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MENTAL GROWTH CURVE OF NORMAL AND SUPERIOR CHILDREN

STUDIED BY MEANS OF CONSECUTIVE INTELLIGENCE EXAMINATIONS

BY

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AND

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CONTENTS

MENTAL GROWTH CURVE OF NORMAL AND SUPERIOR CHILDREN

I. THE MENTAL GROWTH CURVE

1. *Statement of the Problem.* Contemporary discussions of the mental growth curve have their parallel in the early history of anthropometry, when scientists attempted to find the general laws of growth and to depict the trend of the average curve of physical development. Refinement of technique and a better analysis of the growth process have shown wide individual differences in the growth of children, which make it impossible to represent these variations adequately by a single mean curve. It is now known that there are differences in the curves for boys and girls, for tall and short children, for physiologically accelerated and retarded children, as well as for children of different race, different environment, and different social status.

On the analogy of the physical growth curve a number of writers have constructed theoretical mental growth curves, generally with rather a steep rise in the early years of life and a flattening out after the age of puberty. One author has suggested, without experimental data, that this curve should really be concave in the early years, owning to what he believes to be the slow rate of development during infancy. The concept of different rates of development in the subnormal classes has become so firmly established that text-books generally visualize for the student the supposed growth curves of the three classical levels of feeblemindedness. It has also been suggested in the literature that superior children grow at a faster rate and have a steeper curve than the average.

All of these problems concerning the general trend of the growth curve, the rate of improvement of children of different intellectual ability, variability in mental development, the possibility of prediction in mental growth, and the relation between physical and mental growth can be solved only through a study of consecutive re-examinations and observations of the same group of children throughout a number of years. The data of this study

furnish the basis for the beginning of an empirical determination of these aspects of the mental growth process.

2. *Data for this Study.* In September, 1917, several hundred children were examined at the Iowa Child Welfare Research Station by the Stanford Revision of the Binet Scale, with a view to following the mental development of the children from year to year.[1] The continuity of the work was interrupted by war conditions[2] and by the shifting[3] of the school population particularly characteristic of a university town, but 143 individual records are sufficiently complete for the purposes of this analysis. Chart I

CHART I

TYPICAL RECORD CARD FOR SUCCESSIVE EXAMINATIONS.

NAME Holman, Katharine									DATE OF BIRTH 7-12-09							
DATE OF EXAM.–1 10-23-17						2 11/18/18			3 11/14/19			4 11/16/20			5 5/2/21	
GRADE						5th E V			6th E V			8th L W			9th L 9.5	9th L 9.5.
TEST	1	2	3	4	5	6			TEST	1	2	3	4	5	6	7	8
III	X	X	X	X	X	X			IX	X	X	X	X	X	X		
IV	X	X	X	X	X	X			X	X	X	+	X	X	X		
V	X	X	X	X	X	X			XII	+	X	X	X	+	+	/	X
VI	X	X	X	X	X	X			XIV	=	+	X	+	+	X		
VII	X	X	X	X	X	X			XVI		/	/	/	=	/		
VIII	X	X	X	X	X	X			XVIII		/		/				

SCORES	1	2	3	4	5
CHRONOLOGICAL AGE	8³	9⁴	10⁴	11.4	11.10
TERMAN AGE	11⁶	13⁵	16⁴	17.1	17.7
I.Q.	139	143	158	151	149

[1]During the first year the Yerkes-Bridges Point Scale was given at the same time as the Stanford Revision, or a day later. Although this study is limited to the data from the Stanford Revision, the Pearson coefficient of correlation between the ratings by the two scales, all of the examinations being made by the same individual, was found to be for 76 cases +.888 with a P.E. of ±.016.

[2]The original plan for the re-examinations had the support of the Acting Director of the Child Welfare Research Station, Ellsworth Faris, during the Director's absence in military service.

[3]A number of children who had left the university school were followed up and examined in the public schools. A fifth examination on one girl was obtained through the courtesy of Professor L. W. Cole, who examined her in Colorado Springs.

shows a typical record for successive examinations. The records may be divided into four groups: (a) 56 having two examinations; (b) 51 additional cases having three examinations; (c) 42 of the three examination cases on whom a fourth examination was obtained; (d) additional 36 cases having five consecutive examinations.

The conditions for a study of this kind were particularly favorable. The University Observational Schools, in the same building as the Child Welfare Research Station, are attended largely by the children of the professional and business men of the city and of prosperous farmers nearby. The tuition is small, making the expense comparable to that of children attending the public schools of the town where text-books are not supplied. The tone of the school is free and democratic. The children are accustomed to all sorts of educational and psychological experiments and regard the annual re-examination as a regular part of the school program. There is no reason to believe that any undue amount of communication or discussion went on among the children in regard to the mental tests; in fact, the examiner frequently noted the fact that a child remembered having been asked a certain question a year ago but did not give further evidence that the answer had been learned. The investigation had the interest and support of the school staff, most of whom were college graduates who were anxious to make the experimental conditions as favorable as possible.

The examinations were given by four psychologists[1] during the period between September, 1917, and May, 1921. In all 485 mental age determinations were made on 143 children. Of these 178 were given by Miss Vest, 8 by Miss Schriefer (who was devoting her time to the examination of other children entering the school), 77 by Miss Wagoner, and 222 by Miss Stecher.

With a view to tracing the possible effect of the personal equation, the material was arranged (Table XI) so as to show what proportion of the children in a given group were examined by the same examiner.[2] In the Five Examination Group both the first and second examinations were made by Miss Vest in 91.4% of the cases; in the Four Examination Group Miss Vest gave 30.2% of the repeated examinations, in the Three Examination Group

[1]Eloise Vest, A. M., Louise Schriefer, A. M., Lovisa Wagoner, A. M., Lorle I. Stecher, Ph. D.

[2]In the statistical treatment of the data in this *study* the writers had the co-operation of Gladys M. Fairbanks, A. M.

22.2%, and in the Two Examination Group 28.6%. Consecutive examinations of the same children were given by Miss Stecher as follows: in the Two Examination Group 3.5% of the first and second; in the Four Examination Group 18.6% of the second and third, 18.6% of the second and fourth, 100% of the third and fourth; in the Five Examination Group 40% of the third and fourth, 40% of the third and fifth, 100% of the fourth and fifth. That re-examination by the same person is of practically no significance in raising the correlation is shown in connection with the coefficients of correlation on page 45.

The subjects of the study were of average and superior intelligence with a range of I. Q. from 90 to 167. The four groups were nearly equal in mental ability as shown by the mean I. Q. of the boys and girls of the different groups.

Group	5 Exam.	4 Exam.	3 Exam.	2 Exam.
Boys	120.6	114.0	112.8	115.0
Girls	118.8	113.6	112.3	113.4

It will be noted that the mental ability of the boys was practically the same as that of the girls.

3. *Method of Determining the Mental Growth Curve.* Terman (26) 1919, p. 127, has stated that "the standardization of the Binet scale on the basis of age norms makes it a valuable instrument for the investigation of mental growth curves." The mental growth curves presented herewith are probably the first curves for superior and average children of the development of general intelligence studied by means of repeated examinations on the same children.

The mental examinations on which these growth curves are based were made at irregular intervals, ranging on the average from 6 to 16 months within the period of four years. In order to plot the curve at the customary one-year intervals, the mental ages, instead of being assigned to the year nearest the chronological age, as is the usual custom, were calculated and weighted in such a manner as to give the mental age at exact years. This method assumes that the child continues to grow mentally at the same rate between the examination intervals. A child actually measured at the age of 5 years-5 months would, under the usual method, be considered as five years and its mental age averaged with the mental age of other children who might actually have varied between 4 years-7 months and 5 years-6 months at the time of the examination. To prevent this distortion of the real age,

mental and chronological, a new mental age was computed for each chronological age during the period of measurement. The method used was as follows:

For each child the difference between every two successive chronological ages and every two successive mental ages was calculated and the rate of improvement obtained by dividing the difference in mental age by the difference in chronological age. For example, take the case of a boy who had his second examination at the age of 6 years-1 month, and his third examination at the age of 7 years-2 months, giving a difference in chronological age of 13 months. His mental age at the earlier examination was 8 years-8 months, and at the later, 10 years-2 months, the difference in mental age being 18 mental months. The mental age difference divided by the chronological age difference results in a rate of improvement of 1.38. This means that he grew 1.38 mental months for every month of chronological age. The mental age at the time of the earlier examination was then corrected by subtracting from the mental age of 8 years-8 months, or 104 mental months, the number of mental months equivalent to one month's growth at the rate of 1.33 (which is the rate at which he was growing previous to 6-1). This gives a new mental age at 6 years of 104 mental months—1.33 mental months, or 102.67 mental months. The corrected mental age at 6 years was 102.67 months. The corrected mental age at 7 will be the mental age at 6 years-1 month, +11 months at the rate of 1.38, or $102.67+(11\times1.38)$ or 117.85 mental months.

The resultant mental ages were averaged for each chronological age from 5 to 14 for all of the boys and all of the girls of the group and for the normal and superior boys and girls separately. The resultant mental growth curve is shown in Table I and Chart II.

The rates of growth used for correcting the mental ages from the exact year to year by the method of monthly rates described above were averaged by chronological age groups to give the total growth of each child for all year intervals. The resultant composite rates were averaged for each year interval to obtain the annual rate of growth. The corrected mental ages were then divided by the chronological ages at the exact years in order to determine the new rate of improvement between every two successive mental ages. These new rates were averaged by years to give the rate of mental growth shown in Table III and Chart V.

The new I. Q.'s for each exact chronological age were averaged to give Chart IV and Table II.

4. *The Analysis of the Mental Growth Curve.* The mental growth curves obtained by the individualizing method from consecutive measurements of superior and average boys and girls between the ages 5 to 14 present at first glance the appearance of a straight line. The familiar parabolic character of the theoretical growth curve is lacking, since our data furnish us no determinations for ages 14 to 16, during which this slowing up of mental growth is supposed to take place.

TABLE I

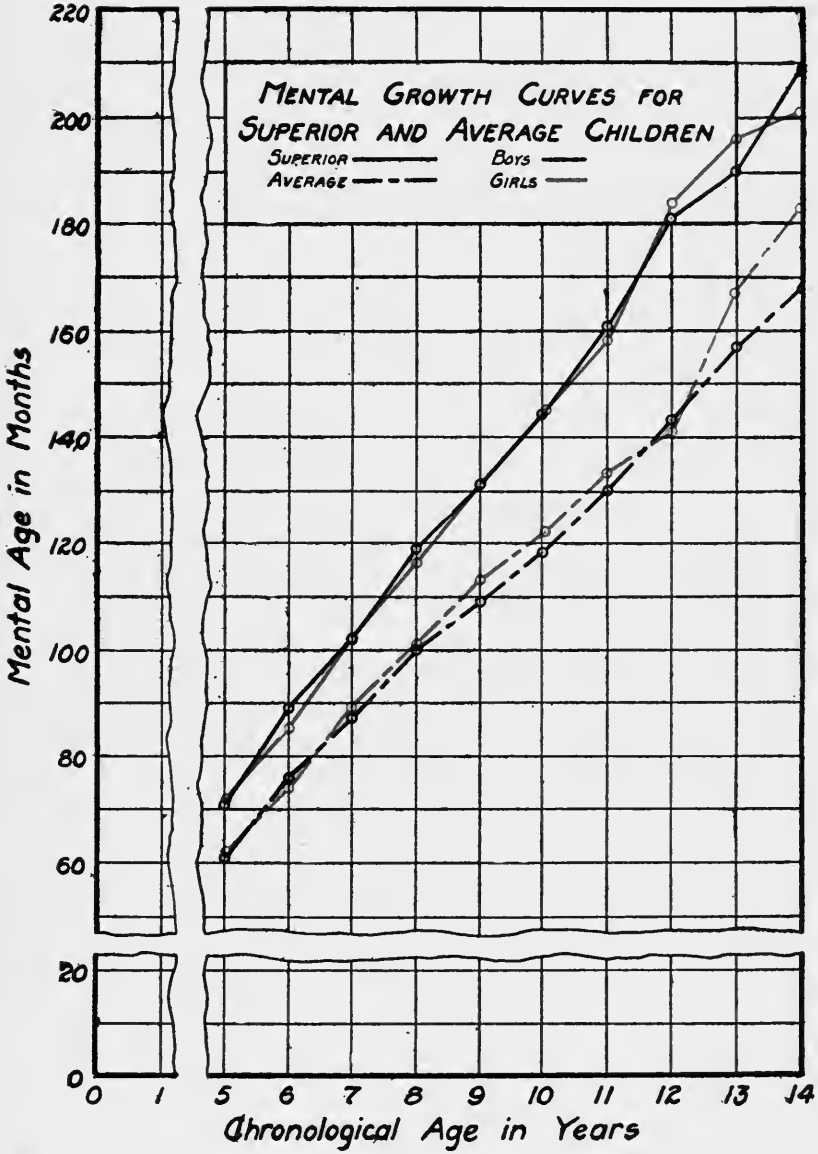
MEAN MENTAL AGE IN MONTHS OF SUPERIOR AND AVERAGE BOYS AND GIRLS FOR SUCCESSIVE CHRONOLOGICAL AGES
(Based on 487 Consecutive Examinations)

Chronological Age	Boys		Girls	
	Intelligence Quotient 110+ (Superior)	Intelligence Quotient 90-110 (Average)	Intelligence Quotient 110+ (Superior)	Intelligence Quotient 90-110 (Average)
5	70.6	60.7	72.0	62.5
6	88.7	75.6	85.0	73.9
7	102.2	87.4	102.2	88.9
8	118.7	100.4	116.3	100.9
9	131.4	109.2	131.1	112.9
10	144.0	117.7	145.5	122.4
11	160.5	130.5	158.5	133.3
12	181.0	143.1	184.1	141.5
13	190.0	157.2	196.0	166.5
14	208.9	168.0	201.0	182.9

It is apparent from these curves that superior and average children develop at different levels and that children of these different intellectual levels grow increasingly dissimilar with increase in chronological age. For example, at the age of 5 the superior and average boys have a mental age of 71 and 61 mental months respectively, but at 14 the superior have 209 and the average 168. The difference of 10 points at 5 years has increased to 41 points at 14 years. The girls show similar differences.

This divergence in the growth curves of average and superior children has long been assumed as probable but has not heretofore been empirically demonstrated. The concept of the I. Q. pre-

CHART II



supposes a certain divergence in the curves of the superior and the average child, as the superior child has to grow at a rate greater than one mental month for one chronological month in order to maintain a constant I. Q.

