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THE RESULTS OF REPEATED MENTAL RE-EXAMINATIONS OF 639 FEEBLE-MINDED OVER A PERIOD OF TEN YEARS

By F. KUHLMANN

Early in 1912 the writer adopted the intelligence quotient method of grading intelligence. This was before Stern's monograph in which this method is proposed appeared.[1] Results from the examination of 1,300 feeble-minded of all ages quoted at that time seemed to indicate that this ratio of mental age to age remained roughly constant through the increasing ages of the feeble-minded. It was pointed out, however, that this constancy required that normal or average mental development progress at a uniform rate from year to year, as measured in absolute units of measurement, an assumption contrary to general observation and theory. In 1911 a ten-year program was begun of re-examining all inmates of the Minnesota School for Feeble-Minded at regular intervals of two years, excluding cases over twenty years of age, all epileptics, and others in whom some special trait interfered with getting a reliable mental age. The object of this study was to test out thoroughly the value of the I. Q. method of classification, and to determine the traits of the mental growth curve.

The examinations involve 639 cases from the grade of idiocy to nearly average normal intelligence, and from one to twenty years of age. Each case was examined from two to five times. About a third of the examinations were made by the writer. The others were made by Maud A. Merrill, Dr. Frances Lowell, Katharine B. Graves, and Rose Anderson, past and present research assistants. All had had ex-

[1] See Kuhlmann, F. "Degree of mental deficiency in children as expressed by the relation of age to mental age." Journ. Psycho-Asthenics, June, 1913.

tensive preparation in psychology and thorough training in
the use of the tests. Variability of results due to different
examiners was probably a negligible factor.

Three disturbing factors were encountered. The first con-
cerned the cases examined. A case once examined did not
always remain in the institution for future re-examinations.
Some were absent temporarily at the time a re-examination
was due. Others were removed permanently through death,
discharge, or transference to other institutions. The second
factor was the possible selective influence on grade of intelli-
gence of the institution in admitting and discharging cases at
different ages. It could not be assumed that cases admitted
or discharged at different ages were of the same grade of
intelligence. The third factor was the varying accuracy of
the tests at different age-levels, and of the different revisions
of the B.-S. scale that were used. The first examinations
were made in 1910 with the original 1908 scale.[2] From 1912
to 1917 my 1912 revision of the tests was used.[3] Since the
beginning of 1917 my last revision was used. The first two
gave on the whole quite the same results, the 1912 revision
being concerned chiefly with standardization of procedure
and extending the scale downwards below the age of three.[4]
The last revision corrected the general tendency of the earlier
scales of giving too high mental ages towards the lower end,
and too low mental ages towards the upper end, and increased
the number of tests to eight for each age group.

The first and second of these disturbing factors could be
met satisfactorily. The influence of the third could be elim-
inated only in part. This will be considered in connection
with the statement and discussion of the data.

Average Yearly Increase in Mental Age

The raw data gives a varying number of cases whose first
examinations came at different ages, from one to eighteen
years. Except for the disturbing factors just mentioned, the
average mental growth curve for these inmates of the insti-
tution could be at once determined by computing the average
mental age at each age of all cases examined and re-examined.

[2] See Kuhlmann, F. " Binet and Simon's system for measuring the
intelligence of children." Journ. Psycho-Asthenics, 1911.
[3] See Kuhlmann, F. " A revision of the Binet-Simon system for
measuring the intelligence of children." Journ. Psycho-Asthenics,
Monograph Supplements, Sept., 1912.
[4] See Kuhlmann, F. " Some results of examining a thousand public
school children with a revision of the Binet-Simon tests." Journ.
Psycho-Asthenics, March and June, 1914.

This procedure, as a matter of fact, gives a growth curve surprisingly close to what is obtained when the disturbing factors are eliminated.   The number of cases at each age is large enough to give a fairly smooth curve in spite of the fact that at each age some of the previous cases have dropped out and other new ones have been added.   The selective influence of the institution, as shown also by special methods of treating the results to determine it, is small, and negligible for most parts of the growth curve.   The mental ages at each age, since the cases include all grades, include a considerable range, and thus partly eliminate or smooth out the varying errors in the mental ages due to inaccuracies in the scale at different levels.

But these relationships change when we attempt to determine the mental growth curves separately for the different grades of intelligence.   The difficulty is increased by the fact that our definition of grade of intelligence in terms of the intelligence quotient involves us in assumptions the correctness of which constitutes our chief problem.   We may attribute a certain range of I. Q.'s to a given grade of intelligence for any particular age, but to use the same range for all ages for this grade of intelligence assumes, of course, that the I. Q. remains constant for all ages.

Table I gives the average mental ages for five successive years of each group of cases whose first examinations occurred at the same age.   This is given separately for the four grades of intelligence termed idiots, imbeciles, morons, and borderline cases.   The manner of deriving these figures needs to be carefully noted in detail.   It was done through the I. Q.'s, as that procedure had certain advantages over that of dealing directly with the mental ages.   The first step was to correct the individual mental ages found for errors due to the general tendency of the scale to measure too high or too low at different levels.   This was done by subtracting from each individual mental age the amount the scale was known to measure too high on the average at this point.   There were practically no mental ages at levels high enough to need additions as corrections.   These corrections could not be made safely for mental ages below four, and could therefore not be extended to low grade imbeciles, idiots, or to the younger morons and borderline cases.   Our norms for these lower mental ages are not sufficiently well established for any scale to allow of any definite conclusion as to what minor degree of error they may still contain.   The data used in making these corrections were the smoothed figures on the average mental ages found with my 1912 revision on 1,000 public

school children, referred to above, and unpublished data for my last revision.

