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THE INFLUENCE OF IMPROVEMENT IN ONE SIMPLE MENTAL PROCESS UPON OTHER RELATED PROCESSES.

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The problem to be solved in the transfer of training is no longer whether improvement in one function will be equally effective for all functions, nor whether improvement in one function is absolutely restricted to that function. It is, rather, to what extent training in one particular function will be effective for another particular function. The formulation of the laws of transfer can result only from amassing a large amount of concrete material, determined from a large number of individuals. To quote from Thorndike,¹ the experimental facts now at hand "are in a sense trivial in comparison with the very great variety of facts which must be measured in order to describe justly the spread of improvement in the work of the schools, trades, and the like."

A historical review of the investigations in transfer would be superfluous in this paper, since several authors have so recently covered the ground. The latest and the most noteworthy is Thorndike's² discussion of the influence of improvement and the extensive bibliography accompanying it.

¹ *Educational Psychology*, Vol. 11, p. 417, 1913.

² *Loc. cit.*

The present experiment, although intended mainly to add to the general fund of transfer studies, differs in several particulars from previous work. First, the training series was continued long enough to bring the curves of improvement practically to a level, before the transfer effect was tested. In the work of Ebert and Meumann, for instance, some of the training series occupied scarcely more time than the test series, that is, there was about as much chance for improvement directly in the test series as there was in the training series. Add to this the fact that they used no control subjects and the conclusions are not especially convincing.³ This defect in transfer studies parallels that of discussing the effects of practice upon a group of individuals from curves which have simply passed beyond the point of most rapid fall. Hollingworth⁴ has shown that the relations among a number of individuals at the end of practice is quite different from their relations after the point of rapid decline in the curve has been passed. Second, the possibility of transfer of the very general factors such as adaptation to the conditions of the experiment, acquaintance with the material, distribution of attention, etc., were eliminated as far as possible. In most of the transfer experiments, these factors make up the bulk of the transferred improvement, just as they cause the rapid fall in a short practice curve. These general factors were eliminated by selecting subjects who were familiar with psychological tests and who in most cases had had experience with the very tests used. In addition to this familiarity with the experiment, a more specific acquaintance with the material was obtained by considering the first two trials in the first and the last test series in the case of both the trained and the control groups as preliminary and not to be calculated in the results. If one is to be able to refer transfer of improvement to specific elements in the process or to the formation of definite bonds between situation and response, these general sources of improvement should be removed. However, one difficulty may seem to arise with this procedure, and that is that the amount of preliminary acquaintance with the tests will be unknown and will most likely differ among the subjects. But this difficulty is present to a certain extent in every

³ For a discussion of the methods of Ebert and Meumann, see Thorndike, loc. cit.

⁴ H. L. HOLLINGWORTH. *Correlation of Abilities as Affected by Practice*, J. OF ED. PSYCH., September, 1913.

practice curve because no individual starts at his zero point of efficiency in any of the functions that we can test. So in this, as in all other work of the kind, we do not attempt to remove this particular difficulty but to make allowance for it in our calculations. The indefinite starting point is especially troublesome in computing per cents. and averages. As there are so few subjects in the experiment, the tables that follow give results expressing improvement in absolute amounts together with the amounts of the initial performance in each test.

The general plan of the experiment was as follows: Eight subjects, and in some of the tests eleven, repeated each of a series of seven tests five times. Four of these subjects were then selected as a training group while the others became the control group. The training group was practised in each of another set of four tests for 100 times. This training continued for a period of nine days with approximately eleven tests each day. On the tenth day, the combined group of trained and control subjects was again tested in the seven tests used at the beginning of the experiment. Five trials were given as at the start. Hence, we may compare the performance of a group who had nine days of special training with a group which had no special training during this interval.

