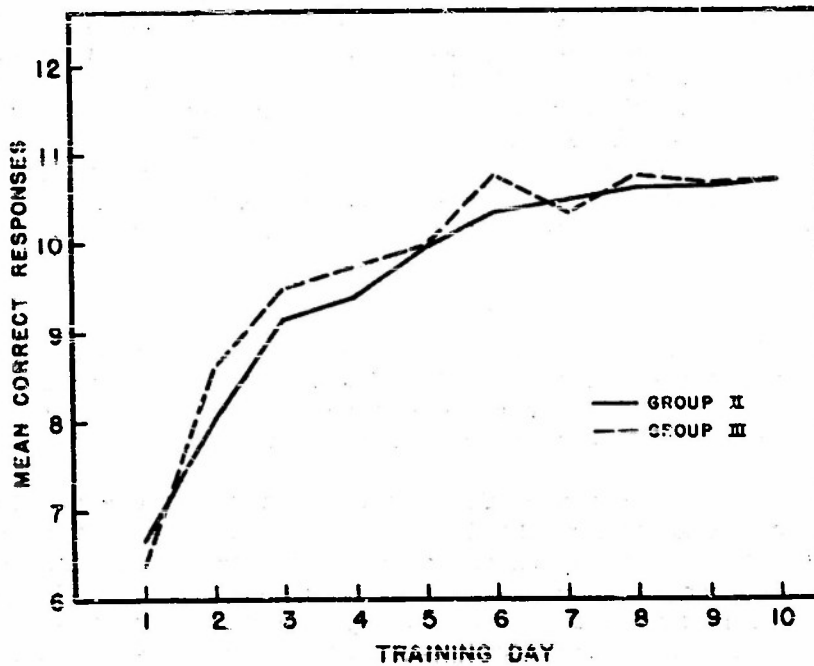


Fig. 3. Mean performance of Groups II and III on all training days

Differences among the A groups were evaluated by simple analysis of variance on total correct responses over all 21 trials. The F was 7.05, which for 2 and 53 df is significant at the 1% level. The hypothesis of homogeneity of variance could not be rejected; χ^2 was .95. Differences between pairs of groups were evaluated by t ; the standard errors of the means were based on the error term from the analysis of variance. Both Group IIA and Group IIIA were significantly different from IA at the 1% level; the t values were 3.13 and 3.35 respectively. The difference between Groups IIA and IIIA was not significant; t was .26. These

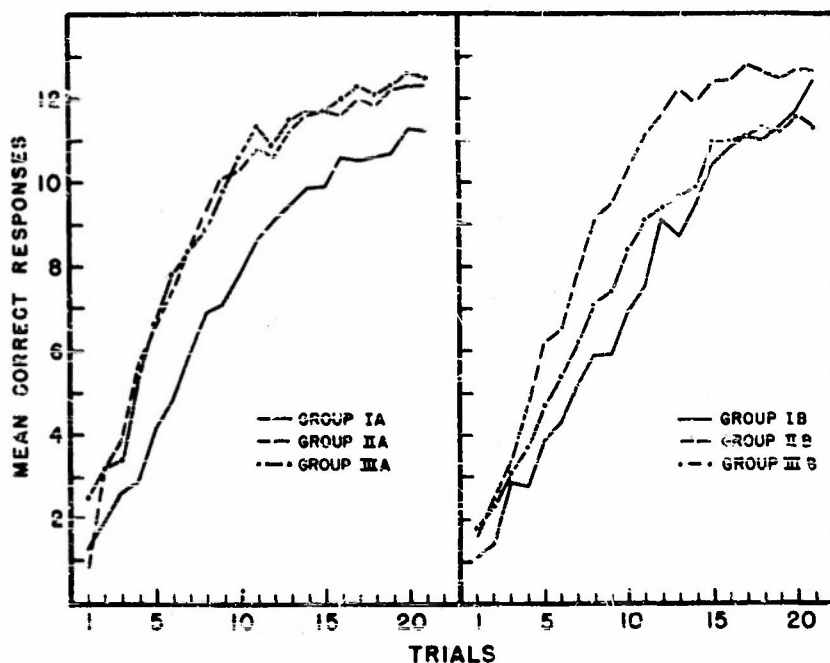


Fig. 4. Performance on the first transfer day, both on the nonsense-syllables task on the left, and on the H-figures task on the right

results show that when transfer was tested with the nonsense syllables task, both methods of varied training yielded equivalent amounts of transfer. This transfer was superior to that of the group trained under constant conditions, even though this group showed considerable improvement over its own performance on the first training day (from a mean total of 131.58 correct responses on the first training day to a mean total of 157.11 on the first transfer day).

