THE EFFECT OF PRACTISE UPON THE RANGE OF VISUAL ATTENTION AND OF VISUAL APPREHENSION.[1]

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SUMMARY.

Two sets of experiments were conducted to determine the effect of practise upon quick visual perception, with special reference to the usefulness of specific "exercises in mind-training," such as have been recommended by Miss Aiken.

In the first set of experiments (range of attention), 5, 6 and 7-place series of isolated letters were exposed for 0.08 sec. with a tachistoscope. The observers were six college students. The quantitative results are, in general, those of other investigators in this field. The average limit of the range of attention is between 4 and 5 impressions: there are but slight individual differences: the longer series admit of a somewhat higher average performance, particularly when grouping can be employed: practise has but a very slight effect, which is easily explicable in terms of habituation to the experimental conditions and of development of the 'trick' of grouping. Range of attention, itself, is, so far as one can see, not affected by practise.

In the second set of experiments (range of apprehension), groups of dots, pictures, drawings, nonsense syllables, and stanzas of poetry were exposed for 3 sec. with the tachistoscope, and collocations of 10 objects were exposed without instrumental aid for 6 sec. The observers were three adults. With nonsense material, the range was but slightly

[1]A brief account of these experiments was presented at the meeting of Section L of the American Association for the Advancement of Science, at Chicago, 1907, and a summary appeared in *Science*, 27: 1908, 526. It was the author's intention to withhold publication until the tests could be repeated with school children. As circumstances have conspired to render this impossible, the results are now published with the hope that other investigators may undertake similar tests with children.

greater than with the short exposures: with sense of material, the range was increased on account of the possibility of more effective assimilation and grouping. Individual differences are so striking and so specific as to negative the notion of a general ability to apprehend, or even of a general ability to apprehend visually. The effect of practise, as before, is negligible when adaptation and assimilative devices are eliminated. A qualitative analysis shows that performance is conditioned by numerous factors, of which the most important are: native capacity, degree of attention, specific capacity for given types of material, ease of assimilation of the material shown, 'obstruction' or distraction, ideational type, voluntary restriction of observation, and grouping

PURPOSE OF THE OBSERVATION.

In 1896, Miss Catherine Aiken published an account of certain exercises, which she conducted with her pupils at a private school for girls at Stamford, Connecticut, for the purpose of mental training, particularly of training in the concentration of attention.[2] The results cited in this book are so extraordinary as to challenge attention both from psychologists and educators, for if it be possible, by devoting ten or fifteen minutes daily to simple exercises, to accomplish the results which are claimed,[3] it would appear to be incumbent upon all teachers to institute such exercises and to regard them as a very essential part of schoolroom training. If, on the other hand, Miss Aiken's results cannot be duplicated,

[2] CATHERINE AIKEN, *Method of mind-training: concentrated attention and memory.* New York, 1896. Pp. 107. For supplementary exercises, see her *Exercises in mind-training.* New York. 1899. Pp. 121.

[3] A single example, drawn at random, will suffice. There were placed upon a revolving blackboard in vertical column, the following numbers: 230, 729, 11, 36, 40000, 16, 40. By rotating the board, these were exposed for 3 seconds only; the pupils were then asked but once to multiply the first number by 2, to extract the cube root of the second, to square the third, to extract the square root of the fourth, to divide the fifth by 2, to multiply the sixth by 24, and to divide the seventh by 4, and then to repeat the changed column, which they did as follows: 460, 9, 121, 6, 20000, 384, 10 (pp. 30-31).

From correspondence with some of Miss Aiken's pupils, I infer that it was her class as a whole, and not any single pupil, that was able to accomplish such a feat. Even so, the performance is amazing.

it is equally important to establish this fact and then, if possible, to find out the cause of the discrepancy.