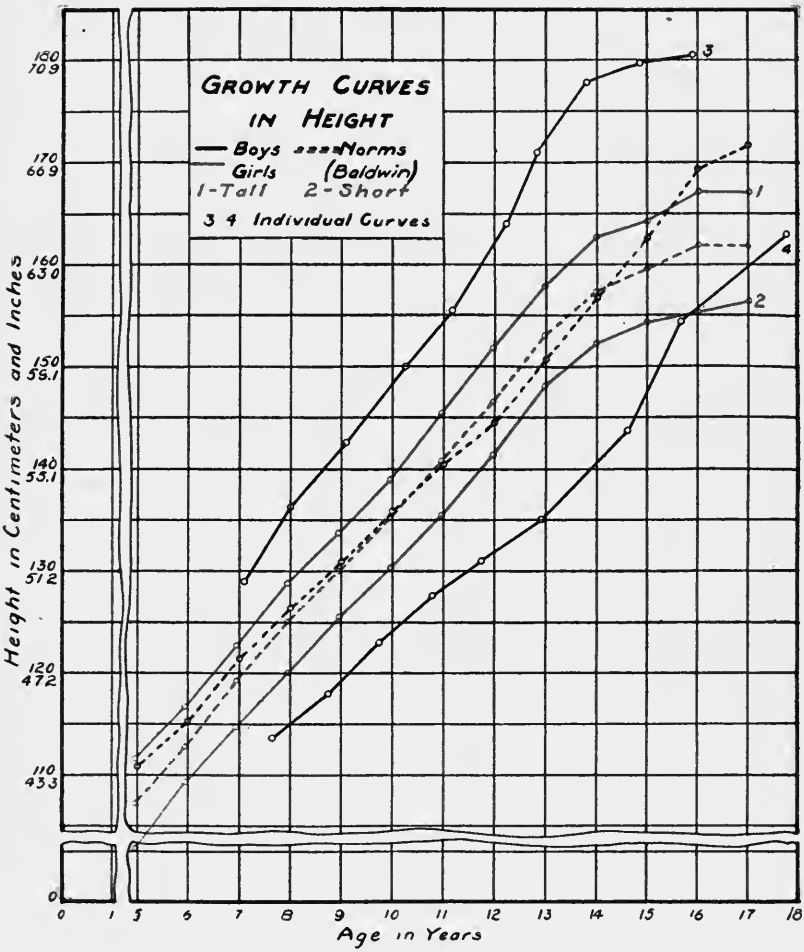
The general straight line appearance previously noted is especially apparent in the growth curve for boys. Further analysis reveals, however, a very significant change in the trend with the approach of adolescence. This is especially marked in the curve for girls where there is a rise in mental development in the superior girls between the ages 11 to 12 and in the average girls a year later, between the ages 12 to 13. The superior boys show a similar acceleration in mental growth at about 12—somewhat later than in the case of the superior girls. The boys of average mental ability have not yet shown this acceleration up to 14 years, which is the latest age for which we have a sufficient number of cases. It seems unlikely that this rise in the curve of mental growth can be explained by defects in the measuring scale at the adolescent ages. There is no reason to believe that the scale was not equally well standardized at all ages. The increased incline of the curve extends, moreover, through several ages, and it is not probable that the tests would be too easy throughout these years.

The mental growth curves of the boys and girls cross repeatedly. There is, however, a tendency in the earlier ages for the average girls to be a little higher in mental age than the average boys, in the later ages for the girls of both groups to be a little superior to the boys. While not without exception, this adolescent superiority of girls is in accordance with other facts indicative of the earlier maturity of girls.

There has been in recent years a movement to discredit characteristic changes in intellectual traits as a result of adolescence. This point of view, which is probably a reaction to undue sentimental emphasis of those changes current in the psychology of twenty years ago, is expressed by Terman (25) 1917, p. 60, who maintains there is little evidence of periodicity, or irregularity as far as general intelligence is concerned, and throws doubt on the existence of the adolescent spurt. Although there is obviously no time in the mental development of the child when new mental traits suddenly appear, the rise in the mental growth curves apparent at the ages of 11 to 14 may be attributed to increased strength of traits that have long been developing, or to increased mental vigor similar to the accelerated growth in physical traits.

The existence of such a period of increased vigor would not necessarily interfere with the stability of the I. Q., providing the scale was adapted in difficulty to such a change. It certainly would not affect the individual's position in the group relative

CHART III



to a norm, since the norm at these ages would also be higher if all children developed in a similar way. A child's physical status in height, for example, remains relatively constant with reference to its group from age 6 through adolescence, as shown by Baldwin (1) 1914, though the norms and individual curves may show adolescent accelerations.

The mental growth curves are strikingly similar to the physical growth curves in height as shown in Chart III. This chart here published for the first time illustrates the differences in the growth of tall, average and short girls and of a tall and a short

boy as compared with the norms for boys and girls. The norms for average boys and girls are based on 6 to 10 years of semi-annual measurements for 60 boys and 60 girls. The curves for tall girls are based on similar material for 52 cases distributed above the norm, and the curves for short girls on 28 cases considerably below the norm. The curves show the same phenomena that have been pointed out in connection with the mental growth curves. In both cases the curve at the higher level shows the acceleration at an earlier age.

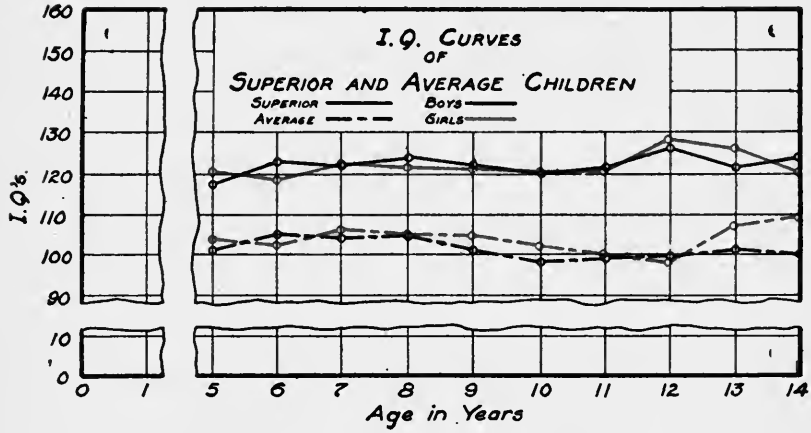
TABLE II

MEAN INTELLIGENCE QUOTIENTS OF SUPERIOR AND AVERAGE BOYS AND GIRLS FOR SUCCESSIVE CHRONOLOGICAL AGES

Chronological Age	Boys		Girls	
	Intelligence Quotient 110+ Superior	Intelligence Quotient 90-110 Average	Intelligence Quotient 110+ Superior	Intelligence Quotient 90-110 Average
5	117.6	101.2	119.9	104.1
6	123.3	105.0	118.0	102.6
7	121.6	104.0	121.7	105.9
8	123.6	104.6	121.1	105.1
9	121.7	101.1	120.5	104.6
10	119.9	98.1	120.3	102.1
11	121.5	98.8	119.8	99.9
12	125.7	99.4	127.9	98.2
13	121.5	100.8	125.7	106.7
14	124.3	100.0	119.7	108.9

5. *The Analysis of the I. Q. Curve.* The mean intelligence quotients (Table II) and the I. Q. curves (Chart IV) for superior and average boys and girls show some of the same characteristics observed in the mental growth curves. The curves are in general approximately horizontal, confirming within limitations the constancy of the I. Q. There appear to be, however, certain definite phenomena associated with physiological development that show themselves in a decrease or increase in the I. Q. at certain chronological ages. A study of the physical development of young children shows that there is considerable fluctuation between the ages 4 and 7. These I. Q. curves suggest a similar condition with a small spurt in mental development, appearing a little later in the boys than in the girls. Both superior boys and girls show a rise in the I. Q. between the ages of 11 and 12. Average girls

CHART IV



also show this adolescent acceleration, although it appears a year later than in the case of superior girls. The I. Q. curve and the mental growth curve of the average boys do not show this phenomenon, possibly because they have not reached this stage of acceleration.

6. *The Analysis of the Curve of the Rate of Mental Growth.* Our tables of original data do not include calculations of the actual number of mental months growth for one chronological month between examinations, although these were used in all

TABLE III

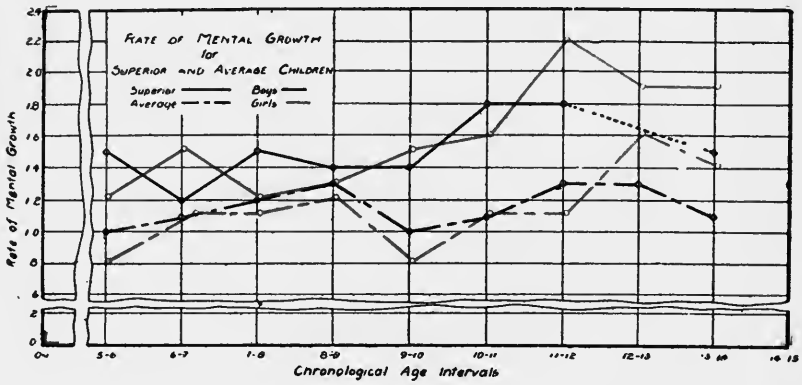
MEAN RATE OF MENTAL GROWTH OF SUPERIOR AND AVERAGE BOYS AND GIRLS FOR CHRONOLOGICAL AGE INTERVALS

Chronological Age Intervals	Boys		Girls	
	Intelligence Quotient 110+ Superior	Intelligence Quotient 90-110 Average	Intelligence Quotient 110+ Superior	Intelligence Quotient 90-110 Average
5-6	1.5	1.0	1.2	.8
6-7	1.2	1.1	1.5	1.1
7-8	1.5	1.2	1.2	1.1
8-9	1.4	1.3	1.3	1.2
9-10	1.4	1.0	1.5	.8
10-11	1.8	1.1	1.6	1.1
11-12	1.8	1.3	2.2	1.1
12-13	(1.1)	1.3	1.9	1.6
13-14	1.5	1.1	1.9	1.4

cases as a basis for the curve of the rate of mental growth. Inspection of the tables will show for individual children great fluctuation in the rate from examination to examination. A child whose rate from the first to the second examination is 1.56 mental months for each month of chronological age may show between the second and third examination a rate of .23 mental months for each chronological month. Part of this discrepancy is of course due to the experimental error of each single mental age determination, but the size of many of the irregularities cannot be explained on this basis. It appears that there is no rate of improvement which is characteristic of the individual and uniformly maintained throughout his years of mental growth although an approximately constant rate is maintained in many cases.

Table III and Chart V show the mean rate of mental growth for these children. The average children grow approximately

CHART V



one mental month for each chronological month, while the superior children have a higher rate (shown by the curve at a higher level) except in the case of boys between 12 and 13, where the small number of cases results in a decreased rate (printed in parenthesis in Table III and represented by a dotted line in Chart V). The effect may also be noted in the mental growth curve for superior boys, Chart I.

There is little difference, on the average, in the rate of growth of these two groups of children. In no case is the difference

greater than seven-tenths of a year. These figures cannot of course be considered as norms, since they depend upon the selection of cases included in the study. The addition of more cases of very superior intelligence, or of more cases of I. Q.'s below 100 would have increased the difference.

The general prepubertal increase in mental development becomes evident earlier in the case of superior children than in average children, and in the case of superior girls about a year earlier than in average boys. In comparing the curves it should be kept in mind that a child who has been growing at a certain rate and then reaches a period of little or no increase will have to reattain the rate of growth at which he was previously developing before an actual acceleration in growth can be considered as taking place. The period of acceleration is therefore later than the point in the curve at which the steep rise begins. In general all of these curves show less difference between average and superior boys in regard to these adolescent phenomena than between average and superior girls, who are usually a year apart in their general development.

Our data do not permit us to give a definite answer to the question whether superior children grow more superior as time goes on through an increase in the rate of mental growth. The curves for the two groups of children seem to diverge slightly at the higher ages, especially in the case of girls at the adolescent years. The facts in regard to the change of I. Q. to be reported later on page .. seem also to indicate some characteristic differences in the growth of children of different I. Q. level. We should hesitate, however, to make any generalization in regard to this matter from the material presented in this study.

7. *Mean Group Differences at Successive Examinations.* Table V is purely descriptive, presenting the mean chronological age at successive examinations and the mean interval between examinations for use in interpreting the findings in other tables. The findings of Table IV are averages of the I. Q.'s obtained at each examination by the children of each particular group.

It is a very significant fact that the mean I. Q. of each of the four groups of children increased with each successive examination, which must be regarded as an effect of greater habituation or practice. The increase in the mean I. Q. is proportionate to the number of re-examinations.

The mean I. Q. for the Five Examination Group increased from 115.39 through 119.5, 119.75 and 123.91 to 126.7. The mean I. Q. for the Four Examination Group increased from 111.06 through 112.02 and 115.16 to 118.20. The mean I. Q. for the Three Examination Group increased from 110.59 through 111.80 to 115.21. The mean I. Q. for the Two Examination Group increased from 112.3 to 115.8. This increase in I. Q. has been noted by previous workers on a single retest in the summary by Rugg and Colloton (21).

TABLE IV
MEAN INTELLIGENCE QUOTIENTS AT SUCCESSIVE EXAMINATIONS

Group	No. of Cases	Exam. 1	Exam. 2	Exam. 3	Exam. 4	Exam. 5
5	36	115.4	119.5	119.8	123.9	126.7
4	42	111.1	112.0	115.2	118.2	.....
3	51	110.6	111.8	115.2	.....	.....
2	56	112.3	115.8	.....	.....	.....

There is also an increase in the mean rate of improvement upon successive examinations. To investigate this phase of the practice effect, the data for the Four and the Five Examination Groups were worked over to give for each child the amount of increase in mental age months for each month of chronological age increase between the first and second examination, the second and third and the third and fourth. The means of these individual rates of improvement reveal a general increase in the rate of mental development which is especially marked between the third and fourth examination in the case of the girls.

Examination	No. cases	I-II Rate	II-III Rate	III-IV Rate
Boys	37	1.48	1.42	1.73
Girls	34	1.29	1.64	2.40

8. *Discussion and Literature.* It is extremely probable that the theoretical mental growth curves found in so many textbooks really misrepresent the facts of mental development. It has been the custom to draw the growth curves of children of different degrees of ability as if all of these curves began with zero ability at the time of birth and from that time on rose steadily. From all that we know in regard to differences in the mental capacity of young children, the curves of mental development, like the curves of physical development, begin at dif-

TABLE V

MEAN CHRONOLOGICAL AGE AND MEAN INTERVAL BETWEEN SUCCESSIVE EXAMINATIONS

Examination	1	1-2	2	2-3	3	3-4	4	4-5	5
Examination Group	Chron. Age	Interval in Mos.	Chron. Age	Interval in Mos.	Chron. Age	Interval in Mos.	Chron. Age	Interval in Mos.	Chron. Age
5 Boys	8-2	16.1	9-3	13.5	10-5	7.9	11-1	6.0	11-7
Girls	8-6	13.5	9-7	16.1	10-11	6.5	11-6	5.9	11-11
4 Boys	8-0	13.2	9-5	13.3	10-6	6.3	11-0	....	....
Girls	8-7	16.9	9-10	10.5	10-9	6.6	11-3	....	....
3 Boys	7-9	15.1	9-3	13.8	10.5	....	....	....	....
Girls	9-0	14.9	10-3	11.3	11-2	....	....	....	....
2 Boys	8-0	16.4	8-3	....	....	....	....	....	....
Girls	7-1	14.7	9-4	....	....	....	....	....	....

ferent levels (points). There are individual mental differences at birth as there are individual differences in height. It is not conceivable that the feebleminded child should begin at the same point with the child of average or superior ability and then drop back in the race as his more gifted brothers gain. The truth of the matter is, he runs on a relatively lower level throughout life.

Much of the work on retests of children has been done with feebleminded subjects. While it is impossible in this study on normal and superior children to go into the question of growth curves of the feebleminded, it will orientate the problem if we review briefly such other studies as have been made with repeated examinations. Bobertag (6) p. 528, reported in 1912 as a result of retests on 83 children whom he had examined the year before that children whose intelligence is above average advance more rapidly; those whose intelligence is below average advance more slowly. He maintained (p. 531) that if one

limits one's self to a few successive years—8, 9, 10, for example—one could say that the I. Q. is approximately constant. If, however, one considers all the ages, or the whole developmental course of children's intelligence it is very questionable whether the assumption of a constant I. Q. is tenable.

Berry (4) in 1913 found on a retest of 82 children that the normal subjects made an average gain of 1 year, and the feebleminded—mental ages 4-11 years—an average gain of .5 of a year. He did not report the correlation between the examinations.

Bloch (5) 1915 re-examined defective children by the Binet scale.

Stern (23) (24) 1914 and 1916, who discussed the subject at length, but without experimental data of his own, believed that the I. Q. did not afford an actually constant expression of degree of feeblemindedness but showed a tendency to fall in value as chronological age increased and the age of arrest was approached.

