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MINOR STUDIES IN LEARNING AND RELEARNING.¹

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Experience as a teacher of educational psychology has left the writer with considerable unfinished data collected both in the class room or laboratory, and also in private study. The following brief account of experiments is offered as representing some difficulties and experimental methods of interest to practical instructors of elementary classes in educational psychology. The first series is descriptive of material for and uses of mirror drawing; the second series concerns an attempt to apply the method of equal groups in the use of substitution tests; and the third experiment includes the construction and use of new material for the cancellation or A test found serviceable for class experimentation.

(1) MIRROR DRAWING. (a) *The problem of neuro-muscular memory*; (b) *Transfer effect as regulated by slightly altered objective elements*.

(a) During 1911 the writer reported tentatively upon a study of mirror drawing undertaken by one subject during October, November and December of 1910. (*Psychological Bulletin*, Vol. VIII, No. 1.) The trials, one a day, were continued through about fifty days. Since December 1910 the subject has done no mirror-drawing. In the *Psychological Bulletin* for January, 1910, there are contained two articles, one by Swift on "Relearning a Skillful Act," and another by

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Starch on "A Demonstration of the Trial and Error Method of Learning" (mirror drawing). Swift used the learning of tossing two balls with one hand, but the two articles suggested to the writer the application of mirror drawing to the problem of relearning and a comparison of results with those of Swift on relearning a skillful act.

The materials used were the figure with semi-circles and the star which were printed from zinc etchings for the writer in Nashville, Tenn., as previously described. The designs are here shown. Figure I.

FIGURE I.

Nearly three years to a day after the first series the subject, J. P. II., has completed (December 16, 1913) eight daily trials as before in 1910, when the practice or daily trials amounted to 48. A comparison of the progress curves, both for speed and accuracy, for 1910 and for 1913 indicates that in about three or four daily trials in 1913 the subject had attained her standard of 1910—that, in fact, at the beginning of the 1913 experiment her status was not considerably below that of 1910—the speed slightly less, the accuracy a fraction more. The curves are seen in Figure II. The curve for 48 days is markedly like that of Starch, and exhibits the usual daily variations. The figures (neglecting fractions of seconds) for time and errors for all of the practice series are shown in Table I.

TABLE I.

SPEED AND ACCURACY. STARS TRACED WITH RIGHT HAND IN MIRROR DRAWING.

Series 1910.

Trial.	Date.	Seconds.	Errors.	Trial.	Date.	Seconds.	Errors.
1	Oct. 29	107	50	25	Nov. 25	45	22
2	30	81	31	26	27	41	25
3	31	76	33	27	28	46	30
4	Nov. 1	74	32	28	29	51	27
5	2	78	25	29	30	38	26
6	4	63	30	30	Dec. 1	37	26
7	5	77	28	31	2	35	24
8	6	60	25	32	3	27	27
9	7	62	25	33	4	27	26
10	8	47	17	34	5	31	27
11	9	60	22	35	6	27	26
12	10	55	26	36	7	?	23
13	12	53	29	37	8	27	21
14	13	59	30	38	9	23	26
15	14	60	28	39	10	28	24
16	15	61	27	40	11	22	25
17	17	62	25	41	12	26	29
18	18	55	25	42	13	24	24
19	19	56	27	43	14	25	25
20	20	52	21	44	16	24	25
21	21	57	21	45	17	28	28
22	22	48	25	46	18	26	24
23	23	53	26	47	19	25	21
24	24	45	27	48	20	24	24

Series 1913.

Trial.	Date.	Seconds.	Errors.	Trial.	Date.	Seconds.	Errors.
1	Dec. 8	36	18	5	Dec. 12	23	19
2	9	32	21	6	13	24	22
3	10	27	22	7	14	26	19
4	11	24	21	8	15	26	19

More than six years intervened between the beginning and end of Swift's tests—interrupted, however, by several "memory" tests in the interim. His original curve of learning does not show the rapid increase during first trials characteristic of ours. It required eleven days for him to regain the skill which in the earlier work had required forty-two days of practice, and the curves suggest that evidently between his first and last series much of the acquired skill had been lost. However, Thorndike in reviewing the experiment points out that, although the impression is given here that the time required for relearning was about one-fourth as long, the actual time required, up to and including the tenth day, was, in fact, al-

most a third as long as the time required to reach an equal ability in the original. Says he, "The eleven days as a whole involved over four-tenths as many tosses as the entire original fifty-two days of practice. The suggestion or conclusion of Swift that 'evidently the mind continues its activity for a time in the furtherance of a learning process after practice and study have ceased' is met by the assertion of Thorndike that 'This may be true, but nothing in the measurements of the permanence of skill in tossing balls gives proof of it.'" [Psychology of Learning, Vol. II, p. 314.]

