Proceedings of the Iowa Academy of Science

Volume 67 | Annual Issue Article 56

1960

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Evidences of Positive and Negative Transfer Effects Between Highly Similar Perceptual-Motor Tasks[1]

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Abstract. One hundred twenty male undergraduates, each assigned to one of two groups, performed highly similar perceptual-motor tasks varying in difficulty. The tasks were provided by the Multipoint Two-Hand Coordinator. On Day 2, one-half of the *S*s in each group changed tasks while one-half continued on the same task. Evidences of positive and negative transfer effects were found with greater positive transfer from the easier to the more difficult task than in the reverse direction. A striking feature of the study was the persistence of negative transfer effects.

Several investigators have studied the nature of the transfer between perceptual-motor tasks of varying difficulty. Many of these experiments have been concerned with the problem of which task to teach first for more efficient later learning. The results of these investigations have been somewhat equivocal. For instance, Barch (1953) found the amount of transfer from three initial tasks of varying difficulty to a later task was an increasing function of the difficulty of the initial task. Barch and Lewis (1954), however, found greater transfer from an easy to a more difficult task than between those of equal difficulty and greater transfer from an easy task to a very difficult one than from a difficult to a very difficult task. Gibbs (1951) reported handle-winding and steering experiments in which greater transfer from a difficult to an easier task was found. Baker, Wylie, and Gagne (1950), using variation in rate of response, also found more positive transfer in going from a difficult to an easier task than from an easy to a difficult one.

This experiment was designed to investigate the types and relative amounts of transfer between two highly similar perceptual-motor tasks varying in difficulty. The performance of *S*s changing from the easier to the more difficult task was compared with the performance of *S*s changing from the more difficult to the easier task. The Multiple Two-Hand Coordinator provided both subject-paced tasks.

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[1]This work was done under the general supervision of Dr. Don Lewis, Department of Psychology, State University of Iowa, Iowa City, Iowa. During the period of its accomplishment, Mr. Leonard was Professor Lewis' chief laboratory assistant while Mr. Peters and Mr. Reil were undergraduate research participants in the program sponsored by the National Science Foundation. Assistance in preparing the manuscript was given by Mrs. Jeanette Peters.

Proceedings of the Iowa Academy of Science, Vol. 67 [1960], No. 1, Art. 56

Apparatus

The Multipoint Two-Hand Coordinator, as shown in Figure 1, consists of a stationary hard rubber disc with 125 brass buttons (1/8 inch in diameter) mounted flush with the surface of the disc. The brass buttons form an irregular "pathway" to be traced with a target follower by *S*. The position of the target follower can be altered by movements of two cranks. The right-hand crank is mounted in a plane parallel to the body; the left-hand crank in a plane perpendicular to the body. Turning the right crank in a clockwise direction moves the target follower to the right. Counterclockwise turning moves it to the left. Clockwise rotation of the left crank moves the target follower toward *S*, and counterclockwise rotation moves it away from him. Thus, movements of the controls result in the "expected" directional movements of the target follower.

In tracing the irregular pathway, a correct response is made when the target follower makes contact with a button in the correct sequence. An audible click is heard when such a response is made. If the *S* fails to make contact with the next successive button and continues around the pathway, a buzzing sound indicates that an