The tests taken by all of the subjects and which will be called the "test series" consisted of the Form Naming test, the Adjective-Noun test, the Number Group Checking test (in two parts), and the calculation tests, including Subtraction, Multiplication, and Division. The tests taken only by the training group and to be known as the "training series" consisted of the Color Naming test, the Opposites test, the Number Checking test, and the Addition test. These tests and the procedure will be described in detail later. All errors were announced by the experimenter and corrected immediately by the subject, except in the case of the Number Group Checking test. Here the errors were turned into time amounts by an arbitrary rule and these amounts added to the time for the test. All results are expressed in terms of the time required to do the whole test.

Table I gives the results of the "training series" for the four subjects, A, B, C, and D. The 100 trials are divided into twenty groups of five tests each. The figures given are the averages of these groups of five trials each, and are arranged in the horizontal

rows under the numbers from 1 to 20. An examination of these figures indicates that the Color Naming test shows the least gain. All of the subjects were familiar with this test, but it is one in which very little gain is possible even in the case of new subjects. For that reason it is a valuable test to use where one wishes to avoid complications due to practice effect. In this test, one subject lost 4.8 seconds as a result of the practice work. The average of the first five tests shows the fastest record of the whole series. Subjects who show this result seem to become confused after naming the colors several times and a kind of inhibition results. Introspection suggests quite strongly that this inhibition is not that of the processes by which the thought of the color is aroused but rather that of the speaking mechanism. In the case of all of the other tests, there was a gain, although in one or two instances it was quite small. In the Opposites test subject A has a high initial time and a very large gain compared with the other subjects. This subject was not as familiar as the other subjects with the particular form of the Opposites test, and his gain in the first few tests was rather rapid.

TABLE I.

Results of the Training Series.

(The 100 separate trials are divided into groups of five each. Each figure in the table represents the average of five trials. These averages are arranged in horizontal rows under the numbers 1 to 20.)

<i>Color Naming.</i>										
Subject	1	2	3	4	5	6	7	8	9	10
A.	43.6	45.0	42.6	42.0	42.0	45.2	41.4	40.4	41.2	40.4
B.	38.4	42.2	36.6	43.4	40.6	43.6	37.4	37.4	41.2	39.2
C.	45.8	51.0	45.8	49.8	44.0	48.6	48.0	54.2	50.2	46.4
D.	31.4	34.0	36.0	34.6	34.0	38.0	38.0	39.4	35.0	37.4
<i>Opposites.</i>										
A.	90.4	74.2	50.0	48.6	45.2	45.2	40.2	42.0	38.0	40.0
B.	31.6	31.2	33.8	31.2	35.4	31.2	37.8	32.2	31.0	32.8
C.	24.6	25.2	24.4	25.0	23.2	24.6	25.4	23.8	28.4	23.8
D.	29.6	27.6	26.8	24.6	25.0	24.6	23.2	25.0	24.6	25.0
<i>Cancellation.</i>										
A.	68.0	66.0	58.6	50.2	49.8	49.8	43.8	45.4	45.4	45.4
B.	60.4	54.6	54.6	51.0	49.0	53.0	50.0	49.4	47.0	48.4
C.	60.0	60.0	56.4	54.0	55.0	50.4	56.2	59.6	50.6	51.0
D.	75.0	77.4	72.8	59.6	59.8	60.8	56.2	57.2	57.6	53.0
<i>Addition.</i>										
A.	109.2	108.0	89.0	83.6	84.6	73.4	66.2	63.2	69.8	59.8
B.	95.2	83.4	77.4	76.6	69.6	78.8	79.4	66.0	61.0	61.8
C.	110.0	86.6	84.0	85.4	81.8	78.6	72.2	60.2	63.0	59.0
D.	242.0	196.4	110.0	91.8	81.6	70.6	67.6	63.2	66.0	63.4

TABLE I (Continued).
Results of the Training Series.
Color Naming.

