LIBRARY OF PSYCHOLOGY AND SCIENTIFIC METHODS

EDITED BY J. McKEEN CATTELL

EDUCATIONAL PSYCHOLOGY

EDUCATIONAL PSYCHOLOGY

BY

EDWARD L. THORNDIKE

ADJUNCT PROFESSOR OF GENETIC PSYCHOLOGY IN TEACHERS COLLEGE,
COLUMBIA UNIVERSITY

NEW YORK
LEMCKE AND BUECHNER
1903

PRESS OF
THE NEW ERA PRINTING COMPANY,
LANCASTER, PA.

PREFACE.

THIS book attempts to apply to a number of educational problems the methods of exact science. I have therefore paid no attention to speculative opinions and very little attention to the conclusions of students who present data in so rough and incomplete a form that accurate quantitative treatment is impossible.

If the book shows to any extent scientific precision and adequate statistical treatment, my thanks are due especially to the teaching of Professors James McKeen Cattell and Franz Boas, to the writings of Dr. Francis Galton and Professor Karl Pearson, and to the personal influence of Dr. R. S. Woodworth.

For help in the collection of the material for the studies by my students or myself which are quoted, I have to thank generous and efficient friends, whose names make up a long list. Among them are:

W. H. Maxwell, Superintendent of Schools of New York City,
Professor Joseph Jastrow, of the University of Wisconsin,
Professor E. G. Dexter, of the University of Illinois,
Professor Arthur Allin, of the University of Colorado,
Professor C. E. Seashore, of the University of Iowa,
Miss Naomi Norsworthy, Tutor in Psychology at Teachers College,
Miss Jeannette F. Seibert, Assistant in Psychology at Teachers College,
Mr. L. W. Cole, Instructor in Psychology, Oklahoma University,
Mr. W. A. Fox, Superintendent of Schools, Albion, Indiana,
Mr. H. A. Ruger, of Columbia University,
Miss Rosalie Pollock, Salt Lake City, Utah,
Miss Almina George, State Normal School, Warrensburg, Missouri,
Miss Edith McLeod, State Normal School, San Diego, California,
Those of my students whose names appear in special connections throughout the book and the following principals of schools:
Miss Julia Richman, New York City,
Miss Caroline E. Hoefling, New York City,
Miss Elizabeth S. Harris, New York City,
Mr. James S. Morey, New York City,
Mr. John A. Loope, New York City,
Miss Christine McKernan, Jersey City,
Mrs. Josephine Hermans, Kansas City,
Miss Alice Hamblin, Minneapolis,
Mr. W. I. Bray, Cliffside,
Mr. F. E. Converse, Beloit.

CONTENTS.

CHAPTER I.

INTRODUCTION.

THE knowledge of human nature which psychology offers to students of educational theory and practice may be roughly divided into four parts. A body of general knowledge about instincts, habits, memory, attention, interests, reasoning, etc., finds place in the ordinary text-books. Detailed descriptions of the thoughts, feelings and conduct of children at different ages are available in the literature of child study. Particular facts which bear upon this or that school subject or method of teaching may be gleaned from researches upon perception, association, practice, fatigue and other topics. Finally there is an even more incoherent mass of facts about the influence of inheritance, environment and general mental development, the beginnings of what we may call a general dynamic psychology, which are relevant to many of the broader questions of education. It is the aim of this book to put this last group of facts at the service of students.

That they have thus far gone without systematic and convenient exposition is due to the complexity of the problems involved, not to any doubt concerning their practical importance. What we think and what we do about education is certainly influenced by our opinions about such matters as individual differences in children, inborn traits, heredity, sex differences, the specialization of mental abilities, their inter-relations, the relation between them and physical endowments, normal mental growth, its periodicities, and the method of action and relative importance of various environmental influences. For instance, schemes for individual instruction and for different rates of promotion are undertaken largely because of certain beliefs concerning the prevalence and amount of differences in mental capacity; the conduct of at least two classes out of every three is determined in great measure by the teachers' faith that mental abilities are so little specialized that improvement in any one of them will help all the rest; manual training is often introduced into schools on the strength of

somebody's confidence that skill in movement is intimately connected with efficiency in thinking; the practical action with regard to coeducation has been accompanied, and doubtless influenced by arguments about the identity or the equality of the minds of men and women; the American public school system rests on a total disregard of hereditary mental differences between the classes and the masses; curricula are planned with some speculation concerning mental development (*e. g.*, the culture epoch theory) as a guide. It is thus easy to find cases where educational practice depends upon opinions about our group of topics. It is still easier to note a similar dependence in the case of educational theory. Abundant illustrations will appear in the course of our study of the topics themselves.

These and their order will be:—

The measurement of mental traits.
The distribution of mental traits.
The relationships between mental traits.
Original and acquired traits.
Mental inheritance.
The influence of the environment.
The influence of special training upon general abilities.
The influence of selection.
The development of mental traits with age.
Sex differences.
Exceptional children; mental and moral defectives.
The relationships of mental and physical traits.
Broader studies of human nature.

CHAPTER II.

THE MEASUREMENT OF MENTAL TRAITS.

THE work of education is to make changes in human minds and bodies. To control these changes we need knowledge of the causes which bring them to pass. Such knowledge necessitates some means of measuring mental and bodily conditions; adequate knowledge necessitates accurate and complete measurements. We do all make measurements of mental as well as of bodily conditions, but commonly our measurements of mental conditions and so of the changes due to any educational endeavor are crude, individual and incomplete. The introduction of a new method, say of teaching arithmetic, is followed by A's statement that the class learned 'more,' B's that they learned perhaps no more, but obtained 'better' training. A and B have both made measurements of the conditions under the old and under the new method, but they were so rough that the comparison gave only the result 'more' or 'better' with no precise statement of how much. Moreover their measurements were taken by the instrument of individual opinion, so that C and D are at liberty to flatly deny the result. Finally they left unmeasured the subtler conditions of permanent interest, the rates of returns to time and effort spent, etc. An adequate measurement of mental traits will be one that is precise enough for us to draw the conclusions we desire, objective or subject to identical repetition by another observer, and complete enough to take in all the features of the condition that are important for our purpose.

If we could make such adequate measurements exhaustively we could describe a man's mind as so many units of that emotional tendency, so many of this sense power and so on through a well-nigh interminable list of possible mental traits. We should then be able to state exactly the difference between any two human beings, between the condition of anyone before and after any course of study or other educational influence; we could compare the results of different systems of education, describe the changes

due to maturity or calculate the personal efficiency of different teachers. In the instance just quoted A could say: "The 600 children in my school under the old method made an average gain of 4 per cent. in a year in arithmetical knowledge, 3 per cent. in interest and zeal, etc. Under the new method the figures are 6 per cent., 7 per cent., etc."

To some extent we can already make accurate objective measurements of mental traits. We can measure the ability to add or to spell or to translate Latin or to discriminate colors as accurately though not by any means as easily as we can height or weight. We can use units of time taken, errors made, facts remembered and such like as well as inches or ounces.

For instance the number of A's marked in a minute on a blank like the one reproduced below gives a measure of a certain complex ability in perception which is capable of the same treatment as any physical measurement.

OYKFIUDBHTAGDAACDIXAMRPAGQZTAACVAOWLYX
WABBTHJJANEEFAAMEAACBSVSKALLPHANRNPKAZF
YRQAQEAXJUDFOIMWZSAUCGVAOABMAYDYAAZJDAL
JACINEVBGAOFHARPVEJCTQZAPJLEIQWNAHRBUIAS
SNZMWAAAWHACAXHXQAXTDPUTYGSKGRKVLGKIM
FUOFAAKYFGTMBLYZIJAAVAUAACXDTVDACJSIUFMO
TXWAMQEAKHAOPXZWCAIRBRZNSOQAQLMDGUSGB
AKNAAPLPAAAHYOAEKLNVFARJAEHNPWIBAYAQRK
UPDSHAAQGGHTAMZAQGMTPNURQNXIJEOWYCREJD
UOLJCCAKSZAUAFERFAWAFZAWXBAAAVHAMBATAD
KVSTVNAPLILAOXYSJUOVYIVPAAPSDNLKRQAAOJLE
GAAQYEMPAZNTIBXGAIMRUSAWZAZWXAMXBDXAJZ
ECNABAHGDVSVFTCLAYKUKCWAFRWHTQYAFAAAOH

Often, however, it seems impossible to find any unit of amount. For instance, how much more fear has a very timid child than a very bold one, or just how much greatness as a writer had Shakspere, or to just what quantity of what do we refer when we think of a certain boy's 'badness'? Although we are thus unable in many cases to describe a mental trait as so much of such a thing, yet it is clear that we still do make measurements in these cases. We measure not by units of amount but by relative position in a group. The timid child we measure as being more timid

than 9 out of 10 children; Shakspere as being better than 99,999,999 out of 100,000,000 in greatness as a writer; the boy as being worse than the average. Such measurements may be as definite and precise and instructive as the more familiar kind. If we know that a boy who was the worst in a thousand has by training become not distinguishable from the average we know the change in him and the value of the training as well as we do in the case of a gain of 10 pounds in weight, or a reduction of 20 per cent. in errors in a certain amount of addition.

It is also often possible on the basis of facts presently to be described to turn a measurement in terms of relative position into a measurement in terms of units of amount. In fact measurements of mental traits can be made and are being made that are as much superior to individual opinions as a measurement by a millimeter rule is to a guess by the unaided eye or as a physician's count of the red blood corpuscles is to a statement that a person looks pale.

One peculiarity of measurements of mental traits deserves special notice, their variability. Physical measurements too are variable. If we measure the length of a wire or the height of a man or the weight of a stone we get at different times slightly different amounts, and physicists use an elaborate system of calculation to get from a group of varying measures the one measure that most probably represents the fact. The marked variability of mental measurements is then not a barrier to accurate treatment of mental traits, but it does make necessary certain precautions in measuring them. These are:

1. *Repeated measurements* in order to estimate from varying results the true status.

2. An expression of the abilities shown by *all* these measurements together, or at least

3. An expression of the essential features of the ability.

For instance A was tested by having a series of 12 letters read at a rate of 2 per second, he being required to write down as many as he could remember and in their proper order as soon as the reading was finished. He made a score of 6. This measurement is so far so good. It is better to believe that A's ability in the test is 6 than to guess at it, but by giving a second test the

score was 8. To say that A's ability is 6 or 8 or averages 7 is better than to have taken the 6 as a measure. But further trials give (including these two)

1	record	of	4	correct.
4	records	"	5	"
4	"	"	6	"
7	"	"	7	"
13	"	"	8	"
3	"	"	9	"
4	"	"	10	"

From all these scores we get as an average 7.94 words correct, calling a record of 4, which of course means from 4 up to 5, 4½, one of 5, 5½, etc. We get as the score above and below which an equal number of trials lie (median) 8.15; and as the most common record (the mode) 8.5. Now the trustworthiness of any one of these is 6 times as great as that of the first single score 6.* Clearly we cannot be sure that the average of the 36 measurements is identical with A's true average ability. In fact we can be almost sure that it is not. 72 measurements might give and almost certainly would give, a slightly different average. True average ability in the case of variable measurements means the measure we would get as an average or median or mode (according to the type we desire to ascertain) from an infinite number of measurements. Only by chance will the result from any finite number of measurements be identical with it. All our measures represent approximations, but the greater the number of measures the closer the approximation will be.

This series of measures is our knowledge of A's ability. We can see the fact more clearly by expressing it in space rather than in figures. If we let each quarter inch along a horizontal line stand for one degree of ability, and each one tenth inch of height above it stand for one manifestation by A of the ability designated by that place, we have figure 1, by which one can see at a glance A's ability, its variability and his general tendency to keep nearer 8 than any other one ability.

* It is found in variable measurements of the ordinary sort that the reliability of an average result increases as the square root of the number of measurements taken.

If we must for any reason abbreviate our description of A's ability we may best take two measures, one of the ability about which his various scores center most closely and the other of the closeness of this grouping. We may term these the center of gravity and the variability. For the former the average or median or mode may be used, for the latter the average of the differences between the individual records and their center of gravity (Average Deviation or A.D.).

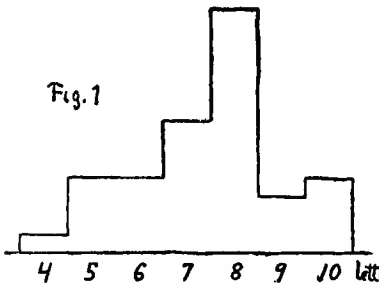


FIG. 1.

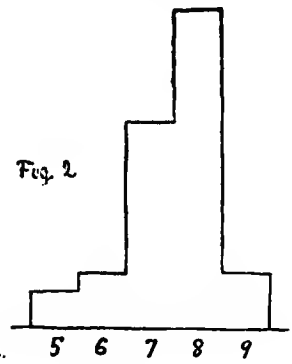


FIG. 2.

Other measurements of the latter that are better for many purposes are the square root of the average of the squares of all these differences (standard deviation, deviation of mean square, σ) and the difference less than which are 50 per cent. of the differences (probable error, P.E. or Q). In the case of our illustration A.D. (reckoned from the mode) = 1.17. This feature of A's ability is for many purposes just as important as its center of gravity.

Let us suppose that with the same test B showed instead of the measures given above the following ability:

2	records of	5	correct.
3	"	6	"
11	"	7	"
17	"	8	"
3	"	9	"

This is shown graphically in figure 2. The average, median and mode would be closely the same as before, but the variability of the measures would be less. The limits before were 4–10.

Now they are 5–9. The average difference of the individual measures from the mode was 1.17. Now it is 0.7. B's ability has the same center of gravity as A's, but B is a more constant performer.

It is obvious that an average from a set of measurements like the second is less likely to deviate from the true status than an average from a set like the first. And in general the less the variability of the single measures the greater the reliability of the result inferred from them. In point of fact, with such measures as one ordinarily obtains, the probable difference of the result obtained from the true status of the trait in question is directly proportional to the variability of the measures and inversely proportional to the square root of their number.

In the case of A's memory we should say, using formulæ the derivation of which need not be described here: From what knowledge we have, the *most likely* true average ability for A is 7.9; the chances are

1 to 1 that the true average does not differ from 7.9 by more than .171
2 to 1 that the true average does not differ from 7.9 by more than .245
3 to 1 that the true average does not differ from 7.9 by more than .291
99 to 1 that the true average does not differ from 7.9 by more than .651
999 to 1 that the true average does not differ from 7.9 by more than .835

This multiplication of measurements and consequent calculation may seem a bit far-fetched and complicated, but it is only what is common in the exact sciences and is well worth the trouble. Any measurement of a mental trait should be accompanied by a statement of its reliability, *i. e.*, of the probable deviation from the true ability. Measurements of mental traits without such a statement, or in its place such an account of the number of measures and their variability as would enable us to calculate it, should be received with skepticism.

Educational science more often uses measurements of groups, such as children of a given age or men characterized by certain training or individuals of a defined class. Here again we shall find that additional thought in arranging the facts and devising numerical expressions of them will be profitable. As a sample group measurement, let us take the ability found in twelve-year-old boys in school in the case of the following test: To mark as

many as possible of the words containing the two letters a and t in the page reprinted below; 120 seconds being allowed for the work.

A.

Dire tengo antipatia senores; esto seria necedad, porque hombre vale siempre tanto como otro hombre. Todas clases hombres merito; resumidas cuentas, sulpa suya vizxonde; pero dire sobrina puede contar dote veinte cinco duros menos, tengo apartado; pardiez tamado trabajo atesorar-los para enriquecer estrano. Vizconde rico. Mios, quiero ganado sudor frente salga familia; suyo, pertenence, tendran. Conozco marido pueda convenirle Isabel: Carlos, sobrino. Donde muchacho honrado, mejor indole, juicioso, valiente? Quieres sobrino. Esposo parece natural, pero. Pero, pero, diablos objeciones hacer. Posible quedandonow solos siempre hacer oposicion. Solo delante hentes eres ministerial. Pues, sidens siempre plan, dicho antes, porque hace tiempo notade cose aflige cierto. Sabes cuante quiero Carlos; consuelo apoyo; despues persona quiero mundo. Como eres buena amable, quieres porque, darme gusto, pero quisiera. Palabra cucsta trabajo; parece sino teines miedo agasajarle, manifestarle carino. Veces tratas cumplimiento veces senor. Probare; ejemplo pudiendo abandonar case negocios, deseaba hubiese acompanado viaje; preferiste sola sobrina doncella. Quise contradecir, pero para sentimiento, para tambien. Voto gasta palabra, dice frases, dice; pero alla adentros quiere. Mientras estado malo, puesto dirigir casa; pardiez aunque carrera, hacia mejor; cabo tiene sobre ventaja poca edad, actividad zelo, pues para contigo digo. Siempre ordenes; dejaria matar alcanzarte billete para opera para baile. Necsitamos para felices; algo estrano, desconocido. Esta resuelto; supuesto hemos hablado esto, mismo preciso empieces darle conocer nuestros planes. Quien mejor. Opone nunca deseos, sera facil nadie persuadirle. Probare menos, preciso sino creere tienes interes decidido proteger vizconde. Pudieras creer siempre inclinado senores cabra tira monte. Pero tengo nada ellos esposo tienes siempre pensativo siempre trists. Diablos tiene Carlos acercate, tiene hablarte. Hola parece sacado letargo tengo algunas instrucciones cajero marcha dentro poco. Para empresa piensa usted establecer Habana. Precisamente bonita especulacion bien manejada sobro todo. Espero pero tengo entre manos etro proyecto interesa aqui estabamos ocupando pienso. Eres porque quieres

B.

porque e tregas defensa peligro lugar huir mujer, harto debil duda pero algun desgracia tuviese luchar sentimientos semejantes tuyos, lejos ceder ellos cobardemente moriria pero triunfaria. Tendras menos valor tendre darte lecciones valor energia. Vamos, Carlos, amigo creeme sentimiento, profundo razon pueda subyugar, desgracia grande pueda soportar vencer nuestro corazon. Ofrezco apoyo eres creo sequiras consejos. Bien, hable usted. Quiere casarte Isabel. Isabel, prima imposible; quiere otro, vizconde amigo. Preciso persuadirselo hare otros partidos habra jamas para jurado nada espero pero conservare siempre entero este amor ella ignora unos juramentos recibido. Enhorabucna otro medio asequarara tranquilidad, uya destino ofrecido aleja Madrid, preciso aceptarle. Privarme presencia felicidad hecho usted para consejo especie embargo preciso seguirle solo puedes conservar amistad elige.

Jamas caballero crei usted digno consejos dejo usted abandonado mismo nada tango decirle Carlos aleja, echa mirade salir Dona mira; suspira sale. Porque inquieta partida desterremos para siempre memoria quiero puedo presente temo; ausente, echo menos, verle sonrojo, nombre hace temblar. Embargo nunca dicho debiera ignorarlo Dios Dame fuerzas para resistir.

165 boys were tested and to each was given a measure; namely, the number of words containing a and t that he marked.* The detailed results for the group are:

3	words	were	correctly	marked	by	1	boy
4	"	"	"	"	"	3	boys
5	"	"	"	"	"	1	boy
6	"	"	"	"	"	3	boys
7	"	"	"	"	"	4	"
8	"	"	"	"	"	4	"
9	"	"	"	"	"	10	"
10	"	"	"	"	"	13	"
11	"	"	"	"	"	13	"
12	"	"	"	"	"	18	"
13	"	"	"	"	"	16	"
14	"	"	"	"	"	9	"
15	"	"	"	"	"	15	"
16	"	"	"	"	"	20	"
17	"	"	"	"	"	10	"
18	"	"	"	"	"	6	"
19	"	"	"	"	"	7	"
20	"	"	"	"	"	3	"
21	"	"	"	"	"	1	hoy
22	"	"	"	"	"	2	boys
23	"	"	"	"	"	2	"
24	"	"	"	"	"	2	"
25	"	"	"	"	"	0	"
26	"	"	"	"	"	2	"

We call the number of individuals who receive any single measure the frequency of that measure or degree of ability in the group. Thus 1 is the frequency of the measure 3, 3 of 4, 1 of 5, 3 of 6, etc. The detailed results just given are then a table of the frequencies of the different measures or degrees of the trait in the group, 12-year-old boys. They give the *distribution* of the trait in the group. Such a total distribution or table of frequencies is the true measure of the trait in the group, and any

* In reality four others took the test but misunderstood its requirements. For simplicity's sake I confine the illustration to the measurement of the trait in 12-year-old boys who understood the test.

average or other simple numerical expression should be regarded as an effort to present briefly the most essential feature of the real fact, not as an adequate equivalent of it. By a diagram the true measure of the trait in the whole group can be realized as quickly as can a single average. We may picture the frequencies of the different grades of ability in the group of varying individuals just as in figures 1 and 2 were pictured the frequencies of the different grades of ability in the varying trials of the same individual.

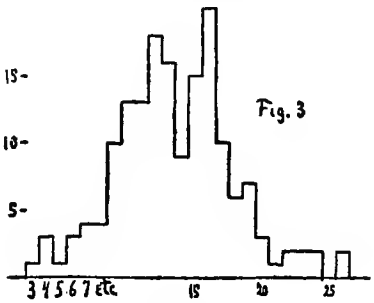


Fig. 3.

Figure 3 thus presents to a single glance (as soon as we understand the method of its construction) our entire table of page 10. Such a graphic measurement of a trait in a group is called the *surface of frequency* of the trait.

The two more important features of a measurement of a group of individuals are its *center of gravity* or the general tendency of the trait, and its *variability*. The case of a group of varying individuals is statistically identical with that of a group of varying performances by an individual.

In our illustration the average ability of the group is 14.06,* the median ability is one fifth of a grade lower (13.8), and the abilities 12 to 16 are much more frequently found than any other consecutive five. The mode might thus be taken to be 12–16.

The variability of the group is, using the three customary measures:

A.D. (average difference between any individual's ability and the average of the whole group) = 3.47.

σ (square root of the averages of the squares of the differences of all the individuals from the average of the group) = 4.31.

P.E. or Q = 3.32 (half of the individuals differed from the average by less than 3.32).

* A rank of 3 really means above 3.0 and below 4.0, one of 4 means above 4.0 and below 5.0. The actual value of 3 is therefore 3.5, of 4, 4.5, etc. The average and median are calculated from these real values.

Besides these customary measures of the variability of a group, we could of course make any that seemed advisable. *E. g.*, all our cases fall between 3 and 26 or inside of 2 and 27, or within 11.06 below and 12.94 above the average; 124 cases out of 165, or 75 per cent., fall between 9 and 17, or within 5.06 below and 3.94 above the averages; there are 25 individuals who differ from the average by from 0 to 1, 33 by from 1 to 2, 33 by from 2 to 3, 23 by from 3 to 4, 16 by from 4 to 5, 11 by from 5 to 6, etc.

As with the separate trials of an individual, so with the different individuals of a group, the average or median is only an approximate measure of the true condition. Its closeness of approximation depends directly upon the square root of the number of cases and inversely upon their variability. There is no excuse for a writer's ignorance of just how reliable his measures of a group are.

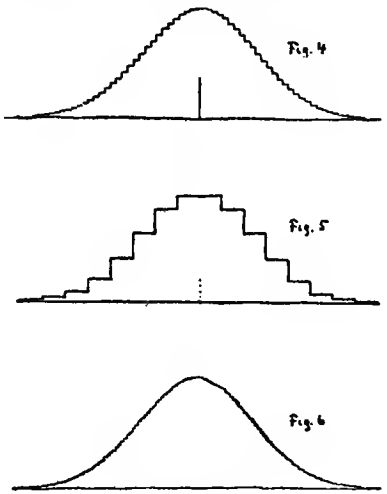
For our illustration, the chances are a little over 2 to 1 that the true average ability of 12-year-old boys will not differ from the average 14.06 by more than 0.235, 21 to 1 that the difference will not be more than 0.47, and 332 to 1 that it will not be greater than 0.705. Thus there is practical certainty that the average ability of 12-year-old boys is between 13.355 and 14.765.

CHAPTER III.

THE DISTRIBUTION OF MENTAL TRAITS.

Do the distributions of mental traits in groups of individuals follow any regular law? Are the differences between individuals in mental capacities and characteristics explainable by any simple set of causes and amenable to any single type of description? If such uniformity exists, the exact study of educational problems is possible and even easy.

It has been supposed, for more or less satisfying reasons, that in any group of individuals representing a single species, in respect to any trait not then influenced by natural selection, the distribution would be that of a chance event, the surface of frequency being that of the probability integral. The exact meaning of this supposition and the basis for it need not be discussed here. Our interest is in discovering whether any one type of distribution does characterize all mental traits in human beings. By using graphic representations rather than algebraic formulæ the answer and the evidence for it can be made clear even to one who knows nothing whatever of the mathematical properties of the surface of frequency of a chance event or of any other.



FIGS. 4, 5, 6.

Figure 4 gives the distribution or surface of frequency of the type to which perhaps all the distributions of mental traits conform. Figure 5 gives the same distribution as figure 4, but with a coarser separation into grades. Figure 6 gives again the same distribution, but this time with a very fine subdivision of grades.

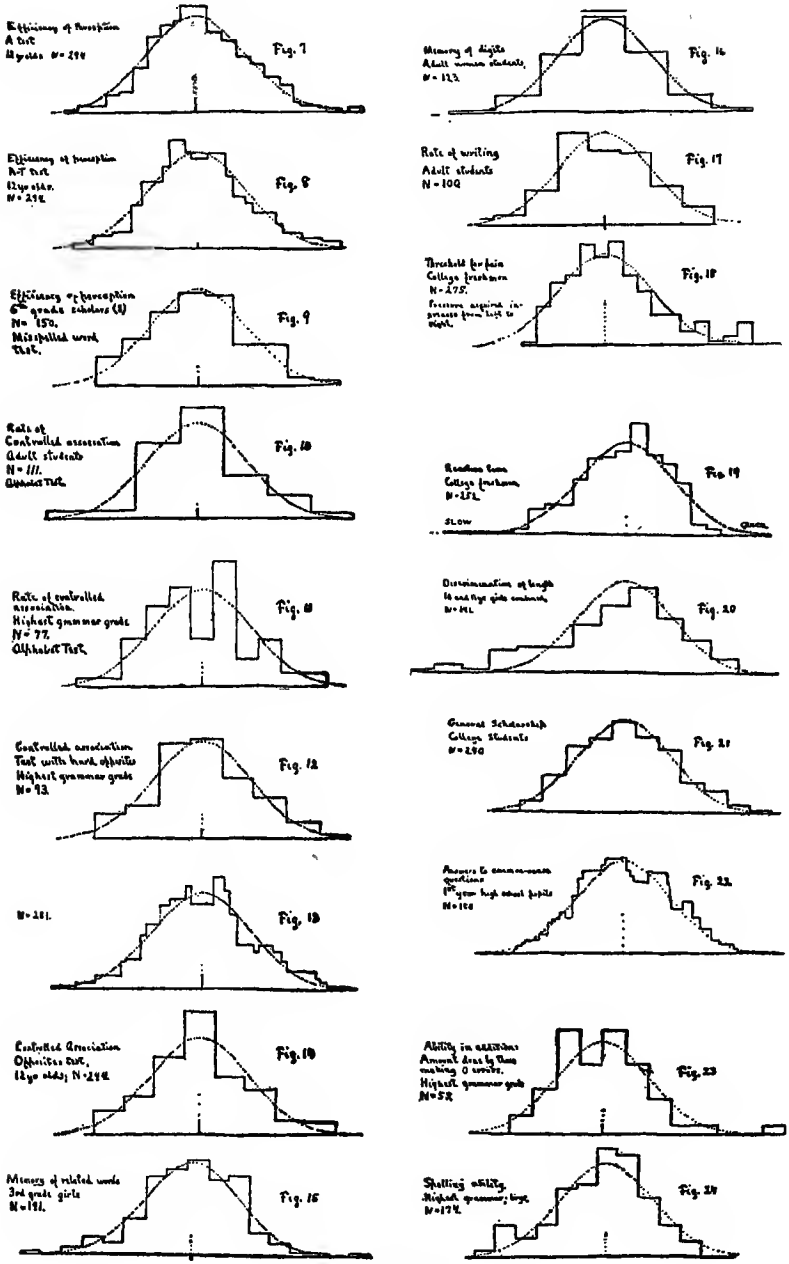
Our question is, "Are mental traits commonly distributed after the type of figures 4–6?" We can answer it by comparing with figures 4–6 figures 7–24, each of which represents the actual distribution found for some mental trait. To make the comparison easy a light dotted line shows in each case the rough outline of figure 6. The reader has then simply to note how closely the actual distributions follow the dotted lines.*

In drawing these surfaces the median value is made to coincide with the median value of the normal surface of frequency. Whenever any distribution represents measurements by different people or under different conditions or of different sexes or with different tests, it is compounded of separate surfaces each drawn with consideration of the mean and variability proper to the single group and then so combined as to allow roughly equal weight to the distributions from equal numbers of cases. No distributions are thus combined unless they all individually represent the same type as they do when combined. Barring the inclusion in the same distribution of the different racial types found in schools, of children sometimes as much as 12 months apart in age in the age groups and children in the school groups as noted, there are no sources of the variability found save precisely those which we are trying to measure. The strongest proof of the approximation of the distribution of mental traits to the normal type is given by a score or more of distributions from too few cases to appear here which yet all follow the normal type.

Since the aim of this section is simply to show the general fact of distribution, not to analyze it precisely, I have made no attempt to ascertain whether after all the combination of mental species is not present. That may well be the case, but for the practical purposes of educational science it makes little difference. Our use of the fact of approximation to the normal type will be justifiable in either case.

In all these cases there is a remarkable uniformity in the distribution of mental traits amongst individuals. In all cases the

* For the sake of the reader versed in statistics, I may add that the scale of the base line for each distribution is so arranged that the deviation of mean square for each one is represented always by the same length and the total number of cases by the same area. It is thus possible to compare any one with any other or with the normal frequency curve.



FIGS. 7–24.

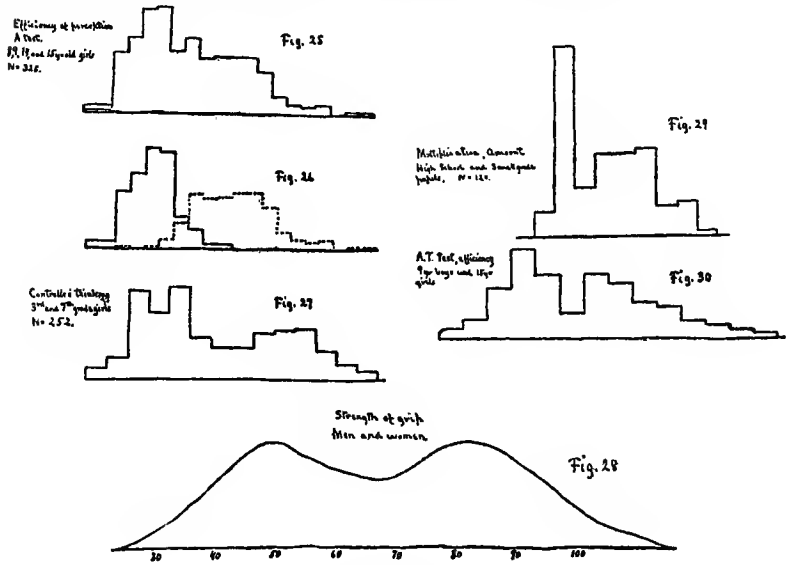
average ability is near the common ability and both are near the point above which 50 per cent. of the cases lie. The greater number of the cases lie near the average, mode or median point, and degrees of ability a certain amount above or below that point are nearly equally common. The more remote a degree of ability is from the average or median or mode, the fewer are the individuals who possess it. The difference between the degrees of ability above and below the average, mode or median between which 50 per cent. of the individuals are included is about two ninths of the difference between the lowest and highest degrees of ability found.

This type of distribution is called the normal distribution. It approximates the types found for most variable organs or functions in nature in the case of any single species when the organ or function in question is not subject to selection.

The so common fact of the approximately normal distribution of mental traits leads to many important theoretical considerations and gives many possibilities of studying human nature that would otherwise not exist. But for our purposes most of its results may be neglected. For us a knowledge of the existence and frequency of normal distribution is of consequence first because it emphasizes the fact of human individual differences and gives us a precise idea of their amount; second, because it enables us to compare groups accurately. In the study of heredity, for instance, we shall compare the group 'children of parents possessing such and such a degree of such and such a mental trait' with children of parents possessing a different degree thereof. In the study of sex differences we shall compare the group men with the group women, the group 10-year-old boys with the group 10-year-old girls. In the study of the influence of the environment we shall compare 'group with such and such training' with 'group without it.' In the study of growth and maturity we shall compare different age groups. In all these cases we can get much more illuminating and precise and extensive knowledge by comparing the distribution curves for the two groups than by using mere arithmetical averages. We shall also avoid a number of misunderstandings and fallacies by bearing in mind the fact of

the variability of mental traits and the prevalence of variability of the normal type.

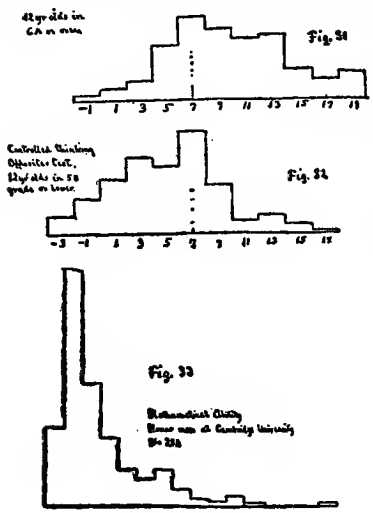
The meaning of cases where the distribution of mental traits does not follow the normal frequency curve will become clear if we examine, first, some cases of the distribution of a trait in a group of individuals of two or more distinct species and, second, cases where some selective agency has been at work.



FIGS. 25–30.

Figure 25 gives the distribution of ability in the test in marking A's of a group of children 8, 9, 14 and 15 years old. From figure 26, which gives separately the distributions (1) for those 8 and 9, and (2) for those 14 and 15, we see clearly that the peculiar flattening of figure 25 is due to the mixture of two species each of which approximates fairly to the normal type. The same result of mixture is shown even more emphatically by figure 27, which gives the distribution of a group composed of about 140 third grade and about 180 seventh grade girls. Here the two modes belonging to the two grades are easily distinguishable. A real case of the same sort of distribution is pictured in figure 28, which gives the distribution of strength of arm in human adults.

The two species here are men and women.* When we find in the surface of frequency of a mental trait a departure from the normal toward a lowering and broadening of the surface or toward two or more modes we may commonly expect to find a mixture of species. Other illustrations of such a condition are given in figures 29 and 30.



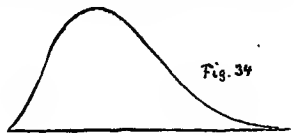
FIGS. 31–33.

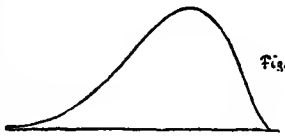
Figure 31 gives the distribution in a test of controlled association of the 12-year-old boys in the 6A grade or higher. The lack of symmetry in the surface is obviously due to the fact that we are dealing with a selected group; that the duller and less mature boys have been eliminated. The influence of the opposite sort of elimination is seen in figure 32, which gives the distribution in the same trait of 12-year-old boys in the grades lower than the 6A. By combining the two we should have a normal frequency surface. Figure 33 gives a real case of a distribution distorted by selection comparable to those artificially produced in our examples. It is the distribution of mathematical ability in the candidates for honors in mathematics at Cambridge University.† Of course such candidacy implies that the poorer grades of mathematical ability are eliminated. Any selective agency which works upon a species of individuals will alter the shape of the surface of frequency for any mental trait unless its selections are random with respect to different amounts of that trait. As the selective action is commonly such as picks out the good or the bad, the result is commonly to produce a 'skewness' of the surface toward one extreme and a blunted condition at the other. When a series of measurements in a group shows a deviation from the

* Drawn roughly from the data given in Galton's 'Natural Inheritance,' p. 200.

† It is taken from Galton's 'Hereditary Genius,' 2d ed., p. 16.