The second step was to compute the I. Q.'s for the ages between two successive examinations by taking the average of the one preceding and the one following. It was then easier and more accurate to compute the average mental age at a given age from the average I. Q. than it would have been to work with the mental ages directly. The examinations did not, of course, occur at the exact ages of seven, eight, and so on, and to have averaged the mental ages of all cases classified as examined at seven, for example, might have been more or less misrepresentative, as the exact average age of these cases could vary from six and a half to seven and a half years. All age classifications were made on the basis of the nearest birthday. The error was eliminated by computing the average mental age from the average I. Q., using the ages as exactly seven, eight, and so on. Results of fourth and fifth examinations of a case were thrown out in order to put all cases on the same basis of a five year period with three actual examinations at two year intervals. Data for ages below seven are not given in this table because the mental ages could not be corrected for the general tendency to error in the scale, in the case of the morons, for ages below this.

The third step aimed to eliminate any selective influence of the institution there might have been on grades of intelligence at different ages, and also the difficulty arising from classifying the cases into the four grades of intelligence at different ages on the basis of the I. Q. This procedure was as follows. (a) Computing the average I. Q. for morons, for example, examined first at the age of seven, and again at nine and eleven. (b) Computing the average I. Q. at eight for those examined first at eight, and again at ten and twelve. (c) Eliminating from this second group of cases low or high grades cases so that the average I. Q. of the remaining cases was approximately the same as the computed average I. Q. at eight for the cases examined first at seven. If there was a general tendency of the I. Q. to change from seven to eight, this procedure insured having the same true grade of intelligence for the group examined first at eight as for the group examined first at seven. On account of the small number of cases at times for such a group, this equating of the I. Q.'s could be done only approximately in many instances. The remaining step was taken to make such exact equating unnecessary. (d) The average I. Q.'s at ten and twelve were

TABLE I
IDIOTS

No.	7	8	9	10	11	12	13	14	15	16	17	18	19	20
6		1.60	1.88	2.17	2.44	2.72								
4			1.88	2.17	2.48	2.53	2.54							
5				2.17	2.36	2.55	2.71	2.86						
11					2.43	2.65	2.88	3.04	3.19					
2						2.61	2.78	2.93	2.97	2.81				
3							2.73	2.91	3.08	3.04	3.00			
2								2.93	3.12	3.10	3.08	3.07		
3									3.09	3.04	2.99	2.87	2.75	
										3.00	3.03	2.97	2.75	

IMBECILES

No.	7	8	9	10	11	12	13	14	15	16	17	18	19	20
8	2.80	3.17	3.53	3.91	4.28									
14		3.17	3.53	3.88	4.14	4.38								
16			3.53	3.77	3.99	4.28	4.44							
21				3.85	3.87	4.40	4.68	4.94						
24					4.07	4.21	4.30	4.38	4.44					
18						4.32	4.44	4.52	4.75	4.66				
25							4.46	4.71	4.94	4.04	4.73			
11								4.64	4.88	4.79	4.73	4.67		
12									4.75	4.74	4.74	4.76	4.78	
14										4.76	4.71	4.65	4.79	4.92
10											4.73	4.33	3.93	3.85
7												4.60	4.68	4.75
													4.55	4.51

MORONS

No.	7	8	9	10	11	12	13	14	15	16	17	18	19	20
11	4.32	5.02	5.75	6.36	7.00									
10		5.02	5.64	6.26	6.96	7.57								
31			5.70	6.17	6.64	7.08	7.49							
24				6.26	6.65	7.00	7.44	7.94						
25					6.81	7.24	7.80	8.13	8.46					
21						7.22	7.55	7.96	8.40	8.28				
17							7.57	8.03	8.48	8.43	8.40			
24								8.01	8.63	8.77	8.73	8.80		
17									8.49	8.55	8.59	8.63	8.73	
17										8.49	8.51	8.58	8.67	8.73
14											8.56	8.41	8.39	8.35
13												8.61	8.41	8.25
													8.55	8.44

BORDERLINE

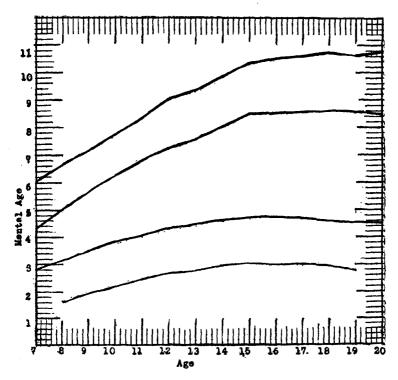| No.	7	8	9	10	11	12	13	14	15	16	17	18	19	20
6	6.07	6.63	7.14	7.57	8.07									
9		6.63	7.25	7.95	8.71	9.47								
10			7.19	7.80	8.59	9.35	9.64							
10				7.77	8.10	8.69	9.31	10.05						
5					8.37	8.77	9.11	9.45	9.73					
5						9.07	9.46	9.83	10.53	10.53				
12							9.38	9.94	10.64	10.59	10.65			
10								9.82	10.62	10.64	10.76	10.77		
5									10.38	10.32	10.38	10.76	10.41	
4										10.52	10.63	10.65	10.80	11.03
5											10.61	10.70	10.79	10.98
8												10.78	10.46	10.14
													10.61	10.68

found for the selected cases examined first at eight, and the intermediate I. Q.'s computed as before for nine and eleven. The average I. Q. at eight for this second group was then placed at exactly the same as the computed I. Q. at eight for the first group examined first at seven.   The change in the I. Q. from eight to nine for this second group was then added to or subtracted from the I. Q. at eight to get the I. Q. at nine.   Likewise, the I. Q.'s at ten, eleven, and twelve were found for the second group by adding or subtracting the amount of change that had occurred since the previous year. This procedure was repeated for each group examined first at nine, ten, and so on.   Thus the course of these derived I. Q.'s for each group examined first at a given age remained exactly the same in form as that of the averages of the actual I. Q.'s found in the examinations, but it might lie at a slightly different level, in the majority of instances in a level not over five points in I. Q. higher or lower.

