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QUALITATIVE DIFFERENCES BETWEEN LEVELS OF INTELLIGENCE IN FEEBLE-MINDED CHILDREN

BY LOUISE ELLISON ORDAHL, Ph. D.,

and GEORGE ORDAHL, Ph. D.

This study was undertaken at Faribault, Minnesota, in the psychological laboratory of the Minnesota School for Feeble-Minded and Colony for Epileptics. Work was begun June 6, 1914, and experiments were abruptly terminated October 26, 1914. The problem was suggested by Dr. F. Kuhlmann, Director of Research, who also rendered the authors valuable assistance in planning and arranging experiments.

The Binet-Simon scale is a means of measuring degrees of general intelligence, but it does not specifically reveal the qualitative differences upon which the various levels of intelligence depend. Groups of children, both normal and feeble-minded, may be graded into different levels of intelligence with a considerable degree of accuracy. But the psychological qualities characteristic of each group, and the consequent qualitative differences between each level has not yet been determined.

In a general way it is quite apparent that the higher grades differ widely from the lower grades and it is quite possible to detect a considerable difference in the behavior of a group of children who are, for example, mentally six years old and another group whose mentality is seven years, but just what this difference may be psychologically is not apparent. It has therefore seemed worth while to attempt a series of experiments calculated to reveal a psychological difference between the subjects doing the experiments. Accordingly this problem was undertaken.

For the purpose of this study it would be best to attempt experiments on the simple mental processes, and in the field already laid out by normal adult and child psychology, and to select experiments for which norms are already established and which at the same time seem likely to yield results with this class

of people. Unfortunately very few exist which are at the same time applicable to the feeble-minded. The authors attempted to devise experiments which should test the psychological processes comprehended within the following rubrics: Sensory discriminations, attention, memory, imagination, judgment, and reason. The individual experiments are designated as follows.

1. Strength of grip, dynamometer.
2. Judgment of movement.
3. Simple reaction to sound.
4. Tapping tests.
5. Attention span.
6. Discrimination of grays.
7. Judgment of forms, two dimensions.
8. Judgment of form.
9. Judgment of size.
10. Judgment of form, three dimensions.
11. Memory for geometrical forms.
12. Modified typewriting.
13. Ink blot test.
14. Drawing designs inverted.
15. Comprehension of complex directions.

Thirty cases of typical feeble-minded "children" were selected, ranging between the chronological ages of fifteen and thirty-five. If it was found that a case was suffering from any special defect such as faulty vision, it was discarded and other cases tried. However, all defects, if of a minor degree, could not thus be eliminated since a case might be well along in the experiment before the defect became apparent.

No cases were taken whose chronological ages were under fifteen. A child under this age with a mentality of ten is possibly quite different from one of the same mentality but chronologically older. If a child is fifteen and grades ten or lower in mentality he is well possessed of the feeble-minded traits and compares favorably with one of the same mental level but chronologically twenty or thirty-five. If, however, the chronological age is greater than thirty-five there is possibility of deterioration

having set in. For this reason our cases were limited to the chronological ages of fifteen to thirty-five.

The cases were taken from three groups of children, whose mental ages were six, eight, and ten, as determined by the Binet-Simon scale. Ten cases were selected from each of these three mental ages, five girls and five boys, thus making an equal number from each sex, a total of fifteen boys and fifteen girls. Subjects were taken who had not more than six months previous to the experiments tested within two-fifths of a year of the mental age. The average chronological and mental ages for each group were as follows.

By Groups	Chronological Age	Mental Age
Mental six	20.5	6.26
Mental eight	22.9	8.20
Mental ten	19.5	10.10

By Sex	Chronological Age	Mental Age
Mental six—girls	21	6.3
Mental six—boys	20	6.2
Mental eight—girls	22.5	8.2
Mental eight—boys	23.4	8.2
Mental ten—girls	21	9.9
Mental ten—boys	17.3	10.16

The chronological ages for the different groups do not differ greatly. The Ten group has the lowest chronological average which may be in its favor. However, it cannot be much since the difference is but one year less than the Six group, and 3.4 years less than the Eight group. Whatever advantage this may give the Tens over the other groups is offset by the lower average mental age which is .1 year less than for the Eight group, and .16 less than for the Six group. The Tens are placed at a further disadvantage by the fact that the girls of this group average slightly below ten years mentally, and two have the mental age of 9 3-5. In each of the other groups no individual was below the mental age for the group. The Tens are at a further disadvantage from the fact that two of its members scored lower than the Eights in many of the tests. This was due

in one case to a peculiar disposition which prevented the subject putting forth proper effort, and in the second case to a peculiarity of vision, and a deficiency in the general physical tonus.

The Eights as a group have an advantage of the Tens in two ways, first, a slightly higher mental average, and second, there were two of its members who in many of the tests stood above the highest Tens. These facts should be born in mind in reading the various tables throughout the following pages. The figures are given as different groups scored, but for actual group differences the Tens should be slightly higher and the Eights slightly lower in every case, thus making the differences between the groups Eight and Ten greater than is actually shown by the tables.

Throughout this study the terms Six, Eight and Ten, when capitalized, refer to, or are abbreviations for mental age six, mental age eight and mental age ten. The number of cases in each experiment is uniformly thirty, and is therefore not recorded in the tables.

Experiment 1. Strength of Grip.

Each subject was tested for strength of grip in right and left hand. Three trials were given on each of three successive days. Smedley's Improved Dynamometer was used and directions followed as given in Whipple's Manual of Mental and Physical Tests, Vol. I, page 100. The test was given in the presence of two others of the group. The subject was handed the dynamometer after it had been fitted to his hands, with the following remarks: "John, here, has pulled most one hundred pounds on this dynamometer. Let us see what you can do." This was usually sufficient stimulus to call forth considerable effort, but it is still questionable if the results record the full capacity of the subjects, especially with the lower grades who did not seem to distinguish between grimaces, contortions, and real muscular action. Several trials were made on a subject with no others present. The great variability in the results led the author to discard this method since the results varied so much with different trials that it was evident only a small effort was being exerted. With

the method used the variations were only a few pounds. The average in Kg. for the groups were as follows.

TABLE I

	Right hand	Left hand
Six	25.2	22.5
Eight	29.4	26.5
Ten	29.7	29.2

TABLE II

Girls

	Right hand	Left hand
Six	23.6	22.5
Eight	27.6	25.0
Ten	26.2	25.6

Boys

	Right hand	Left hand
Six	26.8	22.6
Eight	31.2	28.0
Ten	33.2	32.8

In two cases the left hand grip is greater than the right. One Six boy has a record of sixteen kilograms for the right hand and eighteen for the left hand; one Eight girl has a record of 25.5 for the right and 26 for the left hand. The difference between the right and left hand grip is not very large, but it is sufficient to show a difference, and that the feeble-minded is not necessarily ambidextrous as is sometimes claimed.

The norms given by Smedley for 18-year-old boys and girls are as follows.

TABLE III

Boys		Girls	
Right hand	Left hand	Right hand	Left hand
49.28	45.01	27.75	27.66

Comparison with tables 1 and 2 show that the feeble-minded fall considerably below the normal for eighteen year old boys and girls. And the difference is greater between the feeble-minded boys and normal boys than is the difference between feeble-minded girls and normal girls.

Experiment 2. Judgment of Movement.

As a test of ability to perceive and estimate the extent of

a simple movement, the following experiment was performed. In a meter stick, five holes large enough to accommodate a small iron spike, were drilled at such distances that the space between the hole in the middle of the bar and the inside edge of one hole to the right and one to the left was twenty centimeters, and to the two extreme holes forty centimeters to both sides. A flat wooden slide about one centimeter wide was made to lie flat across the bar and slip easily along its surface where the first finger was rested firmly upon it, and the arm moved to and from the body. The meter bar was clamped to the side of a low table before which sat the subject, and opposite him the experimenter. The whole operation was concealed from the subject by means of a cardboard screen placed horizontally between his hands and eyes. The instructions given were: "Place your first finger on the little wooden slide, move away from you when I say 'down' until you hit against the peg. When I say 'back' move back until you hit the nail right in front of you. Move out again on 'down' and so on. When you have made the movement three times, I shall say 'gone' and remove the peg; then you are to move to where you think you stopped before." The signal words "down," "back" and "gone" were given at a definite rate, one every half second, "gone," of course, being the seventh. After a few preliminary trials to insure proper comprehension of the instructions, regular work began. Five trials in each direction and to each of the two distances from the center constituted the twenty judgments comprising one day's work, and six days a complete set.

Table 4 gives in terms of centimeters the average amount of error for each age. Since there is no evidence of learning present, single day's results are not given.

TABLE IV

	20			40			R			L			Av. Errors				
	+	−	S	+	−	S	+	−	S	+	−	S	+	−	S	D.V.	A.D.
Six	..3.3	.3	3.6	.9	1.3	2.4	2.1	.8	2.9	2.1	.9	3.0	2.1	.9	3.0	.8	1.3
Eight	.2.5	.4	2.9	1.4	1.3	2.7	2.0	1.0	3.0	1.9	.7	2.6	2.0	.8	2.8	.9	1.0
Ten	..1.0	.5	1.5	.6	1.3	1.9	.8	.9	1.7	.9	.9	1.8	.8	.9	1.7	.5	.7

Columns headed "+" show errors of over-estimation; "—" under-estimation; "S" the entire number of errors in any one

rubric. Portions of the table headed "20" and "40" give the results for both hands for the distances of 20 and 40 centimeters respectively. Those headed "R" and "L" give the results for both distances for right and left hands respectively. Under "average errors" stand the average results for the entire 120 judgments made by each subject. Therefore, column "S" under "average errors" should be the same as the average of column S under 20 and 40, and the same as the average of columns under R and L. Column "D. V." stands for the average variation of each individual's single day's work from his average for the six days. Column "A. D." shows the variation of one individual of an age group from other members of that group.