In our experiments with the mirror-drawing little of the previously-acquired skill had been lost in the interim. There was little relearning to be accomplished, little had been forgotten, and it appears that after the warming-up the lost associations were quickly recovered. Our observations of the work of hundreds of trials of mirror-drawing lead to the opinion that there is very little of the trial and error method used in mirror-drawing after the first two or three trials. This accounts, in part, for the initial rapid improvement. Reasoning and even imitation of the attitude and movements of other experimenters very soon intervene. It is the usual happening for certain kinaesthetic sensations to appear plain, and these become associated with perceptions of direction and form and time. It is the recollection of these complexes which constitute relearning of the act, modified by changes in maturity and in attitude of the subject at the time. These complexes of association constitute the fabric of the neuro-muscular memory; and their impression, retention and recall may not be different from the usual aspects of the memory consciousness. In contrasting the first and last curves one must allow for possible ennui in the latter part of the first and for renewed zest, curiosity or interest in the matter of relearning. The performance seems no more remarkable than the instantaneous picking-up of a neglected tune by an old pianist after years of indifference and forgetfulness. Aside from the danger of generalizing from an individual case we cannot see in this case any safe ground for assuming that "the mind continues its activity for a time in the furtherance of a learning process after practice and study have ceased." The problems

of the neuro-muscular memory involved in the case seem to be the problems of the memory aspects of consciousness in general.

It is realized, of course, that three years' disuse in mirror-drawing might produce very different relearning curves from the same disuse of typewriting, ball-tossing, learning poetry or syllables. Thorndike notes the possible advantage in permanence of functions, whose improvement consists in reproducing better by movement of the muscles to some sense presentations, over functions where "surety and speed of bonds from one internally initiated event in the brain to another are the main facts to be improved" (Vol. II, Educational Psychology, p. 326). The contrast is illustrated by skating, dancing, swimming, on the one hand; knowledge of chemistry, geology or the recital of poems or nonsense series, on the other. In this connection the writer desires to add that the same subject, J. P. H., during 1910 was tested during the period November 21 to December 5 for passive touch discrimination by the use of a modified Binet esthesiometer. Some sixty trials at each sitting were given, points at fixed distances being used. It is our intention shortly to test in the same person a relearning after four years of the ability to discriminate one from two points, an experiment which may prove to be of interest in view of the above hypothesis of Thorndike concerning the superiority of sensori-motor functions for permanence.

(b) *Transfer effect as regulated by slightly-altered objective elements.*

In the consideration of the spread of skill as an effect of special practice, the matter of the common element inherent in the reaction of an individual to a situation is important. If we assume that, on the one hand, spread from one situation to another is conditioned upon the coincidence of cerebral and muscular elements, the objective character of the stimuli, on the other hand, permits by manipulation many changes in bringing into action elements of two nearly identical situations. In mirror-drawing, in which it is known that the transfer effect from right to left hand is large, it is possible to

demonstrate nicely the regulation of transfer effect by a slight alteration of the external factors. This has been done by noting in this experiment the amounts of "transfer" of the skill acquired in tracing stars by mirror-drawing, and in the drawing of slightly-dissimilar figures (connected semi-circles), both from the left and from the right hand.

In the year 1910, and also in the series of 1913, the subject made initial and terminal tests with right and left hands, drawing both stars and semicircles; the tests in both series were made both before and after the regular practice series of Table I above. In the summary, Table II, it is seen in the terminal tests of December 20, 1910 (1) that for both hands the improvement was greater for *stars* (identical designs) than for *semi-circles* (slightly different); (2) that improvement ("transfer") in the unpracticed left hand is less than that for the right for stars; (3) that the skill in producing the dissimilar figures (semi-circles) remains almost the same in both hands, with an advantage to the left.

