

# Changes in Mental Traits with Age

## Determined by Annual Re-Tests

*By*

FOWLER DELL BROOKS, Ph.D.

Teachers College, Columbia University  
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F. D. BROOKS

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# I

## PURPOSE AND PLAN OF THIS INVESTIGATION

In discussing the influence of maturity upon individual differences, Thorndike (1914, pp. 275ff.) points out the complexity of the problem in the respect that changes in an individual's mental traits with age may possibly be due to at least three factors: (1) the maturing of the trait, (2) the influence of training upon it, and (3) "the influence of both maturity and training upon the ability to understand and the wish to follow instructions and the ambition to do well in tests." He further insists that a knowledge of differences in mental traits with age does not tell us much about the influence of maturity upon these changes unless we can parcel out their causes among these three factors, and, that such parcelling out is practically impossible. Turning to the more general problem of changes with age he says, "So far upon the supposition that by changes in mental traits with age, we mean changes in the same individuals measured at different ages. The average change would then be the average of the changes in all the individuals studied. But in the studies that have been reported, the difference between the figures for, say, ten and eleven years, is not the average of the changes of all the individuals studied and need not in any real way describe them.

"For (1) the difference between the average of a group at ten and of the same group at eleven years does not describe the real individual changes; and (2) when we measure ten- and eleven-year-olds as we find them in school or elsewhere, we cannot be sure that the eleven-year-olds represent what the ten-year-olds will become . . . To measure the development of mental traits with age we must repeat measurements upon the same individuals and for all purposes of inference preserve intact each of the individual changes."

This investigation seeks to find out what changes in mental traits take place with age, and it seeks to find them out in the only way they can be found out accurately—by discovering what changes actually do take place in the same individuals from one



year to another. This involves re-testing the same individuals and giving appropriate statistical treatment to the resulting data. Two other purposes are (1) to investigate the correlation between mental functions at different ages of the same individuals, and (2) to study the relation of intellectual ability to rate of improvement over a longer period of time than has heretofore been reported upon—two years in this case.

## II

### THE SUBJECTS AND THE TESTS

The subjects were one hundred and seventy-one children enrolled in grades four to nine of the Training School of the Mankato, Minnesota, State Teachers College. They ranged in age from nine to fifteen, and represented a random sampling of various social and economic groups. Practically all of them had been tested by educational or psychological tests before taking the tests given in this investigation. Great care was taken that the conditions of testing, the way the tests were given, and the method of scoring should be uniform and according to the directions usually given in connection with each of the tests. There was practically none of the carelessness or lack of honest effort which is sometimes noticeable when a long series of tests are given by persons not connected with the schools in which the tests are given.

The following tests were selected and were given in May, 1918, in May, 1919, and in May, 1920.

1. *Number Checking.* Woodworth-Wells Number Checking Tests. Four tests were given each year, crossing out 5's, 7's, 4's and 8's. Ninety seconds were allowed for each test. The score is the sum of the correct cancellations in each test. Omissions and wrong cancellations were very rare, and have been neglected in scoring.

2a. *Handwriting Quality.* Quality of handwriting in ordinary written work. Class-room teachers selected at random two different sets of papers handed in by children in the ordinary school subjects. These sets were written a week to ten days apart. They were scored according to the Ayres scale, Gettysburg edition, the mid-point scores on the scale being given, and were all scored by a thoroughly competent person. The score given is the sum of the scores on the two papers.

2b. *Handwriting Quality.* Quality of handwriting on two tests in handwriting, given a week to ten days apart. Scored as in 2a. The score is the sum of the scores on the two tests.

2c. *Handwriting Speed.* The two tests of 2b were also scored for

speed. The score is the sum of speeds in two tests, expressed in letters per minute.

*2bc. Handwriting Quality and Speed.* As a single quantity to represent the handwriting achievement the quality and speed of *2b* and *2c* were combined by using the arbitrarily chosen formula: Score = Quality +  $\frac{1}{2}$  speed.