The experiments which follow were undertaken, therefore, with the intent to carry out, under laboratory conditions, exercises like those used by Miss Aiken and to measure the extent, and to analyze the nature, of the improvement that appeared. It may be admitted at the outset that the negative outcome of these experiments is not entirely conclusive; it may be objected that practise was not sufficiently long; it may be objected that our observers were adults, and that the outcome would have been essentially modified had our tests been applied to children. But neither of these objections seems to us of great moment; we feel that our observers had reached their maximal efficiency, and we are unable to believe that children could be brought to exhibit a range of apprehension so markedly superior to that of competent and well-trained university students and instructors.

Our experiments fall naturally into two groups: (1) Tests with tachistoscope exposures, so brief as to preclude eye-movement or the roving of attention, and (2) tests with exposure of more complex objects for periods of 3, or of 6 sec. The first set of experiments will be considered as tests of the range of attention, the second as tests of the range of apprehension. In both cases, the essential problem was to ascertain the effect of practise upon a small number of college students and adults.

PART I. THE RANGE OF ATTENTION.

APPARATUS.—All the short-exposure tests were conducted by means of a disc-tachistoscope[4] (Fig. 1). This consists essentially of a cardboard disc, 56 cm. in diameter, in which

[4]For a fuller description of this instrument, together with a discussion of the problems of tachistoscopy, see the writer's *Manual of Mental and Physical Tests*, Baltimore, 1910. The instrument is sold by C. H. Stoelting Co., 121 N. Green St., Chicago, Ill.

an adjustable sector has been arranged to expose, as the disc revolves, the stimulus-card placed just behind it. This disc is mounted upon one end of a horizontal axle. A meter-stick, equipped with two adjustable weights, is attached to the other end of the axle. By suitable adjustment of the weights, the disc can be rotated at the speed desired. Just

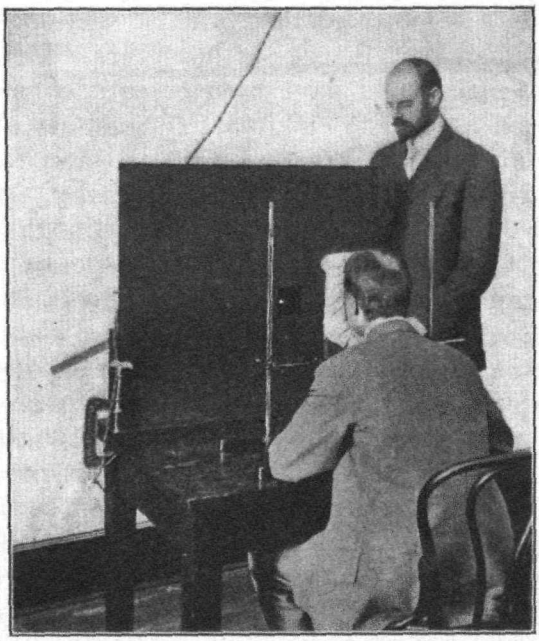

Fig. 1. DISC TACHISTOSCOPE.

before an exposure, the stick is supported upon a release-lever at the back of the instrument. In this position, the stimulus-card (9 x 9 cm., bearing one-half inch black letters) is hidden directly behind a fixation-card, but the fixation-card is visible through a square opening in the large cardboard screen that covers the front of the whole instrument, and through another square opening in the rotating

disc. When the release is pulled, the disc travels downward, the fixation-card is automatically lifted out of the way, and the notched sector of the disc exposes the stimulus-card for about 0.08 sec. The stimulus-card is illuminated from one side by a 16 C.P. frosted, tubular electric lamp. The observer's position is maintained by a headrest, as the cut illustrates.

The material used for these short exposures consisted in the main of 5, 6, and 7-place nonsense combinations of letters, *e. g.,* HFQSL, KTCMKZ, LSCLGYN.

METHOD.—Six college students, only two of whom had had training in psychological observation, served as observers. With two of these, the experiment was not carried far enough to warrant inference concerning practise, though their work, so far as it went, corroborated that of the four that are here mentioned. With these latter, tests were continued until it was evident that maximal practise had been attained. From 124 to 250 and more exposures were given to each observer. Five, six, and seven-place cards were given in irregular order, though the first trials were mainly confined to the shorter, and the final trials to the longer series. Introspective observations were recorded, but they were scanty and tended to become stereotyped. A warning "ready" signal was, of course, given about 1.5 sec. before each exposure.