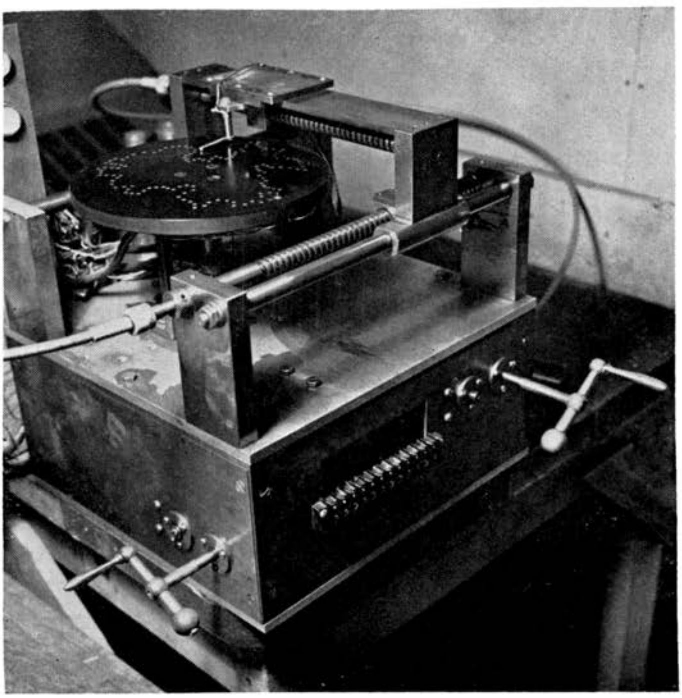

Figure 1. Photograph of the Multipoint Two-Hand Coordinator.

error has been made. The S is then required to retrace the path until he again hears the click and to continue from there.

Procedure

The Ss were given 30 trials on both Day 1 and Day 2. Each trial was 30 seconds in length followed by 25 seconds of rest and a 5-second ready period. The measure of performance was the number of hits made by S during each 30 second trial. The target follower was returned to the starting point by E after each trial.

Variation in task difficulty in this experiment was accomplished by the pattern arrangement of the brass buttons and the sequential responses required in following the pattern. Neither stimulus nor response nor stimulus-response linkage was functionally altered.[2] Previous studies, (e.g., Lewis, 1957) on this apparatus have indicated that starting at point A (see Figure 2) and continuing in a

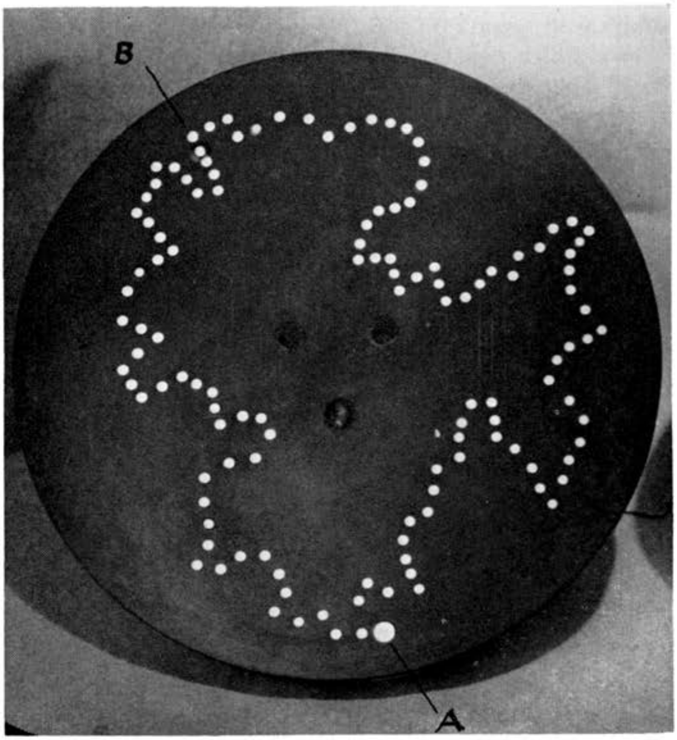

Figure 2. Close-up view of the Multipoint plate showing starting points A and B for tasks E and H, respectively.

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[2]R. H. Day has categorized the previous investigations in this area by these three types of variation of task difficulty.

counterclockwise direction provides an easier task than does starting at point B and continuing in a counterclockwise direction.

Subjects

The *S*s were 138 male undergraduate students enrolled in an elementary psychology course. They volunteered to serve, but received two points toward their final grade for each experimental session. Eighteen *S*s were eliminated for reasons such as apparatus failure and illness.

Experimental Design

On Day 1 the *S*s were assigned randomly to two groups, one of which performed the easy task (E), the other the harder task (H). On the basis of performance over the last five trials on Day 1, the 60 *S*s in each of these groups were subdivided to obtain three levels. Thus, there were 20 *S*s in each level within the two groups. One-half of the subjects in each one of these levels in each group continued on the same task on Day 2, while the other one-half changed to the task which had been performed by the other group on the first day. Thus, on the second day there were four subgroups of three levels each. The subgroups have been designated by the first letter of the task performed on each day, i.e., EE, EH, HH, and HE. Table 1 describes the design.