*3. Spelling.* Sixty words from columns Q, S, and U of the Ayres Spelling Scale were used. The words were dictated in simple sentences, the pupils copying the sentences. The score is the number of words correctly spelled.

*4. Visual Vocabulary.* Thorndike Reading Scales A2 and B, Visual Vocabulary. Both tests were given as follows: A2x and Bx in 1918 and 1920, and A2y and By in 1919. Comparable parts of the tests were counted so that total possible scores each year were the same. The score is the number of words correct on the two tests, the highest possible score being 190.

*5a. Courtis Arithmetic, Form B, Attempts.* The four fundamental operations were tested. The score is the sum of the number of problems attempted in the four tests.

*5b. Courtis Arithmetic, Form B, Rights.* The four fundamental operations were tested. The score is number of problems right in the four tests.

*5ab. Courtis Arithmetic, Form B, Combined Attempts and Rights.* Combined by the formula: Score = Average of attempts and rights.

*6. Woody Arithmetic Scales, Series A.* The four fundamental operations. The score is the sum of the problems right in the four tests.

*7. Stone Reasoning Test.* Stone's directions for scoring were followed, additional weight being given for the more difficult problems, and credit being given for all correct reasoning steps regardless of the numerical computations.

*8. Composition.* The subjects wrote for fifteen minutes on the common subject, "What I Would Like to Do Next Saturday." The papers were scored by five competent judges, on the basis of the Nassau County Supplement to the Thorndike-Hillegas scale. The score is the average of these five scores.

*9. Opposites.* Woodworth-Wells, first list beginning "long, soft." Responses that were correct for any commonly accepted meanings of

the words were scored one. Time, 120 seconds. The highest possible score is 20. The score is the number right.

10. *Directions*. Pintner-Toops Directions Test. Given and scored according to directions given in *Journal of Educational Psychology*, March, 1917. A perfect score is 27, being that of superior adults.

11. *Immediate Auditory Concrete Memory*. Whipple's three-, four-, five-, six-, seven-, and eight-term lists used. The score is sum of words recalled and written down, regardless of order. Perfect score is 33.

12. *Immediate Auditory Abstract Memory*. Whipple's abstract lists. Score is sum of words recalled regardless of order. Perfect score is 33.

13. *Memory for English Equivalents of Italian Words*. On each of three consecutive days pupils were given a printed list of twelve Italian words and English equivalents. Three minutes were allowed for study. These slips were then collected, and printed test slips (containing the Italian words in different order from that of the study lists) were distributed. Two minutes were allowed to write the English meanings. The nine lists used for the three yearly testings were arranged to include words that seemed of approximately equal difficulty, though no attempt was made to standardize them scientifically. The writer doubts very much, however, from a study of the results that the three lists of any year were on the whole equal to the three lists given in any other year. The score is the sum of number of correct English words given in three lists. Perfect score is 36.

14. *Substitution, Woodworth-Wells*. Five Geometric Forms. Time allowed, 90 seconds. Omissions were very rare. Score is number right minus number of wrong substitutions.

15. *Letter-Digit Substitution*. Three different tests. At the top of page were printed the ten digits. Under each was printed a letter. Below this key were printed in four rows one hundred ten digits in mixed order. Subjects were allowed 120 secs. on each test, to make the substitutions in consecutive order from the first. The same three tests were given each year. Scores were computed on basis of number right minus number of wrong substitutions. Omissions were very rare and were not considered in scoring. Score is sum of scores on three tests. Perfect score is 330.

16. *Reasoning*. Part of omnibus test devised by Thorndike and McCall. The score is given in terms of penalties. For the parts used a perfect score would be zero, while the poorest possible score would be 36.

17. *Trabue Language Completion Scales*. Scale C was given in 1918, scale B in 1919, and scale D in 1920. Scored according to Trabue's directions, each sentence scoring 2, 1, or 0. Perfect score is 20.