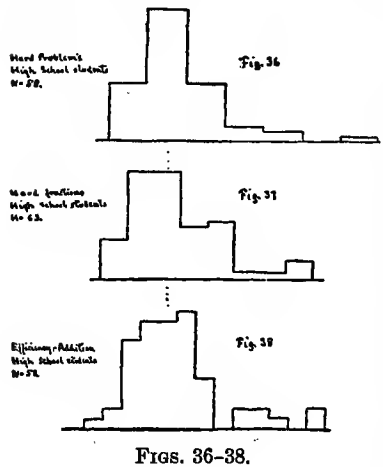
normal law of frequency toward conditions like those in figure 34 and figure 35, it will be wise to look for some selective agency at work upon the group. If the approximately normal distributions figured above are examined carefully a slight elimination of the least efficient will be apparent. This is probably due to the fact that children who are very low in a scale of intelligence are eliminated from the public schools altogether and so are not represented in our tests.





FIGS. 34–35.

Figures 36, 37 and 38 present other samples of asymmetrical distributions due to selection.



FIGS. 36–38.

It is likely that the statistics upon which were based the frequency surfaces on page 15 are slightly influenced by both mixture of species and selection, and that without these they would approximate still closer to the one simple law, and support still more emphatically the hypothesis that the distribution of any mental trait in a homogeneous species undisturbed by selection is that given by the probability integral.

From this hypothesis, two important results follow. The measurement of a mental trait in a group does not, when distribution is normal, require the complete statement of the distribution, since from knowledge of the average or median or mode and of the A.D. or some other measure of the variability of the group about the average we can reconstruct approximately the entire dis-

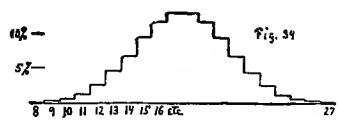


FIG. 39.

tribution scheme. Thus given the facts that the average ability of 12-year-old boys in a test of memory is 17.5 and that the standard deviation is 3.0, and we know that the whole distribution scheme for 12-year-old boys in the test is that of figure 39 and table I. The mathematical formulæ by which this is done need not concern us here.

TABLE I.

Ability.	Percentage of cases possessing it.	Ability.	Percentage of cases possessing it.
8	.1	18	13.1
9	.3	19	11.7
10	.6	20	9.4
11	1.3	21	6.7
12	2.5	22	4.3
13	4.3	23	2.5
14	6.7	24	1.3
15	9.4	25	.6
16	11.7	26	.3
17	13.1	27	.1

The other result is that if we know that distribution is regular and have given the measurements in terms of relative position of a large number of individuals chosen at random, we can turn those measurements into terms of amount. Here again the mathematical formulæ are best omitted. The reader may take it on trust that such a transposition as the following is correct.

Given the knowledge that 1,000 individuals rank in order of excellence in English composition as follows:

Individuals	1– 2	are indistinguishable	in ability but better than any below.
"	3– 5	are indistinguishable	in ability but better than any below and worse than any above.
"	6– 10	are indistinguishable	in ability but better than any below and worse than any above.
"	11– 20	are indistinguishable	in ability but better than any below and worse than any above.
"	21– 40	are indistinguishable	in ability but better than any below and worse than any above.
"	41– 70	are indistinguishable	in ability but better than any below and worse than any above.
"	71– 120	are indistinguishable	in ability but better than any below and worse than any above.
"	121– 280	are indistinguishable	in ability but better than any below and worse than any above.
"	281– 720	are indistinguishable	in ability but better than any below and worse than any above.

Individuals 721– 880 are indistinguishable in ability but better than any below and worse than any above.
" 881– 920 are indistinguishable in ability but better than any below and worse than any above.
" 921– 960 are indistinguishable in ability but better than any below and worse than any above.
" 961– 984 are indistinguishable in ability but better than any below and worse than any above.
" 985– 993 are indistinguishable in ability but better than any below and worse than any above.
" 994– 997 are indistinguishable in ability but better than any below and worse than any above.
" 998–1000 are worse than any above.

and given the knowledge that the distribution in this ability is regular. Take as 0 the ability in composition above and below which half of the individuals lie, and as 1 the ability excelled by 152 of the group and as — 1 the ability less than which 152 of the class have. Then the scheme of distribution is that of table II.

TABLE II.

Highest	2	rank	between	+ 2.87	and	probably	+ 3.00,	perhaps	more.	
Next	3	"	"	+ 2.575	"	+ 2.87	averaging	close to	+ 2.7	
"	5	"	"	+ 2.325	"	+ 2.575	"	"	+ 2.44	
"	10	"	"	+ 2.05	"	+ 2.325	"	"	+ 2.17	
"	20	"	"	+ 1.75	"	+ 2.05	"	"	+ 1.88	
"	30	"	"	+ 1.475	"	+ 1.75	"	etc.		
"	50	"	"	+ 1.18	"	+ 14.75				
"	160	"	"	+ 0.58	"	+ 1.18				
"	440	"	"	+ 0.58	"	— 0.58				
"	160	"	"	— 0.58	"	— 1.18				
"	40	"	"	— 1.18	"	— 1.405				
"	40	"	"	— 1.405	"	— 1.75				
"	24	"	"	— 1.75	"	— 2.145				
"	9	"	"	— 2.145	"	— 2.53				
"	4	"	"	— 2.53	"	— 2.74				
"	3	"	"	— 2.74	"	probably — 3.00, perhaps less.				

From this scheme we can get a measure in amount for any individual whose position compared with the rest is known. For instance the ability of individual 4 is close to + 2.44, that of individual 17 is close to + 2.17, while that of individual 33 is + 1.88. No. 4 is nearly 30 per cent. farther above the average than No. 33. In this scheme of course we do not so far know just what 1.0 or 1.5 or any other measure represents. + 2.98 may be the ability of Shakspere or of a fairly good high school

composition according to the group of 1,000 we are studying. But if we give a few samples of the compositions with the amounts assigned we make the hitherto arbitrary unit of amount a perfectly definite thing, as definite as an inch or an ohm or kilogram. Our study of the distribution of mental traits thus provides us with a means of accurately measuring such physical traits as color of eyes or hair and such mental traits as courage, honesty, ambition or eminence, provided we deal with homogeneous groups and have reason to think that the distribution of the ability in the group studied is normal.

The reader will, I trust, have inferred already two corollaries of the law of distribution: the first that small differences between individuals in the same species are far more common than larger ones, the second that within any one species there is no clear demarcation of ordinary from exceptional grades of ability. It is a common error to distort the truth that in any school grade or at any age there are great differences in ability between the extremes in any mental trait into the error that such great differences are as much the rule as lesser ones. The inference is drawn that teaching which is adequate for say one third the range of abilities found would be adequate for only one third of the students. On the contrary such teaching would be adequate for over two thirds of the students, for over two thirds of the individuals in any homogeneous group are centered within the middle third or less of the total range of ability.

Again it is a common error to imagine that nature has provided distinct classes corresponding to our distinct words, *e. g.*, normal and abnormal or ordinary and exceptional. But within any natural group grades of amount of any trait seem to be continuous. Genius and idiot, precocious and retarded, musical and unmusical, bright and dull and all the host of descriptive words do not mark off distinct varieties of beings, but artificial sections of a continuously varying group. The realization of this fact will prevent a multitude of errors in arguments about the processes and results of education.

CHAPTER IV.

THE RELATIONSHIPS BETWEEN MENTAL TRAITS.

We may expect that knowledge of the relations between mental traits will outvalue knowledge of the traits themselves. If an alteration in one function involves some alteration in others, our knowledge of the condition of the first function is made far more fruitful. Moreover its own nature and means of control may be best known through its relationships.

Amongst educational problems that are essentially problems concerning mental relationships are the following: The disciplinary value of studies; the arrangement of groups of electives in a curriculum; systems of grading and promotion; tests of mental growth and condition.

The extent to which the training of any one mental function secures improvement or better chances for it in other functions depends upon the closeness of relationship between the functions in question. If, for instance, the ability to notice errors in arithmetic is directly correlated with the ability to notice errors in spelling, then improved accuracy in arithmetic may involve improved accuracy in spelling. If the ability to learn Latin is more closely related to the ability to learn Greek than to the ability to learn mathematics, then there is, other things being equal, a reason for putting Greek rather than mathematics with Latin in a common group. If attainments in arithmetic involve equal attainments in English, geography, etc., then to promote pupils upon their standing in arithmetic is not only a simple but also a just method. If motor ability is closely related to general mental maturity we may use it in diagnosis.

In general our ignorance of mental relationships is enormous. This is due to the fact that mental relationships, like mental traits, are variable. The function of being a great warrior is really slightly related to the function of being a great poet, but that does not mean that every great warrior is a slightly better

poet than the average man. It means that occasionally a great warrior is a very great poet. There is a direct relation of 39 per cent. between ability in Latin and ability in mathematics (the abilities being measured by high school marks). But this does not mean that every one x above the average in Latin will be exactly .39 x above the average in mathematics. It means that the *average* of all those who are x above the average in Latin will be .39x above and that they will vary about that point.

For instance 17 students each of whom received a mark 15 above the average of their class in Latin might receive in mathematics the following marks respectively (+ standing for above and — for below the average): 16, 8, 5, 6, — 2, 4, 5, 5, 12, — 4, 7, 7, 5, 6, 5, 8, 6. The average of these is 5.8, or 39 per cent. of 15.

The fact of the variability of relationships has led thinkers to neglect their accurate measurement and either to guess at what relationships exist or to regard them as a matter of chance. They can be treated as accurately as any facts.

It will be helpful to bear in mind the following terms:

The status or station of any individual.
The degree of resemblance or relationship.
The degree of resemblance in a group.
The degree of antagonism.
The degree of antagonism in a group.
The coefficient of correlation.

The status of an individual means his position in the group in comparison with which we measure him. As a measure of it I shall use the difference between his ability and the average or median or modal ability of the group, calling the difference + when he is above and — when he is below the average, median or mode, as the case may be. Thus in a test of sixth grade girls in the quickness and accuracy of perception where the average ability was 15.7, an individual whose ability was 19 would have a status of + 3.3, one whose ability was 11 would have a status of — 4.7, etc.

The degree of relationship between one trait and another in an individual will then be measured by the resemblance between

his stations in the two traits, *i. e.*, their ratio.* A minus sign before the ratio will mean so much antagonism or opposition of the two traits. The degree of resemblance between two mental traits in a group of individuals will be some expression of all the individual degrees of resemblance,—their total distribution, or merely their average, median or mode. When these are negative quantities the relationship would of course be one of antagonism.

The following cases will illustrate these terms:

First Ability = marking off A's on a printed page (see page 4).
Second Ability = marking off words containing the two letters a and t on a printed page (see page 9).
First Ability; Average = 15.7 and variability (A. D.) = 3.65.
Second Ability; Average = 47.2 and variability (A. D.) = 6.92.

Grace Smith's stations in the two abilities were —11.7 and — 2.2. Reduced to a common scale these are $-\frac{11.70}{3.65}$ and $-\frac{2.20}{6.92}$. She thus showed a degree of resemblance of the second to the first ability of

$$-\frac{\frac{220}{692}}{\frac{1170}{365}},$$

which is .09486, roughly 9½ per cent.

In the group of 48 twelve-year-old girls in the sixth grade, in whose cases the relationship between these two abilities was sought, the first ten showed the following degrees of resemblance (in per cents.): 20, 42, 18, 78, —79, 214, —42, 34, —92, 446. The median of all the 48 individual resemblances is + 32 per cent.

In point of fact so cumbersome and inexact a method of finding and expressing closeness of relationship is not used. I have described it at length to show clearly that we can measure and express relationships in the same way that we can mere amounts. The figure we shall use to express the relationship of two traits in a group of individuals is the *coefficient of correlation,* a single

* Comparison of stations necessitates their reduction to a scale that means the same in both cases. This is accomplished by dividing the station in the one trait by the measure of the variability of that trait, and dividing the station in the second trait by the second trait's variability.

figure so calculated from the individual records as to give the degree of relationship between the two traits which will best account for all the separate cases in the group. In other words it expresses the degree of relationship from which the actual cases might have arisen with least improbability. It has possible values from + 100 per cent. through 0 to — 100 per cent. A coefficient of correlation between two abilities of + 100 per cent. means that the individual who is the best in the group in one ability will be the best in the other, that the worst man in the one will be the worst in the other, that if the individuals were ranged in order of excellence in the first ability and then in order of excellence in the second, the two rankings would be identical, that any one's station in the one will be identical with his station in the other (both being reduced to terms of the variabilities of the abilities as units to allow comparison). A coefficient of — 100 per cent. would per contra mean that the best person in the one ability would be the worst in the other, that any degree of superiority in the one would go with an equal degree of *inferiority* in the other, and vice versa. A coefficient of + 62 per cent. would mean that (comparison being rendered fair here as always by reduction to the variabilities as units) any given station in the one trait would imply 62 hundredths of that station in the other. A coefficient of — 62 would of course mean that any degree of superiority would involve 62 hundredths as much inferiority, and vice versa.*

* Coefficients of correlation are obtained simply, though with much arithmetical work, by the formula

$$r = \frac{\Sigma x.y}{n\sigma_1\sigma_2},$$

in which r = the coefficient of correlation; $\Sigma x.y$ = the sum of the products of the two stations of each individual (here the stations are taken unreduced to a common basis); n = the number of individuals in the group; σ_1 = the mean square deviation of one ability, and σ_2 the mean square deviation of the other. The formula is due to Professor Karl Pearson. The reader of statistical interests is referred to the chapter on correlation in Pearson's 'Grammar of Science,' 2d edition, and to his numerous papers in the Transactions of the Royal Society. Mr. G. U. Yule has recently elaborated a formula giving a parallel coefficient for relationships measured by the frequency of association of two conditions (see Proceedings of the Royal Society, Vol. 66, pp. 22 and 23) and Professor Pearson has given this formula an improved form. The reliability of any coefficient obtained by either the Pearson or the Yule

Relationships between mental abilities or functions may be (1) necessary, or (2) secondarily caused. By necessary relationships are meant those cases where the mind is so organized that the condition of the one function always involves such and such a condition of the other function. If by original nature the one function has a certain status the other will be determined. If by training the status is changed the other will change so as to continue the relation. Growth will influence both so that the relation stays unimpaired. The second class of relationships are those due to the action of some cause that influences function 1 and function 2 in similar ways. Growth and training are common instances of such causes.

Thus if we take all the boys in the last five years of a grammar school course the coefficient of correlation between ability in perceiving the A's in a page of printed capital letters and ability in perceiving words containing a and t in a page of print (in Spanish) is +.75. But if we eliminate in part the influence of differences in maturity by taking only the pupils of the limits of a single year, it is less, and if we eliminate still further by taking only those of the same year in age and of the same grade in school, the correlation is only +.53.

Again there might be no inherent relationship between the ability to read and the ability to add, but if we compared well taught with poorly taught children we should find that the best adders tended to be the best readers, for the efficiency of the training would influence adding and reading alike.

The necessary relationships are few and small in amount. The relationships in general are far less close than educational literature would have us believe.

formula can be readily ascertained. For a Pearson coefficient the formula is as follows:

$$\text{The mean square error of the coefficient} = \frac{1 - r^2}{\sqrt{n\,(1 + r^2)}};$$

its probable error is .6745 times the mean square error.

In the case of the two abilities measured in the 48 twelve-year-old girls in the sixth grade, the coefficient of correlation is + 47.7 per cent. That is any degree of the one ability implies in its possessor about half as much of the other ability. The reliability of the .477 is as follows: The chances are a bit over 2 to 1 that the absolutely exact relationship is between .376 and .578, about 21 to 1 that it is between .275 and .679.

One has to hunt a long while to find any necessary relationships. It might, for instance, seem that remembering numbers and remembering words were alike examples of verbal memory, and that any degree of proficiency in one would always imply an equal degree of proficiency in the other. But in fact the correlation is slight and variable. To take a still more emphatic case the function of adding 5 7 4 and that of adding 4 5 7 seem necessarily related, but one may improve the time for the first process by practice without improving the other to an equal extent. Almost any, if not any, one thing in the mind may happen in partial independence of almost any, if not of any, other thing. Certainly the mental traits of importance to education, such as efficiency in earning a living, success in school studies, professional skill, scientific insight of various forms and the other moral and intellectual virtues and vices, may appear with all sorts of mental accompaniments.

It has been common in psychological and educational literature to presuppose that the functions which we group under the same name, *e. g.,* attentiveness, somehow implied each other, that, for instance, a high status in attentiveness to school work was closely related to a high status in attentiveness to social duties, business pursuits, mechanical appliances and all the other facts of the individual's experience. Our rough and ready descriptive words, such as accuracy, thoroughness, reasoning power and concentration, have been used as if the quality must be present in approximately equal amount in all the different spheres of mental activity. The notion of any special mental act, *e. g.,* the discrimination of 100 millimeters from 104, has apparently been that some general faculty or function, discrimination, was the main component, the special circumstances of that particular act being very minor accessories. Thus all the different acts in the case of discrimination would be very closely related through the presence in them all of this same mental component.

In fact the relationships are most noticeable by their absence or slight degree. The striking thing is the comparative independence of different mental functions even where to the abstract psychological thinker they have seemed nearly identical. There are no few elemental faculties or powers which pervade each a

great number of mental traits so as to relate them closely together.

For instance the correlation in adults between (1) memory for figures and (2) memory for unrelated words (memory being used to mean the power to keep a list in mind after once hearing it long enough to write it down) is only .61 (mean square error .09); the correlation in pupils of the highest grammar grade between (1) quickness in thinking of the opposites of words and of the letters preceding given letters of the alphabet and (2) quickness in thinking of the sums of figures is only .30 (.05); the correlation in pupils of the same school grade and year of age between efficiency in perceiving capital A's and efficiency in perceiving words containing a and t is only .51 (.02). Yet the first pair of tests would commonly be used indiscriminately as tests of 'memory,' the second pair as tests of 'association' and the third pair as tests of 'perception,' upon the supposition that the two members of each pair were practically identical traits.

A table of the known degrees of relationship will be given later. It will confirm the statement that the mind must be regarded not as a functional unit nor even as a collection of a few general faculties which work irrespective of particular material, but rather as a multitude of functions each of which is related closely to only a few of its fellows, to others with greater and greater degrees of remoteness and to many to so slight a degree as eludes measurement.

The science of education should at once rid itself of its conception of the mind as a sort of machine, different parts of which sense, perceive, discriminate, imagine, remember, conceive, associate, reason about, desire, choose, form habits, attend to. Such a conception was adapted to the uses of writers of books on general method and arguments for formal discipline and barren descriptive psychologies, but such a mind nowhere exists. There is no power of sense discrimination to be delicate or coarse, no capacity for uniformly feeling accurately the physical stimuli of the outside world. There are only the connections between separate sense stimuli and our separate sensations and judgments thereof, some resulting in delicate judgments of difference, some resulting in coarse. There is no memory to hold in a uniformly tight or loose grip the experiences of the past. There are only

the particular connections between particular mental events and others, sometimes resulting in great surety of revival, sometimes in little. And so on through the list. Good reasoning power is but a general name for a host of particular capacities and incapacities, the general average of which seems to the namer to be above the general average in other individuals. Modern psychology has sloughed off the faculty psychology in its descriptions and analyses of mental life, but unfortunately reverts customarily to it when dealing with dynamic or functional relationships.

But it is just in the questions of mental dynamics and of the relationships of mental traits that we need to bear in mind the singularity and relative independence of every mental process, the thoroughgoing specialization of the mind. The mind is really but the sum total of an individual's feelings and acts, of the connections between outside events and his responses thereto, and of the possibilities of having such feelings, acts and connections. It is only for convenience that we call one man more learned than another instead of giving concrete lists of the information possessed by each and striking averages from all the particulars; that we call one man more rational than another instead of comparing two series of rational performances. In any one field the comparison may give a result widely different from the general average. So also with activity, concentration, or any other of the general names for groups of mental traits.

This view is in harmony with what we know about the structure and mode of action of the nervous system. The nervous system is a multitude of connections between particular happenings in the sense organs and other particular events in the muscles. It has developed in the race as a means of fitting acts to circumstances in concrete particular ways. No one can imagine any cell action in it which should be the parallel of reasoning apart from some particular fact reasoned. It is structurally a collection of protoplasmic bonds between different parts of the body. These function by conducting particular impulses from one place to another place. There seems to be no structural arrangement by which the changes wrought by practice in one set of nerve cells could infect other cells with a similar quality.

It follows that an individual's status in any one function need

not be symptomatic of his status in others. We cannot infer arithmetical abilities as a whole from ability in addition; nor high school work as a whole from work in Latin; nor success in geography from success in English. We can only make such statements as: "A scholar who is marked x above or below the average in Latin will tend to attain a general scholarship mark of $.50x$ above or below the average." "One who is marked x above or below the average in English will tend to attain $.43x$ above or below the average in geography." If the human mind worked in a simple fashion, if we could divide its actions into a few classes and find the efficiency of all the particular acts in any one class identical, we could by a few measurements estimate an individual's make up and know what to expect of him, how to treat him, in what class to put him, whether or not to promote him, etc. The functional complexity of human mental life denies us this easy road to correct educational treatment. To estimate truly the general status of any individual is a long task requiring the separate estimation of his status in traits numerous and well chosen enough to represent all his acts and capacities. Any simple set of tests of mental condition is bound to be inaccurate. The majority of those in actual use in educational practice are inadequate. College entrance examinations, for instance, if considered as an accurate measure of the mental traits necessary to secure a boy profit from a college course, are absurd.

TABLE III.

TABLE OF CORRELATION COEFFICIENTS.

E stands for efficiency, Q for quickness, A for accuracy, app. for approximately. The first column of figures gives the number of cases studied; the second the coefficients of correlation.

In the case of those tests the nature of which is not clear from the name used, brief descriptions are given in Appendix I.

Tests of College Freshmen.	*Men.*	
E Memory of figures (auditory) with		.29 or .39
E Memory of figures (visual)	144	(according to method of scoring).
E Memory of passage (auditory) with		
E Memory of figures (auditory)	94	.05 or .04
E Memory of figures (auditory) with		
E Memory of length of line	91	Apparently 0
E Memory of figures (visual) with		

E Memory of length of line	91	Apparently 0
E Memory of passage (auditory) with E Memory of length of line	91	—.07
E Memory of passage (auditory) with Q Naming colors	93	.03
E Class Standing with Q Reaction time	227	—.02
E Class Standing with Q A test	242	—.09
E Class Standing with Q Association	160	.08
E Class Standing with Q Naming colors	112	.02
E Class Standing with E Memory of passage (auditory)	86	.19
E Class Standing with E Memory of figures (auditory)	121	.16
E Class Standing with any of the other tests	No likelihood of any correlation appeared from a rough examination of the data.	
E Latin with E Memory of passage (auditory)	90	.22
E Mathematics with E Memory of passage (auditory)	90	.11
Q Reaction time with E Memory of passage (auditory)	96	.12
Q Reaction time with E Memory of figures (auditory)	112	.17
Q Reaction time with E Memory of figures (visual)	104	.06
Q Reaction time with A Perception of pitch	100	.01
Q Reaction time with Q A test	252	—.05
Q Reaction time with Q Naming colors	118	.15
Q Reaction time with Q Association	153	.08
Q Reaction time with Q Movement	90	.14
Q Naming colors with Q A test	159	.21
Q Naming colors with Q Movement	97	.19
A Drawing a 10-in. line with A in bisecting it	123	.38
A Drawing a 10-in. line with A in bisecting an angle	123	0
A Bisecting a line with A in bisecting an angle	123	0

A Dot test, A Perception of weight, A Perception of time interval, A Following a rhythm, A A test,	with each other or with A drawing a line, A bisecting it or A bisecting an angle.	All combinations give no correlation.

Tests of Highest Grammar Grade Pupils. Boys and Girls Together.

1.	E Average of easy opposites, hard opposites and alphabet tests with E r-e test	160	0 or slight

2.	E Average of easy opposites, hard opposites and alphabet tests with E addition	160	.30
3.	E Average of easy opposites, hard opposites and alphabet tests with E misspelled word test.	160	.35 (app.)
4.	E Addition with E r-e test	160	0 or slight
5.	E Addition with E misspelled word test	160	.35 (app.)
6.	E r-e test with E misspelled word test	160	0 or slight
7.	E Easy opposites with E hard opposites	160	.28 (app.)
8.	E Easy opposites with E alphabet	160	.36
9.	E Hard opposites with E alphabet	160	.25 (app.)

For quickness in the above tests the coefficients are (following the above order) 0 or slight, 30, 10 (app.), 0 or slight, 10 (app.), 0 or slight, 34 (app.), 27, 15 (app.).

For accuracy the coefficients for 1, 6, 7, 8 and 9 are 0 or slight, 15 (app.), 15 (app.), 30 (app.), and 10 (app.).

Tests of Adults.

Relationships of mental traits in from 33 to 40 adults of very wide differences not only in capacity but also in training, the latter being such as to increase differences due to capacity and so add to adventitious correlation. All these coefficients are approximations.

Delicacy of sense discrimination	with verbal memory with logical " with controlled thinking with perception	0 or slight

Delicacy of discrimination of length with that for weight	.20
length with that for pressure	.20
weight with that for pressure	.30
Desultory memory with logical memory	.60
Auditory memory (desultory) with visual memory (desultory)	.20
Auditory memory (logical) with visual memory (logical)	.90
Memory of forms with memory of words	.50
Memory of forms with memory of numbers	.50
Logical memory with controlled thinking	.75
Perception tests; interrelations. (A, letter combinations in English words, letter combinations in Latin words, letter combinations in German words, geometrical forms, parts of speech, misspelled words)	From .20 to .75
Controlled thinking tests; interrelations. Alphabet, easy opposites, hard opposites, genus-species, part-whole, addition, multiplication, fractions, defining differences between words)	From .20 to .75
Rapidity of automatic movements with rapidity of accurate controlled movement. Rate of reading with rate of writing	.70

Quickness in mental tests with accuracy in mental tests.	In general the quickest and slowest are both more accurate than those of mediocre speed.

Exact coefficients were obtained for the following relationships:
N = from 33 to 40.

General efficiency in desultory memory with general efficiency in controlled thinking with word relationships	.52
General efficiency in desultory memory with general efficiency in perception tests	.59
General efficiency in controlled thinking with word relationships with general efficiency in perception tests	.41
Perception of A's and letter combinations with perception of misspelled words and parts of speech	.56
Memory of numbers (auditory) with memory of unrelated words (auditory)	.61
Memory of numbers (auditory) with memory of numbers (visual)	.07
Memory of numbers (auditory) with memory of words (visual)	.30

Tests of Children 10–15.

Relationships of the abilities in children of the same school grade and same year of age and same sex.

	N	*r*
Memory of related words with memory of unrelated words	200	.18
Efficiency A test with efficiency a-t test	800	.52

(Boys 534, girls 500.)

The relationships in the case of college freshmen are all due to Dr. Clark Wissler's "The Correlation of Mental and Physical Tests." Monograph Supplement to the *Psychological Review*, No. 16. A number of the others are quoted from "Correlations in the Perceptive and Associative Processes," by Aikins and Thorndike, *Psychological Review*, Vol. IX., pp. 374–382.

The Relationships of School Abilities.

Educational literature is full of expressions of opinion about the relationships of the abilities involved in the study of the school subjects. For instance the ability involved in the study of one language is thus regarded as closely allied to the abilities involved in the study of other languages, less closely allied to the abilities involved in the study of history and still less closely to those involved in the study of mathematics and science. In colleges economics and history are grouped together in programs and in the personalities of the instructors as if they demanded the same mental abilities. The formal arrangement of studies in groups and the informal advice given to students as to their choices of subjects depend in part, of course, upon opinions as to the practical usefulness of certain combinations of subjects; but in part also upon our opinions as to the kinships of the mental abilities involved. As the elective system absorbs high school programs the

importance of making our opinions accurate increases. Besides this definite need of precise knowledge of the relationships between linguistic, scientific, mathematical and other abilities, we may expect that the nature of these abilities themselves will be clearer when we have ascertained their interrelations.

The mental traits involved in the pursuit of a school study are always complex and vary with the different aspects of the study and the different methods of teaching used. For instance physical geography taught as a science demands different capacities from commercial geography taught as it commonly is. Formal grammar, theme writing, the history of literature and æsthetic appreciation may all be called 'English,' but they depend on capacities that have little in common. For a psychologically adequate study of the abilities involved in school work we should have to analyze the different studies down to elements that were in each case homogeneous and find the relations amongst them. Such a study would, I may add, at once show what a variety of different mental operations go by the name arithmetic or by the name grammar.

The more immediately pressing question and one more easily answered neglects the heterogeneous nature of a school subject and asks simply: "Taking the subjects as they stand, how are the abilities they severally require related? How far does a person's station in one subject determine his station in any other?"

Dr. Clark Wissler* measured the relationships between the abilities in several of the college studies as taught to undergraduates at Columbia University, using as measures the regular marks. His results are as follows. The figures in parentheses give the number of cases studied:

	Latin.	Rhetoric.	German.
Mathematics	.58 (228)	.51 (222)	.52 (115)
Rhetoric	.55 (223)		
French	.60 (130)	.30 (122)	
German	.61 (129)	.61 (132)	
Greek	.75 (121)		

Mr. W. P. Burris,† again using the teachers' marks as the measure of ability, found the following relationships for high

* 'The Correlation of Mental and Physical Tests.'

† Columbia Contributions to Education, Vol. XI., No. 2, p. 26 [132].

school subjects, as taught in 19 representative high schools, using nearly 1,000 individuals.

	English.	Latin.	Mathematics.	History.	Geometry.
Latin	.48				
Mathematics	.39	.40			
History	.40	.43	.33		
Science	.41	.44	.41	.40	
Algebra					.45

Mr. S. C. Parker, in a study* of the marks of 245 first year high school students, all from the same year's class of the same school, found the relationships, the abilities being measured by the teachers' marks, to be those given in table IV.

TABLE IV.

	English.	History.	Science.	Algebra.	Drawing.	German.	French.	Latin.
English		.62	.58	.55	.15	.65	.49	.62
	.62		.56	.38	.10	.49	.58	.43
History	*245*							
	.022							
	.58	.56		.40	.33	.62	.48	.54
Science	*212*	*212*						
	.026	*.031*						
	.55	.38	.40		.20	.52	.68	.54
Algebra	*243*	*243*	*211*					
	.025	*.034*	*.036*					
	.15	.10	.33	.20		.06	.30	.01
Drawing	*243*	*243*	*211*	*242*				
	.042	*.042*	*.039*	*.041*				
	.65	.49	.62	.52	.06		.33	.38
German	*109*	*109*	*84*	*109*	*109*			
	.031	*.044*	*.038*	*.042*	*.064*			
	.49	.58	.48	.68	.30	.33		
French	*75*	*75*	*75*	*74*	*74*	*29*		
	.053	*.044*	*.054*	*.035*	*.068*	*.096*		
	.62	.43	.54	.54	.01	.38		
Latin	*58*	*58*	*25*	*58*	*58*	*33*		
	.046	*.066*	*.085*	*.055*	*.088*	*.094*		
Av. (without Drawing).	.585	.51	.53	.511	.164	.498	.512	.502

Upper figure = coefficient of correlation.
Middle " = no. of cases.
Lower " = P. E. of $r = \frac{0.6745\,(1-r^2)}{\sqrt{n\,(1+r^2)}}$.

That is, the chances are 1 to 1 that the coefficient obtained from an infinite number of cases would not differ from the upper figure by more than the lower figure.

* As yet unpublished.

AVERAGE OF INTERRELATIONS OF FOLLOWING SUBJECTS.

Parker.		Burris.	
English.	.59	Latin.	.43
Latin.	.53	English.	.42
History.	.49	Science.	.41
Science.	.46	History.	.39
Mathematics.	.46	Mathematics.	.38

Brinckerhoff, Morris and Thorndike,* using the regents' marks given to students all taught in the same high school, found the following coefficients:

	Latin.	English.	Mathematics.	Science.	History.	German.
Latin.....						
English.....	.50 .07					
Mathematics	.31 .10	.09 .09				
Science.....	.35 .13	.26 .09	.07 .11			
History.....	.44 .09	.41 .07	.26 .08	.61 .07		
German.....	.48 .11	.30 .10	.48 .08	.57 .09	.42 .10	
Drawing....	.40 .10	.20 .10	.02 .11	.30 .10	.16 .10	

Mr. A. G. Smith,† using teachers' marks as the measure of ability, found the following relationship for grammar school subjects as taught in the New York City schools during the last four years of the school course. The correlation coefficients were calculated from the marks in English, Mathematics, Geography and Drawing of 739 boys and 786 girls.

	Boys.	Girls.	Average.
English and Mathematics	.36	.43	.395
" " Geography	.49	.38	.435
" " Drawing	.17	.14	.155
Mathematics and Geography	.42	.30	.36
" " Drawing	.16	.12	.14
Geography and Drawing	.14	.11	.125

Correlation coefficients between arithmetic and geography were also calculated from objective tests in the two subjects given to 80 boys and 80 girls in the fourth grade. The results were:

Boys.	Girls.
Grade A .23	Grade A .28
Grade B .43	Grade B .57
Together .33	Together .43

For our purpose the most striking thing about these figures is their small amount. It is safe to say that in a grammar or high

* Columbia Contributions to Education, Vol. XI., No. 2, p. 30 [136].

† *Ibid.*, pp. 13 and 14 [119–120].

school student a deviation from the average ability in any one subject implies by and large a deviation in any other not more than half as great. The most talented scholar in one field will be less than half as talented in any other. The most hopeless scholar in one field will in another be not so very far below mediocrity. The discovery of the exact amount of these relationships thus disposes finally of the opinion that brightness is brightness and that those who possess it may use it equally well in any field, and reemphasizes the existence of special aptitudes for special school studies. It also emphasizes the folly of using any one study as a basis of grading or promoting, and the special folly of so using arithmetic. English is obviously better.

Another impressive characteristic of the figures is the closer correlation of abilities in boys than in girls in the grammar grades. Its explanation is difficult. It may be a real difference of mental organization. If so it would show that males have for ages been more rigidly selected for intellectual capacity than have females. It may be due to the existence in boys of a stronger ambition to reach such and such a grade in all subjects. It may be due to more accurate grading by the four teachers who marked the boys than by the four teachers who marked the girls.

Finally the figures show clearly that the different school subjects have different degrees of kinship. We might say that geography was a sister to English and drawing only a cousin. To make such comparisons in much detail, however, we need correlation coefficients obtained from a wider range of subjects and by more accurate methods. The kinships, so far as measured in these first studies in the field, do not agree at all well with those proclaimed by educational writers. Science, for instance, is here closer to Latin than to mathematics and closer to English than is history. Algebra and geometry are hardly more closely related than mathematical and non-mathematical subjects. From the incomplete study of regents' examination marks and direct tests, I am convinced that the common talk about the affinities of the school subjects is largely guesswork.

A few pages back attention was called to the diverse capacities required by a single school subject. As proof and illustration of the statement there made I will quote from a study made by Mr.

W. A. Fox and myself* of the relationships amongst the abilities involved in addition, multiplication, easy fractions, harder fractions and problems. For high school girls the coefficients were as follows:

1. Addition with Multiplication	.75	.05
2. Addition with Fractions 2	.44	.12
3. Addition with Fractions 1	.19	.19
4. Addition and Multiplication combined with Fractions 1 and 2 combined	.46	.09
5. Addition and Multiplication combined with Problems A and B combined	.55	.08
6. Fractions 1 and 2 combined with Problems A and B combined	.44	.12
7. Addition and Multiplication combined with Fractions 1 and 2 and Problems A and B, all four combined	.54	.08
8. Fractions 1 with Fractions 2	.20	.17
9. Fractions 1 with Rational Computation	.58	.10
10. Fractions 2 with Rational Computation	.57	.09

The figure in the second column gives a measure of the unreliability of the coefficient due to the small number of cases studied. Thus the first line should read, "A relationship of 75 per cent., and the chances are 2 to 1 that if an infinite number of cases had been studied the coefficient then found would not vary from .75 by more than .05, would be, that is, between .70 and .80."

Ability in arithmetic is thus but an abstract name for a number of partially independent abilities. Courses of study in that subject should therefore allow for special capacities for its different phases; and wise teachers will bear in mind that they are teaching not arithmetic to good and bad arithmeticians, but addition, subtraction, multiplication, fractions, problems—computation, manipulation and applied arithmetic—to children whose capacities for these several lines of work are in each case a separate problem. It should be noted also in Burris's table that the coefficient for algebra and geometry is not much higher than that for a mathematical with a non-mathematical subject.