On the whole the difference between the three age levels is almost insignificant, the process probably being too nearly on a mechanical level to be much affected by superiority or inferiority of intelligence, but what difference exists, is in favor of the higher levels. The D. V.'s indicate that the Tens are steadier in their work than lower ages, and the A. D.'s that there is less variation of one member of the group from the others of the group than there is with the two lower mental ages. The most interesting facts come out in comparing the plus and minus errors, particularly under 20 and 40. Under 20, we see that the Sixes made a great deal larger plus than minus error. The Eights show quite a considerable plus error, while the Tens show little difference either in under- or over-estimation. This means, as observation of the work also showed, that the lower levels exerted poor judgment in making too great an innervation for the distance they had to cover. They swung back and forth between the pegs with a jar and trusted to the pegs to confine their movements without trying to estimate the movement they were making, or to be guided by their estimation in their final judgment. Hence, the impetus of this impulse carried them beyond their former stopping place. In the judgment for 40 centimeters of movement, more inhibition is to be overcome in making the larger movement, and therefore this tendency is not in evidence. There is practically no difference between the accuracy of the two hands, as is seen from results under R and L. When re-

duced to per cent. of difference we have: Tens, 100; Eights, 36; Sixes, 24. The results seem to indicate that the process here is of so simple and elementary a nature as to have little dependence on degree of intelligence, and that what difference exists, is probably due to the fact that higher levels comprehend and obey the directions of the experiment more exactly than subjects of less intelligence.

Experiment 3. Simple Reaction time to Sound.

The apparatus used was Ewald's chronoscope and reaction keys. The subject was instructed to hold the lever down and let it fly upon hearing the click of the metal hammer. This metal hammer made electric connections and started the chronoscope. The release of the lever broke the circuit and stopped the chronoscope, which counted the vibrations of the vibrator, vibrating at a twenty-fifth of a second. The subject seemed to find less difficulty in letting the lever go than in pressing it down. The act of holding the lever down seemed to keep him in a more favorable attitude for receiving the "ready" signal and reacting to the sound. Whereas, if he held the lever tightly between the fingers in preparation for the signal, attention was apt to scatter.

The subject was seated behind a screen so as to shut off all view of the apparatus and experimenter, but where the experimenter could observe the position and movement of the subject. Preliminary trials were given so as to accustom the subject to the apparatus and to acquaint him fully with the object of the experiment. In the regular series 20 trials were given each day for five successive days, or until 100 reactions were taken. The results for the age groups, and for boys and girls together, are given in Table 5.

TABLE V

Mental Age	Group average	A. D.
Six	.4115	.1302
Eight	.2759	.0236
Ten	.2385	.0311

By this table we see that the Eights are superior to the Sixes by .1356 second, and the Tens stand .0374 above the Eights.

Considering the highest score as 100 per cent., the difference between the mentel levels is indicated as follows.

Tens, 100 per cent.
Eights, 85 per cent.
Sixes, 28 per cent.

For the feeble-minded this experiment involves much more than simple voluntary processes. For them, it requires an act of volition of considerable complexity. The Six finds it an almost insurmountable problem to attend to one of the two foci, viz., the grip on the lever and the hammer click about to appear. To focus attention upon the grip and at the same time to maintain an anticipatory attitude in the margin of consciousness for the sound of the hammer is too much for him, and to associate two images effectively is out of the question. He must attend as well as he can to one stimulus, forego any effectual anticipatory imagery and make his association after the second stimulus appears. This is true, but in much less degree, of the Eights and Tens. The experiment is valuable, however, in showing the difference between the various levels of intelligence in the capacity for what to normal adults is a simple voluntary process.

Experiment 4. Tapping Test.

As a test of sustained attention and voluntary effort, a simple tapping test was used. The apparatus consisted of a telegraph key clamped to the table and connected with an electric counter. A bell was connected with a pendulum to ring every five seconds, and the experimenter with little difficulty learned to read and record the counter on the tap of the bell. The subject was instructed to tap with the tip of the thumb and first finger as fast as possible, until told to stop. The counter was in his full view as he worked, to act as a spur, and praise and flattery were liberally indulged in to procure maximum effort. The series required 24 minutes to perform, and consisted of tapping alternately with the right and left hand twice, for one minute each, with an interval of five minutes between successive periods of tapping. Table 6 gives the numerical results of the experiment for the different mental ages. The figures give the average number of taps made for each age for each ten-second period. Thus Six, column

3. shows the average number of taps made by the Sixes in the third ten seconds. A. D. is the average deviation of each individual of that age from the general average of the group.

TABLE VI

	1	2	3	4	5	6	Av.	A.D.
Six	42.3	45.0	43.6	42.5	41.7	45.9	43.0	.44
Eight	44.8	47.8	47.0	46.3	45.8	45.7	46.4	.49
Ten	54.1	53.7	52.1	51.0	51.6	50.4	51.9	.22

There is some superiority of each age over the next lowest age, but not as much as might be expected from the results of other experiments. The most interesting fact is the shape of the curve of a minute's work for the three ages. The Sixes start low, rise a little after ten seconds, and drop gradually until at the end of the fifth ten-second period they are below their starting point, when they spurt on the last lap to their highest point. This general tendency is interesting in showing the inhibition to be overcome in the initial warming up process, and the quick fatigue in the middle of the course. Yet, the possibility of the sudden high rise at the end shows that, though the subject believes he has been exerting himself, he has really been loafing at his task. The Eights start a little higher than the Sixes, rise by the end of ten seconds and begin to descend slowly until the close, when they are still higher than at first. Here is seen some inhibition at the beginning, but a greater capacity for sustained effort after speed is once up. However, the great variation among the Eights themselves makes any figures for them of only general value here, for half the Eights resemble Tens in character in this work, and a third, Sixes. The curve for the Tens starts highest and after the second ten seconds gradually decreases until it reaches its lowest mark at the end. The effort put forth does not allow them to recuperate at the end for a spurt higher.

All subjects except one left-handed subject showed a higher average with the right hand, which of course, is the most practiced and the least fatigable.

As a means of further studying the fatigability of the different levels, the averages were computed for the first two trials, and the second two trials separately. Table 7 gives the results. Under 1 is given the average of the first trial with both right

and left hands; under 2, the second trial with each hand. Av. gives the average for girls and boys. The figures show that the second trials are poorer for the Sixes than the first trial, while for the Eights and Tens, they are practically the same.

TABLE VII

	Six		Eight		Ten	
	1	2	1	2	1	2
Average	49.2	43.1	46.9	46.5	50.6	50.6

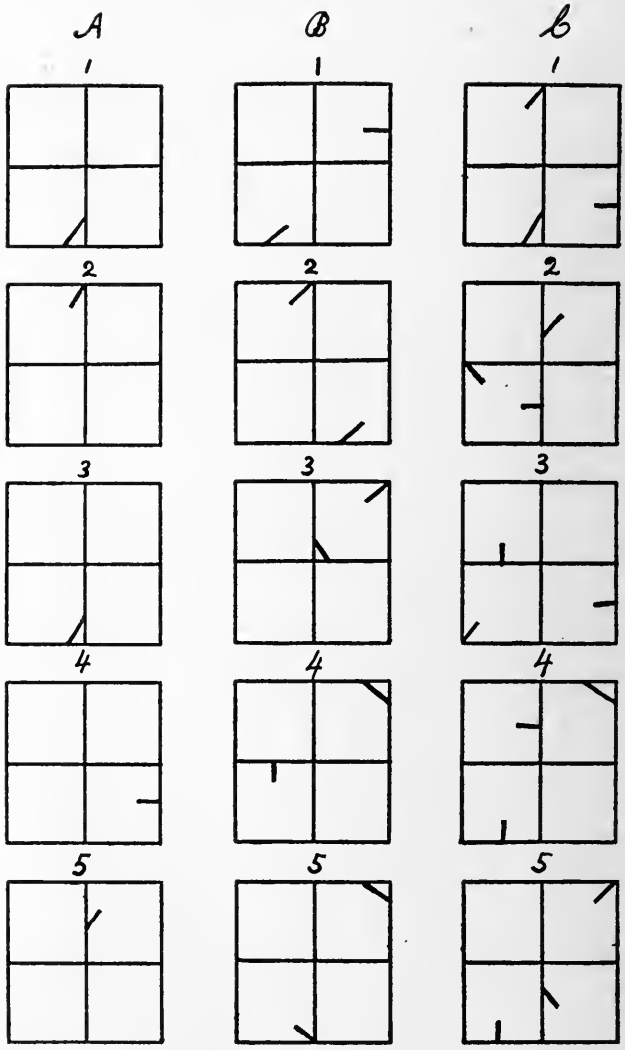
This greater fatigability of the Sixes is partly due to fatigue of attention, but probably for the most part to the fact that they all pounded the keys with great energy and were physically somewhat fatigued by the time they had finished. This expenditure of effort on their part occurred despite the fact that they were all told frequently to tap easily, and were shown how to do so. It is just this lack of judgment displayed here that many students of the feeble-minded find so characteristic. In terms of per cent. the difference between the mental age groups is: Tens, 100 per cent.; Eights, 89 per cent.; Sixes, 82 per cent.

Experiment 5. Visual Attention Span.