Descoeudres (9) 1915 retested 26 children of a special class and found the I. Q. very similar to the previous one with a greater tendency to increase. Cases with three or four examinations showed practically the same I. Q. with less than 50% variation.

Terman (25) p. 55, 1917 concluded from re-examinations that "the results of 140 such tests show as far as the age of 13 or 14, even when the tests are separated by as much as five years, changes of 10 points in 12 are relatively rare. In general, it can be said that the superior children of the first test are found superior in the second, the average remained average, the inferior remain inferior, the feebleminded remain feebleminded and nearly always in approximately the same degree. The most marked exceptions to this rule are found with the feebleminded whose intelligence quotient shows a tendency to decrease considerably."

Cuneo and Terman (8) 1918, retested 77 children and found high correlations between the two tests.

Terman (26) 1919 found considerable agreement in the I. Q.'s of 46 children tested three or more times. He says, p. 147: "It is possible that feebleminded children testing below 60 are less likely to hold their own than those of milder degree of defect. . . . . On the other hand the I. Q. as determined by the Stanford-Binet (or any other intelligence scale yet devised) cannot **indefinitely** hold its constancy in the case of children who are exceptionally superior."

Wallin (28) 1919 discussed the use of the I. Q. in classification without data from retests. His article has been critically reviewed by Rosenow (20) 1920, who presents experimental evidence of approximate stability of the I. Q. from retests of 69 cases examined at about 10 months interval.

Wallin (29) 1921 reported re-examinations on 153 children by different revisions of the Binet tests.

Kuhlmann (17) (18) who had discussed the intelligence of the feeble-minded is also reported by Hollingworth (15) p. 105 in 1920 to have found that "On the whole the I. Q. for a given case remains constant with a slight tendency on the average to decrease after the ages of about nine or ten."

Kuhlmann (18a) 1921 reported results on 639 cases ranging from idiocy to nearly normal mentality examined 2 to 5 times within a 10 year period by the Binet and Kuhlmann series. He found that the I. Q. decreased with age and more for the higher than for the lower grades.

Garrison (13) 1921 retested by the Stanford-Binet 94 children who had previously been tested by the Goddard Revision and found on the whole, a rather close correspondence.

Doll (10) 1921, from a study of numerous growth curves for feebleminded subjects who had received at least 5 annual examinations, believes in an age of arrest for the feebleminded beyond which the I. Q. would decrease. Terman (27) 1921 criticizes this presentation and the conclusion drawn from the data.

Freeman (12) 1921, published an important discussion on the concept of the I. Q. with reference to age scales and point scales.

Rugg and Colloton (21) 1921, have assembled the reports of other workers with Stanford-Binet tests and added data from 137 cases of their own. They find that with one exception investigators have found an average difference in I. Q. on re-examination of 4.5 points, and confirm in some other respects Terman's 1917 conclusions.

The literature summarized above presents many interesting problems in regard to the age of arrest or the limit of mental growth. Our data do not extend far enough to permit us to speculate on the age at which mental growth ceases in the normal or superior child, though there is reason to suspect that the mental age curves of some of the superior girls are beginning to flatten out with a resulting decrease in I. Q. Even so this may be merely

a fictitious slowing up of mental growth due to the inevitable "bumping" into the upper limit of the scale.

Summary and Conclusions

1. The fundamental problems concerning the general trend of the growth curve, the rate of improvement of children of different intellectual ability, variability in mental development, the possibility of prediction in mental growth and the relation between physical and mental growth can be solved only through a study of consecutive reexaminations and observations of the same group of children throughout a number of years.

2. The mental growth curves presented herewith are probably the first curves for superior and average children of the development of general intelligence studied by means of repeated examinations on the same children.

3. The curves constructed from the corrected mental age ratings do not misrepresent the actual growth process as is the case when the chronological age is approximated to the nearest year.

4. It is apparent from these curves that superior and average children develop at different levels and that children of these different intellectual levels grow increasingly dissimilar in mental age with increase in chronological age. This divergence in the growth curves of average and superior children has long been assumed as probable but has not heretofore been empirically demonstrated.

5. An analysis of the mental growth curve reveals a significant change in the trend with the approach of adolescence, which appears earlier in the case of superior children. There is also an adolescent superiority of girls which is in accordance with other facts indicative of the earlier maturity of girls.

6. The mental growth curves are strikingly similar to the physical growth curves in height.

7. The I. Q. curves are approximately horizontal, confirming within limitations the constancy of the I. Q. There are fluctuations associated with physical development.

8. The curves of the rate of mental growth are higher for superior than for average children, and seem to diverge slightly at the adolescent years.

9. The general prepubertal increase appears earlier in the case of superior children.

10. The mean I. Q. of each of the four groups of children increased with each successive examination, which is probably an effect of greater habituation or practice.

11. There is also an increase in the mean rate of improvement on successive examinations.

II. THE POSSIBILITY OF PREDICTION IN MENTAL GROWTH

1. *Intelligence Status of Individuals at Successive Examinations.* The stability of the I. Q. is one of the most important problems under discussion by psychologists at the present time. Upon the relative stability of the ratio between mental and chronological age depends to a large extent the possibility of prediction in mental growth.

Binet and Simon felt very doubtful of the possibility of using the I. Q. for prediction. Even Bobertag (5) and Stern (24), who are among the earliest advocates of the use of the I. Q., did not believe that it would remain constant for later ages.

The question of the stability of the I. Q. has been discussed in a number of theoretical articles. Some writers believe that it remains practically constant and others have found a tendency for the I. Q. of the feebleminded to decrease and for the I. Q. of the superior to increase. Any conclusive answer to the question of whether the I. Q. remains constant depends upon the accumulation of a sufficient number of long-time mental growth curves for children of different intellectual capacity.

Terman (26) 1919, p. 137, states the problem briefly thus: "By applying it [the Binet scale] repeatedly to the same children we can find out whether constancy or irregularity rules. Prediction hinges on the question whether a child who is found by the test to be a given per cent above or below the mental level normal for his age continues to be accelerated or retarded to the same degree. The answer is found in the extent to which the I. Q. remains constant."

Psychologists who have been accustomed to thinking that all that was required for a solution of the problems of mental growth was the accumulation of a sufficient number of re-examinations for long periods will find that the repetition of the intelligence scale brings up many puzzling new problems. A study of the original data, Tables VI and VII, shows just what variations in

TABLE VI

ORIGINAL DATA ARRANGED IN ORDER OF MEAN I. Q.—BOYS

1.	Average I. Q. 158.0.					
	Examiner	E. V.	E. V.			
	Chronological Age	5-3	5-10			
	Terman Age	8-5	9-1			
	I. Q.	160	156			
2.	Average I. Q. 150.7.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological Age	5-11	7-0	7-11	8-6	
	Terman Age	8-5	9-4	13-3	13-9	
	I. Q.	142	133	167	161	
3.	Average I. Q. 143.6.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	5-1	6-1	7-2	8-1	8-7
	Terman Age	7-4	8-8	10-2	11-7	12-8
	I. Q.	144	142	142	143	147
4.	Average I. Q. 142.6.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	8-2	9-3	10-3	11-2	11-8
	Terman Age	11-1	12-1	15	16-11	17-8
	I. Q.	135	130	146	151	151
5.	Average I. Q. 138.2.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	5-8	6-9	7-9	8-8	9-2
	Terman Age	7-6	9-9	10-3	11-7	13-9
	I. Q.	132	144	132	133	150
6.	Average I. Q. 137.					
	Examiner	L. W.	L. I. S.			
	Chronological Age	5-9	6-11			
	Terman Age	7-8	9-9			
	I. Q.	133	141			
7.	Average I. Q. 134.5.					
	Examiner	E. V.	L. W.			
	Chronological Age	6-10	9-2			
	Terman Age	8-9	12-11			
	I. Q.	128	141			
8.	Average I. Q. 131.8.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	10-7	12-1	12-7	13-7	14-0
	Terman Age	12-5	16-8	17-2	18-1	19-0
	I. Q.	117	136	137	133	136
9.	Average I. Q. 129.0.					
	Examiner	L. W.	L. I. S.			
	Chronological Age	6-1	7-0			
	Terman Age	7-4	9-7			
	I. Q.	121	137			
10.	Average I. Q. 128.0.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	
	Chronological Age	6-3	7-4	9-4	9-10	
	Terman Age	8-0	9-4	11-4	13-4	
	I. Q.	128	127	121	136	
11.	Average I. Q. 128.0.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	L. I. S.
	Chronological Age	6-1	7-1	8-8	9-1	9-7
	Terman Age	7-6	9-2	11-3	11-6	12-9
	I. Q.	123	129	129	126	133
12.	Average I. Q. 127.6.					
	Examiner	E. V.	L. S.	L. I. S.	L. I. S.	L. I. S.
	Chronological Age	10-6	12-0	13-1	13-6	14-0
	Terman Age	12-8	15-5	17-0	17-6	18-6
	I. Q.	120	128	129	129	132
13.	Average I. Q. 127.2.					
	Examiner	E. V.	L. I. S.	L. I. S.	L. I. S.	
	Chronological Age	7-1	8-8	9-1	9-8	
	Terman Age	8-6	11-2	12-1	12-4	
	I. Q.	120	129	133	127	
14.	Average I. Q. 126.0.					
	Examiner	L. W.	L. I. S.			
	Chronological Age	7-3	8-1			
	Terman Age	9-2	10-2			
	I. Q.	126	126			

TABLE VI—CONTINUED

ORIGINAL DATA ARRANGED IN ORDER OF MEAN I. Q.—BOYS

15.	Average I. Q. 124.5.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological Age	9-1	10-5	11-0	11-7	
	Terman Age	10-8	12-6	14-6	14-11	
	I. Q.	117	120	132	129	
16.	Average I. Q. 124.2.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological Age	8-4	10-4	11-3	11-10	
	Terman Age	10-9	11-10	14-1	15-4	
	I. Q.	129	114	125	129	
17.	Average I. Q. 124.0.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	8-3	9-6	10-6	11-2	11-8
	Terman Age	10-1	11-11	13-1	13-11	14-7
	I. Q.	122	125	124	124	125
18.	Average I. Q. 123.5.					
	Examiner	L. W.	L. I. S.			
	Chronological Age	6-11	7-10			
	Terman Age	8-8	9-7			
	I. Q.	125	122			
19.	Average I. Q. 123.5.					
	Examiner	L. W.	L. I. S.			
	Chronological Age	8-7	9-3			
	Terman Age	10-4	11-9			
	I. Q.	120	127			
20.	Average I. Q. 123.0.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	10-4	11-11	12-11	13-5	13-10
	Terman Age	12-8	15-0	15-5	16-3	16-8
	I. Q.	122	125	119	121	128
21.	Average I. Q. 122.					
	Examiner	E. V.	L. I. S.			
	Chronological Age	5-4	8-3			
	Terman Age	6-2	10-7			
	I. Q.	116	128			
22.	Average I. Q. 121.7.					
	Examiner	E. V.	E. V.	L. I. S.	L I. S.	
	Chronological Age	9-8	11-3	12-9	13-3	
	Terman Age	11-4	14-1	15-3	16-8	
	I. Q.	117	125	119	126	
23.	Average I. Q. 121.2.					
	Examiner	E. V.	L. W.	L. I. S.	I. I. S.	
	Chronological Age	5-2	6-6	7-3	7-10	
	Terman Age	5-8	7-6	9-5	10-4	
	I. Q.	109	115	129	132	
24.	Average I. Q. 121.0.					
	Examiner	E. V.	E. V.			
	Chronological Age	10-9	12-4			
	Terman Age	11-9	16-5			
	I. Q.	109	133			
25.	Average I. Q. 120.8.					
	Examiner	E. V.	E. V.	L. W.	L I. S.	L. I. S.
	Chronological Age	8-6	9-7	10-10	11-7	12-0
	Terman Age	9-11	11-4	13-3	14-4	14-11
	I. Q.	116	118	122	124	124
26.	Average I. Q. 120.2.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	5-1	5-8	7-0	7-8	8-3
	Terman Age	5-10	7-0	7-10	9-6	10-8
	I. Q.	114	123	111	124	129
27.	Average I. Q. 120.0.					
	Examiner	E. V.	E. V.	L. W.		
	Chronological Age	9-0	10-0	11-3		
	Terman Age	10-8	12-1	13-9		
	I. Q.	118	120	122		
28.	Average I. Q. 120.0.					
	Examiner	L. W.	L. I. S.			
	Chronological Age	5-9	6-5			
	Terman Age	6-6	8-2			
	I. Q.	113	127			

TABLE VI—CONTINUED

ORIGINAL DATA ARRANGED IN ORDER OF MEAN I. Q.—BOYS

29.	Average I. Q. 119.7.					
	Examiner	E. V.	E. V.	L. I. S.	L I. S.	
	Chronological Age	6-10	8-4	9-11	10-5	
	Terman Age	7-4	9-4	12-0	14-5	
	I. Q.	107	112	122	138	
30.	Average I. Q. 119.2.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological Age	5-0	6-6	7-2	7-8	
	Terman Age	5-9	7-11	8-7	9-3	
	I. Q.	115	122	119	121	
31.	Average I. Q. 119.0.					
	Examiner	E. V.	E. V.			
	Chronological Age	7-8	9-1			
	Terman Age	9-2	10-6			
	I. Q.	120	118			
32.	Average I. Q. 118.5.					
	Examiner	E. V.	L. W.			
	Chronological Age	6-0	7-3			
	Terman Age	6-10	8-11			
	I. Q.	114	123			
33.	Average I. Q. 118.0.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	5-3	5-10	7-2	7-10	8-5
	Terman Age	6-2	7-0	8-2	9-5	10-1
	I. Q.	117	120	114	120	119
34.	Average I. Q. 118.0.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	10-1	11-2	12-8	13-2	13-7
	Terman Age	10-4	12-8	15-5	16-5	17-4
	I. Q.	102	113	122	125	128
35.	Average I. Q. 117.6.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S
	Chronological Age	9-2	10-3	11-5	12-3	12-8
	Terman Age	10-3	11-11	14-0	14-10	14-10
	I. Q.	112	116	122	121	117
36.	Average I. Q. 117.5.					
	Examiner	L.S.&E.V.	L. I. S.			
	Chronological Age	11-8	14-3			
	Terman Age	14-3	16-2			
	I. Q.	122	113			
37.	Average I. Q. 117.5.					
	Examiner	E. V.	E. V.			
	Chronological Age	8-10	9-11			
	Terman Age	10-4	11-9			
	I. Q.	117	118			
38.	Average I. Q. 117.0.					
	Examiner	L. W.	L. I. S.			
	Chronological Age	6-1	6-10			
	Terman Age	6-10	8-4			
	I. Q.	112	122			
39.	Average I. Q. 116.6.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	7-9	9-0	10-0	10-8	11-3
	Terman Age	9-6	10-6	10-9	12-7	13-6
	I. Q.	122	116	107	118	120
40.	Average I. Q. 116.5.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	
	Chronological Age	8-3	9-3	11-4	11-10	
	Terman Age	8-11	10-9	13-3	14-10	
	I. Q.	108	116	117	125	
41.	Average I. Q. 116.2.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	
	Chronological Age	10-2	11-9	13-3	13-9	
	Terman Age	11-11	14-1	14-10	16-1	
	I. Q.	117	119	112	117	
42.	Average I. Q. 116.0.					
	Examiner	E. V.	E. V.			
	Chronological Age	8-11	9-11			
	Terman Age	10-2	11-8			
	I. Q.	114	118			