The facts given in this chapter should not only prove the general propositions (1) that knowledge of mental relations is productive of insight into mental life and educational work, and (2) that the mind is a host of highly particularized and independent abilities; they should also demonstrate the opportunity, need and utility of researches in this field. In every section of mental life, in every section of school work, there is an easy chance to measure mental relationships.

* Columbia University Contributions to Education, Vol. XI., pp. 138–143.

CHAPTER V.

ORIGINAL AND ACQUIRED TRAITS.

WHAT a human being becomes in life depends upon what is born in him and what happens to him. What is born in him again depends upon the constitution of the germ and ovum which were his first beginning and upon what happened to the ovum after fertilization, but before birth. We have no common word to designate characteristics due to the constitution of the fertilized ovum which is a human life at its outset. Let us call them *original* qualities or traits or capacities. The words *antenatal* and *postnatal* have been used to distinguish the influences which alter man's nature before birth from those acting thereafter. Since we shall be little concerned with the antenatal acquisitions, I shall use the words environment, nurture, experience or acquisitions to refer to the events after birth.

A human being is then the sum of an original nature acted on by antenatal influences and the later environment.

The first problem of educational science concerns the relative shares of these agencies in determining human thought and conduct. Are there perhaps mental traits which a given environment can produce in any living animal, be it a protozoon or a mammal, a butterfly or a man? Are there, at all events, mental traits which the environment can produce with equal facility in any one of the thousands of children who will enter a city's schools this fall? Are there differences in original nature which will make the same environment produce from one a biologist and from another a chemist? In general how far does original nature prepare for a man's career; how far, on the other hand, is it an indifferent culture medium for the circumstances of life?

This must not be confused with another question, that of how far original nature limits absolutely an individual's total mental growth. Original nature might make the same environment produce from one a biologist and from another a chemist and still not prevent two different environments from making the first a chem-

ist and the second a biologist or leaving both wild savages. The environment may always work to increase or diminish original differences, though how far it may do so is a question. But that environment can alter original natures and mask their intrinsic qualities gives no reason to deny the existence of these qualities. Their existence, their extent and their degree of specialization can be discovered only by a comparison of individuals subjected to the same environment.

One special aspect of the general problem of the extent and degree of specialization of original nature that appears worthy of note in human affairs is the question of how far in human beings particular talents are original. Is a man from the beginning organized to be a novelist or only to be a writer of fiction or only to be an artist of some sort or perhaps even only to be a man of ability? It is a plausible statement that our inner natures are organized only in rough outlines, that the currents of mental activity are fixed in their general direction but left to take what particular channels circumstances may decide. But this or any opposite statement must be put in exact terms of how much, how far, in what cases, to be theoretically satisfying or practically useful. The facts needed to settle these questions could be obtained and measured, though not easily. But they have not been.

If we could submit a sufficient number of children to identical environmental training in some particular, the individual differences which they manifested in spite of the identity in training would serve as a partial measure of the action of original nature plus antenatal acquisitions.* If we could be sure that on the par-

* Antenatal conditions are evidently indirectly influential upon our mental make-up. A mental as well as a physical life may be brought to a sudden end by disease or deformity appearing in utero. It may by similar fate be permanently burdened. The burden may even bear more heavily upon the nervous system, and so upon mental faculty, than upon the other bodily organs. And there might well be a direct influence through the mother's blood which would infect the child with her mental qualities so far as such were due to enzymes or toxins in her blood. There might even be some mysterious bonds by which her mental life might, aside from this known channel of influence, form the child into her likeness. The last case seems highly improbable and the preceding probability is only a matter of conjecture. Nothing is known with quantitative precision concerning the influence of antenatal conditions upon mental traits.

ticular trait in question antenatal influences acted alike in all the cases, we should have a partial measure of the contribution of original nature alone. The action of original nature would then be to produce the amount of the trait by which the extremes of the individuals differed plus an unknown constant. The action of differences of original nature, which is the really important fact, would be to produce all the differences found. Experiments approximating to this ideal type could be made in orphan asylums where the environment was uniform for all. None have yet been made. If we could find children identical in original nature and antenatal influence and observe the results where the environment for some differed from that working upon others, we could have a partial measure of the amount of influence of the environment and a complete measure of the difference in action of differences in the environment, which again is the really important fact. Such data might be furnished by a study of identical twins, and a rough attempt at such a study has been made by Francis Galton.* Unfortunately no one has as yet repeated it.

One might try to argue from the differences found amongst people in general by choosing cases where the environmental action could be allowed for or by correlating amounts of difference in the environmental action with amounts of difference in the mental traits, but the problem thus attacked becomes very intricate. Fairly exact evidence proving that original nature is an active force in determining a man's thoughts and acts, though not measuring its amount, will appear when we consider the facts of family resemblance. These facts will also answer in part the question as to the specialization of original nature, for it must be at least as specialized as is inheritance.

From Galton's article, as the best and indeed the only quantitative study of the potency of original nature, I shall quote at some length. Galton studied twins who were closely similar in infancy but whose environments differed and twins who were in infancy notably unlike but whose environments were in all essential features identical. The persistence of similarities in

* "History of Twins," in "Inquiries into Human Faculty," London, 1883; reprinted in the Teachers College Record, Vol. II., No. 3. The former volume is out of print and is rare.

the former case and of differences in the latter gives a measure of the influence of original nature.

This evidence in the first case consists of illustrations of identical mental habits, tastes, associations of ideas and susceptibilities to mental diseases. The cases of unlikeness seem to him to be due to such alterations in the amount of energy as could be caused by illness or lowered nutrition rather than to fundamental qualities of mind.

The evidence in the case of the twenty pairs in the second group shows no exceptions to the rule that no weakening of inborn differences by similarities of nurture is observable. The following are representative parental observations:

1. One parent says: "They have had *exactly the same nurture* from their birth up to the present time; they are both perfectly healthy and strong, yet they are otherwise as dissimilar as two boys could be, physically, mentally, and in their emotional nature."

2. "I can answer most decidedly that the twins have been perfectly dissimilar in character, habits, and likeness from the moment of their birth to the present time, though they were nursed by the same woman, went to school together, and were never separated till the age of fifteen."

3. "They have never been separated, never the least differently treated in food, clothing, or education; both teethed at the same time, both had measles, whooping-cough, and scarlatina at the same time, and neither had any other serious illness. Both are and have been exceedingly healthy and have good abilities, yet they differ as much from each other in mental cast as any of my family differ from another."

4. "Very dissimilar in body and mind; the one is quite retiring and slow but sure; good-tempered, but disposed to be sulky when provoked;—the other is quick, vivacious, forward, acquiring easily and forgetting soon; quick-tempered and choleric, but quickly forgetting and forgiving. They have been educated together and never separated."

5. "They were never alike either in body or mind and their dissimilarity increases daily. The external influences have been identical; they have never been separated."

6. "The two sisters are very different in ability and disposition. The one is retiring but firm and determined; she has no taste for music or drawing. The other is of an active, excitable temperament; she displays an unusual amount of quickness and talent, and is passionately fond of music and drawing. From infancy, they have been rarely separated even at school, and as children visiting their friends, they always went together.'

7. "They have been treated exactly alike; both were brought up by hand; they have been under the same nurse and governess from their birth, and they are very fond of each other. Their increasing dissimilarity must be ascribed to a natural difference of mind and character, as there has been nothing in their treatment to account for it."

8. "They are as different as possible. (A minute and unsparing analysis of the characters of the two twins is given by their father, most instructive to read, but impossible to publish without the certainty of wounding the feelings of one of the twins, if these pages should chance to fall under his eyes.) They were brought up entirely by hand, that is, on cow's milk, and treated by one nurse in precisely the same manner."

9. "The home-training and influence were precisely the same, and therefore I consider the dissimilarity to be accounted for almost entirely by innate disposition and by causes over which we have no control."

10. "This case is, I should think, somewhat remarkable for dissimilarity in physique as well as for strong contrast in character. They have been unlike in body and mind throughout their lives. Both were reared in a country house, and both were at the same schools till *aet.* 16."

The two lines of evidence taken together justify, in Galton's opinion, the following general statements:

"We may, therefore, broadly conclude that the only circumstance, within the range of those by which persons of similar conditions of life are affected, that is capable of producing a marked effect on the character of adults, is illness or some accident that causes physical infirmity. . . . The impression that all this leaves on the mind is one of some wonder whether nurture can do anything at all, beyond giving instruction and professional training. There is no escape from the conclusion that nature prevails enormously over nurture when the differences of nurture do not exceed what is commonly to be found among persons of the same rank of society and in the same country."

Some measurements of the perceptive and associative powers of pairs of twins which I have been able to make seem to show that the preeminence of inborn nature which Galton finds in the fundamental traits of character does not hold good of more specialized habits and capacities. My measurements are not as yet adequate for a full conclusion; but it is extremely unlikely that they will show correlations between identical twins of more than .70.

The importance to educational theory of a recognition of the fact of original nature and of exact knowledge of its relative share in determining life's progress is obvious. It is wasteful to attempt to create and folly to pretend to create capacities and interests which are assured or denied to an individual before he is born. The environment acts for the most part not as a creative force but as a stimulating and selective force. We can so arrange the circumstances of nurture as to reduce many undesirable activities by giving them little occasion for appearance, and to increase the desirable ones by ensuring them an adequate

stimulus. We can, by the results we artificially attach to wisdom, energy or sympathy, select them for continuance in individual lives. But the results of our endeavors will forever be limited as a whole by the slow progress of change in the original nature of the race, and in different individuals by inborn talents and defects.

Thinkers about the organized educational work of church, library and school need especially to remember three facts.

First.—For the more primitive and fundamental traits in human nature such as energy, capability, persistence, leadership, sympathy and nobility the whole world affords the stimulus, a stimulus that is present well-nigh everywhere. If a man's original nature will not respond to the need of these qualities and the rewards always ready for them it is vain to expect much from the paltry exercises of the school room.

Second.—The channels in which human energy shall proceed, the specific intellectual and moral activities that shall profit by human capacities, are less determined by inborn traits. The schools should invest in profitable enterprises the capital nature provides. We can not create intellect, but we can prevent such a lamentable waste of it as was caused by scholasticism. We can not double the fund of human sympathy, but we can keep it clear of sentimental charity.

Third.—The important moral traits seem to be matters of the direction of capacities and the creation of desires and aversions by environment to a much greater extent than are the important qualities of intellect and efficiency. Over them then education has greater sway, though school education because of the peculiar narrowness of the life of the school room has so far done little for any save the semi-intellectual virtues.

The one thing that educational theorists of to-day seem to place as the foremost duty of the schools—the development of powers and capacities—is the one thing that the schools or any other educational forces can do least.

It is from time to time complained that a doctrine which refers mental traits largely to original make-up, and consequently to ancestry, discourages the ambitions of the well-intentioned and relieves the world's failures from merited contempt. But every

one is agreed that a man's free will works only within limits, and it will not much matter for our practical attitude whether those limits are somewhat contracted. If the question is between original nature and the circumstances of nurture it is rather more encouraging to believe that success will depend on inherent qualities than to refer it entirely to advantages possessed during life, and contempt is merited more by him who has failed through being the inferior person than by the one who has failed simply from bad luck. Whether or not it is merited in either of the two cases we shall decide in view of our general notions about merit and blame, not of our psychological theories of the causes of conduct.

CHAPTER VI.

THE INHERITANCE OF MENTAL TRAITS.

No intelligent person can doubt that our original natures are not a mere matter of chance but are in part determined by the ancestry from which we spring. If the original nature of a dog could by a miracle be given a human birthright and nurture, it would still grow into the body and mind of a dog. And as we have human rather than canine minds because our original natures are the offspring of human beings, so also, we should probably agree, we have the Anglo-Saxon type of minds partly because we spring from Anglo-Saxon ancestry rather than from Australian bushmen. Some of us would feel sure that the original natures of a hundred sons of feeble-minded or insane parents would differ from the original natures of a hundred sons of healthy-minded men and women, though in both cases the race—*i. e.*, the remote ancestry—might be the same.

With sufficient knowledge we could analyze any man's original mental nature into elements due (1) to his being descended from animals rather than plants, (2) to his more immediate descent from vertebrates rather than invertebrates, (3) to his still more immediate descent from mammals rather than reptiles or birds, and (4) from primates rather than rodents, carnivors, etc., and so on with the contributions due to ancestry of the human species, of the European stocks, of the Anglo-Saxon breed, of such and such great-grandparents, grandparents and parents. There would be little dispute about the importance of these elements save in the case of the more immediate ancestry. Here we find the widest range of opinion. This is the more to be regretted because all the social sciences and especially education need as a starting point precise knowledge of the differences in original mental make-up within the human species and of their relationship to immediate ancestry.

Our somewhat extensive study of the facts bearing upon this topic will include the following topics.

1. Methods of measuring similarities of related individuals.
2. Proof that immediate ancestry is a true cause of physical traits.
3. Evidence that the same holds true in at least some mental traits.
4. A review of the measurements of mental inheritance.
5. The general characteristics of mental inheritance.
6. The transmission of acquired mental traits.

A preliminary caution is necessary. To say that a man's original nature depends upon his ancestry does not mean that it is an exact facsimile of any one or any combination of his ancestors. There is no reason to believe that four sons of the same parents and consequently of the same total ancestry will have the same original natures. Indeed we know they will not, save by chance, for twins who have presumably in some cases identical or nearly identical antenatal influences and nurture may vary widely in both physical and mental traits. What ancestry does is to reduce the variability of the offspring and determine the point about which they do vary.

Take for instance the capacity to form intelligent habits or associations amongst sense impressions, ideas and acts. The number of associations between situation and act, the number that is, of things an animal can do in response to the multitude of conditions of life, varies tremendously throughout the animal kingdom. The free swimming protozoa studied by Professor Jennings had in addition to the common physiological functions hardly more than a single habit. The sum of the life of *Paramœcium* is to eat, breathe, digest, form tissues, excrete, reproduce, move along in a steady way, and when passing from certain media into others to stop, back, turn to the aboral side and move along again as before. At the other extreme is a cultivated human being whose toilet, table manners, games, speech, reading, business, etc., involve tens if not hundreds of thousands of associative habits.

If now we take a thousand descendants of human beings and count up the number of associative habits displayed by each we shall of course find a great variability. Some of our thousand human offspring will learn fewer things than some dogs and cats. Some of them may learn many more than any of the

parents from whom they sprang. But on the whole the offspring of human beings will vary about the human average instead of about the general animal average, and the average deviation of the human group will be far less than that of the whole animal kingdom.

To illustrate again, the children of parents who are, say, 3 inches above the mean of the general population in stature will vary not about that general mean but about a point 2 inches above it; and whereas the variability of the general population is 1.7 inches (probable error), the variability of children of the same parents is only 1.0 inches (probable error).*

Immediate ancestry will then, when influential, cause children to deviate from the general average toward the condition of their parents and to vary less among themselves than would the same number of unrelated individuals.

The measurement of the resemblances between brother and brother, parent and child, uncle and nephew, etc., involves precisely the same statistical problem as the measurement of the relationships between mental traits. The difference is that here we measure the resemblance between the stations of two individuals in the same trait, whereas in Chapter IV. we measured the resemblance between the stations of the same individual in two traits. Here the correlation is between individuals, there between mental traits themselves. A Pearson coefficient here measures the general tendency of brother to be like brother or father to be like son in efficiency in the same mental trait, whereas there it measured the general tendency of one mental trait to be like another in efficiency in the same group of individuals. A correlation of 1.00 between brother and brother in mathematical ability would mean that the brothers of a set of men who were $+a$ in that ability would themselves be $+a$, and similarly of course for the brothers of men ranking $-a$ in that ability. .52 correlation would mean that the brothers of men $+a$ and $-a$ will be on the average 52 per cent. of $+a$ and of $-a$ respectively. If we turn the discussion from "the relationship of two traits in the same series of individuals" to "the

* This illustration is based upon the data for stature in Galton's "Natural Inheritance."

relationship of a series of pairs of individuals in the same mental trait," the account of correlation in Chapter IV. will fit perfectly our present purpose.

In some cases hereditary resemblance will be expressed in the less adequate form of a higher probability of a certain condition in those related to individuals of that condition than in people taken at random. This form of expression will be used of the inheritance of deafness and of insanity in families. Exact measures of the reduction of variability due to inheritance are possible by a simple comparison of the variability of the selected class 'children of such and such' with that of the total population.

To avoid the confusion of similarities due to similar home training with those due to similarity in ancestry we should properly measure resemblance in pairs in cases where the training of any one pair is the same as that of any other. This could be done exactly with mental traits in related animals and approximately with brothers and sisters brought up from birth or soon after in asylums. In default of such studies we must choose cases where the environment has little or no influence of a sort to beget family resemblances or get some means of making a proper discount for such influence.

Before describing the similarities of closely related individuals in mental traits I shall present the results of studies in the case of some physical traits which will prove that heredity is a *vera causa,* since in them the causation of the similarities found by similar training is out of the question.

The coefficient of correlation between brothers in the color of the eyes is 52 per cent. (.5169). But parents could not, if they would, exert any environmental influence upon the color of their children's eyes. The fraternal resemblance must be due to the resemblance in ancestry.

In height we find the coefficient of correlation between father and son to be .3, between brother and brother to be .5, in other words a son on the average deviates from the general trend of the population by .3 the amount of his father's deviation, a brother by .5 the amount of his brother's, etc. Now no one can imagine that tall fathers try especially to make their sons tall. Nor will

the class ' men two inches above the average height ' feed their children any more than men one inch above it.

The coefficient of fraternal correlation in the case of the cephalic index (ratio of width to length of head) is .49 (.4861). Here it is utterly incredible that fathers do anything to their children that would tend to produce in them similar indices.

Finally take color of hair. Fraternal correlation is .5452. Here again home influence could not cause one whit of the resemblance.

Immediate ancestry can and does, apart from any other force, cause in whole or in part the abmodality of an individual in the case of stature, cephalic index and eye color. There is no reason to suppose that the brain is less influenced by it than the tissues that cause height, or the shape of the skull bones that causes cephalic index, or the deposits of pigment that cause eye color. Immediate ancestry is thus a probable cause for original mental nature. And when we are in doubt as to a choice between it and the environment as the cause of differences in mental traits of individuals at any age, we must not forget that the influence of the latter is after all largely a matter of speculation, while the influence of ancestry is in physical traits a demonstrated fact.

The Influence of Ancestry on Mental Traits.

1. *Deafness.*

Deafness may be considered a physical trait because it is due to physical causes, but so are all mental traits. The real difference is that we know more about the causes in the one case than in the others. The manifestation and results of deafness are certainly mental traits.

The brother or sister of a person born deaf is found to be deaf in 245 cases out of 1,000, almost one case out of four. We do not know exactly the number of deaf amongst 1,000 brothers and sisters of hearing individuals, but it is certainly less than 1, probably much less. That is, a person of the same ancestry as a congenitally deaf person is at least 245 times (probably many more) as likely to be deaf as a person of the same ancestry as a hearing person. The child of two parents both of whom were

born deaf is at least 259 times * as likely (probably many more) to be deaf as the child of two hearing parents. In this case, as with the physical traits described, there is no reason to impute any efficacy to training. Parents born deaf would take pains to *prevent* deafness in their children.

2. *Ability to learn to spell.*

Mr. E. L. Earle measured the spelling abilities of some 1,000 children in the St. Xavier school in New York by careful tests. As the children in this school commonly enter at a very early age, and as the staff and methods of teaching remain very constant, we have in the case of the 180 pairs of brothers and sisters included in the 1,000 children closely similar school training. Mr. Earle measured the ability of any individual by his deviation from the average for his grade and sex and found the coefficient of correlation between children of the same family to be 51 per cent. That is, any individual is on the average 51 per cent. as much above or below the average for his age and sex as his brother or sister.

Similarities in home training might theoretically account for this, but any one experienced in teaching will hesitate to attribute much efficacy to such similarities. Bad spellers remain bad spellers though their teachers change. Moreover, Dr. J. M. Rice in his exhaustive study of spelling ability† found no relationship between good spelling and any one of the popular methods, nor between poor spelling and foreign parentage. Yet the training of a home where the parents do not read or spell the languages well must be a home of relatively poor training for spelling.

These facts together with those given by Galton prove the existence of mental inheritance. Our questions concerning it are, therefore, vital questions and it becomes our duty to review the measurements of the resemblances of related individuals that have been made.

Measurements of Mental Inheritance.

The first serious study of the inheritance of mental traits was made in the 60's by Francis Galton and reported in 'Hereditary

* Percentages of deaf children, 25.931. E. A. Fay, 'Marriage of the Deaf in America,' p. 49.

† See Chapter VII. for a fuller account of his method and conclusions.

Genius' in 1869. He examined carefully the careers of the relatives of 977 men each of whom would rank as one man in four thousand for eminent intellectual gifts. They had relatives of that degree of eminence as follows: fathers 89, brothers 114, sons 129, all three together 332; grandfathers 52, grandsons 37, uncles 53, nephews 61, all four together 203. The probable numbers of relatives of that degree of eminence for 977 average men are as follows: fathers, brothers, and sons together 1; grandfathers, grandsons, uncles and nephews all together 3. Galton argues that the training due to the possession of eminent relatives can not have been the cause of this superior chance of eminence in the relatives of gifted literary men and artists.

To recapitulate: I have endeavored to show in respect to literary and artistic eminence—

1. That men who are gifted with high abilities—even men of class E—easily rise through all the obstacles caused by inferiority of social rank.

2. Countries where there are fewer hindrances than in England, to a poor man rising in life, produce a much larger proportion of persons of culture, but not of what I call eminent men. [England and America are taken as illustrations.]

3. Men who are largely aided by social advantages are unable to achieve eminence, unless they are endowed with high natural gifts.

Galton demonstrates that the adopted sons of popes do not approach equality in eminence with the real sons of gifted men. He so orders his studies of men eminent in other fields as to leave very slight basis for one who argues that training and opportunity rather than birth caused the eminence attained. Finally Galton's own opinion, that of an eminently fair scientific man based upon an extensive study of individual biographies, may safely be taken with a very slight discount. He says: "I feel convinced that no man can achieve a very high reputation without being gifted with very high abilities."

The historic importance of Galton's 'Hereditary Genius,' the originality and ingenuity of its author and its substantial results should make his book the first to be read by every student of mental inheritance.

In 1889 Galton published his 'Natural Inheritance,' the results of more precise studies * of resemblances amongst related

* These studies were reported in various memoirs from 1871 to 1887.

individuals in stature, eye color, the artistic faculty and diseases. He found the resemblance between parents and their children in the mental trait studied (artistic faculty) to be a little greater than in the case of stature. The essential facts from which this inference is drawn are that in 30 families where both parents were artistic 64 per cent. of the children were so, whereas in 150 families where neither parent was artistic only 21 per cent. of the children were so (page 218). No attempt is made to divide the causation of this resemblance between birth and training.

Professor Karl Pearson, who after Galton is the creator of precise knowledge of hereditary resemblances, has recently widened his studies so as to include mental traits. His investigation of mental resemblances between brothers reported to the Royal Society late in 1901 (*Nature*, Vol. 65, p. 118) is perhaps the most valuable research in educational psychology yet made.

From 800 to 1,000 pairs of brothers were measured by their teachers with respect to the following traits: intelligence, vivacity, conscientiousness, popularity, temper, self-consciousness, shyness. In intelligence the measure was a grade from one to six according to ability; in temper from one to three. In the other traits the individual was put into an upper or a lower class. The coefficients of fraternal correlation were found to be:

Intelligence	.4559
Vivacity	.4702
Conscientiousness	.5929
Popularity	.5044
Temper	.5068
Self-consciousness	.5915
Shyness	.5281
The average of all is	.5214

The nature of all but the first of these traits at once suggests that home environment rather than original nature is the cause of the similarities found. So also does the fact that the resemblance is slightest in the first trait. But such a conclusion would be rash. Professor Pearson finds the fraternal correlations of these same individuals in hair color and cephalic index to be .5452 and .4861 (averaging .5157); and of another large set of brothers in stature, forearm length, span of arms and eye color

to be respectively .5107, .4912, .5494 and .5169 (averaging .5171). The resemblances in these physical traits can not be due at all to the fact that brothers have the same home environment, yet the resemblances here are as great as in mental traits. So argues Professor Pearson, and we must I think agree to prefer a real to a conjectured cause. To believe that the fraternal resemblances in mental traits are due to environmental influences which work to such an extent as exactly to counterfeit in amount the force of inheritance, is hardly possible to a critical mind. To believe that the influence of inheritance in causing these resemblances was supplemented by the influence of environment also requires us to postulate the improbability that the two forces together should in mental traits exactly equal the force of inheritance in the case of physical traits. Galton has suggested that home training may appear much more efficacious than it is because children by birth resemble their parents and so readily follow their guidance and example, while other people's children might be but little susceptible to the same influences.

A second criticism of Professor Pearson's conclusion might be that the teachers who reported cases of brothers tended to select brothers whose likeness was notable and to grade them alike oftener than the facts warranted. It is true that if you seek information from people without special training in the field of science concerned, the answers obtained are well-nigh sure to be compounds of fact and prejudice, but there is apparently no reason to believe that teachers have any prejudicial belief in fraternal similarity. If in any way in the questions asked the suggestion was made that Professor Pearson was interested in resemblances, this second criticism becomes a serious one.

A third criticism is that teachers' measures of the traits in question are very inaccurate. This is a fact, but a fact which in no wise lessens the proof of fraternal resemblance, as a little thought will make clear. It would only lessen the precision of the results.

Tests of 62 brother-brother and sister-sister pairs of school children 10–14 years old with the opposites test (see appendix) gave a correlation of .20; tests upon 113 similar pairs with the A test gave a correlation of .34; and tests with 107 similar pairs

with the a-t test gave a correlation of .27. Using as a measure the ability shown in the last two tests together, the correlation was .34.* In all these cases the coefficients are too low, in the opposites test much too low. For the children, representing the school population of the five highest grades of the grammar school, included an unfairly large proportion of bright relatives and dull relatives of mediocre children.

In the course of this same study any children rated by their teachers as exceptionally bright or exceptionally dull were so recorded. I find that of the 38 children who were the brothers and sisters of the exceptionally bright children 6 were exceptionally bright and none were exceptionally dull, while of the 36 children who were the brothers and sisters of the exceptionally dull children 2 were exceptionally dull and none exceptionally bright.

I have also calculated the resemblance in the case of 86 pairs of siblings (*i. e.*, children of the same parents) tested for delicacy of discrimination of length. I do not regard the material as very reliable, but it is clear that there is real resemblance and that it is above .30 in amount.

Burris † found the resemblance in high school marks to be as follows:

English	.24	550
Latin	.24	400
Mathematics	.20	554
History	.16	450
Science	.21	350
General Scholarship	.22	554

These coefficients, like my own, are subject to a constant error, due to the fact that a high school population is itself a selected group of more than average ability in academic studies. This error probably makes his coefficients lower than they should really be.

In rate of movement, regardless of the accuracy of the result,

* The reliabilities of these figures are, so far as the number of cases is concerned, such that the chances are even that the true coefficients will not vary from them by more than .08, .05, .06 and .05 respectively.

† 'Columbia Contributions to Education,' Vol. XI., No. 2, p. 22 (128).

Miss Norsworthy* found no resemblance amongst siblings (171 pairs).

General Characteristics.

The only known causes of original nature are ancestral contributions and the normal tendency to vary. If one chooses to believe that chance or miracle assists to make the germs and ova of animals and men what they are, it will be very difficult to demonstrate to him that he is in error, but a wise psychology will prefer to use the habitual hypothesis of biology.

Several important questions arise. The chief question is concerning the ancestral contributions. Do they include the results of the ancestors' acquisitions? Does the child inherit the results of his parents' mental improvement or degeneration during life or is his resemblance to them limited to what they were months before they were born? Is his original nature the result of their total make-up or only of their original natures? The answer to this question will in part decide what improvement of the race we can expect from education and also what particular prophecy we can make concerning the original nature of any individual. The evidence bearing upon this now historic quarrel will be presented in a separate section.

A second question concerns the way in which the several ancestors' contributions combine to form the offspring's nature. The mental conditions of a father and mother might in the case of any trait blend, tending to produce in the offspring a condition half way between their own; or one might contribute certain of his traits in their entirety and the other certain of hers; or the combination of one trait in one and another trait in another might produce in the offspring a third trait radically different from either. In briefer terms inheritance might be blended, alternate or creative. A in one parent plus B in the other might tend to produce $\frac{1}{2}(A + B)$, either A or B, or a new thing C.

In human height, for instance, inheritance is blended; in the coloration of animals it is often alternate; in the case of the combination of two species it is perhaps creative. In human mental traits blended inheritance seems far the most common,

* In an unprinted report.

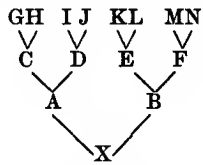
but it is conceivable that, for instance, the children of a superior mathematician and a good speller might be (1) fairly good in both mathematics and spelling or (2) good in either mathematics or spelling or (3) mediocre in mathematics and spelling but good or bad in linguistic work.

The term prepotency, used in discussions of heredity, should not be confused with alternate inheritance. The former means a tendency of some trait in some individual to appear in more of his offspring than chance would warrant in alternate or blended inheritance. Nor should extreme cases of blended inheritance, cases where the normal variability in the proportion of the two parents' shares reaches a maximum, be confused with alternate inheritance. Blended and alternate inheritance can be distinguished by the distribution of the amounts of resemblances.

In the former the amounts of resemblance of children to their two parents taken separately will give a normal distribution; in the latter they will give a distribution compounded equally of two normal distributions. In the former the amounts of resemblance of siblings will give a normal distribution; in the latter they will give a distribution compounded of a species of positive resemblance (due to those cases where the two siblings take after the same parent) and of a species of resemblance or rather lack of it due to the cases where they take after different parents. The mode of the latter will be zero unless resemblance in the trait in question acts as one cause of marriage.

Nothing is known about the frequency of prepotency in mental traits.

A third question concerns the relative contributions of ancestors of different degrees of remoteness. Take for instance the original nature of the individual x whose ancestry is shown in the diagram.



What are the respective shares of *A* and *B*, of *C*, *D*, *E*, *F*, etc., in determining his make-up? There is as yet no exact evidence upon this point in the case of mental traits.

We do know however that the nearer the ancestor the more he contributes, but we do not know just how much more. In the case of physical traits the case is apparently different according as inheritance is blended or alternate. For stature the law formulated by Galton is that the influence of the parents is twice that of the grandparents, and that again twice that of the great-grandparents, etc. For the coat color of Bassett hounds Karl Pearson * finds the different generations back of the parents to be much more equal in potency than this, the chances being that the percentages taking after each ancestral generation will be as follows:

Per cent. taking after	(1) parents	63.256
	(2) grandparents	3.488
	(3) great-grandparents	3.105
	(4)	2.764
	(5)	2.460
	(6)	2.190

Other questions concern the range, amount and degree of specialization of mental inheritance. The data summarized on pages 51 to 57 are too limited to allow any sure statement of the range of mental life over which heredity has influence, or of its general strength. Some mental traits may be little or not at all connected with inheritable qualities. Presumably the influence of heredity will be most marked in traits important for survival and in those that are fundamental in mental life.

In two cases the facts provide us with a means of measuring the specialization of mental inheritance. Burris gives the fraternal resemblance in general scholarship as well as in the separate studies. It is but little greater in the former case (.22 as compared with an average of .21 for the five separate coefficients). It would seem therefore that either the inheritance was specialized for each trait or that the same single trait caused excellence in all studies. But the inter-correlations amongst the studies show the latter alternative to be false. On the other hand the fraternal resemblance in the ability measured by the two different tests of perception taken together was greater than the average of the resemblances found in the two abilities taken separately (.34 *vs.* .305).

* *Proceedings of the Royal Society of London*, Vol. 66, pp. 140–164.

Galton, who had this problem clearly in mind, notes a number of relevant facts, some of which I quote. Concerning the judges of England between 1660 and 1865 he says:

> Do the judges often have sons who succeed in the same career, where success would have been impossible if they had not been gifted with the special qualities of their fathers? . . .
>
> Out of the 286 judges, more than *one in every nine* of them have been either father, son or brother to another judge, and the other high legal relationships have been even more numerous. There cannot, then, remain a doubt but that the peculiar type of ability that is necessary to a judge is often transmitted by descent. ('Hereditary Genius,' pp. 61 and 62.)

Concerning the eminent relatives of eminent statesmen he says:

> Thirdly, the statesman's type of ability is largely transmitted or inherited. It would be tedious to count the instances in favour. Those to the contrary are Disraeli, Sir P. Francis (who was hardly a statesman, but rather a bitter controversialist) and Horner. In all the other 35 or 36 cases in my appendix, one or more statesmen will be found among their eminent relations. In other words, the combination of high intellectual gifts, tact in dealing with men, power of expression in debate, and ability to endure exceedingly hard work, is hereditary. (Ibid., pp. 103 and 104.)

Similar specialization of inheritance is shown to be the case with the relatives of great commanders, literary men, poets and divines. With men of science the fact is much more pronounced, twenty-two out of the twenty-six eminent sons of eminent scientific men having been eminent in science. This extreme specialization of resemblance is in part due, Galton thinks, to training.

> Mendelssohn and Meyerbeer are the only musicians in my list whose eminent kinsmen have achieved their success in other careers than that of music. (Ibid., p. 231.)

The eminent relatives of eminent painters seem to be well-nigh universally gifted in the same special line. In Galton's list all the relatives mentioned are painters save four. These were gifted in sculpture (2), music (1) and embroidery (1).

Of course there is in the case of all of Galton's facts the possibility that home surroundings decided the special direction which genius took, that really original nature is organized only along broad lines. Moreover, it is difficult to see just what in the nervous system could correspond to a specialized original capacity, say to be a judge. Still the latter matter is a question of fact,

and of the former issue Galton's studies make him the best judge. We should note also that it is precisely in the traits the least amenable to environmental influence, such as musical ability, that the specialization of family resemblance is most marked.

Our last question is about the physical basis of mental inheritance. The basis of all the facts of hereditary resemblance is of course the relations not of an adult to adult relatives but of the germs of the one to the germs of the others. All these facts will find their final explanation only in a full account of the influences that act upon the germ plasm and the relation between parental germ plasms and the germs produced thereby. Such a full account is not at hand and even such relevant facts as are known are often incomprehensible by any save technical students of biology. We can, however, hold ourselves in a position to get clear views by never forgetting that children are the direct offspring, not of parents, *but of the germs of those parents.* The qualities of the germs of a man are what we should know in order to prophesy directly the traits of his children. One quality these germs surely possess. They are variable. Discarding syntax and elegance for emphasis, we may say that the germs of a six-foot man include some six-feet germs, some six-feet-one germs, some six-feet-two, some five-feet-eleven, some five-feet-ten, etc. Each human being gives to the future, not himself, but a variable group of germs. This hypothesis of the variability of the germs explains the fact that short parents may have tall sons, gifted parents stupid sons, the same parents different sons. If now we could measure the similarity amongst the germs of the same parent we should have a basis for the similarity amongst related individuals. The amount of difference amongst brothers, for instance, is due to the variability in the germs; the amount of similarity to the correlation in the germs. In one of his most brilliant applications of statistical method Karl Pearson has shown that the correlation between germs from the same ancestor is probably numerically equal to the correlation found in fraternities. The germs may be expected to be in this respect like other undifferentiated like organs and from many samples of such Pearson has calculated coefficients of correlation.

The Transmission of Acquired Mental Traits.

Whether we are by nature* what our parents were by nature alone or what they were by nature plus training may be argued from two points of view. The probability of the latter event may be estimated from our knowledge of the physical relations between parents and offspring or its actual occurrence may be determined from evidence. It is beyond the purpose of this book to present even a summary of such arguments pro and con. Indeed, except for the need of a statement limited to the inheritance of acquired mental traits, it would be unwise to add a new chapter to the voluminous discussions already in print.

Some matters seem fairly sure.

1. Whatever changes occur in the nature of the chromatic substance in the nuclei of the germs and ova of the parents will influence the original nature of the offspring, for the nuclei of the germ and ovum *are* the original nature of the offspring. And nothing else will.

