

THE PSYCHOLOGICAL REVIEW

ASSOCIATIVE AIDS: II. THEIR RELATION TO PRACTICE AND THE TRANSFER OF TRAINING

BY H. B. REED

University of Idaho

III

The methods and materials for this experiment were the same as those described in my paper on 'The Relation of Associative Aids to Learning, Retention, and other Associations.' As stated there, the tests were repeated every day for six days, and on the sixth day, the *B*, *D*, and *U* tests were given in addition. The former enable us to detect the effect of repeated learning or practice upon associative aids, and the latter enable us to detect their influence upon the transfer of training in so far as this means the effect of learning things in one connection upon learning them in a different connection. The solution of these two problems will form the burden of this paper.

The nature of our experiment enables us to measure practice effect in various ways and also to isolate several factors influencing the cause of practice. The former may be measured (1) by the average number of repetitions, *R*, per pair for each day; (2) by the average reaction time, *T*, per pair for each day, and (3) by the number of pairs correctly remembered each day, *NC*. Since the time was taken for every reaction, wrong or right, we were able to tell to what extent practice effect is due to the elimination of errors and to what extent it is due to the improvement in the times of the correct reactions, *CR*. All of these measures were cal-

culated for each individual for each day and test, and their averages for all of the subjects of the experiment. The reliability of these averages was measured by a calculation of the A.D.'S for the group averages. In addition, the A.D. of the Ave. L.T. or T. of each individual for each day was calculated and this measure is called *TAD*. The group average of *TAD* and its A.D. were also calculated. The *TAD* therefore measures the variation of the individual in his own L.T.'s, and the A.D. of the group average of the *TAD* measures the variation of the individual *TAD*'s among each other. The group averages for each day and test of all these measures together with their A.D.'s appear in Table VIII. Following our custom, we have kept the measures of each series separate and in the last section of the table we have given the general averages for all the series.

If we imagine curves for the respective averages in Table VIII, it will be seen that the *R*, *T*, *TAD*, and *CR* curves all

TABLE VIII

SB

	1	2	3	4	5	6	<i>B</i>	<i>D</i>	<i>U</i>
<i>R</i>	1.89	.51	.16	.08	.03	.05	.14	.98	1.26
<i>AD</i>.....	.58	.21	.12	.10	.04	.08	.09	.62	.66
<i>T</i>	7.25	4.25	2.55	1.99	1.65	1.65	2.47	7.85	8.43
<i>AD</i>	3.08	1.26	.54	.64	.69	.49	.62	4.61	2.30
<i>TAD</i> ...	4.30	2.02	1.10	.92	.86	.80	1.68	4.55	5.69
<i>AD</i>	2.04	.95	.70	.60	.68	.67	1.07	2.05	1.16
<i>CR</i>	2.35	2.13	1.73	1.59	1.53	1.46	1.89	3.75	3.38
<i>AD</i>.....	.62	.92	.46	.34	.42	.38	.39	1.05	.44
<i>NC</i>	4.56	5.92	8.44	9.16	9.65	9.55	8.33	3.55	2.70
<i>AD</i>	1.44	1.08	1.44	.80	.56	.76	.55	1.70	.62
<i>N</i>	250	250	250	250	200	210	130	130	70

RC

<i>R</i>	1.67	.50	.15	.06	.04	0	.26	1.08	1.00
<i>AD</i>....	.29	.35	.19	.09	.05	0	.12	.84	.24
<i>T</i>	5.34	3.87	2.74	2.21	1.91	1.54	3.90	7.38	10.60
<i>AD</i>	2.90	.76	1.46	.85	.39	.28	1.59	2.77	3.14
<i>TAD</i> ...	3.19	2.15	1.45	1.37	.79	.50	2.42	5.08	5.64
<i>AD</i>	1.85	1.29	1.15	.90	.47	.30	1.97	1.87	3.31
<i>CR</i>	2.05	2.22	2.01	1.85	1.75	1.51	2.36	2.55	2.64
<i>AD</i>....	.51	.46	.44	.65	.29	.24	.75	.81	.89
<i>NC</i>	5.09	6.59	8.77	9.36	9.47	9.84	7.77	4.16	2.78
<i>AD</i>....	.62	.65	1.44	1.07	.65	.28	.75	2.66	1.18
<i>N</i>	220	220	220	220	180	180	90	70	70

WS

R.....	2.55	.76	.37	.23	.18	.13	.51		.77
AD.....	.59	1.02	.25	.15	.15	.13	.52		.55
T.....	11.89	6.25	3.90	3.10	2.49	2.31	3.52		8.32
AD.....	3.85	3.76	2.44	1.52	1.20	1.03	4.46		4.11
TAD....	6.98	3.94	2.77	2.16	1.54	1.33	3.24		4.81
AD.....	2.62	2.57	1.93	1.72	1.15	.97	2.04		2.87
CR.....	2.82	2.01	1.96	1.77	1.66	1.60	1.96		3.05
AD.....	.73	.40	.53	.77	.42	.21	.51		1.27
NC.....	2.52	6.63	7.11	8.15	8.76	8.63	7.00		4.86
AD.....	1.65	1.86	1.57	1.48	1.01	.73	1.76		2.52
N.....	270	270	270	270	240	230	240		220

WP

R.....	4.30	1.40	.43	.23	.20	.13		1.16	
AD.....	1.08	.75	.29	.24	.20	.15		.88	
T.....	17.50	8.29	4.20	3.15	2.66	2.09		13.36	
AD.....	7.25	4.80	1.99	1.41	.94	.71		5.96	
TAD....	7.78	4.45	2.41	1.83	1.36	1.07		7.05	
AD.....	3.81	2.32	1.42	1.08	.76	.42		3.80	
CR.....	3.24	2.53	2.41	2.11	1.94	1.75		3.68	
AD.....	1.13	.75	.82	.63	.45	.57		1.38	
NC.....	1.07	3.30	7.00	8.11	8.61	9.00		2.50	
AD.....	.76	1.90	2.07	1.51	.92	1.04		.93	
N.....	270	270	270	270	250	220		240	

GENERAL AVERAGES

	1	2	3	4	5	6	B	D	U
R.....	2.60	.79	.28	.15	.11	.08	.23	1.41	1.01
AD.....	.58	.58	.21	.15	.11	.09	.24	.78	.48
T.....	10.49	5.67	3.35	2.64	2.18	1.90	3.29	9.53	9.12
AD.....	4.29	2.52	1.61	1.11	.86	.63	2.22	4.45	3.08
TAD....	5.56	3.14	1.93	1.57	1.14	.92	2.45	5.56	5.38
AD.....	2.58	1.78	1.30	1.07	.77	.59	1.69	2.57	2.45
CR.....	2.62	2.22	2.03	1.79	1.72	1.58	2.06	3.33	3.22
AD.....	.75	.63	.56	.49	.39	.35	.55	1.08	.87
NC.....	3.31	5.61	7.83	8.69	9.12	9.26	7.70	3.40	3.45
AD.....	1.13	1.37	1.64	.97	.78	.70	1.02	1.76	1.44
N.....	252	252	252	252	217	211	153	146	120