Analysis of variance of the groups tested on the H-figures task (on the right in Figure 4) also showed a difference significant at the 1% level; F was 6.51 with 2 and 50 df. On the test for heterogeneity of variance, the corrected χ^2 was 4.21 which is not significant. Comparison of pairs of

groups by t yielded the following: Group IIB was significantly superior to Group IB at the 1% level; t was 3.52. Group IIIB did not differ significantly from Group IB; t was 1.03. The varied-training groups differed significantly; Group IIB was superior to Group IIIB at the 5% level ($t = 2.59$ with 50 df). Thus, these analyses show that when transfer was tested with the H-figures on the first transfer day, only one of the methods of varied training (10 different tasks) yielded transfer greater than that resulting from constant conditions of training. Training with 10 re-pairings of the same task did not produce a significant effect.

Turning now to the data for the second transfer day, it will be recalled that the A groups were tested on H-figures on this day, and the B groups were tested on nonsense syllables. Performance of both sets of groups is shown in Figure 5. Inspection of this figure shows that the differences among groups are much reduced as compared with the first transfer day (Fig. 4). In particular, all B groups perform much the same on nonsense syllables.

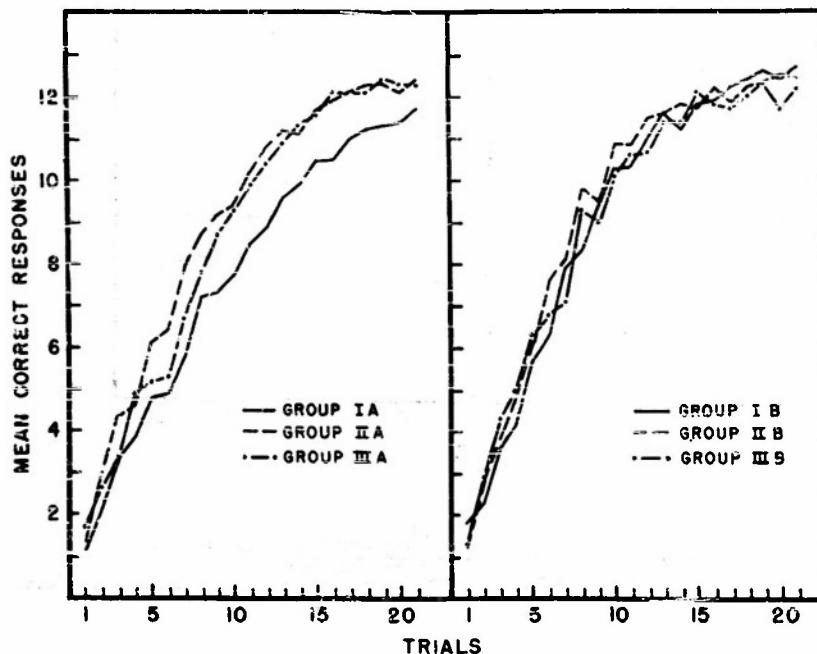


Fig. 5. Performance on the second transfer day both on the H-figures task on the left, and on the nonsense syllables task on the right.

Analysis of variance on the A groups (H-figures) yielded $F = 3.42$. This value is significant at the 5% level for 2 and 53 df. Comparison of pairs of groups by t showed that Group IIIA was significantly different from Group IA at the 5% level; t was 2.49. Group IIIA did not differ significantly from Group IA ($t = 1.90$), nor from Group IIA ($t = .57$). Although the differences

were smaller than on the first transfer day, the 10-task group, and only this group, continued to show transfer superior to the constant- conditions group when tested with the H-figures on the second day.

Analysis of variance of the B groups gave an F -value less than one. The groups did not differ when tested with nonsense syllables the second day.