The material used in this experiment consists (1) of three series of exposure cards, A, B, and C, the first five of each of which are given in Plate I; (2) sheets of paper containing twenty squares, each divided into four smaller squares similar to the exposure cards but lacking the stub lines. The apparatus used for exposure was Whipple's Tachistoscope. Each series of exposure cards contained twenty two-inch squares, each divided into four equal squares. Short stub lines one-quarter inch long were distributed variously around the sides and corners. These lines may be placed across the corners, project from the middle of the sides at an angle of ninety degrees or forty-five degrees; never at any other angle or position. Series A has one stub line in each exposure card. Series B has two stub lines and Series C has three.

The subject was required to observe the position and angle of the stub lines and to insert them in blank squares placed before him. The exposure interval was sixty sigma. The subject was seated at a distance of four feet from the exposure window with eyes approximately on a level with the fixation point. The

Plate I



following directions were given each subject before beginning the experiment: "Notice the short lines are always across the corners, in the corners, or, as you see, at the middle of the side and turned either straight or slanting. I am going to drop some of the cards before the window. You watch carefully for the short lines so you can remember where they are and put them in the square before you just where they should be." From five to ten trial cards were then exposed first for a longer and then for a shorter interval. As soon as the subject seemed to comprehend the problem and to have adjusted agreeably to the situation, the regular series was begun. If, however, at the end of the ten trials it appeared there was no adequate comprehension, the subject was allowed to copy from the trial cards into the blank square until he understood what was wanted; then the trial series was repeated. This last procedure was necessary with all but two of the Sixes; all but two of the Eights, and all the Tens adjusted to the experiment before the tenth trial—some almost immediately.

The score was obtained by counting the number of stub lines correctly placed. Each subject was put through each series once each day for ten successive days. The time required for a daily sitting of sixty exposures varied between 15 and 20 minutes. The daily average number of correct cases for the different age levels is shown in Table 8.

TABLE VIII

	1	2	3	4	5	6	7	8	9	10	Av.	A.D.
SERIES A												
Six	.7	6.7	7.7	8.0	7.2	7.5	7.3	7.3	8.1	9.0	7.5	2.23
Eight	12.9	12.9	14.1	14.6	14.7	16.1	16.4	16.4	15.7	17.3	15.1	2.6
Ten	14.0	14.3	16.2	17.4	17.2	16.6	16.6	16.8	17.6	17.7	16.4	2.99
SERIES B												
Six	5.9	6.9	6.4	8.1	7.5	8.2	8.9	7.9	6.9	7.0	7.39	2.36
Eight	13.9	13.7	15.9	19.5	18.2	19.5	20.9	22.4	20.8	23.5	18.1	4.66
Ten	17.7	18.3	20.0	20.7	20.4	21.0	22.4	22.5	23.9	24.0	21.04	5.34
SERIES C												
Six	6.3	5.7	6.0	6.9	7.1	7.7	5.8	5.4	6.8	10.0	6.77	2.35
Eight	15.3	15.1	16.9	16.6	18.5	18.7	18.4	20.2	19.9	23.9	18.31	5.43
Ten	17.7	18.8	19.0	22.9	24.4	24.5	24.3	27.1	27.0	26.0	23.17	4.31

In series A the Tens score an average of 1.30 above the Eights. This difference alone is not sufficient to indicate a real superiority, but this low score on the part of the Tens is due to

the fact that they were doing so well that they could not feel the necessity of doing better. The Eights' score was slightly over double that of the Sixes. The relation of the three levels to each other stand as follows:

For Series A: Tens, 100 per cent.; Eights, 92 per cent.; Sixes, 45 per cent.

For Series B: Tens, 100 per cent.; Eights, 84 per cent.; Sixes, 35 per cent.

For Series C: Tens, 100 per cent.; Eights, 79 per cent.; Sixes, 28 per cent.

It will be seen from the total average column of Table 8 that the difference between the achievements of the different mental ages increases from series A to C, or with the increasing difficulty of the series. In series A, the Sixes are 45 per cent. of the Tens, while the difference between the Tens and Eights is only 8 per cent. In Series B, the Sixes are 35 per cent. of the Tens, while the difference between the Tens and Eights increases to 16 per cent. In Series C the Sixes fall to 28 per cent. of the Tens and the difference between the Tens and Eights is 21 per cent.

The A series is not a real test for ages above six. The Eights score 75 per cent. and the Tens 82 per cent. correct cases. If we consider this score alone, it appears that it is difficult enough, but the experiment did not create a sufficient demand for effort. It was easy enough after a few trials to observe the correct position of one stub line and consequently there was not sufficient effort put forth to prevent one from slipping by occasionally. On the other hand, 35 per cent. of the correct cases would indicate that the test is too difficult for the Sixes. But their behavior and attitude toward the problem showed a clear comprehension and a general endeavor to score, which would at least indicate that the A series is a good measure for effort of attention. At the same time it gives the subject an opportunity to show whether or not he belongs to a higher level of intelligence. The Eights make their highest score in Series B. Likewise the learning curve is higher here than in Series C, indicating that C is too difficult, either because they become

discouraged and cease to exert maximum effort, or because the effort to grasp three stub lines at one exposure causes confusion of imagery. The Tens make their highest score in Series C, also their learning curve rises highest in this series. There are a few cases in which three stub lines are scored at one exposure, but this represents the maximum of effort. If a subject scored three stub lines at one exposure the score for the next exposure immediately following was sure to fall to one, and more likely to zero.

In consideration of scores made and peculiarities of the groups of Eight and Ten already mentioned, the norms for the experiments should be as follows.

Sixes should score 6 in five trials in Series A.

Eights should score between 15 and 20 in five trials in Series B.

Eights should score between 15 and 20 in five trials in Series C.

Tens should score between 20 and 25 in five trials in Series C.

The learning element in this experiment is small. It is hardly at all perceptible for Sixes and not large in either of the other two levels. If comparison is made between the average for the first five trials and the average of the second five trials of each series, the results stand, as given in Table 9.

TABLE IX

	Series	Av. for first half	Av. for second half	Gain in second half
Six	A	6.10	7.60	1.50
Eight	A	13.84	16.38	2.54
Ten	A	15.82	17.06	1.24
Six	B	6.76	7.78	1.02
Eight	B	16.22	21.32	5.10
Ten	B	19.42	22.76	3.34
Six	C	6.40	7.14	0.74
Eight	C	16.48	20.22	3.74
Ten	C	20.56	25.78	5.22

In this experiment each series was repeated ten times. In Table 9 the left hand column of figures shows the average correct score for the first five trials of the series. The middle column gives the average correct score for the last half or the last

five trials. The right hand column gives the gain made in the last half of each series. There are only two cases out of the thirty who show any drop at all in the second half and these proved to be of an unstable nervous temperament. The Sixes make very little gain in any series. The gain for the Eights in Series B and the gain for the Tens in Series C is rather light, but greater gain is made by the end of the first half of the series, or by the fifth or sixth trial, so that the gain is made by holding the score reached by the end of the first half.

In order that the test may be uniformly one of attention span, each position of the stub line in Series A should be as difficult as another, and in Series B and C, each group of stub lines, or the stub lines grouped in one exposure should be as difficult of perception as the group found in any of the other exposures of the series. This does not seem to have been the case, and it is perhaps not possible to distribute the lines over the field so as to make the large squares of equal or of a graduated difficulty of perception. In Series A, Nos. 10, 19, and 20 gave special difficulty, and there was a general tendency to get the lines of the lower square into the upper squares. In Series B, No. 13 was easiest, No. 16 quite as difficult as any. In Series C, No. 8 was among the first to be gotten correctly. In general, the lines about the center of the square where distances were less, were the most confusing. Two lines in the same small square close together or on the right or left side of the large square presented less difficulty, also lines of similar quality. There seems to have been confusion when the line of vision passed the cross lines of the large squares. This may be due to the tendency of the eye to follow the lines or simply to the greater complexity of the perceptual image. It would seem that one large square with the stub lines distributed around the sides and corners might make a test more nearly free from the disturbance of external factors. Something on this order would have the advantage of greater simplicity, and the stub lines could be more easily grouped in order of difficult.

The experiment has revealed three differences in the mental levels chosen, viz., differences in comprehension of simple prob-

lems, adjustability, and attention span. The first two are not measurable in mathematical terms for this experiment but can be indicated. The Sixes had virtually to be put through the experiment before they could comprehend it, and they required the longest time to adjust even inadequately to the situation. The Eights can comprehend more easily, but required concrete demonstration, and adjusted more slowly than the Tens. The Tens comprehended from a verbal explanation and took up the proper attitude for work and adjusted most readily within five minutes.

Differences in attention span are fairly represented in terms of percentage: Tens, 100 per cent.; Eights, 84 per cent.; Sixes, 45 per cent.

Experiment 6. Discrimination of Grays.

As a test of sensory discrimination, matching different shades of gray was used. The apparatus consisted of a card board about 12x18 inches, in which were fifteen openings two inches square, arranged in three rows of five squares each. In each square, except the middle one, were pasted from one to fourteen thicknesses of white tissue paper, one thickness in the first increasing by direct increment of one up to fourteen. Around the middle opening were arranged strips of cardboard to form a casing in which to slip small square frames. There were fourteen of these frames consisting of two-inch square pieces of white tissue paper, each frame holding thicknesses varying from one to fourteen pieces to correspond with the openings in the large card. The card with the fifteen openings was pasted flat against a ground glass window with a north light, and the subject seated directly in front of it. (Of course the light showing through the papers would produce the brightest gray in the square with one thickness of paper and the darkest for the fourteen thicknesses). A small frame was then slipped into its place in the middle opening, and the subject told to "point to the gray just like this one." A constant irregular order was used to insure procedure without knowledge of the subject. Matching each of the fourteen grays twice comprised one day's work, and

three days, or eighty-four judgments for a subject, constituted a test.