R = No. of repetitions per pair

T = Learning time in seconds

TAD = Ave. of AD's of individuals in their T's per pair

CR = Reaction time for correct responses

NC = No. of pairs correctly remembered

N = No. of pairs upon which averages are based.

have the same general shape. They fall rapidly for the first three days and very slowly for the other days. In the sixth day, they turn their direction, rising gradually for the B, D, and U tests respectively. The NC curve has just the reverse shape. These characteristics are shown clearly in Chart I,

which is based on the general averages at the bottom of table VIII. If we measure the difficulty of the different series by their height from the zero abscissa line, the order of difficulty beginning with the easiest is *SB*, *RC*, *WS*, and *WP*. It is noteworthy that the *CR* curve is the lowest one and has the flattest shape. But there is a very gradual fall from day

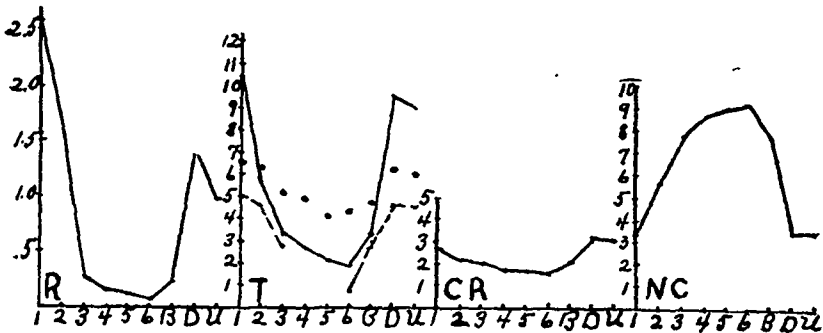


CHART I. Based on general averages in Table VIII. *R* = No. of repetitions per pair. *T* = Learning time in seconds. *CR* = Reaction time for correct responses in seconds. *NC* = No. of pairs correctly remembered. - - - Dashes = No. of associative aids, general averages, Table IX. . . . Dots = No. of associative aids, general averages, Table X. Abscissas = Days of practice and *B*, *D* and *U* tests.

to day. This shows that improvement is due principally to the diminution of error but it is also due in part to a shortening of the correct reaction from day to day, *i. e.*, a mechanizing of the correct responses.

If we wish to discover the relation of associative aids to the practice effect just described, we can do so by calculating the average frequency of the pairs that were associatively learned from day to day. As stated above, we recorded, after the learning of each series, the associative aids on the first, second, third, and sixth days for eighteen subjects, and after each response on each day for 9 subjects. The first procedure prevented the creation of artificial reports and interference with the natural course of associative aids by a continual stimulation of them. On the other hand, the second procedure enables us to picture the details of the course of associative aids that would be forgotten and omitted in the

former procedure. The results of the first procedure are given in Table IX and those of the second in Table X.

TABLE IX

TABLE SHOWING AVE. NO. OF ASSOCIATIVE AIDS IN THE 1ST, 2D, 3D, AND 6TH DAYS, AND IN THE *B*, *D*, AND *U* TESTS. FIRST PROCEDURE

SB							RC						
1	2	3	6	B	D	U	1	2	3	6	B	D	U
5.68	4.88	4.00	0.84	1.93	4.30	4.25	6.92	6.08	3.52	0.70	4.40	5.71	4.55
<i>N</i> =	250			140	63	108	<i>N</i> =	250			50	140	63
WS							WP						
4.60	4.32	1.66	0.72	2.40		5.00	3.68	3.33	2.44	0.56		4.10	
<i>N</i> =	250			150		171	<i>N</i> =	250				171	

From Table IX it will be seen that the frequency of associative aids decrease very little on the first two days, but on the third day they take a sharp drop, and by the sixth day have almost completely slumbered away. However, they are again slightly awakened by the *B* test and have become fully active in the *D* and *U* tests. There is thus a very close parallelism between the *R* and *T* curves, on the one hand, and the curves for the frequencies of associative aids on the other. This is shown in the dots and dashes with the *T* curve in Chart I. They are based on general averages calculated from Tables IX and X. This relationship means that associative aids disappear with practice and that their disappearance shortens the reaction time. My records

TABLE X

TABLE SHOWING AVE. NO. OF ASSOCIATIVE AIDS EACH DAY FOR INDIVIDUALS FROM WHOM VERBAL REPORTS WERE TAKEN AFTER EACH RESPONSE. SECOND PROCEDURE

SB									RC								
1	2	3	4	5	6	B	D	U	1	2	3	4	5	6	B	D	U
8.00	7.20	5.83	5.20	6.00	6.30	6.30			9.00	7.50	5.50	5.50	2.50	2.00		6.50	
<i>N</i> =	60			40		40			<i>N</i> =	20						18	
WS									WP								
5.00	4.40	4.25	3.75	2.71	3.66	3.20		6.33	4.86	6.37	5.75	5.50	5.50	5.66		6.33	
<i>N</i> =	80			60	60	54			<i>N</i> =	80			60	60		54	

show that a pair that was accompanied by an associative aid on the sixth day always had a longer reaction time than one that was not so accompanied. This is what we should expect, for, other things being equal, the more middle terms between a stimulus and a response, the longer the reaction time would reasonably be. From this principle as well as from the facts of Table IX., it is safe to assume that the disappearance of these middle terms is another factor conditioning the rate of improvement from day to day.

That the presence of associative aids should shorten the L.T. on the first and second days and lengthen it on the sixth day is not at all a contradiction in terms if we remember their natural course and the nature of the learning process. But in any case, however contradicting this may appear from the standpoint of logic, the facts of the matter force us to accept its rationality. During the early stages of learning, associative aids supply a connecting link between two unrelated terms and thus make an easy transition from one term to the next. If there is no such connecting link, the learner usually has to wait a little while until the response comes, and besides, has to make an effort to recall a fact, which always consumes a long time in comparison to a case where the connections are ready at hand. In neurological terms, we may think of an associative aid as supplying a roundabout conduction unit of low resistance between two newly stimulated cells. When one of these is stimulated the excitation travels readily to the other. When there is no associative aid, the excitation of the neurone for the one term is blocked and must travel slowly to the neurone for the next term because of the high resistance, and therefore results in a long reaction time. After a period of exercise, however, the synapses of the neurones for the new terms become open and the excitation travels rapidly and directly from the one to the other, producing the shortest possible reaction. A roundabout path is no longer necessary, and if the excitation travels through it, it requires that much more time. The associative aid is thus a means of opening the synapses or for reducing the resistance of the newly stimulated neurones, and when it has

once performed that function, the connection becomes direct. Or on the psychological side, the function of associative aids is to connect new terms, and when they have made that connection, they disappear.