TABLE VI—CONTINUED

ORIGINAL DATA ARRANGED IN ORDER OF MEAN I. Q.—BOYS

43.	Average I. Q. 115.5.					
	Examiner	E. V.	E. V.			
	Chronological Age	6-10	7-10			
	Terman Age	7-8	9-4			
	I. Q.	112	119			
44.	Average I. Q. 114.6.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	5-4	5-11	7-3	7-11	8-6
	Terman Age	5-8	7-0	8-6	8-10	10-4
	I. Q.	106	118	117	111	121
45.	Average I. Q. 113.6.					
	Examiner	E. V.	E. V.	L. W.		
	Chronological Age	9-2	10-2	11-6		
	Terman Age	9-8	10-10	15-0		
	I. Q.	105	109	130		
46.	Average I. Q. 113.4.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	L. I. S.
	Chronological Age	5-6	6-6	8-1	8-7	9-1
	Terman Age	5-10	7-4	9-0	10-2	10-11
	I. Q.	106	112	111	118	120
47.	Average I. Q. 113.0.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	8-9	9-9	11-1	11-8	12-3
	Terman Age	9-7	10-6	12-9	13-4	14-8
	I. Q.	109	107	115	114	120
48.	Average I. Q. 112.7.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	
	Chronological Age	11-0	12-7	14-1	14-7	
	Terman Age	11-3	14-10	16-8	16-8	
	I. Q.	102	117	118	114	
49.	Average I. Q. 111.6.					
	Examiner	E. V.	E. V.	L. W.		
	Chronological Age	6-3	7-3	8-7		
	Terman Age	7-2	8-0	9-6		
	I. Q.	114	110	111		
50.	Average I. Q. 111.5.					
	Examiner	L. W.	L. I. S.			
	Chronological Age	7-4	8-2			
	Terman Age	8-4	9-0			
	I. Q.	113	110			
51.	Average I. Q. 111.0.					
	Examiner	M.	L. I. S.			
	Chronological Age	5-4	6-7			
	Terman Age	5-8	7-8			
	I. Q.	106	116			
52.	Average I. Q. 110.5.					
	Examiner	L. W.	L. I. S.			
	Chronological Age	7-4	8-6			
	Terman Age	7-8	9-10			
	I. Q.	105	116			
53.	Average I. Q. 110.0.					
	Examiner	E. V.	E. V.	L. I. S.		
	Chronological Age	6-8	7-8	9-3		
	Terman Age	7-0	8-4	10-10		
	I. Q.	105	108	117		
54.	Average I. Q. 110.0.					
	Examiner	L. W.	L. I. S.			
	Chronological Age	6-4	7-2			
	Terman Age	7-2	7-8			
	I. Q.	113	107			
55.	Average I. Q. 108.7.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological Age	6-4	7-10	8-5	8-11	
	Terman Age	7-0	8-0	9-2	10-2	
	I. Q.	110	102	109	114	
56.	Average I. Q. 107.5.					
	Examiner	E. V.	E. V.			
	Chronological Age	6-2	7-1			
	Terman Age	6-6	7-10			
	I. Q.	105	110			

TABLE VI—CONTINUED

ORIGINAL DATA ARRANGED IN ORDER OF MEAN I. Q.—BOYS

57.	Average I. Q. 106.7.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological Age	5-11	7-5	8-1	8-7	
	Terman Age	6-2	7-10	8-3	9-5	
	I. Q.	104	106	107	110	
58.	Average I. Q. 106.7.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological Age	11-0	12-2	13-0	13-6	
	Terman Age	12-0	12-11	14-1	14-1	
	I. Q.	109	106	108	104	
59.	Average I. Q. 106.0.					
	Examiner	E. V.	E. V.			
	Chronological Age	11-1	12-5			
	Terman Age	11-6	13-5			
	I. Q.	104	108			
60.	Average I. Q. 105.7.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	
	Chronological Age	11-2	12-3	14-2	14-8	
	Terman Age	11-1	13-7	14-11	16-0	
	I. Q.	99	110	105	109	
61.	Average I. Q. 105.6.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological Age	12-5	13-11	14-11	15-4	15-10
	Terman Age	12-2	14-8	15-3	17-2	17-8
	I. Q.	97	105	102	112	112
62.	Average I. Q. 105.5.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological Age	5-4	6-6	7-5	8-0	
	Terman Age	5-6	6-6	7-8	9-3	
	I. Q.	103	100	103	116	
63.	Average I. Q. 105.5.					
	Examiner	E. V.	L. I. S.			
	Chronological Age	9-7	12-0			
	Terman Age	10-1	12-9			
	I. Q.	105	106			
64.	Average I. Q. 103.0.					
	Examiner	E. V.	L. I. S.			
	Chronological Age	8-8	11-2			
	Terman Age	9-0	11-5			
	I. Q.	104	102			
65.	Average I. Q. 103.0.					
	Examiner	L. W.	L. I. S.			
	Chronological Age	10-4	11-1			
	Terman Age	10-5	11-8			
	I. Q.	101	105			
66.	Average I. Q. 102.7.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	
	Chronological Age	11-8	13-3	14-9	15-3	
	Terman Age	11-7	14-1	15-0	15-10	
	I. Q.	99	106	102	104	
67.	Average I. Q. 102.5.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological Age	5-5	6-11	7-6	8-0	
	Terman Age	5-5	7-3	7-7	8-5	
	I. Q.	100	104	101	105	
68.	Average I. Q. 99.5.					
	Examiner	E. V.	L. I. S.			
	Chronological Age	6-7	8-10			
	Terman Age	6-8	8-8			
	I. Q.	101	98			
69.	Average I. Q. 97.5.					
	Examiner	E. V.	L. I. S.	L. I. S.	L. I. S.	
	Chronological Age	7-3	8-10	9-3	9-10	
	Terman Age	7-2	8-4	9-2	9-8	
	I. Q.	99	94	99	98	
70.	Average I. Q. 97.5.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	
	Chronological Age	10-9	12-0	13-10	14-4	
	Terman Age	10-8	11-8	13-1	14-3	
	I. Q.	99	97	95	99	

TABLE VI—CONTINUED
ORIGINAL DATA ARRANGED IN ORDER OF MEAN I. Q.—BOYS

71.	Average I. Q. 96.0.					
	Examiner	E. V.	E. V.			
	Chronological Age	12-2	13-9			
	Terman Age	11-8	13-3			
	I. Q.	96	96			
72.	Average I. Q. 95.0.					
	Examiner	E. V.	E. V.			
	Chronological Age	11-2	12-9			
	Terman Age	10-1	12-9			
	I. Q.	90	100			
73.	Average I. Q. 93.2.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	L. I. S.
	Chronological Age	12-6	14-1	15-1	15-6	16-0
	Terman Age	11-0	13-1	14-7	14-7	15-5
	I. Q.	88	92	96	94	96
74.	Average I. Q. 93.2.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological Age	8-7	10-0	10-8	11-2	
	Terman Age	8-2	9-3	9-8	10-7	
	I. Q.	95	92	91	95	
75.	Average I. Q. 92.0.					
	Examiner	L. W.	L. I. S.			
	Chronological Age	10-8	11-5			
	Terman Age	10-2	10-2			
	I. Q.	95	89			
76.	Average I. Q. 92.0.					
	Examiner	E. V.	L. I. S.			
	Chronological Age	9-5	11-11			
	Terman Age	8-6	11-2			
	I. Q.	90	94			

the I. Q. occur. In order to illustrate this more completely the 36 children of the Five Examination Group were arranged in the order of merit on the basis of the I. Q. for the first examination. For all of the children the first I. Q. was plotted, Chart VIa and b, and the points connected by a solid line to show this array of children in the original order of increasing I. Q. The vertical scale represents the range of I. Q.'s from 80 to 100. The numbers running horizontally across the chart are the identification numbers of the children in the tables of original data. The four succeeding I. Q.'s for each child were plotted on the same vertical axis as the point for the first I. Q. and different kinds of lines drawn in order to make it possible to identify the I. Q.'s of different children at the 2d, 3d, 4th and 5th examinations. The heavy horizontal lines indicate the conventional classifications of I. Q. level, 90 to 110 being considered average ability; 110 to 120 superior, with an additional classification of very superior for 120 to 140. In this study the very superior cases were not sufficiently numerous to permit of the last classification. Accordingly, all children with a mean I. Q. of 110 or above are classed as superior.

TABLE VII

ORIGINAL DATA ARRANGED IN ORDER OF MEAN I. Q.—GIRLS

1.	Average I. Q. 148.0.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological	8-3	9-4	10-4	11-4	11-10
	Terman	11-6	13-5	16-4	17-1	17-7
	I. Q.	139	143	158	151	149
2.	Average I. Q. 146.6.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological	8-11	10-0	11-0	12-0	12-5
	Terman	12-6	13-11	16-7	18-7	18-7
	I. Q.	140	139	150	155	149
3.	Average I. Q. 140.5.					
	Examiner	L. I. S.	L. I. S.			
	Chronological	8-10	9-7			
	Terman	12-7	13-4			
	I. Q.	142	139			
4.	Average I. Q. 131.7.					
	Examiner	E. V.	L. I. S.	L. I. S.	L. I. S.	
	Chronological	7-0	8-2	8-8	9-3	
	Terman	8-8	10-5	11-3	13-6	
	I. Q.	123	128	130	146	
5.	Average I. Q. 130.7.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	
	Chronological	9-1	10-2	11-8	12-2	
	Terman	11-3	12-10	15-10	17-8	
	I. Q.	123	126	136	138	
6.	Average I. Q. 130.5.					
	Examiner	L. W.	L. I. S.			
	Chronological	6-4	7-2			
	Terman	7-6	10-3			
	I. Q.	118	143			
7.	Average I. Q. 130.2.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	L. I. S.
	Chronological	9-6	10-7	12-1	12-7	13-0
	Terman	11-0	13-7	15-11	17-8	17-8
	I. Q.	115	128	132	140	136
8.	Average I. Q. 130.0.					
	Examiner	E. V.	E. V.			
	Chronological	7-0	8-1			
	Terman	9-2	10-5			
	I. Q.	131	129			
9.	Average I. Q. 128.8.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological	8-10	9-10	11-1	11-10	12-4
	Terman	9-10	11-6	15-5	16-7	17-1
	I. Q.	111	116	139	140	138
10.	Average I. Q. 127.8.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	L. I. S.
	Chronological	6-6	7-5	9-0	9-6	9-11
	Terman	8-2	9-2	10-8	12-9	13-8
	I. Q.	125	123	119	134	138
11.	Average I. Q. 125.5.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological	9-8	10-8	11-3	11-10	
	Terman	10-3	13-4	15-1	16-3	
	I. Q.	106	125	134	137	
12.	Average I. Q. 125.0.					
	Examiner	E. V.	E. V.			
	Chronological	8-9	9-9			
	Terman	10-8	12-6			
	I. Q.	122	128			
13.	Average I. Q. 124.7.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological	4-11	5-6	6-6	7-0	
	Terman	6-4	6-10	8-0	8-8	
	I. Q.	128	124	123	124	
14.	Average I. Q. 124.6.					
	Examiner	E. V.	L. S.	L. I. S.		
	Chronological	10-9	12-3	13-3		
	Terman	12-4	15-6	17-8		
	I. Q.	115	126	133		

TABLE VII—CONTINUED

ORIGINAL DATA ARRANGED IN ORDER OF MEAN I. Q.—GIRLS

15.	Average I. Q. 124.0.					
	Examiner	L. W.	L. I. S.			
	Chronological	5-9	6-7			
	Terman	7-4	8-0			
	I. Q.	127	121			
16.	Average I. Q. 123.5.					
	Examiner	L. W.	L. I. S.			
	Chronological	5-7	6-9			
	Terman	6-6	8-10			
	I. Q.	116	131			
17.	Average I. Q. 123.2.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological	9-11	11-2	11-11	12-5	
	Terman	11-0	12-11	15-7	16-11	
	I. Q.	111	116	130	136	
18.	Average I. Q. 122.5.					
	Examiner	L. W.	L. I. S.			
	Chronological	5-1	6-4			
	Terman	6-6	7-6			
	I. Q.	127	118			
19.	Average I. Q. 122.4.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	L. I. S.
	Chronological	8-9	9-10	11-4	11-9	12-3
	Terman	10-5	11-1	12-3	15-3	17-8
	I. Q.	119	112	108	129	144
20.	Average I. Q. 122.0.					
	Examiner	L. I. S.	L. W.	L. I. S.	L. I. S.	
	Chronological	11-5	13-1	14-1	14-8	
	Terman	13-0	16-4	18-0	18-6	
	I. Q.	113	124	128	123	
21.	Average I. Q. 121.0.					
	Examiner	E. V.	E. V.			
	Chronological	6-1	7-6			
	Terman	7-6	8-11			
	I. Q.	123	119			
22.	Average I. Q. 120.5.					
	Examiner	E. V.	L. I. S.	L. I. S.	L. I. S.	
	Chronological	6-8	8-3	8-8	9-3	
	Terman	8-0	9-6	10-10	11-3	
	I. Q.	120	115	125	122	
23.	Average I. Q. 120.0.					
	Examiner	L. W.	L. I. S.			
	Chronological	5-11	7-1			
	Terman	6-8	9-0			
	I. Q.	113	127			
24.	Average I. Q. 119.0.					
	Examiner	E. V.	E. V.	L. W.		
	Chronological	7-10	8-11	10-5		
	Terman	9-7	10-9	12-0		
	I. Q.	122	120	115		
25.	Average I. Q. 118.6.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	L. I. S.
	Chronological	10-0	11-1	12-6	13-0	13-6
	Terman	11-3	12-3	14-9	16-5	17-8
	I. Q.	112	110	118	126	127
26.	Average I. Q. 118.0.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	L. I. S.
	Chronological	10-5	11-6	13-0	13-5	13-11
	Terman	11-5	13-1	15-5	17-2	17-2
	I. Q.	109	113	118	127	123
27.	Average I. Q. 117.2.					
	Examiner	E. V.	L. I. S.	L. I. S.	L. I. S.	
	Chronological	8-0	9-8	10-0	10-7	
	Terman	8-10	11-2	12-2	13-0	
	I. Q.	110	115	121	123	
28.	Average I. Q. 117.2.					
	Examiner	E. V.	L. I. S.	L. I. S.	L. I. S.	
	Chronological	7-7	9-2	9-7	10-2	
	Terman	9-1	10-8	10-11	12-2	
	I. Q.	120	116	114	119	

TABLE VII—CONTINUED

ORIGINAL DATA ARRANGED IN ORDER OF MEAN I. Q.—GIRLS

29.	Average I. Q. 117.0.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological	5-7	6-9	7-8	8-2	
	Terman	6-6	7-8	9-0	10-0	
	I. Q.	116	113	117	122	
30.	Average I. Q. 116.8.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological	8-11	10-3	11-4	11-11	12-5
	Terman	10-7	11-9	12-1	14-4	15-8
	I. Q.	118	114	106	120	126
31.	Average I. Q. 116.2.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	
	Chronological	9-3	10-9	12-4	12-10	
	Terman	10-9	12-5	14-1	15-5	
	I. Q.	116	115	114	120	
32.	Average I. Q. 116.0.					
	Examiner	L. W.	L. I. S.			
	Chronological	5-11	7-2			
	Terman	6-2	9-2			
	I. Q.	104	128			
33.	Average I. Q. 115.6.					
	Examiner	E. V.	L. S.	L. I. S.	L. I. S.	L. I. S.
	Chronological	5-1	6-1	7-7	8-1	8-7
	Terman	5-0	7-4	9-2	9-10	10-2
	I. Q.	98	120	121	121	118
34.	Average I. Q. 115.5.					
	Examiner	L. W.	L. I. S.			
	Chronological	5-4	6-7			
	Terman	6-6	7-2			
	I. Q.	122	109			
35.	Average I. Q. 114.5.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological	9-4	10-5	11-4	11-11	
	Terman	10-10	11-11	12-10	13-9	
	I. Q.	116	114	113	115	
36.	Average I. Q. 113.5.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological	11-6	12-5	13-1	13-9	
	Terman	12-6	13-9	15-1	16-7	
	I. Q.	108	110	115	121	
37.	Average I. Q. 113.5.					
	Examiner	E. V.	E. V.			
	Chronological	6-1	7-1			
	Terman	6-10	8-2			
	I. Q.	112	115			
38.	Average I. Q. 113.4.					
	Examiner	E. V.	L. S.	L. W.	L. I. S.	L. I. S.
	Chronological	6-2	7-1	8-9	9-3	9-8
	Terman	7-6	8-4	9-8	10-3	10-7
	I. Q.	121	117	110	110	109
39.	Average I. Q. 112.0.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	L. I. S.
	Chronological	11-4	12-11	14-0	14-4	14-10
	Terman	11-6	14-10	14-10	17-7	17-7
	I. Q.	101	114	106	122	118
40.	Average I. Q. 112.0.					
	Examiner	E. V.	E. V.	L. W.	L. I. S.	L. I. S.
	Chronological	8-2	9-3	10-7	11-2	11-8
	Terman	9-4	10-2	11-2	12-0	14-7
	I. Q.	114	109	105	107	125
41.	Average I. Q. 110.5.					
	Examiner	L. W.	L. I. S.			
	Chronological	6-8	7-6			
	Terman	7-4	8-4			
	I. Q.	110	111			
42.	Average I. Q. 110.0.					
	Examiner	E. V.	L. I. S.	L. I. S.	L. I. S.	
	Chronological	9-4	10-7	10-11	11-6	
	Terman	9-7	10-6	12-3	14-7	
	I. Q.	102	99	112	127	