2. The germs and ova are made directly from the germ plasm (ovaries and testes) of the parents, not from their bodies in general. Just as the bone marrow makes blood, or the cells of the neural tube the nervous system, so the germ plasm makes the germs and ova.

3. The cells which are specialized to form the germ plasm, that is to do the work of producing the next generation, are set off and begin their more or less separate careers long before the individual is born.

4. The line of inheritance is thus from germs to germ plasm to germs to germ plasm and so on.

5. The germ plasm is connected with and related to other structures in the body, including those of the central nervous system, in no more intimate way than are the other structures amongst themselves. The nervous system influences the growing germ or ovum as it may influence the cells of the liver or heart or skin.

* It will be observed that antenatal influences from the mother are excluded from the discussion. A mother may, for instance, acquire some diseases and transmit them through the blood, but she transmits them by infecting the growing child, not by altering the quality of its original nature.

6. No known mechanism exists by which such alterations of the nervous structure or of the quality of the nervous tissue as would correspond to changes in human mental traits, might produce in the germs changes fitted themselves to become in the adult form similar structures or qualities to those which caused them.*

7. The acquisition of specific mental traits by an individual seems thus unlikely to modify his germs so as to reproduce the trait acquired. With very general traits such as mental vigor or weakness, health or degeneracy, the case might well be different. Such general mental traits might be correlated with bodily conditions which would include the germ plasm as well as any other parts of the body. The correlation, however, is by no means perfect. As to precise measures of how far acquired conditions of general health involve changes in the germ plasm and of how far such changes influence mental qualities in the offspring, there are none.

The obvious way to settle our question is not by contemplating these inferences from present knowledge of the process of development, but rather by making the crucial experiment of letting animals acquire some mental traits and observing the nature of the offspring. No such experiments of a decisive nature have been made. If for generation after generation mice were offered palatable food always in the shape of yellow cubes smelling of grease and unpalatable food always in the shape of white balls smelling of cheese, were kept in a cage so arranged that on going into a certain alley they always received an electric shock, and were otherwise given a chance to learn certain habits, an observer could measure for generation after generation the quickness of formation of these habits and detect the slighest improvement. Ten or twenty generations would thus give a final answer to an ancient quarrel.

* It should however be said that Professor Jacques Loeb has suggested (*Monist*, Vol. VII., pp. 481–493) that in some cases of instinctive mental traits the organic basis may be the presence of some chemical substance, and that in these cases the change during life in the nature or amount of such substance might directly affect the germs so as to perpetuate the acquisition. This possibility is, so far as human mental traits are concerned, wholly a matter of speculation.

The popular idea of evidence on the question is as follows: "Jones studied mathematics and became a great mathematician. So was his son. His father's studies must have helped to make him so." The retort is of course easy: "Why was Jones No. 1 a great mathematician? Because of his original nature. Why was Jones No. 2? Because his father's original nature made him so." We shall never get on with this question by begging it. The mere fact of family similarity never need imply the inheritance of parental acquisitions.

A more advanced type of argument adduces the growth of some mental trait in the species as a whole. For instance it is said: "How explain the growth of language save by supposing that the constant exercise of the mind in this respect has resulted in ever-increasing facility in offspring until the few shouts and mutterings and wails of primitive man have become the complicated speech of to-day."

The retort is as easy as before: "Language has grown because on the whole those with the most inborn capacity for it lived and begot their like while those with the least inborn capacity died and left few or no heirs to their linguistic poverty." Not the inheritance of acquisitions but the selection of those who could acquire!

The field of animal instincts has been well canvassed by biologists in search of light upon our general question. The gist of their discoveries is: (1) that many instincts are certainly not the result of a summation of acquisitions, *e. g.*, those that appear only once in a lifetime. (2) Most instincts are generalized rather than specific, though most acquired habits are specific rather than generalized. But a specific habit inherited should give a specific instinct. Thus instead of a number of fears of special enemies such as cats, hawks, skunks, etc., chicks have a general alarm at strange and impressive objects. (3) Useless instincts are very slow in being lost unless selection is at work.* Thus chicks swim, though not 1 in 1,000 of their ancestors has done so for thousands of years.

* If acquisitions became inherited of course unused habits would tend to disappear, would, we might say, be disinherited.

It is remarkable that certain evidence from human psychology has failed to receive attention in all these long debates. Human life offers a favored case for transmission of an acquired trait where transmission has clearly failed. The congenitally blind from eye defects do not have visual images of the sun, stars or any other of the permanent objects of the natural world, yet their ancestors for at least hundreds of generations, save in the cases of those lacking in visual images, had such images again and again. If the hourly experiences of hundreds of ancestral generations do not become a part of inborn equipment, we could hardly expect anything to do so.

The burden of evidence is thus against the transmission of acquired traits. Adequate experiments may conceivably reverse some of the conclusions based on existing evidence, but for the present we must deny the mental acquisitions of one generation any considerable share in the original natures of the next. Original nature springs from original nature. Its improvement depends on the elimination of the worse, not on their reformation. It depends on nothing else, unless there be an inherent tendency in human germs to vary in a definite direction, and that a good one. We educate the original nature of the race only by fostering its good elements and encouraging their fertility and by debarring the worse elements from reproduction or by eliminating them outright.

There is a peculiar superstitiousness and prudishness in present-day life which recoils from thinking of death as a benefactor or of fertility as a duty and a crime. A college president can get hundreds of thousands of dollars to teach men various accomplishments, but he would be laughed at if he asked for $10,000 to prevent the most gifted young man in the college from remaining childless until 35. Either from ignorance or from timidity the writers on both education and sociology never add to their perpetual exhortations to petty improvements of social conditions a reference to the *summum bonum,* improvement of that which must be the sole preserver of the good that is and the creator of the better that may be—the original nature of the race.

CHAPTER VII.

THE INFLUENCE OF THE ENVIRONMENT.

The Amount of Influence.

THE questions suggested by the title of this chapter include all those of the mental and moral education of individuals. It would be silly presumption to pretend to answer them all. Precise quantitative answers, to which this book is restricted, can be given to none of them.

Theoretically there is no impossibility. Once we have estimated the original nature of a man or group of men, we have simply to note the mental changes consequent upon this or that change in climate, food, school-training, friendship, sermon, occupation, etc. Practically the complexity of the action of physical and human influences upon intellect and character hampers scientific study and favors guesswork. The environment includes a practical infinitude of different causes; these act differently upon different types of original nature and at different ages and with different cooperating circumstances; in many cases their action is very complex and must be observed over long intervals of time. Indeed it has been common to deny even the possibility of a science of the dynamics of human nature and to remain content with the haphazard opinions of novelists, proverb makers and village wise men.

Moreover it is only by the utmost ingenuity and watchfulness that studies of changes in human nature can be freed from a characteristic fallacy—that of attributing to training facts which are really due to original nature or to selection. For instance, college graduates are found to have a much greater likelihood of being elected to Congress than have non-graduates. Therefore it is said that a college education causes to some extent political success. But it is clear that even before they went to college the group of youth who did go were different from those who did not. Their later election to Congress may as well have been due to the mental traits which they possessed by birth or otherwise and which caused

their inclusion in the class 'boys who go to college' as to any changes produced in them by the college training itself. In other words, that they were the class *selected* by the college is as important a fact as that they were the class trained by it.

Again it is said: "Who can doubt the enormous disciplinary value of the study of Latin and Greek when we see the admirable intellects of the men so trained in the English universities?" But of course in England being born from the class whose children go to the university of itself ensures to an individual uncommon mental ability.

To avoid this confusion of causes which train with those which select is extremely hard. Any class of individuals whom we study because they have been subjected to a certain training is almost sure to be a class not only trained by but also selected by that training. Suppose that we wish to study the influence of a high-school course, or that of the classical as opposed to the scientific course, or that of training in independent research, or that of immoral surroundings. High school graduates are but 8 per cent. of grammar school graduates; and no one would claim that they represent an entirely random picking therefrom. They are surely selected for better birth, better abilities and better ideals. Again, in most high schools the graduate of the classical course represents not only a different training but also a different selection, commonly a superior selection. So also scientific men are a class resulting not only from the training given by research work but also from the selection of those eager to do and fitted to do that work. Children brought up in a morally bad environment are almost sure to be of morally inferior ancestry. The ordinary arrangement of social and educational careers rarely presents us with convenient cases of similar nature, some with, some without, the form of training we are studying.

The difficulty of eliminating the influence of selection is no excuse for its neglect. Yet one may hunt through thousands of pages of discussions of the influence of certain studies, school systems, schemes of culture, religious beliefs, etc., without finding a hint of its recognition.

Either because of the general complexity of environmental influences upon any mental trait and the mixture of selective

with formative influences or because of the infrequency of scientific habits and ideals in students of education, there are few facts of sufficient security and precision to be quoted.* Only rarely has educational science progressed beyond the reasoned opinions of more or less capable judges. We have our beliefs about the causal relations between a hot climate and indolence, necessity and invention, lack of parental control and crime, religious training and morality, etc., but we can not be said to know these influences with adequate surety or to have any knowledge whatever of their precise amount.

One general statement may be added concerning the amount of influence of the environment. Since the factor of selection is commonly neglected the influence of the environment is commonly over-estimated; in the judgment of the present writer very much so.

In place of any general summary of conflicting and insecure opinions I shall quote at some length from the studies by Dr. J. M. Rice of the influence of various environmental factors upon efficiency in spelling and in arithmetic. Although their author does not take advantage of some important statistical methods, these studies represent in a general way the type of investigation which should be made in every field.

Dr. Rice tested the spelling ability of some 33,000 children in twenty-one schools representing a great variety in spirit, methods, time given to spelling and in other respects.† He then compared the conditions in schools where the pupils did well in spelling with those in schools where they did badly. He notes first of all the slight differences between schools, only 6 out of the 21 schools being outside the limits 73.3 and 77.9, and the decrease in variation amongst schools as we pass from lower to higher grades (see table V), facts which show that the differences in spirit or method that characterize schools can not make much difference in achievement. Of school systems where mechanical methods are in use as compared with more progressive systems he says:

* In the literature of sociology and economics there may be studies qualified by their statistical adequacy and freedom from the fallacy of selection to serve as models. If so they are not readily discovered.

† *Forum*, April and June, 1897.

Indeed, in both the mechanical and the progressive schools the results were variable; so that while, in some instances, the higher figures were secured by the former, in others they were obtained by the latter; and the same is true of the lower figures. For example, School B, No. 11, in which the best average (79.4) was obtained, belongs to a very progressive system; while School A, No. 12, which made only 73.9, belongs to one of our most mechanical systems. And it is a peculiar incident that, in both these cities, the results in the only other school examined are exactly reversed, although the environment is about the same.

He eliminates the possibility that home reading or cultured parents or English rather than foreign parentage is the cause of the differences amongst schools by making the comparisons of table VI.

TABLE VI. (No. 3 of the original account).

	Grade.	No. of Cities.	No. of Classes.	No. of Pupils.	General Average.	Children of Foreign Parentage.	Average.	No. of Children Hearing Foreign Language at Home.	Average.	Children of Unskilled Laborers.	Average.
Sentence Test.	Fourth..	4	27	821	64.7	155	65.2	159	64.9	129	62.5
	Fifth	4	29	829	76.	153	77.4	157	76.7	129	74.5
	Sixth.....	4	22	778	69.7	185	69.6	165	70.3	119	70.4
	Seventh.	4	18	566	78.8	81	82.5	52	81.5	55	76.8
	Eighth..	4	19	528	83.1	72	83.2	64	83.2	76	85.

Dr. Rice further tabulated the results in accordance with the methods of instruction used in the different schools, interviewing some two hundred teachers for that purpose. He does not give the detailed results, but assures us that there is no reason to believe that there is any clear choice between oral and written spelling, writing isolated words and writing sentences, the sight or flash method and its absence. Phonic reading does not make bad spellers, nor do written language work and wide general reading make good spellers. "In brief," says he, "there is no direct relation between method and results. . . . The results varied as much under the same as they did under different methods of instruction."

That the amount of time given is not the cause of success in teaching spelling is shown by the facts of table V. Schools giving 15 or 20 minutes daily to spelling do as well as those giving 40 or 50.

TABLE V.

AVERAGES FOR INDIVIDUAL SCHOOLS.

City.	School.	4th Year.			5th Year.			6th Year.			7th Year.			8th Year.			School Av., Sentence-Test.	City.	School.
		Sentence-Test.	Composition-Test.	Minutes Daily.	Sentence-Test.	Composition-Test.	Minutes Daily.	Sentence-Test.	Composition-Test.	Minutes Daily.	Sentence-Test.	Composition-Test.	Minutes Daily.	Sentence-Test.	Composition-Test.	Minutes Daily.			
1	A	67.6	—	—	79.6	—	45	77.2	—	20	76.7	—	25	—	—	—	77.1	1	A
1	B	—	—	—	—	—	—	—	—	—	—	—	—	82	—	—		1	B
1	C	61.8	96.8	50	72.6	97.4	50	77.7	98.8	50	—	—	40	86.1	99.6	20	75	1	C
7	A	B 71	96.7	45	81.8	98.4	35	71.5	98.2	40	78	98.7	30	85.8	99	30	77.6	7	A
		B 77	95.9	30	73.6	97.8	20	64.2	97.8	20	73.1	—	—	84.9	—	30			
		A 68.6	97.5	40	79.4	98.3	15	73.4	98.6	40	—	99.4	40	—	99.4	35	75.2		
7	B	B 64.5	97	—	75	—	30	71.1	—	45	77.2	—	30	87.2	99.4	—		7	B
		A 75.8	97.9	20	81.1	—	40	80	—	50	81.1	—	15	86.7	99.3	30	77.9		
7	C	B —	97.5	—	—	97.6	—	—	97.8	35	—	98.7	—	—	99.4	15		7	C
		A —	97.4	35	—	98.6	15	—	99.1	45	—	99.2	30	—	—	—	—		
9	A	B 70.8	—	—	71.3	—	—	66.5	—	—	85.6	—	—	—	—	—		9	A
		A 66.6	—	40	78	—	—	72.8	—	35	—	—	50	—	—	—	76.6		
9	B	B 66.4	96.1	—	74.8	97.6	—	73.2	98.7	35	—	99.4	—	—	—	—		9	B
		A 68.4	96.8	—	76.8	97.9	45	75.1	98.4	45	86.5	99.2	60	—	—	—	77.7		
9	C	B 66	—	—	70	—	—	76.1	—	40	—	—	—	—	—	—		9	C
		A 66.4	—	40	83.2	—	—	79.4	—	35	84.7	—	20	—	—	—	77.9		
10	A	B —	—	—	—	—	—	—	—	—	80	99.2	—	83.5	99.2	—		10	A
		A —	—	—	—	—	—	—	—	—	79.5	98.6	20	82.5	99.1	20	76.2		
10	B	B 61.4	96.6	—	76.6	98.6	—	72.7	99.2	—	—	—	—	—	—	—		10	B
		A 75.9	98.3	35	77.2	98.9	20	—	—	20	—	—	—	—	—	—	—		
11	A	B 61.2	—	—	70.4	—	—	63.4	—	—	—	—	—	—	—	—		11	A
		A 63.6	—	25	70.6	—	—	65.8	—	25	76	—	30	86.4	—	40	72		

Small B indicates first half, and small A second half of school year.

AVERAGES FOR INDIVIDUAL SCHOOLS (*Continued*).

City.	School.	4th Year.			5th Year.			6th Year.			7th Year.			8th Year.			School Av. Sentence Test.	City.	School.
		Sentence-Test.	Composition-Test.	Minutes Daily.	Sentence-Test.	Composition-Test.	Minutes Daily.	Sentence-Test.	Composition-Test.	Minutes Daily.	Sentence-Test.	Composition-Test.	Minutes Daily.	Sentence-Test.	Composition-Test.	Minutes Daily.			
11	B	B 76.4	96.3	—	74.6	97.9	—	74	98.5	—	—	—	—	—	—	—	79.4	11	B
		A 79.8	97.9	35	81.8	98.5	25	—	—	30	80	98.8	40	86.7	99.1	40			
12	A	B 53.2	—	—	66.4	—	—	75	—	—	—	—	—	86.3	—	—	73.9	12	A
		A 63.1	—	—	73	—	—	75.7	—	—	78.3	—	—	90.2	—	—			
12	B	B 53.3	—	—	74.4	—	18	73.1	—	—	—	—	—	90.3	—	—	79.0	12	B
		A 67.2	—	18	79	—	10	78.4	—	9	90	—	12	94.6	—	12			
15	B	B —	—	—	73	96.8	—	57	97.7	—	76.7	98.3	—	83.9	99	—	73.4	15	B
		A —	—	—	73.4	97.4	—	71.5	98.1	—	83.3	98.7	—	87.2	99.4	—			
15	D	B —	—	—	81.6	—	—	68.3	—	—	74.7	—	—	86.2	—	—	78.8	15	D
		A 74.3	—	20	83.6	—	20	72.7	—	20	84	—	20	88.6	—	20			
15	E	B 66.2	97	—	74.4	97.8	—	72.8	98.5	—	—	—	—	—	—	—	77.3	15	E
		A 70.8	96.6	15	79.4	98.3	20	69.6	98.1	20	80.6	98.7	20	89.4	99.2	20			
15	H	B 67.2	—	—	76.2	—	—	69.8	—	—	81.4	—	—	89.9	—	—	77.9	15	H
		A 69.1	—	20	79.1	—	25	76.2	—	25	—	—	25	89.4	—	25			
16	A	B 62.6	97.4	—	73.6	98.5	—	61.9	97.6	—	71.1	98.2	—	84	99.1	—	72.0	16	A
		A 59.2	97.9	20	76.4	98.6	15	68.7	98.7	20	72.8	98.8	20	89.9	99.4	6			
16	B	B 68.4	—	—	70.6	98.5	—	—	98.1	—	71.3	98.5	—	81.2	98.9	—	72.7	16	B
		A 65	97.9	20	74.4	98.2	20	—	97.7	15	75.3	99.3	10	80.2	99.2	5			
19	A	B 61.8	—	—	66.8	—	—	68.8	—	—	78	—	—	84.3	—	—	73.8	19	A
		A —	—	20	76.6	—	40	72	—	35	84	—	—	—	—	—			
19	B	B 57.4	—	—	73	—	—	61.3	—	—	69.5	—	—	85	—	—	73.3	19	B
		A 68.4	—	40	78.2	—	—	69.5	—	30	84	—	30	86.8	—	—			

TABLE VII.

	School.	4		5		6		7		8		School Average.			Minutes Daily.	When Taken.
		Result.	Principle.	Result.	Principle.	Result.	Principle.	Result.	Principle.	Result.	Principle.	Result.	Principle.	Per Cent. of Mechanical Errors.		
City III.	1	68.4	76.7	79.5	82.5	79.3	80.3	81.1	82.3	91.7	93.9	80.0	83.1	3.7	53	A.M.
City I.	1	72.7	81.4	84.7	88.8	80.4	81.5	64.2	67.2	80.9	82.8	76.6	80.3	4.6	60	A.M.
City I.	2	.....	.....	80.3	87.1	80.9	83.4	43.5	50.9	72.7	79.1	69.3	75.1	7.7	25	A.M.
City I.	3	54.5	66.0	74.7	78.3	72.2	74.0	63.5	66.2	74.5	76.6	67.8	72.2	6.1	45	A.M.
City I.	4	60.0	73.3	70.8	79.3	69.6	72.2	54.6	57.8	66.5	69.1	64.3	70.3	8.5	45	P.M.
City II.	1	81.3	87.7	78.2	85.6	71.2	75.3	33.6	35.7	36.8	40.0	60.2	64.8	7.1	60	P.M.
City III.	2	70.1	79.9	53.6	60.0	43.7	45.0	53.9	56.7	51.1	53.1	54.5	58.9	7.4	60	P.M.
City IV.	1	70.5	76.4	73.2	77.7	58.9	60.4	31.2	34.1	41.6	43.5	55.1	58.4	5.6	60	A.M.
City IV.	2	62.9	72.8	70.5	76.8	59.8	63.1	.....	.....	22.5	22.5	53.9	58.8	8.3	...	P.M.
City IV.	3	59.8	72.7	65.3	73.5	54.9	58.1	35.2	38.6	43.5	45.0	51.5	57.6	10.5	60	A.M.
City IV.	4	53.5	62.2	53.5	65.7	42.3	45.1	16.1	19.2	48.7	48.7	42.8	48.2	11.2	...	P.M.
City V.	1	38.5	46.3	67.0	71.0	44.1	48.7	29.2	32.5	51.1	58.3	45.9	51.3	10.5	40	P.M.
City VI.	1	28.1	31.7	38.1	44.2	68.3	71.3	33.5	36.6	26.9	30.7	39.0	42.9	9.0	33	A.M.
City VI.	2	41.6	51.9	45.3	52.1	46.1	49.5	19.5	24.2	30.2	40.6	36.5	43.6	16.2	30	P.M.
City VI.	3	36.8	54.2	55.0	62.8	34.5	36.4	30.5	35.1	23.3	24.1	36.0	42.5	15.2	48	P.M.
City VII.	1	59.3	69.3	53.7	63.1	35.2	37.7	29.1	32.5	25.1	27.2	40.5	45.9	11.7	42	A.M.
City VII.	2	47.4	55.2	65.4	71.4	35.2	38.7	15.0	16.4	19.6	21.2	36.5	40.6	10.1	75	P.M.
City VII.	3	41.1	58.0	37.5	44.5	27.6	33.7	8.9	10.1	11.3	11.3	25.3	31.5	19.6	45+	P.M.
General average.	...	59.5	69.9	69.4	75.5	60.7	63.2	39.4	42.5	49.4	51.9	55.7	60.6	8.1		
Per cent. of mechanical errors.	...	.....	14.8	.....	8.1	.....	3.9	.....	7.3	.....	4.8					
Number of pupils examined.	...	.....	1,422	.....	1,593	.....	1,285	.....	974	.....	689	Total, 5,963.				

After this admirable array of facts Dr. Rice jumps rather hastily to this speculative conclusion: "The facts here presented, in my opinion, will admit of only one conclusion, viz., that the results are not determined by the methods employed, but by the ability of those who use them. In other words, the first place must be given to the personal equation of the teacher, while methods and devices play a subordinate part."

This statement should have been based upon a demonstration of a high coefficient of correlation between the measure of a grade in spelling and the measure of its teacher in ability, or of a great increase in variability in spelling ability as we pass from the children taught by one teacher to the children taught by 10 or 20 different teachers. I calculate that if the reliabilities of Dr. Rice's eighth grade averages are what they would seem to be from tests made in eighth grades by myself and my students,* the differences amongst them are not much greater than we would expect by the law of chance if the teaching were in all cases equally efficient. The average deviation from their mean of the 12 eighth grades which were tested in the first half of the year is 1.9; that of the 13 eighth grades tested in the last half of the year is 2.6; the average deviation by pure chance of 12 eighth grades of 40 students each would be 1.9, the variability of individuals being 12.2. In the case of the eighth grades then we may need no cause at all for the differences amongst schools save the inaccuracy of the averages due to the small number of cases.

Dr. Rice measured the arithmetical ability of some 6,000 children in 18 different schools in 7 different cities.† The results of these measurements are summarized in table VII. This table "gives two averages for each grade as well as for each school as a whole. Thus, the school at the top shows averages of 80.3 and 83.5, and the one at the bottom, 25.2 and 31.8. The first represents the percentage of answers which were absolutely correct; the second shows what per cent. of the problems were correct in principle, *i. e.*, the average that would have been received if no mechanical errors had been made. The difference represents the

* These give a variability of 12.2 amongst the individuals of the grade.

† See pp. 296–298 of the *Forum*, October–December, 1902, for the tests given.

percentage of mechanical errors, which, I believe, in most instances, makes a surprisingly small appearance."

From these results Dr. Rice seeks the causes of excellence in arithmetical work as in the case of spelling by comparing the condition in the successful schools with those in the unsuccessful. He deals seriatim with (1) the home environment of the pupils; (2) the size of the classes; (3) the age of the children; (4) the time of day of the test; (5) the time devoted to arithmetic in the school; (6) the amount of home work required; (7) the methods of teaching; (8) teaching ability as represented by a combination of education, training and the personality of the teacher; (9) the course of study; (10) the superintendent's training of teachers; (11) the establishment of demands in regard to results; (12) the testing for results (*a*) by teachers alone, (*b*) by teachers and superintendents, (*c*) by principals, (*d*) by principals and superintendents.

He finds that the work depends upon the method of testing for results, that teachers and pupils do about what is demanded of them, and that the best work appears when the superintendent, in connection with principals of schools, tests and rates the work of the classes.

The following are samples of the reasoning by which he eliminates one after another of the possible causes:

Home Environment.

If the part that is played by the home environment should be as important as it is generally supposed to be, we should, of course, expect to find that the schools represented in the upper part of the table had been attended by children from cultured homes, while those in the lower part had been attended by those whose home environment was very poor. However, if a line should be drawn across the middle of the table, and the schools above it compared with those below, such a condition would not be found. Indeed, careful inspection would show that the odds were certainly not in favor of the "aristocratic" districts. Of the eighteen schools, three in particular are representative of the latter, and the best of these secured the tenth place, while the others ranked eleventh and sixteenth, respectively. The school that ranked seventh was distinctively a school of the slums. That is to say, the school laboring under the poorest conditions in respect to home environment obtained a better standing than any one of the so-called aristocratic schools. The building which stands fifth is representative of conditions just a shade better than those of the slums. And when I add that, from the standpoint of environment, the schools of City I. did not

average a single degree better than those of Cities VI. and VII., I have said enough to show that the poor results secured in the latter cities cannot be condoned on the ground of unfavorable environment. Thus, as in spelling, so in arithmetic, this mountain, upon close inspection, dwindles down to the size of a molehill.

Size of Classes.

Equally surprising, if indeed not more incredible, may appear the statement that no allowance whatever is to be made for the size of the class in judging the results of my test. I shall not enter into the details in regard to this point, but will dismiss it with the remark that the number of pupils per class was larger in the highest six schools than it was in the schools of City VI., and that the classes were exceptionally small in the school that stands at the lower end.

Age of Pupils.

His argument is here too lengthy to quote and is rather awkward, but sufficiently proves that the differences between schools could have been due only in a very slight degree if at all to differences in the ages of the pupils. The obvious way to eliminate age is to compare a group from city VI. or VII. with a group identical in age and grade from city I. or III.

Time of Day.

This can not be the cause of much of the difference found for within any one city the time of day of the test makes little difference.

The Time Devoted to Arithmetic in the School.

A glance at the figures will tell us at once that there is no direct relation between time and result; that special pressure does not necessarily lead to success, and, conversely, that lack of pressure does not necessarily mean failure.

In the first place, it is interesting to note that the amount of time devoted to arithmetic in the school that obtained the lowest average—25 per cent.—was practically the same as it was in the one where the highest average—80 per cent.—was obtained. In the former the regular time for arithmetic in all the grades was forty-five minutes a day, but some additional time was given. In the latter the time varied in the different classes, but averaged fifty-three minutes daily. This shows an extreme variation in results under the same appropriation of time.

Looking again toward the bottom of the list, we find three schools with an average of 36 per cent. In one of these, insufficient pressure might be suggested as a reason for the unsatisfactory results, only thirty minutes daily having been devoted to arithmetic. The second school, however, gave forty-eight, while the third gave seventy-five. This certainly seems to indi-

cate that a radical defect in the quality of instruction cannot be offset by an increase in quantity.

If we now turn our attention from the three schools just mentioned and direct it to three near the top—Schools 2, 3, and 4, City I.—we find the conditions reversed; for while the two schools that gave forty-five minutes made averages of 64 per cent. and 67 per cent., respectively, the school that gave only twenty-five minutes succeeded in obtaining an average of 69 per cent. This would appear to indicate that while, on the one hand, nothing is gained by an increase of time where the instruction in arithmetic is faulty, on the other hand, nothing is lost by a decrease of time, to a certain point, where the schools are on the right path in teaching the subject. Perhaps the most interesting feature of the table is the fact that the school giving twenty-five minutes a day came out within two of the top, while the school giving seventy-five minutes daily came out practically within one of the bottom.

The Amount of Home Work Required.

The greatest amount of home work was required in the lowest ranking city while it had been practically abandoned in the first five schools of the table.

In the other cases the facts are given more vaguely, and in his presentation of positive evidence that differences in supervision by tests are the leading causes of the differences in achievement of the different schools, Dr. Rice seems to reach his conclusion simply from observing (1) that all conditions in City VI. were favorable save that examinations were given only by the teacher, (2) that in City VII. the examinations were given by the teacher and perfunctorily by the superintendent, while (3) in City I. the superintendent with the principals took pains in setting the tests. It seems highly probable that the cause he alleges is a real and important one, though even his own facts show the cooperation of other causes. This I take it he does not mean to deny.

In these two studies the argumentation would be much clearer, neater and more precise if put as follows: the coefficients of correlation or association for knowledge of arithmetic with size of classes, age of children, time devoted, amount of home work required, etc., are respectively a, b, c, d, e, etc. A zero coefficient would mean no causal relation and the amount of any coefficient would measure the relative importance of the factor in question as a cause or co-result of some common cause.

The reader may note in the results some interesting facts which Dr. Rice has not explicitly mentioned. For instance in arithmetic the resemblance between different grades of the same school is .64 while in spelling it is only .16. The variation amongst schools in arithmetic increases from .260 in the fourth grade to .504 in the eighth, while in spelling it *decreases* from .114 to .031.* These measurements show clearly that efficiency in arithmetic is dependent upon the spirit and work of a school to a far greater extent than is spelling.

The Method of Action of the Environment.

I shall here present a descriptive account which is frankly a matter of speculation rather than proof. It is in brief that the environment changes mental traits only by:

1. Furnishing or withholding conditions for the brain's growth and actions.

2. Furnishing or withholding adequate stimuli to arouse the action of which the brain is by original nature or previous action capable.

3. Reinforcing some and eliminating others of these activities in consequence of the general law of selection in mental life.†

According to this description we should look upon the mental life of an individual as developing in the same way that the animal or plant kingdom has developed. As conditions of heat and food-supply have everywhere been the first requisite to and influence on animal life, so the physiological conditions of the brain's activities are the first modifiers of feeling and action. As the stimuli of climate, food, unknown chemical and electrical forces and the rest have been the means of creating variations in the germs or of stimulating to action the inner tendency of the germs to vary and so have rendered possible the

* These figures are the coefficients of variability. It is doubtful whether Dr. Rice's tests in different grades were commensurate and consequently whether any comparison of variability can be strictly accurate.

† In all animals capable of profiting by training any act which in a given situation brings pleasure becomes thereby more closely associated with that situation so that when that situation recurs the act will recur also. An act that brings pain becomes dissociated from the situation and less likely to recur.

production of millions of different animal types, so the sights and sounds and smells of things, the words and looks and acts of men, the utensils and machinery and buildings of civilization, its pictures and music and books, awake in the mind new mental varieties, new species of thoughts and acts. In a score of years from birth the human mind like the animal world originates its universe of mental forms. And as in the animal kingdom many of these variations fail to fit the conditions of physical nature and die after a generation or two, so in any one of us many of the mental forms produced are doomed to a speedy disappearance in consequence of their failure to fit outside events. The elimination of one species by others in the animal world is again paralleled by the death of those thoughts or acts which are out of harmony with others. Species of thoughts like species of animals prey upon one another in a struggle in which survival is the victor's reward. Further just as species of animals fitted to one environment perish or become transformed when that environment changes, so mental forms fitted to infancy perish or are transformed in school life; mental forms fitted to school life perish in the environment of the workaday world; and so throughout the incessant changes of a mind's surroundings. In mental life resulting pain or discomfort is the cause of the extinction of a species. The condition of a man's mind at any stage in its history is then, like the condition of the animal kingdom at any stage in the history of the world, the result not only of the new varieties that have appeared, but also of a natural selection working upon them. The tale of a human mind's progress is the tale of the extinction of its failures.

Possibility of existence, stimuli to variations, selection by elimination: these words that describe the action of the environment on animal life are equally competent to tell the record of a human life.

The substitution of these simple names for the real types of influence in place of the indefinite and unsuitable terms, maturity, training, practice, imitation, culture, discipline, etc., leads to a number of interesting suggestions about the description and even explanation of changes in human nature which must, however, be left to the reader's own inferences. I will mention only the terms

in which I should describe the work of education, following the analysis just given. The work of education is:

1. To supply the needs of the brain's healthy growth and to remove physiological impediments to it.

2. To provide stimuli to desirable mental variations and to withhold stimuli from the undesirable.

3. To make the outcome of desirable activities pleasurable and to inhibit their opposites by discomfort.

The three chief practical problems of education would thus be those of hygiene, of opportunity and of incentives and deterrents.

CHAPTER VIII.

THE INFLUENCE OF SPECIAL FORMS OF TRAINING UPON MORE GENERAL ABILITIES.

One of the quarrels of the educational theorists concerns the extent to which special forms of training improve the general capacities of the mind. Does the study of Latin or of mathematics improve one's general reasoning powers? Does laboratory work in science train the power of observation for all sorts of facts? Does matching colored sticks educate the senses for all sorts of discriminations?

The problem, which is clearly one of psychological fact, may be best stated in psychological terms as follows: How far does the training of any mental function improve other mental functions? In less technical phrase, How far does an ability, say to reason, acquired with data *A*, extend also to data *B*, *C*, *D*, etc?

No one can doubt that all of the ordinary forms of home or school training have some influence upon mental traits in addition to the specific changes which they make in the particular function the improvement of which is their direct object. On the other hand no careful observer would assert that the influence upon the other mental traits is comparable in amount to that upon the direct object of training. By doubling a boy's reasoning power in arithmetical problems we do not double it for formal grammar or chess or economic history or theories of evolution. By tripling the accuracy of movement in fingering exercises we do not triple it for typewriting, playing billiards or painting. The gain of courage in the game of football is never equalled by the gain in moral courage or resistance to intellectual obstacles. The real question is not, 'Does improvement of one function alter others?' but, 'To what extent and how does it?'

The answer which I shall try to defend is that a change in one function alters any other only in so far as the two functions have as factors identical elements. The change in the second function is in amount that due to the change in the elements common to it and the first. The change is simply the necessary result upon the

second function of the alteration of those of its factors which were elements of the first function and so were altered by its training. To take a concrete example, improvement in addition will alter one's ability in multiplication because addition is absolutely identical with a part of multiplication and because certain other processes, *e. g.*, eye movements and the inhibition of all save arithmetical impulses, are in part common to the two functions.

Chief amongst such identical elements of practical importance in education are associations including ideas about aims and ideas of method and general principles, and associations involving elementary facts of experience such as length, color, number, which are repeated again and again in differing combinations.

By identical elements are meant mental processes which have the same cell action in the brain as their physical correlate. It is of course often not possible to tell just what features of two mental abilities are thus identical. But, as we shall see, there is rarely much trouble in reaching an approximate decision in those cases where training is of practical importance.

The standard psychology and pedagogy books with few exceptions answer our questions in a manner very different from this. They extend the influence of any special form of discipline much farther, and describe its manner of operation only by vague and I think meaningless phrases.*

In place of any descriptive account I shall give a number of quotations picked almost at random from all the statements about the influence of special training on general ability made in some fifty representative books on psychology and pedagogy. These will represent fairly the prevailing attitude.

Systematic treatises on psychology, with two or three exceptions, neglect the functional aspect of mental life and so do not furnish any apt quotations. Their implied point of view however is, again with one or two exceptions, that alterations in mental powers are alterations in the general facility of attention, reasoning, etc.

* The leading exception in psychology is James' 'Principles of Psychology,' and in pedagogy is the Herbartian literature. The often correct conclusions of the latter are however based upon defective principles.

Books on applied psychology express this implication outright, and books on education carry it to an amazing extreme. The following quotations represent accurately a widespread opinion:

Since the mind is a unit and the faculties are simply phases or manifestations of its activity whatever strengthens one faculty indirectly strengthens all the others. The *verbal* memory seems to be an exception to this statement, however, for it may be abnormally cultivated without involving to any profitable extent the other faculties. But only things that are rightly perceived and rightly understood can be *rightly* remembered. Hence whatever develops the acquisitive and assimilative powers will also strengthen memory; and, conversely, rightly strengthening the memory necessitates the developing and training of the other powers. (R. N. Roark, 'Method in Education,' p. 27.)