It is clear that, with the method used here of counterbalancing transfer tasks over transfer days, differences in transfer produced by varied vs constant training conditions are much reduced on the second transfer day. Comparison of Figures 4 and 5 shows that this is largely due to the gains made by both Groups IA and IB from the first to the second transfer day. The mean total correct responses of Group I (A & B combined) was 155.86 on the first, and 175.97 on the second transfer day. Group III showed a slight gain over transfer days; from a mean of 182.14 to a mean of 186.36. Group II showed a slight decrease over transfer days, from 195.42 to 192.06.

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 and a fourth transfer day. The tasks used on these days were Gibson figures and colors. The A groups learned the Gibson figures on the third day, colors on the fourth day. The B groups were given the color task on the third day, Gibson figures on the fourth.

Performance on the third transfer day is shown in Figure 6. The Gibson figures are learned rapidly by all three A groups. As a matter of fact, all 56 subjects in the A groups were errorless (13 correct responses) on trials 20 and 21. The color task is learned less rapidly and the B groups show differences among themselves.

Figure 6 shows that the performance of all three A groups is essentially asymptotic beyond the tenth trial. Therefore, only the total score for the first 10 trials was used in the analysis of variance. Although Figure 5 shows that the rank order of the groups over the first 10 trials was what would be expected from previous results, i.e., II above III and III above I, the differences were not significant (F was 2.35).

Performance of the B groups on the color task was evaluated by two analyses of variance, one on total for all 21 trials, and one on total for the first 10 trials only. Over all trials the differences were not significant; F was 2.62. Over the first 10 trials F was 3.30, which with 2 and 50 df is significant at the 5% level. By t -test, Group IIB differed significantly from Group IB ($t = 2.52$), but Group IIIB did not ($t = 1.67$). Thus the different-tasks group showed some superiority to the constant-conditions group on the third transfer day, but the re-paired group did not.

Performance on the fourth transfer day is shown in Figure 7. On the left of Figure 7 the performance of the A groups on the color task is represented. Although Group IA is lower, the groups do not differ significantly when tested by analysis of variance. Using total over all trials as the score, F was 2.88; over the first 10 trials F was 2.53.

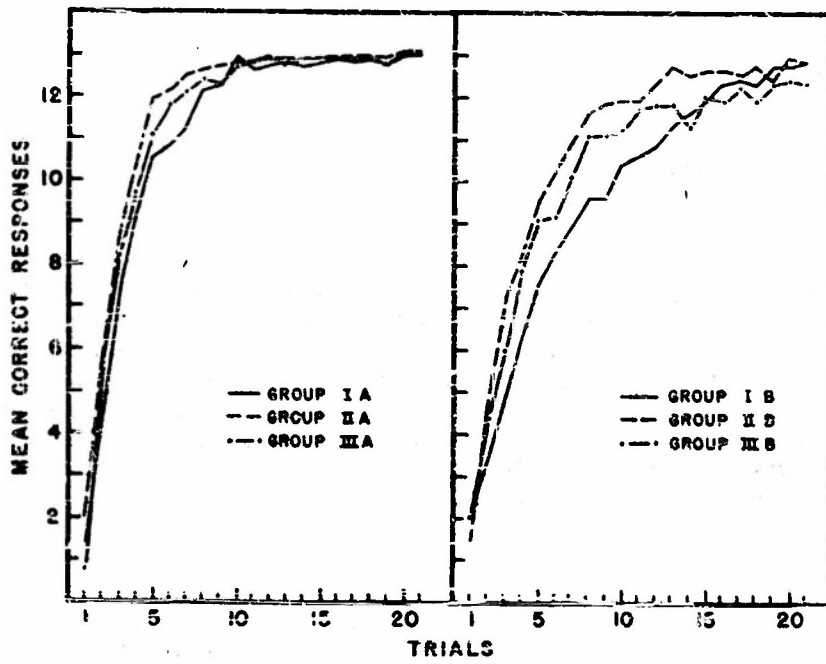


Fig. 6. Performance on the third transfer day, both on the Gibson-figures task on the left, and on the colors task on the right.