All subjects comprehended the task readily, yet it was difficult to get some of the lower grades to take the time and pains to really discriminate. Then, again, three of the Tens took so much time to make their decisions that after-images and fatigue must have had something to do in affecting the value of their judgment.

In scoring a judgment, the amount of error for that judgment was estimated by the distance in the scale of grays lying between the gray chosen as identical with the standard and the one actually identical. For example, if gray number 14 was shown, and the number 12 pointed to as identical, the error was recorded as 2, or if 13 was chosen when 10 was shown, the error amounted to 3. The average for each day's trials was taken and the average for the entire three days' work. Since there was no evidence of effect of practice, only the average results are given. which are contained in Table 10.

TABLE X

Six	Eight	Ten
2.7	1.5	1.3

The errors for all levels are surprisingly few, though Sixes show a score of errors twice as large as that of the other ages. The three levels would have been more nearly equal but for four very careless Sixes. In term of relative percentage it amounts to, Tens, 100; Eight, 98; Sixes, 80.

The following table gives the average error for each particular gray, ranging from one, which stands for brightest, to 14, the darkest. Naturally the easiest grays to discriminate in this series are the brightest, and the most difficult the darkest.

TABLE XI

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Six	2.7	2.7	2.3	2.0	2.6	2.2	2.7	2.7	2.8	2.9	2.9	3.0	2.6	3.0
Eight	0.6	1.1	0.8	1.6	1.8	1.3	0.9	2.2	2.4	1.9	2.3	1.6	0.7	0.4
Ten	0.2	0.8	0.8	1.2	1.3	1.2	1.6	2.6	1.8	2.2	1.9	1.8	1.1	0.6

The Sixes make about the same amount of error for each

gray, showing that it is not for them so much a matter of difficulty of discrimination, as whether they could attend closely enough to compare. The Eights show more nearly the error curve we should expect, except in the big drop in the middle at seven. Here again attention is the factor which explains, for seven was to the left of the window into which the variable gray was slid, and the one with which it was natural to compare it. Hence, fewer mistakes were made here than might be expected.

The experiment, on the whole, does not seem a particularly good one for detecting differences in mental levels. In fact, results indicate that when an imbecile can be induced to attend, his powers of discrimination are about equal to those of a moron. But the fact that he concentrates perfectly one minute and wanders the next, makes the results less valuable as criteria of discriminability than of attentive capacity.

Experiment 7. Judgment of Forms.

It is quite evident that feeble-minded children and adults have sensations not greatly different from normal persons except in the time of response. The difference, then, should lie in what might be termed the manipulation of mental elements or mental imagery. We have attempted an experiment which should test the relative ability of the different mental ages to receive, retain and transfer imagery from one sense to another.

A number of forms were cut from thick pasteboard and mounted on other pasteboard cards five inches square. The subject was allowed to pass his hands under a cloth screen and to feel of the form by passing his fingers around the edges and over the top while it was held in a stationary position. After this he was required to point out the form just felt among the ten forms drawn full size on one large card. The subject was given directions as follows: "Put your hands under this cloth and feel of a form there something like this one, until you are sure you know what it looks like, then I will let you see these drawings, and you are to point out which one you have just felt."

The series was presented once each day for five successive

days, one trial being allowed for each form, or 40 trials in all. The results are given in Table 12.

TABLE XII

		Av. daily errors				Av. total errors	A.D.
Six	5.6	6.8	7.1	6.7	6.5	6.54	4.32
Eight	4.2	3.8	4.9	1.2	1.2	3.07	4.00
Ten	3.7	1.6	3.4	1.7	1.45	2.37	4.32

According to Table 12 the average errors for five trials is not large for Eight and Ten. In terms of per cent. the difference between the levels stands thus: Tens, 100 per cent.; Eights, 90 per cent.; Sixes, 45 per cent. Following the daily score from left to right, it will be noted that learning is quite rapid for Tens and Eights. When we add to this the fact that errors were almost constantly made on three particular forms, the experiment does not appear to have much value. It may, however, be a test of superficiality since it would have been quite possible for the Eights and Tens to have made an almost perfect record. They were satisfied with approximate certainty. The characteristic to be content with approximate results and to overlook small but essential differences is not so apparent in experiments that at once challenge effort and put the subject on his mettle.

Experiment 8. Judgment of Forms, Two Dimensions.

On account of the relatively unsatisfactory results found in experiment No. 7, that experiment was modified and another experiment attempted. This contains the same forms as Experiment No. 7, but they were rendered more difficult by cutting off corners and thus changing their shape. The procedure was further changed by allowing the subject to observe the forms he had felt instead of the drawings of them. This changed two factors simultaneously with the result that we cannot ascribe difference in results to either of the two factors, more difficult forms, and the observations of actual forms instead of drawings of them. However, a few forms were not changed but remained the same for both experiments, 7 and 8. Comparison of the blanks for both experiments show only a very slight improvement in Experiment 8 for forms not changed, while for the changed forms, the score immediately drops off. This would in-

dicate that there is little difference in observing actual forms or drawings of the forms. However, there was a greater interest in choosing the correct forms from the real forms than from drawings. The results of the experiment are given in Table 13.

TABLE XIII

	Av. daily errors					Av.	
	1	2	3	4	5	errors	A.D.
Six	8.4	9.2	8.4	8.2	7.9	8.52	4.16
Eight	5.3	4.2	4.3	4.4	2.8	4.26	5.96
Ten	3.4	2.7	3.6	2.0	1.6	2.66	4.29

The relative differences between the age levels are: Tens, 100 per cent.; Eight, 78 per cent.; Sixes, 20 per cent.

The differences here in scores are more marked than in Experiment No. 7. There is need for greater attention; discrimination is finer and the process of identification more complex. And yet it appears that the fundamental process is one of transfer of touch and kinaesthetic imagery to visual imagery. It is probable, however, that the discrimination is due to practice in alternate feeling and seeing since an expression of recognition is made on feeling of an object which has been, just previously, the focal point of attention. It becomes, therefore, the recall of a visual image through touch and the recognition of this image through vision. In feeling of an object not yet seen, the image is indefinite until it has been seen. When the second touch-motor experience takes place, the process is simultaneously touch-motor-visual.

The test is not a good one for the Sixes. The children of this level do not have the necessary capacity for sustained consecutive thought. The low score would indicate that the Sixes are out of court here. Chances are one in ten for a correct score, which lowers the actual choice and renders the test unfit. Besides the attitude in rendering a choice indicates they were making a wild guess.

The problem is entirely within the capacity of the Eights and Tens, but Experiment 8 is superior to Experiment 7, since it calls for clear attention and finer discriminations. The norms for this test should be 50 per cent. correct for Eights and 70 per cent. for Tens.

Experiment 9. Judgment of Sizes, Two Dimensions.

This experiment was designed for the same general purpose as seven and eight, and is constructed on the same plan, except that the forms remain constant while the size varies. Four different forms were used, the circle, rectangle, triangle and square. These sizes were made from heavy cardboard and mounted on cards five inches square. The procedure was the same as in Experiment 8. The dimensions for the forms are given in Table 14.

TABLE XIV

Circles	Diameter	Squares	Side	Rectangles	Triangles	Base	Altitude
1.	1¾ in.	1.	1¼ in.	1. 1 x2 in.	1.	1½ in.	1½
2.	2 in.	2.	1½ in.	2. 1¼x2¼ in.	2.	2 in.	2
3.	2¼ in.	3.	1¾ in.	3. 1½x2½ in.	3.	2½ in.	2½
4.	2½ in.	4.	2 in.	4. 1½x4 in.	4.	3 in.	3
5.	2¾ in.	5.	2½ in.	5. 1¾x3 in.	5.	3½ in.	3½

The forms were presented once each day for five successive days, thus making 20 trials each day, or 100 trials in all. Errors were determined by counting the number of places a size was removed from the correct place, e. g., if the subject judged No. 1 to be No. 2, the error would be one. If No. 3 was judged to be No. 5, the error would be two. Since there are five sizes called for in each form, the highest possible error for any judgment is four, and for the four forms given at one sitting is 80. It would therefore be possible for a subject to score 400 errors for the five sittings. Table 15 shows the results for this experiment.

TABLE XV

		Av. daily errors of all forms					A.D.
Six	19.9	21.4	18.3	20.0	19.0	19.9	2.1
Eight	11.8	8.7	8.6	8.3	9.0	9.2	2.0
Ten	8.7	6.5	6.6	5.1	4.0	6.1	1.5

This experiment is too difficult for the mental Six. It was quite evident that his judgments were largely accidental. However, his error for any one judgment is rarely over two, but commonly one. The Eights and Tens comprehend the problem readily and have very definite feelings as to the correctness of their judgment. However, in the first trials there is a feeling of uncertainty, and the subject will remark: "Well, I don't know, I am guessing." The guess, however, is more often correct than

otherwise; so much so that one is inclined to infer that the touch and kinaesthetic image is directing the choice, although it has not yet quite fused with the visual image. One form was about as difficult to judge as another.

The differences between the various ages are as follows: Mental Tens, 100 per cent.; Eights, 77 per cent.; Sixes, 7 per cent.

This test might be a serial test beginning with the six-year level if a score with error one is considered normal for the Sixes. In this case there should be allowed no more than 10 per cent. of error in going through the four series once. The Tens should be able to go through the four series once with no more than 25 per cent. of error, the Eights with 35 per cent. of error.

Experiment 10. Judgment of Forms, Three Dimensions.