It is as a means of training the faculties of perception and generalization that the study of such a language as Latin in comparison with English is so valuable. (C. L. Morgan, 'Psychology for Teachers,' p. 186.)

Arithmetic, if judiciously taught, forms in the pupil habits of mental attention, argumentative sequence, absolute accuracy, and satisfaction in truth as a result, that do not seem to spring equally from the study of any other subject suitable to this elementary stage of instruction. (Joseph Payne, 'Lectures on Education,' Vol. I., p. 260.)

By means of experimental and observational work in science, not only will his attention be excited, the power of observation, previously awakened, much strengthened, and the senses exercised and disciplined, but the very important habit of doing homage to the authority of facts rather than to the authority of men, be initiated. (*Ibid.*, p. 261.)

. . . The study of the Latin language itself does eminently discipline the faculties and secure to a greater degree than that of the other subjects we have discussed, the formation and growth of those mental qualities which are the best preparatives for the business of life—whether that business is to consist in making fresh mental acquisitions or in directing the powers thus strengthened and matured, to professional or other pursuits. (*Ibid.*, p. 264.)

I wish to understand by mental discipline the exercise of some faculty of the mind, which results in increasing the power or readiness of that faculty. (E. H. Babbitt, p. 126, of 'Methods of Teaching the Modern Languages.')

The faculty which is by far the most important of the human mind, and which we most earnestly strive to develop and perfect in our pupils, is the faculty of judgment, or the reasoning faculty (I am not trying to be psychologically exact), the faculty whose perfection gives what we call a logical mind—a mind which has a ready perception of the relations of things and is not likely to be misled by false reasoning. (*Ibid.*, p. 127.)

The most valuable thing in the way of discipline which comes from a study of a foreign language is its influence in improving the pupil's command of his own. Of course this means the improvement in general judg-

ment and discrimination which is evinced by a finer linguistic sense. . . . (*Ibid.*, p. 129.)

Let us now examine in detail the advantages which a person who has taken the ordinary Bachelor's degree has derived from the study of classics. Aside from the discipline of the will, which comes from any hard work, we find the following: (1) His memory for facts has been strengthened by committing paradigms and learning a new vocabulary. (2) He has been obliged to formulate pretty distinctly a regular system of classified facts—the facts which form the material of the grammar—classified in due form under chapter, section, subsection and so on. This means that he has learned to remember things by their relations—a power which can hardly be acquired without practice in forming or using such classified systems. (3) He has had his judgment broadened and strengthened by constant calls upon it to account for things which cannot be accounted for without its exercise. (*Ibid.*, p. 130.)

Correct use of the language is always to be insisted upon. This especially in the oral exercises makes *concentration* imperative and serves in an eminent degree as a disciple of the *will*. . . . Practice in the use of a foreign language cultivates the *imagination*. . . . I have not mentioned the cultivation of the memory. The study of modern languages offers wide opportunity not only for the exercise of verbal memory, but especially for the rational use of this important power, by means of association, comparison, discrimination. (A. Lodeman, 'Methods of Teaching Modern Languages,' pp. 104–105.)

The value of the study of German 'lies in the scientific study of the language itself, in the consequent training of the reason, of the powers of observation, comparison and synthesis; in short, in the upbuilding and strengthening of the scientific intellect.' (Calvin Thomas, 'Methods of Teaching Modern Languages,' p. 27.)

[*Advantages resulting from the teaching of drawing.*] The visual, mental and manual powers are cultivated in combination, the eye being trained to see clearly and judge accurately, the mind to think, and the hand to record the appearance of the objects seen, or the conceptions formed in the mind. Facility and skill in handicraft, and delicacy of manipulation, all depend largely upon the extent to which this hand and eye training has been fostered. The inventive and imaginative faculties are stimulated and exercised in design, and the graphic memory is strengthened by practice in memory drawing. The æsthetic judgment is brought into use, the power of discerning beauty, congruity, proportion, symmetry, is made stronger; and the love of the beautiful, inherent more or less in mankind, is greatly increased. (J. H. Morris, 'Teaching and Organization' (edited by P. A. Barnett), pp. 63–64.)

As regards the first point, it may be noted that the pursuit of mathematics gives command of the attention. A successful study increases or creates the power of concentrating the thoughts on a given subject and of separating mixed and tangled ideas. The habits of mind formed by means of this one set of studies soon extend their influence to other studies and to the ordinary pursuits of life. The man or woman who has been drilled by means of mathematics is the better able to select from a number of possible

lines which may be suggested that which is easiest or most direct to attain a desired end.

The second purpose of this study is the one which has been most universally acknowledged in all ages, namely, the strengthening and training of the reasoning powers. (R. Wormell, 'Teaching and Organization' (edited by P. A. Barnett), p. 78.)

We may conclude this list by quotations from a recent inaugural address at a great American college and from the reasons given by a number of presidents of colleges to the question, 'Why go to college?'

"We speak of the 'disciplinary' studies . . . having in our thought the mathematics of arithmetic, elementary algebra, and geometry, the Greek-Latin texts and grammars, the elements of English and of French or German. . . . The mind takes fiber, facility, strength, adaptability, certainty of touch from handling them, when the teacher knows his art and their power. The college . . . should give . . . elasticity of faculty and breadth of vision, so that they shall have a surplus of mind to expend. . . ." (Woodrow Wilson, *Science*, November 7, 1902.)

Thomas J. Conaty, Rector of the Catholic University of America: "I would say, in one word, for discipline."

Nathaniel Butler, President of Colby College: "It has been well said that an educated man has a sharp ax in his hand and an uneducated man a dull one. I should say that the purpose of a college education is to sharpen the ax to its keenest edge."

H. M. MacCracken, Chancellor of New York University: "He will possess a better disciplined mind for whatever work of life he may turn his attention to."

Timothy Dwight, late President of Yale University: "Such an education is the best means of developing thought power in a young man, and making him a thinking man of cultured mind."

The last four statements appeared in the *Penn Charter Magazine,* at just what date I am unable to ascertain.

It is clear that the common view is that the words accuracy, quickness, discrimination, memory, observation, attention, concentration, judgment, reasoning, etc., stand for some real and elemental abilities which are the same no matter what material they work upon; that these elemental abilities are altered by special disciplines to a large extent; that they retain those alterations when turned to other fields; that thus in a more or less mysterious way learning to do one thing well will make one do better things that in concrete appearance have absolutely no community with it.

The mind is regarded as a machine of which the different faculties are parts. Experiences being thrown in at one end, per-

ception perceives them, discrimination tells them apart, memory retains them and so on. By training the machine is made to work more quickly, efficiently and economically with all sorts of experiences. Or in a still cruder type of thinking the mind is a storage battery which can be loaded with will power or intellect or judgment, giving the individual 'a surplus of mind to expend.' General names for a host of individual processes such as judgment, precision, concentration are falsely taken to refer to pieces of mental machinery which we can once for all get into working order, or still worse to amounts of some thing which can be stored up in bank to be drawn on at leisure.

The chapter upon the relationships of mental abilities proved that there was every reason to disbelieve in the existence of any such truly general abilities, that the general words memory, attention, etc., represented a summation of or abstraction from a host of particular capacities largely independent of each other. The argument from the static independence of mental functions must not be pressed too far in arguing that they are functionally independent. Two traits might show little or no correlation and yet training of one might improve the other. On the other hand, two traits might show perfect correlation and yet one be in no wise influenced by alteration in the other. What the static independence of mental traits does prove is the specialization of the mind, the general absence of *necessary* relationships. It thus destroys two of the *a priori* arguments for the common view of functional dependence. The next section of this chapter will demonstrate that in point of fact learning to do one thing well has a much less influence upon one's other abilities than these authors have led teachers and others to believe.

Only a few experiments have been made upon the spread of ability from the one function trained to others. The studies of James,* Gilbert and Fracker,† Thorndike and Woodworth,‡ Judd,§ and Bair|| which will be summarized in this chapter are

* 'Principles of Psychology,' Vol. I., pp. 667–668.

† University of Iowa, 'Studies in Psychology,' Vol. I.

‡ *Psychological Review*, May, July and November, 1901, Vol. VIII.

§ *Psychological Review*, Vol. IX., pp. 27–39.

|| *Psychological Review*, Monograph Supplement, No. 19, pp. 25, 28, 64–67.

the only studies that deal specifically with this question. I shall however describe also the studies of Volkmann,* Scripture, Smith and Brown,† Davis,‡ and Woodworth,§ upon cross-education or the extent to which training one organ of the body improves the bilaterally symmetrical organ. Their results have been improperly used as evidence upon our question. We must therefore examine them.

Volkmann found that by practice of the left arm in discrimination until an initial ability of 23.6 improved to 11.2, the right arm without any practice showed an improvement from 26.4 to 15.7. Similar results were found for other cases of cross-education and for the spread of improvement in discrimination of touch at certain spots on the skin to neighboring spots.

Scripture, Smith and Brown found that improvement in strength of grip in one arm in consequence of its exercise was in one subject accompanied by 80 per cent. as much improvement in the other arm. Only one subject took the practice. In precision the gain was 2 per cent. greater in the unpracticed arm, in the one individual studied. Davis found that the improvement in quickness of tapping with the right toe due to its practice was accompanied by 151 per cent. as much improvement in the left foot, 100 per cent. as much in the right hand and 83 per cent. as much in the left hand. Exercise of the biceps of the right arm was followed by increase of the number of flexions endurable to the amount of 433, 950, 900, 300, 200 and 532 per cents. in the six subjects of the experiment. The increases for the *left* arm consequent upon the exercise of the right were respectively 200, 37, 60, 12, 300, 553. Practice in lunging at a target with a foil 100 times with the right hand was followed by an improvement in the left about three fourths as great as in the right (six subjects gave ratio of left arm to right arm improvement 1.14, 1.03, .80, .54, .99 and .11 respectively). Unilateral practice in gripping a dynamometer was followed by improvement of both sides. The ratios of improvement in the unpracticed to improvement in the

* 'Bericht der Kgl.-sachs. Ges. d. Wiss., Math.-phys. Cl.,' 1858; X., 38.

† *Yale Studies*, Vol. 2.

‡ *Yale Studies*, Vols. 6 and 8.

§ *Psychological Review*, Monograph Supplement, No. 13, p. 105.

practiced side ranged for the 25 subjects from — 44 per cent. to 411 per cent. the median value being — 3 per cent.

Woodworth measured the influence of practice of the left hand in the accuracy of hitting a dot upon the ability of the other hand in the same performance. The results were as follows:

	Accuracy at 40 motions per minute.	At 120.	At 200.
Left hand:	Before 3.5	4.2	8.3
	After 0.4	3.8	7.2
Right hand:	Before 3.1	3.9	7.1
	After 0.7	3.8	6.6

In repeating these experiments it seemed to the writer certain that the important cause of improvement was the acquisition of skill in moving the eyes quickly and accurately. This would of course be an identical feature of both trained and tested acts.

These facts are not strictly relevant to our problem, for the influence of training one part of the body in a certain task upon the efficiency of the bilaterally symmetrical half of the body in the same task is a very peculiar case. The sensations from or movements of any pair of bilaterally symmetrical organs are in a way quite different from those of a pair of organs taken at random. It is therefore fallacious to connect the facts of cross-education with such inferences as the following: "The capability of concentrating attention on a certain point in question, in whatever field it is acquired, will show itself efficacious in all others." (Stumpf, "Tonpsychologie," 1883, I., 81, quoted by Davis, *Yale Studies,* 6, p. 46.)

"Development of will power in connection with any activity is accompanied by a development of will power as a whole." (Scripture, *Psy. Rev.,* VI., 165, quoted by Davis, *Yale Studies,* No. 6, p. 47.)

"Will power and attention are educated by physical training. When developed by any special act, they are developed for all acts." (W. W. Davis, *Yale Studies,* No. 8, p. 103.)

These statements are unjustifiable: (1) Because they imply that any two functions are related as are sensations or movements of one organ with identical ones from the bilaterally symmetrical one. This is utterly false. (2) Because they imply that the amount of improvement of 'attention' or 'will power' in the

one organ is equaled in the case of the other. It is not. (3) Because they make no adequate effort to discover whether the amount of improvement that is common to both is not due entirely to identical elements of a concrete sort such as acquaintance with the *oneness* and *twoness* feelings in the case of touches with compass point or points, or actual contractions of both muscles when nominally only one is being exercised, or the habit of gripping the dynamometer in a certain way and suddenly. These are *veræ causæ* and may be sufficient to explain the facts. The phenomena of cross-education are an interesting chapter in experimental psychology but are not fair samples of the general facts we seek. Nor is their significance at all clear.

The first group of studies mentioned on page 85 will give a fair idea of the influence of training in one function upon the condition of another if we bear in mind: (1) That in all the experiments the two functions were very closely similar, were in fact such as the psychologies and pedagogies generally would regard as identical, and (2) that the individuals who took the training were of a gifted class compared with people in general and would be much more likely than they to use the ideas and habits acquired in one field when tested in another.

James took measurements of the ability to memorize one kind of verse before and after a fixed amount of training with a different kind of verse. The results were:

	Time before Training.	Amount of Training.	Time after Training.
Subject 1.....	131 5/6	First book of 'Paradise Lost'	151 1/2
Subject 2.....	14.75	416 lines of German poetry	14.54
Subject 3.....	13 26/60	?	12 16/60*
Subject 4.....	3.67	450 lines	3.04*
Subject 5.....	14.34	?	14.55

The amounts of improvement in the function especially trained are not given.

In Gilbert and Fracker's experiments two subjects were tested for their quickness in moving the finger: (1) When they heard a certain sound, (2) when they felt a certain electric shock, (3)

* Subjects 3 and 4 had in the tests before and after training 32 and 30 days of training which, as Professor James thinks, gave too much chance for special practice.

when they felt a certain blow, and (4) when they saw a blue surface. In all these cases they were warned two seconds before the stimulus and no other stimuli could be confused with it. They were also tested for their quickness in moving the finger at these same stimuli when either the given sound or one less loud, either the given shock or one less intense, either the given blow or one less hard, either the blue or a red might appear. They were then trained for a number of days in quickness in reacting to the sound, (A) when only it was given, and (B) when either it or the weaker sound might be given. They were then tested as before. The results showed improvement in all cases save one with one observer. One observer was trained only in (A). He improved markedly in the corresponding tests, but not so much as the others in the second set of tests. The small number of cases and the low correlation between an individual's improvement in the special act trained and in his gain in the other acts tested make the argument from the amount of this gain insecure. It was however large, as will be seen from table VIII. It is obvious that the functions trained and the functions tested contained many identical elements, the operations being absolutely identical with the exception of the kind of a signal used.

TABLE VIII. (TABLE VII. OF THE ORIGINAL ARTICLE).

PER CENT. OF TIME GAINED BY PRACTICE.

	Reaction.			Reaction with Discrimination.				Discrimination.			
	H	*E*	*T*	*S*	*h*	*e*	*t*	*s*	*h'*	*e'*	*t'*	*s'*
J. A. C.	12	0	17	3	53	35	9	14	92	78	0	26
G. C. F.	23	21	10	45	47	60	38	34	83	64	56	18
J. C. P.	13	16	6	11	14	24	4	19	18	35	22	26

J. C. P. was practiced only in reaction time, while the other two were practiced in both reaction and reaction with discrimination and choice. All figures of the above table represent per cent. of gain by practice. The 0's in the second and eleventh columns really mean losses.

Judd's experiments were too narrow and of too technical a nature to be fully described here. The important results for our purpose were that an improvement in the direction of attention and in the character of eye movements caused one observer to improve more quickly than he would otherwise have done in a closely similar task, but caused in another observer a fixed habit which

absolutely prevented him from improving in the similar task at all. (*Psy. Rev.*, IX., pp. 27–39.)

Thorndike and Woodworth made a great variety of experiments upon the result of training in estimating areas, lengths and weights of certain shape and size upon the ability to estimate areas, lengths and weights similar in shape but different in size, different in shape but similar in size, different in both shape and size. A still more extensive series of experiments measured the influence of training in various forms of observation or perception upon slightly different forms. Only a few samples of their measurements can be given here.

Individuals practiced estimating the areas of rectangles from 10 to 100 sq. cm. in size until a very marked improvement was attained. The improvement in accuracy for areas of the same size but of different shape due to this training was only 44 per cent. as great as that for areas of the same shape and size. For areas of the same shape but from 140–300 sq. cm. in size the improvement was 30 per cent. as great. For areas of different shape and from 140–400 sq. cm. in size the improvement was 52 per cent. as great.

Training in estimating weights of from 40–120 grams resulted in only 39 per cent. as much improvement in estimating weights from 120 to 1800 grams. Training in estimating lines from .5 to 1.5 inches long (resulting in a reduction of error to 25 per cent. of the initial amount) resulted in no improvement in the estimation of lines 6–12 inches long.

Training in perceiving words containing e and s gave a certain amount of improvement in speed and accuracy in that special ability. In the ability to perceive words containing i and t, s and p, c and a, e and r, a and n, l and o, misspelled words and A's, there was an improvement in speed of only 39 per cent. as much as in the ability specially trained, and in accuracy of only 25 per cent. as much. Training in perceiving English verbs gave a reduction in time of nearly 21 per cent. and in omissions of 70 per cent. The ability to perceive other parts of speech showed a reduction in time of 3 per cent., but an *increase* in omissions of over 100 per cent.

These experiments showed very clearly the influence of: (1)

The acquisition during special training of ideas of method of general utility and also (2) of facility with certain elements that appeared in many other complexes. Instances of (1) are learning in the 10–100 cm. training series that one has a tendency to overestimate all areas and consciously making a discount for this tendency, no matter what the size or shape of the surface may be; learning to look especially for the less common letter (*e. g.*, s in the case of e-s words, p in the case of s-p words) in the training series and adopting the habit for all similar work; learning to estimate areas in comparison with a mental standard rather than the objective 1 sq. cm., 25 sq. cm. and 100 sq. cm. squares which each experimenter had before him (after one gets mental standards of the areas he judges more accurately if he pays no attention whatever to the objective standards). An instance of (2) is the uniform increase of speed of eye movements in all the perception tests through training in one, an increase often gained at the expense of accuracy.

In the opinion of the authors these experiments show that:

" Improvement in any single mental function need not improve the ability in functions commonly called by the same name. It may injure it.

" Improvement in any single mental function rarely brings about equal improvement in any other function, no matter how similar, for the working of every mental function-group is conditioned by the nature of the data in each particular case.

" The very slight amount of variation in the nature of the data necessary to affect the efficiency of a function-group makes it fair to infer that no change in the data, however slight, is without effect on the function. The loss in the efficiency of a function trained with certain data, as we pass to data more and more unlike the first, makes it fair to infer that there is always a point where the loss is complete, a point beyond which the influence of the training has not extended. The rapidity of this loss, that is, its amount in the case of data very similar to the data on which the function was trained, makes it fair to infer that this point is nearer than has been supposed.

" The general consideration of the cases of retention or of loss of practice effect seems to make it likely that spread of practice

occurs only where identical elements are concerned in the influencing and influenced function."

Bair made several experiments on the influence of practice in forming certain associative habits upon the ability in certain different habits. I summarize his statements here.

Six keys of a typewriter are labeled with six symbols (letters or figures). Fifty-five of these letters or figures (in chance order) are now shown one by one and the subject on seeing one taps the corresponding key. The time taken to tap out the series is recorded. Six different symbols are then used with a new series composed of them and the subject's time record is taken as before. This is kept up until twenty different sets of symbols have been used. Although the symbols have been changed each time there is a steady improvement, the changes being for four subjects 62 to 52, 95 to 85, 71.5 to 58, 62 to 52, and 65 to 56. The major part of this gain could not have been due to merely getting used to the machine or the general features of the experiments, for the fourth subject was already used to these and still gained about nine tenths as much as the other three.

The other experiment "consisted in taking daily records, for twenty days, by means of a stop watch, of the time required to repeat the alphabet from memory. Each day's experiment was as follows: First, the alphabet was repeated as rapidly as possible forward; secondly, the letter *n* was intercepted between each of the letters; thirdly, the alphabet was repeated as rapidly as possible backward; and lastly, the alphabet was repeated backward intercepting *n* between each of the letters. At the end of twenty practices in each order the subject repeated the alphabet, first, forward, intercepting, instead of *n*, the letter *x* and repeating three times; secondly, intercepting *r* and repeating three times; then lastly, repeating backward, and in like manner intercepting *x* and *r* and repeating three times."

How far now did the training with the training series (*ABC, AnBnCn, ZYX, ZnYnXn*) help the ability in the tested series (*AxBxCx, ArBrCr* and *ZxYxXx*). There was improvement in the tested series, the effect of the twenty days' training with the training series being to put the abilities in the tested series as far ahead as three days of the direct training would have done.

In both of these experiments as in the others quoted the influence of training is measured within a very narrow field.

On the whole what knowledge we do have of the actual influence of improvement of one function upon the efficiency of others harmonizes with the facts concerning the relationships between mental traits and makes it imperative that the present conceptions of the disciplinary effect of environmental agencies be subjected to a new critique on the basis of actual evidence. They surely overestimate its amount.

Their error is due in part to the fallacy of selection emphasized in Chapter IX. Since those who succeed in the study of Latin are better in general discrimination and judgment than those who fail, we conclude that learning Latin vastly improves general discrimination and judgment. Since those who succeed in science are more efficient observers and reasoners about concrete things than those who fail, we conclude that science is the mother of general observation and concrete inference.

Another fallacy, that of attributing to the disciplinary effect of studies and occupations what is really due to mere inner growth or maturity, contributes its share. Boys and girls become more efficient in general discrimination, attention, self control, etc. At the same time they have been undergoing these special disciplines. It suits the vanity of educational theory to fancy that the changes are wholly due to the discipline. But it is almost certain that maturity alone would cause a fair gain in efficiency.

Still a third fallacy, that of judging others by ourselves, has helped to blind educational theorists to the real state of affairs. They themselves are likely to be gifted men who could as boys and girls readily acquire and apply general ideas and habits. They fail to realize the state of mind of those to whom every task is a concrete performance to be done blindly, unproductive of any tendencies outside its own sphere. They mistake their own aptitudes at extracting general value from special disciplines for a general trait in human nature.

CHAPTER IX.

THE INFLUENCE OF SELECTION.

At the outset of our study of the influence of the environment was noted the common confusion of causes which train with causes which select.

The recognition of the fact that environmental agencies not only alter those whom they affect but also select those whom they shall affect is of importance aside from the prevention of radically false conclusions. For their selective action is itself of no small consequence. If doctors of philosophy are superior teachers, presidents of colleges will not stop to inquire whether they were so by nature or by training. If high school graduates make superior clerks, business men will care little whether they were so by general wits and ambition or by virtue of the doses of algebra, Latin, etc., that they have taken.

All environmental agencies and especially our educational agencies are a great system of means not only of making men good and intelligent and efficient, but also of picking out and labeling those who for any reason are good and intelligent and efficient. In the latter case they may be said to improve not the production, but the distribution of mental and moral wealth. They help to put the right men in the right places. They help the individual somewhat in so far as they advertise his true make-up and they help society in general tremendously by providing it not with better men, but with the knowledge of which men are good. In estimating the value of any educational system this selective function should never be disregarded.

To have gone to school at all means not only that you have perhaps learned to read and write but also that you were not an invalid, idiot or runaway. To have progressed half way through the graded schools means not only that you have learned somewhat but also that you were not one of the 10 or 20 per cent.* who by lack of means or ambition or health or mental ability

* These figures are true for large cities.

have been eliminated from the school system. To have graduated from a high school means that you are one of a very small percentage of the group who entered school with you, a percentage picked for survival not by chance, surely. And so on with colleges and professional schools.

In the case of the cities of Boston, Chicago and St. Louis the amount of the elimination is that given in table IX,* which gives the number of children in each grade above the first in percentages of the number in the second grade. By the last year of the high school course *97 per cent.* of the original group have been eliminated. Of these not more than 17 per cent. have died; the remaining 80 per cent. are dead only to the school system.

TABLE IX.

	2d	3d	4th	5th	6th	7th	8th	1st H.S.	2d H.S.	3d H.S.	4th HS.
St. Louis	100	93	83	50	29	21	14	7	4	3	2
Chicago	100	91	78	71	52	37	26	12	7	5	3
Boston	100	97	91	85	74	59	44	25	15	10	4

A college degree means literally that a man is the one man out of about 200 who has survived in the educational struggle. The important question here and at all stages is, "Which man is he? What are the traits of personality or circumstances that ensure survival?"

That is the efficient school system in which survival is grade by grade the portion of those most fit to profit by the future training and to use well the distinction given them by the fact of that training. Too often however poverty is the eliminating force. And within the schools themselves the selection has been confined too narrowly to a basis of ability in abstract and symbolic studies such as mathematics, languages and pure science. The boy destined to efficiency in affairs, in applied science and technical industries, in the organization of manufacturing and commerce, has been eliminated from the system because he was not fit for survival in it, though he was in every way one of the most fit for extended training.

It is common to bewail the elimination of so many from school life and to rejoice at any numerical increase in the proportion

* This table is taken from the excellent study of this question by Professor C. M. Woodward in the 1899–1900 report of the U. S. Commissioner of Education, Vol. II.

of children at any age who are under school influences. These opinions are probably justifiable, but the more important cause for regret or satisfaction lies, not in the quantity of those who continue school work, but in their quality. Out of a thousand six-year-olds there are a score whose higher education is of more value to the community than that of a hundred of their fellows.

It is also an American habit to clamor about equality of opportunity as the prime virtue of a school system. Equality at the start there should be, but the higher opportunities like the higher distinctions should be, as they always have been, earned. The schools always have and always will work to create a caste, to emphasize inequalities. Our care should be that they emphasize inequalities, not of adventitious circumstances, but of intellect, energy, idealism and achievement.

Just how the educational systems of the United States do select individuals for different forms of training is a question the importance of which is in inverse ratio to the amount of our knowledge about it. We have here and there a measurement more or less precise. The small number of institutions for the training of the feeble-minded shows that the great majority of these are altogether eliminated from systematic education. Woodward, in the report quoted, demonstrates that the pupils who in the middle grammar grades are the older tend to be more frequently eliminated. Thomas* found the high schools to select the younger and the higher ranking pupils, though in the schools studied only to a slight extent. They obviously select also those of relatively superior social position. They select from the general population more girls than boys. The scientific and modern language courses in colleges have far too often selected boys for their inability to pass the entrance examinations or do the work of the classical course. The theological schools select, by a peculiarly unfortunate custom, those young men who are attracted by free lodging and other gratuities. In general merit is chosen, but the student of education who shall discover the precise nature of the selective influence of American education will I fear convict us in some instances of a folly equal to that of the nations who eliminated their choicest stock by the monastery and the battlefield.

* In an unpublished study made at Teachers College in 1903.

CHAPTER X.

CHANGES IN MENTAL TRAITS WITH AGE.

Some of the best known and most commended studies in educational psychology deal with the differences in mental traits between children of different ages. The most extensive and also the most painstaking study of this sort is Dr. Gilbert's "Researches on the Physical and Mental Development of School Children." * A fairly careful examination of its method and results will be our best introduction to the general problems of the chapter.

Dr. Gilbert made a number of measurements of both physical and mental traits in boys and girls from six to seventeen years old. The mental traits were:

1. Delicacy of discrimination of weight. (Ten weights identical in shape and size but weighing 84 grams, 86 grams, etc., were set before a child and he was asked to sort out all those which seemed to him to be of exactly the same weight as the 82-gram one (which was marked by a white dot). Delicacy of discrimination is then measured inversely by the difference in weight of the weights thought to be identical.)

2. Delicacy of discrimination of color. (A series of reds varying progressively in darkness were used as the weights were in 1.)

3. Force of suggestion. (Measured by the amount a child overestimated a weight small in size compared with the same weight made much larger.)

4. Reaction time. (Measured by the time taken to see a signal and react by pressing down a key.)

5. Reaction with discrimination and choice. (Measured by the time taken to see that the signal was blue and not red and to react by pressing down a key.)

6. Time memory. (The child was told to listen to a certain continuous sound to see how long it lasted and, the sound being

* *Studies from the Yale Psychological Laboratory*, Vol. II.

again made, to give a signal when he thought it had continued as long as before. The length used was two seconds.)

TABLE X.

MUSCLE-SENSE.

Age.	*D*	*MV*	*B*	*G*
6	14.8	5.2	13.0	16.8
7	13.6	4.4	13.2	13.2
8	11.4	4.6	12.2	11.0
9	10.0	4.4	10.2	10.0
10	8.8	4.4	8.6	9.2
11	8.6	3.8	10.2	7.6
12	7.2	3.0	7.6	7.6
13	5.4	3.0	6.0	5.6
14	5.6	3.0	5.2	7.2
15	6.8	2.2	6.2	7.2
16	6.6	2.4	6.0	6.8
17	5.8	2.6	6.0	6.4

SENSITIVENESS TO COLOR-DIFFERENCES.

Age.	*D*	*MV*	*B*	*G*
6	9.6	1.8	8.3	9.6
7	9.0	2.1	8.3	9.6
8	8.3	2.3	9.6	7.0
9	6.3	2.2	6.1	6.6
10	5.4	1.9	6.0	5.2
11	5.4	1.7	6.0	4.9
12	5.1	1.5	4.8	5.1
13	4.6	1.7	5.2	4.1
14	4.7	1.4	4.8	4.6
15	4.4	1.1	4.1	4.6
16	4.3	1.3	4.3	4.0
17	3.9	1.4	4.0	4.9

FORCE OF SUGGESTION.

Age.	*H*	*MV*	*B*	*G*
6	42.0	17.0	43.5	42.5
7	45.0	15.5	43.5	43.5
8	47.5	13.5	45.0	49.5
9	50.0	10.5	50.0	49.5
10	43.5	12.5	40.0	44.0
11	40.0	11.5	38.5	40.0
12	40.5	9.0	38.0	41.0
13	38.0	9.0	37.0	38.0
14	34.5	9.5	31.0	33.5
15	35.0	10.5	33.0	38.0
16	34.5	10.0	32.0	38.5
17	27.0	12.0	25.0	31.0

VOLUNTARY MOTOR ABILITY.

Age.	*T*	*MV*	*B*	*MV'*	*G*	*MV''*
6	20.8	2.4	21.0	2.5	19.7	2.5
7	22.5	2.9	22.8	2.7	21.2	2.5
8	24.4	2.9	24.9	3.4	23.9	2.2
9	25.4	2.5	25.8	2.5	25.0	2.9
10	27.0	2.8	27.7	2.6	26.9	2.8
11	29.0	3.3	29.7	3.2	27.8	3.0
12	29.9	3.3	30.3	3.1	29.6	3.0
13	28.9	2.8	29.8	3.0	28.1	3.3
14	30.0	3.6	31.2	3.2	28.0	3.4
15	31.1	3.0	31.3	2.6	29.8	3.2
16	32.1	3.3	33.0	3.0	31.8	3.4
17	33.8	2.9	35.0	2.4	31.5	2.3

FATIGUE.

Age.	*F*	*MV*	*B*	*MV'*	*G*	*MV''*
6	21.4	8.1	22.8	9.4	21.3	7.0
7	21.0	8.9	22.5	9.7	20.2	6.7
8	24.0	7.3	24.7	8.3	23.3	7.1
9	21.0	7.1	22.5	6.7	20.7	7.8
10	22.0	7.5	22.7	7.8	19.0	7.1
11	20.0	6.2	20.3	6.5	18.0	5.5
12	16.0	6.3	18.0	6.0	14.0	6.7
13	14.5	6.4	15.8	6.7	14.7	5.8
14	14.0	6.5	17.8	6.2	12.0	6.1
15	12.7	5.8	13.8	4.9	11.5	5.7
16	14.7	5.2	15.3	4.6	11.7	5.6
17	13.8	5.3	14.5	6.3	13.5	4.3

REACTION-TIME.

Age.	*Ta*	*Tp*	*MV*	*B*	*MV'*	*G*	*MV''*
6	31.7	29.5	5.0	28.2	4.6	29.5	5.4
7	30.9	29.2	5.5	26.7	4.6	31.5	5.2
8	28.7	26.2	3.9	24.5	3.9	26.0	3.1
9	26.9	25.0	4.1	24.3	5.4	25.5	4.9
10	23.3	21.5	3.6	21.0	2.6	22.5	4.3
11	21.0	19.5	3.4	18.5	3.1	20.6	3.4
12	20.7	18.7	3.1	17.8	2.7	19.8	3.5
13	20.5	18.7	3.0	17.8	2.9	20.5	3.5
14	19.1	18.0	2.9	18.0	3.0	18.7	3.0
15	18.4	17.2	2.7	16.7	2.3	18.9	2.7
16	17.0	15.5	2.3	14.7	1.6	17.2	2.6
17	17.0	15.5	3.3	14.7	1.9	16.3	2.6

REACTION WITH DISCRIMINATION AND CHOICE.

Age.	*Ta*	*Tp*	*MV*	*B*	*MV'*	*G*	*MV''*
6	55.8	52.5	6.0	53.5	5.3	51.0	6.5
7	54.1	53.0	8.1	49.0	8.8	52.8	9.4
8	48.8	47.8	6.5	48.0	5.7	47.5	5.5
9	47.5	45.0	6.8	44.5	6.3	46.0	7.2
10	42.2	41.0	4.9	40.0	4.9	41.5	4.5
11	40.5	38.5	5.8	38.7	5.8	38.8	5.7
12	38.9	37.0	5.5	38.5	6.0	37.0	4.9
13	39.9	39.5	5.8	36.0	5.1	41.5	5.5
14	36.3	36.5	4.9	36.7	4.5	35.5	5.4
15	34.8	33.5	4.9	31.1	5.5	34.5	3.8
16	34.0	32.5	4.3	31.5	3.9	35.0	3.9
17	32.1	31.2	4.0	30.5	3.5	31.5	4.4

TIME-MEMORY.

Age.	*Ea*	*Ep*	*MV*	*B*	*MV'*	*G*	*MV''*
6	56.7	62.0	23.4	56.5	25.1	67.0	23.2
7	59.6	66.5	20.2	63.5	20.6	68.5	20.4
8	52.7	54.3	22.8	48.5	22.3	57.0	22.3
9	56.2	60.0	23.5	47.5	22.4	73.5	19.3
10	48.9	48.5	18.1	48.5	21.8	46.5	15.8
11	44.2	41.0	18.2	40.5	16.6	41.0	20.2
12	41.6	36.8	21.3	35.8	21.8	37.5	18.7
13	36.3	33.0	21.4	24.5	22.0	36.0	19.5
14	35.9	30.0	16.1	31.5	14.2	31.0	17.8
15	37.6	38.0	19.4	34.5	15.3	39.0	21.9
16	41.6	44.0	16.7	38.0	16.5	49.0	14.0
17	39.9	35.5	15.8	34.0	13.8	40.0	17.8

The essential results of Dr. Gilbert's study are given in table X.* These tell us with fair accuracy the median ability for every such group as nine-year-old girls or thirteen-year-old boys, and the variability of every such group except in the first three measurements. In these the variability is given only for boys and girls combined.

Just what do these median abilities mean? Just what do the differences between those for six and seven, seven and eight, etc., tell us about the development of mental traits in life? Just what do we learn about human nature from these comparisons of the capacities of children of different ages?

It is clear that an alteration in any mental trait in any individual with age might be due to the mere maturing of some characteristic of original nature or might be the creation of some

* Quoted from Dr. Gilbert's paper, but with some rearrangement.

environmental force. The educational inferences would be exactly opposite in the two cases. In the former we should say: This change comes as a gift from nature which we may not be able to refuse without damaging general growth. It is given as the partial basis and starting point for education. We do not have to try to get it. In the latter case we should say: This change comes as the earnings of training. It is a product of education. With a different training it might be absent. We may lack or possess it as we choose.

Moreover in the case of many measurements of mental traits, for instance those quoted, the change due to an individual's age would be possibly due not only to the maturing of the trait or the influence of training upon it, but also to 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. This complex of traits I shall call general ability in tests. It is even conceivable that the last factor was the sole cause of all the changes quoted above.

