ON THE TRANSFERENCE OF TRAINING IN MEMORY.

GEORGE CUTLER FRACKER, A.M., PH.D.

CONTENTS.

Researches in the transference of training, or "spread of ability," seek to determine the influence of practice in one activity upon our abilities in other activities. There are, in general, two methods by which this problem has been attacked—the method of correlation, and the method of direct experiment. The method of experiment was chosen for this study. The usual means of conducting research by the experimental method in the transference of training is to employ two sets or series of experiments; one set to be given before and after training; the other a training set, in which one may be practiced for some time. The experiments given before and after training may be called the test series, and the other set, the training series. The test series is made up of several experiments, some of which are like the training series, while others differ.

The object of these two sets of experiments is to discover what effect practice in the training set has upon the test set, in

which the observer is not trained. This effect is measured by the difference in the results between the test series given before the training, and the test series given after the training. In order to measure the amount of training in the test series itself, two sets of observers are used: one set who take both the test and training experiments and another set who take the test experiments only. The difference in the gain between those trained and those untrained indicates the influence of the training experiments. The observers composing these two sets are selected on the basis of similarity in age and ability.

The present research is devoted to a study of certain aspects of memory. The training series consisted in practice in memory for the order of four tones. The experiments of the training series and the manner of conducting them will be explained under "Training Series." The test series consisted of eight experiments, as follows:

1. Memory for poetry.
2. Memory for the order of four shades of gray.
3. Memory for the order of nine tones.
4. Memory for the order of nine shades of gray.
5. Memory for the order of four tones.
6. Memory for the order of nine geometrical figures.
7. Memory for the order of nine numbers.
8. Memory for the extent of arm movement.

The relation of the respective test series to the training series, in the above experiments, was as follows:

The four grays; different in content, same in method.

The nine tones: same content, different in method.

All the other tests: different in content and method.

This relation between the training and the test experiments was planned in order that the elements concerned in transference might be determined by analysis of the final results. In order to aid still further in this analysis, each observer was asked to write a careful introspection at the close of each day's training, after each experiment of the test series, and a general introspection at the close of the experiments giving his observa-

tions and conclusions concerning the essential elements in improvement and transference. The object of the introspection was to discover the method or lack of method of each observer. Every effort was made to guard against giving the observer any hints as to how to perform the memory part of the experiments. At the beginning of each test, observers were given written instructions describing just what they were expected to do in response to the stimuli, but conveying no information as to how to do it.

The test experiments present the following important advantages: (1) Each is a task sufficiently difficult to demand intense application while it lasts. (2) Each test is so brief that it affords a minimum amount of training within itself. (3) The time between the first and second tests is fairly long. (4) The tests similar to the training series were taken in double fatigue order. (This order is explained under "General Experimental Conditions.") (5) The test material is of such nature that the second test could be made exactly equivalent to the first test without being a repetition of it.

DESCRIPTION OF THE TEST SERIES OF EXPERIMENTS

Experiment I. Memory for Poetry. Two stanzas of "Eve of St Agnes." The observer memorized two stanzas of this poem so that he could repeat each aloud to the experimenter without error. A record was kept of the time taken for each stanza, and of the errors made.

Experiment II. Memory for the order of four shades of gray. This experiment consisted in exposing before the observer, numbers two, seven, thirty and forty-five of the Hering Grays, by means of the psychergograph. The psychergograph consists of two main parts, the stimulator and the recorder. As the recorder was not used in these experiments, the description of it is omitted here. The following partial description of the stimulator is quoted from the original description by Seashore, Univ. of Iowa, Studies in Psychology, III, p. 5.

"The stimulator is a plain case, 40 cm. square, with a slanting cover. Near the front edge of the cover is a signal window, 8 millimeters wide by 20 milli-

meters long, through which the signals are seen. One hundred signals are pasted or printed on a paper disk, 38 cm. in diameter, so that when the disk revolves they are seen singly in succession right back of the signal window. The paper disk is clamped on a metal wheel which has fifty teeth on its edge. This wheel is energized by a strong clock spring which revolves it and the disk one one-hundredth of a revolution, thus exposing a new signal every time the detent which holds it is released. This detent is in the form of a lever escapement and is operated by electro-magnets." * * *

"A circle of the revolving disk is seen through the cover. On this there is a cross line which passes before the circular scale of a hundred units and indicates to the experimenter which signal is in view. This indicator serves at once as a counter of the number of acts performed and as a guide for the beginning and ending of the series. The order of the signals is determined in the making of the series, either by chance or by some suitable system. The experimenter, therefore, knows the actual sequence of the signals in every series, but the observer has no means of knowing at any time what signal shall appear."

The stimulator was arranged to expose each of the four gray disks for one-half second, an interval of one-half second being allowed between each exposure. Each disk was seven mm. in diameter. After the four grays were exposed, a blank remained before the observer for four seconds, then another arrangement of the four grays was given and another blank exposed. When the second blank appeared, the observer responded, giving aloud the order of the first group of four grays. After the third group had been exposed, he responded to the order of the second group, and so on through the series. The series consisted of forty groups taken in double fatigue order. In responding to the order of the four grays, the observer called the darkest gray, 4; the next lighter, 3; the next lighter, 2; and the lightest, 1. The grays were given in twenty-two different mutations, but the orders 1, 2, 3, 4, and 4, 3, 2, 1 were not used.

Experiment III. Memory for the order of nine tones. The third set of stimuli used consisted of four tones, varying in intensity, and delivered to the observer through a telephone at the rate of one tone per second, each stimulus sounding one-half second. The four sounds were produced by placing a telephone receiver in circuit with a 100 v.d. electro-magnetic fork and branching the circuit through four lines of resistance so adjusted as to produce four readily distinguishable tones when

the four keys of these branches were closed in turn. The e. m. f. was kept constant. These four tones were arranged so as to form a group of nine tones. After the delivery of the stimulus group, an interval of nine seconds was interposed, during which the observer responded aloud to the order in which the nine tones had been given. The tones were called 1, 2, 3, 4, in the order of loudness, 4 being the loudest. The 1, 2, 3, 4 and the 4, 3, 2, 1 orders were avoided. Twenty groups of nine tones each were given in double fatigue order.

Experiment IV. Memory for the order of nine grays. In this experiment, the four grays of Experiment II, were so arranged as to form a group of nine grays. These were exposed on the stimulator at the rate of one per second; exposure, one-half second. After each group of nine grays had been exposed, there followed an interval of nine seconds, during which the observer gave aloud the order of the grays in the group just given. Twenty groups of the nine grays were given in double fatigue order.

Experiment V. Memory for the order of four tones. The four tones were those composing the major chord on the piano. Instead of responding by number, the observer responded by the names Do, Me, Sol, Do–2. The tones were produced in the same order, with the same duration, at the same rate and with the same response intervals as the grays in Experiment II.

Experiment VI. Memory for the order of nine geometrical figures. The nine figures drawn upon a card are described as follows:

"Each figure is composed of three lines; the lines are all straight; two lines are equally long, and the third is half as long as these; the two long lines always adjoin each other; the lines join either at the end or in the middle; no line is crossed; no two figures are alike; the angles are right angles." [1]

The stimulus card was exposed ten seconds, and the observer was given one minute in which to reproduce all the figures he could remember, drawing them in the same relative positions and proportions as on the card. Five records were taken.

Experiment VII. Memory for the order of nine numbers.

[1] Seashore, "Elementary Experiments in Psychology."

The stimulus for this experiment was nine numbers of two figures each, read aloud at the rate of one pair each second and a half. After nine pairs had been read, the observer was given fifteen seconds in which to write as many of the pairs as he could remember. Ten sets of nine pairs made up the test.

Experiment VIII. Memory for the extent of arm movement. The apparatus for this experiment consisted of a glass rod mounted one-half inch above a metric scale. A hard rubber cylinder, about one inch in diameter, was fastened firmly at one end of the glass rod so that its edge tallied with the zero point of the metric scale. Upon this glass rod was a second hard rubber cylinder freely adjustable. The observer, with eyes closed, moved his finger with a free arm movement along the glass rod, from the fastened cylinder to the adjustable cylinder, held at a standard point by the experimenter. The observer was allowed to move the finger out and back twice. The experimenter then moved the adjustable cylinder away from the standard position, and the observer moved his finger along the rod until he thought he was reproducing the standard distance. Three standards were used; viz: fifteen, twenty, and twenty-five cm., and ten trials were taken in varied order for each standard.

DESCRIPTION OF THE TRAINING SERIES OF EXPERIMENTS

The apparatus for the training series consisted of that described in test Experiment III, the nine tones. The four intensities of tone of the fork were arranged in all possible combinations except the 1, 2, 3, 4, and the 4, 3, 2, 1, order. Enough of these combinations were used and repeated to make a series of seventy-five groups. The observer, seated comfortably at a table with a telephone receiver carefully adjusted to his ear, listened to the four intensities of sound. The experiment was carried on in exactly the same way as the four grays of the test series except that tones were used instead of grays and the number of groups extended to seventy-five, four sets of which made up a day's practice. It was possible to give seventy-five groups in about ten minutes. At the end of each ten minutes, a rest of one minute was taken.

For three observers, Tuesdays, Thursdays and Saturdays of each week were the practice days; for five, Tuesdays and Thursdays, or Wednesdays and Fridays, of each week.

METHOD OF RECORDING AND OF ESTIMATING RESULTS.

The observer's responses were kept by a recorder who used mimeographed sheets corresponding to the sheets used by the experimenters as a guide in giving the stimulus. These mimeographed sheets consisted of columns of numbers corresponding to the order of the numbers of the grays or tones used in the test and training series. The order in which the groupings were given was readily changed by beginning at different parts of the sheet. If the observer omitted to respond to any stimulus group, a line was drawn through that number upon the record sheet. If he responded incorrectly, his reply was written above the corresponding number on the record sheet.