Table 1
Experimental Design

		Day 1 E	Day 1 H
Day 2	E	Level I Level II Level III	Level I Level II Level III
	H	Level I Level II Level III	Level I Level II Level III

Results

The results of the trials on Day 1 are depicted in Figure 3. This graph clearly displays the difference in difficulty between the two tasks at various stages of practice. After the initial period of acclimation to the task, there is a fairly rapid divergence in the curves representing the scores of the two groups. During the last 20 trials, this difference remains fairly constant. An analysis of variance was performed on the means of the last five trials for each subgroup on Day 1. The null hypothesis of no difference between the groups was rejected at the .01 level of significance. Since the overall hypothesis was not tenable, a test was made of the differences between each two of the four subgroups. The t statistic, $t = \left(\frac{m_1 - m_2}{\sqrt{2ms_w/n}} \right)$, where ms_w is the mean square within groups, the error variance, was used. As might be expected, the comparisons between subgroups practicing on the same task were not significant, while those comparisons between subgroups practicing on different tasks yielded highly significant t's. Thus, it may be inferred that the easy task was in fact less difficult than the hard task and, in addi-

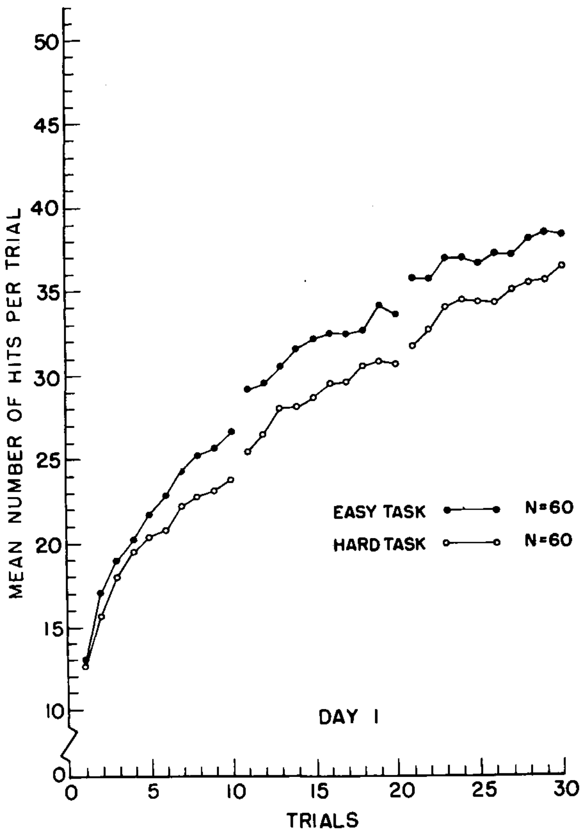

Figure 3. Performance curves for groups E and H on Day 1.

tion, the two subgroups within each main group were comparable at the end of Day 1.

Correlation coefficients between adjacent trials within groups are presented in Table 2. The obtained coefficients indicate that the

Table 2

Selected Correlation Coefficients Between Adjacent Trials

	Trials	EE	HE	EH	HH
Day 1					
	1-2	.79	.79	.89	.75
	21-22	.80	.87	.82	.92
	29-30	.76	.80	.84	.90
Day 2					
	1-2	.79	.76	.82	.90
	3-4	.68	.84	.75	.84
	9-10	.61	.77	.63	.80
	29-30	.80	.75	.64	.80

scores are quite reliable as none of them are less than .61.

Differences in the mean scores of the subgroups before and after the 24-hour rest and shift in tasks are illustrated by Figure 4. The dependability of these differences is attested by t tests for related measures performed on the means of trial 30 of Day 1 and trial 1 of Day 2. The obtained t's were significant for all subgroups at or beyond the .02 level.

The effects of the shift are obvious from the curves in Figure 4. The differences between groups EE and HE on trial 1 of Day 2 were significant beyond the .001 level, as were the differences between the scores of groups HH and EH.