Mere knowledge of changes of mental traits with age without knowledge of how their causation is distributed amongst these three factors can not guide us in the development of the trait. For instance, twelve-year-olds do better than eleven-year-olds in addition. Shall we conclude that age causes the difference and that practice in addition between those dates is a waste of time, or that training does it and that if before six we should give as much training as we now do before twelve, six-year-olds would then do as well as twelve-year-olds now? Such knowledge does inform us about what abilities to expect at different ages under the conditions of birth and training of those measured and thus may be of practical service in grading children with similar training, deciding whether they are getting on well in their education, and suiting a curriculum to their capacities. It also allows justifiable comparisons within the tests, such as of the sexes or of the amount of change at various stages in life.

So far upon the supposition that by changes in mental traits with age we mean changes in individuals measured by measuring the individuals at different ages. The average change would then be the average of the changes of all the individuals studied.

But in the quotations given 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 represent 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 can not be sure that the eleven-year olds represent what the ten-year-olds will become.

The first point will be made clear by the following illustration. Suppose that eighteen boys showed at the age of ten and a half years the abilities in some mental trait denoted by the measures in the first column and made the gains during the next year shown by the figures in the second column, their consequent records at eleven and a half years being given in the third column. (Case 1.)

Case 1.			Case 2.		
Ability at 10½.	Change.	Ability at 11½.	Ability at 10½.	Change.	Ability at 11½.
2	5	7	2	0	2
2	5	7	2	0	2
3	4	7	3	1	4
4	3	7	4	0	4
4	4	8	4	1	5
5	4	9	5	3	8
5	1	6	5	1	6
6	3	9	6	1	7
6	3	9	6	1	7
6	1	7	6	3	9
6	1	7	6	3	9
7	1	8	7	1	8
7	3	10	7	4	11
7	1	8	7	4	11
8	0	8	8	3	11
9	1	10	9	4	13
9	0	9	9	5	14
11	0	11	11	5	16
Avg. 5.94	2.22	8.16	Avg. 5.94	2.22	8.16

If instead of this complete record we had simply the figures: 10½ years, Av. 5.94; 11½ years, Av. 8.16; Change in average ability, 2.22, we should lack the essential features of our fact; viz., (1) the variability of the changes and (2) the antagonism

between ability at ten and a half years and growth during the next year. There is an almost inevitable tendency when a single figure is given to represent change to fancy that all children show exactly or nearly that amount of change. This is of course never true. Rate of change as well as absolute ability is variable. And it is precisely in relating the different degrees of progress found in individuals with their original capacities and individual circumstances, that educational insight will accrue. The real individual changes may often prove to be a partial function of the amount of ability already acquired, as in our illustration. The mere change in average ability given above could have come as well from a condition, shown in Case 2, just opposite in this respect to that of Case 1.

Here the better a boy is at ten and a half years the more he gains, whereas before the better he was the less he gained. Case 2 would, I venture to prophesy, be the fact in the progress with age of real mental efficiency, while with physical growth from thirteen to eighteen we should have something like Case 1, the children who had matured early and so attained high stations in stature growing little, while those who matured slowly would keep on growing at a fair rate. In brief the growth of averages does not accurately describe and may positively misrepresent the real growth of the individuals in the group.

Our second point was that the eleven-year-olds tested need not represent what the ten-year-olds would become. The average changes stated in the quotations at the beginning of this chapter were obtained from facts like the following: Ten-year-olds *A, B, C, D, E, F, G, H,* etc., give an average x; eleven-year-olds *L, M, N, O, P,* etc., give an average y. The change in average ability is $y—x$. Now the individuals of the two groups not being identical the chance is given for the fallacy of selection to run riot. The eleven–twelve-year-olds certainly represent only those ten–eleven year-olds who will live; in any test given in schools they represent only the ten–eleven-year-olds who will continue in that type of school. Now if one measures a mental trait in grammar school children from the third through the seventh year of school life he gets for different ages something like the following fig-

ures:* Twelve years, 301; thirteen years, 256; fourteen years, 198; fifteen years, 99.

Nobody can imagine that the fifteen-year-olds here would give anything like a fair sampling of what the twelve-year-olds would become. The brightest twelve-year-olds pass out of the grammar school before they are fifteen. Some mental defectives leave for special institutions. Some moral defectives leave for reform schools or the free life of thievery and trampdom. Some children of very poor parents go to work. If we fill up our quota of fifteen-year-olds by adding 150 to 200 from the high schools we jump from the frying pan into the fire, for they are a selection of the brighter, the more ambitious, those whose parents are fairly well off financially and are intellectually inclined. The opposite action of selection holds of course for five and six-year-olds taken in the first year of school life.

I conclude, therefore, that the progress of mental traits with age has not been and can not be measured by such studies as those quoted. To measure it we must repeat measurements upon the same individuals and for all purposes of inference preserve intact the total fact of all the individual changes, measured in accordance with the statements about measurements of mental traits in a group of individuals made in Chapter II.

It is doubtful how far we know anything about the changes of mental traits with age; it is certain that from the probable changes which can be inferred from the studies made, the part caused by mere maturity has not been analyzed out. How insecure then must be any statements about the different rates of maturing for different functions, about general fluctuations in the rate of growth at different years, about sex differences in mental growth, or about the relation of bodily and mental growth. The plain and direct answers which repeated measurements properly handled would give are entirely lacking. Arguments there are from the observed facts, but they are so intricate and unfinished that it is a question whether it is not wiser to simply state the questions as problems to be solved. Indeed I shall do little more than that.

* Obtained from two public schools in New York City.

1. *The Specialization of Growth with Age.*

We may best take up this question separately in the case: (1) Of powers or capacities such as delicacy of sense discrimination, different sorts of memories, the perceptive functions; (2) of intellectual and emotional propensities, such as fits of rage, liking for puzzles, interest in science; (3) of habits, such as truancy, gambling, biting the nails, business industry, sleeping after dinner; (4) of knowledge, *e. g.*, of addition or spelling, of Latin or anatomy, of how to study.

Of course these divisions all shade into each of the others, but, understanding always that the divisions are to some extent arbitrary, we shall gain clearness by their aid.

1. *Powers and Capacities.*

1. It is a favorite dictum of popular pedagogy that the mental powers ripen in a serial order, that each has its nascent period

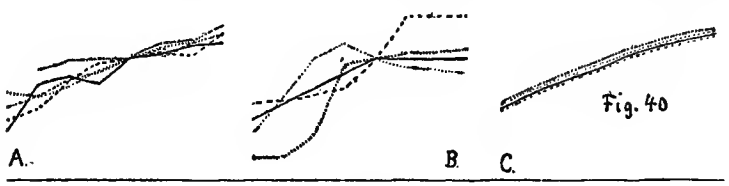


FIG. 40.

when it gains rapidly, holds the stage for a while and then sinks back into relative stagnation while some other waxes, leads and then in its turn passes.

The examination of the facts, however, shows no such antagonism between the rate of growth of one function and that of the rest. On the contrary when we find rapid growth in delicacy of discrimination we find it also in the control of the higher powers, in accuracy of associations and in efficiency of memory and all the rest. General observation gives many competent students the opinion that facility in mere verbal memory does not increase after the age of ten or thereabouts, but the numerous systematic studies that have been made agree in finding a continuous improvement.

The other extreme view, that the mind grows as an absolute unit, all powers progressing at the same rate, is equally unfounded. There are differences in the rates of change of different functions, which would surely appear in the results of repeated measurements as well as in the figures at hand.

There is community of growth in functions, but there is also disparity. The question is not of the existence of these facts but of their amount. If we represent the changes in a power with age by the slope of a line then the facts will not be those of B or C in figure 40, but something like those of A, though the exact slopes in A are not known.

2. Intellectual and Emotional Propensities.

These are specialized in growth in so far as they are due to instinctive tendencies, which are characterized in many cases by a sudden appearance and quick rise to a high intensity from which they may even fall off if they do not bring a sufficient increment of satisfaction to confirm them as habits. For instance, the zeal for physical combat evidently has its birthday in boyhood and commonly dies long before old age.

Any single account of the manner of specialization of growth of these propensities is however an impossibility, for their progress depends little on any universal development of mental structure from within and much upon physical and human surroundings and specific training. Some octogenarians like to fight, some boys to sleep after dinner. Some races never lose the roving instinct that we Anglo-Saxons rarely see after boyhood. Inner nature has a large share in making certain instincts appear at certain epochs in development and last for certain lengths of time, but their future courses are unpredictable save by a complete knowledge of the environmental conditions of the individual throughout life. Their very appearances too, we must remember, may be hastened or delayed or modified in their manifestations by outer circumstances.

3. Habits.

These are obviously specialized in all sorts of ways for the same reasons as were given in the case of 2.

4. Knowledge.

Mere age has almost nothing to do directly with the growth of knowledge, except that the material for knowledge, feelings of 'things' and images, does not appear till toward the end of the first year of life and that in the degenerative processes of old age knowledge often decreases. Indirectly age furnishes time as one condition of the increase in knowledge, a variety of instinctive feelings and acts as another, changes in capacities and powers as a third and new features of the environment as a fourth condition of changes in both the quantity and quality of knowledge.

On the whole the different systems or masses of knowledge go each its own way in development depending on the special nurture they receive. Their rates of progress are necessarily alike only to the slight extent of their dependence upon the community of maturity of capacities and powers.

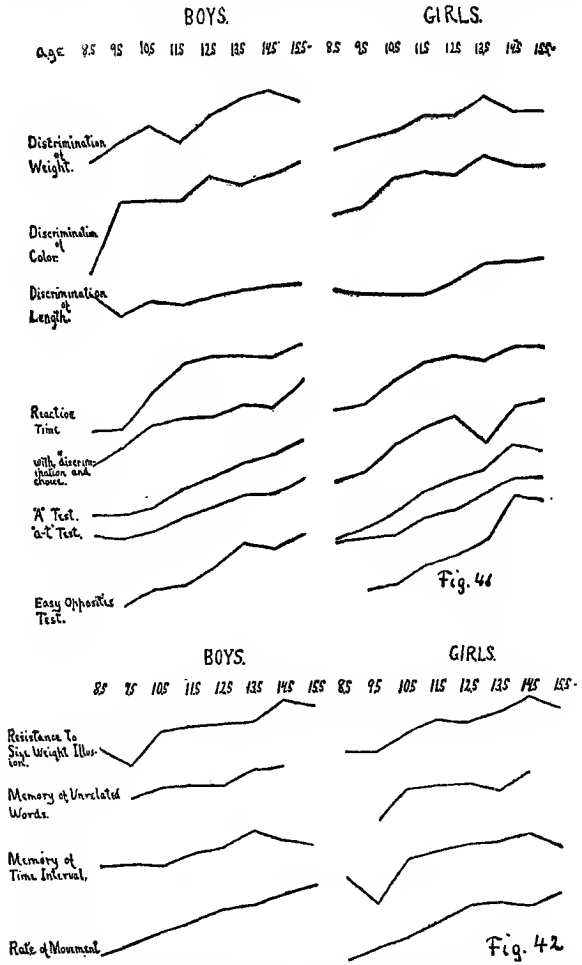
Fluctuations in Mental Growth.

If one picks his way through the facts without being misled by the fallacy of selection into attributing a change in average ability of age groups to age when it is really probably due to the elimination of certain individuals, his conclusion must certainly be that mental growth is very steady.

In figures 41 and 42 are given the average abilities for different ages of such mental traits as have been measured in age groups from eight to fifteen with at least forty individuals in each group.

If we consider these in the light of the probable action of selection, we find no evidence that would justify us in asserting of any one epoch between eight and sixteen that it was the period of most rapid mental growth, or of any other epoch that it was the period of least rapid growth, though I venture the prediction that more complete and accurate knowledge will justify a common opinion by showing a rapid mental growth following upon the rapid physical growth at the time of puberty. At present, however, there is insufficient evidence. There is certainly no very great fluctuation, for such would appear clearly even in the few and confused statistics that we do possess.

The reader must not forget that fluctuations in the growth of individuals are to a large extent independent of the fluctuations



FIGS. 41 AND 42. An upward slope of the line means improvement. The degree of slant represents the amount of improvement. These amounts are in every case measured in terms of the variability of twelve year olds as a unit. The different tests are thus rendered as nearly commensurate as may be. The top left hand figure would thus read: At 8.5 years the delicacy of discrimination of weight is 1.53 below that of 12.5 year olds, 1.00 equalling the mean variation of 12 year olds; at 9.5 years it is .87 below that of 12.5 year olds; at 10.5, .33 below; at 11.5, .87 below; at 13.5, .53 above; at 14.5, .80 above; at 15.5, .47 above. The progress is thus: 8.5 to 9.5, a gain of .66; 9.5 to 10.5, a gain of .54, etc.

of the averages. *A* might go up and down and *B* at the same period go down and up with no effect upon the average. How

Sex Differences in Development.

often and to what extent such individual fluctuations occur will be ascertained when repeated measurements of mental traits are taken over a number of years.

If we compare the progress for boys and girls shown in figures 41 and 42, once more keeping in mind the changes that might be made by proper measures of growth, we find no clear and emphatic sex differences. Figure 43, which gives the averages for different ages, in those functions where we have the least inadequate information, also fails to show any difference of practical importance.

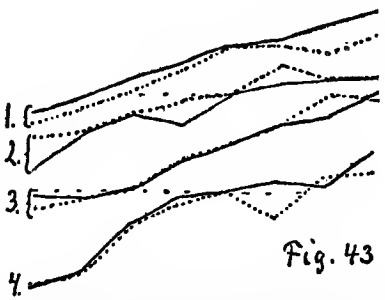


FIG. 43. Drawn in the same manner as 41 and 42, save that the continuous lines represent the progress in the case of boys and the broken lines that in the case of girls.

The Relationships between Physical and Mental Growth.

These can not be profitably discussed until repeated measurements are at hand. The correlation between changes in physique and changes in mental traits *in individuals* and not between the average changes in groups is the measure we need. At present one can only guess at them.

Lest the reader put undue emphasis upon these comments on the specialization of mental growth, its fluctuations, sex differences and the connection between bodily and mental growth, I repeat again that the facts necessary to fully justify conclusions of any sort are still unknown.

CHAPTER XI.

SEX DIFFERENCES IN MENTAL TRAITS.

The general practice of systematic and home education has been to treat boys and girls differently. Unreasoning tradition has for the most part been the basis of practice, but recently as the result of a growing tendency, strongest in America, to eliminate differences of training, there has been a conscious effort to attain a theoretical basis for both the old and the new practices. This effort has been guided more by hopes, fears and prejudices than by calm logic and pure scientific curiosity, and the literature representing it is not of the most satisfying candor.

By way of preface to our account of sex differences let us note first that their existence does not necessarily imply in any case the advisability of differences in school and home training, and per contra that even if the mental make-up of the sexes were identical it might still be wisest to educate them differently. It is true that a difference of two groups in a mental trait will theoretically involve differences in treatment, but practical considerations apart from that of developing the highest efficiency in that trait may outweigh the advantages of the differential treatment. For instance, consumptives theoretically need a different mode of life from people with healthy lungs, but it might in some cases be wiser to leave a consumptive to his ordinary habits rather than to cause in him consciousness of his disease and worry concerning it. On the other hand, two boys might be identical in mental structure, yet their education might best be quite different if we wished to make one of them a chemist and the other a psychologist.

Let us note in the second place that the existence of differences need not imply the need of different training, because those very differences may have been due to the different training actually received and might have never appeared had training been alike in the two classes. It is folly to argue from any mental condition in an individual or class without ascertaining whether

it is due to original nature or to training. And the contents of this chapter should properly have appeared under the two separate headings of 'the mental traits due to the differences in the environments acting upon the two sexes' and 'the mental inheritance correlated with sex.' It is only because in most cases we are ignorant of the most important fact of all, the causation of the sex difference in question, that we are driven to the unsatisfactory method of describing sex differences and adding here and there what evidence we can about their causes.

A further caution is necessary before this description and incomplete analysis begins. It is not to confuse differences in behavior, achievement and mental activities indirectly caused by physical traits with such differences directly caused by mental traits. Lack of muscular strength and the phenomena intimately associated with bearing children may serve as samples of such physical traits. Only 10 per cent. of women are stronger than the weakest 5 per cent. of men! Consequently even if women possessed mental capacities for business identical with those of men, they still would not in active work do as much.

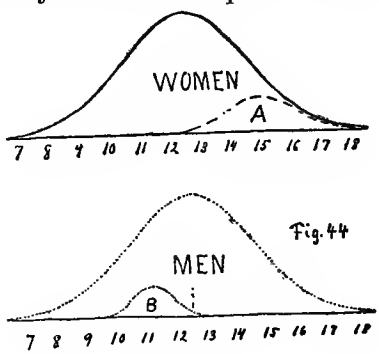


Fig. 44

Fig. 4.

In the fourth place the fallacy of selection must not be forgotten in our comparisons of men and women. Comparison will never be justifiable unless the men and women taken as samples are selected from the same sections of the two surfaces of frequency for the trait in question. We learn nothing but errors about men and women in general by naïvely comparing directly the two groups represented by *A* and *B* in figure 44.

For instance, any inference from a comparison of young men and women in college or of working women with men in the same profession is untrustworthy. College women and college men are two classes selected by different agencies. For instance, of the children of fashionable people many girls go to academies to be adorned for life's leisure, while their brothers go to college. Again

the intellectual impulse is relatively a more powerful agent in sending girls to college, while convention and the demand for a pleasant social and athletic life act more powerfully on boys. In the case of an industry, say laundering, women are selected by relative ignorance, strength, widowhood, drunken husbands, etc., while the men are selected largely by Chinese birth. Let not the bizarre nature of this particular illustration blind us to the fact that women and men physicians, lawyers, stenographers, teachers or government clerks represent different samplings of the two sexes. It is possible theoretically to make a discount for the differential influence of selective agencies and thus permit a fair comparison, but actually such a procedure is well-nigh useless. The advocate of male superiority in intellect might thus say that high school teaching selects from the higher ranks of female intellect and from mediocre ranks of men, yet men teachers of this species are brainier. But the major premises may be doubted. Perhaps relative poverty is the chief factor that selects women for high school teaching.

As always, the safest comparison will be one of the two total distributions. If, however, the distributions are normal the center of gravity alone may be used and if we allow for differences in variability, the measures of any percentile grade. For obviously if the two distributions are of equal variability the measure of the highest man or the seventh highest in a hundred or the twenty-fifth highest or the sixteenth from the lowest or any other will be as much above or below the measure of the woman holding a corresponding position among women as the average man is above or below the average woman. In many cases comparison of the upper limits in a trait is much more convenient than that of averages. We shall profit therefore from ascertaining whether or not the sexes are of equal variability. What the influence upon comparison of unequal variability would be need not concern us until we find it to be the fact.

Besides its importance as a prerequisite to any comparison of the general amounts of a mental trait present in the two sexes, knowledge of their variability is intrinsically of importance. Let us suppose, for instance, that the average morality for men and

women is the same and call its amount *m*. Let us suppose that the standard deviation of men from *m* is .1 *m* and for women .3 *m*. Then all the men* will be between .7 *m* and 1.3 *m*, the best man being not quite twice as good as the worst man. The limits for women however will be .1 *m* and 1.9 *m*, the best woman being nineteen times as good as the worst. Nearly 16 per cent. of women will be better than the best man and nearly 16 per cent. worse than the worst man. Thus, though the average morality is the same, we have differences of tremendous practical moment. The great acts of honor, philanthropy, nobility and sacrifice would all be due to women. At the same time they would commit all the basest of crimes and iniquities. They would lead in all moral endeavor but would also fill the jails and dens of wickedness, while the men would present lives of equable uninteresting mediocrity of both vice and virtue. If the reader will contemplate the practical importance of a similar difference in the variability of the sexes in intelligence, originality, musical talent, piety and other traits he will see that its measurement is in no wise an academic luxury or the perverse fad of theoretical statistics.

In studying sex differences both in the amounts of mental traits and in their variabilities, it is important to treat different ages separately. For in the first place any sex difference that did exist would perhaps appear only after puberty and increase up to the time of physical maturity, and in the second place the meaning of sex differences for educational theory varies with the age when the difference exists. Differences in adults must be considered in connection with the question of different aims in the education of the two sexes, but may only indirectly recommend differences in the means and methods with children in the grammar school period. Differences in boys and girls will bear directly upon the practical questions of coeducation, curriculum, hours of attendance and methods of teaching.

The Variability of the Sexes in Mental Traits.

It is a common belief that the male is the more variable. Karl Pearson has, to use his own words, 'laid the axe to the

* More precisely 9,974 out of 10,000 of them.

root of this scientific superstition' in the case of physical traits, but his measurements are of a narrow range and his opponents still find reasons for persisting in their view.

In comparing the variabilities of the sexes we must of course make an allowance for differences in absolute ability. If the same law governed the variations in height of six-footers and five-footers the absolute variability of the former would still in figures be larger than that of the latter. The absolute variation in the length of the sermons, for instance, would be much greater than that in the length of the sentences of which they were composed, but really the latter are much more variable. We may make our allowance by taking the proportion of the average or median that the variability is. This figure is called the coefficient of variability.

It is unfortunate that so little information is available for a study of sex differences in the variability of mental traits in the case of individuals over fifteen. Such statistics as I have been able to secure give measures in 26 objective tests, with from 100 to 1500 individuals, and in 25 records of school marks with from 60 to 1,000 individuals.

The comparisons in the case of reaction time, reaction time with discrimination and choice and time memory are based on the measurements given by Gilbert (Yale Studies, Vol. II, 40–100). For the data in spelling, arithmetic and in the r-e and o-n tests I am indebted in part to Messrs. E. L. Earle, W. A. Fox and L. W. Cole.

The nature of the material, which represents measurements taken by different individuals and often with only small groups, makes inferences from details unreliable. The data would be slightly more accurate if all records had been reduced to a common month age at least, but this could not be done with the measurements taken by other observers than myself and would involve an amount of labor out of proportion to the increase in accuracy. The main facts that are relevant to our present purpose are as follows:

TABLE XI.

RATIO OF FEMALE TO MALE VARIABILITY.

By ages.	9	10	11	12	13	14	15	16	17
A test	.86	1.11	1.04	.94	1.08	1.03	1.07		
A-t test	.91	1.05	1.05	1.07	1.35	1.07	.73		
Easy opposites test		.97	.81	1.10	1.24	.89	1.15		
Word test			1.05	.91	.85	.87			
Memory (related words)	.77	1.37	.93	.72					
Memory (unrelated words)	.77	.46	.94	.66	.77	1.28			
Discrimination of length	.75	.80	.81	.98	1.04	.70	.78		
Simple and discriminative reaction time	.98	1.21	.98	.93	1.00	1.11	.83	1.14	1.22
Time memory	.56	.75	1.21	.82	.85	1.27	1.26	.66	1.06
General ratio. Average			.92			1.025	.97		
Median			.93			1.035	.95		

The chances are 1 to 1 that the true result will not vary from the one obtained by more than .023 (9–12 yrs.), .04 (13–14 yrs.), .055 (15 yrs.).

By grades.	4	5	6	7	8	1st high.
R-e and o-n tests	.77	1.19	.97	.82	.85	
Spelling	.55	.69	.55	.68	.68	
Addition	1.00	.91	1.06	.85	.97	
Multiplication				.56	1.15	

In a number of tests (six in all) the ratio of first-year high school girls to boys in variability was .975.

In tests in arithmetic (six in all) the ratio of high school girls to boys in variability was .96; in regents' examinations in Latin, English and in history, it was .96; in school marks in eight subjects, it was on the average .86.

In college marks in fourteen different courses the ratios averaged .85.

These facts make it extremely probable that, except in the two years nearest the age of puberty for girls, the male sex is slightly more variable. From the time of puberty for boys to maturity this difference seems to increase rapidly, though the records of marks which support this conclusion are not the best of evidence. The difference in variability is not sufficiently great to make any radical change in educational methods advisable, but does perhaps explain in part the general experience of teachers that the most striking cases of intellect, character and behavior are commonly boys. It also proves conclusions about the capacities of the sexes in general based upon the comparison of the extremes in both cases to be certainly risky and probably false. For instance, suppose that we picked out the hundred most gifted

intellects from a million men and a similar hundred from a million women. Even if in both sexes the average intellectual ability was identical we should, if the variability of women was 95 per cent. of that of men, probably find no woman of our hundred who was equal to any one of the hundred men. Conversely if we were arguing concerning the general moral superiority of women from a comparison of the frequencies of criminal offenses in the two sexes.

Differences in Ability.

The general facts which appear from such measurements of sex differences in mental abilities as I have been able to collect or make are given below. The material used in the comparison is essentially the same as was used in comparing the variabilities of the sexes. To make the measures comparable I have stated them in terms of the percentage of boys who reach or exceed the ability shown by 50 per cent. of girls. If the sexes are equal then, the figure will be 50. If the figure is 99, it means that all but one per cent. of boys are better than the median (practically the same will hold for the average) girl. Unless the figure is under 25 or over 75 the difference does not amount to much practically. This may be seen clearly from the diagrams of figure 45, which show approximately the forms the distributions will take in the case of various differences. This method of stating differences has the advantage of showing the amount of resemblance at the same time as the amount of difference and of freeing figures from ambiguities due to differences in the scales of measurement or in the variabilities of the traits. Moreover from the extent to which the two groups coincide we can determine the practical importance of a differentiation of school work to meet the sex difference in ability.

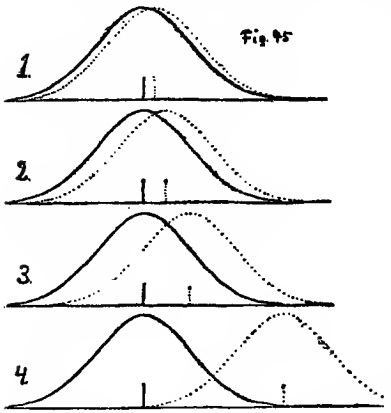


FIG. 45. The dotted lines enclose the surfaces of distribution for boys and the continuous lines those for girls. 1 shows how very similar the abilities of the sexes are in a casewhere 60 per cent. of boys reach or exceed the median for girls, 2 shows the facts when about 69 per cent. of boys reach or exceed the median for girls, 3 the facts when the percentage is 84, and 4 when it is 100.

TABLE XII.

SEX DIFFERENCES IN ABILITIES.

IN THE CASE OF BOYS AND GIRLS 8–14 YEARS OF AGE.

In delicacy of discrimination	56%	of boys who reach or exceed the ability reached or exceeded by 50% of girls.		
In reaction time	57%	"	"	"
In tests of the associative and conceptual processes, *e. g.*, opposites test, alphabet test, addition, multiplication, word test	48%	"	"	"
In the rate and accuracy of perceptive processes	33%	"	"	"
In temporary memory	40%	"	"	"
In spelling	33%	"	"	"
In resistance to the size weight illusion	55%	"	"	"

IN THE CASE OF BOYS AND GIRLS 15, 16 AND 17 YEARS OF AGE OR OF GROUPS TAKEN AS FOUND IN HIGH SCHOOLS.

In sense discrimination	60%	of boys who reach or exceed the ability reached or exceeded by 50% of girls.		
In reaction time	76%	"	"	"
In tests of the associative and conceptual processes	50%	or > "	"	"
In English (regents' examinations and school marks)	41%	"	"	"
In mathematics (regents' examinations and school marks)	57%	"	"	"
In Latin (regents' examinations and school marks)	57%	"	"	"
In history (regents' examinations and school marks)	60%	"	"	"

IN THE CASE OF COLLEGE STUDENTS.

In English about	35%
" mathematics about	45%
" history and economics about	56%
" mental sciences about	50%
" modern languages about	40%

These figures are not to be taken without remembrance of the fact that in the colleges whence they came the selection of women is the narrower and probably the better.

It is clear in the case of the mental traits that have been measured, (1) that the two sexes occupy almost the same stations, (2) that the greatest difference is the female superiority in the perceptual processes.

This difference accords well with the time-honored theory that in the perceptual and absorptive powers the female leads. The other half of the theory, that the male is the more aggressive and logical is not verified by our figures. It is unfortunate, as I suggested earlier in this chapter, that the measurements of individuals over fifteen are so scanty and so confined to school abilities.

The differences in ability, like those in variability, are not of sufficient amount to be important in arguments concerning differentiation of the curriculum or of methods of teaching in conformity with sex differences. They may serve perhaps to make the expectations of teachers and superintendents concerning the accomplishments of pupils somewhat more rational. In strict justice, for instance, we should in school work, as in scientific investigations, assign any one marks in relation to the average for his sex. And of course the figures have a great value as a rebuke to those who indulge in wild speculations about this or that great difference between the capacities of boys and girls.

We have now to turn from a careful and fairly satisfactory study of sex differences in a score or so of mental traits all of the type of intellectual capacities, to a looser discussion of the life of feeling, action and general achievement. Here precise measurements will be seldom at our service.

The most striking difference in instinctive equipment consists in the strength of the fighting instinct in the male and of the nursing instinct in the female. No one will doubt that men are more possessed by the instinct to fight, to be the winner in games and serious contests, than are women; nor that women are more possessed than men by the instinct to nurse, to care for and fuss over others, to relieve, comfort and console. And probably no serious student of human nature will doubt that these are matters of original nature. The out and out physical fighting for the sake of combat is preëminently a male instinct and the resentment at mastery, the zeal to surpass and the general joy at activity in mental as well as physical matters seem to be closely correlated with it. It has been common to talk of women's 'dependence.' This is, I am sure, only an awkward name for less resentment at mastery. The actual nursing of the young

seems likewise to involve equally unreasoning tendencies to pet, coddle, and 'do for' others. The existence of these two instincts has been long recognized by literature and common knowledge but their importance in causing differences in the general activities of the sexes has not. The fighting instinct is in fact the cause of a very large amount of the world's intellectual endeavor. The financier does not think for money nor the scientist for truth nor the theologian to save souls. Their intellectual efforts are aimed in great measure to outdo the other man, to subdue nature, to conquer assent. The maternal instinct in its turn is the chief source of woman's superiorities in the moral life. The virtues in which she excels are not so much due to either any general moral superiority or any set of special moral talents as to her original impulses to relieve, comfort and console.

Training undoubtedly accentuates these inborn differences since boys play more with boys and are trained more by men, the opposite holding with girls. A reversal of training by which girls would be surrounded by the social milieu now affecting boys would, as we often see in isolated cases, lessen the sex difference. But we may be sure that if we should keep the environment of boys and girls absolutely similar these instincts would produce sure and important differences between the mental and moral activities of boys and girls.

Since these differences in instinctive equipment are true causes it seems wise not to invoke other less probable traits to account for any fact which these seem fairly adequate to explain. For instance, if the intellectual achievement of men was found to be superior to that of women we could explain it either by an actual difference in intellect or by the zeal and activity due to the fighting instinct. Our rule would be to exhaust first the influence of the known physical differences and second the influence of the instinct in question. Only if these were inadequate should we resort to the hypothetical cause of differences in purely intellectual caliber.

On the basis of the facts known a decade ago Havelock Ellis* chose as general sex differences the greater variability, affectability and primitiveness of the female mind. The first point has

* 'Man and Woman.'

been discussed fully. By affectability he means not only greater impressibility by and responsiveness to stimuli of all sorts, but also less inhibition of the emotions and other instinctive reactions. The fact seems indubitable though its exact amount can not be even roughly estimated. Not only the superiority in tests of perceptual power and the greater suggestibility which we have noted, but also the relative frequency of dreams, trance states and emotional outbreaks and the common differences between our treatment of the men and of the women with whom we are associated, witness to it. In his evidence for and discussions of the primitive nature of women Mr. Ellis seems to have physique in view primarily. How far women resemble uncivilized races and children in mental make-up is, to me at least, not at all clear.

The same author emphasizes as so many others have done the fact of female dependence or lack of aggressiveness in intellect. The qualities that we call original, constructive, organizing and critical are ill defined and comparisons are hard to arrange because men and women have devoted the active powers of the intellect to such different fields. Comparison of the most eminent representatives from both sexes is obviously unfair in so far as men are more variable.

If we are to believe the novelists and playwrights women are more concerned with their own feelings and personalities than men, are emotionally more subjective. This is not inconsistent with the existence of greater sympathy of the motherly sort, nor with the possibly superior gifts of men in the examination and intellectual manipulation of subjective conditions. An interesting bit of evidence supports the conventional view of fiction. Many people carry on as a systematic day dream a continued story in which they figure and which possesses its interest from the chance it gives to think pleasantly of oneself. Three and a half times as many women as men do this (46.7 per cent. and 13.5 per cent.).*

* Mabel W. Learoyd, 'The Continued Story,' *Am. J. of Psy.*, Vol. VII., pp. 86–90.

CHAPTER XII.

EXCEPTIONAL CHILDREN.

From the discussion of the distribution of mental traits in Chapter III. it was evident that unless peculiar causative or selective agencies are at work there will be a few individuals who will possess so little of any given capacity or quality as to be obviously 'defectives' in it, as well as a few who will possess so much as to be obviously 'prodigies.' There will be a larger number who will possess so little as to merit the popular term 'weak' in color vision, memory, self-control, moral sense, general intelligence or whatever the trait may be. They again will be balanced by an approximately equal number of 'remarkable' or 'exceptionally gifted.'

If the mental trait in question is the compound of many traits which we call intelligence we shall find at the lower end of the distribution curve children whom medical diagnosis would name idiots, and next them a number who would be termed imbeciles, and nearer still to the average the group to whom the name weak or feeble-minded would be applied. If the mental trait is the compound called 'morality' the individuals at the low extreme will perhaps be diagnosed as cases of 'moral insanity' or as 'moral degenerates.' If the trait be more specific, for instance if it be ability to learn to spell, ability to learn to read, cruelty, musical ability, memory, visualizing power or what not, we shall find few if any special names for different degrees of its possession, though there will as truly be defectives in respect to any such specific mental trait as in respect to general intelligence.

The means which educational endeavor will use and the results which may be expected from it will in the case of any individual depend upon his station in the trait in question. No one unless he were himself an 'idiot' in the trait of common sense would train a genius and an idiot alike or expect them to develop alike. At present there is a widespread practice of providing separate treatment at home or in institutions for idiots and im-

beciles, though some are to be found in the common schools. And there is a growing demand for institutions and separate classes for the feeble-minded. Notable moral defectives are being cared for in separate classes in some cities. They also, when the parents are wealthy, find refuge in private schools of a certain type and in the somewhat mercenary ministrations of private tutors. The children exceptional in their great superiority to the average are not systematically given any special attention except here and there by systems of rapid promotion. Exceptionally high- or low-grade children in any single trait are unprovided for apart from the wisdom of parents or teachers.

For the proper treatment of exceptional children we need knowledge of the exact distribution of all the mental traits which we desire to develop or abolish, of the causes which determine an individual's station in each, of the symptoms by which we may conveniently find out any one's station in each, and of the agencies, educational, hygienic and medicinal, which alleviate or intensify the different conditions. The last involves the study of the differential action of stimuli upon individuals of different stations. For instance the training of idiots should rest upon:

1. A consideration of the distribution of intelligence which will tell us what the frequencies of different degrees of low mental capacity are.

2. A study of the extent to which original nature decides an individual's station in intelligence and of the displacements of individuals from their original station to a lower station by accident, disease, unwise training, etc.

3. A study of the physical and mental symptoms which enable us to measure a person as very, very low in intelligence.

4. A study of the influences of climate, food, operative surgery, medicines, manual work, school work, good and bad example, etc., which make the mental condition better or worse.

In the case of idiocy, imbecility and pronounced feebleness of mind, psychology, mental pathology and medicine could show a respectable array of facts for the student, though precise quantitative studies fit to serve as models for study are lacking. We know at least roughly the frequency of intellects so defective as to disturb the home, resist school influence and excite popular

pity or derision (about 1 in 500). We know that in all probability by original nature human beings are distributed according to a frequency curve with some elimination at the low end, and that one's ancestry decides one's position; that the ordinary circumstances of life in which people differ do not much alter one's position compared with his fellows, but that many special influences, *e. g.,* brain injuries, hydrocephalus, cretinism, scarlet fever, etc., may displace a person to a lower station. Some of these influences probably act indifferently upon individuals of all original stations, so that so far as concerns them idiocy may be caused in one of the most intelligent ancestry. On the other hand many of these produce idiocy only upon the fertile soil of originally weak mental structure. As regards symptoms we are not so well off as we may hope to be in the future. Idiocy can not be recognized as early in life as it should be nor always distinguished from mere backwardness, nor can its different degrees be measured with convenience or with precision. As regards treatment for amelioration we have a great amount of information, though not all of the best quality.