From Table X the decrease in frequency of the associative aids is much slower than in Table IX. There is, however, a decrease, and it is the most marked in the *RC* or easiest series. This indicates that with this procedure it would simply take a longer time for the associative aids to disappear. The slow decrease shown in this table in comparison with Table IX makes it evident that the ever-recurring demand after each response to report what was thought of between the stimulus and the response not only kept the associative aids in a high degree of excitation but also engendered an attitude or set that favored such an excitation.

Having sketched the general course of associative aids as it is influenced by repeated learning, we may now illustrate it by examples from our records.¹

	FIRST PROCEDURE			
	March 10	March 11	March 12	March 16
Mistake clean	5. Clean 1" 4. No 2" 3. No 8" 2. No 2" 1. 0"	4. Clean 1" 3. No 3" 2. No 4" 1. No 4"	1. Clean 1"	1. Clean 2.5"
First day	Nothing			
Second day	"			
Third day	"			
Sixth day	"			
Simmer tarry	2. Tarry 2.5" 1.	1. Tarry 2"	1. Tarry 1"	1. Tarry 1.5"
First day:	Thought of something on the stove and tarrying a long time.			
Second day:	Same.			
Third day:	Same.			
Sixth day:	Nothing.			
Miss Jen. 5 P.M.	March 10 3. Time 4.5" 2. No 4.5"	March 11	March 12	March 16
Galley time	1.	1. Time 3"	1. Time 2"	1. Time 1"
First day:	Thought of boat with galley slaves, and it took a long time to get in the boat.			

¹ For an explanation of the arrangement, see this volume, p. 139.

Second day: Same.
 Third day: Same.
 Sixth day: Nothing.

	3. Betide 1''			
	2. No 5''	2. Betide 1''	2. Betide 1''	
Space betide	1. 0''	1. No 8''	1. No 8''	1. Betide 1''

First day: Space between the tides.
 Second day: Same after prompting.
 Third day: Nothing.
 Sixth day: Nothing.

SECOND PROCEDURE

Mr. Teh.

	8-9 A.M.	May 18	May 19	May 20
		2. Coffee .8''		
Radish coffee	1.	0''	1. Coffee 2.6''	1. Coffee 1.6''

	May 21	May 22	May 24
	1. Coffee 1.7''	1. Coffee 1''	1. Coffee .5''

First day: Saw a radish and a cup and a saucer on the table.
 Second day: Just the word coffee came into my mind.
 Third day: Saw a radish, coffee came immediately.
 Fourth day: Saw a red radish and a table, then the word coffee came.
 Fifth day: Nothing.
 Sixth day: Nothing; expected it.

	May 18	May 19	May 20	May 21
	2. Wall 2.3''			
Soup wall	1. 0.0''	1. Wall .6''	1. Wall 1''	1. Wall 1.2''

	May 22	May 24
	1. Wall 1.6''	1. Wall 1.8''

First day: I immediately connected these with serve-hold, waiter holding soup and spilling it on wall.
 Second day: Just tray and then wall came.
 Third day: Same.
 Fourth day: Vague image of tray, then wall came.
 Fifth day: Nothing.
 Sixth day: Thought of Zool. Lab., then Miss Wall. She makes so much noise over there.

	May 18	May 19	May 20	May 21
	5. Lek 3.4''			
	4. Rem 13.6''			
	3. Rem 2.4''	3. Lek 2.3''		
	2. Zum 3''	2. No 10.6''		2. Lek .8''
Yab lek	1. 0.0''	1. No 4.6''	1. Lek 3.4''	1. No 8''

	May 22	May 24
	1. Lek 1.4''	1. Lek 2.3''

First day: 2. Zum seemed right.
 3. Rem seemed right.
 4. Response has an *e*, had said rem but it was wrong, but I could think of nothing else.
 5. Thought of rem, right response begins with letter before *m*, so I got it. Thought of this after last prompting.

Second day: 1. Only yab.
 2. Thought of rem, not right because I tried it twice before; don't know.
 3. Thought of rem, not right, response has an *e* in it and begins with first consonant before *m*.

Third day: Same.

Fourth day: Same, but could not think of lek.

Fifth day: First rem, then lek immediately.

Sixth day: Rem, then *lek*.

Miss Bro.

3-4 P.M. May 24 May 25 May 26 May 27

		2. Stencil 2.4''	Design		
Kimono-stencil	1.	0.0''	1. Stencil 2.6''	1. Stencil 1.6''	1. Stencil 1.4''
		May 29	June 1		
		1. Stencil 1.8''	1. Stencil 1.0''		

First day: Had picture of a design stenciled on kimono.

Second day: Same.

Third day: Thought of design, then stencil.

Fourth day: Only stencil.

Fifth day: " "

Sixth day: " "

The above examples enable us to picture the course of associative aids as they are influenced by repeated learning. The first procedure shows us that in some cases they come up almost in the same way for three experiment days, but have wholly disappeared by the sixth experiment day. In some cases they occur only on the first and second days; and in others only on the first day. This is in agreement with the frequency curves for the four series of pairs learned by 18 subjects. There is a gradual fall in the curves for the first three days, but by the sixth it touches the zero line. The second procedure has the advantage in enabling us to tell not only what happens to the course of associative aids on the fourth and fifth experiment days but also how they are influenced by repeated promptings on the same day. Mr. Teh.'s reports are enlightening in this connection. This

student had the benefit of two semester's work in both theoretical and laboratory psychology and had learned to become a skillful observer. For example, the pair 'troll-blast,' learned by him required four promptings, *R*'s, on the first day and an L.T. of 26.7". Before the second *R*, he could think only of the stimulus, 'troll.' Before the third *R*, he could remember only that he was prompted. Before the fourth *R*, he again could think only of the stimulus. But he now succeeds in devising an association. He thinks of trolls as mountain spirits in one of Ibsen's dramas. The idea of mountain calls up mining, and mining calls up the idea of blast. He now has a connection between troll and blast, and the next time he responds correctly. On the second day, he recalls this association at once and has an L.T. of 2". By the third day it has almost slipped away, but it comes back slowly and he has an L.T. of 5". On the third day, he thinks of placing 'trolls' in a book, which immediately calls up blast. The intermediate links of 'trolls' in the mountains and mining, and of mining and of blast, have disappeared. On the fifth day, he thinks only of 'trolls' in a book. The idea of placing them definitely has disappeared. On the sixth day the response is immediate without any association, the L.T. being only 1". The learning of 'yab lek' is another example showing in detail a similar psychological process. A third example may be taken from the learning of 'soup wall.' On the first day, Mr. Teh. thinks immediately of a previous pair, 'servehold,' then of a waiter holding soup and spilling it on the wall. By the second day, most of this has disappeared, and he thinks only of a tray and a wall. The same occurs on the third day. On the fourth day, the image of a tray becomes very vague, and on the fifth day, the response is immediate without any association or imagery. The example from Miss Bro. is a type of great frequency. In learning 'kimono-stencil' for the first day, she pictures a design stenciled on the kimono. This picture recurs on the second day. On the third day, she thinks only of the words, design and stencil. On the fourth, fifth, and sixth days, the response, *stencil*, is immediate without any association or picture. These

examples show quite clearly how the associative connections between a stimulus and a response became shorter and shorter until finally the connection became immediate and direct, producing the shortest reaction time.