In this table the number of cases examined for the first time at a given age is indicated in the first column of figures on the left.   The last figure under any age gives the average mental age for that age.   The total number of cases on which each average is based may be computed by adding up the figures on the left.   The average mental growth curve from seven to twenty years for each of the several grades of intelligence is then given in these last figures for each age.   The following graphs are based on the average mental ages in Table I.

The main features of these growth curves present but little that is not now pretty well known.   They show that the feeble-minded do develop mentally, and at a rate in proportion to the grade of intelligence.   This was still a disputed point at the time this study was begun.   This rate of development decreases with age for all grades.   The rate of this decrease cannot, of course, be shown with this data, as we do not know how much mental growth in terms of absolute units the mental year represents at different age levels.   In the graphs each addition of a year in mental age is represented as equal to preceding additions of a year, but even so the curves decline with increasing age.   Could they be plotted in terms of absolute units of growth they would decline very much more. This will be made more obvious below, in discussing the intelligence quotient.

Age of Cessation of Mental Age Increase.   Space will not be taken here to review in detail previous studies and dis-

cussions on this matter. It will be remembered that Stern[5]
assumed that the age of cessation of mental development
changed markedly with grade of intelligence, the idiot grade
ceasing developing relatively very soon after birth. Others
since have accepted this assumption. Recently Doll[6] has
claimed that his results on the re-examination of feeble-minded
verified this assumption of earlier arrest for the lower grades.
Grading his cases on the basis of the final mental ages they
attain in reaching maturity, he summarizes as follows.[7] I

Final mental age....	1	2	3	4	5	6	7	8	9	10
Age of arrest.......	?	?	7	11	11	12	12	12	15	15

find myself unable to agree with Doll that his own results in
this study will bear the interpretation given in these figures.

   [5] See Stern, W. " The psychological methods of testing intelli-
gence."   Trans. by G. M. Whipple, 1914.
   [6] See Doll, E. A. " The growth of intelligence." Princeton con-
tributions to psychology, 1920.
   [7] See page 76.

The Goddard revision of the B.-S. tests, which was used in this study, is not adequate for the determination of mental ages much below five, as it does not include standardized tests for ages below three. Doll's average growth curvè for cases with a final mental age between 6 and 7 rises markedly beyond the age of 12. The same is true of his next curve, for cases with a final mental age between 7 and 8. His curve for cases with a final mental age between 9 and 10, and the next for cases with a final mental age between 10 and 11 show a still more obvious rise beyond the age of 15.[8] In fact, my own interpretation of Doll's results would be that they do not disagree seriously with my present results, based on a larger number of cases. In considering my own table and graphs, it should be noted that the different grades are defined in terms of the I. Q. at the age of seven,—eight for the idiot grade. At this age, cases with I. Q.'s from 0 to 24 were classed as idiots, cases with I. Q.'s from 25 to 49 as imbeciles, 50 to 74 as morons, and over 74 as borderline. The upper and lower limits of these ranges of I. Q.'s for these different grades then decreased with age, as explained above. It is seen that the average growth curves extending from the age of seven to twenty all rise to the age of fifteen at least. They indicate that idiots, as here defined, develop to the age of fifteen, inclusive, imbeciles to fifteen or sixteen, morons to about seventeen, and borderline cases to about eighteen. In other words, all grades develop much longer than Stern and others have supposed, and the difference for different grades is not nearly as great as has been assumed. These facts are shown even more strikingly in the I. Q. curves below than in the present mental age data. Since the mental age of cases of fifteen years or over was always divided by fifteen to get the I. Q., the I. Q. rises beyond this age, when the mental age continues to increase.

Frequency of Yearly Gain and Loss in Mental Age. In considering this question the results for all grades of cases will be combined. It will not be necessary to take into account the three disturbing factors noted above. Not correcting the mental ages for errors in the scale will also enable us to include all the results for mental ages below seven. Since the mental age increase for the two-year interval between two successive examinations is nearly always much less than two years, and since any two successive mental ages will both be affected in the same direction through the error in the scale, the amount of loss or gain in mental age between two

[8] See page 75.

successive examinations is hardly ever seriously affected by the error the scale made. The gain or loss in mental age for each case was computed in terms of the average number of months per year. That is, for each case, the average yearly change in months between the first and second examinations was computed, and the same for the two-year interval between the second and third examination, and so on. These two or three yearly averages for a case were then again averaged, and this final average was taken as his average rate of gain or loss. The average period covered for a case was about five years. This procedure smoothes out the effect of errors in any given mental age due to not getting the best efforts from a case during any particular examination, or to other unknown factors. A number of quite questionable results were eliminated, reducing the total to 600 cases. The following table gives the number of cases that gained or lost 1, 2, 3, etc., months a year in mental age. It includes all grades.

TABLE II

	Gain																						Loss						
Mos.....	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		1	2	3	4	5	6	7
No......	1	1	1	2	3	3	3	5	10	12	12	18	22	25	32	30	37	61	81	78	66		37	32	16	6	4	1	1
%	4.8									68											11		16						

For the percentages in the last line in the table the cases are divided into four classes; first, those that gain at a rate of twelve months or more a year, that is, at a rate equal to or greate than that of the average normal rate; second, those that gain one to eleven months a year; third, those that are practically standing still, gaining or losing less than a month a year; and fourth, those that actually lose in mental age, the deteriorating class. It is probable that these four classes represent more or less distinct types, the difference between which might perhaps be accounted for if we had a detailed, knowledge of their history, heredity, health records, and physical conditions. This data is at present not available for these cases. It is particularly significant to find 4.8 per cent who gain at a rate greater than that of the average normal rate, and 16 per cent that deteriorate. There are undoubtedly some cases in the first class whose rapid gain is due to a too low and erroneous mental age for the first examination.