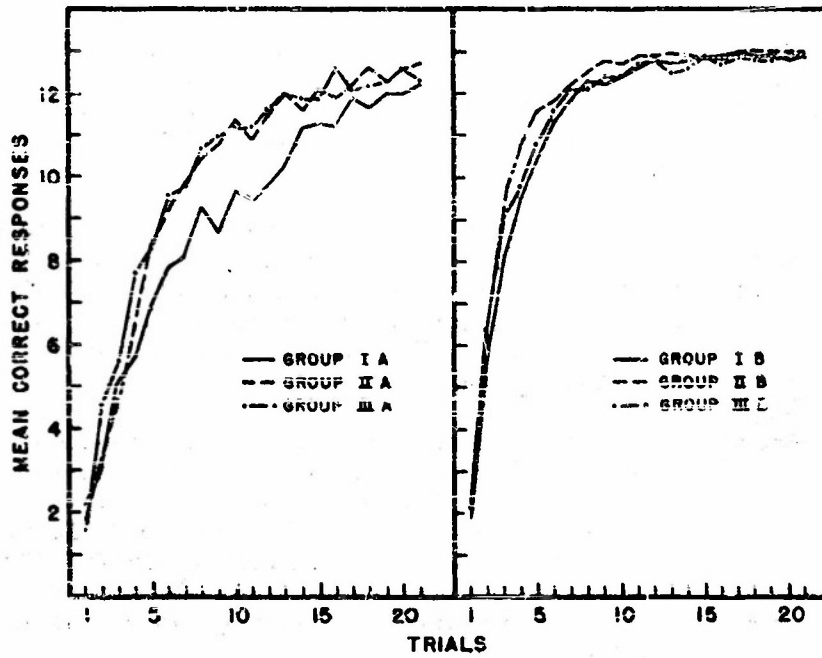


Fig. 7. Performance on the fourth transfer day, both on the colors task on the left, and on the Gibson-figures task on the right.

Differences among the B groups on the Gibson figures, on the right in Figure 7, are so small that no tests of significance were performed. By the fourth transfer day differences among all groups have largely disappeared.

DISCUSSION

If one asks whether training varied in some way will yield superior transfer to that provided by constant practice on one task, common sense would seem to favor the varied method. The present data certainly permit the conclusion that varied training yields greater transfer, but they also indicate that this conclusion should be qualified on two counts. In the first place, much of the relative advantage of varied training had disappeared as early as the second day of testing for transfer. This was almost entirely due to the gains made by the constant-conditions group from the first to the second transfer days, rather than to any losses by the varied-training groups. After having highly overlearned their one training task, the subjects in the constant-training group were materially benefitted by the single "variation" provided by the tasks presented on the first transfer day. In short, the relative superiority produced by varied training was not particularly enduring.

The second reason for qualifying the conclusion of better transfer performance following varied training is the relationship found between the kind of varied training and the nature of the transfer task. Only those subjects trained with a different set of stimuli every day were superior to the constant-trained group on more than one transfer task. Even on the first test for transfer, the subjects trained by re-pairing the same task did no better than the constant group on the H-figures task. Thus, this finding raises the problem that the effect of certain kinds of varied training may not be very general, may, in fact, be restricted to only a few tasks with which transfer might reasonably be tested.

In further emphasis of the finding that the different-tasks group was less affected than the re-paired group by the particular transfer task used, it may be noted that in one way the method of training by re-pairing the same task "looks" much more like training on different tasks than it does to continued practice on one task. Every day during training the re-paired group had to start from scratch, as did the different-tasks group, in the sense that each of 15 stimuli had to be associated with a different response. The subjects had no way of knowing which response was going to be correct. (It is true that, by trying to recall what associations had been correct on the previous day or days, the re-paired group might eliminate certain possibilities, but it will be argued below that such retention of earlier associations would be a hindrance rather than a help.) There was no improvement on the first trial from day to day during training in either the re-paired or different-tasks groups. Furthermore, both intra- and inter-task performance of these groups during training was quite similar, as Figures 2 and 3 show.

In contrast, the constant-training group had, as reported above, largely learned their one task by the end of the first day of training. All subjects in this group had mastered the task after four days, so the poorest subject spent at least six days, 120 trials, overlearning the same task. Thus, the

constant group and the re-paired group were trained quite differently, and yet they did not differ, even on the first transfer day, when tested with the E-figures task. It is clear that mere practice at associating stimuli with responses, on which the re-paired group had as much training as the different-tasks group, is only a portion of learning to learn.