When the mean of the first five trials for group EE on Day 1 is compared with the mean of the first five trials for group HE on Day 2, the difference is highly significant. Similar results were found in a comparison between these means for groups HH and EH. These results indicate some positive transfer has occurred.

Examination of the curves in Figure 4 reveals, however, that considerable differences between subgroups still exist as late as the last ten trials on Day 2. Furthermore, the curves at this stage appear to be relatively parallel and also seem to have reached an asymptote. The F test was applied to the means of the scores during the last ten trials for the subgroups. The hypothesis of no difference between the subgroups was rejected ($F = 66.96$, $df = 3$ and 1188, $p < .001$). Using the formula $d = t_{.05} \sqrt{2ms_w/n}$, a difference between means of $\pm$ 1.08 was found to be significant at the .05 level. Thus, all the differences between the means of the subgroups were significant with the exception of the difference between the means of EH and HE. An analysis of variance was

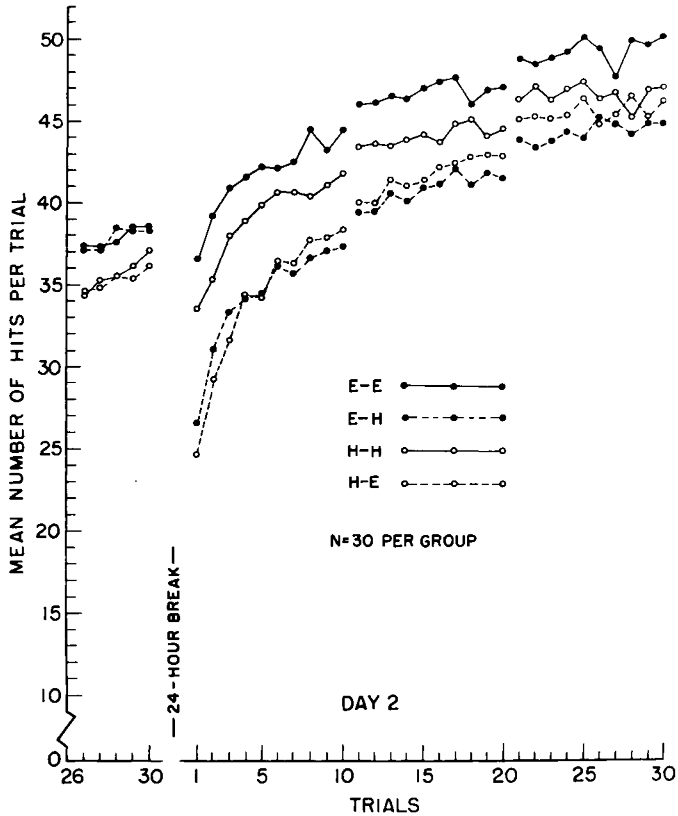

Figure 4. Performance curves for the 4 subgroups on the last five trials of Day 1 and all trials on Day 2.

also performed on the means of the last 10 trials for each subgroup. None of the overall F's were significant beyond the .20 level. Hence, the hypothesis of zero slope is tenable for all subgroups.

A measure of the differential transfer is provided by the difference of the differences between the mean scores obtained on Day 2 for groups performing the same task. Symbolically this difference is $|EE—HE| - |HH—EH|$. The absolute values are used to facilitate comparison with the performance of these subgroups on Day 1. When the shift occurs on Day 2 the direction of the difference is reversed in the second term. On Day 1 the scores for the E group were always larger, while on Day 2 the scores were always larger for the groups which remained on the same task. If the transfer from one task to the other is of the same magnitude, it might be expected that approximately one-half of the time the sign of the difference as symbolized above would be positive and the rest of the time negative. When this comparison was made for the 30 trials of Day 1 as a check on the procedure, exactly (almost embarrassingly, in fact) 15 of these differences were positive. This merely reflects the comparability of the subgroups. On 28 of the 30 trials for Day 2 the sign of the difference was positive. By assigning a value of one to positive differences and zero to negative differences the binomial probability distribution with mean 15 and variance 7.5 may be used to test the significance of this result. Since the binomial rapidly approaches a limiting normal distribution when the probability is one-half, this approximation was used. A value of 24 was found to be significant at the .001 level. Although these differences included four sources of variance and consequently might be considered somewhat unreliable, the check on Day 1 results and the level of significance attained attests some dependability of the differences.