But if we look for similar information concerning other mental defects we are doomed to disappointment. And exceptional children at the high end of the distribution curve have been so little studied that the very words exceptional and abnormal are commonly used to refer only to those exceptionally defective. A systematic treatment of the whole subject is thus out of the question and we must be content with (1) a series of rather disconnected and ill-proportioned comments representing the present state of knowledge and opinion on matters which concern educational theory and practice and (2) an outline which will suggest what we ought to know but do not.

Exceptional Superiority.

The greater the superiority in any mental trait or combination of traits the rarer it is. This decrease in frequency is roughly that of the normal frequency curve of Chapter III.

Exceptional superiority almost certainly exists in the case of every mental trait or combination of traits.*

* Possible exceptions here and in the case of exceptional inferiority would be traits where over a certain amount, say x, or under a certain

Some of the obvious and practically important cases are:

Total intelligence.
Mental balance.
Efficiency or capability.
Energy.
Quickness of mental processes.
Breadth of mental processes.
Strength or intensity of mental processes.
Abstract power.
Permanence of memories.
Mathematical ability.
Musical ability.
Ability in drawing or painting.
Mechanical insight.
Steadiness.
Courage.
Sociability.
Affection.
Enthusiasm.

The list might of course be indefinitely prolonged.

Causation.—The causation of exceptional superiority is original nature plus or minus a displacement, commonly slight, due to environmental influence. The environment may displace a person downwards to a great extent, but upwards much less easily. The forceps of the physician, the strain of disease, the shock of brain concussion, may reduce original superiority to pronounced defect; but medicine, favorable training and the impetus of zeal seldom elevate a mediocre person to top rank. In the case of the combination of gifts which we call intelligence they never do, for it is only by the concentration of much energy in a narrow line that an originally inferior person becomes superior. For him to do so in all lines is impossible.

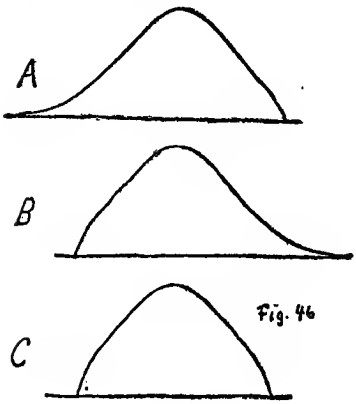


Fig. 46.

amount, say y, of a mental quality would prevent survival, while conditions just below x or just above y would be much more favorable. We should then have distributions like *A*, *B* or *C* in figure 46, according to whether the first or second or both of these hypotheses were the fact.

Diagnosis.—The symptoms of superiority in any trait are clear when the trait itself can be directly measured. It is easy to tell an exceptionally good speller in school or scientist in adult years or soldier in war or orator in the pulpit. But when we have to infer the future from present and past symptoms in young children or judge a general trait from a few particular manifestations, our inferences lack surety and precision. Superior efficiency in life's work, for instance, is not at all clearly shown by superiority in school tasks; success in formal grammar is not clearly symptomatic of general abstract ability; the best boy in a thousand in discriminating length may not turn out much if at all above the average in general keenness of sense discrimination. When the relationships of a great many mental traits have been worked out in the way shown in Chapter IV., any one measurement will serve as a symptom to an extent now impossible. At present a wise rule is never to infer from a symptom any condition which moderate effort will enable you to measure directly, and never to infer future conditions from present symptoms without continuing observations into the future and modifying your inference as they direct.

Control.—The development in individuals of a trait in which they are exceptionally superior would undoubtedly be aided by training different from that of those who approach the modal condition, but as to what sort that training should be our concrete intuitions will be as good a guide as any theory psychology can now offer. In general superiority seems to show a comforting power to look after itself and get on with almost any training.

Exceptional Defects.

Existence and Amount.—The distribution of mental traits at the low end has not been determined, for the children accessible to the scientist in schools probably do not include all of the children defective in any important particular. Most of those who are very deficient in general intelligence are sure to be secluded at home or in institutions. Some of the moral defectives will be in reform schools, or will be habitual truants or the companions of thieves and tramps, or will be in the care of private schools or tutors. To a less extent those very deficient in memory or

abstract power or nervous control will tend to disappear for a longer or shorter time from the schools. It is probable that the distribution in many cases would deviate somewhat from the normal, taking a form like figure 47. The increase of defectives over the probable frequency would be due to the action of environmental forces which may lower a person from almost any station but do not raise him far. For instance there seem to be many more people totally blind than just able to see, the passage from good eyesight to blindness being more frequent than the opposite.

FIG. 47.

Exceptional inferiority characterizes some members of the human species in almost every mental trait or combination of traits.

The list given on page 124 is appropriate here. Attention may also be called to defects of the senses; defects of attention; defects of nervous action, *e. g.,* chorea; to the cases where a very great amount of a trait is a defect, *e. g.,* cruelty or the instinct to possess oneself of what one desires; the minor automatisms, such as biting the nails or counting groups of objects; morbid or useless impulses, such as touching every tree one passes; and fetichisms, *e. g.,* great affection for a red rag.

Causation.—The causes of exceptional defects are the same as of exceptional superiority, but, as has just been said, environmental causes play here a more important rôle. Their action has been carefully studied only in the case of defects of sight, hearing, nervousness, choreic disturbance, general intelligence and the psychological defects with which medical practice deals. To the medical literature on these topics the reader is referred with the warning that precise quantitative statements will unfortunately rarely be given.

Diagnosis.—What was said about symptoms in the case of exceptional superiorities may be applied equally here. In the case of general lack of intelligence there will be some special facts to be noted. Such additional information is also at hand in the case of those other defects which have received the attention of medical

science. The reader is referred to text-books on sense defects, on children's diseases and on idiocy and imbecility.

Control.—We know almost nothing about the remedial action of special forms of training upon those mental defects which medical practice has disregarded. Leaving one side such means as should be prescribed and administered by a physician, we may make the following recommendations:

For nervousness: out-of-door life, much absolute rest, freedom from competitive work and the exciting features of school and social life, but not from participation in both physical and mental work.

For hysteria: out door life, removal from the home environment, calm but insistent training in good habits, the example of a well-balanced, unemotional teacher, objective interests in nature, industry and human affairs, freedom from the exciting features of school and social life.

For general intellectual weakness: removal to a special institution, a stimulating physical and mental environment (though not for the few cases complicated with great nervous irritability), stirring physical play, out-of-door life, systematic stimulation of the senses and of curiosity, the arousal and direction of bodily movements, systematic physical training.

The teacher or the consulting psychologist needs the cooperation of the physician in almost all cases of mental defect. Their causes, symptoms and relief are all connected with physical changes. These are sometimes apparent to the ordinary practitioner, as in defective school work due to indigestion or nasal or throat obstructions; sometimes apparent to the specialist, as in defective ability to read and spell due to retinal defect; sometimes unrecognizable but yet doubtless existing, as in defective ability to form general and abstract notions.

General Mental Defect.

The psychology of those deficient in general intellect (idiots, imbeciles and the feeble-minded) has been discussed at some length by many students. The chief questions concern classification, causation, symptoms and treatment. The aim of this section will not be to review the facts and opinions that have been

stated, but simply to help the reader to study the literature of the subject intelligently.

English writers agree in using the terms idiots, imbeciles and feeble-minded to refer in order to the three lowest conditions of intellect. This common use makes the terms very convenient, but it is certain from our knowledge of the distribution of mental traits that any effort to separate sharply idiocy from imbecility and the latter from feebleness of mind must fail. The words are but names used roughly for sections of a continuous surface of frequency. The obvious thing to do is to arrange a scale of intellect and describe that of each individual by his precise station on that scale, not by a vague name.

Numerous more detailed classifications have been proposed, some on the basis of mental traits, *e. g.*, the degree of capability in attention, the capacity for feeling relationships, the efficiency of the senses and motor apparatus; some on the basis of the conditions accompanying them, *e. g.*, a classification into paralytic idiocy, epileptic idiocy, syphilitic idiocy, etc.; some on the basis of causation, *e. g.*, a classification into congenital and acquired.

The fact is that the varieties of human nature referred to by the words idiot, imbecile and feeble-minded, are numerous, that all sorts of combinations of mental qualities, accompanying diseases, causes and physical stigmata occur and that no simple classification can be adequate for all purposes. To grade idiots before courts of law or for asylum treatment a classification by mental ability as measured by attentiveness or some other mental traits may be best; to provide for medical treatment their separation into groups according to concomitant diseased conditions may be wise; for medical science the brain changes correlated with the mental conditions may be the key to the useful classification; and so on through possible classifications for prophecy of amelioration, for educational treatment, for psychological analysis, etc.

I suggest as one of the most fundamental and useful classifications a division into: (1) Those whose condition is due to original nature, who hold the position in the scale of intelligence which the make-up of their germs decreed, and (2) those who by accident or disease have been displaced downward from their original positions in the distribution scheme. The condition of

members of the first class should as knowledge advances be capable of early diagnosis; they should possess many characteristics in common and allow of further subclassification; medical treatment would be relatively inefficient, but from wise educational and hygienic control we should expect much. The second class would present fewer characteristics in common; strictly medical or surgical treatment would be of more importance than educational training; they should be studied in connection with mental diseases in general. Roughly it would be fair to say that for the first class we need psychologists and special schools, while for the second we need physicians and hospitals.

It seems desirable further to separate children who are feeble-minded and are destined to remain so from those who are simply backward in mental growth and may eventually reach a fair station. We know that in physical growth some children who from six to twelve or thereabouts are far below average stature for their age, in later years make up part or all of the deficiency, and there are many reasons for believing the same to be the case with mental growth. The essentially dull should never be confused in theory or in actual treatment with those temporarily deficient.

To the discussions of the causation of idiocy, imbecility and feebleness of mind in the standard texts I have nothing to add save that where so complex and so interrelated causes are studied, great help will come from more precise measurements of amount and from estimating the efficiency of partial causes by the coefficients of correlation between them and their supposed effects, and between different ones amongst them.

In the case of the symptoms of these conditions also, precise measurements with objective tests would permit an advance in knowledge which is impossible so long as cases are studied by an undefined general examination and described by the loosest of adjectives.

Amongst the recommendations for educational treatment those which are in accord with the following facts should be given especial weight: (1) Learning by the unconscious selection of reactions which produce pleasure and elimination of reactions which produce pain, is widespread throughout the animal kingdom and may be depended upon when learning from explanation, in-

sight and general principles is impossible. (2) The lower the mental capacity of an individual the closer in time must the pain or pleasure follow the reaction. (3) The connections between impressions and obvious movements of the body are more easily formed than between impressions and ideas or the more subtle movements of the muscles of the face, throat and trunk which perhaps always parallel ideas. The first type of connections may be formed in individuals incapable of the second. The so-called kindergarten and manual training methods are therefore particularly suited to defectives. (4) Mental defect often involves a sluggishness of action on the part of the nervous system which makes a rapid succession of stimuli interfere with each other and result in mental confusion, and necessitates the continuation of the same stimulus over a long interval or its repetition. (5) The extreme narrowness of the field of attention and the inability to control sudden alternations of attention from one topic to another and back make it necessary for the teacher to take up but one small issue at a time, to progress along one single line. (6) Knowledge of relations, including appreciation of general and abstract notions and the symbols for them, is practically beyond the capacity of these inferior minds. It is therefore wisdom not to pretend to give it and economy not to try. They need sense training, object lessons and concrete work throughout. (7) Suggestion is potent here as elsewhere. By treating the feeble-minded like normal children as far as is possible we help to make them more normal. They should have their school, church, entertainments, trades, excursions, etc. They should not be made to appear peculiar in dress or encouraged in eccentric habits.

Exact Measurements of Exceptional Children.

Johnson* made in the case of 72 feeble-minded and idiotic children measurements of the memory span for digits, of certain features of motor control and of the time of uncontrolled association of ideas. It is difficult to interpret his results because he does not give the total distributions nor provide the most desirable data for comparison with ordinary children. His most elaborate study is of the memory span for numbers, where he dupli-

* *Ped. Sem.*, Vol. III., pp. 246–301.

cates certain tests made by Galton with 44 feeble-minded girls. Comparison with normals is only roughly possible, owing to differences in the selection of groups by Jacobs, Bourdon and Bolton. But approximately 25 per cent. of idiots do reach or exceed the ability reached or exceeded by 50 per cent. of ordinary children. This difference is not much greater than that between boys and girls in spelling ability. As Johnson points out, it is more likely to be due to differences in habits of attention than to a difference in mere retentiveness.

In the tests of motor control the feeble-minded were inferior to ordinary children, but so far as I can estimate from the incomplete figures given, not more so than in memory span. I quote the facts given. In the swaying tests, larger figures mean less control over movement.

"Swaying tests were made on seven boys and five girls with the ataxiagraph. Nine of these children were school cases. The averages were as follows:

7 boys [feeble-minded], average age 13 years, 6.52 c.m. by 4.44 cm., eyes open.

5 girls [feeble-minded], average age 13.4 years, 5.76 cm. by 4.7 cm., eyes open.

"Hancock's tables show the following results (*Ped. Sem.*, Vol. III., No. 1):

35 boys, 5 years old, 5.8000 cm. by 5.2228 cm., eyes open.
22 girls, 5 years old, 5.7773 cm. by 4.9500 cm., eyes open.

"Tests were made in order to find the ratio of the rapidity of shoulder to finger movements. The number of revolutions that the arm could make in ten seconds was recorded, and also the number of times that the hand could be opened and shut in the same number of seconds. The averages were as follows":

	Shoulder.	Finger.	Ratio.
8 feeble-minded boys, average age 13.6.....	21.60	17.62	100: 81.
8 feeble-minded girls, average age 16.1.....	21.25	20.25	100: 93.2
13 boys, normal, average age 13.6.....	26.85	25.15	100: 93.6
12 men, normal.....	25.4	32.7	100:128.
5 women, normal.....	22.6	32.	100:141.

In the time of association (of word with word) the greatest difference was found. Not one of 30 feeble-minded tested had as quick a rate as the average of ordinary children, the figures being:

	Average.	Slowest.	Quickest
30 feeble-minded boys averaging 13.3 years.....	5.35 sec.	10.70	2.70
10 ordinary boys.....	2.61	3.47	2.06

As to the nature of the ideas associated with the words given, "a comparison of the tables shows a much greater tendency upon the part of the feeble-minded to make simple objective (rather than logical) associations."

There is an ill-defined group of children separated roughly from others of their age by the fact that they do not get on in school work and still are capable enough in many matters to make unjustifiable the titles idiot, imbecile or feeble-minded as commonly used. Theoretically this group is composed of a number of different species of individuals. Some fail in school work because of defects of vision or hearing which their teachers fail to allow for. Some are nervous, fretful and easily distracted. Some are extremely unimpressionable and slow. Some lack only the capacity to deal with abstract ideas and symbols and succeed well enough in concrete acquisition. Some may even possess full capacity and lack only interest. Some are weak in intellect throughout, belonging on the border line between the brighter of the feeble-minded and the duller of the so-called normal children. Some are simply too immature for the work. Practically the group possesses the unity of a negative characteristic, inability to profit by the methods of teaching the usual subjects, reading, writing and arithmetic. In any school of a thousand pupils the principal can pick out from twenty to forty such children who are the despair of their teachers, a hindrance to their classmates and a source of worry to their parents. Even after sense defects are corrected or allowed for, after adenoids have been removed, even when wise teaching prevents excitement and nervous worry and arouses interest, a majority of these will be just as they were before. The group thus left has never attracted the attention of medical science or of educational psychology to the extent that its practical importance deserves.

Miss Norsworthy* has compared such a group of 30 girls, 8–13 years old, picked out from about a thousand in a city school on the ground of inability to profit by the regular school

* In a study as yet unpublished.

work, with ordinary children of the same age who lived in the same environment, attended the same school and were measured by identical tests given by the same individual. In giving instructions explanations were made very clearly and the process required was also shown by samples put upon the board. The measurements taken were as follows:

1. Height.
2. Weight.
3. Body temperature (taken at the mouth).
4. Pulse.
5. Rate of movement; tested, (*a*) by the number of crosses made in ten seconds (two trials); (*b*) by the number of up-and-down movements made in ten seconds (two trials).
6. Accuracy of movement; tested, (*a*) by the number of touches made in drawing a line between the lines of figure 48; (*b*) by the regularity and evenness of the figures made in the tests for the rate of movement.

FIG. 48.

7. Efficiency of perception (rate and accuracy combined). Tested by the *A* test.
8. Efficiency of perception (rate and accuracy combined); tested by the *a-t* test.
9. Delicacy of discrimination of length; tested by the variable error in drawing a line equal to a 10-cm. line (ten trials).
10. Efficiency in a test of perception and movement combined, viz., the time taken to insert different shaped blocks into a board made with depressions to fit them.
11. Memory of unrelated words; number remembered out of ten after a single hearing (two trials)—red, dog, day, tree, buy, never, sick, song, boy, box, long, green, arm, inch, true, run, dress, break, friend.

12. Memory of related words; number remembered out of ten after a single hearing (two trials)—school, teacher, book, desk, pen, read, write, add, spell, word, river, water, brook, flow, ice, cold, winter, snow, sled, skate.

13. Semi-logical memory; memory of four simple dictations, viz., (1) I have one head, two eyes, two hands and ten fingers. (2) I sit in my seat. I read from a book. I write with a pencil. (3) One and two are three. Three and four are seven. Five and six are more than ten. (4) In the morning I go to school. After school I play. At night I go to bed.

14. Ability in the formation of abstract notions, the appreciation of relationships and the control of associations; measured by the following tests: (*A*) to write the opposites of a given list of words; (*B*) to mark those words in a list which are names of things; (*C*) to write a word representing some kind of the thing named by a given word; (*D*) to write a word representing some thing of which the thing named by the given word is a part; (*E*) to write the opposites of a list of words, the converse of the list used in *A*, after the correct responses for *A* have been read to the class.

The detailed results of the comparison can not be given here. Their general outcome is perfectly clear. In the physical traits there is very little difference except in the rise of temperature at the mouth in the course of twenty minutes of work at the tests. This invariably occurred with ordinary children, but in only 60 per cent. of the special cases. The pulse rate of the special cases is a trifle lower. The difference increases as we pass from physical traits to tests of movement, then to tests of verbal memory and then to tests of perception, but even in the last case the special cases rank about with the lower half of ordinary children. But with tests 12, 13 and 14 the difference becomes increasingly greater, until in the last the special cases come to rank as the extreme end of the school population of their age (Fig. 49).

FIG. 49. The abilities in tests of controlled associations and conceptual thinking of 73 mediocre 9-year-old children and 19 very dull children 8.5–13 years old. The upper figure is for the mediocre 9-year-olds.

The one chief and essential characteristic of these children is thus their inability to think in symbols or with relationships or in such a way as to let a number of processes combine to decide what a given thought or reaction shall be. Concrete facts they can think and respond to one by one, but they can not think in symbols that stand for groups of facts or elements in facts, nor can they think facts together in causal or other series or respond correctly to related groups. In short they are the weakest members

of a school population in thinking of the pure human type. Besides this main defect there is a slight diminution of mental vigor, quickness and tenacity along all lines. In no mental tests do they do quite as well, and they give us some reason to believe that as they grow older they will develop continually less and less rapidly than ordinary children and so fall farther and farther behind in the mechanical as well as rational capacities.

Moral Defectives.

There are no general conclusions based upon exact measurements of moral deficiency and its causes and accompaniments. There is an abundance of ineffective detail stored up in medical comments upon so-called moral insanity and morbid impulses, in prison reports and in the minds of experienced schoolmasters. The greater complexity of the phenomena will always make the psychology of moral defectives more intricate than that of the feeble-minded.

The one general truth which can be asserted is that all sorts of moral defects exist, are far from perfectly correlated and are due to a multiplicity of causes. There are extremes of cruelty, deceit, egotism, passion, knavery, destructiveness and of all moral traits conceivable. There are boys and girls notably defective in only a single respect and others in whom every meanness and vice seems to thrive. We imagine, however, and probably with justice, that the correlations between certain defects are particularly high, so that certain common types or more correctly features emerge.

Such are perhaps types of moral defectives or features of moral defect characterized by: (1) Extreme predominance of the animal instincts, shown, for instance, by brutality and teasing, excessive sexual appetites, fits of rage and sulking, unreasoning greed and malice; (2) extreme egotism and lack of appreciation of the feelings and rights of others; (3) extreme weakness of control and moral instability, shown by susceptibility to all temptations and petty vices, alternations of affection with cruelty, anger with tears, peevishness, untrustworthiness,—an hysterical and irresponsible mental type, bad more because of the weakness of good habits than because of the strength of evil impulses; (4) the existence of one or

more morbid impulses of an immoral sort. Children may have intense desires to cut or tear without being generally extremely cruel, to run away from home and live tramp life without being generally extremely disobedient, to be kleptomaniacs but generally fairly honest, incendiaries without general destructiveness or to be sexually disordered without being of excessive passions.

Of course there is no rigid adherence to these types. Combinations, intermediate conditions and children falling outside these groups all exist. The extent to which such a grouping of cases is allowable or useful can be told only after measurements of the correlations between special immoral traits have been made.

Our feature 1 would seem likely to be due to original nature accentuated or relieved by training; feature 2 to be also an original defect in sympathy coupled with lack of abstract intellectual power and commonly made worse by the spoiling and selfishness of parents; feature 3 to be due to original nervous instability displayed in moral more than intellectual matters as a consequence of feeble and vacillating parental interference. The morbid impulses of 4 are probably more ingrained in original nature and less influenced by environmental conditions.

General moral defect commonly involves intellectual inferiority. The brightness and precocity that seem to characterize many cases of types 2 and 3 are really glibness, pertness and lack of restraint. It is therefore likely that general moral defect is due in part to generally inferior nervous organization.

Exceptional Rates of Growth.

Precocity, retarded development* and arrested development are terms loosely used to refer to children who are exceptional in the rate of mental growth. As we find them in books they hardly mean anything more definite than very rapid growth, very slow growth and absence of growth. But they may be made exact descriptive terms if we establish standards of change with age from which exceptional rates may be measured.

* The term retarded development is at times used not for an undefined slowness of growth, but for a slowness in growth *which will later* be made up. I shall therefore replace the two uses of the single term by the two terms *slow growth* and *delayed growth*.

By far the best arrangement would be to give stations above or below the average in rate of growth in just the same way that we do in the case of static conditions of a trait, and to speak in terms of these numerical stations rather than in the vague terms supernormal, normal, subnormal, etc. When any individual's rate belongs to a distinct species of mental growth the fact can easily be made clear by giving the total distribution scheme as well as his station therein.

As a matter of fact precocity, retarded development, etc., are rarely measured thus directly from the rate of change. Instead they are inferred from the fact that an individual is above or below the condition usual at his age. The term retarded development, for instance, is thus applied to a case which may be one of slow rate of growth at the time of observation, or of a slow rate in years long past, or of low initial station. This is unjustifiable. Exceptional degrees of ability should be dealt with apart from exceptional rates of change in ability.

Precocity.

There is a popular opinion much encouraged by physicians that children who in early life grow mentally very rapidly and so attain high stations are likely to come to grief, and be soon surpassed in health and mental ability by their less precocious fellows. It is an illustration of the superficiality of human thinking that so unhesitating an acceptance should be given to the paradox that rapid mental improvement from 0 to 10 should be an evil, but from 20 to 35 the greatest of blessings. For if we pass beyond a few striking examples which prove nothing it is hard to see any evidence for the first statement of the paradox. On the contrary bad physique and nervousness accompany dullness oftener than brightness; and early mental superiority is prophetic of later.

Thus Warner found abnormal nerve signs in the dullest 7½ per cent. of children over nine times as frequently as in the other 92½ per cent. (55.39 per cent. and 6.08 per cent.) and low nutrition over eight times as frequently (16.12 per cent. and 1.91 per cent.).*

* Calculated from the table on page 249 of the 'Study of Children.'

These correlations are in the writer's opinion much too high, owing to the fact that dullness was not estimated objectively. But even if we cut them down one half they still show a marked antagonism between brightness and bodily or nervous disorder.

In the case of 70 children chosen at random, for each of whom I had records of ability in the school work of grade 4 and of grade 7 or 8, that is at about the tenth and about the fourteenth and fifteenth years, I find the relationship between the ability shown in the early and that shown in the later period to be not at all one of antagonism but of resemblance. The Pearson coefficients are:

r for 4–7 grade (40 cases) $= +.18$
r for 4–8 grade (30 cases) $= +.31$

The mistake seems to have arisen from a number of fallacies. First, physicians meet with cases of physical or mental breakdown in mentally superior children. They still oftener meet similar cases in mentally inferior children, but the former cases excite more pity and are more interesting and dramatic. They tend therefore to remain in the physician's mind while the others fade. Second, an interest in and acquaintance with topics suitable for older people, such as sex, theology or adult human social relations, is often taken to be the sign of a precocious mind. Now these phenomena are often morbid and may therefore well go with an unstable mental organization and so be somewhat prophetic of disaster. But they are not *per se* indicative of superior mental growth. For the few supernormal children who exercise their gifts on such questions there are many who are ahead in school, play, leadership and accomplishments. We can not take the word precocious in the bad sense of unbalanced superior gifts and argue from premises thus obtained to conclusions about precocity in the sense of generally supernormal mental growth. In the third place, physicians often take the word of the parents for the children's precocity. It then means probably mere forwardness, ready talk, so-called 'bright' sayings and doings and even impertinence. These all witness to subnormal mental ability disguised by lack of inhibition. The quiet child thinks of many much brighter things to say but also has the strength of mind *not* to say them. Lack of inhibition and impertinence are pro-

phetic of poor mental growth in the future because they are indicative of it in the past and present as well. Finally it must be said that the average medical man in his ignorance of the subtle hereditary and environmental causes of mental breakdown grasps at any cause he can. If the child is dull, mental weakness is to blame; if he is bright, precocity!

Slow Growth.

In the absence of any quantitative studies of slowness of growth, this section will be limited to brief comments upon the question as to whether slowness of growth in one mental trait implies equal slowness in the growth of others, and the question of the desirability of a slow mental growth.

Slowness of mental growth is undoubtedly specialized, though to just what extent is not known. An obvious illustration is given by the sex instincts, which may mature far in advance of or far behind the intellectual powers. So also with social facility or musical talents. The resemblances between traits in an individual in their rate of maturing are, however, probably much greater than in their final condition.

Slowness of mental growth is in general an unfavorable sign. It is correlated slightly with low original capacity and low ultimate attainment. In some cases, of course, the growth is only delayed and the individual who seems to be far behind may come out well ahead. Moreover, as in height the boys who grow less than the average before thirteen grow more than the average afterward,* so in mental traits retardation before puberty may mean acceleration after it. Still by and large slowness is related to unfavorable conditions.

The opposite view, a corollary to the superstition about precocity, has gained credence, I fancy, first because of the supposed slowness in maturing of superior races, and secondly because of the supposed ill success at school of gifted men. But the apparent mental attainments of children of inferior races may be due to lack of inhibition and so witness precisely to a deficiency in mental growth. Moreover we can not argue from inferior races to inferior members of one race. The failure at school work of

* For this fact I am indebted to Professor Franz Boas.

children destined to become eminent men is a myth. The percentage is far higher for thieves and paupers and lack-wits.

Inefficiency due to slow mental growth, especially in those cases where the future will prove it to have been only delayed mental growth, must not, however, be confused with inefficiency due to inevitable incapacity. The correlation would have to be 1.00 to permit the interchange of these terms as synonyms.

Accurate tests to differentiate inherent incapacity from immaturity would seem to be of great practical value. They would prevent the injustice and discouragement due to mistaking the second for the first and the false hopes inspired by mistaking the first for the second. An approximation to such a differential diagnosis can be made by using the following tests.

A. *Tests of Maturity Chiefly.*

Motor control (rate of tapping, rate of making crosses, maze tests).

Memory of unrelated words, pictorial forms, etc.

Perception (*A* test, *a-t* test, geometrical forms test).

Delicacy of sense discrimination (of length and of weight).

B. *Tests of Intelligence Chiefly.*

Logical memory (memory of passages that involve connected and systematic exposition or argument).

Controlled association (alphabet and easy opposite tests or the like).

Perception of relations (filling up the blanks in passages like the following):

In everything that we do . . . need . . . be both quick . . . careful . . . we are . . . quick we do not get much done . . . . . we . . . . . careful we do not do our work . . . well . . . others. It is better to be careful . . . than to be quick . . . the best worker . . . the one . . . can do . . . things . . . do . . . well . . . . . we can not all be the best, we can . . . improve.

Let us suppose a boy who does not get on well in school to be tested and given stations in *A* and *B* with reference to the median for his age and sex. The lower his station is in *A* and the higher it is in *B* the more chance there is that he will grow out of his difficulty. Conversely the higher his station is in *A* and the lower it is in *B* the greater is the probability that he is essentially dull.

Arrested Development.

The phrase 'arrested development' is used in medicine to mean just what it says. Bodily organs including the brain may remain stationary or nearly so in one individual at a period when

in the great majority they are growing. In the case of the brain there may be no arrest apparent in gross structure, and yet the neurons themselves may not have attained their full development in complexity and delicacy. If we knew fully the history of the growth (normal or pathological) of the neurons themselves, we could probably extend the conception of arrested development to the entire field of mental life and distinguish in post-mortem examinations between the clodhopper who stagnates mentally after a score of years, and the Gladstone or Virchow whom the allotted span of life leaves still progressing, as we now distinguish between the brain of an amaurotic idiot and an average boy. It seems therefore justifiable to use the phrase arrested development from the psychological point of view in the case of any mental trait in any individual which remains stationary or nearly so at a period when it ordinarily is advancing. Medical men commonly apply the phrase to only those well-marked cases of general mental weakness which are correlated with gross developmental defects of the body or brain.

Arrest may be temporary or permanent. In the former case sickness, low nutrition and disuse are the probable causes; in the latter definite brain lesions or original lack of developmental force. It may be general or specialized. In every trait permanent arrest comes sooner or later to almost all of us. The differences amongst men are not in its presence or absence but in its date. There is, of course, no absolute date for any trait which is 'normal' for it. The date is variable, and abnormality here as elsewhere can mean only some arbitrarily chosen difference from the average.

It is a common habit of pseudo-scientific writers about education to decry one thing or another in school practice on the ground that it causes arrested development. Such speculations lack any adequate basis of fact. We do not know whether any school methods can, much less whether they do, cause special or general arrest of mental growth.

CHAPTER XIII.

THE RELATIONSHIPS OF MENTAL AND PHYSICAL TRAITS.

It has been fashionable to proclaim a close relationship between mental and bodily efficiency, to suppose that desirable mental conditions go hand in hand with desirable physiques. These statements in spite of their plausibility are so vague and undiscriminating that any one of scientific training would expect them to need much modification, and the arguments adduced hardly bear the scrutiny of any one who is aware of the real complexity of the facts. Moreover what we mean by asserting a connection between bodily well-being and mental superiority varies according to our use of the terms. The former may mean for us, (1) stature and weight, (2) strength, (3) freedom from recognized anatomical deformities or bodily diseases, (4) motor control (the opposite of nervousness) or (5) motor skill (dexterity, adroitness in executing movements). The latter may mean (1) mental health or balance (relative freedom from insanities, eccentricities, morbid impulses and habits, etc.) or (2) mental ability (defined as the ability to do those mental tasks which men in general try to do). There is not then one single problem, but a group of ten separate problems. All might conceivably have identical answers, but the chances would be great that the relationships in the ten cases would differ in important respects and to a notable degree.

Indeed we may properly claim that the analysis should be carried much farther and that the really fruitful studies will be of the relationships between each particular species of bodily condition and each particular species of mental ability or of mental health; that the specialization of relationships is so extreme that within any one of the ten cases just mentioned there will be different degrees of relationship. Thus deformities of the palate may have a significance which deformities of the joints do not;

epilepsy and paralysis obviously have a significance that diabetes, small-pox and typhoid fever do not.*

* An instructive instance of such specialized relationship is the case of the body temperature measured in the mouth and general intelligence as manifested in school work. Ireland ('Mental Affections of Children,' p. 45) and others have noted that the temperature of idiots is frequently very low. Prescott (*Pedagogical Seminary*, Vol. IX., pp. 437 and 438) found that of 10 children whose temperatures were the highest out of 71, 80 per cent. ranked excellent or good in studies, while of 7 children whose temperatures were the lowest only 43 per cent. ranked good (none ranking excellent).

Miss Norsworthy (in an unpublished study) found the temperature at the mouth in the case of 20 very bright girls, 31 nine-year-old girls picked at random from the third-year classes of a public school and 38 very dull children ranging from 8 years 0 months to 13 years 6 months. The results are given in Table XIII.

TABLE XIII.

TEMPERATURE AT THE MOUTH OF SCHOOL CHILDREN.

	Bright.	Ordinary.	Very Dull.
95.4 up to			1
.6			0
.8			0
96.0			0
.2			1
.4		2	2
.6		0	1
.8		0	0
97.0		1	0
.2		0	3
.4		0	1
.6	1	3	1
.8	0	2	0
98.0	1	2	4
.2	1	2	3
.4	1	7	4
.6	2	3	4
.8	0	3	3
99.0	2	0	6
.2	3	1	2
.4	2	3	1
.6	2	2	0
.8	3		0
100.0	1		1
.2	1		
Median,	99.3+	98.5	98.5
Average,	99.2+	98.4+	98.3—

The last two series were tested before and after simple tests of mental abilities. Miss Norsworthy noted that no one of the ordinary children showed a fall of temperature, while a third of the dull ones did. The medians for the temperatures after the tests were: Ordinary nine-year-olds, 99.1; very dull children, 98.8.

After the discovery of a relationship there is the equally important task of interpreting it. The common inference, for example, that if freedom from recognized anatomical deformities and bodily diseases goes with superior mental ability, we may improve the latter by securing the former, is by no means necessary. In original nature there might be a correlation between the two traits, yet alteration of the one by hygiene or medicine or surgery might leave the other uninfluenced.

It is always a special problem to determine how far improvement in one trait, physical or mental, alters any other. In general, as we have already noted in previous chapters, a relationship found may mean not that there is an essential connection in human organization between the two, but only (*A*) that we have been misled by the fallacy of selection, or (*B*) that growth influences both traits alike, or (*C*) that one trait causes the other indirectly through its influence upon the conduct of life, or (*D*) that both are brought about by some artificial outside cause which need not exist or so act, but happens to in the present organization of society. It may mean something still different.

Illustrations of these different cases are the following:

(*A*) Physicians are more likely to notice defects in mental health in cases presenting also physical deformity and disease, for they are more frequently consulted when the latter are also present. Their estimates of the relationship will therefore be on the basis of an unfair selection of cases and will be too high.

(*B*) As boys and girls grow with age they gain in mental capacity. We find therefore a relationship between stature and mental ability, but if we could get a group of identical maturity this relationship might not appear. Thus there is no correlation between the ratio of height sitting to total height and mental ability, but if we took children of all ages we would apparently find such, for with age the ratio of the length of the trunk to total length decreases.

(*C*) Diseases of one sort or another might debar individuals who were by organization of average mental ability from the use of books, laboratories, etc., or drive them to farming or manual labor and so eventually reduce their intellectual stations below the average.

(*D*) Ignorance and carelessness in parents would favor the development of diseases and deformities in children and also the development of stupidity, mental laziness and bad methods of mental work, thus producing a positive correlation.

To study adequately relationships between physical conditions and mental health requires a knowledge of medical science beyond the reach of the writer and presumably of the readers of this book. Suffice it to say, therefore, that the precise relationships have not been determined; that 3 and 4 surely have some essential relationship with mental health and that 1, 2 and 5 have much less, if any, and that there is a clear specialization of relationships within 3 and 4.

The relationships between physical conditions and mental ability I shall now deal with seriatim.

Stature, Weight and Intellect.

This problem apparently so simple is really very intricate. I shall dispense with a critical résumé of the evidence and deal summarily with the main conclusions.

The correlations between stature and mental ability in adults have not been computed. There are some indications of a slight direct correlation. College students are taller than the average population. Galton found eminent English men of science to be half an inch taller than their fathers. But the interpretation of such facts is complicated, and the amount of the correlation is unknown. It is surely very small and its causation is probably complex. We may however be rather glad than otherwise to find the stature of the race increasing.