It seemed from the behavior of the subjects in Experiments 8 and 9 that discrimination involving variation in three dimensions instead of two might involve a more complex mental process in the transfer of touch into visual imagery. Twenty hardwood blocks were cut out, ten with the dimensions 2 in. by 2 in. by 2 in; ten 3 in. by 2 in. by 1 in. These blocks were then shaped into a series somewhat on the pattern of the forms used in Experiment 8. The blocks are given in Plate II. It was attempted to make these forms into a series of graduated difficulty of perception, but results show that some represented much greater difficulty than others.

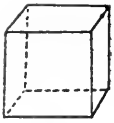
The same procedure was followed in this experiment as in Experiment 9, except that the blocks were held stationary by two small holes bored in each block which fitted over two brads driven into the table just before the subject, and the blocks were placed in four rows always in the same order. The subject was put through the series once each day for five successive days. The results are given in Table 16.

TABLE XVI

	Av. daily errors						
	1	2	3	4	5	Av.	A.D.
Six	15.7	15.9	15.5	15.5	15.2	15.56	7.5
Eight	11.0	10.4	8.1	7.4	5.8	8.44	5.8
Ten	5.8	4.6	4.6	2.7	2.1	3.96	4.4

The above table shows the same characteristic group differ-

Plate II



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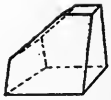

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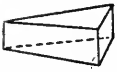

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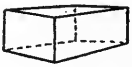

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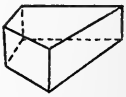

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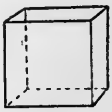

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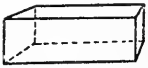

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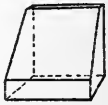

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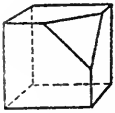

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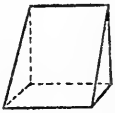

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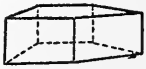

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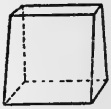

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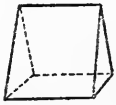

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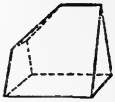


19

20

ences as are seen in Experiments 7 and 8. The Sixes can distinguish very simple forms, but cannot proceed beyond these. The differences are: Tens, 100 per cent; Eights, 71 per cent., and the Sixes 21.4 per cent.

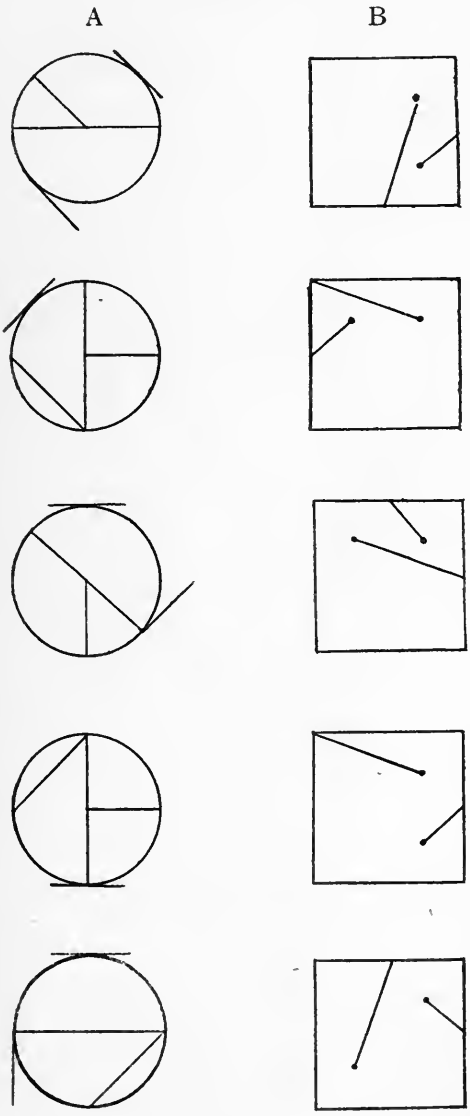
A few forms were recognized by all—the cube, the rectangle and the divided cubes, 6 and 7, were most often confused and presented difficulty to all subjects. The Tens adjust the most readily, the Eights more slowly and the Sixes not at all. The experiment offers opportunity to observe the readiness of adjustment on the part of the subject. There are many forms so similar that they could be distinguished and differentiated only through trial and error. The psychological process is difficult to determine since introspection is much needed here for anything like a correct interpretation; but introspection is something the feeble-minded cannot furnish. A few illusions evidently arise which disappear only with direct comparison. A large portion of the form comes immediately as one passes the fingers over the blocks, or shoots into form as the fingers turn the corners or measure the angles. But even with this immediate flash into consciousness there remains a certain indefiniteness to the imagery until the object is observed visually. After getting the touch and kinaesthetic experience it remains for the subject to retain the image against the visual perception of many forms, some similar, until the form identical with his image is sighted. The subjects differ apparently in two ways. One class was "impressionist" and the other "rationalist." The former are visualists and do not consciously turn over the imagery mentally, but rely upon a feeling of familiarity to determine their choice as they looked over the field of 20 blocks. The second class would note similarities, but they would fix upon one essential difference and rely upon this factor for the choice of a block. Those who pursued the latter method were able several days after the last trial had been concluded to pick out the form felt when the blocks were piled miscellaneously in a heap on the table, without a single error. The "impressionists" were not able to do this and when asked to indicate how they distinguished the forms one from the other, could not do so. Dis-

crimination by noting carefully the characteristics of the object was common to both Eights and Tens. But the Tens exercised more control than did the Eights. The experiment calls for perceptions of relations, capacity for forming clear-cut distinctions, and a certain small amount of reasoning. While it is not an absolute certainly, there are certain strong indications that it requires some mental effort to make the transfer from a touch-kinaesthetic imagery to visual, and that this experiment reveals the process in an elementary way. The experiment as a whole was more interesting to the subjects than Experiment No. 9, and for this reason is superior as a mental test.

Experiment 11. Memory for Geometrical Forms.

As a test of simple visual memory, ten cards, each containing a geometrical form were used. Each form consisted of a circle two inches in diameter, with the diameter drawn through it horizontally, vertically, or at 45 degrees from either horizontal or vertical, one or two one-inch lines lying outside the circle as tangents, and one or two one-inch lines lying inside as chords, there being always four such lines in all to a circle, as shown in Plate III, A. Since each drawing was entirely different, by turning a card in each of the four possible positions, forty instead of ten variations of form were produced. The cards were placed in two parallel rows on a table at which the subject sat, the order being a definitely planned irregular one, to avoid the factor of place memory. A cloth curtain hung before the subject to conceal operations. The subject was told, "I am going to show you a card with a drawing on it, study it, and after ten seconds I shall take it away, and you must pull the curtain aside and point to the one you have been studying." The card was slipped under the curtain and shown to him for the ten seconds, and immediately put back into place, when he tried to pick it out from the other drawings. After the ten cards had been exhibited, they were placed in the second position, then in the third and fourth, thus making forty trials in a day's work. Three days' work of 120 trials for each subject constituted a complete series.

Plate III



After the above experiment on immediate recall, a similar one was used for delayed recall, the only difference in method being that the subject waited ten seconds after having seen the card before he tried to select it from the others. Here, owing to necessity of leaving experimentation entirely, only two days' records were taken and only twenty judgments on each day, making forty the total number.

In a third experiment the delay was extended to one minute. Since only ten judgments could be allowed here, the results do not bear a value entirely comparable with those of the first two forms of the experiment, but the results are given for what they are worth.

Table 17 gives the average percentage of correct cases for each age of the three forms of the experiment.

TABLE XVII

	Immediate recall	10-second interval	1-minute interval
Six	16	20	20
Eight	56	55	63
Ten	77	90	85

There is quite a distinct and remarkable difference between the different age levels. The Sixes do practically nothing, the Eights get about half, and the Tens more than three-fourth. The task of discriminating the differences between the arrangement of meaningless lines was too complicated and difficult a problem for the weak attentive capacity of the Sixes. Memory hardly seemed a factor here, judging from their careless manner of studying the card during its exposure and the haphazard way in which they made their selection when it was time to judge what card they had seen. The Eights were more sensible in their methods, but it is probable that here, too, discriminability and attentive capacity was an important factor.

Reduced to per cent. difference, the three ages stand:

Immediate recall—

Sixes, 20

Eights, 72

Tens, 100

Ten seconds delay—
Sixes, 22
Eights, 60
Tens, 100
One minute delay—
Sixes, 23
Eights, 74
Tens, 100

For the Tens only is there any considerable difference between the three forms of recall, who profit by the ten second intervals, and are but a little lower after one minute interval, though higher than in immediate recall. Individual figures show no learning for any age, except for the Tens, and here only a very slight degree.

The experiment demands too great a degree of attentive capacity for the Sixes, so that whatever value it might have as a measure of retentiveness is eliminated. Perhaps it is even a little too difficult for the Eights, but for Tens it might make a good mental test, if 70 per cent. or more correct judgments were required, with an improvement in the case of delayed recall. Eights should be required to get about half the cases right for immediate recall and do at least no worse in delayed recall.

Experiment 12. Modified Typewriter.