This last remark leads us to inquire what information concerning learning to learn can be gleaned from a comparison of the re-paired with the different-tasks conditions. The chief differences between the groups are that the re-paired group showed more rapid improvement early in training but were equalled late in training by the different-tasks group, and that, on the whole, the different-tasks group performed better on the transfer tasks. In attempting to account for these differences certain factors can be disposed of immediately, since they were the same for both groups. Specifically, whatever is contributed to learning to learn by practice at associating stimuli and responses, and by response differentiation or other factors on the response side, should have been identical for both groups. The same can be said for such factors as getting used to the situation, reduction of tension, etc.

It appears that the performance differences noted above must somehow be related to the stimuli presented during training and during transfer. One group had the same stimuli every day; the other group was confronted with a new set of stimuli every day. One explanation for the more rapid learning to learn by the re-paired group early in training might be based on retention of the associations made on the previous day or days, which would allow the subjects to reject those associations as possibilities on later days. (The re-paired subjects were told each day that all 13 stimuli and responses had been re-paired.) This explanation might account for the poorer performance of the different-tasks group early in training, but it cannot account for the differential effect of the transfer tasks, since these tasks involved stimuli which were new to both groups. In addition, it will be argued later, in another connection, that retention of the associations learned the preceding day would be an interference rather than a facilitation.

An explanation that appears more promising is one based on some kind of stimulus differentiation. The argument runs as follows. The stimuli of all training tasks were relatively meaningless forms; thus, intratask similarity appeared to be high. Both the re-paired and different-tasks groups may therefore have learned, on the first training day, to differentiate the stimuli while simultaneously associating them with responses. Of course, all 13 stimuli in any task could be seen as different if observed all together. But as used here stimulus differentiation means that, due to experience with the stimuli, they are more quickly or more easily discriminated from each other than before; they have achieved "identity" in Hebb's (8) sense. And, still following Hebb, stimuli that possess the property of "identity" enter more easily into S-R connections.

On the remaining training days the re-paired group was confronted with the same stimuli which had already been at least partly differentiated the first day. The different-tasks group lacked this advantage; these subjects were confronted with a different set of stimuli every day. Thus, the more rapid improvement of the re-paired group early in training is understandable on this basis.

Late in training the different-tasks group equalled, and on the transfer tests did better in several cases, than the re-paired group. A possible reason for this may lie in the fact that the 10-task subjects had considerable practice at differentiating stimuli. If such practice is helpful it should show up most clearly later in training and particularly on the transfer tasks, where, for the first time since the initial training day, the groups practiced on tasks whose stimuli were equally new to both.

It should also be noted that differentiation of stimuli may occur not only among the stimuli within one task but among the stimuli comprising different tasks as well. Practice at intertask differentiation would help in suppressing intertask interference. As Riopelle (12) has recently demonstrated, suppression of intertask interference occurs during the development of learning sets. If the different-tasks group had developed greater ability to suppress intertask interference, the finding that their performance on the first transfer day was better than the re-paired group on H-figures but not on nonsense syllables is understandable. The H-figures are more similar to the training tasks than are the nonsense syllables and are therefore more susceptible to interference.

Although the inferences discussed above concerning learning to learn were derived from comparisons of the different-tasks and the re-paired groups, it is clear that the discussion could as well apply to comparisons between the transfer performance of the different-tasks and the constant-conditions groups. Practice at differentiating stimuli both between and among tasks with the consequent ability to suppress intertask interference, processes which are assumed to develop with training on different tasks, would account for all cases where the 10-task subjects were superior to the one-task group on the transfer tests.

Turning attention now to a different matter, it will be recalled that during training the re-paired group showed a sharp gain from the fifth to the sixth training days (see Figure 3). It has been noted that a 72-hr. rest intervened between (training) Days 5 and 6, whereas all other training days were separated by 24-hr. It was suggested that the longer rest permitted greater forgetting of interfering associations. We shall try to show that in the light of certain other findings, this seems to be a reasonable assumption.

Gagne, Baker, and Foster (4) have argued that negative transfer will result when subjects are required to learn a second task which is constructed by re-pairing the stimuli and responses of the first task. An experiment (11) testing this fully confirmed the prediction. With verbal lists of 12 paired-associate adjectives, significantly more trials to learn were needed and significantly more errors were made on the re-paired list than on the first list. But the results in the present study with the re-paired group are directly contradictory. Figure 3 shows considerable positive transfer from the first to the second training day.