Results in both the test and the training series are estimated on the basis of the per cent of correct responses. Training curves are plotted to show the per cent of correct responses in each of the four sets of seventy-five groups. Test results are shown by lines drawn across the charts.

GENERAL EXPERIMENTAL CONDITIONS.

Every observer was allowed a short preliminary practice at the beginning of each test or training period with the grays and the tones in order to secure adaptation. This seldom took more than a few trials.

No observer knew of the results of his records until after the experiments were entirely completed, with the single exception of G. C. F., during his second training series.

Every effort was made to preserve uniform conditions, especially for the two test series. A record was kept of the hour of the day when each experiment was taken; and the same day of the week, and the same hour of the day, were kept for each observer. Great care was used to keep the temperature, light, and sound conditions of the room as constant as possible. The

experiments were carried on in a room where the apparatus remained in the same position, and all the above elements could be easily controlled.

In order to determine the amount of improvement due to training, the observers were divided into two classes: (1) Those who took both the test and training experiments, and (2) those who took the test experiments only. Of the first class there were eight, and of the second class, four.

The following order was maintained in giving the experiments in the test series:

1. Poetry, two stanzas.
2. Four Grays, twenty groups.
3. Nine Tones, ten groups.
4. Nine Grays, ten groups.
5. Four Tones, twenty groups.
6. Geometrical Figures, five trials.
7. Nine Numbers, ten columns.
8. Arm Movement, ten trials for each of three standards, 15, 20, and 25 cm.
9. Four Tones, twenty groups.
10. Nine Grays, ten groups.
11. Nine Tones, ten groups.
12. Four Grays, twenty groups.

This arrangement gives a double fatigue order for the four experiments most closely resembling the training series.

The observers. G. C. F. is a teacher of psychology and has carried on experiments in this subject on two former occasions. With Professor Seashore, he devised the experiments of this series, set up the apparatus for the tests, worked out the scheme for the mimeographed record blanks, and served as experimenter and recorder for several of the observers. He is considerably older than the other observers. D. S. was also a trained observer and an instructor in psychology; thoroughly familiar with the material and method of this experiment. Nearly two years previously, he had been trained in experiments almost identical with this series[1] as regards stimuli and

apparatus, but the responses had been made by signals on four keys, instead of speaking. F. S. was a graduate student in psychology, trained in many forms of psychological experiment. E. M. C., H. C. E., A. R. F., M. M. M., and M. L., were college juniors with some experience in psychological observation. These observers took both the training and the test experiments.

J. W., M. C., M. D. F. and D. D. W. took only the test experiments; J. W. was a senior in college and somewhat older than the others. M. C., M. D. F., and D. D. W. were college juniors and all were familiar with psychological experiment and observation.

RESULTS OF THE TRAINING SERIES.

The practice curves and the curves of improvement in the test series are shown on Charts I to IX inclusive. All the observers except one were trained for four weeks, two or three days per week. G. C. F. was trained for eight weeks three times per week. Two charts, I and II, show the results for this observer.

Each point in the heavy curves represents the average for seventy-five groups of tones. Four such sets, of seventy-five each, represent a day's work. The curves are plotted on the basis of the per cent of correct responses. Each day's average is shown by a heavy horizontal line.

These curves show the progressive gain by practice in the training series and the relative ability in the end tests before and after the training.

G. C. F. thinks that the advantage he has had in his experience as experimenter is offset by the development of automatism which he was forced to break when he became observer. Before beginning the training, he had served as experimenter for three other observers, and had thus made about 10,000 reactions from the same stimuli but with attention upon the beat of the metronome, the delivery of the stimulus, etc., instead of upon the sounds of the stimulus. At the beginning of the training,

[1] SEASHORE AND KENT, "Periodicity and progressive change," Univ. of Iowa, Studies in Psychology, IV, p. 82 ff. (see practice curve opposite p. 85).

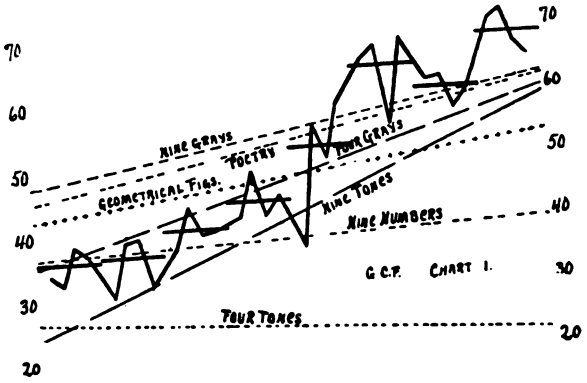


FIG. 1

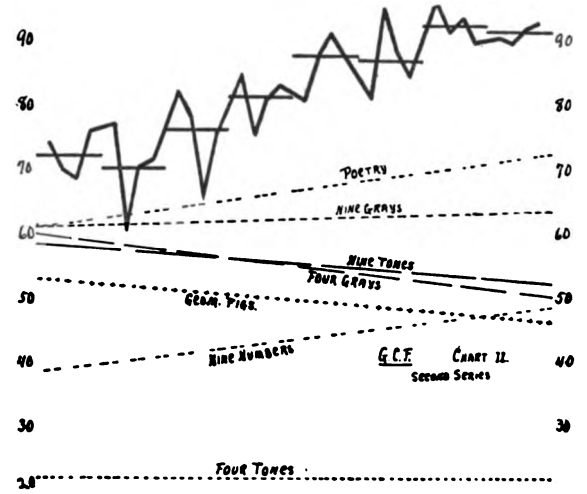


FIG. 2

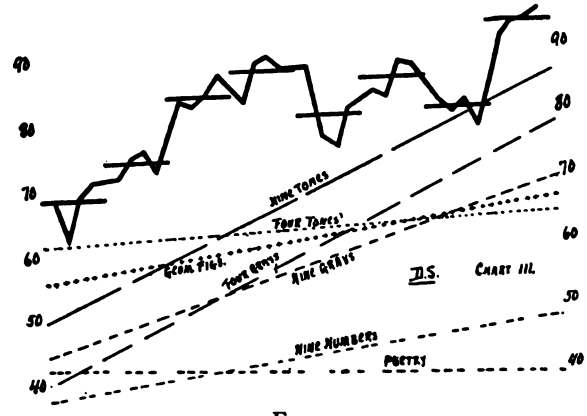


FIG. 3

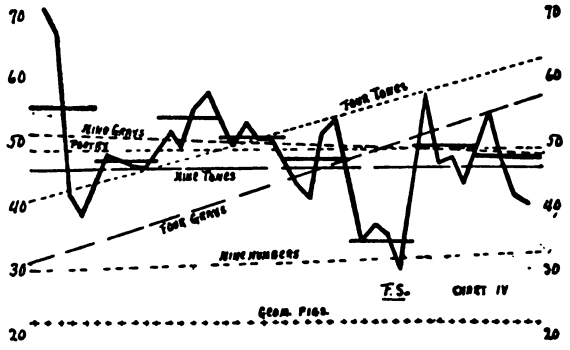


FIG. 4

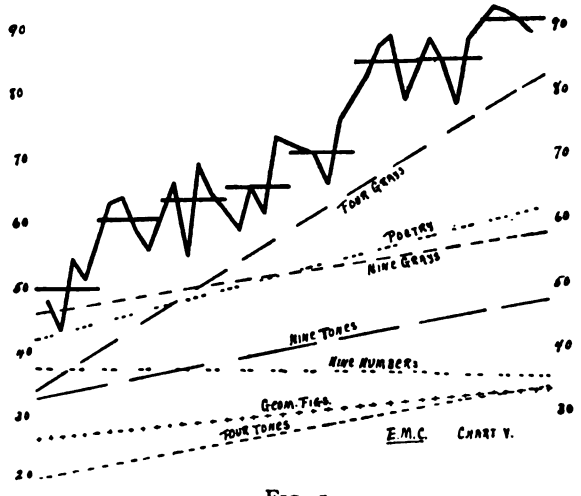


FIG. 5

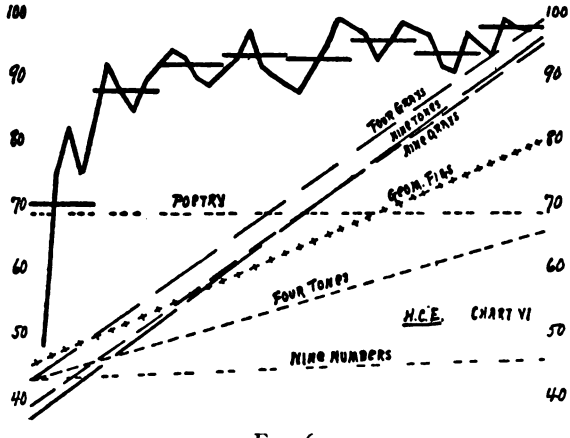


FIG. 6

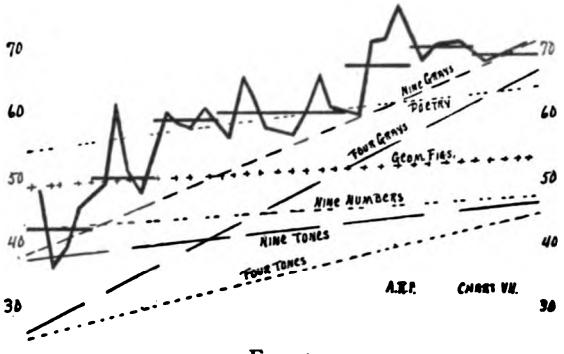


FIG. 7

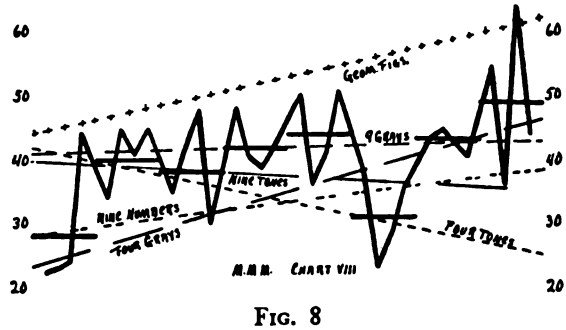


FIG. 8

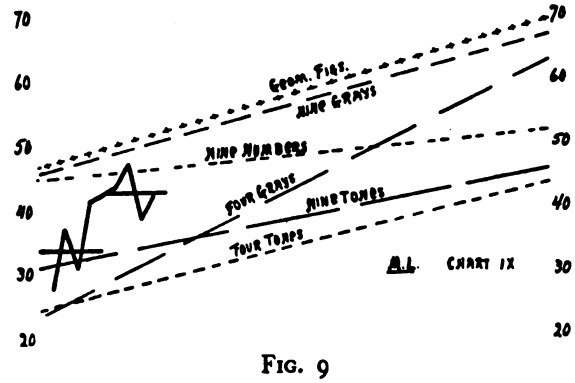


FIG. 9

this kind of response had to be broken up and the attitude of the experimenter interfered with that of the observer. Lack of familiarity with conditions of experiment and with apparatus is mentioned by other observers as a cause for the low starting point of the curves. Another reason given is the tendency to bring outside associations into the practice. Inability to hold the attention to the new task is also mentioned.