This was an experiment in learning a connected series of visual-motor coordinations. The apparatus used was an arrangement resembling in principle a simple typewriter of four keys. On each key was pasted a color, and when any key was pressed a different color appeared just above it, through a slot in a vertical screen, which was the color of the next key to be struck. A red key threw up yellow; a yellow, blue; a blue, green, and green, red, the last key of the series throwing up the color of the first, making an uninterrupted process to be continued until a signal to stop. Each key was connected with an electrical counter, so that every stroke registered a count. A bell was connected with a second pendulum to ring once every minute, as a signal for starting and stopping. The errors were easily observed and recorded by the experimenter. After the principle

of the apparatus and the task was explained briefly to the subject, he was allowed a few trials to make sure that he understood. Every subject was instructed to use four fingers, the first and middle fingers of both hands, and to strike each color with its own particular finger. But the latter was impossible for some subjects, and though all were given the same instructions, only part of them succeeded in using four fingers. Ten one-minute trials a day with a minute interval between successive trials and six days' work constituted a regular series. When results indicated that the subject might be able to work without the aid of the visual cue, a cardboard screen was placed to conceal both the colors on the keys and the small colors the keys showed on being pressed. Where a subject could not work without the aid of vision at the end of six days of practice, the series was continued for four more days. The numerical results show only six days' work. Throughout, the subject was kept informed as to the score and mistakes.

The problem for the subject then involved a series of four motor reactions to specific visual cues. It comprised the perception of the color shown through the slot, the perception of the key with the same color pasted on it, the choice motor reaction involved in the pressure of that key, and the choice of the finger used.

Table 18 shows the results in numerical form for the different mental ages. "S" indicates the number of strokes in a minute, "E" the number of errors, and "C" is "S" minus "E," or the correct strokes. The figures at the head of the columns indicate days. Thus the figure under Six, column 6, "S," stands for the average strokes made by the Sixes on the sixth experimental day. Column A. D. gives the average deviation of each individual of the group from the average for that group.

TABLE XVIII

Days—	1	2	3	4	5	6	Av.	A.D.
SIX								
S.	27.0	35.2	42.7	48.9	53.3	61.8	45.5	
E.	4.3	4.9	4.5	5.2	6.6	7.0	5.8	
C.	22.7	30.3	38.2	43.7	46.7	54.8	39.8	21.8
EIGHT								
S.	50.8	81.8	114.3	128.0	138.3	147.4	111.0	
E.	5.7	5.7	6.6	9.7	6.1	2.1	5.0	
C.	45.1	76.1	107.7	118.3	132.2	145.3	106.1	44.4
TEN								
S.	85.4	151.3	187.5	217.7	246.9	281.8	201.7	
E.	4.7	2.9	1.7	1.6	2.8	2.1	2.7	
C.	80.7	148.4	185.8	216.1	244.1	279.7	299.0	37.9

All ages show an increase from day to day, the sixth being about twice that of the first day's record. The Sixes start lowest and increase at the slowest rate, the Tens start highest and increase at the fastest rate, while the Eights show a result just between the two. The errors of the Sixes remain about constant, though the number of strokes increases, showing an improvement in accuracy; the errors of the Tens decrease, despite the great increase in strokes, giving a practically perfect record as to accuracy, while the Eights again show a middle tendency. Though the A. D. is large, it indicates rather a variation within the group than an over-lapping of the three groups.

Further interesting differences of the three mental ages is seen in the following table, which gives the result of each trial for the first days' work done by the three levels.

TABLE XIX

Trials—	1	2	3	4	5	6	7	8	9	10
Six	16.4	17.4	20.2	21.5	21.9	22.3	25.5	27.6	24.3	28.8
Eight	29.7	35.1	34.8	42.0	42.8	47.3	48.5	49.1	57.8	61.7
Ten	47.8	67.6	75.3	87.8	99.4	98.9	108.2	110.4	117.6	120.7

As in the case of the record of the entire time, the Sixes start very low, the Eights almost twice as high as the Sixes, and the Tens twice as high as the Eights, while about the same relationship holds between each of the ten trials.

In their manner of working, the subjects fell into almost as definite groups as their numerical results show. All subjects grasped the problem after some slight explanation, but the Sixes required more instruction and more practice before regular work could be started. Using four fingers, one for each key, seemed to

be the most difficult task of all and only two of the Sixes succeeded in doing so, even after the tenth day. Half of the Eights managed it, with considerable difficulty, but all of the Tens were using four fingers by the end of the second day's work. Of course, this was a more economical method if it could once be acquired and resulted in a quicker mechanization of the process and a more rapid rate of work. For half of the Eights and all but two of the Sixes, it was too complicated a matter to distinguish the proper one of the four fingers and use it when required, and no results would have been possible had they not been allowed to use only the index finger of each hand.

Sixes with one exception were careless in their work, and many times they would push any key which happened to be the easiest, until urged to be careful. Three of the Eights were faulty in this respect, but rather on account of confusion resulting from effort at high speed at the expense of correctness, while Tens were all anxious to make a high score, all were noticeably more careful than the Sixes, or the average run of the Eights.

There were varying degrees of interest on the part of the subjects in the problem itself, in the subject's own progress, both in respect to his own record and his relation to others. Sixes were all working only because they were told to, and any effort exerted was merely for the sake of approbation. Eights were interested at first and glad to work, but toward the end of the time became tired of the experiment and wanted to quit, or take up something new, yet when once at work they all seemed to put forth considerable, if not maximum, effort. One exception to the Eights is to be classed with the Tens. The Tens from the first were interested. There was a high degree of self rivalry, and of rivalry with each other. Each child knew his score, and remembered it to compare notes with the others later. Among the Ten boys this was very pronounced; so great was their desire to excel that all practiced the finger movement, whose sequence they easily learned in the first and second day's work, and when in their playroom one used a table top, two a piano, one an organ, and one drummed in the air. The practice of the girls was all confined to work in the laboratory.

Only one Six was able to work with the keys and small colors concealed. One Eight managed it on the second day; five on the third; one on the fifth; one on the sixth, and two not at all, while all of the Tens succeeded by the beginning of the third day—five on the first day, four on the second and one on the third.

The experiment is a valuable one for indicating the ability of an individual to comprehend a simple explanation of details, his power of motor coordination, capacity for voluntary effort and sustained interest. It might be used as a simple test of intelligence if ten trials were taken at one sitting. When according to our results a Six should comprehend the experiment, be able to use two fingers and have a record averaging about 20 correct strokes, with a moderate increase in his curve from first to last. An Eight should comprehend that he is to use four fingers and make some attempt to do so and reach an average of about 50 correct strokes. A Ten should use four fingers correctly by the tenth trial and make an average of at least 75 correct strokes.

Experiment 13. Ink Blot Test.

As a study of imagination an ink blot test was used, the ink blots being the first ten in the series of twenty described in Whipple's manual of Mental and Physical Tests.

A card was shown to a subject to whom it was explained that "This blot was made by dropping a blot of ink and smearing it around. What do you think it looks like? Of course it is not exactly like anything, but what does it make you think of?" After giving all he could see in one position, the card was changed until it had been in all four positions. Two minutes were allowed, but most subjects refused to look longer than a minute and a half, and many would use less than one minute. This was particularly true of the Sixes and least true of the Tens.

Naturally the experiment does not lend itself well to numerical classification, but we find, in a rough way, that the average number of objects seen to a card are:

TABLE XX

Sixes	Eights	Tens
1.6	2.8	3.2

This shows an increasing superiority in wealth of imagination from the lowest to the highest grade. Reduced to terms of per cent. of difference, it stands:

Sixes 50
Eights 87
Tens 100

The Sixes found difficulty in seeing a different object in an ink blot when once it had suggested anything to them, and no matter in what position this card was turned, the picture was apt to remain the same. The blot was to them not so much a suggestion of an object as an actual picture of that object. To a less extent this tendency existed among the Eights, but was hardly noticeable in the Tens. An occasional Six enumerated objects which the blot could not have suggested and which they could not point out when asked to do so. To all children the blots suggested mainly people and animals, but the Sixes only name the object, the Eights add some description and qualifying terms, while the Tens both describe and attempt to interpret and give a somewhat subjective character to their report. Thus a Six would say: "That's a lady, here is her shoe and here is her hands." An Eight would state: "That is a lady with her hair all tumbling down, and holding her foot in her hand," while a few Tens would say: "She is all excited, and she is kicking up her feet and her hair is tumbling down and she is angry." Tens were the least concrete and limited in their range of objects suggested by the pictures, such as "dead leaves blowing across a ravine," and situations occasionally being given instead of definite well-known animals, persons or common objects. Eights possessed a very little of this tendency, but Sixes none at all.

Since the work had to be discontinued before the experiment could be carried further, the above account is given rather to indicate the possibilities of the "ink blot test" as applied to the feeble-minded than as an attempt to show anything conclusive. A more careful study along this line would be well worth while.

Experiment 14. Drawing Designs From Memory in Inverted Position.

The material used in this experiment consists of twenty 2 by 2 inch squares drawn on a pasteboard card 3 by 4 inches. In each square were drawn two lines projecting inward from the middle of the sides or from the corners as is shown in Plate III, B. Sheets of paper containing twenty blank squares of the same size were supplied. The subject was presented with the designs one at a time with the following instructions: "Study this design until you can see where these lines would be if the square were turned around until the bottom is where the top is and the top is where the bottom is. As soon as you can see where both lines should be, and can remember, start to draw them in this blank square and I will take this one away." It was necessary to say "turn around," otherwise the subject might conceive the card as "turned over" and would conceive it as transparent, and draw the lines accordingly. The subject was allowed as much time as he needed. If attention appeared to wander, the experimenter would say: "Just as soon as you have it, I will take the card away." Each subject was put through the series of twenty once each day for five successive days. The results are given in Table 21. The score is obtained by counting the number of lines correctly placed. It would therefore be possible to score forty at each trial.