But the majority of them cannot be explained in that way, as the large yearly gain is shown throughout the course of three or more examinations.   Barring the erroneous results, all cases of this class are improving in *rate* of development, as may be true, of course, of some of the 68 per cent in the next class.   A very small number in the improving class continue this greater than average normal rate long enough to make up their deficiency entirely.   They attain a final I. Q. of 1.00 or more.

For the same reason that most of these cases showing unusual gain cannot be explained on the grounds of an erroneous mental age for the first examination, the majority of cases comprising the 16 per cent that lose in mental age cannot be explained on the grounds of too low a mental age for the last examination.   The tendency to deteriorate shows a marked relationship to grade, as was to be expected.   Attributing the I. Q. ranges given above to the four grades, irrespective of age, shows the following percentages of this deteriorating class belonging to these grades.

Idiots............................	35 per cent
Imbeciles.......................	23 "
Morons..........................	12 "
Borderline......................	2 "

It should be noted that it is, of course, easier for the lower grade cases to show actual loss in mental age through an accidentally too low a score in the last examination than it is for the higher grade cases.   The small accidental error of a few months may more easily exceed the real gain of a low grade case than it can the larger real gain of the higher grade case.

The tendency to deteriorate is also definitely related to age. The loss in mental age occurs more frequently with the older cases.   In the following table the age figures in the first column indicate the ages at which the first examination was given. The figures in the next three columns give the number of cases under the respective classes, and the last column gives the percentage of cases at each age that lose in mental age.

These figures indicate a rather abrupt increase in the percentage losing in mental age at the age of eleven, which increase on the whole rises up to the final age of twenty, beyond which no examinations were made.   It was expected that this increase with age in the percentage losing would come more from the lower than from the higher grades. When, however, the idiots and imbeciles, on the one hand, and the morons and borderline cases, on the other hand, are

TABLE III

Age	Number Gaining	Number Stationary	Number Losing	Per cent Losing
2	2	0	0	0
3	6	0	0	0
4	13	1	1	7
5	19	0	0	0
6	17	1	1	5
7	30	0	0	0
8	41	0	1	2
9	57	2	2	3
10	52	2	2	4
11	47	4	13	20
12	35	0	13	27
13	42	5	5	10
14	33	3	8	18
15	16	5	14	40
16	16	9	11	30
17	11	6	12	38
18	16	6	18	45

compared, 91 per cent of the lower grade cases that lose occur after the age of ten, while 94 per cent of the higher grade cases that lose occur after the age of ten. It seems, therefore, that age is also a factor determining deterioration quite independently of grade.

Constancy of the Intelligence Quotient

The method of determining the continuous course of the I. Q. from seven to twenty years from results that are limited to four year periods of examinations and re-examinations for any given case has already been explained in presenting the mental age growth curves. Table IV gives the I. Q.'s that correspond to the mental ages given in Table I. In plotting the average, continuous I. Q. curve from these figures, however, it becomes necessary to take into account the variations between the different groups of cases whose first examinations occurred at given ages. The irregularities in the average curves are thereby at once explained. Thus, in the moron grade especially, the cases examined first at seven happen to be improving cases, and their I. Q.'s cause a rise in the average I. Q. curve from seven to nine.

These results determine certain tendencies of the I. Q. It decreases with increasing age for feeble-minded. That decrease is larger for the high grade than for the low grade cases. Nearly every group examined first at a given age shows both these facts. The averages, given in the last figure under each age, showing the continuous course of the I. Q. to age twenty, reveal them more strikingly. That the I. Q. of the feeble-minded would decrease with age was anticipated, but that it would decrease more for the higher grade than for the lower grade cases was contrary to expectation. I shall show later that both these tendencies of the I. Q. follow mathematically from the fact of a certain type of decreasing rate of growth with increasing age of average normal children, when that growth is measured in absolute units of measurement instead of by the variable unit given in mental ages.

The above figures do not decide the question as to whether the decrease in I. Q. takes place at a uniform rate for all ages for a given grade, or whether it decreases more rapidly at some ages than at others. The rise in the I. Q. beyond the age of fifteen is due, of course, to the fact already noted that the mental age continues to increase beyond this age, while fifteen was the highest age by which the mental age was divided to get the I. Q. Not considering ages beyond fifteen it seems from these figures that there are no very marked changes in the rate of decrease of the I. Q. for different ages, and that the course of the I. Q. is roughly a straight line. A different method of treating the results, given below, however, shows some unquestionable age effect. Taking that part of the average I. Q. curve for each grade that is not obviously disturbed by accidentally varying groups, gives the following average yearly decline in the I. Q. for each of the four grades.
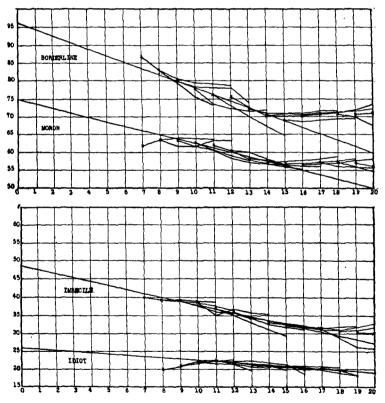
Borderline............................	2.19 points[9]
Morons..............................	1.21 "
Imbeciles.............................	1.04 "
Idiots................................	.37 "

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[9] In studying the results to determine this average yearly decrease in the I. Q. several different methods were used for eliminating the disturbing factors discussed at the beginning of this article. These methods gave somewhat different figures, but all showed that the I. Q. decreased more with the higher grades than with the lower grades. Even when no attempt was made to eliminate these factors, and when the same range of I. Q.'s was attributed to a grade at all ages, and the average I. Q. computed at each age as found in the raw results these figures were, for borderline 2.2 points yearly loss, for morons 1.3, for imbeciles .5, and a negligible change for idiots.