G. C. F. believes that his continued practice as experimenter during the training was a cause of fluctuation in his curve.

The progression in the curves ranges from a loss of 9 per cent to a gain of 48 per cent, or an average gain of 28 per cent. The average point at which the curves begin is at 50 per cent, and the average summit of the curves is 73 per cent. The range of the points of beginning is from 32 to 70 per cent, and the range of the summits is from 46 to 98 per cent. The rapidity of the rise is so closely connected with method that it will be discussed under that head.

The explanations offered for the fluctuations in the curves are mainly inability to hold attention, disconcerting associations, guessing at results, and lack of a method to which to adhere.

The introspections reveal the methods used by different observers. At the beginning of practice these introspections show that every observer did more or less guessing in responding. A number of devices were tried during the first days of training. All observers began by repeating as many times as possible, before the response, the order of the stimulus group. Several attempted to divide each group of four sounds into groups of two sounds each. Some tried to locate the loudest and the faintest sound in the group and remember the order of the other sounds by these. There were difficulties with all these methods. In the attempt to repeat the first group as often and as rapidly as possible observers found that, when the second group came, the repetitions had to cease while attention was given to the new stimulus. As a result the first group was lost in the attempt to fix the second, or in responding to the first the second was forgotten. Under such stress there is a strong tendency to guess, or to become confused. Both these things happened frequently. Several observers attempted to separate the stim-

ulus from the response. With G. C. F. this became a factor in his method. With F. S. there seemed to be a tendency to try new methods throughout the training. In guessing, some times the whole group is guessed at, other times one or two of the numbers of the group. All observers said that speaking in response disturbed the retention of the first group. After trying several schemes observers settled down to a definite way of retaining the groups and of making the responses. The individual methods adopted can be shown best by quoting from the introspections.

G. C. F: "The principal features of my method are: first, an imagery of position in space for the four tones. Number four is right at the ear, three is about four or six inches away from the ear, two is several feet away, and one is a faint sound a long distance off. The exact position of two and one is not clear, but the position of three and four is definite. Second, there is a separation in attention between the stimulus and the response, that is, attention is given to the first group, which is fixed by the imagery above described, and placed upon the tip of the tongue to be spoken immediately after the second group is heard. When the first group is thus delegated to the motor side, it is dismissed from active attention, which is then focused upon the second group. The second group is fixed almost while the first group is being automatically responded to."

With D. S. the method used goes back to his previous training. In the introspection following the first day's practice he said that many "names" used formerly came back during the hour and helped materially in the responses. The names referred to are the forms of imagery used by D. S. to identify different arrangements of the four sounds. On the second day of practice the system of "names came back completely," and he attributed practically all of his improvement to the recovery of his system. From thence he improved steadily.[1]

F. S. tried to remember the tones in groups of fours and to hold them by rapid repetition. After the second group was given he responded to the first group, and then immediately repeated the second group as often as possible before the next stimulus was given. Later he tried to remember the first two numbers of a group and guessed at the other two. When he missed a

[1] For full account of the method used by D. S. in his former training series see Seashore and Kent, op. cit. pp. 87–90.

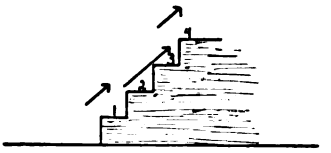
group altogether he guessed at it. Sometimes he grasped the first two numbers of a group with the last number and supplied the third. He found great difficulty in retaining one group while securing the next. Speaking in the response disturbed the retention of the second group. As practice proceeded he noticed no new method but seemed able to take things more quietly and to respond with less effort. He noticed especially a tendency to listen to the loud tone and to locate it in the group. This tendency results in a species of auditory imagery, but an imagery not definitely recognized. In the last introspections, the observer said that there was a tendency to locate the loudest and faintest tones in a group.

H. C. E: "In this training I used two methods of remembering. The first four numbers I repeated several times during the four seconds interval, and continued repeating them while the next four were being given; then I would give them aloud without giving any actual attention to them. While the second group was being given, I turned my active attention to it, first getting a visual image of their position and at the same time repeating the first four. In the four intervening seconds, I repeated aloud the first four members without any active attention to them, keeping my active attention on the visual image. Just as soon as the first four were repeated aloud and gotten out of my mind, I would immediately turn the visual image of the second group into a repeating image and wait for the next group of four. This same process was kept up throughout the experiment. The imagery is a vertical arrangement of the numbers of the four tones, in appearance somewhat like keys. The lowest number or key was 1, and the highest, 4. The keys were apparently numbered as though printed. Some groups, however, such as 4, 1, 2, 3, were divided into two, 4 being in a group by itself, and the 1, 2, 3 combined. The visual image is not an image of the numbers. They are arranged in vertical order and I pick them out vertically but do not see the numbers themselves. The one highest up or number four, is the largest, and number one is very small, with numbers three and two correspondingly between. As near as I can tell, they are round or disk-shaped and appear thus:

As practice continued the visual image became more familiar and found myself more and more able to remember the groups without giving much attention to them."

A. R. F.: "After repeating the numbers of the first group, I would form a sort of mental picture of how they would look on a scale, and this would help me in remembering them. When I got confused, I just stopped and did not

try to recall, but went on with the next group. The figure I find myself using after the third or fourth day of training is like the following:



There was a flight of four steps, each numbered in ascending order. This figure illustrates the group 2, 3, 1, 4; 2 and 3 being consecutive were represented by a long arrow and, because they came first, the arrow was close to the stairs. 1 came next and was a little farther away, and was a short arrow, being alone. 4, the last one, was still farther out, and was also a short arrow. I recalled the group by the position and direction of the arrows in the mental image. After listening to the second group, I go back and, from the picture, get the numbers in the order given. The mistakes I make are caused by taking too long to form the picture or to recall it."

M. M. M. developed a method of very vivid imagery rapidly. He says:

"In remembering these groups I thought of them as being in a position like four keys on a piano, such as C, D, E, F. I remembered them as 1, 2, 3, 4, and while one groupwas being given I tried to keep a picture of the order the keys took in the preceding group. It was much easier to remember the group when the numbers came together, such as 1, 3, 2, 4; in this case, I thought of 3, 2, as being between 1 and 4. I could see the keys just as if they were pressed down. In trying to remember a group, I sometimes hung to it too long and became confused in getting the next group. As practice continued this method became more reflex, and it was easier to remember the groups."

E. M. C. began the training by repeating to himself, about twice during the four seconds interval, the first group. Later the repeating became automatic, so also did the response; and he adds:

"I find that if I miss a group, that breaks into the rhythm and it is hard to get into the swing again. Sometimes I give a group and guess just to keep up the rhythm. During these tests I have been convinced that the subconscious does a great deal for us."

It seems that E. M. C. did not recognize a particular form of imagery as did the other observers. It is not clear from his introspections that he had an imagery form, nor is it clear that he did not have one. Throughout the introspections for the second test experiments, however, E. M. C. speaks of the aid

he received from the training series method in securing results in the test experiments. There seem some indications, therefore, that he had a method or some particular form with which he had become familiar during the training and which he used in the final test. This method must have been something more than that of repetition which he used in the first test experiments.

In the case of M. L. the training was carried on for two days only, and the introspections contain no definite statement concerning the specializing of method in the form of imagery. But under her introspection for the nine grays it is fully described. During the final test series she says that there was a decided help from the first test and the method of the training series. She says:

"The loudest tone seemed to serve as a sort of station around which the others grouped themselves. This scheme helped very much in securing correct results. Sometimes the lowest tone served as a station. Such combinations as 3, 2, 1, 4, or 2, 3, 4, 1, were much easier, because of my way of remembering."

In the matter of recognition of a method, or what seems to be the same thing, the recognition of an individual imagery, the observers did not all recognize a particular method to such an extent as to describe it in introspections. From what has been quoted it is apparent that all but two, F. S. and E. M. C., recognize a peculiar imagery; and the evidence shows that they also used imagery but did not recognize it as such. The relation which the recognition of the method or imagery bears to improvement is significant. Without a conscious recognition of the imagery an observer may improve rapidly, or slowly, but a steady improvement seems to follow if an imagery exists, and is consistently used. E. M. C. seems to illustrate this. F. S. illustrates an observer who had imagery but who failed to use it consistently. With observers who recognized imagery the rate of the improvement seems to coincide with its recognition. This is reasonable for, as observers say, the recognition of a method gives one confidence in his ability to do the work. With G. C. F. imagery was recognized about the fourth or fifth day, and the rise in the curve is most rapid immediately after.