TABLE XXI

	Daily average of correct cases						
	1	2	3	4	5	Gen. Av.	A.D.
Six	0	0	0	0	0	0	0
Eight	1.4	5.4	11.6	10.7	16.0	11.02	9.7
Ten	13.3	19.7	19.2	22.0	27.6	20.36	3.7

This table shows the average number of correct cases for Eights to be 4.56 out of a possible 40, and for Tens 10.18 out of 40. The score is too low to indicate any adequate comprehensions on the part of either the Eights or Tens. But the daily averages show the learning in both cases to be rapid. The Eights rise from 1.4 on the first day to 16.0 on the fifth day. The Tens increase from 13.3 to 27.6 in the same time. This is

not a large score, since it is possible for a subject to score 40 by the fifth trial, as was actually done by two of the Tens, and yet the score together with a constant intelligent effort on the part of higher grades would place the test within the comprehension of Eights and Tens. No norms, however, can be suggested, but it is quite likely better results would be obtained if only ten designs were used and the sittings continued over ten days.

This experiment was calculated to be a test of what the writers have termed manipulation of mental imagery. The experiment has in some means met the purpose for which it was designed. Visual imagery figures largely in this problem, but motor imagery, or simple calculation with whatever imagery used may suffice.

A certain number of persons were unable to tell how they do this experiment; they "just see it." But among the 30 feeble-minded cases certain characteristic kinds of behavior were observed. They would seize upon one line, attempt to image it, turn around to the reversed position, become confused on the first turn and slip back to try again. Or they would succeed in getting it to the reversed position, then forget or be unable to image which way it should slant. Some would succeed in getting one line reversed, but would forget its position before the second line had become located. Again, they might apparently succeed in imaging the design reversed and then lose the image entirely before it could be drawn. Not a few would go a step further, and lose only one line in the process of construction. A few would draw the lines not reversed but as presented. This is an interesting phenomenon of confusion of imagery. The subject sees the design reversed and then reverses this image, and consequently draws the design as first presented. Two of the subjects, both Ten boys, succeeded by the end of the fourth day in making a perfect score. They had discovered the principle that the lines must take opposite positions. They would take one glance at the design and then draw. It appears they imaged the design as presented, then drew the lines according to the principle in opposite positions.

Whatever the method finally adopted, the initial trials involve a mental process of considerable complexity. The Sixes seemed to realize what was wanted, but were totally unable to make the essential mental change. The writer made several individual experiments of a simpler sort, on four different Sixes. A simple drawing of a tree was presented upside down, with the instructions to draw it right side up. Invariably it would be drawn with the trunk upright, but the branches would slant down at an abrupt angle. One case succeeded in drawing a boy with his head on the ground and a crude body on top of that, but when he came to the legs, they were put on the shoulders slanting down to the ground.

The problem is, however, within the grasp of Eights and Tens, with the advantage decidedly in favor of the Tens. Four Eights failed almost completely and two Tens made very poor records.

An attempt was made to correlate the time required to draw the twenty designs with the accuracy of the drawing, but there seemed to be no relation. Some seemed over-cautious and would take so much time that they became confused, others would take too little time to make sure of their imagery. Another class would allow the attention to wander. The time shortened between the first and last trial for those who worked steadily and learned rapidly. The average time required by the Eights was 26.4 minutes. This was reduced to 15 minutes for the last trial. The Tens have an average time of 24.5 minutes which was reduced to 13 minutes in the last trial. It is, however, questionable if the time element has any meaning for these experiments as conducted. But from general indications, it is probable that the most stable mentality would require the medium amount of time.

Experiment 15. Comprehension of Complex Directions.

This experiment was conducted with the expectation that it would test capacity to comprehend and execute slightly complex directions. The material used consisted of (1) a number of squares one inch each way with a dot in the center printed on

sheets of paper; (2) a number of circles one inch in diameter with a dot in the center printed on sheets of paper; (3) a series of directions, as follows.

A

1. Show me the center of that square.
2. Show me the middle of the upper side.
3. Show me the lower left corner.
4. Show me the middle of the right side.
5. Show me the upper left corner.
6. Show me the middle of the lower side.
7. Show me the upper right corner.

B

8. Draw a line from the center of that square to the upper left corner.
9. Draw a line from the center of that square to the middle of the left side.
10. Draw a line from the center of that square to the lower right corner.
11. Draw a line from the center of that square to the middle of the upper side.
12. Draw a line from the center of that square to the upper right corner.
13. Draw a line from the center of that square to the middle of the right side.

C

14. Draw a line from the middle of the right side to the upper left corner.
15. Draw a line from the lower left corner to the middle of the upper side.
16. Draw a line from the middle of the left side to the lower right corner.
17. Draw a line from the upper right corner to the middle of the lower side.
18. Draw a line from the middle of the left side to the middle of the upper side.
19. Draw a line from the middle of the lower side to the middle of the right side.

D

20. Draw a square on that circle so that the upper left corner of the square will be at the center of the circle.
21. Draw a square on that circle so that the middle of right side of the square will be at the center of the circle.
22. Draw a square on that circle so that the lower left corner of the square will be at the center of the circle.
23. Draw a square on that circle so that middle of upper side of the square will be at the center of the circle.
24. Draw a square in that circle so that the upper right corner will be at the center of the circle.

Series A was intended to be preliminary only, but the Sixes found great confusion here. A few succeeded in getting half of the directions correctly, but even when they could find the right point with urging, there was no certainty they would do so again within the next few minutes.

Great care was taken to secure the utmost attention on the part of the subject while giving the directions. After Series A was completed no direction was repeated. Three trials were given on three successive days and the average taken of these three trials. There was practically no average to take since the subjects all stopped at the same point each day. There was no evidence of learning for the three trials given. The results are given in Table 22.

TABLE XXII

Series—	A	B	C	D
Six	0	0	0	0
Eight	10	10	4	0
Ten	10	10	7	4

Table 22 shows the number of cases that comprehend and execute the different series of commands. All of the Eights and Tens pass Series A and B, four Eights pass C and none of the Eights pass D. Six Tens pass C and four Tens pass all four series.

A common error in Series C, the one made by six Eights and three Tens, was always to draw the line through the center of the square, no matter from what point the line started or terminated. For example, if the direction was No. 19, "Draw a

line from the middle of the lower side to the middle of the right side," the subject would draw his line to the center, then to the middle of the right side. This may have been because of a habit established in executing the commands of Series B, but even so, it is an error caused through superficial attention and inability to control more than one idea at a time.

The errors made in Series D were various. The characteristic mistake was to interchange the part of the square mentioned with the part of the circle, e. g., for direction No. 20, "Draw a square on that circle so that the upper left hand corner of the square will be at the center of the circle," the subject would draw a small square in the upper left portion of the circle.

The experiment does not at first notice appear to be difficult, but it is probably the best test of the fifteen for the control of ideas, and comes more nearly to being an elementary test in the higher thought processes. The errors made already indicate the difficulty the Tens had in keeping ideas distinct and clearly in mind when there is more than one. It also indicates a looseness of association, and reveals likewise an indisposition to mental effort, and a tendency to be satisfied with superficial observation and any kind of an execution. On the other hand, the fact that four typically feeble-minded children of the mental age Ten can comprehend the directions and make the executions readily, indicates a certain individual difference in the higher thought processes of the feeble-minded. It is quite possible that persons may be capable of exercising a relatively high degree of control of the associative process and yet be sufficiently defective in other ways to make him feeble-minded.

In summarizing the per cent. difference between the age levels for the fifteen experiments, we find in Table 23, that the Tens are 100 per cent., the Eights 74 per cent. and the Sixes 29 per cent. Since one experiment is not directly comparable with another in numerical terms, their averages are not an absolute measure, but from all evidence they are a reasonable indication of the psychological difference between the mental levels studied.

TABLE XXIII

Experiment	Ten	Eight	Six
1	100	98	84
2	100	36	24
3	100	85	28
4	100	89	82
5	100	84	45
6	100	86	07
7	100	90	45
8	100	78	20
9	100	77	07
10	100	71	21
11	100	68	21
12	100	36	13
13	100	87	50
14	100	54	0
15	100	78	0
Average	100	74	29

If the experiments are grouped according to the main psychological process involved, the various levels are related as indicated under the following heads.

TABLE XXIV

	Ten	Eight	Six
Sensory Discrimination (Experiments 2 and 6)	100	61	15
Attention (Experiments 5, 3, 4, 1)	100	89	62
Memory (Experiment 11)	100	68	21
Learning (Experiment 12)	100	36	13
Judgment (Experiment 7, 8, 9, 10)	100	79	23
Imagination (Experiment 13)	100	87	50
Reasoning (Experiment 14, 15)	100	66	0

This grouping has seemed justified from what could be learned in observation of the subjects at work. Each experiment involves a varying degree of complexity, but for the subjects of this experiment the above named processes seem to be the chief ones involved.

In all experiments attention is involved and it is probable that this is the psychological process in which the levels of intelligence differ. The Sixes seem to have a consciousness qualitatively different from Eights and Tens. It may be characterized as an inconsistent shifting blur. Sensory discrimination is low for this reason. For this same reason memory is feeble and association irrelevant. Learning is a slow process and because

of their wavering attention and inability to perceive essential differences, their judgment is defective, and their imagery indefinite and limited. They are practically unable to perform the simplest problem involving reasoning. The zero score in the last column holds true for all experiments where reasoning is involved.

There is sufficient difference between the score of Eights and Tens to indicate that the Eights differ likewise in a qualitative way from the Tens, but it is not so apparent from their general behavior in the laboratory. They fall behind the Tens in every case involving a complex situation, or where two or three ideas are concerned, thus indicating a difference in power of perceiving relations and making logical associations. Indications are that the Eights would have appeared different from the Tens qualitatively in making relevant associations, could further experiments have been made involving higher thought processes. The Tens are superior in every process involved in the fifteen experiments, but they fall short of normal in purpose, genuine interest and ability to see the meaning of things.

Sex Differences.