TABLE VII—CONTINUED

ORIGINAL DATA ARRANGED IN ORDER OF MEAN I. Q.—GIRLS

43.	Average I. Q. 109.0.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	L. I. S.
	Chronological	7-6	8-10	10-1	10-5	11-0
	Terman	8-4	9-8	10-7	11-10	11-10
	I. Q.	111	109	104	113	108
44.	Average I. Q. 108.5.					
	Examiner	L. W.	L. I. S.			
	Chronological	6-5	7-7			
	Terman	6-8	8-7			
	I. Q.	104	113			
45.	Average I. Q. 108.0.					
	Examiner	E. V.	E. V.	L. W.		
	Chronological	8-8	9-9	11-0		
	Terman	9-7	10-4	12-1		
	I. Q.	110	105	109		
46.	Average I. Q. 108.0.					
	Examiner	L. S.	L. W.	L. I. S.	L. I. S.	
	Chronological	12-7	14-2	15-3	15-9	
	Terman	13-8	15-6	16-8	16-8	
	I. Q.	108	109	109	106	
47.	Average I. Q. 107.7.					
	Examiner	E. V.	L. I. S.	L. I. S.	L. I. S.	
	Chronological	8-11	10-3	10-8	11-2	
	Terman	10-2	10-8	11-6	11-9	
	I. Q.	114	104	108	105	
48.	Average I. Q. 107.5.					
	Examiner	E. V.	L. I. S.			
	Chronological	6-3	9-9			
	Terman	7-0	10-1			
	I. Q.	112	103			
49.	Average I. Q. 107.5.					
	Examiner	E. V.	E. V.			
	Chronological	9-9	11-3			
	Terman	10-4	12-3			
	I. Q.	106	109			
50.	Average I. Q. 107.0.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological	6-7	7-11	8-8	9-3	
	Terman	7-0	8-4	9-9	9-9	
	I. Q.	106	105	112	105	
51.	Average I. Q. 107.0.					
	Examiner	L. S.	E. V.	L. I. S.		
	Chronological	15-7	16-9	17-8		
	Terman	15-3	18-0	18-0		
	I. Q.	97	112	112		
52.	Average I. Q. 106.5.					
	Examiner	L. W.	L. I. S.			
	Chronological	6-0	7-4			
	Terman	6-6	7-8			
	I. Q.	108	105			
53.	Average I. Q. 106.0.					
	Examiner	L. W.	L. I. S.			
	Chronological	6-6	7-4			
	Terman	6-10	7-10			
	I. Q.	105	107			
54.	Average I. Q. 105.5.					
	Examiner	L. W.	L. I. S.			
	Chronological	5-1	6-4			
	Terman	5-8	6-4			
	I. Q.	111	100			
55.	Average I. Q. 105.3.					
	Examiner	E. V.	E. V.	L. I. S.		
	Chronological	11-3	12-6	13-10		
	Terman	11-1	13-0	15-10		
	I. Q.	98	104	114		
56.	Average I. Q. 104.6.					
	Examiner	L. I. S.	L. I. S.			
	Chronological	6-0	6-9			
	Terman	6-2	7-2			
	I. Q.	103	106			

TABLE VII—CONTINUED

ORIGINAL DATA ARRANGED IN ORDER OF MEAN I. Q.—GIRLS

57.	Average I. Q. 103.5.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	
	Chronological	8-8	9-8	11-8	12-3	
	Terman	9-8	10-5	11-4	12-2	
	I. Q.	111	107	97	99	
58.	Average I. Q. 102.7.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	
	Chronological	9-2	10-3	12-3	12-9	
	Terman	9-8	10-9	12-0	13-3	
	I. Q.	105	104	98	104	
59.	Average I. Q. 102.6.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	L. I. S.
	Chronological	7-11	9-0	10-7	10-11	11-5
	Terman	8-2	9-9	10-3	10-9	12-4
	I. Q.	103	108	96	98	108
60.	Average I. Q. 102.5.					
	Examiner	E. V.	L. I. S.			
	Chronological	12-6	14-10			
	Terman	13-0	14-11			
	I. Q.	104	101			
61.	Average I. Q. 102.5.					
	Examiner	L. W.	L. I. S.			
	Chronological	8-3	9-3			
	Terman	8-4	9-7			
	I. Q.	101	104			
62.	Average I. Q. 98.5.					
	Examiner	L. W.	L. I. S.			
	Chronological	5-4	6-6			
	Terman	5-2	6-6			
	I. Q.	97	100			
63.	Average I. Q. 93.8.					
	Examiner	E. V.	E. V.	L. I. S.	L. I. S.	L. I. S.
	Chronological	9-6	10-4	11-6	11-11	12-6
	Terman	8-8	10-4	10-7	10-10	11-10
	I. Q.	91	100	92	91	95
64.	Average I. Q. 93.5.					
	Examiner	E. V.	E. V.			
	Chronological	9-8	10-7			
	Terman	8-10	10-2			
	I. Q.	91	96			
65.	Average I. Q. 92.7.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological	6-4	7-7	8-4	8-11	
	Terman	5-10	7-0	7-9	8-5	
	I. Q.	92	92	93	94	
66.	Average I. Q. 91.7.					
	Examiner	E. V.	L. W.	L. I. S.	L. I. S.	
	Chronological	9-3	10-6	11-0	11-6	
	Terman	9-4	9-6	9-9	10-2	
	I. Q.	100	90	89	88	
67.	Average I. Q. 91.5.					
	Examiner	L. W.	L. I. S.			
	Chronological	11-2	12-3			
	Terman	9-8	11-9			
	I. Q.	87	96			

It is apparent that these class names have very little real significance, as almost all of the children vary from their original classfiication on re-examination. A variation of only a few points in the I. Q. measuring actual mental growth or occurring as a chance error of examination would be sufficient to transfer a child from the average to the superior class. The same amount of variation might keep a child within its class if the original I. Q. has been sufficiently low. This fallacy in the use of type names has

long been recognized by careful students of individual differences, but it needs to be emphasized again because of the loose use of these terms by "Binet testers."

Inspection of the variations in each child's I. Q. as shown in Chart VI shows that the original I. Q. is only approximately constant upon successive examinations. In two cases the second, third, fourth and fifth I. Q.'s are actually below the first I. Q.; in five cases one of the later I. Q.'s is below the original one and in ten cases two or more of the later I. Q.'s are below the first. The remaining 19 cases show a general increase in I. Q., though each succeeding examination does not always give a higher I. Q. than the one preceding.

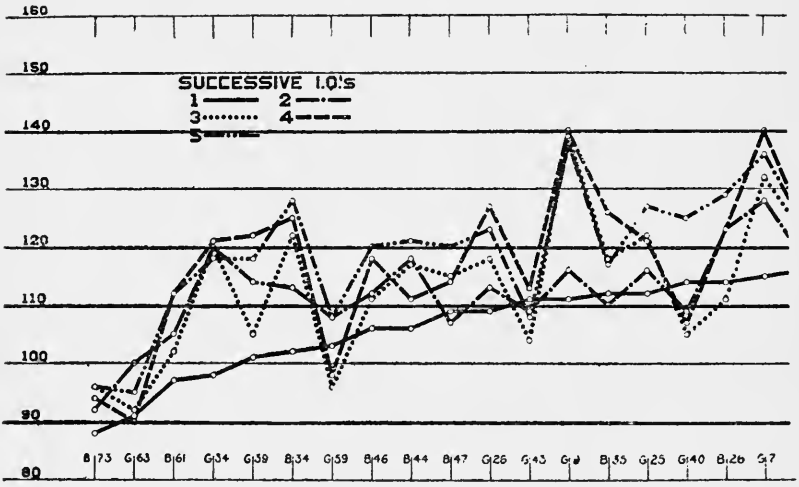
The uniform and homogeneous nature of the mean I. Q. curves in Chart IV tends to give a false impression of the individual child's successive I. Q.'s. For this reason the individual curves of the 36 children who had the largest number of examinations were plotted in Charts VII and VIII in order to show the actual variations in I. Q. that occur. A comparison of the charts for boys and girls shows a greater irregularity of development in girls, together with a tendency toward greater decrease in I. Q. at the later ages, probably due to the fact that the girls, who are more advanced in their development, can not maintain their original rates because of having passed so many of the tests at the upper limit of the scale. The fairly consistent and uniform curve which would correspond to an absolutely stable I. Q. is not exemplified in any of the girls' curves and in only two of the boys' curves, Nos.[1] 3 and 17. A gradual steady increase in I. Q. is observable in some instances, as for example in the curves of boys Nos. 25, 34 and 61 and girl No. 5. Examples of curves showing a steady rise followed by a decrease in I. Q. are: for boys Nos. 11 and 8 and for girls Nos. 1, 7 and 26. Curves showing marked irregularities with the I. Q. alternately increasing and decreasing are: for girls Nos. 63 and 39, and for boys Nos. 47 and 33.

While many of these changes are well within the 5 point limit of safety, a sufficient number show deviations of such magnitude[2] that extreme care should be exercised about making any dogmatic statements in regard to what a child's future status will be. For

[1]These numbers correspond to the numbers assigned the children in the tables of original data.

[2]Cf. Root, W. T. Two Cases Showing Marked Change in I. Q., *J. of Appl. Psychol.*, (5) 1921, 156-158.

CHART VIa

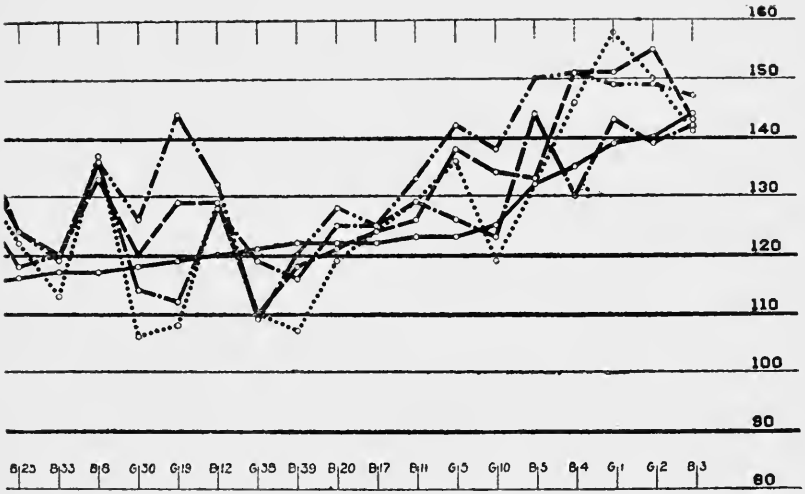


example, Girl No. 9 (Chart VIb) whose I. Q. in the first test was 111, obtained on four subsequent tests 116, 139, 140 and 138. A careful study of this case showed no difference in the method of examination and no unusual physical condition aside from the adolescent physiological acceleration.

No doubt these fluctuations in general mental achievement were modified more or less by such factors as time of day, health conditions at the time of the examination, fatigue, interest of the child in a particular examination, and changes in the home and school environment. Similarly conditioned changes in attitude on the part of the examiner might also have their effect.

2. *Deviations of Individuals from their Mean I. Q. Level.* In order to determine other causes of the variability that is apparent from an inspection of the individual I. Q. curves, each child's deviation in I. Q. for every examination was calculated from his mean I. Q. in all of his examinations. For example, one boy of very superior general intelligence showed on 5 examinations, deviations of +.4, —1.6, —1.6 and +3.4; another boy of average ability showed very different deviations. It is possible that these deviations are influenced by chance errors of examination. Nevertheless it is apparent that the size of these deviations depends not only on the real (inherent) variability of the child, but also upon the size of his mean I. Q. A large deviation on a high I. Q. may

CHART VIb



not be very different from a small deviation on a low I. Q. In order to make all deviations comparable they were expressed as percentages of each child's mean I. Q. These percentages were then averaged for each child and the mean of the individual

TABLE VIII

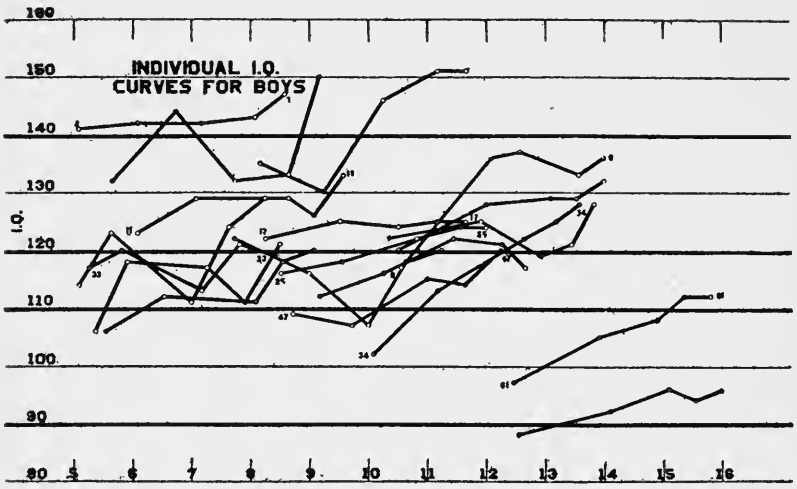
MEAN OF INDIVIDUAL DEVIATIONS FROM INTELLIGENCE QUOTIENT LEVEL

	Boys		Girls	
	Mean	P. E.	Mean	P. E.
Superior I. Q. 110+	4.48	.53	6.92	.78
Average I. Q. 90-110	2.65	.23	3.80	.29
Total	3.99	.38	5.95	.57
Under 10 at last examination	3.60	.31	5.14	1.19
Over 10 at first examination	4.85	1.26	7.09	1.36

variabilities obtained for various classes of subjects (Table VIII). The mean for all the boys was 3.99 ± .38; for all of the girls 5.95 ± .57. The mean for the superior boys was 4.48 ± .53, for superior girls 6.92 ± .78. The mean for average boys was 2.65 ± .23; for average girls 3.80 ± .29.