Subject	11	12	13	14	15	16	17	18	19	20
A.....	38.2	39.8	40.0	42.8	39.6	39.0	39.2	40.4	40.8	38.6
B.....	37.2	34.0	36.0	34.8	37.0	38.0	35.8	37.6	36.2	37.4
C.....	52.4	44.6	44.0	44.0	45.0	47.0	39.4	44.8	50.0	43.4
D.....	34.8	36.0	34.4	38.6	35.8	35.6	34.0	36.4	35.8	36.2
<i>Opposites.</i>										
A.....	34.8	35.8	34.0	35.2	36.4	36.6	34.2	34.8	34.0	32.6
B.....	28.4	30.4	29.2	30.4	28.4	28.2	25.4	30.6	29.0	28.5
C.....	25.4	23.0	25.2	24.4	22.6	24.0	22.4	21.2	22.0	20.6
D.....	23.4	24.0	23.2	23.8	23.8	24.0	23.8	22.8	20.2	23.1
<i>Cancellation.</i>										
A.....	41.4	40.6	42.4	42.4	42.6	41.0	40.0	40.8	40.2	38.0
B.....	49.8	44.0	43.0	44.8	44.0	43.4	45.8	42.2	42.0	39.4
C.....	49.8	43.8	46.0	50.4	40.4	46.8	49.6	45.0	47.0	44.1
D.....	51.8	56.0	53.6	51.2	50.6	57.6	54.2	54.0	51.6	52.5
<i>Addition.</i>										
A.....	61.6	59.6	59.6	57.6	57.6	58.8	54.2	54.2	59.2	56.8
B.....	61.0	53.4	54.8	50.2	57.0	51.8	54.8	57.2	49.8	60.0
C.....	59.0	55.0	54.0	52.6	52.0	50.2	52.0	50.4	51.2	48.6
D.....	59.6	53.2	58.8	52.4	52.0	52.2	50.6	49.2	54.2	51.2

I. INFLUENCE OF TRAINING IN THE COLOR NAMING TEST UPON ABILITY IN THE FORM NAMING TEST.

The first problem is the influence of the training in the Color Naming test upon the ability in the Form Naming test. The value of first eliminating from possibility of transfer all of the general bonds between the situations and responses becomes apparent when we take up the above problem. If we had not done so, the cross transfer among the different tests of the "test group" and the "training group" would leave us hopelessly confused. As the results will show later, the bonds between situation and response in this experiment are too specific to cause confusion by transfer among the tests not directly compared.

The Color Naming test consists in naming as rapidly as possible the five most familiar colors, red, blue, yellow, green, and black, each repeated twenty times. These colors are presented on a sheet, in the form of a square with ten colors on a side. At each trial the sheet is turned 90 degrees so that the same order is given every fourth time. The Form Naming test has an identical arrangement, the only difference being that five familiar forms, the star, square, circle, cross, and triangle, take the place

of the five colors. The procedure in both tests is the same. The difference is, then, one of content while the form remains the same. Two types of specific bonds or connections are possible here. First, the formation of connections between the particular arrangement of the objects to be named and the proper method of response. Under this head would be included: the largest number of objects that could be seen at one fixation of the eyes, how far one could safely look ahead, how fast one can speak the words without getting confused, and various other tricks which a subject may acquire. These connections appear to be the same in both cases. It is possible, however, that in case of the most economical speed, for example, there might be a difference between the two tests, so that one finally learns that he must speak the colors more slowly than the forms. Second, the formation of connections between the object seen and the name spoken—this is a direct bond, and differs in the two cases. Forming a bond between red and its name thought or spoken has no influence upon the strength of the bond between star and its name thought or spoken. It is easier perhaps to conceive that the one connection should inhibit the other, the response red by continual repetition might become so habitual that the wrong stimulus, a circle for instance, might tend to produce it. But theoretically one would expect no interference between the two kinds of specific bonds.

Table II gives the results of these tests. The table is divided into two main sections. The first represents the training series (Color Naming), the second represents the test series (Form Naming). The second section is divided into two further sections representing the test series for the trained group and that for the untrained or control group. In each of these divisions will be found the amount of the initial performance and the gross gain. In all cases the initial performance is the average of the last three of the five tests in the first series. The final performance from which the gross gain is calculated is the average of the last three of the five tests in the final series. In the training series, the initial ability is the average of the first five tests and the final ability from which the gross gain is calculated is the average of the last five tests in the training series (See Table I). The gross gain in every case is simply the difference in seconds between the initial and final performance. On account of the

small number of subjects and certain differences in initial time it seems best not to attempt to express the results in per cent. or by more elaborate methods. Although averages are given, references will be made constantly to the individual records. These averages will be found at the bottom of the table, and the reliability of the average is given in terms of its probable error.