The scoring was done by the simple method of crediting one unit for each letter correctly observed, and then deducting 0.5 for each error of transposition or insertion, *e. g.,* BVXTN or BXVTIN for BXVTN was scored 4.50.

RESULTS.—(1) As Table 1 shows, the *average number of letters* that can be grasped in a single exposure lies between 4 and 5 (4.82)—a result in close accord with previous tachistoscopic work.

(2) There are only slight *individual differences* in the work of different individuals.

TABLE I.

Average Scores in the Exposure of Isolated Letters.

Obs.	Number	5-Place Series	6-Place Series	7-Place Series	General Average
B.	124	4.85	5.09	5.25	5.06
E.	177	4.84	4.49	4.48	4.53
N.	249	4.74	4.92	5.38	4.97
T.	124	4.51	4.86	4.40	4.71
	674	4.74	4.84	4.88	4.82

(3) *Comparison of the series* shows that the 7-place series are somewhat more favorable than the 6-place, and these somewhat more favorable than the 5-place series in average scores. This is not, of course, because the longer series are easier, but because they offer opportunities for occasional scores of 6 or 7. This advantage slightly overweighs the disadvantage of greater complexity.

(4) The instances just cited in which 6 or 7 letters are reported correctly are almost invariably instances in which the presence of vowels permitted the *formation of syllables, e. g.,* WAEGZME, KMDEMBH, etc.; in other words, these high scores are due to mental grouping of the elements exposed.

(5) Observers frequently assert that more has been seen than can be reported a moment later. That constituent elements of the stimulus may make an impression, and yet not a sufficiently strong impression to be named an instant later, is entirely probable; in fact, it can be demonstrated by asking the observed whether a given letter was exposed or not. It is possible that practise may augment the observer's capacity to hold these more fleeting and transient impressions, but we have no direct evidence to offer on this point.

(6) The *effect of practise* is indicated by the summarized data of Table 2, examination of which will suffice to convince the reader that attentive and effortful observation

through a series of from one to two hundred or more exposures has a curiously small effect upon the range of attention.

TABLE II.[5]

Effect of Practise in the Exposure of Isolated Letters.

	5-Place Series			6-Place Series				7-Place Series		
Observer.....	B.	N.	T.	B.	E.	N.	T.	E.	N.	T.
First Period..	4.87	4.44	4.50	5.03	4.75	4.38	4.73	4.25	4.90	3.83
Middle Period	——	4.87	——	——	——	4.85	——	4.02	5.54	——
Last Period...	4.78	4.77	4.50	5.25	5.08	5.06	5.08	4.90	5 40	5.80

This small effect is easily explained. It is due almost entirely to two factors; first, to habituation to the experimental conditions; second, to the development of a device of forming groups of the letters and of using these groups, however arbitrary or inexact they might be, as bases for report. Habituation takes place quite rapidly in these experiments; a marked improvement is observable in the first sitting Combination or grouping appears more clearly in the 6 and 7-place series, probably because these series afford more opportunities for its exercise.. If these two factors were eliminated, the practise-effect would be negligible, if not altogether absent. In other words, adult observers very quickly reach a physiological limit of visual observation when the exposure is so restricted as to prohibit eye-movement and roving of attention.

PART II. THE RANGE OF APPREHENSION.[6]

1. Three seconds' exposure with the tachistoscope.

APPARATUS.—The same tachistoscope was employed, but

[5]In explanation, it may be said that observers *B*. *E* and *T* had less than 200 exposures, so that, to eliminate fluctuations due to chance variations in the material, their work is divided into two periods observer *N* gave a longer time to the work and it is instructive to divide his performance into three periods. In his case. the number of exposures represented is 249: over 300 were actually made, but the results of two sittings were unfortunately destroyed. Our notes taken at the time show. however, that the general results would not have been affected had these figures been included.