With D. S., imagery was recovered the first and second days and the rise in the curve is most rapid during the first, second and third days. With H. C. E., imagery was recognized the first day and the gain is very rapid the first two days. With A. R. F., imagery was described on the fifth and sixth days and the gain is greatest on the sixth day, although the gain is great on the second day also. In the case of M. M. M., whose curve shows only a slight gain during practice, yet who recognized imagery on the first day, the rise is great on the first day but is not great thereafter until the seventh and eighth days when he began to recover from an attack of the grip, from which he suffered severely on the sixth day.

With A. R. F., whose imagery seems somewhat intricate, the relation between complexity and rate of improvement is shown. This observer speaks of losing many groups because he had not time enough to adjust his imagery to the group.

In the case of untrained observers, a recognition of imagery is not alone sufficient to give this confidence of improvement; for many say that they are not sure that they can use the imagery in other tests. A certain familiarity with imagery would seem, therefore, essential. This familiarity the training series gives.

The fact then seems to be that steady improvement may take place because of the use of an imagery without a conscious recognition of its presence. An imagery may even be recognized without adding essentially to the speed of improvement, but a recognition of it adds confidence in one's ability and reliance upon one's method, which is pretty sure to result in rapid improvement.

The essentials of method in training as brought out by these experiments are; first, familiarity with conditions of training, such as the room, the light, heat, furniture, apparatus, the experimenters, the adjustment of the observer to the apparatus, and learning what is expected of the observer; second, the use of rapid and frequent repetition in order to retain; third, the sorting out of things essential to the performance of the act from those things that are non-essential;[1] fourth, the selection,

[1] See Coover and Angell, "General practice effect of special exercise," Am. Jour. Psychology, XVIII, pp. 328–341.

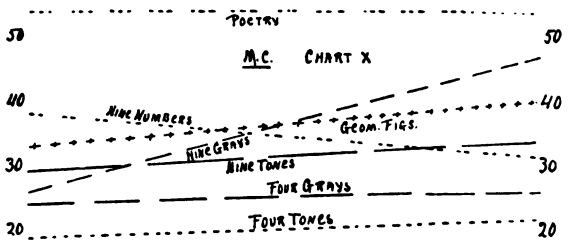


FIG. 10

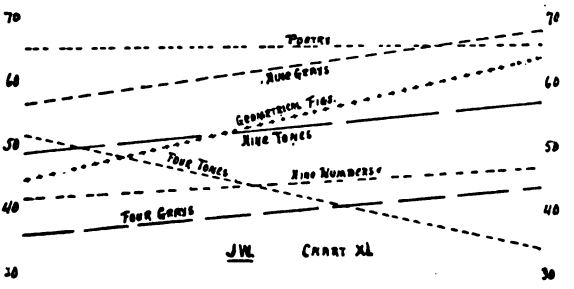


FIG. 11

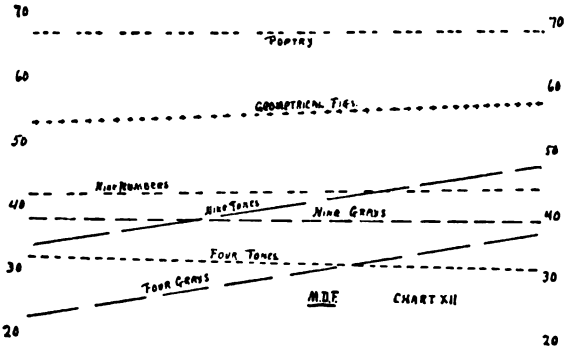


FIG. 12

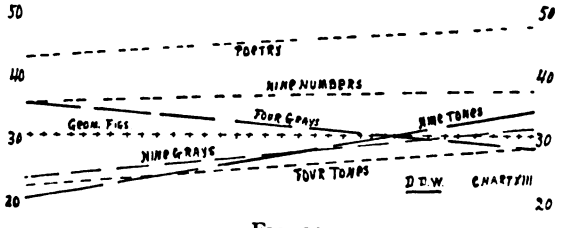


FIG. 13

TABLE I.

Results of Test Series for Trained Observers.

	G. C. F.						D. S.			F. S.		
	1″	2″	3″	2″—1″	3″—2″	3″—1″	1″	2″	2″—1″	1″	2″	2″—1″
Poetry												
1″ Stanza	43	61	67				36	39		44	45	
2″ "	49	62	77	+15	+11	+26	49	39	−3	55	54	0
Av.	46	61	72				42	39		49	49	
4 Grays												
1″ Trial	29	51	41				43	95		25	59	
2″ "	45	68	61	+22	−8	+13	39	61	+37	38	56	+26
Av.	37	59	51				41	78		31	57	
9 Tones												
1″ Trial	13	61	58				49	82		54	49	
2″ "	37	56	48	+34	−6	+27	51	91	+35	38	46	+1
Av.	25	59	53				50	85		46	47	
9 Grays												
1″ Trial	54	59	71				47	72		44	50	
2″ "	63	63	57	+2	+3	+6	42	68	+26	59	48	−2
Av.	59	61	64				44	70		51	49	
4 Tones												
1″Trial	36	24	31				69	53		45	58	
2″ "	18	18	11	−6	0	−6	54	76	+3	38	69	+22
Av.	27	21	21				61	64		41	63	
Geom. Figs.												
5 Trials	44	53	47	+9	−6	−3	56	67	+11	22	22	0
9 Numbers	37	39	49	+2	+10	+12	37	48	+11	30	34	+4
Movement												
15 cm.	96	95	95	−1	0	−1	95	94	−1	94	96	+2
20 cm.	97	97	98	0	−1	+1	98	95	−3	94	93	−1
25 cm.	98	97	98	−1	+1	0	97	94	−3	94	95	+1

1″, 2″, and 3″ = First, second and third tests.
2″—1″ = Average of First test minus average of the second test.
+ = Gain.
— = Loss.

TABLE I (Continued)

	E. M. C.			H. C. E.			A. R. F.			M. M. M.			M. L.		
	1″	2″	2″—1″	1″	2″	2″—1″	1″	2″	2″—1″	1″	2″	2″—1″	1″	2″	2″—1″
Poetry															
1″ Stanza	41	56		54	65		61	70					89	97	
2″ "	44	66	+19	84	73	00	48	59	+10				92	100	+8
Av.	42	61		69	69		54	64					90	98	
4 Grays															
1″ Trial	10	83		24	98		25	73		15	48		19	69	
2″ "	59	83	+48	63	100	+56	29	60	+39	33	46	+23	30	56	+39
Av.	34	82		43	99		27	66		24	47		24	63	
9 Tones															
1″ Trial	27	47		23	94		31	43		30	36		28	38	
2″ "	40	50	+15	52	99	+59	44	48	+8	50	34	+5	33	54	+15
Av.	38	48		37	96		37	45		40	35		31	46	
9 Grays															
1 Trial	39	64		26	93		53	70		42	31		40	68	
2″ "	54	52	+12	53	98	564	23	71	+32	40	56	+2	52	67	+21
Av.	46	58		39	95		38	70		41	43		46	67	
4 Tones															
1″ Trial	20	40		33	63		30	44		41	32		29	43	
2″ "	19	29	+15	54	70	+23	20	46	+20	44	19	−16	23	45	+19
Av.	19	34		43	66		25	45		42	26		25	44	
Geom. Figs.															
5 Trials	27	33	+6	45	80	+35	49	54	+4	44	62	+18	47	69	+22
9 Numbers	38	36	−2	43	46	+3	43	47	+4	29	38	+9	45	52	+7
Movement															
15 cm.	96	95	−1	98	96	−2	96	95	−1	97	95	−2	88	94	+6
20 cm.	98	96	−2	98	98	−0	95	96	+1	97	97	0	89	97	+8
25 cm.	97	97	0	97	96	−1	97	96	−1	97	93	−4	90	93	+3

TABLE II.

Results of First and Second Tests for Untrained Observers.

	M. C.			J. W.			M. D. F.			D. D. W.		
	1″	2″	2″—1″	1″	2″	2″—1″	1″	2″	2″—1″	1″	2″	2″—1″
Poetry*	48	34	∞	65	65	0	70	63	+2	40	51	+5
	61	74					64	75		47	45	
	54	54					67	69		43	48	
Four Grays	21	37	+2	32	41	+7	25	28	+15	36	23	−7
	28	14		40	46		20	46		36	35	
	24	26		36	43		22	37		36	29	
Nine Tones	30	30	+5	33	55	+9	28	43	+14	24	28	+14
	29	38		63	60		39	51		18	42	
	29	34		48	57		33	47		21	35	
Nine Grays	19	43	+21	48	64	+11	40	44	0	22	36	+8
	33	51		65	72		38	34		25	30	
	26	47		57	68		39	39		24	32	
Four Tones	20	21	+2	37	31	−17	29	28	0	18	28	+6
	18	21		66	37		36	36		28	30	
	19	21		51	34		32	32		23	29	
Geom. Figs.	33	40	+7	44	64	+20	53	58	+5	31	31	∞
Nine Numbers	39	31	−8	41	47	+4	42	44	+2	36	38	+2
Movement	94	94	0	88	97	+9	97	92	−5	96	96	0
	97	96	−1	92	97	−5	98	95	−4	95	96	+1
	98	95	−3	95	97	−2	97	95	−2	96	97	+1

* Notation same as in Table I.

consciously or subconsciously, of an individual way of picturing the stimuli, sometimes also including the response, and which consists of a particular form of imagery; fifth, the use of this imagery until it becomes reflex; sixth, the appearance of rhythms in the ability to hold the image-changes in attention; and seventh the formation of associations between the giving of the stimulus and the response, after the use of the imagery becomes reflex.

RESULTS OF THE TEST SERIES.

The results of the test series for all observers are shown on Charts I to XIII inclusive by the broken lines which run directly across the chart. The results are also shown numerically in Tables I to III. The ability in each of these tests is expressed in the per cent of correct responses, as in the training records. The tests are discussed in the order in which they were taken.