SUMMARY

Associative aids disappear with practice and condition the rate of improvement. They greatly facilitate the formation of new responses but delay those which have been mechanized. Psychologically their function is apperceptive, that is, they connect the old with the new terms and then disappear. Neurologically they seem to provide indirect conductive units of low resistance between newly stimulated neurones and serve to connect them directly by the shortest paths.

IV

We may think of this experiment as an experiment in the transfer of training in which the regular tests for the six days constituted the training series, and the *B*, *D*, and *U* tests as the test series by which the spread of improvement from the training series may be measured. Although there were no tests before training, we may assume that in the average the L.T.'s for the *B*, *D*, and *U* tests would have been the same as the L.T.'s of the regular tests on the first day. We may measure the spread of improvement in one way by the difference between the L.T.'s of the training and test series, and in another way by the number of correct responses without prompting in the *B*, *D*, and *U* tests. Since the former measure mixes up the pairs in which there was facilitation with those in which there was interference, we had better take the latter measure, for it keeps these two sorts separate. In the *B* tests the pairs were learned backwards, *i. e.*, the subjects named the first word as a response to the second word as a stimulus. The reaction time in the average is almost twice as long as for the regular tests on the sixth day. The frequency of associative aids is from two to six times as great. Or in comparison to the regular tests, the associative frequency as well as the L.T.'s in the *B* test compare favorably to what they were on the third day of the regular tests.

This means that learning a given pair of words *forwards* completely for *six* days will reduce the time for learning it *backwards* as much as three days of practice in the forward direction. Learning forwards then helps learning backwards. The reappearance of associative aids in the latter makes it probable that an association which aids learning in one direction also aids it in another. This is more clearly shown in the *D* and *U* tests, in which the influence of associative aids was studied more carefully. Table VIII shows that the L.T.'s for the *SB* and *RC* series are higher in the *D* and *U* tests than in the regular tests for the first day. According to this measure, although these pairs were learned in the same order every day for six days, the learners were yet unable to name the first words in either an *up* or *down* order. There were, however, some correct responses in these tests, averages of 3.55 and 4.16 in the *D* test for *SB* and *RC* series respectively, and averages of 2.70 and 2.78 in the *U* test for the same series. That is, learning the pairs forwards completely each day for six days enabled the learner to name little over one third of the first words of the pairs in a *down* order and a little less than one fourth of them in an *up* order. But the learning of the other words was so much longer than the average that time was lost in the *D* and *U* orders because of the six complete learnings in the forward direction. Learning the pairs in one connection therefore in some respects produced very great interference with learning them in another connection. But it also greatly facilitated the learning of some of them. The *WS* and *WP* series do not show this interference in the average L.T.'s. Their L.T.'s in the *D* and *U* tests are, however, higher than the average L.T.'s on the second day of the regular tests, but less than those on the first day, showing very little profit by the six complete learnings in the forward direction. The number of correct responses, however, is 4.86 for the *U* test in the *WS* series and 2.50 for the *D* test in the *WP* series. These successes can only be accounted for by assuming that the training gained by the six days' practice on the pairs in the forward direction was transferred to learning them in both the *up* and the *down* orders. The question now is, how shall

we explain this transfer? The answer again is found in the influence of associative aids. This was determined by calculating, on the one hand, the per cent. of the correct responses that were made possible or rather accompanied by a revival of some association established in the training series, and on the other hand, the per cent. of such successes due to guesses or perseveration. Table XI shows the results of the calculation for the respective series.

TABLE XI

SB						RC						WS			WP		
D			U			D			U			U			D		
NC	% AA	% PSV	NC	% AA	% PSV	NC	% AA	% PSV	NC	% AA	% PSV	NC	% AA	% PSV	NC	% AA	% PSV
45	91.1	6.6	29	79.3	6.9	73	87.6	4.1	18	94.4	5.6	112	83.9	5.3	80	85.0	6.3
N = 117			N = 99			N = 144			N = 72			N = 216			N = 252		

NC = the number of correct responses in the D or U tests.

%AA = % of these accompanied by associative aids.

%PSV = % of these due to guesses or perseveration.

It will be seen that from 84 to 91 per cent. of these successes are accompanied by a revival of former associations, from 4 to 7 per cent. of them appear to be mere guesses, and the small remainder are unexplained. The fact that such a high percentage of correct responses are preceded by associative aids suggests that the successes are possible through them. This will be made more evident by reproducing some examples from the records which are worthy of careful study. The following points should be noticed: (1) The rare frequency of successes which cannot be explained by a previously established association. (2) The absence or confusion of such associations in cases of failure. (3) The high frequency of successes connected with associations of order and position. (4) The absence of direct connections between stimulus and response. (5) The connection of the latter by a roundabout previously established associative path which was reexcited either in the same direction in which it was established or in

a reverse direction. (6) The formation of new associations where a success was not obtained without prompting.

In the examples below the stimuli are printed along the margin at the left in the order in which they were given. In the *D* test, the subject was asked to name the first word of the pair next to 'sauce,' 'mistake,' etc. The responses and the times are given opposite the pair containing the correct response. Immediately below this are given the associations which the subject had formed with these responses, the connection being indicated by the corresponding numbers. In the *U* test the subject was asked to name the first word of the pair before 'space,' 'kimono,' etc. The reader must bear in mind that in this test such terms as before, after, first, and last, when used by the subject have just the reverse meaning from that which would be indicated by their position on the page. This is because the stimuli in this paper are printed in the reverse order from that in which they were in the original sheets.

Miss Bov. April 22, 4-5 P.M. *D* test.

Sauce balloon:

Mistake clean: 1. Elephant 3.4''. 2. Mistake 1.4''.
2. Prompting reminded me that mistake follows sauce.

Elephant steeple: 1. Elephant 1.8''.
1. If elephant is not second, it is third.

Simmer tarry: 1. Tomato 11.0''. 2. Simmer 3.6''.
2. Remembered prompting.

Ring kitten: 1. No 6.6''. 2. Galley 1.4''. 3. Kitten 1.6''.
3. Remembered prompting.

Turkey among: 1. Turkey 2.2''.
1. Thought ring, kitten, among, turkey.

Chest muffin: 1. Chest 1.8''.
1. Thought turkey, among, muffin, chest.

Galley time: 2. Kimono 10.6''. 2. Galley 2.2''.
2. Remembered prompting.

Kimono stencil: 1. Kimono 2.2''.
1. Kimono is next to last.

Space betide: 1. Space 1.2''.
1. Space is last.

1. Miss Ber. 4-5 P.M. *D* test.

Sauce balloon:

Elephant steeple: 1. Elephant 8.3''.
1. Thought sauce-balloon steeple-elephant.