It is believed that this contradiction can be explained by the fact that in the adjective-list study the intertask interval was only two min., whereas in the present study the interval was at least 24-hr. In the adjective experiment there was little or no forgetting of the first task, with the result that considerable interference occurred during learning of the re-paired task from the strong first-task associations. It is assumed that in the present experiment the 24-hr. interval permitted some forgetting of the interfering S-R connections learned the previous day, while factors contributing to positive transfer were apparently better retained. (Bunch (1) has reported

that general transfer effects are retained better than specific S-R associations.) It should also be noted that in the adjective study the stimulus-response interval was only two sec. whereas in the present study it was four sec.; with the longer time there is more opportunity to suppress erroneous response tendencies. Thus, it should follow that a 72-hr. interval would allow even greater forgetting of previously-learned S-R connections, permitting positive transfer factors to appear more strongly. Furthermore, it is even possible that the drop in performance from the sixth to the seventh training day (Figure 3) may be due to the quite strong, and therefore too well retained, associations learned on the sixth day.

IMPLICATIONS FOR THE DESIGN OF TRAINING EQUIPMENT

The situations confronting military personnel in the performance of regular duties are often quite varied. Skillful performance in response to varying problems demands a certain degree of flexibility on the part of the personnel concerned. The question therefore arises as to whether it is possible to provide training that will facilitate a flexible approach to the varying demands of the operational situation. In particular it would help to know whether training devices should be designed to require considerable variation in the behavior of the trainee, thus simulating more closely the demands of the operational situation. Although the research upon which this report is based was designed primarily to contribute to a background of information and the development of principles which will be widely applicable, the present results have certain implications relevant to the above questions.

Some of the findings detailed in this report imply that it would be worthwhile to develop training devices that can provide varied training. In the first place, it was shown that, in general, varied training resulted in superior transfer performance. Perhaps more important was the finding that those trainees who had to respond during training to several different sets of stimuli performed well on all transfer tasks. Now it is likely that most military situations requiring the operation of complex equipment present the operator with a variety of situations. It is therefore implied that in training personnel to operate complex equipment, training devices might well be designed to provide a considerable variety of input information.

It must be pointed out, however, that other aspects of the results raise some questions about the advisability of designing highly flexible training devices. Increasing the complexity of training devices is likely to be expensive. Furthermore, varied training is more complex to administer and may be more expensive. It is pertinent to ask whether the advantages to be gained are worth it. In the first place, it may be inferred from the present results that not every kind of variation which might be built into training devices will necessarily be helpful. The results presented for those subjects trained by re-pairing each day the stimuli and responses of one task show that mere practice at associating stimuli and responses does not always provide superior transfer. This was true even though such practice had been considerable in amount and transfer was tested with tasks similar in many respects to the training task. It is perhaps not surprising that the results should imply that not every method of varying training, which might be provided by appropriate design of training devices, will facilitate performance on operational equipment.

Secondly, although varied training may result in superior performance at first, such superiority may be relatively temporary. This occurred in the present study. Thus, the results imply that one must weigh the extra cost and complexity of highly flexible training devices against the total gain to be achieved.

CONCLUSIONS

1. In general, varied training resulted in better performance upon testing for transfer than did training restricted to continued practice on one task.
2. Varying training by requiring practice on different tasks effected superior performance in several of the tests for transfer.
3. Varying training by requiring practice on the same task re-paired every day produced more transfer in one transfer test only.
4. Much of the difference in transfer performance between varied and constant training conditions had disappeared after the first day of testing for transfer. All groups were equivalent in performance after the third transfer day.
5. It was suggested that the facilitation of transfer performance following training with different tasks was due to practice at differentiating stimuli both within and between tasks and consequent suppression of intra- and intertask interference.
6. The results imply that flexible training devices may produce better transfer to operational situations than non-flexible training devices. It is a separate question as to whether the costs of providing flexible training may outweigh its advantages.