TABLE IV

IDIOTS

No.	7	8	9	10	11	12	13	14	15	16	17	18	19	20
6		20.00	20.84	21.61	22.17	22.67								
4			20.84	21.70	22.56	21.06	19.56							
5				21.69	21.49	21.29	20.85	20.40						
11					22.07	22.12	22.16	21.71	21.25					
2						21.79	21.37	20.95	19.83	18.71				
3							20.99	20.76	20.52	20.27	20.02			
2								20.96	20.81	20.66	20.56	20.46		
3									20.60	20.27	19.93	19.13	18.33	
										19.98	20.17	19.80	18.33	

IMBECILES

No.	7	8	9	10	11	12	13	14	15	16	17	18	19	20
8	40.00	39.63	39.26	39.10	38.93									
14		39.63	39.20	38.77	37.63	36.49								
16			39.23	37.73	36.23	35.70	34.17							
21				38.53	35.20	36.63	35.97	35.30						
24					37.00	35.05	33.09	31.28	29.46					
18						35.97	34.14	32.30	31.69	31.08				
25							34.34	33.64	32.94	32.24	31.54			
11								33.13	32.54	31.95	31.54	31.13		
12									31.66	31.64	31.62	31.75	31.87	
14										31.73	31.38	31.02	31.91	32.80
10											31.52	28.87	26.22	25.67
7												30.69	31.19	31.68
													30.30	30.05

MORONS

No.	7	8	9	10	11	12	13	14	15	16	17	18	19	20
11	61.73	62.80	63.88	63.55	63.60									
10		62.80	62.67	62.58	63.25	63.05								
31			63.28	61.68	60.40	59.02	57.59							
24				62.60	60.47	58.36	57.20	56.70						
25					61.93	60.31	60.00	58.08	56.37					
21						60.19	58.06	56.84	56.03	55.21				
17							58.21	57.34	56.51	56.23	56.02			
24								57.24	57.51	57.79	58.20	58.66		
17									56.61	56.98	57.25	57.56	58.20	
17										56.55	56.86	57.17	57.81	58.20
14											57.08	56.09	55.93	55.69
13												57.37	56.09	54.83
													57.01	56.24

BORDERLINE

No.	7	8	9	10	11	12	13	14	15	16	17	18	19	20
6	86.67	82.83	79.33	75.67	73.33									
9		82.83	80.50	79.50	79.16	78.94								
10			79.92	78.02	78.06	77.92	74.22							
10				77.73	73.63	72.40	71.60	71.80						
5					76.05	73.05	70.05	67.45	64.85					
5						75.58	72.78	70.18	70.18	70.18				
12							72.16	70.99	70.91	70.60	71.02			
10								70.11	70.81	70.90	71.71	71.82		
5									69.19	68.79	69.19	69.39	69.39	
4										70.12	70.87	71.02	72.02	73.52
5											70.70	71.30	71.90	72.50
8												70.88	69.75	67.58
													70.76	71.20

The straight lines in the following graphs approximate
very closely this average rate of decline, assuming that it is
the same for all ages for a given grade.   It will be seen in
a moment that this assumption cannot be entirely correct.   In
these graphs the course of the I. Q. for each group of cases
examined first at a given age is plotted separately.   The small
crosses mark the course of the average I. Q. curve.   It is
seen that this average curve misrepresents the more probably
true curve in several instances, most markedly for the begin-
ning of the average curves for the idiot and moron grades.

*Relation of Rate of Decline of the Intelligence Quotient
to Age.*   It was seen already that the percentage of cases whose
mental age decreases as they grow older increases with age.
So far as this might be a general tendency for all cases this
effect of age should be more marked for the I. Q., for the

I. Q. may decrease considerably with age without causing an actual loss in mental age. Table V gives the percentage of cases at each age whose I. Q. decreases. The results for all grades are combined, and include no eliminations or corrections for the disturbing factors considered in connection with some of the other questions already discussed. Correcting the mental ages for errors in the scale was found not to make any material difference. The I. Q.'s for intermediate years between two successive examinations of a case were computed and these computed I. Q.'s were used for the results in this table.

TABLE V

Age	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15
Nunber cases	15	42	58	71	122	151	186	233	215	163	182
% decreasing	20	19	45	49	60	71	76	78	75	67	66

These figures show an unquestionable age effect on the decrease in the I. Q. that is not revealed in the figures of the preceding table. The frequency of cases losing in I. Q. increases with age up to about eleven years, the age at which the frequency in mental age loss was found to increase rather suddenly. When the results are computed separately for each of the four grades each grade shows an age at which the frequency of loss in I. Q. is at its maximum and beyond which it declines again, just as for the results of all grades taken together. For idiots this maximum age is twelve, for imbeciles eleven, for morons ten, and for borderline cases seven and twelve. The average mental ages for these grades at these maximum ages are 2.6, 4.1, 6.3, and 6.1 and 9.1, respectively. This relation of frequency of I. Q. decrease to age is therefore not the effect of errors in the mental ages due to the scale of tests. If this were the case the maximum frequency in loss in I. Q. should have occurred approximately at the same mental age. When the mental ages are corrected for these errors, as could be done for mental ages of four and over, the number of cases left for each age becomes rather small for reliability. It makes no material difference for the borderline cases, but raises the maximum age for the morons from ten to thirteen. The correction should, of course, have made more difference for the borderline group than for the moron. We may conclude with safety only that the frequency of loss in I. Q. increases with age, irrespective of grade, up to a certain age. Whether or not this frequency declines beyond a certain maximum age is not so certain.