- Ring kitten: 1. No 10.3''. 2. Ring 2.0''.
1. Thought of muffin-chest stencil kimono; these are not right, no.
2. Nothing.
- Chest muffin: 1. Chest 5.0''.
3. Thought ring, muffin-chest.
- Kimono stencil: 1. Kimono 2.6''.
1. Thought chest-muffin, stencil-kimono.
- Mistake clean: 1. Simmer 4.0''. 2. Mistake 5.4''.
1. Thought kimono-stencil, tarry-simmer.
2. Remembered prompting. Saw objects for kimono-stencil but words only for mistake-clean.
- Simmer tarry: 1. Simmer 2.0''.
1. Thought mistake-clean-simmer.
- Turkey among: 1. Turkey 4.0''.
Saw simmer-tarry, among-turkey in order.
- Galley time: 1. No 17.0''. 2. Galley 2.0''.
1. Saw the words turkey-among and time, but could not see galley.
2. Remembered prompting.
- Space betide: 1. Space 2.3''.
1. Saw the words galley, time, betide, space.
- Miss Wal. April 20, 3-4 P.M. *D* test.
- Radish coffee:
- Serve hold: 1. Serve 6.1''.
1. Serve hold is the second pair.
- Pork cocoa: 1. Pork 2.2''.
1. Pork cocoa is next to serve hold.
- Cheese tomato: 1. Cheese 2.3''.
1. Gussed it.
- Speak weigh: 1. Speak 1.2''.
1. Had these arranged like this: First there was something to eat, and then there wasn't, then there was again, and then there wasn't again.
- Ribbon banana: 1. 1. Celery 4.2''. 2. Being 8.6''. 3. Ribbon 1.0''.
3. Nothing.
- Being credit: 1. Celery 2.4''. 2. Being 1.4''.
2. Gussed it.
- Miss Bro. 3-4 P.M., June 1. *D* test.
- Sauce balloon:
- Elephant steeple: 1. No 16.2''. 2. Elephant 9.8''.
1. Only balloon.
2. Only elephant.
- Ring kitten: 1. Ring 2.8''.
1. Thought it belonged here somewhere.

- Chest muffin: 1. Turkey 3.0''. 2. Tarry 10.4''. 3. No 30.8''.
 1. Turkey the only one in the list that I could think of.
 2. Only simmer-tarry.
 3. First didn't know whether elephant came before or after, concluded it came before, but could not think what was right.
 4. Thought of elephant all the time, then thought it was something a kitten could eat, chest-muffin.
- Galley time: 1. Galley 1.0''.
 1. Guessed at it.
- Kimono stencil: 1. No 7.5''. 2. Kimono 1.8''.
 1. Nothing.
 2. Guessed at it.
- Miss Ric. 2-3 P.M. *U* test.
- Geigen fiddle:
- Citrone lemon: 1. Citrone 2.0''.
 1. Thought of the last and the next to the last pairs.
- Besonder particular: 1. Besonder 1.6''.
 1. Thought citrone-lemon, besonder-particular, and knew that besonder came before citrone.
- Angriff attack: 1. Angriff 1.7''.
 1. Thought besonder-particular, Angriff-attack.
- Ereignen happen: 1. Ereignen 1.7''.
 1. Thought Angriff-attack; ereignen-happen.
- Dach roof: 1. Körper 2.0''. 2. Dach 5.6''.
 2. Thought ereignen-happen; dach-roof.
- Anregen stimulate: 1. Stimulate 6.2''. 2. No 18.0''. 3. Anregen 1.2''.
 3. Remembered prompting.
- Körper body: 1. Körper 1.6''.
 1. If Körper is not before ereignen, it is before anregen.
- Beharren persevere: 1. Beharren 2.2''.
 1. Thought Körper-body, persevere-beharren.
- Wipfel-summit: 1. Wipfel: 1.7''.
 1. Thought beharren-persevere, summit-wipfel, and that wipfel and beharren are the first and second words.
- Mr. Kin. 5-6 P.M. *U* test.
- Soup wall:
- Troll blast: 1. No 6.0''. Troll 1.6''.
 2. Remembered from prompting that they were the last and the next to the last pairs.
- Celery wafer: 1. No 3.3''. 2. No 5.5''. 3. Lettuce 8.0''. 4. Celery 5.4''.
 4. Saw celery and remembered prompting.
- Being credit: 1. No 3.2''. 2. Being 2.7''.
 2. Remembered prompting.
- Ribbon banana: 1. No 1.6''. 2. Lettuce 3.0''. 3. No 6.2''. 4. Ribbon 3''.
 4. Remembered prompting.

- Speak weigh: 1. No 4.8''. 2. No 2.4''. 3. Cheese 10.2''. 4. Speak 2.0''.
 4. Remembered prompting. A fellow selling ribbon in a dry goods department and then saw Dept. filled with groceries, and saw a cheese on the counter, and beside the cheese there was a ham, and then I saw a girl from the refreshment department serving radishes.
- Cheese tomato: 1. No 1.6''. 2. Cheese 2.3''.
- Pork cocoa: 1. No 1.6''. 2. Pork 2.0''.
- Serve hold: 1. No 1.8''. 2. serve 2.8''.
- Radish coffee: 1. No 1.4''. Radish 1.4''.
- Mt. T. 8-9 P.M., May 24. *U* test.
- Geigen fiddle:
- Besonder particular: 1. Ereignen 2.8''. 2. Besonder 1.0''.
 1. Thought of Angriff and then ereignen.
 2. Nothing.
- Ereignen happen: 1. Ereignen 1.4''.
 1. Nothing.
- Anregen stimulate: 1. No 29.0''. 2. No 22.4''. 3. Anregen 3.6''.
 1. Thought of stimulate but could not find the German.
 2. Same.
 3. Remembered prompting.
- Beharren persevere: 1. Beharren 14.6''.
 1. Thought of anregen-stimulate, and that persevere is before stimulate and goes with beharren.
- Citrone lemon: 1. Angriff 17.0''. 2. Citrone 3.0''.
 1. Had an image of the particulars of two words. Angriff is before beharren. There is something in between, but I could not find it.
 2. Nothing.
- Angriff attack: 1. Angriff 1.6''.
 1. Nothing, knew from previous associations.
- Dach roof: 1. Dach 6.6''.
 1. First a blank, then I recalled that something was before. I started at the top of the list, found the place for each word, and when I came to this place, Dach occurred to me.
- Korper body: 1. Korper 2.0''.
 1. Suggested by previous association.
- Wipfel summit: 1. Wipfel 2.8''.
 1. Wipfel is first and Körper second.

The first example is from the *D* test with Miss Bov. E. pronounced the first word of the first pair, 'sauce.' The proper response is 'mistake,' but the actual one was 'elephant' with a reaction time of 3.4 seconds. After prompting, E.