After the conclusion of the practice series of December, 1913, the terminal tests of December, 1910, were repeated, with the results also shown in Table II. Comparison of the finals of 1913 with the finals of 1910 reveal the following: The practice designs (stars) show gains over 1910, with some advantage in the unpracticed left hand. The unpracticed designs (semi-circles) show marked losses, but with a 20 per cent. gain in accuracy in one instance. It would seem that the losses of the unpracticed semi-circles may be due partly to interference of associations with the more deeply established connections for the other (star) design, as well as simply to the lack of permanence of the others since 1910, due to lack of practice. For demonstrating the regulation of transfer effect by the substitution of the semi-circles for the star, the results of the practiced right hand are sufficient. The data from the left hand are complicated by the conditions of cross-transfer, general awkwardness, etc. All of the terminal tests are, of course, in a measure affected by practice in the initial test.

Altogether, in addition to the uses of mirror-drawing pointed out by Downey, Dearborn, Starch, Burt and others,

TABLE II

INITIAL TESTS, OCT., 1910, AND TERMINAL TESTS, DEC., 1910, AND DEC., 1913

Date	Hand.	Design.	Seconds	Errors.	Remarks.	Percentages gam Oct		
Oct. 29, 1910	R	Star	107	50	Unpracticed.	29, 1910, to Dec. 20,		
Oct. 29, 1910	R	S. Circles	115	60	Unpracticed	1910.		
Oct. 29, 1910	L	Star	104	64	Unpracticed	Time.	Accuracy.	Av.
Oct. 29, 1910	L	S. Circles	118	71	Unpracticed.	78	52	65
Dec. 20, 1910	R	Star	24	24	Practiced.	63	17	40
Dec. 20, 1910	R	S. Circles	42	50	Unpracticed.	69	38	54
Dec. 20, 1910	L	Star	32	40	Unpracticed.	63	27	45
Dec. 20, 1910	L	S. Circles	44	52	Unpracticed.			
Dec. 16, 1913	R	Star	22	15		Dec. 20, 1910, to Dec.		
Dec. 16, 1913	R	S. Circles	55	58		16, 1913		
Dec. 16, 1913	L	Star	27	21		Time.	Accuracy.	Av.
Dec. 16, 1913	L	S. Circles	58	41		8	38	23
						—31	—16	—24
						16	48	32
						—32	21	—6

the repetition of this experiment upon a group of individuals offers interesting possibilities in analyzing out for class discussion some of the elements of transferred learning, whether it be due to unknown factors, to interferences, partial practice in terminal and initial tests, identical elements or to an altered external factor, as in the case of our semi-circles.

2. CLASS EXPERIMENT ON PERIODS OF LEARNING BY USE OF SUBSTITUTION TESTS.

A group of ten students, chiefly teachers, practiced for twelve days the formation of new associations between letters and numbers, using as material the blanks in Starch's book. (*Experiments in Educational Psychology*). The task is to substitute for the letters in the reading matter the appropriate figures or numbers according to the prearranged key. An initial test was also given on different material where geometrical designs were used to be substituted for numbers, and at the end of the practice series a terminal test was made, using material similar to, but not identical with, the initial test. In the initial and terminal tests time was recorded in seconds for the completion of a page; the number of substitutions during a given time was recorded in the practice series.

It was proposed at the outset of the experiment to divide the class into two approximately equal groups upon the basis of the performance of the initial test (geometrical designs—numbers). A consideration of the rank of the subjects in Table III shows that there was small correlation between the initial and the first practice (letters—numbers) trials. The table shows the rank of the subjects with regard to: (1) Initial test (geometrical designs—numbers); (2) First ten minutes of practice tests (letters—numbers); (3) Improvement by practice; (4) Improvement in terminal, or "transfer," test without practice. (Table III.)

TABLE III.

Individual.	Initial Test.		Ten Minutes of First Practice Substitutions.		Improvement by Practice.		Improvement on Terminal Test.	
	Sec.	Rank.		Rank.	Per cent.	Rank.	Per cent.	Rank.
A.	119	1	266	1	138	9	24	1
B.	114	2	157	7	158	7	21	2
C.	112	3	167	6	231	3	20	3
D.	111	4	108	10	240	2	12	8
E.	111	5	187	4	204	5	17	5
F.	110	6	157	8	182	6	17	6
G.	109	7	179	5	42	10	20	4
H.	107	8	146	9	227	4	5	9
I.	98	9	216	3	142	8	16	7
J.	85	10	225	2	269	1	— 1	10

The class was divided into two groups, upon the basis of performance of the first practice results. Group I worked ten minutes per day. Group II twenty minutes every other day. Total time for both groups, two hours. The figures show that with one exception (G), all of the subjects of Group I, working ten minutes per day, gained a larger percentage than any of those working twenty minutes on alternate days. The improvement in the terminal tests of the twenty-minute series shows a tendency to excess over that of the ten-minute series, although our small numbers restrict inferences. (Table IV.)