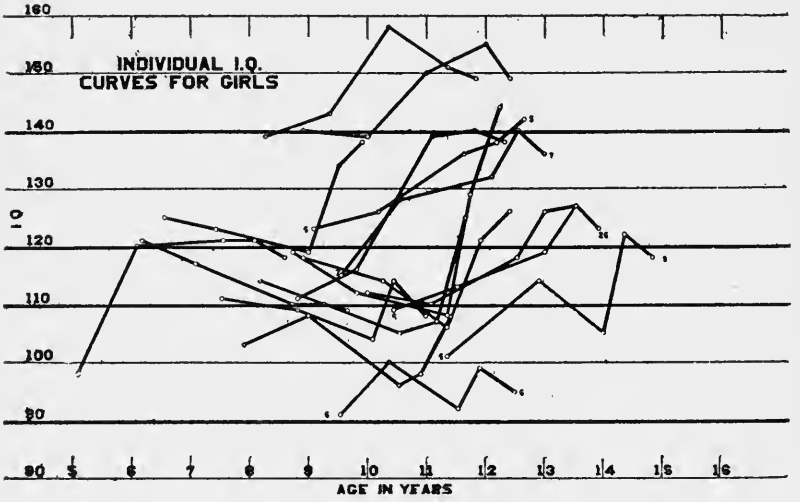
To determine whether chronological age was also a factor tending to make the individual vary from his I. Q. level, means were obtained for boys and girls who were under 10 years of age at

CHART VII



the last examination and for those over 10 at the first examination. The mean for the boys who were under 10 years of age at their last measurement was 3.60 ± .31; for boys who were over 10 at their first measurement was 4.85 ± 1.26. The mean for girls who were under 10 years of age at their last measurement was

CHART VIII



5.14 ± 1.19 and for those over 10 at their first measurement was 7.09 ± 1.36.

The P. E. of all these means is sufficiently large to obscure the difference between the means for the group under comparison. There is, nevertheless, a constant tendency in all the groups for the girls to be more variable than the boys, for the superior children to be more variable than the average children and for the older children to be more variable than the younger.

3. *Differences in I. Q. at Successive Examinations.* One method of studying the stability of the I. Q. is that of direct observation of the changes that take place on re-examination. For every possible combination of examinations in the four groups the differences of I. Q. for each child were computed and the increases in I. Q. tabulated as positive and the decreases as negative. These positive and negative variations were then grouped by class intervals of 5 point differences in I. Q. and the per cent of cases showing each amount of difference calculated. For example, 16 of the 74 boys who had two examinations showed a decrease of 0 to 5 points on the second examination; i. e., 21.6% showed this amount of negative difference. The percentage distribution of the differences, exclusive of the cases showing no differences, is shown for boys and girls in Table IX and Chart IX.

Between the first and second examination the percentage distribution of differences approximates the normal frequency curve with the greatest number of cases showing a positive change within the 5 point range. As the interval between examinations increases the effect of the repeated examinations intervening becomes apparent in a shift toward the positive end of the scale. Although there is no large sex difference, the girls have a wider range of deviation, particularly those of the Four and Five Examination Groups, where the last examination fell for the majority of the children within the period of adolescence.

The mean change in I. Q. was found to be

Examination	1-2		2-3		3-4		4-5	
Deviation	—	+	—	+	—	+	—	+
Boys	4.61	7.39	5.12	7.60	3.42	7.27	2.50	5.14
Girls	4.53	7.32	5.17	8.00	3.75	6.79	3.44	7.75

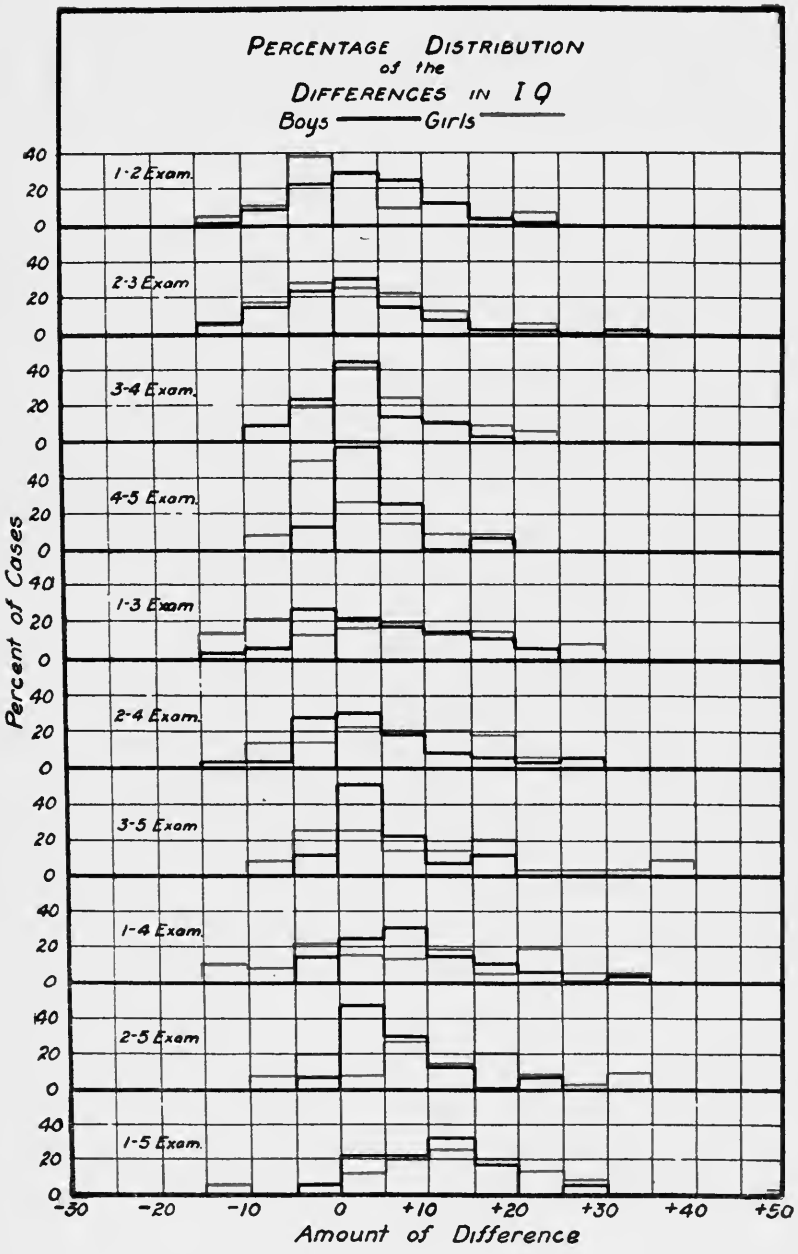
Here there is evident a shift in the relation between negative and positive changes as the number of examinations children have taken grows larger.

TABLE IX

Percentage Distribution of the Differences in Intelligence Quotients

BOYS																					
Examination	1-2		2-3		3-4		4-5		1-3		2-4		3-5		1-4		2-5		1-5	
Amount of Differences in Intelligence Quotients																				
0- 5	21.6%	28.3%	23.2%	30.2%	23.0%	43.5%	12.5%	56.2%	26.1%	21.4%	27.5%	30.0%	11.1%	50.0%	13.5%	24.3%	5.9%	47.0%	5.3%	21.0%
5-10	8.1	24.3	13.9	13.9	7.7	12.8		2.5	4.8	16.6	2.5	17.5		22.2		29.7		29.4		21.0
10-15	1.4	12.1	4.6	6.9		10.2			2.4	14.2	2.5	7.5		5.5		13.5		11.7		31.5
15-20		2.7		2.3		2.5		6.2		9.5		5.0		11.1		10.8				15.7
20-25		1.4		2.3						4.8		2.5				5.4		5.9		
25-30												5.0								5.3
30-35				2.3												2.7				
Total	31.1%	68.8%	41.7%	57.9%	30.7%	69.0%	12.5%	87.4%	33.3%	66.5%	32.5%	67.5%	11.1%	88.8%	13.5%	86.4%	5.9%	94.0%	5.3%	94.5%
No. of cases	23	51	18	25	12	27	2	14	14	28	13	27	2	16	5	32	1	16	1	18
Zero cases	2		2		2		3		3		1		1		4		2		0	
No. in group	76		45		41		19		45		41		19		41		19		19	
GIRLS																				
0- 5	36.3%	27.2%	25.6%	23.1%	16.6%	38.8%	47.1%	23.5%	9.5%	14.2%	11.8%	20.5%	23.5%	23.5%	19.5%	13.8%	18.7%	6.2%	5.9%	11.7%
5-10	9.1	7.5	15.3	20.5	5.6	22.2	5.9	11.7	19.0	16.6	11.8	17.6	5.9	11.7	5.6	11.1	6.2	25.0		17.6
10-15	3.0	10.6	2.6	10.2		8.3		5.9	11.9	9.5		17.6		11.7	8.3	16.6		12.5	5.9	23.5
15-20		1.5				5.6		5.9		11.9		14.7		17.6		2.8		18.7		17.6
20-25		4.5		2.6		2.8				2.4		2.9				16.6		6.2		11.7
25-30										4.8		2.9				2.8				5.9
30-35																2.8		6.2		
35-40														5.9						
Total	48.4%	51.3%	43.5%	56.4%	22.2%	77.7%	53.0%	47.0%	40.4%	59.4%	23.6%	76.2%	29.4%	70.4%	33.4%	66.5%	24.9%	74.8%	11.8%	88.0%
No. of cases	32	34	17	22	8	28	9	8	17	25	8	26	5	12	12	24	4	12	2	15
Zero cases	1		3		1		0		0		3		0		1		1		0	
No. in group	67		42		37		17		42		37		17		37		17		17	

CHART IX


Percentage Distribution
of the
Differences in IQ
Boys —— Girls ——
1-2 Exam.
2-3 Exam.
3-4 Exam.
4-5 Exam.
1-3 Exam.
2-4 Exam.
3-5 Exam.
1-4 Exam.
2-5 Exam.
1-5 Exam.
40
20
0
Percent of Cases
-30
-20
-10
0
+10
+20
+30
+40
+50
Amount of Difference

These I. Q. changes cannot, however, be taken at their face value, since a large change on a high I. Q. may not be more significant than a small change on a low I. Q. In order to make all changes comparable, the mean gains and losses from the first to second, second to third, third to fourth, and fourth to fifth examinations were expressed as per cents of the mean I. Q. at the 1st, the 2d, the 3d or the 4th examination, depending on the comparison being made. The material was also arranged to give a separate mean for average and superior children. The per cents of change in I. Q. follow:

Examination	1-2		2-3		3-4		4-5	
Deviation %	—	+	—	+	—	+	+	—
Superior								
Boys	4.3	7.0	5.1	6.5	3.1	7.5	2.0	4.2
Girls	3.5	8.5	3.5	7.1	4.1	5.8	2.5	6.3
Average								
Boys	3.9	5.0	3.0	6.5	2.3	4.8	0	1.9
Girls	5.0	5.5	6.8	6.3	2.9	5.7	5.0	7.0

This tabulation shows a slightly greater per cent of change, especially in the positive direction, for superior children, due probably to the fact that superior children profit more readily by practice.

It would be of great interest to know what is the effect of chronological age upon the change in I. Q., but the writers have been unable to devise any reliable method of determining the facts from the data available. The computation of the mean I. Q. change at each chronological age is not permissible because of the varying amounts of practice. For example, at age 8 there are the first examinations for some children, and also the second, third, fourth and fifth for others. Such tabulation of cases with reference to the age at the first test would, moreover, class the children whose second examination was given after a considerable time, with those who had been re-examined at a shorter interval, and would tend to obscure any characteristic chronological changes occurring. It would seem that the question of whether older children show a different amount of I. Q. change than younger children could be solved only by a special experiment with a series of examinations beginning at a uniform age, on children of equal intelligence, and applied at uniform intervals.

No determination can be made in this study of the effect of the interval separating the examinations. The change from the 1st to

the 5th I. Q. cannot be compared with the change at other intervals because of the different amounts of practice intervening.

Terman (26) 1919, p. 138, used the method of I. Q. comparison described as follows:

"Tests have been given to 315 children in the vicinity of Stanford University. To 46 of these children, three or more tests have been given. In case of a child tested several times each test has been compared with each of the others, for example, the first test with the second, third, and fourth, separately, the second test with the third and fourth separately, and the third test with the fourth. This gives in all 435 I. Q. comparisons."

Terman (26) p. 140, reports that his comparisons show: "that it makes little difference whether the child was bright, average or dull, how long an interval separated the tests or what the age of the child was at the earlier test. The majority of the changes are for all groups relatively small....

"The central tendency of change is represented by an increase of 1.7 in I. Q.: the middle 50% of change lies between the limits of 3.3 decrease and 5.7 increase; the probable error of a prediction based on the first test is 4.5 points in terms of I. Q."

The method of I. Q. comparison as used by Terman is open to the objections stated above. The I. Q.'s obtained after repeated examinations are pooled with those from a first examination, and the average tendency of change computed on the basis of these data. It seems to us that the differences in practice would make it inadvisable to pool these examinations.

Such a tabulation of change in I. Q. with reference to the age at the first test would, moreover, afford no opportunity for the special characteristics of the adolescent period to show themselves if they existed. As has been demonstrated in connection with the mental growth curves, and the physical growth curves, boys and girls have a period of adolescent acceleration at different chronological ages, and children of superior and average mental and physical status show a similar difference. A pooled classification of these different classes of data tends to destroy any characteristic chronological age changes in I. Q.

We have felt that the solution of these problems would not be obtained by the use of this method. The 695 separate I. Q. comparisons afforded by the data in this study would have been reduced to a very small number if the comparisons had been made only with children of the same chronological age, sex, I. Q. level, and physical status.

4. *Intercorrelations.* The stability of the I. Q. can be investi-

gated by another means than that of noting the size of the differences in I. Q. and calculating the central tendency of change. The similarity in the relative rankings of children on successive examinations can best be studied by means of the method of correlation. Although several writers have reported correlations between two examinations no data have so far been presented in the literature to show the intercorrelations of several examinations given on the same group of children for several years. From such an array of correlations one can determine whether the majority of children maintain at a later examination their relative position above or below the mean of their group and tend to deviate from this mean by approximately the same amount after several years interval. The accuracy of the prediction is conditioned by the size of the correlations. A high correlation between the I. Q.'s obtained by a group of children on two examinations would mean considerable stability in I. Q. and the possibility of predicting with a high degree of accuracy the future status of children of any I. Q. level.

For this method of investigating the evenness of the mental growth there were calculated Pearson coefficients of correlation for four groups of children. One group consisted of 56 children who had been examined twice; the coefficient of correlation for the two examinations was $+.81 \pm .03$. Another group consisted of 51 children who had been examined three times; the coefficient for the first and second was $+.76 \pm .04$; for the first and third $+.69 \pm .05$; for the second and third $+.83 \pm .03$.

It was possible to give a fourth examination to all but 9 of this group. The coefficients for this smaller group were, for the first and second examinations $+.79 \pm .04$, for the second and third $+.86 \pm .03$, for the third and fourth $+.93 \pm .02$, for the first and third $+.77 \pm .04$, for the second and fourth $+.82 \pm .03$, and for the first and fourth $+.72 \pm .05$.

The last group of 36 children was given five examinations. The correlation between the first and second was $+.85 \pm .03$, between the second and third $+.85 \pm .03$, between the third and fourth $+.91 \pm .02$, between the fourth and fifth $+.92 \pm .02$, between the first and third $+.74 \pm .05$, between the first and fourth $+.78 \pm .04$, between the first and fifth $+.82 \pm .04$, between the second and fourth $+.80 \pm .04$, between the second and fifth $+.82 \pm .04$, and between the third and fifth $+.84 \pm .03$.