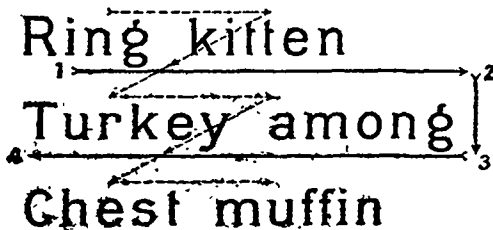
gave 'mistake' as a stimulus and obtained 'elephant,' the correct response. Subject's association was that if elephant did not come second, it came third. After E. went through the list in this way, he gave those stimuli again which were not correctly responded to the first time. He began with 'sauce' and obtained the correct response, 'mistake,' in 1.4 seconds. The previous prompting reminded the subject of the correct position of mistake. Miss Bov. has five successes in this test. Three of these are due to *associations of position*. Thus elephant is the third word, kimono is the next to the last, and space is last. The other two successes are due to *associations of order*. For example when she was asked to name the first word of the pair after 'turkey' she thought the words 'turkey,' 'among,' 'muffin,' 'chest,' and then said 'chest.'

The above two types of association explain most of the successes in the *D* tests. Words near or at the ends were associated with absolute position and those in the middle with the order of learning. There are a few instances, however, in which the order of the pairs was connected with meaningful associations. For example, Miss Wal. had the first five pairs of the *RC* series connected with the story. "First there was something to eat, and then there wasn't again, and then there was again, and then there wasn't again." Some had scarcely any association of position or order, and the *D* test presented a case of learning a new series. The first record from Miss Bro. is a case in point.

The *U* tests show only one important difference in the associations by which the successes were obtained, namely, that they are worked out in the reverse order from that followed in learning. For example, when Mr. T. was told: "Name the first word of the pair that comes before 'anregen'" he replied correctly, 'beharren,' with a reaction time of 14.6". The association was: "I thought of 'anregen-stimulate,' and that 'persevere' is before 'stimulate' and goes with 'beharren.'" The associations of absolute position are just as frequent as in the *D* test. A few subjects showed pronounced visual imagery in this test, e. g., when Miss Ber. was asked to name

the word before 'Angriff,' she reported that she saw a 'Dach' above it and the third from the top. The second record from Miss Bro. is an example of a subject who had few successes in the *U* test, and who had to form a set of new associations in order to learn the pairs in this order.

Although not all of the pairs fall within the category of order and position, the latter are the only ones of importance. The diagram given below will serve as a basis for discussing these associations. A success in the *D* test depended on a definite association both from 1 to 4. A success in the *U* test depended on the ability to travel the path from 4 to 1. A success in the *B* test depended on the ability to travel the path from 2 to 1. Most frequently the path extended only from 1 to 2. Sometimes it extended in addition to 3, and the subject named the word at 3 but was unable to think of the word at 4. Sometimes the path extended only between 2 and 3 and between 3 and 4, enabling the learner to travel from 4 to 3 but no farther. It is important to mention these incomplete paths because they explain the failures in the *D* and *U* tests just as the complete paths explain the successes.



The great frequency of the associative path designated by the solid lines gives rise to the question why the subject did not associate the pairs in the order of presentation as is indicated by the broken lines. At first thought it would appear that the latter would also be the order of the learning. The solid line arrows, however, indicate the direction in which the subject *thought* them and *reacted* to and with them. For the subject to think: "After 'kitten,' I say 'among' to 'turkey' and then 'muffin' to 'chest'" was a simpler order

then to think: "After 'kitten' comes 'turkey' to which I say 'among' and then comes 'chest' to which I say 'muffin'." There are cases of the latter order, but they are much rarer than the former. It appears here that the order of *thinking* and *reacting* is much more important for establishing an associative path than the order of presentation. In spite of the fact that E. said the first words in the same order many times, day after day, the learner after all did not establish any association in that order nor achieve any successes in the *D* and *U* tests by such associations. The order of *listening* counted for little in comparison to the order of *responding*.

This emphasizes the importance of selective activity on the part of the learner in the formation of associations and leads me to a digression on the law of contiguity, which appears to be at variance with the facts of experience. The mere togetherness of two presentations in space or time is no proof that they will be associated. If it were, there should have been few failures in the *D* and *U* tests, for the frequency of the connection 1-2, was hardly any greater than that of the connection, 1-2-4, in the above diagram. Yet the subject, on the sixth day, remembered the former connection in over 95 per cent. of the cases, but in the latter he failed in 66 per cent. of the cases. This is striking proof that the frequency of contiguous presentations is not alone sufficient to establish an association between them. Some factors determining this situation were: The subject was interested in the connection, 1-2, it was exercised, and its exercise was satisfactory. The subject was not interested in the connection 1-2-4, and it was not exercised although it was objectively presented. But of these, the most important factor is probably exercise. From a neurological standpoint, it is not at all certain that the presentation of an object to a learner stimulates his sense organs, and if it does, it is again not certain that it stimulates a complete sensory-motor arc. Even if the latter does occur, the exercise of the bond in question may be so feeble as to leave no after-effect. But whatever the explanation of the failure may be, it at least appears from the results of this

experiment that only those experiences to which we definitely react are associated. The following formula of the law of contiguity is therefore suggested: If a learner reacts to *A* and *B* together in some experience, and if later he again responds to one of them, the former reaction to both of them tends to follow; or stated more simply, if a learner reacts with *A* to *B* and if later *B* recurs, *A* tends to follow. In this connection I am reminded of Hunter's revision of the law of association in the *PSYCHOLOGICAL REVIEW*, May 1917. While I agree that the second term of an association may be either sensory or ideational, I do not think that the failure to recognize this is the fundamental weakness of the traditional formulation. Its weakness is rather that it emphasizes the togetherness of an experience that is important in the establishing of an association. But as we have seen, this is of little importance in comparison to a positive reaction to the experience for the purpose in question.

Coming now to the main question at issue in these *D* and *U* tests, the explanation of the transfer of training, it appears from the above results that learning one thing helps to learn another only in so far as the associations which were established in the first can be made use of in the second. It is clear from the results of this experiment that learning things in one direction helps to learn them in another, that is, when two or more objects are learned well enough in one direction, it is possible at another time to recall these objects in a new order; but, if so, the objects in question must have been connected by some *actual* association *between* them. If association explains the transfer of training, it also should explain the variability in the amount of transfer between one individual and another. That this is the case is evident from Table XII., which shows that the number of correct responses in the *D* and *U* tests varies concomitantly with the number accompanied and preceded by associative aids. Now and then there is an exception which is easily explained by perseveration or a possible forgetting of the association in question. But the correspondence is so close that the main conclusion is inevitable.