TABLE II.

Influence of Training in Color Naming Test Upon Ability in Form Naming Test.

TRAINING SERIES			TEST SERIES			
Subject			Trained Group		Control Group	
			Subject			
	Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain
A.....	43.6	5 0	62 2	3.7	E 68 5	5 0
B.....	38 4	1 0	60 5	-13 2	F 78 6	10 1
C.....	45 8	2.4	51 4	- 6.3	G 57 2	10 1
D....	31.4	-4 8	58 4	7.1	H 75 8	1 1
					I 68 9	3 8
Av.			58.1	- 2 2	69 8	6.0
P. E....				3.2		1.2

A glance at the averages of the test series for the trained group and the control group suggests that the practice caused interference rather than transfer of improvement. The probable error of the averages concerned, however, shows that the difference in time between the two is unreliable. If one considers the separate subjects, it will be seen that for B and C the practice apparently caused interference. For subjects A and D there was a gain of 3.7 and 7.1 seconds respectively. But when this gain is compared with the average gain of the control group, which is 6.0 seconds, this would appear to be no gain attributable to the training series. In considering the lack of transfer, one must note the small gain in the training series. Subject D, who lost in the training series, is the one who gained most in the test series (7.1 seconds). Such phenomena have been reported many times in transfer work. But in this case the matter is simple enough. The gain made by this subject is only one second more than the average gain of the control group, which is 6.0 seconds. Keeping in mind the P. E. of this average, which is 1.2, the gain of 7.1 seconds is what might be expected from one who had had no training whatever.

This experiment, then, shows only very slight gain in the training series, no reliable transfer or interference in the case of two subjects, and interference in the case of the other two. The slight amount of improvement as a result of the long course of training obviously makes the test a poor one for studies in transfer.

II. THE INFLUENCE OF TRAINING IN THE OPPOSITES TEST UPON ABILITY IN THE ADJECTIVE-NOUN TEST.

The opposites test which forms the training series consisted of 50 moderately difficult opposites given in the Woodworth and Wells monograph on Association.⁵ The Adjective-Noun test used in the test series consisted of the same set of stimulus words to which appropriate nouns were to be attached. If the process involved here be analyzed, we find the objective situation to be identical in the test series and training series, but the response is different, an appropriate noun instead of an opposite being required. A bond formed in the training series between a word and its opposite must be broken and a new bond formed between the given stimulus word and an appropriate noun. Thorndike, in analyzing such connections as this, says, "In the case of alternate systems of bonds, there is, then, often an inhibition for a time, reducing to zero as the two systems of bonds get organized into connection with two systems of mental sets or attitudes, and perhaps giving way to facilitation by reason of certain serviceable identities in the bonds."⁶ In the present experiment there is no opportunity for such alternate bonds to be established by long training, and the question is: Will the formation or strengthening of a certain bond facilitate the formation of a possible alternate bond?

The results of this test are given in Table III. The arrangement of this table is identical with that of Table II. The initial performance in the training series and the gross gains are obtained from Table I. The average gross gain in the test series for the trained and control group show an interference as a result of training. Two of the subjects, A and B, have a poorer record in the final test than in the first test series, as indicated by the minus signs. But the other two subjects, C and D, who show a

⁵ Psych. Rev. Mon. Vol. XIII, No. 5, 1911.

⁶ Loc. cit., p. 356.

gain of 5.5 and 1.0 seconds respectively, have gained less than the control subject who gained the least (Subject F with a gain of 7.2 seconds). The probable error of the averages here is small enough to make the difference between the trained and control group significant. Subject A, who made the greatest gain in the training series, also showed the greatest interference in the test series. These results suggest that, when the possibility of transfer is limited to specific elements, the formation of bonds between a given stimulus and a certain response interferes with the formation of a bond between the same situation and a new response.