Trained Observers.

Poetry. The gain in the tests for poetry was not very great in the case of any observer. Various methods were used. A large number read the stanza over first. Some divided it into parts of two lines each, some of four lines each, some into two parts. More than half of the observers speak of using imagery in remembering. Several say that they pictured the lines on the page in relation to each other. Several divided the stanza into parts according to the pictures it contained. Many memorized by these images in the stanza, and then combined the images into a whole picture. Two observers say that the training series may have helped in securing improvement. One says that the training may have helped by emphasizing imagery, and the other says that it may have helped in dividing the stanza into parts.

The Four Grays. The gain in the four grays is often greater than the gain in the training; it is usually as great, seldom less. In the first test the methods used were—to catch alternate groups, to divide groups into two groups of two figures each, and to remember each group. F. S., especially, noticed a tendency to image the groups. His first impulse was to remember the

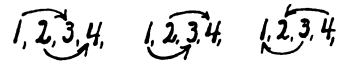
groups by a picture of the numbers of the grays or the grays themselves, but the time was too short to work out the picture for each group. Often observers tried two or three ways of remembering during the first test for the four grays. In the second test every trained observer but one says that the method developed in the training helped in securing a better record. Six of the trained observers say that they used the same imagery in the final test series that they used in the training series. There was more or less hesitancy in using the same imagery because of the difference in the stimuli of the training series and this test. The difficulty seems to depend upon the imagery. With G. C. F., whose imagery was visual-auditory for the tones of the training, there was great difficulty in using it with the grays. With D. S., whose imagery was visual, there was but a slight hesitancy in fitting the imagery into the responses for the grays. This was true also of H. C. E., A. R. F., M. M. M. and probably of E. M. C., for he says that the training helped him decidedly in the final tests, though he does not record a specific type of imagery. The same is true of M. L. F. S. says, in the introspection for the second test, that he remembered the groups by visual imagery with which he had no difficulty. He did not repeat the numbers as in the first test and as in the training series, but saw them in two groups of two in each group.

The Nine Tones. Four observers gained more in the nine tones than in the training series. Two made the greatest gain in the nine tones of any of the test experiments. The influence of the training therefore seems to be very strong. G. C. F. says that with him visual imagery is usually the strongest. Yet he made the greatest gain in the nine tones. His training imagery is auditory-visual, and he thinks that most of the gain in the second test for the nine tones is due to the influence of the training imagery. D. S. says that during the second test he was able to transfer his imagery system directly to this test by grouping the nine tones into fours. All the trained observers say that the training series helped in the second test. All except M. M. M. used the training imagery in the second test with the nine tones. M. M. M. divided the nine into numbers of three figures each, as 421, 343, 124. All had a different

way during the first test, and all found that the immediate succession of the second group of four tones after the first group led to confusion.

The Nine Grays. Three observers made a greater gain in the nine grays than in the training. One observer made his greatest gain in the nine grays. The introspections show the same characteristics regarding the influence of the training in the second test over the first. Two observers, G. C. F. and D. S., say that they find it easier to use their imagery with the tones than with the grays. But there is the same difficulty experienced in the immediate succession of the second group after the first, and the same change of method from the first to the second test. Under her introspection for this test M. L. descr bes her imagery:

"Toward the last of this series I thought of a new method of getting these by fours. It was by sort of picturing them with braces connecting them, with a top brace being the first one thus:



This would represent the combinations 1, 3, 2, 4, 2, 4, 1, 3, and 4, 2, 3, 1. This method helped me most when the grouping was something of the skipping order, and not 1, 2, 4, 3, where the numbers were right next to each other."

The Four Tones. One observer only, F. S., gained more in the four tones than in the training series, and no observer made the greatest gain in this test. As the name implies this test is most like the training series and therefore suggests that it should show the greatest gain if training is to influence tests similar to it. G. C. F. says that the failure to improve is due to the different method of response. Instead of responding by numbers the observers were instructed to respond by the syllables—Do, Me, Sol, Do-2. All observers say that there was a distinct tendency during the second test to use the methods and imagery of the training, but in the effort to make the syllable response, the tendencies developed in the training were broken up. Nearly all think that they could have made a better record if they could have responded by the use of numbers. The similarity to the

training series made the interference the more effective. M. M. M. says "the practice series was a hindrance here, because the numbers were so drilled into me that it was hard to change."

Geometrical Figures. Several observers think that the experience of the first test is sure to suggest methods for the second test. Motor imagery was strong with many observers for they moved the pencils over the paper while trying to retain the figures in memory between the trials of the test. The method most used was to remember the figures because of their similarity to letters of the alphabet. Some observers tried to remember the entire nine figures after a ten second exposure but most observers adopted the method of remembering two or three at each exposure. H. C. E. thinks that the training series helped here because he was able to group things together and think of two groups at once. M. M. M. knows of nothing in the training series that helped except that he was better able to concentrate attention on what he was doing. The other observers saw no connection between this test and the training series.

The Nine Numbers. F. S. made his greatest gain in this test. The common method here was to remember two or three of the first pairs, and to hold two or three of the last pairs because of their recency. No one recognized any way by which the training helped here.

Movement. The method employed by most observers is indicated by the introspection of D. S.: "The movements of the finger along the glass rod were always accompanied by an eye movement and a visual image of the distance traversed. It is evident that the estimate was made both by muscular and visual imagery." Not all observers recognized these factors but nearly all speak of visual and motor imagery.

Final Introspections. The opinion of the trained observers in regard to the factors that make for improvement and the relation of the training to the tests is shown by the following quotations from introspections written after the experiments were completed.

D. S.: "The following are the most important effects of the training series upon the test series:

1. The system of 'names.' The most important and effective factor.

2. Imagery was very prominent in the training and seemed to be more prominent in the second test than in the first.

3. Greater economy in mental effort and attention.

4. Development of ingenuity in devising methods. The method of 'names' was a very essential part of the improvement in the training series. Without it, I believe that I could not have reached the proficiency I did. In the last test, I felt that somehow I could better master the situation."

F. S.: "If I made any improvement in the last test, I think it was due to the following causes:

The idea that I was going to improve.

I found it easier to hold my attention on the work during the second test.

I felt a distinct sense of improvement in only one test, namely, the four grays. This was due to a change of method. I also have a feeling that I improved in the four tones. This may have been due to a general familiarity with the test. I was able to recall these tones with much less difficulty than the telephone tones. The gain in the four tones is due to the fact that I used the same method as in the training series. I had formed a certain habit of imagery which served me in this test."

E. M. C.: "There is a marked relation between the training series and the four grays, the nine tones, the nine grays, and the four tones, but apparently not much relation between the other experiments and the training series. Practically all the gain shown in the second test is due to the influence of the method used in the training series."

H. C. E.: "I think the thing that accounts for the improvement in the second test over the first is the system or method which was developed from the training series. In the last test series, I used the same method as in the training series, except that the system of imagery was changed slightly for the grays; that is, the grays appear in a vertical row just as for the tones, but instead of each being represented by a disk of different size they are now the same size and have the respective brightnesses of the four grays. I think it would make no difference what sort of tests I might be given where these four numbers were used; I could do as well as with the tones and grays."

Untrained Observers.

The methods used by the untrained observers will not be described unless they differ, in particular tests, from the methods used by the trained observers.

The Four Grays. Three of the four observers note a tendency to visualize the four grays. M. C. says, "The visual impressions seemed rather strong during the first test." In the second test, however, she abandoned the attempt to image. M. D. F. speaks of the use of an imagery he had adopted in some of the first tests. In the second test D. D. W. says, "I

tried to remember the grays as a row of figures; also to get a mental picture of them but the time was too short."

The Nine Tones. M. C. says that she saw the figures in a "group imagery" and retained them in that way. M. D. F. tried to repeat the numbers as tones, that is, high tones to low tones in each group, or low tones to high in each group of four. The four tones gave him an image of a board with four keys but he is not able to state the form of the keys or of the board, but tried to remember how the place or point suggested by each tone would skip around. In the introspection for the second test, he says:

"I can see fairly distinctly before me a key-board, and the tones go up and down. Four is at the top, and one is at the bottom, and I simply let the tone suggest the position, and when it comes time to respond, the image of the key-board returns. This test seems easier for me than the other experiments and also easier than the first test of this experiment, that is, it appears that the key-board helps me to remember."

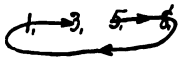
With D. D. W. and J. W., a number of methods were tried during the first test. Both adopted the method of grouping by fours during the second test.

The Nine Grays. In the first test, M. C. tried to picture the numbers as they were given and also to note how often one of any kind was repeated. In the second test he tried to remember the nine grays in groups of fours, but this time they appeared not in imagery of figures, but as a picture of the dots. This aided materially in retaining the groups. J. W. says that he tried visualizing, but it was a complete failure because of lack of time to recall the picture in detail. M. D. F. says:

"Each color as it appeared suggested a number, and I had no trouble in classifying the colors. Nine, however, was too great a number for me to retain at once. Some groups I found much easier than others, for instance, 4, 1, 2, 3, and 3, 2, 1, 4, etc., appeared arranged in a vertical column, and attention skips from the four, which is always at the top, to the other numbers in the order in which they were given, somewhat as follows:"

M. D. F. used the same method in the second test. D. D. W. said that he tried to remember all the numbers of the group, but the nine seconds interval was too short, to form a distinct image of either the grays or the numbers they represent.

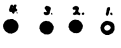
The Four Tones. M. C. thinks that the imagery which was used in the nine grays assisted here, but says that the different response interfered. In the first test J. W. tried to form an auditory image of the four tones but failed. He complains of an annoying fusion of the tones, a sort of harmony, which prevented him from remembering. With M. D. F. each note suggested a position on the piano, as 1, 3, 5, 8, and he remembered the order of the tones in that position. For instance, 5, 8, 1, 3, would be like this:



As long as he kept his mind concentrated on the above form he could remember, but it was very easy to allow the second group to confuse the one already received.