[6]A series of preliminary tests was conducted with the observers of Part I., using complex visual material, drawings, lines of poetry, columns of figures,

the fixation-card was removed; the device for holding the stimulus-card was replaced by a larger one suited for sheets of stiff paper, 5 x 8 inches; the weights and sector were adjusted for an exposure of 3 sec.

The material exposed was of five kinds: (*a*) dots, (*b*) pictures, (*c*) nonsense syllables, (*d*) drawings, (*e*) stanzas of poetry.

The dots were irregularly arranged groups of asterisks, numbering 6 to 20, placed by a typewriter within a space 35 mm. square in the center of the sheets of paper. The pictures consisted of drawings, cuts, lithographs, etc., cut from magazines, and they occupied, frequently, the full space of the blank, *i. e.*, 5 x 8 inches. The nonsense syllables, printed in a single horizontal row with a typewriter, were 8 to 10 in number, each being composed of 3 letters. The drawings, which were made with pen and ink, were for the most part meaningless combinations of lines or symbols, though a few gave some hint of meaning. The poetry, also typewritten, consisted of four line stanzas from Keats' *Isabella*.

METHOD.—The form of material to be shown was stated, and exposure for 3 sec. was made when the observer was thoroughly prepared, by fixation and attention, to receive it.

In reporting his observation, the observer made a rough pencil sketch of the dots, drawings, and often of the pictures, though these last were commonly described orally. He wrote or recited, at his will, the nonsense syllables and the poetry. The report was supplemented, as a rule, by a "quiz" on the part of the experimenter to determine whether details not reported had escaped observation, or had merely been neglected in the report. In the case of the pictures and drawings, the experimenter usually also confronted the observer with the card and asked him what details he had failed to note, what he had forgotten, or what he had misapprehended.

The performance of the observers was scored in the following manner: with the dot-cards, any mistake, even by one

etc., exposed without the aid of apparatus. These tests gave valuable hints for the arrangement of the final experiments, and threw light upon the mental processes concerned, but as they were not pushed far enough with any observer to warrant reliable inference as to the effect of practise, they will not be discussed further in this paper.

number, was considered as a failure; with the pictures and the drawings, the report was graded upon a scale of 10 points (for an adequate or complete report); with the nonsense syllables, one unit was credited for each letter correctly reported, but 0.5 was deducted for an error of transposition or insertion, whether of letters within syllables or of the syllables themselves; with poetry, the same method was followed, substituting words for letters.

OBSERVERS.—In these apprehension tests, the observers were Dr. H. A. Ruger, Professor of psychology at Colorado Springs College; Dr. L. A. Geissler, instructor in psychology at Cornell University, and Miss Helen Vermilyea, a school teacher with a small amount of psychological training.

2. Six seconds' exposure without the tachistoscope.

MATERIAL AND METHOD.—A small table was covered with a full-sized sheet of gray cardboard. Upon this as a background was placed a group of 10 objects (*e. g.*, pencil, spoon, tin box, leaf, key, postcard, pipe, wooden cube, pebble, watch), with the precaution to avoid combinations of obviously related objects, such as a pen and an ink-stand. Ten different objects were used for each test. A gray cloth covered the objects while the observer was taking his position. For the exposure, he stood directly in front of the table, and held a small sheet of cardboard before his eyes. A noiseless seconds' pendulum, off at one side, served the experimenter as a time-control, and he himself, after removing the cloth, took the observer's cardboard screen and, after a warning "ready," made the exposure by removing the screen for six seconds. The replacement of the screen terminated the exposure: the observer wheeled about, to turn his back to the table, and then immediately described (usually, also, sketched roughly) the objects on the table. Stress was laid primarily upon naming as many objects as possible, secondarily upon describing their details and their spatial relations.

One unit was credited upon the observer's score for each object correctly named.

These tests were made upon the same three observers just mentioned and were interspersed with the 3-sec. exposures. The experiments as a whole occupied some six weeks time.