TABLE XII

SB				RC								WS			WP								
D			U				D			U					D								
S	NC	NA	PSV	S	NC	NA	PSV	S	NC	NA	PSV	S	NC	NA	PSV	S	NC	NA	PSV				
Joe	7	7		Fac	5	4		Fra	8	8		Ber	4	3	I	Jen	9	9		Gib	6	5	
Ber	6	6		Jen	4	4	I	Sin	7	7		Ham	4	4		Tra	8	5		Pfe	6	3	
Gre	6	5	I	Tra	4	2		Wol	7	5		Joe	4	4		Ber	7	7		Bov	5	4	
Bov	5	5		Wal	4	4		Gib	6	5		Pan	4	4		Fac	7	5		Gre	5	4	I
Kel	4	4		Dav	2	2		Jen	6	5	I	Hil	2	2		Joe	7	7		Sul	5	5	
Ham	3	3		Hof	2	1		Pfe	6	6		Kel	2	2		Pfe	7	3	I	Bro	4	2	2
Hil	3	3		Huf	2	1	I	Tra	6	6		Rip	0	0		Rie	7	7		Huf	4	3	
Pip	3	2	I	Sul	2	2		Dew	5	4		Wic	0	0		Bov	6	4	I	Pan	4	4	
Bro	2	1	I	Swa	2	2		Eva	5	4					Eva	6	6		Bor	3	3		
Kin	2	2		Pfe	1	1		Rie	5	4					Pan	6	5	I	Dav	3	3		
Pan	2	2		Rie	0	0		Teh	4	4					Teh	6	6		Fac	3	3		
Woo	2	2						Bor	2	2					Bor	5	5		Fac	3	2		
Wic	0	0						Hof	2	2					Bro	5	4	I	Huf	3	3		
								Huf	2	2					Ham	4	3	I	Kel	3	3		
								Woo	2	2					Hil	4	4		Teh	3	3		
								Swa	0	0					Huf	4	3		Wall	3	2	I	
															Kel	4	4		Woo	3	3		
															Tra	4	3		Ber	2	2		
															Woo	4	3		Ham	2	2		
															Gre	2	1	I	Hof	2	2		
															Kin	0	0		Joe	2	2		
															Rip	0	0		Wic	2	2		
															Swa	0	0		Hil	1	0	I	
															Wic	0	0		Pip	1	1		
																			Swa	1	1		
																			Tra	1	1		
																			Kin	0	0		
																			Rie	0	0		

S = Subject.

NC = No. of correct responses.

NA = No. of correct responses having associative aids.

PSV = No. of correct responses apparently due to perseveration.

The training and the tests of this experiment are not sufficiently varied to prove conclusively that associative bonds are the only factors which determine the extent, limit, and possibility of the spread of improvement. But we can test the validity of this theory to a certain extent by examining how far it appears to be adequate for explaining the results obtained by other investigations in this field.

If the transfer of training takes place by means of common associative bonds, then the explanation of this phenomenon is simply a case of bringing it under the laws of association. Theoretically the problem with the experiments

on the transfer of training is to find in them illustrations of the laws of association. If the mind is primarily a psychophysical mechanism for reaction, then common associative bonds may occur either through identity and similarity in the stimulus or through identity or similarity in the response. The stimulus may be either sensory or conceptual and the response may either be conceptual or overt. Training may then be transferred from one performance to another when the two have (1) common sensory stimuli; (2) common conceptual stimuli; (3) common overt responses; (4) common conceptual responses.

It may be difficult to bring all the reported cases of the transfer of training under the above categories, but it appears that most of the authentic cases of transfer or of its failure can be so classified.

The following cases of positive transfer may be noticed: When there is transfer of training from estimating areas 10-100 sq. cm. in size to estimating areas 10-250 sq. cm. in size in proportion as the size of the latter approach the size of the former, there appears to be a common response because of similarity in size. When training in cancelling words with e and s is transferred to cancelling words with e and r, or s and p more than it is to cancelling misspelled words or to cancelling capital A's mixed up with a number of other capitals, there is again a common response to the extent that there is a common sensory stimulus in the letters or small geometrical forms in a certain order.¹ When practice in typewriting certain visual stimuli in one order improves the ability to typewrite them in another order, there are common sensory stimuli in small letters appearing at the same place and in a certain order and in the feel of the keys. There are also common responses in the eye movement from copy to keys and in the finger movements to the particular visual stimuli.² Transfer from improvement in discriminating intensities of red to discriminating intensities of mixtures of yellow and

¹ Thorndike and Woodworth, *PSYCHOL. REV.*, 1901, 8, 247-261; 384-395; 553-564.

² Bair, J. H., *PSYCHOL. MONOG.*, No. 19, 1902.

green, intensities of orange, and differences in pitch, is a case of common response by careful observation of small differences. That there is more transfer between small differences within the same modality than there is between those in different modalities again shows the influence of the extent of similarity in the stimulus. Transfer from training in reproduction of one order of four intensities of sound after hearing them in another order to similarly arranged reproductions of the order of four grays, four tones, nine grays, nine tones, nine geometrical figures, two stanzas, and nine numbers—involves common sensory stimuli in separating out order and in the arrangement of stimuli; a common conceptual stimulus in 'Remember one order while perceiving another'; a common conceptual response in associating the stimuli in a certain order; and a common overt response in naming them in a certain order.¹ The order in which the test series were named above shows the extent of the improvement from most to least, and this again shows the importance of the extent of the similarity in the stimulus in number, quantity, or span. Transfer of training in descriptive geometry in amount from most to least to ability to name the number of lines necessary to construct various geometrical objects, to state the number of strokes necessary to write certain words in the straight-line alphabet, to divide mentally three-place numbers by one-place numbers, to state the number of one-inch cubes in a three-inch painted cube which have 0, 1, 2, and 3 painted sides respectively, and to write as many words as possible from the letters in 'material,' is a case that invokes a common sensory stimulus in spatial elements; a common conceptual stimulus in 'Separate them out, hold them apart and put them together'; and a common conceptual response in the mental manipulation and association of spatial elements.² The influence of a common stimulus is again evident here because there is more transfer to geometrical objects than to quasi-geometrical objects and more to the latter than

¹ Fracker, G. C., *Психол. Моног.*, No. 38, 1908, 56-102.

² Rugg, H., 'The Experimental Determination of Mental Discipline in School Studies,' 1916.

to non-geometrical objects. Transfer of training from learning nonsense syllables by one method to learning them by another method involves common sensory stimuli in similar material; a common conceptual stimulus in 'Learn them as soon as possible'; and common conceptual responses in the form of association and reproduction.¹ Transfer from neatness in one school subject to neatness in another school subject is a case of responding to the common² conceptual stimulus 'Be neat.'

Certain cases of failure in transfer of training are equally significant for the theory stated above. The following may be noticed.

Training in card sorting does not improve ability to typewrite. Training in estimating areas 10-100 sq. cm. does not improve ability to estimate similar areas over 200 sq. cm. in size. Training in estimating lines .5 to 1.5 inches long does not improve ability to estimate objects from 2.5 to 8.75 inches long when the latter consist of such things as envelopes, brushes, and wrenches. Training in estimating four intensities of sound does not improve ability to estimate the extent of arm movement. Training in cancelling parts of speech does not improve ability to cancel words having the letters e and t.³ Training in memorizing 'Paradise Lost' does not improve the memory for Hugo's verse.⁴ Training in memorizing nonsense syllables does not increase the memory-span for letters, numbers, nonsense syllables, disconnected words, Latin-English vocabularies, poetry, and prose; nor the ability to memorize completely meaningless visual characters, Latin-English vocabularies, and passages of poetry and of prose.⁵ Training in memorizing prose substance does not improve the ability to memorize dates, nonsense syllables, poetry, points on a map, dictation, letters, and names. Training in memorizing tables does not improve ability to memorize

¹ Reed, H. B., 'Repetition of Ebert and Meumann's Practice Experiment in Memory,' *J. OF EXP. PSYCHOL.*, 1917, 2, p. 315.