TABLE IV.

<i>Group I.</i>			
Individual.	Substitution.	Per cent. improvement.	Per cent transfer.
J	225	269	— 1
D	108	240	12
C	167	231	20
H	146	227	5
G	179	42	20
<i>Group II.</i>			
I	216	142	16
F	157	182	17
E	187	204	17
B	157	158	21
A	266	138	24

However similar objectively the work of the initial and of the practice series may seem to be at the outset, it is evident in attempting to divide a class into equal groups by the criteria of equal performances that it should not be done upon the basis of reactions that are of seemingly slightly different

character from the practice material. It is possible from our data to select two approximately equal, although small, groups, and the final results will not contradict the conclusion that frequent short periods of work are more economical for acquisition of skill than half as many longer periods distributed throughout a number of days. This conclusion would be worthless, however, not only because of the smallness of the groups, but also because the groups were not assuredly equal at the outset for the practice task in hand.

A further question suggested by this class experiment is an important one in its ultimate pedagogical bearings: What is the relation that the amount of transfer or general effect (spread) of learning bears to the different intervals of learning? To know how the *general* effect of a practice may be increased is as important as to record mere increase in speed and accuracy of acquisition of a special skill.

3. CANCELLATION TESTS: NEW MATERIAL AND AN EXPERIMENT.

Our object here is to call attention to a convenient form for the cancellation or A-test, suitable alike for group or individual tests, and to describe a group test upon the effect of practice in marking A's, and upon the transfer of the improvement to marking words containing e and r. A short horizontal stroke was used in the marking.

In constructing the cancellation sheet it is believed that the following method of distribution is preferable to that of mixing type by the printer. Twenty-six marbles, each marked with a letter of the alphabet, were shaken in a small basket, and thereupon a marble was withdrawn. After the letter was written down, another mixing and withdrawal was made, and finally the MS. thus constructed was printed in linotype. A set of the forms beginning H D was printed on sheet of paper $5\frac{1}{2} \times 18$ inches. Another set beginning with H J was made by simply transposing the order of linotype lines. Counting the A's in both sheets shows a uniform distribution, there being about fifteen A's to every ten lines. The chance order was adhered to in the printing, save where three A's were found grouped. This method of distributing the twenty-six letters, although laborious, secures for practical purposes one hundred alphabets, arranged in chance order.

A corresponding sheet for words was made by linotyping solidly, without paragraphs, some inches of Cicero's orations in Latin.

The effect of practice in marking A's. Twelve young women, college students at the Callender Laboratory, Newcomb College, Tulane University, under the writer's direction, marked A's upon two sheets for two minutes per day at the same hour for fourteen days. How much the learning curve is modified by the fact that sheets (H D and H J) reoccur at intervals is not known. Practically all continued the work without interruption from November 21 to December 5. Average cancellations of A's for the group are, omitting fractions:

TABLE V.
CANCELLATIONS OF "A."—TWELVE PERSONS.

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Average . . .	37	40	41	42	44	46	46	45	49	49	51	55	55	58
M. V.	8.1	7.7	8.3	8.4	9.5	7.9	9.2	11.9	8.5	9.5	9.7	8.1	7.6	9.1

The mean variations with these averages denote the range of individual performances during the successive days. In the complete series two students among the twelve missed two and three trials, respectively.

Improvement in marking words containing e and r. Before and after the practice series each subject marked the words containing e and r for two minutes as initial and terminal tests. The averages for the group were, for cancellations or speed, respectively: in the initial e-r test, 49, M.V. 5.3; in the terminal e-r test, 58.7, M.V. 6.5.

The averages for errors were: initial test, 4.7, M.V. 2.2; terminal test, 5.3, M.V. 2.7. The improvement in speed for the e-r tests was 20 per cent., which is about one-third as much as the improvement in marking A's (57 per cent.). Since the same Latin text was used for initial and terminal tests, it would seem that the actual net transfer was less than this amount. Only by a control group under identical conditions could the effect of one repetition of the initial test be estimated.