The final introspection for M. C. describes the form of imagery used and therefore it is quoted entire:

"I felt that I did better in the last end series than in the first, because I understood what I was supposed to do and was not confused. The only thing I know that helped me was the picture of the four dots, the dots appearing in a horizontal line,—



It seemed to me that if I could close my eyes during the test for the four and the nine grays, and not have the other group follow so closely, I could get them all correct. I used this imagery in my last tests for the four groups, but it seemed much easier with the grays than with the four or nine tones. This method did not help me in the other four tests. They seemed independent, and concentration in the first test did not help me in any of these four tests—geometrical figures, nine numbers, poetry, and movement. My greatest hindrance was that I often felt that I was not getting them right, and that confused me so that I could not concentrate my attention."

COMPARISON OF RESULTS.

Definition of Transference. It is first necessary for us to seek an understanding of what is meant by transference. We may mean by transference, the ability to use in one act the elements involved in another act. If we mean by transference that the training one receives in using a number of elements in one act is transferred to another act in which these elements do not occur, then the phrase "spread of training" would describe our meaning more accurately. In the sense of "spread of training," we can hardly say that there is "transference." A technical meaning of transference is answered only by the first definition. Both conceptions are involved in the present experiments.

If, as in the first definition, transference means simply the use of identical elements in different tasks, then the analysis of the conditions must be somewhat as follows: Let us suppose that any act is composed of the elements a, b, c, d, e; another act of the elements l, m, n, o, p, The two acts would be represented by two sets of elements, totally different, in which case there could be no such thing as transference. If, however, we examine an act composed of the elements a, b, c, d, e, and a second act composed of the elements e, f, g, h, i, where the element e appears in both acts, we would have the possibility of transference as far as the element "e" is concerned. If we had an act composed of the elements a, b, c, d, e, and another composed of the elements b, c, d, e, we would have a much stronger possibility of transference since all the elements except a in the first act are identical.

But, in the case of "spread of training" if we had an act composed of the elements a, b, c, d, e, and another act composed of the elements f, g, h, i, j, then the influence of training in the first act upon the elements composing the second act, will be measured by the amount of relationship between the elements of the two acts, that is, it will be measured by the amount of subconscious and actively conscious connection made between the elements by the observer. The application of the principle of "spread of training" can be made only to such cases where the elements concerned in the two acts are not identical, but related.

Of course, it were to beg the question if we used the phrase "natural connection," or the phrase "a natural relationship." The experimental difficulty involved is to determine which elements of experience are identical, which are related and which unrelated. The answer differs with individuals. Things related in one mind are not necessarily related in another mind. The relation between the things in experience depends, therefore, upon the relation which each person establishes in his own life—whether the frequent occurrence together of elements has built them into a purely automatic relation, or a connection is worked out by logical consciousness. At any stage of life an individual has a lot of relations which are automatic and another lot in which he has traced out a conscious relationship. We are often surprised by the discovery of a relation where we thought none existed. On the other hand we must guard against the conception that any mental components of a complex act enter into another complex act without being modified.

Relation of the Gain by the Trained to the Gain by the Untrained.

The following lists show the order of the tests arranged according to the greatest improvement for the trained and untrained observers:

Trained Observers.	*Untrained Observers.*
Four Grays	Nine Tones
Nine Tones	Nine Grays
Nine Grays	Geometrical Figures
Geometrical Figures	Four Grays
Four Tones	Poetry
Poetry	Nine Numbers
Nine Numbers	Movement
Movement	Four Tones

The rank of these tests, as shown by the greatest gain for each observer, is indicated in Table III. The four grays, with seven observers, show the greatest gain, and second greatest gain with two observers. The nine tones received first rank

with three observers, and second rank with five observers. The nine grays received first rank with two observers and second with two. The four tones received no first or second rank.

TABLE III.

Comparison of Results by Gain or Loss.

	G. C. F.	D. S.	F. S.	E. M. C.	H. C. E.	A. R. F.	M. M. M.	M. L.	M. C.	J. W.	M. B. F.	D. D. W.	Average Trained	Average Untrained	Difference between Trained and Untrained.
Training Series	32 (24)	25	−9	41	27	29	17	[9]					21		
Four Grays	22	*37*	*26*	*48*	56	*39*	*23*	*39*	2	7	*15*	−7	36	4	32
Nine Tones	*34*	35	1	15	*59*	8	5	15	5	9	14	*14*	22	11	10
Nine Grays	2	26	−2	12	56	32	2	21	*21*	*11*	0	8	19	10	9
Four Tones	−6	3	22	15	23	20	−16	19	2	−17	0	6	10	−2	12
Average	13	25	12	23	49	25	4	24	8	11	15	5	22	6	16
Difference between training gain and test of greatest gain	2	12	35	7	32	10	6	30							
Geom. Figs.	9	*11*	0	6	*35*	4	*18*	*22*	7	*20*	*5*	0	13	8	5
Nine Numbers	2	*11*	*4*	−2	3	4	9	7	−8	4	2	2	4	0	4
Movement	−1	−2	1	−1	−1	−1	−3	6	−2	1	−4	1	0	−1	−1
Poetry	*15*	−3	0	*19*	0	*10*		8	0	0	2	*5*	7	2	5
Average	6	4	1	6	10	5	6	11	0	6	1	2	6	3	3

All figures represent differences between first and last tests.
The record of the test which shows the greatest gain is printed in italics.
Minus sign means loss.

In Table III, the tests are ranked by similarity and by dissimilarity to training series. In the ranking for first and second places geometrical figures received first rank with six observers and second with three. The nine numbers received first rank with two observers, and poetry received first rank with four observers. Movement did not receive first, second or third rank with any observer.

The amount of gain of the trained over the untrained is shown by the amounts recorded in the last column of Table III. This column shows that for the four grays there was a difference between the results for the trained and the untrained of 32 per cent, or a gain nine times greater in the trained than in the untrained; for the nine tones, a difference of 10 per cent, or a gain twice as great for the trained as for the untrained; for the nine grays a difference of 9 per cent or a gain twice as great; for the four tones, a difference of 12 per cent; for geometrical figures, a difference of 5 per cent; for the nine numbers, a gain of 4 per cent; for the movement a difference of – 1 per cent; and for poetry a difference of 5 per cent.

The difference of the gain of the trained over the untrained in tests intentionally similar to the training series is 16 per cent. The corresponding difference between the trained and the untrained for tests intentionally dissimilar is 3 per cent. The gain of the trained in tests similar to the training is three and one-half times as great as their gain in tests dissimilar. The gain of the untrained in tests similar to the training is twice as great as their gain in tests dissimilar.

Let us now analyze, if possible, the influence of the training series upon each of these tests.

The four grays differed from the training series in but one factor, that is, grays instead of tones were used for stimuli. A reference to the table shows that the average gain for all observers in the four grays over the training series, is about 15 per cent. This is true of every observer except one.

The test showing the second greatest gain was the nine tones. Here the test differed from the training series in method, but was identical in content. In estimating the influence of the training upon test experiments in tones the first test may be regarded as the first practice series. This would tend to lift the recorded results for the first training above the first record for the tests in tones. This, in turn, would tend to increase the gain of the test over that of the training series. On the part of five of the observers there was a gain in the nine tones greater than the gain in training. The average shows a difference of 1 per cent in favor of the nine tones.

The nine grays show the third greatest gain. In the case of five observers the gain is greater in the nine grays than in the training. The difference between the averages of the two for all observers is greater by 2 per cent for the training than for the nine grays. The nine grays differ from the training series in both content and method.

The four tones differ from the training series in the use of pitch differences, instead of differences of intensity of the same tone, and in the method of response. The results show a gain in the training series greater than in the four tones, except for two observers. In reality there is a gain in the tones greater than in the training in the case of one observer only, for M. L. trained but two days. F. S., the other observer, made no gain in his training, but there was a gain of 22 per cent in the four tones. It seems that of those who gained in training and trained the full time, there was in no case a gain in the four tones equal to the gain in the training. In two cases there was a loss in the four tones. For all observers the average shows that the gain in the training was twice as great as in the tones. It is to be pointed out that this test is very similar to the training series. The different response required was planned because it was thought that it would be more familiar to the observers than the number response. As already mentioned, however, the introspections show that it was the different nature of the response that accounted for the failure to gain more in the four tones; several observers speak of this as a hindrance to correct responses.

Table III, shows also the difference between the gain in the training series and the gain in the test making the greatest gain. Every observer made a greater gain in these latter than in the training series.

The test showing the greatest gain for trained observers in the class of dissimilar tests was geometrical figures. In the case of two observers (including the observer trained for two days only) there was a greater gain in this test than in the training series for the same observers. This is the test among those unlike the training series in which the untrained observers make the greatest gain. This test also shows a greater gain in the

case of trained observers than does the test for the four tones. But for the other dissimilar tests there is so small an improvement that the trained observers gain on the average three and one-half times as much in the similar tests as in the dissimilar ones.

Table III indicates great variations in the amount of improvement made by different observers in the different tests. It might be expected, judging from the way the experiments were planned, that it would be easy to subtract the amount of improvement in the several tests from the improvement in the training series, and thus arrive at a direct estimate of the influence of the training upon that particular test. This, however, is not an easy matter. Individual differences and factors beyond those brought out in the numerical results enter to complicate the estimates. It is only possible to make such an analysis when the introspective evidence is sufficiently full and accurate to enumerate and define all the factors involved.

Three significant features have thus been noted in the above table; first, the difference between the improvement of the trained over the untrained; second, the difference of improvement in the tests similar to the training series in trained observers over their improvement in tests dissimilar; and third, the greater amount of improvement in the tests than in the training.

The Factors in Improvement and Transference.

The things most commonly mentioned by observers as contributing to improvement and transference have already been enumerated. It remains to point out some of the considerations bearing upon the interpretation of these factors.