TABLE III.

The Influence of Training in the Opposites Test Upon Ability in the Adjective-Noun Test.

TRAINING SERIES			TEST SERIES			
Subject			Trained Group		Control Group	
			Subject			
	Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain
A	90 4	57 8	77 2	-7.7	E 75 3	15 0
B	31 6	3.1	53 5	-6.8	F 60.3	7 2
C	24 6	4 0	67 4	5 5	G 57 2	11.3
D	29.6	6 5	107 9	1.0	H 119 8	37 1
					K 52.2	7.6
Av.			76 5	-2 0	73.0	15.6
P. E.				2 2		3.2

III. THE INFLUENCE OF TRAINING IN THE CANCELLATION OF 3 AND 5 SEPARATELY UPON CANCELLATION OF GROUPS CONTAINING BOTH 3 AND 5.

The material for these cancellation tests consisted of the number checking blank described by Woodworth and Wells for the training series, and the number group checking blank, described by the same authors, for the test series. Only one-half of the number checking blank was used at a time. The time for completing each blank was taken, no error being permitted. As in the previous cases, the test series consisted of five tests before and five after the training interval, while the training consisted of 100 repetitions of the given test. In this case, the training consisted of the cancellation of 3's in 50 blanks and of 5's in 50

blanks, the first blank being for 3 and the second for 5 and so on. The procedure in the number group checking test consisted in canceling every group which contained the two numbers 3 and 5. Errors in this test were not immediately corrected. A penalty was arbitrarily assigned for each error. The average time for each figure canceled was determined for each blank and this multiplied by the number of errors. This amount was added to the total time for that blank. This correction for errors made no appreciable difference in the results.

In this experiment, the training series consists in forming two bonds between separate situations and responses, one in the cancellation of 3's and the other in the cancellation of 5's. The test series when analyzed shows these two stimuli to be present, the response now being to a total situation containing these two stimuli. This bond seems to resemble quite closely that described by Thorndike⁷ as "Entire similar change by composition of totals," in which he employs the following example: "The bonds ABC-1, 2, 3, and XYZ-48, 49, 50, being strengthened, the bond ABCXYZ-1, 2, 3, 48, 49, 50 is strengthened."

The results of this experiment are shown in Table IV. This table is constructed exactly as Table II. The average gain in the training series is 22.4 seconds. The average gain in the control group in canceling the number groups containing 3 and 5 is 11.5 seconds, with a high P. E. of 4.0. The average gain in the trained group in canceling like number groups is 23.7 seconds. This difference of 12.2 seconds in favor of the trained group may be attributed to the transfer of the effect of the training. The reliability of this difference expressed in terms of the P. E. of the difference is about 5.0. That is, the difference is about 2.5 times the size of its probable error. The chances of this difference being real are then about 900 in 1000. Expressed in terms of per cent. of the initial performance, the average gain due to transfer would be about 8 per cent.

This test seems to indicate that learning is facilitated by incorporating into the process to be learned previously formed bonds between situation and response, or, in other words, it indicates the transfer of identical elements.

⁷ Loc. cit., p. 351.

TABLE IV.

Influence of Training in Cancellation of 3 and 5 Upon Cancellation of Groups Containing 3 and 5.

Subject	TRAINING SERIES		TEST SERIES			
			Trained Group		Control Group	
			Subject			
	Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain
A.....	68 0	30 0	144.4	16.3	E 166 1	4 9
B.....	60 4	21.0	125.0	16.0	F 159 5	17 0
C.....	60 0	15.9	171 4	26.0	G 150.6	24 8
D. . . .	75.0	22.5	163 1	36 5	J 139.5	-0 9
Av....			151.0	23 7	153 9	11 5
P. E....				3.2		4.0

IV. THE INFLUENCE OF TRAINING IN THE CANCELLATION OF 3 AND 5 SEPARATELY UPON CANCELLATION OF GROUPS CONTAINING 4 AND 7.

In these tests the material and procedure are the same as described in the preceding section. The test series consisted in the cancellation of groups containing 4 and 7, instead of those containing 3 and 5. In this case there is no combination of ready formed specific bonds into the new situation-response as there was in the preceding case. There are here no identical elements concerned in the two processes except the more general adaptations which we have tried to eliminate. Although there are no identical elements in the two situations, there is still no necessity of breaking, in the test series, any specific bond formed in the training series, as was the case in Experiment II, the Opposite and Adjective-Noun test.