Relative Frequency of Loss and Gain in Intelligence Quotient. One of the chief questions concerning the I. Q. has been the possibility of predicting future and final mental ages on its basis for the individual case. If the present I. Q. has been determined for a case in a given single examination, how well can his mental age for any age in the future be predicted? Unfortunately this question has been confused with the question of the constancy of the I. Q., with which it has no necessary connection. The ability to make this prediction does not, of course, depend on its constancy but on the regularity of its change in successive examinations at different ages, if there is a change. The traits of the I. Q. established by the present results have complicated its use as a means of prediction. It decreases with age, and the amount of decrease for any given year is dependent on the two further factors of age and grade. Accurate prediction requires that we know not only the presence of these tendencies, but also their extent at each point. But, having discovered these tendencies, we can make corresponding allowances in predicting future mental ages, and thereby reduce a general tendency to error in prediction that would otherwise be present. The following frequency distribution results on the loss and gain in I. Q. gives a fair idea of the general reliability of the I. Q. when used for prediction without allowing for the tendencies to change that was found. Table VI gives the number and percentages of cases that lost or gained 1, 2, 3, 4, etc., points a year. In this table the results of all examinations are again included without eliminations or corrections. They are grouped according to the four grades, and irrespective of age. This, of course, introduces the error into the classification resulting from attributing the same range of I. Q.'s at all ages to a given grade. Since we now know the general tendencies of the I. Q. to change with age and grade the effect this may have on the distribution will be understood. The task of determining the true range of I. Q.'s for each grade at different ages, taking the decline with age of the I. Q. into account, is too complicated for satisfactory solution. Our previous task of determining what cases should be classed under each grade at different ages involved only getting approximately correct average I. Q.'s at each age, which was a relatively simple matter. It is evident that the present procedure cannot give a materially different distribution from what would result if the error in question were eliminated.

TABLE VI

		Over −10	−10	−9	−8	−7	−6	−5	−4	−3	−2	−1	0
Idiots....	No.								1	6	25	35	48
	%								.6	3.6	15.9	22.6	30.5
Imbeciles.	No.					2	5	6	23	44	178	235	179
	%					.2	.6	.6	2.7	5.4	20.6	27.2	20.6
Morons ..	No.		3	3	11	3	15	49	71	119	133	149	100
	%		.3	.3	1.2	.3	1.5	5.0	7.3	12.2	13.6	15.3	10.2
Borderline	No.	5	10	6		6	43	34	34	23	25	22	11
	%	1.8	3.6	2.2		2.2	15.6	12.3	12.3	8.3	9.0	8.0	4.0

TABLE VI—Continued

		+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	Av.
Idiots.............	No.	19	9	9		3				2		−.06
	%	12.1	5.7	5.7		1.8				1.2		
Imbeciles..........	No.	114	33	23	5	2		2				−.55
	%	13.2	3.8	2.7	.6	.2		.2				
Morons............	No.	95	75	65	34	13	4	10	10	2		−.72
	%	9.7	7.7	6.7	3.5	1.3	.4	1.0	1.0	.2		
Borderline..........	No.	10	17	13	5	4	3	2				−2.7
	%	3.6	6.2	4.7	1.8	1.5	1.1	.7				

The following summaries from the figures in this table might serve as a rough guide in making predictions, which can then be much improved by taking into account the central tendencies of the I. Q. to decrease with age as found above.[10]

[10] I hope at some time later to discuss more fully the general problem of prediction, in which the present data will be treated specially with reference to this question.

IDIOTS	
Per cent.	Points Change
31	1
65	2
87	3
96	4
97	5
99	6

IMBECILES	
Per cent.	Points Change
21	1
61	2
85	3
94	4
97	5
98	6

MORONS	
Per cent.	Points Change
10	1
35	2
57	3
75	4
86	5
93	6
94	7
96	8
98	9

BORDERLINE	
Per cent.	Points Change
4	1
16	2
31	3
44	4
58	5
72	6
88	7
91	8
91	9
94	10

These figures are to be read as follows. Of the idiots 31 per cent change less than 1 point in I. Q. a year; 65 per cent change less than 2 points in I. Q. a year, etc. It is seen from even this rough method of stating the results that much is left to be desired. Yet, we are far from justified in concluding, as is often done, that the I. Q. is of no value at all in making predictions. And further, if predictions are to be attempted at all, what other procedure or method have we that would be even approximately as reliable as predicting on the basis of the I. Q.? Aside from the question of prediction, the I. Q. remains the most accurate and convenient method available for expressing grade of intelligence at any given age of a case.

The Normal Absolute Growth Curve

It remains now to account for the traits of the I. Q. changes with age as found in the present results. The traits to be considered are, (1) that the I. Q. on the whole decreases with age; (2) that this decrease is largest for the highest grade cases studied, those with an I. Q. over .75, and becomes smaller the lower the grade; (3) that loss in I. Q. increases at least in some measure with age.

Considering the general principles of the B.-S. scale, the method of establishing norms and of deriving the mental age and I. Q., there seem to be three possible suppositions that might explain these general facts wholly or in part. The first

is that these traits of the I. Q. result directly from changes in the rate of growth, even when that rate of growth is measured in terms of absolute units.   This would mean that the idiot child grows at a retarded rate that kept approximately the same relation to that of the average normal, losing only slightly in relative rate with age.   As this retarded rate, however, approaches that of the average normal, giving us the higher grades of subnormals, this loss in relative rate increases, at least up to the grade called borderline in the present study. It is obvious that this loss in relative rate must then decrease again as we approach the average normal rate still closer, since at exactly average normal rate this loss becomes zero and the I. Q. remains constant at 1.00.   The correctness of this first supposition is so entirely improbable on the face of it as to really need no further consideration.