18. *Thorndike Reading, Alpha 2, Paragraph Reading*. Papers scored, using Kelley's tables for computing individual scores (*Teachers College Record*, May, 1917).

19. *Army Alpha*. Given to those tested in 1920. Scored according to directions given in manual.

20. *Thorndike Group Intelligence Test, III, Series L*. Given to group tested in 1920. Given and scored according to directions furnished by the author.

The following tests were not given in all three years: 10, 19, and 20. Test 10 was given in 1919 and 1920, the other two being given in 1920 only.

Twenty-six of the subjects took the following tests only: Nos. 1, 2a, 2b, 2c, 4, 8, 11, 12, 13, 14, 15, 17, 18—twice, at year intervals.

Seventy-eight of the subjects took all of the tests two years.

Sixty-seven of the subjects took all of the tests three years.

### III

## HISTORICAL SURVEY OF EXPERIMENTAL DATA ON AGE AND CHANGES IN MENTAL TRAITS

### I. INTRODUCTION

It is not within the scope of this investigation to consider the literature on the relationship between mental and physical development. Those who desire experimental data on this problem will find extensive bibliographies in Whipple (1910, 1914), Burk (1898), Meumann (1907, 1911), and in the *Psychological Review Index*.

Experimental work first concerned itself with testing one or more functions in one or more individuals—usually adults—to illustrate some psychological law or principle. Then the question of the development of different functions led to the examination of children. The earlier studies were often limited to experiments upon a few children of two or three grades or ages; quite often they were qualitative in character and more or less complex. Later there were devised simpler tests, the results of which could be treated quantitatively. Such quantitative results were often reported according to the grade the child had reached in school, the age, if mentioned at all, being the average age of the grade. There are numerous experimental studies which seek to trace the development of mental functions in this way. Greater refinement and precision in the technique of measurement have finally led to carefully devised, standardized, objective tests and exact quantitative treatment of results, and to the reporting of results, not only by grades but also by age and sex.

There is a vast mass of experimental literature on the problem of age and changes in mental traits. Space permits reference only to the most significant parts of it. It seems wise, therefore, to omit reference to practically all investigations which report results in either of the following ways: (1) by grade only, or by average age (except where average age, such as 9 years, 7 months, 15 days, is the average age of persons within a single year span, e. g., from 9.0 years to 9.9 years); (2) by age, but not separately for

boys and girls. Reporting by grade is of very practical value in administration and has value in psychological study, but for an exact knowledge of individual differences, especially of differences in growth or development, it is too crude a method; we must have age data as well. I have omitted much of the data not giving results separately for boys and girls in order to bring together results of investigations which have been presented in the same way as my own. I have presented results separately for boys and girls in all tests and at all ages. This has been done, not because of any belief in pronounced sex differences in mental traits or in the development of mental traits, but because it seems desirable that data from all investigations should be presented in such a form as will make them available for any future studies of sex differences.

The efficiency of single mental functions, or of narrow groups of functions, in relation to age, while the subject of a great many studies during the past thirty years, has, still, been investigated in nearly all cases by testing a group of children of different ages once or a few times, with usually only a short interval of a few hours or days between the tests, and with no re-tests of the same individuals six months or a year later to determine individual changes. Age status has been determined from these groups, and the differences between different age norms have been taken as the changes due to age. As Thorndike points out, such changes do not represent the changes in the same individuals, and such differences may or may not be the real individual changes with age.

## 2. NON-RE-TEST EXPERIMENTS

Any study of changes in mental traits with age must refer to the pioneer work of Binet, who after many years of careful experimentation finally published in 1905 the Binet-Simon tests of intelligence, which were revised, by the authors in 1908 and in 1911, by Goddard, by Kuhlmann, and later, by Terman and others at Stanford University. All of this work is too well known to require any further reference or any evaluation.