RESULTS FOR BOTH TESTS OF APPREHENSION.—(1) The most striking quantitative result of these tests is the very small increase for certain kinds of material, in the number of items observed with the exposures of 3 and 6 sec. as compared with the exposures of 0.08 sec. (range of attention tests). Thus, for instance, with an exposure of 6 sec., the average number of objects named was 6.03, while, with an exposure only 1-75 as long, between 4 and 5 objects could be named. Similarly, only 3 to 4 nonsense syllables (10.15 letters) could be read correctly in 3 sec. On the other hand, the longer exposures materially increase the range of perception of sense-material which admits of quick assimilation: nearly 12 words were read in poetry as against the 4 to 6 limit in ordinary tachistoscopy. The advantage in this material is evidently due to the same factor discerned in the exceptional results with isolated letters, viz: grouping and combination into meaningful units.[7]

(2) *Individual differences* in quick apprehension are clearly indicated in Table 3. Thus, *V* excels in the estimation of dots and in reading poetry, but is the poorest of the observers in reading nonsense syllables, in reproducing drawings, or in describing pictures and objects. *G* excels in these last performances, but is inferior in reading poetry and in estimating dots.

These facts are important in connection with our study of the effect of practise, because they negative the idea of general ability in apprehension, or even of general ability in

[7] In the case of poetry, our observers felt that the limit of their performance was set simply by the amount that could be read during the exposure, whereas even in the 6 sec. exposures, there is not time enough clearly to apprehend 10 disparate objects. The maximal correct reproduction of poetry was that of *R.* who, in 3 sec., read the first 19 words of the following:

"Were they unhappy then? It cannot be.
Too many tears for lovers have been shed.
Too many sighs give we to them in fee.
Too much of pity after they are dead."

visual apprehension: we may state only that a given individual excels in the attentive observation of pictures, of drawings,

TABLE III.

Individual Differences in Visual Apprehension.

	Dots	Pictures	Nonsense Syllables	Drawings	Poetry	Objects
G	33	6.96	10.9	8.65	9.42	7.10
R	46	6.89	10.7	6.42	12.92	5.57
V	80	4.40	8.9	3.70	13.21	5.50

NOTE.—The scoring is as follows. For dots, the percentage of exposures in which the dots were correctly counted. For pictures and for drawings, the average merit, as estimated on a score of 10. For nonsense syllables, the average number of letters, and for poetry, the average number of words correctly reproduced. For objects, the average number correctly described.

of words, or of certain kinds of objects, etc., not that he excels in all-around observation. Thus, *V*, it will be seen, is more than twice as efficient as *G* in the perception of groups of dots, but *G* is more than twice as efficient as *V* in the perception of drawings. These considerations make it still more improbable that a series of classroom exercises, like Miss Aiken's, will train and develop general capacity to attend.

(3) The *effect of practise* is shown in Table 4. Here, each period represents the average of three exposures, usually one daily for three days. Inspection of these data gives little warrant for the belief that systematic practise would enable an adult markedly to improve his ability for quick visual perception.

TABLE IV.

Effect of Practise upon Visual Apprehension.
Averages for Three Observers.

Period	1	2	3	4	5	6	7	8	9
Pictures	6.6	4.9	5.9	6.3	6.9	6.9	6.5	5.5	
Nonsense	9.3	10.6	8.4	10.8	11.7	10.6	10.4	8.9	9.2
Drawings	6.6	6.3	5.0	5.6	5.0	7.7	6.5	6.6	5.7
Poetry	10.7	11.5	11.3	10.8	13.0	12.5	13.0	11.7	
Objects	5.6	6.3	5.9	6.0	5.9	6.5	6.4		

The tests with dots do not lend themselves readily to quantitative treatment. The seeming improvement with drawings during the sixth period was due to the use of one very easy drawing in that group. There is evidence of a slight improvement in reading poetry (amounting roughly to an increase of one word), but this may be attributed to increased familiarity with the peculiar style of the poem in use. If any improvement can be inferred in the case of the objects-test, it must amount to an increase, on the average, of less than one object correctly reported.