A second supposition is that these traits of the I. Q., or at least the first two, may be the result of error in standardizing the scale of tests.   It is assumed that the norms for the tests at each age are for non-selected children, representing true averages of all children at each age.   This assumption is probably not entirely correct for any scale of tests yet devised.   The public schools have always furnished the children in question, and it is recognized that the schools have a selective influence on the average intelligence of the children at each age or school grade.   As we pass from younger to older, higher and higher grades of the subnormals are eliminated from the schools through failure to keep up, increasing the average level of intelligence of those that remain. The effect of this process of elimination on the I. Q. with a scale of tests standardized with such so-called non-selected school children would then be as follows: The I. Q. as found would decrease with age for all children of true average intelligence or less, since at each higher age the scale would measure a little bit more too low.   It would not increase with age for children above average intelligence.   The total decrease in I. Q. for a given period of years, let us say to sixteen, would be the larger the higher the grade of case in question, because the higher grade cases would attain a higher final mental age than the lower grade cases.   To make this clear, let us suppose that our scale of tests were standardized in this way for the ages of one to sixteen.   Let us assume a group of 100 truly non-selected children at birth, from which one child with a true I. Q. of .70, will drop out each year through some such selection as the schools exert on children in the schools.   If norms for tests were established with the

remaining of these 100 children at each age, the I. Q.'s obtained
with such tests would be .3 point too low at the age of one,
.6 too low at two, .9 too low at three, and so on, to 4.8 points
too low at sixteen. With such tests, the average child would
lose 4.8 points in I. Q. in sixteen years; the child with a true
I. Q. of .75 and attaining a final mental age of twelve at the
age of sixteen would lose 3.6 points; the child with a true
I. Q. of .50 and with a mental age of eight at sixteen would
lose 2.4 points, and so on. Now it is more than probable
that the schools exert this selective influence, but there is no
data available at present to indicate exactly how much effect
this may have had on our norms for our tests. It is possible,
therefore, to explain the first two traits of the I. Q. of the
feeble-minded, at least in part, on the basis of this resulting
error in the scale of tests. I believe that the present results
are in some measure due to this factor. The third trait of
the I. Q. however, cannot be explained on this ground, nor
would it explain an increase in I. Q. with age for children
above average intelligence.

The third supposition that may be made to explain the three
traits of the I. Q. is that for the average child the yearly
increments in mental growth as measured in terms of absolute
units decrease each year, giving the general type of growth
curve usually assumed to be correct. I shall attempt to show
now that this assumption explains not only the three traits
of the I. Q. found in the present results, but also the increase
in I. Q. found by others for children above average intelli-
gence. This will also suggest certain other traits of the growth
curves of subnormals and of the I. Q. that the preceding
analysis of the results has not revealed.

In a recent discussion Freeman[11] presents two types of
normal growth curves either of which it is claimed would
result in the constancy of the I. Q. for cases developing
at a subnormal rate. The first is the logarithmic curve,
y=log. x. The second is the straight line, assuming a constant
rate of development from year to year. For each normal or
median curve he plots a mental age curve of a hypothetical
case so that at any age the mental age of this case is .66 of
the mental age of the median at the same age. That is, the
growth curve for the hypothetical case is so plotted in both
instances that the I. Q. *will* remain constant at .66. Freeman
does not discuss the fact that if the ratio between the median
rate of growth and the subnormal rate, measured in absolute

[11] The Interpretation and Application of the Intelligence Quotient.
J. Ed. Psychol., Jan., 1921.

units, is assumed to remain constant the logarithmic growth
curve cannot give constant I. Q.'s for subnormals. In the
case of the straight line type of growth curve for the median,
any subnormal developing at a slower than median rate and
with a constant I. Q. will also maintain a constant ratio to
the median rate of growth, when growth is measured in terms
of absolute units, which in this case would be a year of median
growth. Now for the logarithmic growth curve this is not
true at all. Here these ratios, determined from the y values
of the subnormal and median curves at each age, increase
with age while the I. Q. remains constant. Thus, for the
illustration used by Freeman, the figures run as follows:

Age	3	6	9	15
I. Q.	.66	.66	.66	.66
Ratio	.61	.78	.80	.85

Vice versa, if the rate of growth of a subnormal maintains
a constant ratio to the median rate, the I. Q. cannot remain
constant, but will decrease with age. Since we have found
as a matter of fact that the I. Q. does decrease with age, we
must look for the explanation in a median growth curve that
will give this decrease in the manner found.

It would be a relatively simple matter to determine the
exact nature of the median growth curve if we knew the exact
course of the I. Q. from birth to mental maturity, and if
we could assume that the rate of development for any grade
of intelligence above or below median maintained a constant
ratio to the median, when rate is measured in terms of abso-
lute units. We could then construct an absolute median
growth curve that would fit the course of the I. Q. changes.
We can determine the whole course of the I. Q. from birth to
maturity for the grades of cases studied only by assuming
that it declines at a uniform rate for all ages. It was seen
above that this assumption is probably not very far wrong,
the general course of the I. Q. being approximately a straight
line, with a small tendency for the rate of decline to increase
with age. We may tentatively accept also the assumption that
the rate of growth of any grade maintains a constant ratio
to the median rate, and then construct an absolute median
growth curve that will fit the rate of decline of the I. Q. of
one of the four grades of our cases, and with that median
growth curve determine the course of the I. Q. for other
grades of intelligence. This will show the following. (1)
That the absolute median growth rate decreases each year,
giving a type of curve similar to the logarithmic, but with the
yearly increment in growth decreasing at a much slower rate

than for the curve $y = \log x$; (2) that this type of growth curve accounts for all the traits of the I. Q. that were established in the above results; (3) that the I. Q. for grades of intelligence above the median will increase with age instead of decrease.

I will take the moron grade, assume that its I. Q. declines at all ages at the uniform rate of 1.21 points a year, which was the average rate of decline found for morons. This gives this grade an average I. Q. of .74 at birth, and of .5585 at the age of fifteen. This gives the following I. Q.'s at the different ages of 0 to 15, with the corresponding mental ages.