Binet and Henri (1894) after testing school children on memory of words say, "We have not succeeded in establishing clearly, in the primary elementary schools, which include pupils from seven to

twelve years of age, the influence of age on the number of words reported. We do not doubt that this difference exists but it is possible that it produces an effect little marked between seven and twelve years; it is possible also that the conditions, always changing a little some of the group experiments, have introduced into the results of different classes, some differences which have masked those of age... One observes between the first class (*cours supérieur*) and the fourth class (*cours élémentaire*) (the highest and lowest grades of the elementary school) a mean difference of less than one word." Later experiments by other investigators have shown that there is a difference in memory span, between ages seven and twelve, of one to two words.

Another of the earlier important studies of purely mental functions was that of Ebbinghaus (1897), who examined several hundred school children, using mental arithmetic, memory, and his "combination method." His data are given by grade or class, and by sex, though the average age of the classes is also given.

Ziehen (1898) investigated the association of ideas in children eight to fourteen years of age. He is one of the first to use re-tests of the same individuals over a period of a half year or more; some of his subjects were re-tested over a period of two and a quarter years. He concluded that the speed of association (free or uncontrolled) increases with age, whereas Winteler, Wreschner, and Rusk (1909) find that "for different children the speed of association bears no direct relation to age," and that "no conclusion, however, can be drawn from present results as to the relation of speed of association to age in the case of the same child." Ziehen's re-tests are more reliable measures of what age means for an individual, but he took no account of practice effect, nor did he re-test enough individuals to give any conclusive results.

Smedley (1902) investigated the development of immediate memory by testing 937 Chicago boys and girls, ages seven to nineteen, in visual and auditory memory for digits. Finding small sex differences, he reports data for sexes combined. Auditory memory develops more rapidly up to fourteen than thereafter, though there are times of slow growth, notably from eight to nine and from eleven to thirteen; visual memory develops more rapidly also up to fourteen, with gains and losses after that time, reaching, however, as in the case of auditory memory, its highest point at nineteen. Smedley



says of his results, "There is no 'memory period', no period in early school life when the memory is stronger than it is at any later portion of the child's life, a period especially adapted to memorizing." I give here his results in terms of per cent correct at different ages.

<i>Age</i>	<i>No. Tested</i>	<i>Aud. %</i>	<i>Vis. %</i>	<i>Age</i>	<i>No. Tested</i>	<i>Aud. %</i>	<i>Vis. %</i>
7	19	36.4	35.2	14	114	66.2	80.5
8	58	44.6	42.8	15	94	65.6	78.2
9	100	45.0	47.4	16	77	66.9	81.3
10	89	49.4	56.4	17	56	65.5	84.1
11	91	55.4	64.7	18	25	67.2	77.5
12	93	55.7	72.3	19	12	70.0	85.3
13	109	57.9	76.8				

We do not know just how typical of school population were the children examined by Smedley; selection no doubt was playing a part during the later ages; nor do we know how well those examined do represent all children of the same ages. Thorndike (1917) has shown that school population is made up of a selected group and that the higher the age, the greater is the amount of selection. In the absence of any careful study of the composition of the group tested we can only guess at the extent to which they represent children of these ages.

Winch (1906), interested in Dr. Rivers' investigations of visual illusions among primitive peoples, conducted an experiment upon 42 English boys, ages eight to fifteen, to see if the civilized child passes through the same stage of development found in the savage. Three different tests of the vertical-horizontal illusion were made with each boy for each of the three forms of the test. Recalculating his data upon the age basis, and computing the illusion in the average per cent of error for each age, we get the following:

Age . . . . .	8	9	10	11	12	13	14	15
Error in Per Cent . . . . .	14.09	16.92	9.29	11.31	6.13	5.63	5.41	3.10

The small number of cases, two to eight at each age, enables\*us to say merely that the amount of illusion seems to decrease with age.