TABLE X

INTERCORRELATIONS OF INTELLIGENCE QUOTIENTS FOR TWO, THREE, FOUR AND FIVE EXAMINATION GROUPS

Examination		1 and 2	1 and 3	2 and 3	1 and 4	2 and 4	3 and 4	1 and 5	2 and 5	3 and 5	4 and 5
5 Exam. Group	Coef.	+.85	+.74	+.85	+.78	+.80	+.91	+.82	+.82	+.84	+.92
	P. E.	±.03	±.05	±.03	±.04	±.04	±.02	±.04	±.04	±.03	±.02
4 Exam. Group	Coef.	+.79	+.77	+.86	+.72	+.82	+.93				
	P. E.	±.04	±.04	±.03	±.05	±.03	±.02				
3 Exam. Group	Coef.	+.76	+.69	+.83							
	P. E.	±.04	±.05	±.03							
2 Exam. Group	Coef.	+.81									
	P. E.	±.03									

The coefficients (Table X) are uniformly high and reliable with low probable errors, ranging from +.72 ± .05 to +.93 ± .02. The coefficients of correlation for near-lying examinations, that is, two examinations with none intervening, are highest, the mean being +.88. For three correlations with one intervening examination the mean is +.79. For the two with two intervening examinations the mean is +.80, and for the one with three intervening examinations the correlation is +.82. Although the coefficient is highest for near-lying examinations there is no tendency for the correlation to decrease with increase of interval.

TABLE XI

PERCENTAGE OF CHILDREN TESTED BY SAME EXAMINER

Group	Examiner	1 and 2 Exam.	1 and 3 Exam.	2 and 3 Exam.	1 and 4 Exam.	2 and 4 Exam.	3 and 4 Exam.	1 and 5 Exam.	2 and 5 Exam.	3 and 5 Exam.	4 and 5 Exam.
5 Exam.	E. V.	91.4%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	L. S.	0	0	0	0	0	0	0	0	0	0
	L. W.	0	0	0	0	0	0	0	0	0	0
	L. I. S.	0	0	0	0	0	40	0	0	40	100
	Misc.	8.6	100	100	100	100	60	100	100	60	0
4 Exam.	E. V.	32.2	0	0	0	0	0				
	L. S.	0	0	0	0	0	0				
	L. W.	0	0	0	0	0	0				
	L. I. S.	0	0	18.6	0	18.6	100				
	Misc.	99.8	100	81.4	100	81.4	0				
3 Exam.	E. V.	77.8	0	0							
	L. S.	0	0	0							
	L. W.	0	0	0							
	L. I. S.	0	0	0							
	Misc.	22.2	100	100							
2 Exam.	E. V.	28.6									
	L. S.	0									
	L. W.	0									
	L. I. S.	3.5									
	Misc.	67.8									

It is possible that the size of the correlation might be influenced by the fact that a number of children were examined on both occasions by the same examiner. A study of Table XI shows that although for the two highest coefficients +.93 and +.92, 100% of the examinations were made by the same examiner, the next highest coefficient, +.91, showed only 40% by the same examiner. Other high coefficients are +.86 with 18.6% of the examinations and +.85 with 91.4% of the examinations by the same examiner. A correlation of +.85 was also found where no child had been examined twice by the same examiner and a coefficient as low as +.76 was obtained with 77.8% of the examinations made by the same examiner. It would appear then that the personal equation of the examiner although of some influence is not the important factor in the size of the correlation.

In general it is not justifiable to compute correlations for a group with such a wide range in chronological age. Such a procedure would tend to raise the correlation. The correlations between I. Q.'s are probably not subject to criticism from this point of view, since the I. Q. compensates for the difference in the chronological ages.

Considerable doubt has been thrown by K. Pearson (Proc. Roy. Soc., 1897 (60) 489.) on the justifiability of correlating ratios. From this point of view the calculation of correlations between I. Q.'s may result in spurious correlation. This method is, however, the only feasible one at this stage in the development of the problem.

In each group the highest correlations occur between near-lying examinations at the end of the series of examinations where the children were better adjusted to the situation and had apparently reached a certain stability of position within the group.

For comparison it is of interest to note the size of the correlations obtained by other examiners. These were: Bobertag, +.95 (Binet); Terman, +.93 (Stanford); Cuneo and Terman, +.95, +.94, +.85 (Stanford); Rosenow, +.82 (Binet and Stanford); Rugg and Colloton, +.84 (Stanford).

5. *Probable Error of Estimate.* Knowing the value of the coefficient of correlation between the first and any succeeding test, we can predict what any future I. Q. would be and compute the difference between the I. Q. as predicted and as actually obtained, or the error of estimate.

DIFFERENCE BETWEEN THE OBTAINED AND PREDICTED INTELLIGENCE QUOTIENT ON 2D, 3D, 4TH AND 5TH EXAMINATIONS.

No.	First	Second			Third			Fourth			Fifth		
	Obtained I. Q.	Obtained I. Q.	Predicted I. Q.	Diff. between Obtained and Predicted I. Q.	Obtained I. Q.	Predicted I. Q.	Diff. between Obtained and Predicted I. Q.	Obtained I. Q.	Predicted I. Q.	Diff. between Obtained and Predicted I. Q.	Obtained I. Q.	Predicted I. Q.	Diff. between Obtained and Predicted I. Q.
1	139	143	137.90	5.10	158	141.00	17.00	151	145.16	5.84	149	148.19	.81
2	140	139	138.70	.30	150	141.90	8.10	155	146.06	8.94	149	149.10	.10
3	144	142	141.80	.20	141	145.50	4.50	143	149.66	6.66	147	152.74	5.74
4	135	130	134.80	4.80	146	137.40	8.60	151	141.56	9.44	151	144.55	6.45
5	132	144	132.50	11.50	132	134.70	2.70	133	138.86	5.86	150	141.82	8.18
6	123	126	125.40	.60	136	126.60	9.40	138	130.76	7.24	142	133.63	8.37
7	117	136	120.80	15.20	137	121.20	15.80	133	125.36	7.64	136	128.17	7.83
8	115	128	119.20	8.80	132	119.40	12.60	140	123.56	16.44	136	126.35	9.65
9	123	129	125.40	3.60	129	126.60	2.40	126	130.76	4.76	133	133.63	.63
10	111	116	116.10	.10	139	115.80	23.20	140	119.96	20.04	138	122.71	15.29
11	120	128	123.10	4.90	129	123.90	5.10	129	128.06	.94	132	130.90	1.10
12	125	123	127.00	4.00	119	128.40	9.40	134	132.56	1.44	138	135.45	2.55
13	122	125	124.70	.30	124	125.70	1.70	124	129.86	5.86	125	132.72	7.72
14	122	125	124.70	.30	119	125.70	6.70	121	129.86	8.86	128	132.72	4.72
15	116	118	120.00	2.00	122	120.30	1.70	124	124.46	.46	124	127.26	3.26
16	122	116	124.70	8.70	107	125.70	18.70	118	129.86	11.86	120	132.72	12.72
17	117	120	120.80	.80	113	121.20	8.20	120	125.36	5.36	119	128.17	9.17
18	112	116	116.90	.90	122	116.70	5.30	121	120.86	.14	117	123.62	6.62
19	114	123	118.40	4.60	111	118.50	7.50	123	122.66	.34	129	125.44	3.56
20	112	110	116.90	6.90	118	116.70	1.30	126	120.86	5.14	127	123.62	3.38
21	119	112	122.30	10.30	108	123.00	15.00	129	127.16	1.84	144	129.99	14.01
22	109	113	114.50	1.50	118	114.50	4.00	127	118.16	8.84	123	120.89	2.11
23	102	113	109.10	3.90	122	107.70	14.30	125	111.86	13.14	128	114.52	13.48
24	98	120	105.90	14.10	120	104.10	15.90	121	108.26	12.74	118	110.88	7.12
25	118	114	121.50	7.50	106	122.10	16.10	120	126.26	6.26	120	129.08	3.08
26	121	119	123.90	4.90	110	124.80	14.80	110	128.96	18.96	109	131.81	22.81
27	106	118	112.20	5.80	117	111.30	5.70	111	115.46	4.46	121	118.16	2.84
28	106	112	112.20	.20	111	111.30	.30	118	115.46	2.54	120	118.16	1.84
29	109	107	114.50	7.50	115	114.00	1.00	114	118.16	4.16	120	120.89	.89
30	101	114	108.30	5.70	105	106.80	1.80	122	110.96	11.04	118	113.61	4.39
31	114	109	118.40	9.40	105	118.50	13.50	107	122.66	15.66	125	125.44	.44
32	111	109	116.10	7.10	104	115.80	11.80	113	119.96	6.96	108	122.71	14.71
33	97	105	105.20	.20	102	103.20	1.20	112	107.36	4.64	112	109.97	2.03
34	103	108	109.80	1.80	96	108.60	12.60	98	112.76	14.76	108	115.43	7.43
35	91	100	100.50	.50	92	97.80	5.80	90	101.96	11.96	95	104.51	9.51
36	88	92	98.10	6.10	96	95.10	.90	94	99.26	5.26	96	101.78	5.78
Mean				4.7			8.5			7.9			6.40
P. E. of Estimate			±4.2			±7.0			±6.2			±5.5	

Our data for five consecutive examinations of 36 children have been used to make a comparison of the I. Q.'s actually obtained and the I. Q.'s predicted by means of the regression equation:

$$y_1 - \bar{y} = r\frac{\sigma_y}{\sigma_x}(x_1 - \bar{x}),$$

where y_1 = the I. Q. to be predicted, $\bar{y}$ = the mean of the obtained (later) I. Q.'s, $\bar{x}$ = the mean of the obtained first I. Q.'s, x_1 = the individual I. Q. on the first test, and σ = the standard deviation of the x or y series.

The equation can more conveniently be used in the simplified form:

$$y_1 = r\frac{\sigma_y}{\sigma_x}(x_1) + (\bar{y} - r\frac{\sigma_y}{\sigma_x}\ \bar{x}),$$

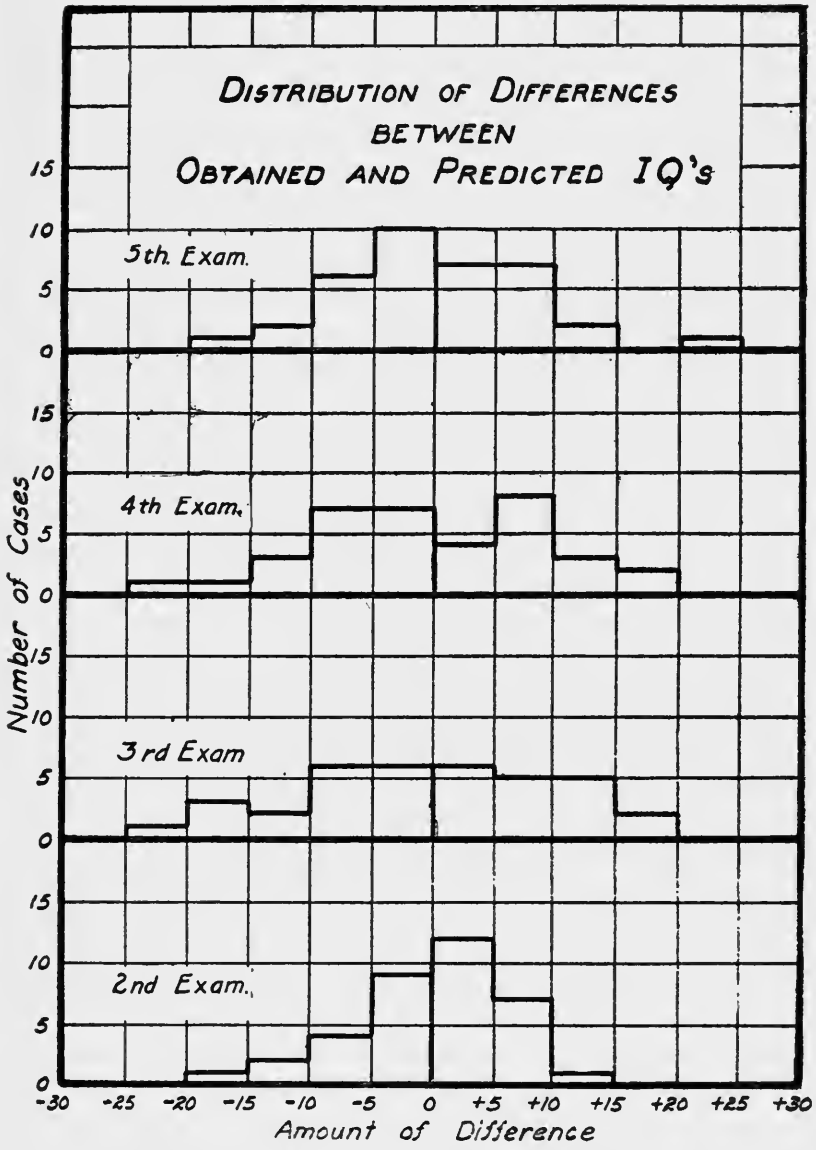
The quantity $r\frac{\sigma_y}{\sigma_x}$ is a constant through a whole prediction series, a different constant being used for each of the four prediction series (second, third, fourth and fifth I. Q.'s from first I. Q.'s). The quantity $\bar{y} - r\frac{\sigma_y}{\sigma_x}\ \bar{x}$ is also a constant in each of these four prediction series, which reduces the formula to $y_1 = k(x_1) + k_1$. For example, by substituting the constants for the prediction of the second I. Q. one obtains $y_1 = .78(x_1) + 29.5$. For the prediction of the third from the first I. Q.: $y_1 = .90(x_1) + 15.9$.

TABLE XIII

DISTRIBUTION OF DIFFERENCES BETWEEN OBTAINED AND PREDICTED I. Q.'s (Errors of Estimate)

Examination	2		3		4		5	
Amount of I. Q. Difference	Number of Cases							
0-5	—9	+12	—6	+6	—7	+4	—10	+7
5-10	—4	+ 7	—6	+5	—7	+8	— 6	+7
10-15	—2	+ 1	—2	+5	—3	+3	— 2	+2
15-20	1	0	—3	+2	—1	+2	— 1	0
20-25	0	0	—1	0	—1	0	0	+1

CHART X



For the prediction of the fourth from the first I. Q.: $y_1 = .90(x_1) + 20.1$. For the prediction of the fifth from the first I. Q.: $y_1 = .91(x_1) + 21.7$.

By the use of this formula the second, third, fourth and fifth I. Q.'s for each child were predicted and the differences between

the predicted I. Q.'s and the I. Q.'s actually obtained at each of these examinations (the errors of estimate) calculated, together with the mean of the differences for the group as a whole. The I. Q.'s as actually obtained and as predicted are shown in Table XII. The distribution of the differences between obtained and predicted I. Q.'s is shown in Table XIII and Chart X.

On the average the prophesied second I. Q. differs from the obtained second I. Q. by 4.7 points, P. E. ± .5, i. e., the chances are equal that the average for the differences between the predicted and obtained I. Q.'s will not be less than 4.2 or greater than 5.4. The average difference between the predicted and obtained third I. Q. or the average of the errors of estimate is 8.5; between the predicted and obtained fourth I. Q. is 7.7 and between the predicted and obtained fifth I. Q. is 6.3. The mean interval between the second and first examination was approximately 13 months; between the third and first was 28 months; between the fourth and first was 36 months and between the fifth and first 41 months.

While Table XII shows for each prediction series the most probable predicted I. Q. for each child, a better sampling from a larger number of cases might have resulted in another predicted I. Q. In other words, while 137.9 is the proper estimate for the second I. Q. for case 1, the probable error of estimate gives the number of points variation above or below this estimate that will take in 50% of all the other possible estimates. Knowing the value of the 4 coefficients of correlation involved, one can calculate the probable error of estimate for each of the prediction series by means of the formula P. E. $= .6745 \times \sigma$ var. $\sqrt{1-r^2}$. This formula gives as a probable error of estimate for the prediction of the second from the first I. Q. ±4.2, for the prediction of the third from the first I. Q. ±7.0; for the prediction of the fourth from the first I. Q. ±6.2; for the prediction of the fifth from the first I. Q. ±5.5. The P. E. of estimate of the second from the first is ±4.2 as previously stated, i. e., the chances are equal that the true predicted second I. Q. will not vary from the calculated I. Q. by more than ±4.2. The chances that the true predicted I. Q. will not vary from the calculated I. Q. by more than ±8.4 (or 2 P. E.) are 1802 in 10,000 or 1 chance in every 4.5. The chances that the true predicted I. Q. will not vary from the calculated by more than ±12.6 are 434 in 10,000 or the chances that a deviation greater than ±12.6 would occur are 1 in 22. The same chances of

error per 10,000 on 2 P. E. and 3 P. E. exist for the other prediction series, the only difference in each case being the size of the P. E. The P. E. of estimate for the second examination is very nearly the same as that reported by Rosenow (20) which was 3.988.