The results of this experiment are shown in Table V. If the average gains in the trained and control group are compared, the two will be found to agree, 15.0 and 15.9 respectively. The probable errors of these averages show that they are fairly reliable. Here one finds neither an interference nor a facilitation as a result of the training, while the analysis showed neither transfer nor breaking of specific bonds.

TABLE V.

Influence of Training in Cancellation of 3 and 5 Upon Cancellation of Groups Containing 4 and 7.

Subject	TRAINING SERIES		TEST SERIES			
			Trained Group		Control Group	
			Subject			
			Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain
A.	68 0	30 0	130.6	10.4	E 134 3	14.5
B.	60 4	21.0	118.8	15.8	F 143.3	16 3
C.	60.0	15.9	162.7	11 8	G 124 1	24 0
D.	75.0	22.5	159 1	22.0	J 124.7	8 9
Av. . . .			142 8	15 0	131 6	15.9
P. E..				1.6		1.8

V. THE INFLUENCE OF TRAINING IN SIMPLE ADDITION UPON ABILITY IN SUBTRACTION.

The material for this test consisted of a series of 50 two-place numbers ranging between 20 and 80 and excluding all numbers containing a zero. The task was to add 17 to each of these numbers as rapidly as possible. The same 50 numbers were used during the whole training process, but were presented in 10 different arrangements. The subtraction test consisted in subtracting 17 from each of a list of 25 numbers as rapidly as possible. This list was obtained directly from the addition list by adding 17 to each. All errors were announced by the experimenter and corrected by the subject. The results are given in terms of time, as in the other tests.

In this experiment there are no identical bonds in the two cases. There is no identity either in the situations or in the responses. It must be said here that in the long training the responses in the addition test never became a matter of such simple association as one finds in the ordinary association tests. Except in the case of a very few numbers, the addition process was actually carried out, although various short cuts were devised.

The results are given in Table VI. The gross gain in the trained group was 8.8 seconds, and in the control group 15.1 seconds. The large gain of the control group is seen to be due to subjects F, I, and O, whose initial performance was high. The difference between the two groups, 6.3 seconds, with the high probable error

TABLE VI.

Influence of Training in Addition Upon Ability in Subtraction.

Subject	TRAINING SERIES		TEST SERIES			
			Trained Group		Control Group	
			Subject			
	Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain
A.....	109 2	52 4	59.7	7.0	F 107.7	20.3
B.....	95.2	35.2	67.9	14.9	I 147.3	49 1
C.....	110 0	61 4	64 5	4.3	J 70.7	4 8
D ..	242 0	191 2	143.8	8 9	K 91 8	0.0
					L 46.2	-1.9
					N 101 6	5 6
					O 122 9	27 5
Av.			84 0	8.8	98.3	15.1
P. E.....				0.7		4.8

attached to the control average, is of little significance and cannot be considered as evidence of interference.

Here again there is an absence of identical bonds in the training and control tests and an absence of transfer or interference as a result of the training.

IV. THE INFLUENCE OF TRAINING IN ADDITION UPON ABILITY IN MULTIPLICATION.

The training series in this test is the same as that in the preceding experiment, i. e., the Addition-Subtraction test. The test series consisted in multiplying each of 25 of these same figures by 7, instead of adding 17 as in the training series. Here the stimulus is the same in the training and control material, while the response is different. The test series necessitates the formation of new connections and the consequent breaking of those formed in the training series. This is a condition analogous to that found in Experiment III, where the association process was changed from the naming of opposites to the naming of nouns to fit the adjectives. It will be remembered that in that case there was an interference. In multiplication by a two-place number there is a certain amount of identity with addition, in that the latter is involved as a part process, but addition plays no part in multiplication by a one-place number.