Imagery. No suggestions were given observers regarding imagery. Indeed, it was not until the experiments were completed and work on results began that the uniformity of the testimony of observers concerning it was realized.

Eight of the twelve observers, all but two of the eight trained and two of the untrained, record a specific type of imagery. The two trained observers, F. S. and E. M. C., who did not do so, show by the language of their introspections that they

used imagery, but did not recognize a particular form. Of the untrained observers, two recorded the development of a complete imagery system, while with the other two there was a strong tendency to develop an imagery. As is shown by their introspections, in the case of observers who took only the test series, it is evident that the brevity of the tests together with the rapidity of change, would not permit the development of imagery with such facility as in the training series. Nevertheless two of the untrained observers, M. C., and M. D. F., developed a specific, well recognized imagery.

The fact that the stimulus of the training series was sound would lead us to expect auditory imagery. However, reference to the introspections already quoted will sufficiently indicate that there are three main types of imagery represented among the observers. G. C. F.'s may be called a visual-auditory type; that of D. S. and M. C., a purely visual type, and that of M. M. M., A. R. F., H. C. E., M. L., and M. D. F., a visual-motor type.

Everyone who does any act like this memorizing has a characteristic method. The evidence derived from these experiments indicates that the essential element in method is imagery.

Having once selected, consciously or unconsciously, an imagery, improvement seems to depend upon the fidelity of the observer to that imagery. Improvement depends also upon the fitness or adequacy of the imagery to do the thing for which it was adopted.

Whether each has an imagery for each separate act, whether each has a great many forms of imagery, corresponding perhaps to the customary things of life, or whether we have a few forms of imagery which we use for many different things, are interesting questions. If we do not have an imagery for each act, then the question of the use of imagery in different acts is just the one we are seeking to answer in regard to "transference" or "spread of training" by these experiments.

If an imagery is selected which is complicated, such as that of A. R. F., the observer is doing no other than selecting a complex method, which requires longer use to secure accuracy and speed. Or, if one selects an imagery which is not adequate to

the task as a whole, but serves for part only, such as an imagery for certain groups of sounds in the practice series, illustrated possibly by the imagery of D. S., then the observer must adopt a double or even a manifold system of imagery, and improvement in speed and accuracy would seem slower. Also, if one should change his type of imagery, it would lead to a lack of improvement or to fluctuation in improvement. This is a possible explanation of the failure of F. S. to improve.

For a short practice series, it would seem better to adopt a method or type of imagery as soon as possible, and, even though it is found to be cumbersome, remain faithful to it; for tasks long continued or to be oft repeated, the sooner one selects the best imagery, the better for the final outcome. Native ability finds its field in the readiness with which one selects an imagery adequate to secure the accuracy and speed demanded by a skillful performance of the task.

The prominence thus given to imagery as the essential characteristic of method has been pointed out before. Binet, in his "Psychology of Reasoning," insists upon imagery as the essential factor in all mental operations. Nearly every research in imagery since then has indicated something of the large place which imagery occupies in mental life. Coover and Angell have shown the value of the "careful elaboration of the plan of work, the actual working out of the method in the form of detailed introspections, and the searching and thorough analysis of results in experiments of this kind." Their research, however, not only fails to bring out the fact of an individual imagery, but even seems to seek to eliminate imagery altogether as a factor in improvement in training. Its presence, however, seems to be indicated in some of the introspections quoted.

"Am able to abstract from visual imagery of the apparatus entirely, and yet refer sounds to external stimuli. This seems to take the least effort, and is most satisfactory,"

They say—"The introspections indicate that the discrimination processes were accompanied by much imagery from other domains of sense, which in some cases determined the judgment. This imagery was largely kinesthetic and visual." "One reagent seemed to compare the intensities of bodily reactions to the sound stimuli themselves or to imagery called up by the stimuli, e. g., the 'flash of a bicycle lamp.'"

Still they say explicitly—"Many introspections * * * near the end of training were, 'No imagery.' "[1]

The relation of type of imagery to "transference" or "spread of training" is indicated in part by the results. In the case of G. C. F., the visual-auditory imagery used was that of a localization in space of the four tones. When in the test experiments, the four tones were changed to grays, there was a strong tendency to remember the grays in the same manner as the tones were remembered, because the stimulus rhythm and the method of response were the same. But the grays refused to take the position in space that had been customary in the case of the tones. An improvement was made between the tests for grays, but this tendency to use the practice imagery had to be overcome. The more thoroughly he was trained in the use of his imagery the less able was he to make a good record in the tests where he found a tendency to use it, but to which it seemed inapplicable. He gained about 20 per cent during his second practice period, but the results of the third test series shows not only no gain over the second test results but an actual loss of 8 per cent in the four grays, and of 6 per cent in the nine tones. These are, however, the tests in which he had made the greatest gain between the first and second tests. He gained but 3 per cent in the nine grays in the third test, and he made no gain in the four tones. His tendency to gain is shown by the gains of 11 per cent in poetry, 10 per cent in nine numbers, and 6 per cent in geometrical figures.

Nearly every observer, especially those who developed a clear imagery, was troubled with the same difficulty in the case of the four tones, for here the change in the response interfered with the use of the practice imagery.

On the other hand with D. S., H. C. E., A. R. F., M. M. M., M. L., M. C., and M. D. F., the type of imagery developed was as easily used with the grays as with the tones. These observers illustrate the benefits of making an imagery capable of being used in several acts thoroughly automatic as quickly as possible. With these observers, the longer

[1] Coover and Angell, *op. cit.*

they were trained, the easier it became to use the automatic imagery in the tests. So strong did this connection seem to H. C. E., that he said: "I think it would make no difference what sort of test I might be given where these four numbers were used; I could do equally well as with the tones and grays." The longer the observer was trained, therefore, the more non-essentials were cast aside, while the few essentials became habitual. When attention was long confined to the essentials, each element among them became welded into the imagery system.

Now, if a task differing in one essential only, from the trained one is given, the whole system feels the shock of the change in a vital part, until the adjustment is made. If the new task differed in two or three points, the shock is still greater. If the task was so different that the observer recognized no similarity, that is, if for him there was no way of applying his system of imagery, or if the imagery did not apply itself, then a new system of imagery was built up for the new task. It would seem, then, that the best time to make transfers of training in tasks which we recognize as dissimilar, is in the moments of beginning a new task, because the non-essentials which we use at first may be the essential ones in the second task. Thus, there may be advantages in learning several acts at about the same time.

Cases in which the amount of improvement in the test is greater than the amount of improvement in the training, are explained in part by the nature of the imagery used by the observers; the imagery used by the majority of observers was more readily applied to the tests than to the training. Such imagery as that of H. C. E., A. R. F., M. M. M., M. L., M. C., and M. D. F., supports such a view. The question of transference, then, becomes in very large part, a question of the nature of the imagery employed in the practiced task.

The significance of practice in the first test must be estimated here. Tables I and II show the difference between the first and second trial of each test, for both the first and second tests. It will be noticed that the gain between the first and second trials of the first test is often greater than the gain between the two tests. This is in accord with the well known fact that practice shows the greatest gain at the beginning of a training series.

The influence of one end test upon another is, therefore, the more serious in the "before" tests; and the effect of these tests upon the beginning of the training series may, in some cases, amount to more than the effect of a day of training in the training series.

The relation of improvement to one's ideas of improvement has often been raised as an experimental question in psychology. Many experiments have shown how often results differ from the feeling regarding improvement. It seems probable, from this series of experiments, that the feeling of improvement or the lack of it, is more or less closely connected with familiarity or lack of familiarity with imagery. All observers in this series of experiments were kept ignorant of results, but were asked to note in their introspections their own feelings regarding improvement. It often occurred that the feeling and the fact coincided. This seems to be more uniformly true in the case of those who developed a recognized form of imagery. It seems to be more often true in the case of those who did not recognize an imagery, and of those who had not yet recognized their imagery, that the fact did not correspond to the feeling.

The factor of attention and its control seems to be an important one in improvement and transference. In the opinion of observers it ranks next after imagery. Introspections at the beginning of the tests, and early in the training, show that observers recognize attention or the lack of its control as an important element in selecting the essentials from the non-essentials. Many speak of the rapid fluctuations of attention at this time. Observers who had a vivid imagery, speak of the fluctuations of attention in the use of the imagery; later in training, when the use of the imagery has become automatic, they say that control of attention seems to be the chief factor in rapid improvement, and the lack of it, the cause of error. Nearly every observer who seemed to approach the limit of his ability in training, testifies that the slightest fluctuation of attention produces a change in the results. In early training, therefore, attention seems to be drawn easily to the new conditions of work, i. e., to non-essentials. In improvement during practice, attention is more and more given to the central element concerned,

i. e., to the imagery which the observer uses. Toward the limits of training, attention may be permitted to run off on associations for the automatism of the imagery permits extra time between the stimulus and the response. When observers are making every effort to miss no stimulus or response, slight disturbances, such as slight changes in the stimulus, or noises from without, break the rhythm and produce rapid changes in attention. Practice curves of these observers, if plotted with regard to the grouping of the fours, where there is no change of method, are an excellent representation of the normal fluctuations of attention.

Association is another factor in training and transference. Most observers say that at the beginning of training and in the first test there is no time to form other associations than those among the elements concerned, but toward the close of training, nearly all speak of lapses of attention, due to associations with outside things formed in the interval between the stimulus and the response, or between the response and the stimulus. The relation between the training series and the test series may be called association, but it is better defined from the standpoint of imagery.

Automatisms have already been mentioned several times in connection with training and transference. It is inevitable that they should be formed in any process of training. The rapidity with which they are produced depends directly upon the fidelity of the observer to the imagery adopted, and upon the simplicity or complexity of the imagery to the observer. For example, H. C. E. adopted an imagery the first day of training and used it throughout training. His imagery was to him easy and readily used, and became automatic very quickly and thoroughly. A. R. F. did not recognize an imagery early and, when he did recognize it, it seemed to him complex and difficult of use. His imagery became automatic slowly, and before it became very thoroughly so, the training was over.