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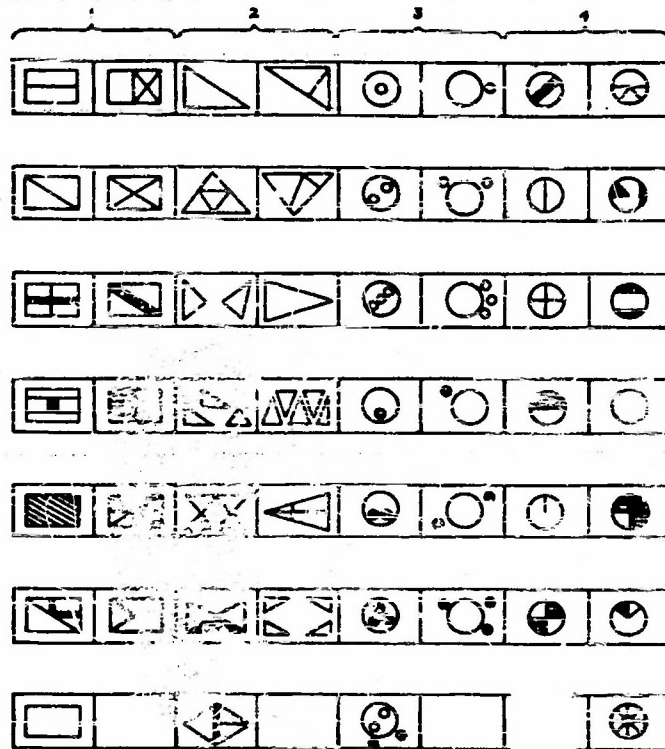
APPENDIX A

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". 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	X		
5 different tasks			
2 different tasks			
1 task	X		
1 task re-paired 10 times	X		

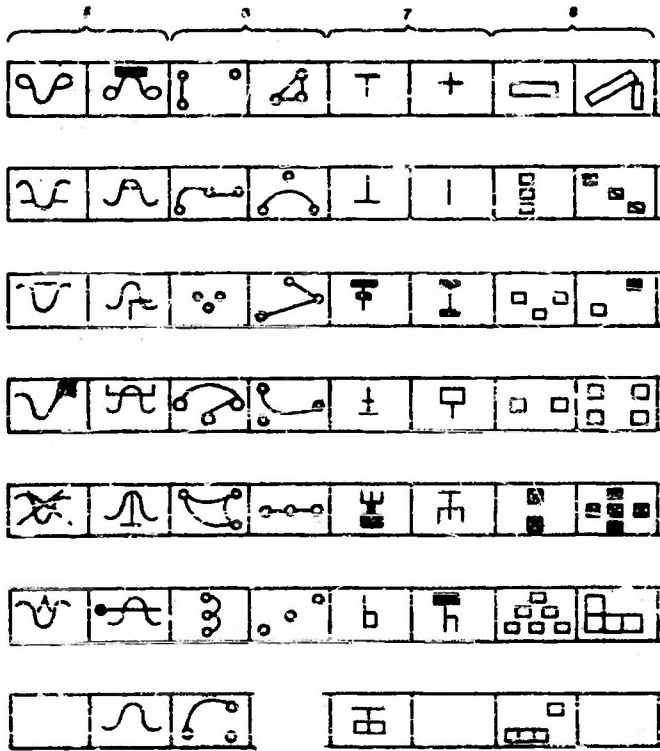
APPENDIX B

On this and the next two pages are shown the sets of stimuli comprising the different training and transfer tasks. The 13 stimuli within each of the 10 training tasks are arranged in adjacent columns under a numbered bracket. Three of the transfer tasks, the nonsense syllables, the H-figures, and the Gibson figures, are shown. Transfer task four consisted of patches of 13 different colors and is not shown.



APPENDIX B

(continued)



APPENDIX B

(continued)

		10		TRANSFER 1		TRANSFER 2		TRANSFER 3	
↔	←	⊙	⊕	TOV	YOB	⊥	⊥	⊗	∞
→	✕	⊖	⊙	GIW	ZIL	H	H	⊖	↗
⊗	⊙	⊕	⊖	LAJ	VEC	⊥	⊥	⊖	⊖
⊗	↔	⊖	⊕	XUK	FEH	⊥	⊥	⊖	⊖
↔	⊖	⊙	⊕	QOB	JID	⊥	⊥	⊖	⊖
↔	↔	⊕	⊖	MEF	WUQ	H	H	⊖	⊖
⊖		⊙		DAX		⊥		⊖	