The size of the P. E. obviously depends on the size of the coefficient of correlation for the particular comparison involved. At first thought one might expect that an increase of interval between the examinations would result in a larger error of estimate. An increase in the probable error of estimate was, in fact, observed to take place in the prediction of the third from the first, where the interval was lengthened by one year. As was noted in connection with the correlations, however, the coefficient does not decrease regularly with an increase of the interval, but reflects the general habituation and improvement that has taken place and the tendency for each individual to find and remain at his characteristic level.

The calculation of the regressions and of the probable errors of estimate is of no special significance for this particular group, since the later I. Q.'s are already known. The real value of the procedure lies in utilizing the knowledge in regard to the correlation between earlier and later examinations for predicting the later I. Q. of other children who have received only the earlier examination. Chart X shows there is a conspicuous increase in the positive and a decrease in the negative differences observable where the group has had considerable opportunity for becoming adjusted to the examinations. It is not possible from the data at hand to make an exact determination of the amount of error of prediction for various intervals of examination since all of the children in this group have had repeated measurements in between, which influences the size of the correlations for the longer intervals. In order to determine how accurately one may predict a child's I. Q. one year later, two years later, etc., the correlations will have to be obtained on a sufficient number of children at each examination interval without intervening practice. In the absence of such long-time data, one can say that it is possible to predict a child's I. Q. with a probable error of from 4 to 7 points. Larger amounts of error would of course occur at the extremes of distribution. That such extreme variations do occur is shown by numerous cases in Table XII; for example in the

case of number 10, a difference of 23.2 exists between the predicted and obtained third I. Q.

The concept of a stable I. Q. involves a supplementary concept of a sort of initial acceleration or impetus of mental growth which predetermines the rate and level at which mental progress takes place and results in an approximately constant I. Q. The intelligence quotient could not, however, remain constant if serious fluctuations in the individual's rate of mental growth occurred.

If it should be proven that at certain ages children normally grow at an increased rate, the usefulness of the I. Q. would be considerably limited. It would always be of value still in determining the relative mental status of children of the same age but it would lose much of its prestige as a convenient diagnostic instrument for predicting the status of a child at later stages of its mental growth. In a previous chapter we have shown that considerable fluctuation in the rate of mental growth occurs, notably a sharp rise in the mental age curve at the approach of adolescence. This general intellectual renaissance is apparently a function of physiological age, occurring earlier in girls than in boys and earlier in children of superior intellectual endowment than in those of merely average ability. The inevitable result of this phenomenon is an increased I. Q. which in many cases could not have been predicted from the child's intellectual status at an earlier age and which would be a very unsafe basis in certain instances for inferring at the age of puberty what his earlier I. Q. had been. Prediction would still be possible, however, if one had a complete knowledge of the normal irregularities in mental growth at different ages.

Summary and Conclusions

1. The tabulated results of individual cases show that the I. Q. is only approximately constant during successive examinations.

2. Considering each child's deviation from his mean I. Q. expressed as a per cent of his mean I. Q. there is a tendency for the girls to be more variable than the boys, for the superior children to be more variable than the average children, and for the older children to be more variable than the younger.

3. Considering the difference between the first and second examination the larger number of cases show a difference of less than five points (— or +) in I. Q.; between the first and other

later examinations with intervening practice, many more cases show greater amounts of difference, the positive differences becoming more and more marked.

4. With the change expressed as a per cent of the previous I. Q. there is a slightly greater change in the positive direction for superior children, due probably to the fact that these profit more readily by practice.

5. No final determination can be made of the effect of chronological age or of the interval between examinations on the change in I. Q.'s.

6. The coefficients of correlation between all examinations within the four groups are high and reliable, ranging from $+.72 \pm.05$ to $+.93 \pm.02$, showing that they may be used as a basis for prediction. The correlations are probably only slightly modified by the personal equation of the examiners.

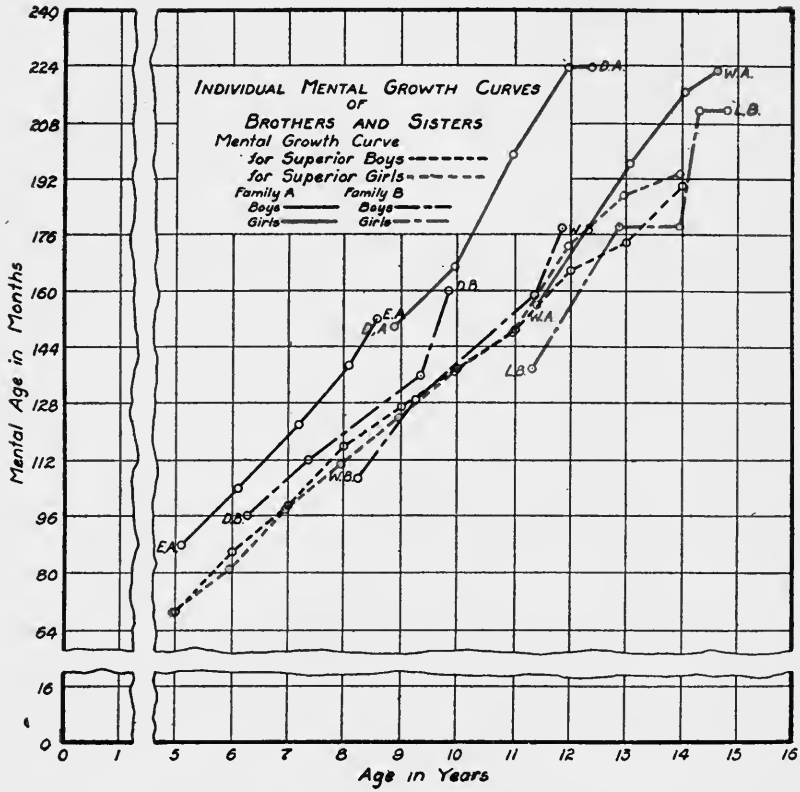
7. The value of the probable error of prediction lies in utilizing the knowledge in regard to the correlation between earlier and later examinations for predicting the later I. Q. of other children who have received only the earlier examinations. The P. E.'s of estimate range between 4.2 and 7.0 for the prediction of the second, third, fourth and fifth examination from the first.

III. THE RELATION BETWEEN PHYSICAL AND MENTAL GROWTH

1. *Data.* During the time that the psychological examinations were being made, physical measurements and x-ray photographs were taken with a view to analyzing the physical status and development of the children. A description has been given in an earlier study of the technique of taking the height and weight measurements and determining the area of the exposed surface of the carpal bones which serves as an index of anatomical development and is closely related to the physiological changes with their accompanying physical and mental phenomena. Mental measurements were also available for the children, some made on the same day as the physical examinations and others at varying intervals with a few separated by as long a time as six months.

2. *Resemblances in the Mental and Physical Development of Brothers and Sisters.* Among the children measured in the school in which our data were collected there happened to be a number

CHART XI



who were related to each other. Chart[1] XI shows the individual mental growth curves of two families in each of which three members had been given repeated measurements. Family A includes a boy No.[2] 3, and two girls, Nos. 2 and 20, two of whom are superior to the mean for the superior children of this study. Family B includes two boys, Nos. 10 and 40, and one girl, No. 39. These children are closer to the mean, and the girl is below it for a considerable part of its course. The members of Family A show a certain resemblance in the smooth and even rise of their growth curves, whereas the curves for Family B are more irregular and L. B. even shows periods of no measureable mental growth. There will be noted a similarity in the general trend

[1]The norms on this chart are the mean for the superior and average children in this study.

[2]These numbers correspond to those assigned to individuals in the tables of original data.

of the mental growth curves of the brothers in Family B, and also of the sisters in Family A.

3. *Mean Mental Age of Physiologically Accelerated and Retarded Children.* The children included in this study were divided into 4 groups on the basis of general physical development. Group 1 consisted of the boys whose height and weight were above the norms for their age, and Group 2 of the boys whose height and weight were below the norms, or very close to the norms in one or the other of these two measurements. Group 1 consisted then of physiologically accelerated boys and Group 2 of physiologically retarded boys, since it has been shown by Baldwin (1) and (3), that height and weight are closely correlated with physiological maturation. This division was made on the basis of the physical measurements without knowledge of the mental age of the child. A similar division into two groups was made for the girls.

The corrected mental ages of the children in each of the four groups were then averaged for each chronological age as shown in Table XIV. The mean mental age of physiologically acceler-

TABLE XIV

MEAN MENTAL AGE IN MONTHS OF PHYSIOLOGICALLY ACCELERATED AND RETARDED BOYS AND GIRLS

Chronological Age	Boys		Girls	
	Accelerated	Retarded	Accelerated	Retarded
5	72.0	62.8	74.4	57.6
6	89.4	83.2	81.3	79.0
7	101.3	97.1	99.9	95.0
8	118.2	110.8	114.6	107.0
9	131.1	120.3	128.6	119.1
10	142.4	131.0	141.1	131.0
11	155.3	137.6	151.2	144.3
12	171.1	150.1	176.7	168.2
13	179.0	158.4	(182.5)	189.2
14	194.2	166.2	194.9	183.7

ated boys is uniformly higher than the mean mental age of retarded boys. For the girls the same holds true with the exception of age 13, where the mean (printed in parenthesis) is too low because of the inclusion of the measurements of some girls who were of superior intellectual ability but of the very tall, thin type.

This table confirms the findings of other investigators summarized in (2), who in general agree that superior mental development accompanies superior physical development as a rule. The first investigation to trace the correspondence between pedagog-

ical acceleration and physical development by means of consecutive school marks and physical measurements was made by Baldwin (1) in 1914. The present study is the first to determine for the same individuals the relation between general physical status and mental growth as indicated by consecutive intelligence examinations.

4. *The Relation between Physical Traits and Mental Age.* A correlation between height and mental age previously reported by Baldwin (2) was +.71±.04 for boys and +.62±.05 for girls. In the present study the particular mental age selected for each child was the one which had been determined nearest to the time of physical measurement. In no case was there more than a few months interval between the physical and mental measurement. The correlations obtained between height and mental age are for 72 boys +.84 ±.02, and for 61 girls +.89 ±.02. The correlation between weight and mental age by Baldwin (2) was for boys +.68 ±.04 and for girls +.56 ±.06. In the present study the correlations for weight and mental age are higher, that is, for boys +.86±.02 and for girls +.77±.04.

The significance of the growth of the carpal bones in relation to general physical development was first emphasized by Rotch in 1910 and is summarized by Baldwin (3). In order to determine the relationship between anatomical age as indicated by the comparative development of the carpal bones and mental development as shown by the mental age rating, Pearson coefficients of correlation have been worked out by us. These coefficients give the first determination of the interdependence of these physical and mental traits. The coefficient of correlation between mental age and an index of anatomical age, (exposed area of the carpal bones of the right wrist) was for 54 boys +.873 ±.021; for 50 girls +.869 ±.023.

Earlier correlations between height and weight and the exposed area of carpal bones for a group of children were reported by Baldwin (3). The correlations between height and total exposed area of carpal bones of the right wrist were for boys +.88 ±.03 and for girls +.73 ±.05. The correlation between weight and area of carpal bones was for boys +.76 ±.05 and for girls +.77 ±.05. For this study the correlations between height and weight for boys was +.92 ±.01, and for girls +.89 ±.02.

As has previously been pointed out by Baldwin (2) the size of these coefficients is increased by the wide range of ages. It is

possible to gain some knowledge of the influence of the age factor by the method of partial correlation. The results for 49 girls selected because of the completeness of the data, show the following intercorrelations of height, weight, X-Rays, mental and chronological age.

TABLE XV
INTERCORRELATIONS BETWEEN PHYSICAL TRAITS, CHRONOLOGICAL AND MENTAL AGE

	Chr. Age	Weight	Height	Mental Age
Age				
Weight	.84			
Height	.88	.86		
Mental Age	.88	.71	.89	
X-Ray	.92	.88	.92	.83

The partial correlations with one factor constant for these same girls are given in Table XVI.

TABLE XVI
PARTIAL CORRELATIONS BETWEEN PHYSICAL TRAITS, CHRONOLOGICAL AND MENTAL AGE

Traits	Constants				
	Chron. Age	Mental Age	Height	Weight	X-Ray
Height-Weight	.57	.80			.38
Height-Chr. Age		.41		.52	.16
Height-Ment. Age	.53			.81	.59
Height-X-Ray	.62	.73		.65	
Weight-Chr. Age		.66	.30		.14
Weight-Ment. Age	—.15		—.40		—.11
Weight-X-Ray	.52	.76	.37		
X-Ray-Chr. Age		.72	.62	.71	
X-Ray-Ment. Age	.09		.04	.63	
Chr.-Ment. Age			.47	.76	.54

The influence of chronological age is more important with some traits than others. For example the correlations between physical traits are very little influenced by keeping chronological age constant (+.89 to +.53). Although there is no correlation between weight or X-Rays and mental age for this group when chronological age is kept constant, there is a positive correlation between height and mental age.

Summary and Conclusions

1. There is a similarity in the mental growth curves of brothers and sisters. The resemblance between brothers and sisters is further shown in physical traits by the correlation of the height X-Ray and weight quotients and in mental traits by the correlation between the I. Q.'s. The correlations are higher for the physical traits than for the mental.

2. The mean mental age of physiologically accelerated is higher than the mean mental age of physiologically retarded children. This study is the first to determine for the same individuals the relation between general physical status and mental growth as determined by consecutive intelligence examinations.

3. The coefficients of correlation between height and mental age are high even when the influence of chronological age is eliminated.

IV. GENERAL CONCLUSIONS

For years the literature has been full of statements in regard to the desirability of obtaining repeated measurements on the same children in order to study the process of mental development. The use of the Stanford Revision of the Binet scale even for the relatively short period of four years shows the unsuitability of this scale in its present form as a means for measuring mental growth. The limited number of alternative tests results in a certain practice effect on repeated examinations. Another defect of the present system of tests is the lack of a sufficient number of tests at the higher levels to measure the mental growth that apparently goes on in a bright young child even after the exhaustion of the 16 or 18 year old tests. It is commonplace in clinical psychology that a gifted child has more opportunity to gain a high I. Q. if measured early in his life where he has a greater range of tests in which to succeed. Theoretically it would seem to be a better measure of mental growth to use a combination of point scales for specific mental traits, each scale to be sufficiently extended to measure whatever ability exists and the whole system to include a sufficient variety of traits to afford a general measure of the development of the individual.

The findings of this study have been summarized in detail at the end of each section. A survey of these results show the importance of many factors influencing mental growth processes,

and producing differences in the mental growth curves of boys and girls, and of children of superior and average ability.

An analysis of the individual growth curves shows that the I. Q. is only approximately constant during successive examinations. The amount of difference between I. Q.'s obtained at various examinations is sufficiently small, and the correlations between the examinations are sufficiently high with small probable errors of estimate, to permit of predicting from an earlier examination what the individual's later development will be.

The most significant outcome of this study is the empirical determination of the mental growth curve and the establishment of the close interrelation between mental and physical development as shown by the general similarity between growth in height and in mental age, the rise in the mental age curve at the adolescent years, the superior mental development of physiologically accelerated children, and the high correlation between mental age and height.

It is evident that mental age ratings by the present scale are the result not only of native intelligence but also of the degree of physiological acceleration over that which is normal for the age. This latter factor is of extreme importance in any educational or social treatment of the individual. A high I. Q. reflects this factor as well as the general intelligence that it is designed to measure.

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