Data as to sex differences are, of course, only of general value in this experiment owing to the limited number of cases chosen. However, the results for the different sexes are given, because of what they show in regard to the children studied. In comparing the sex differences, the relationship was reduced to a percental basis in each experiment, and each age, by considering the actual score of the higher ranking sex as 100 and dividing the lower score by this to get its per cent. Thus, in memory with immediate recall the Ten girls scored 68, the Ten boys 87. Hence, the boys were valued 100 per cent. and the girl 78. In experiments 11, 14 and 15, the Sixes did practically nothing, and hence are not considered in the comparison, but are valued at zero.

TABLE XXV

	Six		Eight		Ten		Sex Superiority		
	Girls	Boys	Girls	Boys	Girls	Boys	Six	Eight	Ten
1. Strength of grip	88	100	80	100	79	100	B	B	B
2. Judgment of movement	100	79	100	66	100	94	G	G	G
3. Simple reaction time..	66	100	100	89	89	100	B	G	B
4. Tapping test	73	100	85	100	98	100	B	B	B
5. Attention span A	100	74	100	99	79	100	G	G	B
Attention span B....	100	82	100	74	90	100	G	G	B
Attention span C.....	100	80	100	80	70	100	G	G	B
6. Discrimination of grays	92	100	93	100	100	83	B	B	G
7. Judgment of forms, two dimensions	86	100	100	100	65	100	B	O	B
8. Judgment of form....	95	100	79	100	10	100	B	B	B
9. Judgment of size.....	77	100	100	85	100	86	B	G	G
10. Judgment of forms, three dimensions	77	100	69	100	10	100	B	B	B
11. Memory of geometrical forms:									
Immediate	0	0	100	95	78	100		G	B
10-second	0	0	100	95	90	100		G	B
1-minute	0	0	100	97	81	100		G	B
12. Modified typewriting..	100	91	100	91	67	100	G	G	B
13. Ink blot test	77	100	100	91	64	100	B	G	B
14. Drawing designs inverted	0	0	100	84	46	100		G	B
15. Comprehension of direction	0	0	85	100	100	100		B	
Average	88	93	94	84	62	98			

Table 25 given the relative difference for each age and experiment. Under the columns headed "sex superiority" are given letters "B" and "G" indicating whether the boys or girls are superior for that age and experiment. Here we see that on the average for the Sixes and Tens the boys rank higher, and for the Eights the girls rank higher. The greater superiority of the Ten boys is partly due to the fact that the boys average a little higher according to the scale of intelligence than the Ten girls, and that one of the Ten girls was handicapped by a visual defect. Further than this there seems to be no explanation for the sex differences.

Individual Variations.

In many of the experiments there were individuals of one mental age whose results resembled more nearly those of the higher or lower group. For example, if the averages of the thirty individuals are arranged in order of rank with respect to the others in that experiment, one of the Sixes ranked up somewhere between the tenth and twentieth, two of the Eights around

twenty-second or twenty-third, and two of the Tens down among the second ten subjects. But it was the same individuals who ranked above or below the others of his mental age. One superior Six was a girl of exceptionally good physical endowment, who had the advantage of a naturally good motor co-ordination and freedom from physical fatigue. One of the Eights who out-ranked her fellows was also thus favored physically, besides being interested in the tasks and having an eagerness to succeed which made her put forth her best efforts. The other Eight who excelled was infinitely patient, and made up in effort and pains for what he lacked in intelligence. The two Tens who fall below do so because of an indisposition to try, and in the case of one an eye defect which hindered in some experiments. One was indifferent and careless, and the other sometimes hostile to the work, but when they could be induced to put forth effort they ranked well up among the Tens. Despite these variations it is interesting to note that in the experiments of a more difficult character involving more complex mental processes, such as the comprehension of directions, drawing reversed designs, and memory, the classes are distinct and separate, with no overlapping.

Summary and Conclusions.

Certain general facts stand out in regard to the findings of the different experiments. Experiment 1 shows that in strength of grip the feeble-minded children, while physically they may be as strong as the average normal individuals of the same age, fall below because of inability to make the voluntary effort necessary to produce their best results. Feeble-minded children show a decided difference in the results for the two hands, and are therefore not ambidextrous as has often been supposed. There is a slight difference in the three mental ages, Sixes ranking lowest and Tens highest.

Experiment 2 shows that in a test so simple as judgment of extent of movement there is little difference in the three mental levels, the superiority of the Tens over the Eights and the Eights over the Sixes being due rather to more intelligent be-

havior in following the instructions of the experiment on the part of the upper grades of intelligence.

Experiment 3 shows that a simple reaction experiment is, for the feeble-minded, more than a simple voluntary process; what would be marginal or reflex for normal subjects are for these distinctly conscious processes, so that reacting to a stimulus involves holding several factors in consciousness before reacting to them. The lower the mental level the more this is true and the harder the task is.

In Experiment 4, the curve of tapping shows the greatest lack of voluntary effort on the part of the Sixes, and least on the part of the Tens, who are still slower and show a different curve from what we would expect for normals. Pounding the key and waste of energy by the Sixes evidences their lack of judgment.

Experiment 5, which is a real attention experiment, shows more difference in the results of the three levels, the score being proportional to the mental age, and the more complex the series, the greater the difference in the results of the three groups. Here we find a difference in the power of comprehending the demands of the problem and adjusting to them, and a difference in attention span varying directly with the mental age, the Sixes being the weakest.

Experiment 6, discrimination of grays, seems to indicate that as far as brightness discrimination itself is concerned the three levels are about equal, the differences that the results show being due to the fact that the lower levels are sometimes careless in making their decisions. Any variation is rather a matter of attention than of discriminibility.

Experiments 7 and 8 show that an experiment should be difficult enough to require some effort on the part of feeble-minded subjects, for they are too easily satisfied with moderate success; if they get things "almost right," they cease to try when perfection would be possible with a little extra effort. Experiment 8 was too difficult for the Sixes because there was too much to hold in consciousness at once and too much sustained attention demanded. Experiment 9, the judgment of size and form, is not an immediate process. It is an association of imagery of different

sense realms, which is not spontaneous, but constructive, and involves some reasoning. Hence the greater difficulty for the lower levels of intelligence.

Experiment 10 on the judgment of forms of three dimensions is a better test for comparing the three levels of intelligence than the preceding tests because of its complexity. It is a severe task for the Sixes, easier for the Eights and least difficult for Tens.

Experiment 11 on the memory of complex geometrical forms involves so much discrimination of difference in form and so much attention that it is more than a test of retentiveness. In fact, it is difficult to determine in how far demands made on these higher mental processes hinder it from being a memory experiment for the Sixes, for the distinguishing of the forms themselves is an almost impossible task.

Experiment 12 on the modified typewriting varies in difficulty with the different mental ages, both as to speed, accuracy, and rate of learning. This difference was due to the greater unity of consciousness of the higher levels, since for them some factors were from the start marginal, while for a Six, and to a lesser degree for an Eight, all factors were apt to be of equal value in consciousness, with a resulting confusion. Rivalry was characteristic of the Tens, Eights showed little rivalry, but a pleasure in a good record, while Sixes worked because they had to, but enjoyed the approbation of the experimenter.

Experiment 13, the ink blot test, gave higher results in proportion to the height in intelligence. This is due to the greater wealth of imagery the brighter subjects possessed, owing to their capacity for taking in more ideas with a resulting richer mental content than lower grades.

Experiment 14, on comprehending directions, shows a decided lack of reasoning ability on the part of the Sixes. They have difficulty in holding details in mind long enough to relate and compare them. It means a degree and duration of attention and voluntary effort not possible for the Sixes, difficult for Eights, but relatively easy for the Tens.

In general, results of the above experiments and impressions made during the study show the following.

(1) There is a noticeable lack of energy and capacity for voluntary effort on the part of the feeble-minded, and Sixes stand the lowest, Eights next and Tens highest among the subjects in question.

(2) All are weak in degree, duration and span of attention, the Sixes being lowest and Tens highest. So characteristic is this feebleness of attention, that experiments dealing with other mental processes are difficult to interpret, since every task requires more or less concentration.

(3) Probably all ages would be equal in sensory discrimination, if the factors of attention and voluntary effort could be eliminated, but since the simplest sensory experiment involves attention, it is doubtful whether the feeble-minded can be justly compared as to these simple processes.

(4) The lower the feeble-minded person in the scale of intelligence the less unified his consciousness. There do not seem to be two levels of attention where one group of perceptions is in the focus and the rest in the margin, but all factors in consciousness seem to be of about uniform importance. This lack of unity makes it difficult for the feeble-minded to perceive the real meaning of a life situation and leaves him without sufficient stability of purpose to direct his own activities.

(5) The three levels of intelligence differed as to their emotional attitude toward the experiments. A Six was capable of amusement, but had no genuine interest in the work. There was no desire to succeed other than that provoked by the pleasure of approbation by the experimenter. An Eight took pleasure in the actual performance of the work, but not from any personal or social interest. A Ten showed general interest in his success, wished social approval and was actuated by the spirit of rivalry.

(6) Lower grades are more pronounced in their inability to comprehend directions and to hold them in mind long enough to act on them; also in their difficulty of adjusting themselves to the conditions of an imposed task. Eights suffer less from this inferiority and Tens least.

(7) The lower the level of intelligence, the more the subject is lacking in reasonableness and good judgment in performing his work.

(8) The feeble-minded have pronounced individuality, but are deficient in personality; that is, their individual characteristics are very pronounced, but their traits and peculiarities are not closely unified into a personality. A Six hardly regards himself as an individual, an Eight makes superficial personal distinctions, while even for a Ten self-realization does not become a reality.