APPENDIX C

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

Trial	Training day									
	1	2	3	4	5	6	7	8	9	10
1	1.3	1.1	1.4	2.1	2.1	1.9	1.7	2.7	2.3	1.9
2	1.7	2.3	3.3	3.4	4.2	3.7	3.8	4.4	4.5	4.4
3	2.4	3.1	4.1	4.8	4.7	5.1	5.4	5.6	6.2	6.1
4	2.7	3.8	5.9	5.6	6.2	6.8	7.3	7.3	7.4	7.7
5	3.4	4.9	6.7	6.8	7.2	8.4	8.6	8.4	8.8	8.9
6	4.0	6.3	7.7	7.4	8.3	9.4	9.5	10.1	9.9	9.8
7	4.7	6.2	8.6	8.0	9.3	10.0	10.4	11.0	10.3	11.2
8	4.9	7.1	8.8	9.3	10.2	10.8	11.1	11.3	10.9	11.4
9	6.1	7.5	9.7	9.7	10.3	11.5	11.8	11.5	11.7	11.8
10	6.5	8.5	10.1	9.9	10.9	11.9	11.8	11.9	12.1	12.4
11	6.5	8.9	10.3	10.8	11.4	12.1	12.1	12.1	11.9	12.2
12	7.4	9.4	10.7	10.9	11.6	12.4	12.3	12.5	12.3	12.5
13	8.5	9.8	11.0	11.5	11.9	12.1	12.5	12.6	12.3	12.6
14	8.8	10.3	11.4	11.4	12.1	12.4	12.5	12.4	12.7	12.6
15	9.0	10.5	11.4	11.8	12.4	12.3	12.6	12.6	12.7	12.7
16	9.7	10.6	11.8	12.1	12.5	12.6	12.7	12.8	12.6	12.7
17	9.9	11.1	11.8	11.9	12.5	12.6	12.8	12.7	12.6	12.7
18	9.8	11.3	12.2	12.2	12.6	12.7	12.8	12.6	12.7	12.8
19	10.6	11.6	12.3	12.3	12.6	12.8	12.9	12.8	12.7	12.8
20	11.1	11.7	12.4	12.4	12.7	12.8	12.8	12.8	12.8	12.8
21	11.1	11.8	12.6	12.4	12.8	12.8	12.8	12.8	12.9	12.9

APPENDIX C

(continued)

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

Trial	Training day									
	1	2	3	4	5	6	7	8	9	10
1	1.1	1.3	1.5	1.6	2.0	1.6	1.8	1.8	1.8	2.1
2	2.1	3.3	4.4	4.6	4.5	6.0	5.1	5.6	5.2	5.5
3	2.1	4.4	5.4	5.6	5.8	7.3	6.3	6.7	5.9	6.8
4	2.8	5.4	5.9	7.3	7.2	8.8	7.6	8.5	7.9	7.9
5	3.8	5.9	7.0	7.4	7.9	9.5	8.7	9.1	9.3	8.8
6	3.8	6.9	8.0	8.4	8.5	9.9	8.9	9.7	10.1	9.7
7	4.2	7.1	8.9	9.0	9.4	10.6	10.2	10.8	10.2	10.2
8	5.4	8.1	9.3	9.7	9.8	10.9	10.9	11.4	11.5	11.1
9	5.3	8.6	9.3	10.1	9.9	11.5	11.2	11.9	11.7	11.5
10	6.3	9.2	10.2	10.3	10.6	11.9	11.5	11.9	11.8	12.1
11	6.7	9.5	10.6	10.9	11.3	12.4	11.9	12.2	12.0	12.3
12	7.4	10.2	10.9	11.3	11.4	12.3	12.1	12.4	12.1	12.4
13	7.9	10.4	11.5	11.3	12.1	12.4	12.3	12.4	12.4	12.6
14	8.3	10.5	11.4	11.5	11.8	12.5	12.3	12.6	12.5	12.5
15	8.6	10.9	11.8	11.6	12.2	12.6	12.3	12.5	12.5	12.6
16	6.8	10.9	12.2	12.0	12.3	12.6	12.3	12.8	12.7	12.8
17	9.5	11.3	12.1	12.2	12.4	12.6	12.2	12.6	12.7	12.7
18	9.3	11.4	12.0	12.2	12.4	12.7	12.4	12.6	12.7	12.9
19	9.8	11.5	12.3	12.3	12.4	12.7	12.5	12.7	12.7	12.8
20	10.1	11.8	12.3	12.4	12.4	12.7	12.8	12.8	12.9	12.8
21	10.4	11.9	12.5	12.3	12.4	12.7	12.5	12.7	12.9	12.9

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