TABLE VII

Age	0	1	2	3	4	5	6	7
I. Q....	.74	.7279	.7158	.7037	.6916	.6795	.6674	.6553
M. A...		.73	1.43	2.11	2.77	3.40	4.00	4.59

TABLE VII—Continued

Age	8	9	10	11	12	13	14	15
I. Q..	.6432	.6311	.6190	.6069	.5948	.5827	.5706	.5585
M. A.	5.15	5.68	6.19	6.68	7.14	7.58	7.99	8.38

To construct an absolute median growth curve that will give these I. Q.'s we may set the total growth during the first year from birth to age one arbitrarily at 100 units. Then $1 + \dfrac{.74y - 100}{\frac{x}{2}} = .7158$; also, $y = 100 + x$, when x equals the increment in growth from one to two years, and y equals the total number of units of growth at age two. Here .74y is the total number of absolute units of growth at age two for this grade of case, and 100 is the total number of units of growth at age one for the median. $1 + \dfrac{.74y - 100}{x}$ is then the mental age of this case, which, divided by 2, equals the I. Q. .7158. Solving for x and y, gives 84.31 units increase in

TABLE VIII

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Increase	100	84.31	76.20	67.48	60.65	54.59	48.36	44.66	39.10	36.03	32.02	29.36	26.55	24.75	20.68	
Total		100	184.31	260.51	327.99	388.64	443.23	491.59	536.25	575.35	611.38	643.40	672.76	699.31	724.06	744.75

growth from 1 to 2 years, and a total of 184.31 units at 2. To get the increase from 2 to 3, we have $2 + \dfrac{\dfrac{.74y - 184.31}{x}}{3} =$ .7037, where y equals the total number of units of growth at 3, x the increment from 2 to 3, and $2 + \dfrac{.74y - 184.31}{x}$ equals the mental age at age 3, which divided by the age 3 equals the I. Q. of .7037 at age 3. Here $y = 184.31 + x$. Solving again for x and y, gives 76.20 units of increase from 2 to 3, and a total of 260.51 units at age 3. Repeating this process, gives the following median growth curve in terms of absolute units of growth, and which will result in the decline in the I. Q. from .74 at birth to .5585 at the age of 15, as found for the moron grade and given in Table VII.

It is seen that this absolute median growth curve decreases from 100 units of growth a year to 20.68 units at the age of 14 to 15. Had either of the other grades instead of the moron grade been chosen and the absolute median growth curve constructed in like manner the general character of this curve would have remained the same. We may next adopt this growth curve tentatively as correct, and determine the resultant I. Q.'s for different grades of intelligence.

Table IX gives the resulting I. Q.'s at age 10 for different grades of intelligence from 1.20 down to .20 in ten point steps. These are derived with the use of the median growth curve given in the figures of Table VIII. It is assumed again that the ratio of total units of development of any grade to the total median units at the same age remains constant. That is, if it is .50 of the median number of units at age 1, it will be .50 of the median at any other age.

TABLE IX

Grade	1.20	1.10	1.00	.90	.80	.70
I. Q. at age 10	1.45	1.20	1.00	.84	.70	.57
No. points change	+.35	+.10	0	—.06	—.10	—.13

TABLE IX—Continued

Grade	.60	.50	.40	.30	.20
I. Q. at age 10	.46	.37	.28	.20	.13
No points change	—.14	—.13	—.12	—.10	—.07

This shows that the median growth curve that results in the I. Q. changes with age as found with morons will give the I. Q. of other grades, in general, as found by our actual

re-examinations of cases. The I. Q. decreases for the lower grades, and more for the higher grades, up to a certain point beyond which this decrease becomes smaller again, reaching zero, of course, for the median grade of 1.00. It also shows that the I. Q. for grades above the median increases with age instead of decreases. The maximum decrease in Table IX is at grade .60, while as actually found in the re-examinations the I. Q. for borderline cases decreased most. The present data are not adequate for determining at just what grade this maximum decrease in I. Q. occurs with the true median growth curve. The median growth curve constructed to fit the moron grade may be more or less incorrect, because (a) the average yearly decline of 1.21 points for morons may be somewhat incorrect; (b) the decline may vary with age more than is assumed here; (c) the ratio of the subnormal rate of growth to the median rate of growth may not remain constant. It can be shown as a matter of fact that this growth curve is probably considerably wrong, by computing the I. Q.'s at each age from 1 to 15 for the idiot, imbecile, and borderline grades, for this median growth curve, and then compare these I. Q.'s with the I. Q.'s of these grades as actually found.

When these computations are made it is found that the present median growth curve gives I. Q.'s that are increasingly higher, from 1 to 15 years, than the I. Q.'s as found for the borderline grade, and increasingly lower than the I. Q.'s as found for the imbecile grade. For the borderline grade, this difference is +.28 points at the age of fifteen. In like manner, the median growth curve that fits the moron grade as found does not correspond with the median growth curve that fits the I. Q.'s of the borderline grade.

This lack of correspondence must be due to one, two or all three of the factors just noted. If the first two factors are not sufficient to give the amount of discrepancy found here, we are forced to the important conclusion that the ratio between median rate of growth and any subnormal rate does not remain constant. In that case it would become necessary to determine the growth curve for every grade empirically by re-examination at successive ages in order to establish the general tendency for each grade in more detail than the present results do.

The median growth curve constructed so as to give the course of I. Q. changes as found for morons cannot show what changes with increasing age in the rate of decline in the I. Q. may take place for other grades, as it is based on a rate of I. Q. change that remains constant at 1.21 points loss

7. The rate of decline of the intelligence quotient increases some with age.

8. The several traits of the intelligence quotient are all due chiefly or possibly entirely to a decrease with age in the yearly increment in mental growth of average normal children, as measured in terms of absolute units, and follow mathematically from the nature of this median rate of growth. They may in some measure be due to the scale of tests measuring increasingly too low with increasing age, because this scale is based on the average abilities at each age of school children from which the lower grades have been more and more eliminated by the schools with increasing age.

9. It is probable that even if mental development were measured in terms of absolute units of growth the ratio between the median rate and any other rate above or below it will not remain constant from year to year.

10. The intelligence quotient of cases above the average will increase with age instead of decrease, for the same reason that it will decrease for cases below average.