Just as in the short-exposure experiments, the slight practise-effect which can be discerned here is entirely explicable in terms of habituation to the experimental conditions, and of the development of grouping schemes or other devices of observation to be mentioned below. It is highly improbable that this period of practise trained the attention of our observers in such a manner as to enable them to surpass others in the quick observation of objects or incidents other than those used in the experiments.

(4) A *qualitative analysis* of the data secured in this experiment shows that the efficiency in visual apprehension exhibited by any individual is conditioned upon the following factors:

(*a*) *Native capacity* for concentrating attention in general. This factor we believe to have been unaffected by practise.

(*b*) The *degree of attention* given at the exposure. In theory, each exposure is accompanied by maximal attention: in practise, this condition is not always secured, and when it is not, the range is reduced.

(*c*) The *type of material* in use,—drawings, nonsense syllables, etc.,—has an effect upon the performance, and this effect varies in individual observers.

(*d*) *The ease of assimilation* of the particular stimulus in use obviously conditions performance: thus, an easy bit of poetry will increase the range of all observers; a drawing that

can be *named,* however fancifully, can on this account be held longer and reproduced better by most observers.

(*e*) *Obstruction or distraction.* Some detail in the object displayed, whether important or trivial, will often catch the observer's attention, interfere with his exploitation of the rest of the exposure-field, and thus measurably reduce his performance. For instance, a misprint in a line of poetry, or the presence of some unusual word, will induce most observers to reread the line, even at the obvious expense of their record.

(*f*) *Ideational type.* Visually minded observers hold drawings, pictures, and objects by their visual appearance, and are inclined to use visualization for the reproduction of at least portions of the nonsense material and poetry. Auditory-minded observers hold verbal material by auditory imagery: if decidedly auditory-minded, like the writer, they may also attempt to hold even pictures, drawings, and objects in auditory terms, by using verbal formulations as cues for recall.

(*g*) *Restriction.* Observers often intentionally restrict their range. Thus, in the exposure of nonsense syllables, it was early discovered by all the observers that, although by an effort, all ten of the syllables might be read over, only a poor reproduction (two or three at most) would result; if, however, attention were confined to the first four syllables, these could be read over twice and reproduced with some chance of accuracy. There may have been a similar intentional restriction of the range of apprehension to other types of material.

(*h*) *Grouping.* As noted above, apprehension is greatly facilitated by any scheme that permits of grouping the constituent elements in the field. The development of these grouping schemes is perhaps the most important single factor in practise-improvement, at least after the habituation of the preliminary trials. Thus, in the dot-tests, the collocation of irregularly arranged dots was by most observers, arbitrarily rearranged (subjectively) into two, three or sometimes four

groups of dots,—each group containing three to six dots. In a similar manner drawings were frequently split up into component elements and then recombined by a sort of analysis and synthesis. In auditory-minded observers, this process is usually accompanied by the application of verbal symbols as tags for recall, *e. g.*, "a rectangle, two peaks, and an arrow." This analytic-grouping is commonly found to be more effective than the "steady stare" or "impression-of-the whole" method which observers are prone to use at first.

Professor E. L. Thorndike, of Teachers College, Columbia University, recently delivered at the University of Illinois a series of five lectures on "Individual Differences and Their Causes." The lectures discussed "Measurements of Individual Differences," "The Influence of Sex," "The Influence of Race," "The Influence of Immediate Ancestry," "The Influence of Training."

Dr. Clouston, Edinburgh, addressing a meeting of the Dundee Child Study Society, said he believed that, if they could find a way of improving the self-control of the coming generation, they would do more good than the House of Commons does in fifty years, and he believed it was a quality that could be improved if they went about it the right way. With the aid of school medical inspectors the teachers would now be able to apply general rules in specific ways, as at present it was one of the difficulties of the teaching profession that general rules of education could not apply to large groups of children. The ideal kind of education would be to sort out the children on certain natural rules, and subject each group to the kind of education and environment that suited its particular brain cell qualities. While that was still in the region of the ideal, teachers were at present endeavoring to individualize their children, and apply the rules of education to the individual instead of to the class in bulk.—*Educational Times.*