The results of this experiment are given in Table VII. Comparing the gains of the trained and control group in the test

series, we find the former gained 11.4 seconds and the latter gained 29.7 seconds. Taking the gain of the control group as typical of untrained subjects, we find an interference effect from the training amounting to 18.3 seconds. The probable error of this difference is 6.5, making the difference about 3 times its P. E.

Here again we have an interference resulting when the multiplication process requires the breaking of definite bonds formed by training in the addition process.

TABLE VII.

Influence of Training in Addition Upon Ability in Multiplication.

Subject	TRAINING SERIES		TEST SERIES			
			Trained Group		Control Group	
			Subject			
	Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain
A.....	109.2	52.4	F 186.5	60.8
B.....	95.2	35.2	85.3	- 5.0	G 126.1	31.3
C.....	110.0	61.4	119.3	-19.4	J 132.3	26.1
D.....	242.0	191.2	205.4	19.9	L 101.3	12.8
					M 84.8	17.3
					N 168.7	29.6
Av.....			136.7	11.4	133.3	29.7
P. E.				5.3		3.8

VII. THE INFLUENCE OF TRAINING IN ADDITION UPON ABILITY IN DIVISION.

The training series in addition is identical with that in the two preceding tests. The test series consisted in dividing a series of 25 numbers by 7 as rapidly as possible. This list of 25 numbers was obtained by multiplying each number in the addition list by 7. Since 25 numbers constituted only half of the original list of 50 numbers, there were twenty different arrangements of the numbers in this test as in the two preceding experiments. As before no errors were permitted.

In this experiment the processes involved in the test series show neither a specific situation nor a specific response in common with the training series. Neither is there the necessity of breaking

any specific bonds formed in the training series in adapting one's behavior to the test series.

The results are given in Table VIII. If one takes into account the reliability figure attached to the gain in the case of the trained and control groups in the test series, one finds no difference in the gain made by the trained and control groups. A difference of 1.8 seconds between 21.3 and 19.5 would be of no significance. We conclude that there is neither interference nor facilitation shown as a result of the training in addition.

TABLE VIII.

Influence of Training in Addition Upon Ability in Division.

Subject	TRAINING SERIES		TEST SERIES			
			Trained Group		Control Group	
			Subject			
	Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain	Init. Perf.	Gr. Gain
A.....	109.2	52.4	72.9	19.0	E 258.9	55.4
B.....	95.2	35.2	52.7	5.3	F 82.3	5.9
C.....	110.0	61.4	88.9	9.3	G 85.7	19.9
D.....	242.0	191.2	186.3	51.5	L 60.4	-1.1
					M 63.2	20.8
					N 76.8	16.3
Av.....			100.2	21.3	104.6	19.5
P. E.....				6.3		4.3

VIII. CONCLUSION.

The experiment as a whole is intended as an intensive study of the transfer problem, upon a small number of subjects, with material that can be analyzed into stimulus and response fairly easily. It aims to determine the influence of training in cases where the relation between the processes varies from close similarity to complete antagonism. It aims, further, to limit the transfer effect to specific bonds between stimulus and response by eliminating the more general and common sources of improvement. It will probably never be possible to analyze any process into terms of stimulus and response within the nervous system, where any real transfer must finally be located. But if the commonly accepted meaning be given to the terms stimulus, response, and bond or connection, the experiment seems to show the following:

1. Where there are no identical bonds between stimulus and response in the two processes, the influence of one test upon another will be neither positive nor negative, i. e., there will be neither transfer nor interference. (Cancellation of 3 and 5—Cancellation of 4-7 group; Addition-Subtraction; Addition-Division; possibly Color Naming—Form Naming.)

2. Where there are identical elements in the two situations, or where a given process involves one or more bonds previously formed, there will be a positive or transfer effect. (Cancellation of 3 and 5—Cancellation of 3-5 group.)

3. Where one test necessitates the breaking of previously formed bonds and the formation of new ones, there will be a negative effect or an interference. (Opposites—Adjective-Noun; Addition-Multiplication.)