The relation of automatisms to the final tests is one of assistance, or of interference. The more automatic an act becomes, the less likely are its elements to be transferred to unlike elements. If it can be used, all goes smoothly. But if the task

is sufficiently different in content or method, for the observer, to awaken conscious efforts to use it in the new tasks, then automatism becomes a hindrance. In improvement in training, therefore, the more quickly automatisms may be cultivated the better. In transference, the cultivation of automatisms may be either a help or a hindrance according to the nature of the imagery of the observer.

GENERAL CONCLUSIONS.

The original research by Professor James (Psych., Vol. 1, p. 667), which served as the starting point for the investigations, contains this sentence, "All improvement of memory consists in the improvement of one's habitual methods of recording facts." Several experimenters have interpreted their facts for or against James' conclusions as seemed evident to them. The fact is, however, that many researches interpreted adversely are capable of interpretation to support his contention. A research which the writer carried on with Professor Gilbert, published in the University of Iowa Studies in Psychology, Vol. I, on "Practice in Reaction and Discrimination" left a distinct impression in the writer's mind that Professor James was wrong. The evidence of that same research seems now to be capable of an interpretation in support of Professor James as otherwise. Among the researches which have been interpreted as against James' conclusions are those of Judd (Psy. Rev., Vol. IX, pp. 27 to 39); several researches on cross-education, such as those of Scripture, Smith and Brown (Yale Studies Vol. II), Davis (Yale Studies, Vols. VI and VIII), Ebert and Meumann (Arch. f. d. ges. Psy., Bd. 4). The researches which take the ground apparently in support of Professor James are those of Thorndike and Woodworth (Psy. Rev., Vol. VIII), Bair (Psy. Rev., Mono. Sup. No. 19), Coover and Angell (Am. Jour. of Psy., XVIII, p. 328). A distinct effort to analyze the elements concerned in improvement in practice and in transference has characterized the later researches. As typical of this tendency, we may quote the researches of Thorndike and Woodworth, and of Coover and Angell. Thorndike and Woodworth say that after

practicing with rectangles 10 to 100 sq. cm., observers learn that one has a tendency to over-estimate all areas and consciously make a discount for this tendency, no matter how different other sizes or shapes of surfaces used in tests may be; also to look for the variations or the exceptional occurrences among the elements involved in training and in tests; third, learning to estimate in comparison with a mental standard, rather than an objective standard. This analysis of factors involved has a bearing only upon the tests carried on by these experimenters. They simply point out what seem to them to be the elements in their set of experiments.

Coover and Angell give a more translatable list of elements that seem to them concerned in improvement and transference:

"We find, therefore, causes of the tranference of facility to be: (a) the formation of a habit of reacting directly to a stimulus without useless kinesthetic, acoustic, and motor accompaniments of recognition, which results in (b) an equitable distribution of attention to the various possible reactions so as to be about equally prepared for all; and (c) the consequent power of concentrating the attention throughout the whole series without distraction."

The elements that appear on the surface in our experiments are, while in the main in support of the analysis given by Thorndike and Woodworth, and Coover and Angell, contain elements both somewhat at variance with, and in addition to, those discovered in these researches. If, in the following from Coover and Angell: "Improvement seems to consist of divesting the essential process of the unessential factors, freeing judgments from illusions, to which the unnecessary and often fantastic imagery gives rise, and of obtaining a uniform state of attention which is less than a maximum," and "useless kinesthetic, acoustic and motor accompaniments of recognition," by "fantastic imagery" is meant such imagery as appears in our experiments or if it means such imagery as one of Coover and Angell's observers mentions, when he "seemed to compare the intensities of bodily reactions to the sound stimuli themselves or to imagery called up by the stimuli, e. g., the "flash of a bicycle lamp," then we must regard our results as distinctly divergent. Such imagery is an essential factor, if not the most essential factor in training and transference. With Coover and Angell's

general conclusion regarding the factors common in cases of training of dissimilar stimuli; i. e., "the habit of stripping the essential process of unnecessary and complicating accessories," we are in agreement.

In regard to the experiments of Thorndike and Woodworth, the difference between their conclusions and the conclusions of this series may be pointed out as follows: "After one gets mental standards of the areas, he judges more accurately, if he pays no attention whatever to objective standards." If Thorndike and Woodworth mean by this the same condition of imagery as developed in our experiments, which we imagine is possible, that is one point of agreement.

"Improvement in any single mental function need not improve the ability in functions commonly called by the same name. It may injure it." With this our conclusions also agree. Some definition, however, as Thorndike admits, needs to be made of the phrase "single mental function."

"Improvement in any single mental function rarely brings about equal improvement in any other function, no matter how similar, for the working of every mental function-group is conditioned by the nature of the data in each particular case." The results of our experiments do not support the statement contained in this sentence, especially in the first half of it. Improvement in many cases is absolutely greater in amount in the tests than in the training. The truth of the latter part of the quotation is verified in our experiments if the word "imagery" may be substituted for the word "data."

"The very slight amount of variation in the nature of the data necessary to affect the efficiency of a function-group makes it fair to infer that no change in the data, however slight, is without effect on the function." This our results corroborate.

"The loss in the efficiency of a function trained with certain data, as we pass to data more and more unlike the first, makes it fair to infer that there is always a point where the loss is complete, a point beyond which the influence of the training has not extended." Again our results corroborate.

"The rapidity of this loss, that is, its amount in the case of

data very similar to the data on which the function was trained, makes it fair to infer that this point is nearer than has been supposed. Again our results corroborate.

In the light of results here secured, we would change the following statement: "The general consideration of the cases of retention or of loss of practice effect seems to make it likely that spread of training occurs only where identical elements are concerned in the influencing and influenced function," to read—spread of practice occurs only where an imagery develops capable of being used by the individual observer in both training and test fields.

Our results do not corroborate the following statement from Coover and Angell, p. 339, as far as the freeing from any system is concerned:

"At the beginning of training, they matched the color of the cards with the labels on the compartments; then to increase speed a system of mnemonics is employed, designed to form associations in the mind between a compartment and its color; this system then goes through a process of mutation,—becomes abbreviated, changed in part, supplemented, or is superseded by another; finally, through repetition, reactions to particular compartments become coordinated with their respective colors and are made directly—free from any 'system' except in rare cases."

The evidence from the introspections of all of our observers shows that there is no tendency to do away with the imagery or to free from the imagery system. Such cases as D. S., who had been trained by a long series of reactions practically identical with those in which he is trained here, and of G. C. F., who was trained for two months in the practice reactions used in this experiment, reactions which were selected for the intensity of application required in improvement and because of a possibility of reaching the limit of training for different observers within the practice period—such cases do not show any tendency to abandon the system. In this, therefore, our results do not agree with those of Coover and Angell.

With the statement of Professor James our results are in accord inasmuch as all the factors we have discovered have to do with methods.

There are two factors then, which we are seeking to analyze; first, to determine the factors that make for improvement; and

second, to determine the factors that make for spread of training or transference of training. If the problem were attacked from the standpoint of numerical results only, the analysis into elements would be most confusing.

SUMMARY OF CONCLUSIONS.

Some elements concerned in *improvement* and *transference* have been enumerated. Of these the central or most essential element is individual imagery.

Improvement seems to depend upon the consistent use of some form of imagery, whether it is the most advantageous form or not.

Imagery may be sub-consciously developed, but if it comes to be consciously recognized the improvement is more rapid. The rate of improvement seems to depend directly upon the conscious recognition of the imagery, and upon attention to its use.

A change of imagery during practice increases the rapidity of the improvement if a better form is adopted and adhered to. It may prevent improvement if a change of imagery is frequent, or if a less adequate form is adopted.

Individual differences are clearly shown in different types of imagery by the rapidity with which the imagery develops, and by the clearness or definiteness of the imagery.

The habit of guessing interferes with the formation of imagery and therefore, results in lack of improvement.

Transference may be divided into two kinds. It is either the use of identical elements in different tasks, or it is of the nature of "spread of training." The evidence of these experiments is in favor of the use of identical elements, or at least in favor of a limited spread of training. We are able to say that transference depends upon the nature of the imagery employed in practice, rather than upon any other factor. Whenever the training has become automatic and the difference between the training and the test consists of a few elements, these different elements serve as a hindrance only. We have then something of the nature of spread of training. If the difference is so very

slight that the elements are practically identical, as between the four tones of the training series and the four grays, there is little difference between the gain of the training and the test series. We have here something of the nature of transference, though transference as we have defined it, demands a complete identity between the elements of the acts. When the acts are made up of quite different elements, there is a distinct breaking up of the habit of responding, by the intrusion of the different elements, which raises the whole act into active consciousness so that the transfer of elements from one act to another act, other than the identical ones, is a conscious transference. It seems, therefore, that a conscious effort to use the elements of training in a different task, assists in making the transfer.

Factors that lead to improvement in the training do not necessarily lead to improvement in the tests; they may hinder it. The nature of the imagery, and the training in it seems to determine this. If, in the mind of the observer, the imagery is capable of adjustment to different tasks, it can be used in both improvement and transference, for the elements of the training act are thereby made the same as those of the test act. If it is adapted, in the mind of the observer, to the training task only, it may assist in improvement but it may interfere with transference.

Native ability appears to have abundant opportunity in the recognition of similarity or difference in the capability of the imagery for use in various tasks.[1]

[1] "Images, along with sensations, constitute the material of all intellectual operations: memory, reasoning, imagination, are acts which consist, in an ultimate analysis, of grouping and co-ordinating images, in apprehending the relations already formed between them, and in reuniting them into new relations." BINET, Psychology of Reasoning.

"Just as the body is a polypus of cells, the mind is a polypus of images." Taine, "On Intelligence."