A further test is indicated by the experimental design. Although the subjects were grouped into three performance levels on the basis of Day 1 scores primarily to equate the groups, the interaction between groups and levels over the last ten trials of Day 2 was tested and found to be significant ($F = 3.40$, $df = 6, 1188$, $p < .005$). Because of the interaction, the differences between subgroups were tested at each level, separately. In each case the F value obtained was significant, and a critical difference was obtained in the manner previously described.

The origin of the interaction, apparently, was in the ordering of the scores of the subgroups from level to level. Although the order remained the same from level to level, i.e., EE, HH, HE, EH, from high to low, the differences between the last three groups at the lowest level were negligible. At each of the other levels these differences were significant. These differences were slightly, though not dependably, greater at the highest level than at the intermediate level. Table 3 shows the extent of the differences.

Table 3

Differences of Mean Scores for Subgroups Over Last 10 Trials of Day 2

	Level I			Level II			Level III		
	HH	HE	EH	HH	HE	EH	HH	HE	EH
EE*	3.12**	3.32**	3.43**	1.92**	3.15**	4.97**	2.98**	4.66**	6.50**
HH		.20	.31		1.23**	3.05**		1.68**	3.52**
HE			.11			1.82**			1.86**

*Larger Mean in Column
**Significant at .05 Level

From these results the question arose as to whether the differential transfer was dependent only on the lowest performance level or was present at all levels. Therefore, analyses of the differences similar to the one performed on the scores of the subgroups as a whole were done for each level of performance. Essentially the same results were found for all levels; however, at the intermediate level of performance, the results fell far short of the significance found for the other levels.

Discussion

The study was designed to obtain information about the relative amounts of transfer between functionally similar tasks of differential difficulty. Indications of positive transfer between the two tasks are evident in a comparison of the scores for subgroups EH and HE on the first five trials of both days. After the change in task on Day 2, both subgroups were performing at a much higher level than they had on the early trials of Day 1.

Evidence obtained in the experiment supports the view that transfer from the easy task to the more difficult one was greater than that in the reverse direction. Inferences made from these data are, however, not to be considered highly dependable because of the fact that four sources of variance are involved.

Further difficulty in interpreting these differences is occasioned by the inconsistency of the results from level to level. However, it seems that, taken as a whole, transfer on this task is greater when the shift is made from the easier to the more difficult task than when the opposite shift is made.

Perhaps the most interesting finding of this study was the persistence of negative transfer effects from previous training on a different task. The hypothesis that all four subgroups have reached asymptotic level by the last ten trials of Day 2 was found to be tenable. It was expected that subgroups practicing on the same task on Day 2 would reach approximately the same level of proficiency by the end of the second day's trials. But the level of proficiency reached by the subgroups which changed tasks on Day 2 was dependably lower than that attained by the subgroups which remained on the same task. One possible explanation for these results is the development of sets to approach the different tasks in different manners during the trials of Day 1. A methodical, deliberate approach, though advantageous on the sharp turns of the difficult task, may impede performance when *S* is shifted to the easier task. Similarly, the tendency for more rapid movements of the handles controlling the target follower developed during the easy task may interfere with *S*'s performance when shifted to the more difficult task.

Assuming the existence of the set factor, an explanation of the differential transfer follows fairly simply. Although the group using the deliberate approach would have no reason to change, those *S*s shifted to the task requiring a more precise manner of turning might be forced to modify their approach because of the errors resulting from too rapid turning of the handles. In addition, the finding that the means over the last ten trials for the lowest level of the subgroups EH and HH were approximately the same might be attributed to the lack of speed for subgroup EH on the first day's trials. That is, these *S*s did not develop enough skill on the early task to have the same amount of interference as the others on Day 2. This follows from the more general theory of Lewis as outlined by Barch (1953). This theory states that when response tendencies appropriate to an initial task are inappropriate to a second task, the skill achieved on the first becomes interference on the second.

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