² Reudiger, W. C., *Educ. Rev.*, 1908, 36, p. 364.

³ Kline, L. W., *J. of Educ. Psych.*, May, 1914.

⁴ James, W., 'Principles of Psychology,' 1890, Vol. 2, p. 67.

⁵ Reed, H. B., *J. OF EXP. PSYCHOL.*, 1917, 2, 315ff.

dates, poetry, prose, prose substance, dictation, letters, and names. Memorizing poetry does not improve ability to memorize dates, poetry of another sort, prose, prose substance, points on a map, dictation, letters, and names.¹

I have also examined the results of experiments on the transfer of training by Bagley and Squire,² Briggs,³ Burnet,⁴ Coover,⁵ Dallenbach,⁶ W. F. Dearborn,⁷ Foster,⁸ Hewins,⁹ Judd,¹⁰ Ruger,¹¹ Scholkow and Judd,¹² Wallin,¹³ Whipple,¹⁴ and Winch,¹⁵ but have not been able to make them the basis of a theoretical discussion because they were too indefinite, irregular, or complicated to bring within a consistent rule. However, no theory that is at all specific can explain all cases of reported transfer. The psychological factors in the cases of positive transfer described above were pointed out. In the cases of negative or zero transfer it is difficult to find common sensory stimuli, and common conceptual stimuli that may exist are too general to be effective. It is also difficult to find common conceptual or associative responses. But some cases of positive transfer are equally baffling; for example, training in memorizing poetry has been found to improve the ability to locate points on a map and to memorize nonsense syllables, but interfered with the ability to learn poetry of another sort, prose, or prose substance. Memorizing tables improved the ability to locate points in a circle and to learn nonsense syllables, but interfered with the ability

¹ Sleight, W. G., *British J. of Psych.*, 1911, 4, 386-457.

² Bagley, W. C., 'Educational Values,' 1905, p. 188 ff.

³ *Teachers College Record*, Sept., 1913.

⁴ 'Formal Discipline,' Columbia University Contributions to Education, 1907.

⁵ *PSYCHOL. MONOG.*, No. 87, 1916.

⁶ *J. of Educ. Psychol.*, 1914, 5.

⁷ *J. of Educ. Psychol.*, 1911, 1, 386-457.

⁸ *J. of Educ. Psychol.*, 1911, 2, 11-21.

⁹ 'The Doctrine of Formal Discipline in the Light of Experimental Investigation,' 1916.

¹⁰ *PSYCHOL. REV.*, 1902, 9, 27-39.

¹¹ 'Psychology of Efficiency,' *Archives of Psychology*, No. 15.

¹² *Educ. Review*, 1908, 36, 28-42.

¹³ 'Spelling Efficiency in its relation to age, sex, and grade,' *Educ. Psychol. Monographs*, 1911.

¹⁴ *J. of Educ. Psychol.*, 1910, 1, 249-262.

¹⁵ *British J. of Psychology*, 1908, 2, 284-293.

to learn dates, poetry, or prose. The difficulty with all these studies is that the associative processes were not investigated. If we knew what the common bonds of association had been in these cases of positive and negative transfer, we probably should have the cue to their explanation. The correlation between observable stimuli and observable responses is too irregular to make a consistent principle inferable with certainty, but such regular correlations as there are point quite definitely to the solution of the problem in the laws of association. It is to be hoped that future investigators of this problem will more carefully examine the internal facts of transfer, *i. e.*, the common associative bonds.

The above theory does not contradict Thorndike's theory of identical elements. It simply makes it more specific and states that these identical elements consist of associations. The difficulty with the theory of identical elements is the indefiniteness of its meaning. At first it meant principally identity of content but later was extended to identity of procedure and identity of neurological process, but these again are terms of no specific meaning. The wide latitude of the meaning of identical elements is clearly shown by Coover who, both by observation and by introspection, found no less than "40 varieties" of the identical element between one process and another. But the scientific problem with them is to show in verifiable, quantitative evidence which of those forty factors are important and which are not important. That an element is common between two processes tells us nothing about how much one process influences another process unless there is concomitant variation between the amount of this influence and the amount of the common factor.

An examination of Coover's results from this standpoint brings disappointment. His results were recently reported in a three hundred-page monograph. Space prevents me from reviewing it, but if the reader will turn to the sections on "Card-sorting" and "Typewriter reaction," pages 118-131, he will get an idea of Coover's method. He finds no less than "twenty varieties" of the card-sorting process.

When he gives the results on the amount of transfer by various subjects in visual apprehension, sound reaction, and mnemonic devices upon the card-sorting reaction, he finds a residual gain of 10 per cent. on the part of the eight trained subjects. But there were only two controls and these gained as much as two of the trained, and a good deal more than one of them. How then can he be certain that the 10 per cent. greater gain by the other five subjects is not a matter of accidental variation? As an explanation of this very uncertain transfer, he offers the following factors: heightened sensitivity for visual impressions, heightened reproductivity of imagery, coördination of part-processes, exercise of continuous attention and reproduction of memorial elements and habituation to distraction. But he offers not an iota of quantitative evidence that any of these factors are important for improvement or for transfer. If these hypothetical factors are of any importance in either connection, we should have some scientific and objective evidence as a ground for our judgment, *e. g.*, some constant connection or concomitant variation ought to be shown between any of these factors and improvement or transfer. Unless an investigator can produce such evidence, his results only multiply the difficulties of the problem in question.

SUMMARY

In this experiment evidence that learning things in one order helps to learn them in different orders is considered proof of transfer of training. Such transfer takes place through the use of associative bonds common to the old and new orders. Such a use is essentially a case of thinking through old associations in new directions.

The evidence for the theory that transfer of training must be explained by common associative bonds is contained in Tables XI and XII. The former shows that from 84 to 94 per cent. of the cases of transfer are accompanied by associative aids and the latter shows a concomitant variation between the number of cases of transfer and the number of associative aids. On these grounds a causal relation is assumed.

Further evidence for the theory is furnished by an examination of the literature of the clearest cases of transfer. If associative bonds are the media of transfer, then the explanation of these cases is simply a problem of bringing them under the laws of association. This would mean that training may be transferred from one performance to another when the two have (1) common sensory stimuli; (2) common conceptual stimuli; (3) common overt responses; (4) common conceptual responses. An attempt to explain the clearest cases of transfer by these principles appears reasonably successful.

The above theory does not contradict Thorndike's theory of identical elements, but simply gives it a specific meaning. It also insists that identical elements cannot be assumed to be media of transfer unless the quantitative proof for them is clear.

Incidentally the experiment demands a reformulation of the law of contiguity. The togetherness of objects in experience is not a sufficient condition of association unless it is accompanied by active attention.