Porter* found the ten-year-old children in higher grades to be heavier and taller than the ten-year-old children in lower grades, and similarly for all ages. He argues that there is a direct relation between brightness and superiority in weight and stature. The argument is: Children in high grades are larger than those of the same age in lower grades. Among children of the same age those who have gotten on farthest in school are the most intelligent. Therefore size goes with intellect. The argu-

* *Transactions of the St. Louis Academy of Science*, Vol. VI., pp. 161 and ff.

ment is doubly fallacious. First his facts do not prove that children in high grades are larger than those of the *same* age in lower grades, but only than those of the same *year* age. It might be, for all that he says, that all the 13-year boys in the eighth grade were 13 years and 182 days and all those in the third grade 12 years and 184 days old (he measured age to the nearest birthday). There might be almost a year's difference in their ages and the difference he found in size might be due to it. Some progressive difference in age between children in the same year of life who are in different grades there will surely be, those near the end of the year of age being more frequently in the high grades and vice versa.

In the second place, as Boas* has noted in a criticism of Porter's results, children do not reach a given school grade early merely because of intelligence. Mental maturity decides in part the age at which they shall be sent from home, their ability to do school tasks and their promotion or retention in a grade.

This second criticism applies also to the reports of a similar though less extensive study by the Department of Child Study of the Chicago school system.†

Gilbert,‡ Boas§ and West‖ have compared the ranks of children in intelligence as estimated by their teachers with their physical standing with reference to their age and find a slight inverse relationship. I suspect that this method is not entirely free from objection. Some big twelve-year-olds who have been pushed ahead of others of this age because of physical and mental maturity will, we know from the Chicago report and from a properly modified statement of Porter's results, be in a grade with children older on the average than they. The teacher, who makes all estimates by comparison within the class, may call such boys dull, though if they were with their own age she might judge them to be of average ability. Moreover in Gilbert's studies the sexes are not kept separate. Sex differences may distort the facts.

* *Science*, New Series, Vol. I., 225–230.

† Dated July, 1899, to July, 1900; reprinted from the 46th Annual Report of the Board of Education of Chicago.

‡ *Yale Studies*, Vol. II., and *Univ. of Iowa Studies*, Vol. I.

§ *Science*, New Series, Vol. I., pp. 225–230.

‖ *Science*, New Series, Vol. IV., pp. 156–159.

On the whole it seems wisest to expect both a correlation of rapidity in physical with rapidity in mental growth and a very slight correlation of rapidity in physical growth with intellectual gifts.

The relationship between bodily strength and intellect in adults is not known, but there is certainly no marked connection. In children rough attempts to measure the relationship have been made by the Department of Child Study of the Chicago School System and by Dr. J. A. Gilbert. As with stature, in neither case was age determined closer than to a year. And the same imperfect measures for intellect were used—school grade reached and relative position to the rest of the class in the teacher's opinion. As with stature, the first method showed a decided direct correlation and the second showed a zero or slightly negative correlation. Our previous criticisms hold here in the same way and for the same reason, the most likely conclusion being that there is a very slight direct correlation between intellect and rapidity of growth in strength.

Deformities and Sickliness and Intellect.

Warner* found a rather close relationship between what he calls 'developmental defects' and dullness; viz., that a child possessing the former was seven times as likely to be dull as one not possessing them. But his criteria for distinguishing children with developmental defects from children without them are certainly arbitrary and inexact and likely to bend one way for stupid-looking children and the other for bright-looking children. Worse still, his criteria for dullness are not even stated. Who picked out the dull children and how he did it are unanswered questions. So until his results are made more precise and corroborated by other observers they should be judged cautiously in the light of general knowledge. The same holds good of the correlation which he finds between sickliness or a poorly nourished condition and dullness (that the latter condition goes with the former nearly seven times as often as with its opposite). In both cases the habits of a physician would be such as to make the correlation too high.

* 'Study of Children,' p. 249.

Bad Nervous Action and Intellect.

Warner's statistics are again the chief source of information. He finds that children who manifest marked signs of nervous disorder such as involuntary twitching, asymmetrical posture, etc., are about 11½ times as likely to be dull as are those who do not. The same judgment as before must be made concerning the reliability of his estimate, especially since another investigator* finds that "The feeble-minded were remarkably free from the nervous twitchings and the bad hand postures mentioned by Dr. Warner. [Out of 72 cases] I found one case of convulsive hand and two of twitching fingers. In two cases the arms twitched but not the fingers. Occasionally the thumbs drooped."

Motor Skill and Intellect.

Dr. W. C. Bagley† has reported a study of this problem. Unfortunately he used reaction time as a partial measure of mental ability, calculated the correlation by a very inaccurate method, did not compare children of precisely the same age and made two gross errors in his figures. Reaction time we have seen (page 32) to be very little symptomatic of mental ability. Within any grade the teacher's marks for mental ability (Dr. Bagley's other measure of mental ability) will probably be due to the comparison of brighter young pupils with older dull pupils, while motor ability, which we know to improve steadily with age, will be low for the young and high for the older. To get the real relation between the two we must work out the correlations for groups of children of the same age, all the individuals of each group being measured by the same standards for the two traits. Dr. Bagley used only a very coarse subdivision into groups 14–17 yrs., 13–14, 12–13, 8–11.

With this too coarse grouping he gets the following results:

Ages 14–17,	those ranking in motor ability			962.1	ranked in mental ability			894.6
"	"	"	"	941.2	"	"	"	894.7
"	"	"	"	930.5	"	"	"	927.3
"	"	"	"	908.0	"	"	"	929.3

* G. E. Johnson, *Pedagogical Seminary*, Vol. III., p. 276.

† 'On the Correlation of Mental and Motor Ability in School Children,' *Am. J. of Psy.*, Vol. XII., pp. 193–205.

Ages 13–14,	those	ranking	in	motor ability	967.9	ranked	in	mental ability 903.6
	"	"	"	"	947.9	"	"	" 925.8
	"	"	"	"	935.2	"	"	" 919.8
	"	"	"	"	899.6	"	"	" 930.7
Ages 12–13,	"	"	"	"	943.3	"	"	" 939.5
	"	"	"	"	921.0	"	"	" 927.6
	"	"	"	"	912.4	"	"	" 921.2
	"	"	"	"	887.6	"	"	" 901.6
Ages 12–12,	"	"	"	"	944.8	"	"	" 952.2
	"	"	"	"	931.1	"	"	" 950.1
	"	"	"	"	912.8	"	"	" 942.5
	"	"	"	"	881.4	"	"	" 938.5
Ages 8–11,	"	"	"	"	926.5	"	"	" 944.5
	"	"	"	"	902.2	"	"	" 948.3
	"	"	"	"	889.9	"	"	" 958.0
	"	"	"	"	874.5	"	"	" 934.2
Average of all age groups.....					948.9			926.9(8)
					928.7(6)			929.3
					916.2(6)			933.8(7)
					890.2			926.9(8)

There is evidently no antagonism between motor and mental ability. By an error of some sort Mr. Bagley makes the first two averages of all age groups in mental ability 906.8 and 909.3 giving the appearance of antagonism, and so concludes that 'there is a general inverse relation between motor and mental ability.'

If we take the 12–12* and 12–13 groups where the age differences within the group are not so great, we find a direct correlation. So far then as so inaccurate measurements as these can be taken to prove anything they prove that if we should compare children of the same age we should find a slight direct relationship between mental ability and motor ability.

Gilbert in the two studies already so often quoted compared the rates of movement for children of the same year-ages who were rated bright by their teachers with the rates of those similarly rated average and dull. In general those rated bright did better. The differences of the average and dull from the bright are given in the following table (XIV) first in absolute amounts and then in terms of the mean variations for boys and girls of

* It must include some 11 years old and really be 11–12, for Dr. Bagley states that the average age was 12.0.

the age in question. For the reasons referred to on page 146 we can not be sure just what these differences mean. It should be noted that the differences between bright and average are very small and that the differences between bright and dull are on the whole only seven per cent. of the difference between the extremes of motor ability for the same age (calling that difference seven times the mean variation, which is approximately correct).

TABLE XIV.

THE RELATIONSHIP BETWEEN MENTAL ABILITY (AS ESTIMATED BY A TEACHER) AND THE RATE OF TAPPING.

	Number of Taps.			Absolute Differences.		Diff. in Terms of Varia'ty.		No. of Cases
	Bright.	Aver.	Dull.	Bright–Aver.	Bright–Dull.	Bright–Aver.	Bright–Dull.	Studied
6	22.1	22.3	21.5	— .2	.6	—.09	.28	91
7	25.2	25.3	21.2	— .1	4.0	—.04	1.48	96
8	26.0	26.5	24.0	— .5	2.0	—.20	.82	93
9	27.0	26.9	26.0	.1	.7	.04	.28	100
10	27.1	28.5	27.5	—1.4	— .4	—.45	— .13	108
11	29.0	27.4	27.4	1.6	1.6	.50	.50	97
12	29.7	30.0	27.8	— .3	1.9	—.10	.62	111
13	31.0	30.3	29.0	.7	2.0	.21	.61	101
14	32.0	31.0	28.8	1.0	3.2	.26	1.16	92
15	33.4	33.2	31.0	.2	2.4	.08	.91	95
16	34.0	33.8	33.2	1.2	1.8	.39	.58	92
17	34.0	34.0	34.6	.0	— .6	.00	— .23	100
18	36.1	35.1	35.0	1.0	1.1	.36	.40	100
19	36.2	36.3	36.0	— .1	.2	—.03	.06	81
				All ages together		+.07	+ .52	

I found no correlation direct or inverse between school marks and the accuracy of movement, though my cases were too few to make the conclusion sure. I judge from a few measurements that in the case of adults a direct correlation, but less than .05 in amount, does exist. Havelock Ellis claims, however, that bodily awkwardness is commoner among men of very superior intellects than among common men.*

Even this inadequate study of the relations of bodily conditions to mental ability shows some things clearly.

The dependence of mental ability upon the general bodily conditions that we have reviewed is surely slight. The most gifted five per cent. and the least gifted five per cent. mentally are not *much* unlike in stature, strength, health, muscular control or phys-

* *Popular Science Monthly*, Vol. 59, p. 272.

ical dexterity. I am sure that we could pick out mentally gifted men or children more successfully by ten minutes' observation of their facial expression, manners and opinions than by a day's work in measuring any combination of anatomical traits or motor activities.

The efficient action of those parts of the brain which are related to the intellectual life is to a large extent independent of the station of the individual with respect to the efficiency of other physiological functions.

The expectation that the improvement of general bodily welfare or of muscular dexterity will produce an improvement in mental efficiency is justifiable only if we expect it in slight amount and in a limited number of cases. If a person ranks —10 in intellect and is a physical weakling, we may raise him to —9 or —8 by gymnastics and manual training, but we will never get him far above his original station. Again if a thousand dull boys are given physical and motor training the majority of them, I fancy a very large majority, will be as dull after as before. Such admirable features of school training do not need the support of any absurd exaggerations of their effects on mental traits.

CHAPTER XIV.

BROADER STUDIES OF HUMAN NATURE.

WITHIN the last fifteen years there have been, in connection with the so-called child-study movement, a number of studies of concrete facts of human nature which follow a fairly definite type, though it is hard to find a single phrase by which to describe them. They are attempts to answer such questions as: "What are the attitudes of human beings toward water, or toward trees, or toward dolls, or toward punishment? What are the actual facts about the influence of teachers, parents, books? What is the rationale of human fears, of human affection, of children's interests?" They are characterized by the effort to reach generally valid conclusions from a wholesale collection of individual experiences. They commonly start with a list of general topics for study rather than with definite questions to be solved. Their material is almost without exception not direct observation, but either the answers written in reply to a printed list of questions or the papers written by school children as a school exercise in response to some question or suggestion. They have purported to be important to educational science on some such basis as this: Any true account of the real life of men and women, boys and girls will help us to control those lives in accord with our educational ideals, and will give suggestions of forces in human nature at the service of educational endeavor which have been hitherto neglected.

If the reader has read or will read any half dozen of the following articles he will have a concrete idea of this type of work that will be a better introduction to the discussion to follow than any further description.

'A Study of Peculiar and Exceptional Children,' *Pedagogical Seminary*, Vol. IV., pp. 3–60.

'A Study of Dolls,' *Pedagogical Seminary*, Vol. IV., pp. 129–175.

'Teasing and Bullying,' *Pedagogical Seminary*, Vol. IV., pp. 336–371.

'A Study in Moral Education,' *Pedagogical Seminary*, Vol. V., pp. 5–40.

'Some Mental Automatisms,' *Pedagogical Seminary*, Vol. V., pp. 41–60.

'The Psychology and Pedagogy of Adolescence,' *Pedagogical Seminary*, Vol. V., pp. 61–128.

'Manifesting the Instinct for Certainty,' *Pedagogical Seminary*, Vol. V., pp. 313–380.

'Reverie,' *Pedagogical Seminary*, Vol. V., pp. 445–474.

'The Only Child in the Family,' *Pedagogical Seminary*, Vol. V., pp. 475–496.

'A Genetic Study of Immortality,' *Pedagogical Seminary*, Vol. VI., pp. 267–313.

'The Psychology of Ownership,' *Pedagogical Seminary*, Vol. VI., pp. 421–470.

'Children's Ideals,' *Pedagogical Seminary*, Vol. VII., pp. 3–12.

'Children's Interest in the Bible,' *Pedagogical Seminary*, Vol. VII., pp. 151–178.

'The Collecting Instinct,' *Pedagogical Seminary*, Vol. VII., pp. 179–207.

'A Study of the Teacher's Influence,' *Pedagogical Seminary*, Vol. VII., pp. 492–525.

'Old Age and Death,' *American Journal of Psychology*, Vol. VIII., pp. 67–122.

'A Study of Fears,' *American Journal of Psychology*, Vol. VIII., pp. 147–249.

'A Study of Conversion,' *American Journal of Psychology*, Vol. VIII., pp. 268–308.

'A Study of Puzzles,' *American Journal of Psychology*, Vol. VIII., pp. 431–493.

'Some Aspects of the Early Sense of Self,' *American Journal of Psychology*, Vol. IX., pp. 351–395.

'The Institutional Activities of American Children,' *American Journal of Psychology*, Vol. IX., pp. 425–447.

For the sake of readers to whom these articles are not readily accessible I will quote from one of the best devised and most instructive of these studies* at sufficient length to give a rough idea of the method in its more successful application.

Some of the questions asked were:

Growth generally. When was growth in height or weight greatest? Was this period of growth attended by better or deranged health? Give any details, as to how much, where, how long, etc.

General Health, then and now. If imperfect, how, respecting eyes, nerves, head, stomach, etc.? Was sleep or dreams, or appetite for food affected?

Changes of Form and Feature. Did chin, nose, cheek-bone, brow, chest, hair, and other features change, and how? Was there a different facial expression? New resemblances? To whom?

Senses and Thought. Are the senses keener, wider ranged? More en-

* Lancaster's 'Psychology and Pedagogy of Adolescence,' *Pedagogical Seminary*, Vol. V., pp. 61–128.

grossing? Is there a change from sense to thought; from the present to the future; the near to the far? What new *ideals*, abstract or personal?

Language. Was it harder or easier to express one's self, and was there a dumb, bound feeling? Was truth-telling harder or easier?

Future. Were careers, plans, vocations, trades, etc., dwelt upon?

Home. Did the attractiveness of home diminish, and was there a tendency to be out, go far away, strike out for self, seek new associations and friends? Should home be left part of the time?

Parents and Family. Did parental influence decline? How differently were father and mother, brother, sister, and other relatives regarded? Parental authority, punishments?

School. Was there a disposition to leave school, change studies or teachers, defy authority, or to *feel* more deeply studies, punishments and discipline?

The author gives in every case of importance samples of the replies. For instance, from the replies to the question about careers, plans, vocations, etc., he quotes the following:

F., 18. As a child I dreamed much of the future. Wanted to be a musician, elocutionist, artist, milliner, bookkeeper, dressmaker and a school teacher. Have often desired to be as beautiful in character as Christ himself.

F., 24. One of the greatest pleasures of my life has been to make plans and map out an ideal career.

F., 20. Planned to teach in my early childhood. At 13 I began to declare it, and after much discussion my wish was granted, and I began to prepare for it, to my great delight.

M., 50. Nothing is more intense and vivid than my plans for the future. One scene. A high hill with bald summit. Had been blamed for something and went to that peak. Alone there I had a very deep and never-to-be-forgotten experience. I paced back and forth and said: 'Now I will, *I WILL*, make people like me, and *I WILL* do something in the world.' I called everything to witness my vow.

F., 23. My plans for the future were all for literary fame. School aroused my ambition and for three successive years I took essay prizes.

M., 18. I look to the future. Think of myself as teaching, reading law, at the bar, in legislature, an active speaker always taking the side of right and denouncing wrong. I have had many ideals, one to be a minister.

F., 19. I often think of the future and wonder what it has in store for me. I sometimes wish that ten years would pass in a night.

M., 19. Planned his future and painted it with the tints of the seashell.

F., 19. In mind I have planned the first day of school and gone through it many, many times. At one time I wanted to be a trained nurse. I pictured myself among the patients and how I would act in an operation. Then how I would study abroad and get a fine position.

He also discusses each topic in a general way. The following is his presentation of facts and conclusions, with reference to the attitude of adolescents toward home, parents and family:

403 answered the question regarding home. 253—153 M., 100 F., had a desire to leave home and strike out for themselves or found home less attractive. 150—29 M., 121 F., had no desire to leave home.

107 thought that home should be left a part of the time, 20 thought it should not.

As to parents and family, 281 replied. 99–33 M., 66 F., said parental influence did decline, while 181—35 M., 146 F., found their parents just as dear and obeyed them as readily as in childhood.

100–32 M., 68 F., felt a disposition to leave school or did leave for a while during this period. 192—98 M., 94 F., had no such feeling.

It must be borne in mind that these returns were mostly from normal school, high school, academy and college students, a majority of whom were away from home when they wrote.

75—34 M., 41 F., say that punishment was felt much more deeply. 18—9 M., 9 F., experienced no change.

This gives a very true picture of the feelings of young people toward home, school, and authority at this period of life, because the answers were given under conditions allowing free speech and favoring home, parents and school. It is a very forcible illustration of the fact that a boy or girl from 12 to 18 is fully conscious of personality and the rights of individual recognition.

This feeling that home is shut in and the desire to get away and travel, to see for one's self and form new associations, is an instinct as old as the race and common to all animal life. It is like the migratory instinct of birds. It may spring up suddenly with the most obedient and well-bred children. It is not a sign of degeneration or of less love for the home or parents. It is often associated with the most intense love of home and family.

The feeling is strongest at 16 to 18 or about the time of the final approach to maturity.

The sudden feeling of rebellion against authority, which often surprises the child as much as the parent, is another instinctive habit of the race. These crop out in the best children, sometimes with a violence that shocks everybody.

It is not necessarily a bad sign, unless frequently repeated. The desire to leave school, together with the desire to leave home, is a true and natural impulse to adjust himself to the life which he is already living in his imagination in company with his ideals.

Sympathy, not punishment, is the proper corrective.

Studies of this type have not been quoted in connection with the topics discussed in our previous chapters because they are in many cases unrelated to those chosen for treatment in this book and because when the topics are appropriate the facts they claimed to present have been stated in terms with which quantitative

science can not deal. Partly to explain this apparent neglect of a large number of researches in educational psychology and partly to assist the reader to a just estimate of their value, we must now answer certain questions.

1. Can the loves and hates, fears, interests, ideals, habits, notions and opinions, etc., of human beings, the influence of books, teachers, religions, games, toys, etc., be made the objects of successful scientific investigation?

2. What profit will accrue to educational science from such investigations?

3. To what extent are the methods that have been employed in these studies reliable?

4. To what extent are their conclusions reliable?

5. To what extent are their conclusions important?

1. There is no reason why we can not list and describe and estimate quantitatively and relate to any other set of facts, any features of human life. Affection for dolls can be studied as scientifically as reaction-time or rate of movement, though not as easily. Those who deny the ability of the statistician to measure any facts of mental life are ignorant or forgetful of the theory of measurement by relative position used by Galton years ago. The complex nature and the variability of these facts make scientific work hard but not impossible.

2. We can not tell until the investigations have been made and can not tell fully until the complete course of science and life has been run. The action of knowledge on practise is complicated, indirect and often long deferred. But either directly or through its helpful influence toward some other discovery, either soon or after it is supplemented by some other fact, any new bit of knowledge seems sure somehow to economize human effort and increase human control. The faith in science which urges us to collect butterflies and mastodons, to spend vast sums to observe eclipses, to devote years to Latin inscriptions and lives to the vagaries of primitive religions, ought to justify the study of even minor features of human minds and characters.

The third question can not be answered so summarily. And in the nature of the case no single absolute answer will fit all the different studies. A method useful in one case may be quite use-

less in another. Some general principles, however, are sure and may guide us in estimating the worth of the method in any single case. First of all, the ignorance of a thousand people is no better than that of one; truth can not be manufactured from constant errors by getting a great number of them. For instance, from scoring up replies to the question, 'When did your child first reason?' we do not necessarily learn anything about the date of appearance of reasoning, but only about opinions of people as to that date. From scoring up replies to the suggestion, 'Describe some miser of your acquaintance,' we attain knowledge not of misers, but of what our correspondents notice or think they have noticed in some obvious types of miserliness. No research can ever attain a reliability beyond that possessed by the data with which it starts. And the first duty of any study of individual responses to questions or suggestions is to measure their reliability as measures of the trait in question. Adults even so well trained as college seniors and even in the simplest matters of present objective fact such as are involved in the questions, 'How tall are you?' 'What is the circumference of your sister's head?' make gross errors. The errors increase in number and amount when the report requires memory; increase further when the fact is a report of subjective condition, and multiply like bacilli when it involves the consideration of the general drift of a series of experiences. Again, no matter how clearly the question is put some individuals misunderstand it. Finally any question acts as a suggestion and with uncritical minds will surely produce affirmative answers.

There are means of avoiding many of these errors and recognizing and allowing for many of the others. But these means have not been used in the investigations under discussion. We can feel but little confidence in a method which pretends to secure truth from a collection of the answers of young people in normal schools to such questions as the following:

Have liberalizing theological opinions made you better or worse, and how? *Ped. Sem.*, Vol. V., p. 8.

What is your own temperament? *Ibid.*, p. 13.

Has your belief in immortality been an unfoldment of your nature or is it the result of parental influence, scriptural teaching, observation of

natural phenomena, loss of friends in death, or your own inability to conceive your existence as coming to an end? *Ped. Sem.*, Vol. VI., p. 287.

What effect has [*sic*] a new overcoat, high hat, high heels, ribbons, plumes, bright buttoned uniforms, articles of jewelry, buttons, badges, etc., upon the self-confidence, self-assertiveness and personality of the owner? *Ibid.*, p. 430.

What force and motive led you to seek a higher and better life? *Am. J. of Psy.*, Vol. VIII., p. 269.

What is the educational value of puzzles? *Ibid.*, p. 448.

Is the puzzle-loving mind or state like that of the scientific man bent on solving problems of laboratory or study? *Ibid.*, p. 447.

What do you know of beggars? Their habits, laws, customs? *Ped. Sem.*, Vol. VI., p. 431.

What studies have best developed your memory? *Am. J. of Psy.*, Vol. X., p. 229.

Can blood pressure be tested? *Am. J. of Psy.*, Vol. X., p. 529.

In the second place the facts reported by individuals who respond to sets of printed questions need not and commonly will not represent the true state of affairs in the group ostensibly studied. Psychological questionnaires are commonly sent to 'those interested' or to psychology classes in normal schools and answered by only a limited number of those who receive them, namely by the individuals to whom the questions especially appeal and who have something to report or by those who answer them as an academic study. The replies thus represent an extremely partial sampling of people in general. Moreover, of those who do reply either from zeal or as a matter of school work, only a small number answer all the questions. In the case of any one question then we get answers from the few, probably from those who have a positive or emphatic answer. We can be sure beforehand that these replies will not give a representation of the facts that really exist in the total group. Here again it would be possible to correct the bias of the replies from such a selected group by the study of fifty or a hundred individuals chosen quite at random. But this has never been done.

For instance, in the case of the study already quoted there were received about 500 replies from classes in normal schools, colleges and academies and about 300 replies from individuals. The group of students certainly do not represent the general population. How the 300 were selected we are not told, nor what proportion they were of the total number to whom the questions

were sent. There was not a single question asked in the list that was answered by all of the 787* whose replies are the basis of the article. Out of the total number for each sex the following numbers (in percentages) replied to the different questions which the author discusses.

TABLE XV.

Each number is the percentage that the number of answers to some one question was to the number replying to the questions as a whole.

Males.	Females.	Males.	Females.
17.0	28.9	11.4	11.7
40.2	48.9	29.3	41.5
13.2	35.5	15.0	22.8
13.2	14.8	49.9	77.1
10.3	17.5	97.4	97.3
19.9	35.2	85.6	68.6
23.6	20.7	105.0	77.1
29.1	55.4	63.1	63.2
72.7	48.0	74.2	54.7
53.4	49.6	81.2	64.8
19.9	47.5	72.4	61.9
24.6	19.3	44.9	51.1
34.7	53.9		

These percentages range from 10.3 to 105 for males and from 11.7 to 97.3 for females. The averages are: Males, 44; females, 47. The variabilities (*A. D.*) are 24.7 and 16.8. There are marked sex differences in the number replying, the extremes being, women 66 per cent. as many replies as men and 269 per cent. as many. These facts demonstrate that chance is not the cause for the number of replies and failures to reply and that some real principle or principles of selection do determine them.

It is incredible that the 85 per cent. of men who do not answer at all the question, 'Were there impulses to reform self, others, religion, state, society, etc.?' had the same feelings about the matter at adolescence as the 15 per cent. who did answer, and

* The author does not even take pains to make this number clear. In one place we read, '827 (replies) have been received . . . these answers have been grouped and condensed and the results will be given' (p. 67), and two pages later we read: '341 males and 446 females answered part or all of it' (the syllabus of questions). My percentages are based on this second statement, to avoid any possibility of injustice. From the fact that one percentage thus computed is 105, I regard it as likely that the 827 is correct and that my percentages are even too large by 5 per cent.

of whom practically all (approximately 97 per cent.) say, 'Yes.' The probability indeed is that of the 85 per cent. few or none had felt such impulses to any noticeable extent and that the real affirmatives amongst the 341 males replying to the question should be reckoned at from 15 to 20 per cent. This percentage calculated from the interested and from academic students would be further reduced if mechanics, day laborers, clerks and the rest of the youth of the land were studied. The figures for the girls are of the same order of magnitude. Yet the author says: 'This feeling . . . is very characteristic of adolescence.'

I have attempted to make an estimate of the partiality of the sampling in these studies as a whole by computing from all such articles in the volumes of the *American Journal of Psychology* and *Pedagogical Seminary* from 1896 to 1900, the proportion of individuals replying to individuals questioned, and the proportion that the answers to each question are of the individuals replying to the questionnaire as a whole. Such an estimate can not be made because the ignorance or neglect of the fallacy of selection has been so great that only one article in the eight volumes gives clearly the number of individuals questioned, and none gives full information regarding the number of replies received to each detailed question. Some do not even give the number of individuals replying to the questions as a whole. In the one case where the number of those questioned is given, less than one sixth replied (15.67 per cent.).

In the third place the use of replies to questions and of school compositions involves the exercise of much personal opinion as to the meaning of each report. Different individuals will differ somewhat even in their measurement of a line, will differ markedly in their estimate of the intelligence shown in any test, and would certainly differ in their rating of the replies to such complex and subtle questions as many of those on pages 157–8, or of the school compositions on the topics quoted. The statements finally used to inspire conclusions are thus a compound of the actual reports and the subjective bias of the compiler. This could be avoided by the simple expedient of having several unbiased clerks go over the papers. By combining their opinions one could eliminate personal idiosyncrasies of judgment. This has not been done.

In the fourth place the progress from a set of statements about individuals to a statement about a group including them is by no means a matter of simple addition. There is a fairly complex science of mental statistics which has been found necessary to keep students out of pitfalls. Failure to take advantage of it is always a suspicious characteristic in any method of studying groups.

Conclusions about the facts studied only indirectly through the reports of incompetent observers, in the case of individuals representing a partial and undefined selection, compiled by a single and possibly prejudiced student without the knowledge of the technique and logic of statistics, are utterly unreliable. They may be true; they may be false; they are probably a mixture. But we can not know how true or false they are.

Our last question (To what extent are the conclusions reached in these investigations important?) should properly be replaced by as many separate questions as there have been separate conclusions. Still some statements may be made that will apply fairly well to the bulk of these studies. First it is questionable whether we ought nowadays to pay any attention in our theorizing about education to conclusions that are utterly unreliable. There would be a great saving of time and a desirable moral effect if we restricted ourselves to facts of measured reliability. From this point of view, the importance of these studies would seem to shrink to small proportions. However, their conclusions are at least the opinions of thoughtful and experienced students who have reviewed a large array of data, and in so far as the intellectual virtues of the student outweigh the vices of the method these conclusions are superior to habitual opinions.

A second consideration is worthy of note. Mere inventories of traits are of relatively little importance in comparison with knowledge of their relationships among themselves and to other things. Thus information about 1,000 people with respect to one trait is of far less importance than information about 100 traits in each of 10 individuals. Human nature is so complex that we rarely learn much about any one aspect of it if that is dissociated from all the rest, or studied without reference to all the factors of original nature and environment which are its causes.

The failure to connect the facts studied with the total lives from which they are tiny excerpts and to seek the facts which will elucidate causal action in mental life is perhaps the one characteristic of these studies which detracts the most from the importance of their conclusions.

On the whole, then, although their purpose—to deal scientifically with the rich content of human nature and so secure a basis for educational control—is in every way laudable, these studies have not sufficiently realized it to be accepted as desirable examples of educational science. It is to be hoped that if an equal amount of genius and effort is spent in the next decade upon similar problems, the work will be done by means of direct expert observation of representative cases with reference to all the factors involved, and with a moderate amount of statistical care.

CHAPTER XV.

THE PROBLEM OF EDUCATION AS A SCIENCE.

A THEORY of education must decide two questions: (1) What ought people to be? (2) How shall we change them from what they are to what they ought to be? One's answer to the first question, the question of the aim of education, will be given in accord with his conceptions of ultimate values and will be judged not by facts but by ideals. The studies which have been made in this book have nothing to do with it.

They are relevant to the second question of the ways and means of education. To know the original natures of the beings to be educated and to know the influence of the forces of nature, human lives and all the paraphernalia of civilization upon these original natures is to know how to control their education in the interest of the aim we have chosen.

It is not the purpose of this book to criticize existing theories or to attempt the construction of a new one. For there is no chance for any simple general theory. The work of education is to work changes in countless individuals all different by original nature. These changes are again infinite in variety. Each bit of knowledge, each interest, each habit, each power, each ideal has its own best means of attainment. Multiply the number of different changes desired by the number of different original natures to be changed and the resulting number of concrete problems will measure the number of separate concrete precepts which the art of education must include. For this boy in this information,—leave him alone. For this girl in that interest,—example. For this man in that habit,—beat him with rods. For this power in that youth,—this study. For this ideal in that race,—give up the task; nature has denied it to them. Such is the variety of recommendations which we know must needs exist. The true general theory must be the helpless one that there can be no general theory, or be made up of such extremely vague conclusions as the features common to all human natures and the changes

everywhere desirable allow. Such conclusions are on a level for helpfulness and illumination with the inane tautologies of hygiene books. "Good air, nutritious food and proper exercise are sure to assist health."

A true educational science must be inductive, must be made up from the study of the particular facts in answer to thousands of different questions.

It is the vice or the misfortune of thinkers about education to have chosen the methods of philosophy or of popular thought instead of those of science. We ruminate over the ideas of Pestalozzi or Herbart or Froebel as if writing a book a hundred years ago proved a man inspired. We discuss the outpourings of successful college presidents as if devising a public address was a voyage of discovery for truth, and the newspaper type of argument its crucial test. We are like chemists who should quarrel over the views of Paracelsus or Arnauld of Villeneuve and debate about the latest articles by Maria Parloa. In education everything is said but nothing proved. There is a plentiful lack of knowledge while opinions more and more abound. They are often very good of their kind but they are not science.

The science of education when it develops will like other sciences rest upon direct observations of and experiments on the influence of educational institutions and methods made and reported with quantitative precision. Since groups of variable facts will be the material it studies, statistics will everywhere be its handmaid. The chief duty of serious students of the theory of education to-day is to form the habit of inductive study and learn the logic of statistics. Long after every statement about mental growth made in this book has been superseded by a truer one the method which it tries to illustrate will still be profitable and the ideals of accuracy and honesty in statistical procedure by which I hope it has been guided will still be honored. We conquer the facts of nature when we observe and experiment upon them. When we measure them we have made them our servants. A little statistical insight trains them for invaluable work.

APPENDIX I.

EXPLANATORY INDEX OF THE LESS COMMON TESTS MENTIONED IN THE TEXT.

A test (see page 4).

a-t test (see page 9).

Alphabet test. Writing letters as rapidly as possible, each letter to be the letter preceding in the alphabet a given letter. The letters given were f, k, s, p, w, l, e, r, d, o, v, j, n, t, h.

Association time or Q association. The time taken to call up and write a mental associate for each of ten words, the words being printed on a blank.

Association time (as used by Johnson). A key word was given and thirty seconds were allowed for saying the words which came to the mind, each word being written by the experimenter as soon as spoken. The number of seconds divided by the number of words written gives the average association time. The key words were; house, tree, chair, ship, clock, Fourth of July.*

Genus-species test. Writing as rapidly as possible a word meaning some species of the genus meant by a given word.

Geometrical forms. Tests in marking circles, hexagons or some simple figure on a blank printed with a chance mixture of a score of different geometrical figures.

Letter combinations. Tests like the a-t test or e-r test.

Maze test. The amount done and the touches made in an attempt to draw a line within a pathway 2 millimeters wide in a figure like that shown (reduced to ½) in figure 48. In another figure the pathway was curved.

Memory of related words. Memory of such series as—school, teacher, book, desk, pen, read, write, add, spell, word. . .

Memory of unrelated words. Memory of such series as—red, dog, buy, day, sick, never.

Misspelled word test. The number of misspelled words marked in a given time on a blank printed as follows:

MARK EVERY WORD THAT IS NOT SPELLED CORRECTLY.

1. On the 3d of September, 1832, inteligence was broght to the collecter of Tinnevelly that som wildd eliphants had appeared in the neighborhod. A hunting party was imediately formed, and a large number of nattive hunters were engaged. We left the tents, on horsback, at half-past sevin o'clock in the morrning and rode thre miles to an open spote, flanked on one sid bye Rice-fields, and on the other by a jungle.

2. After waiting som time, Captain B——— and myself walked acros the rice-fields to the shad of a tree. There we herd the trumpett of an elephant; we reshed acros the rice-fields up to our knes in mud, but all in vaiu, thogh we came upon the trak of one of the animels, and then ran five or six hundredd yards iutoo the jungle.

* An abstract from the account of the test given by Johnson, who used it, on page 282 of Vol. III. of the *Pedagogical Seminary*.

3. After varius false allarms, aud vane endevors to discuvor the obgects of our chace, the colector went into the jungle, and Captin B——— and myself into bed of the stream' where we had sen the traks; and here it was evedent the elaphents had passed to and fro. Disapointed and impasient, we allmost determened to giv up the chace and go home; but shots fird just before us reanimated us, aud we proceded, and found the collecter had just firred twicce.

4. Of we went throuh forest, over ravin, and through strems, till att last, at the top of the ravine, the elephants were seen. This was a momant of excitment! We wer all scatered. The collector had taken the midle path; Captain B———, some huntsmen, and myself took to the feft; and the other hunters scrabled down that to the rite. At this momunt I did not see enything but after advanceing a few yards, the hugh hed ef an elephunt shaking abuve the jungle, withen ten yards of us, burst sudenly upon my view.

5. Captain B——— ande a hunter justt befor me; we al fired at the same moment, and in so dirrect a line that the percussion-cap of my gun hitt the hunter, whome I thougt at first I had shoot. This accident, thogh it pruved slight, troubled me a litle. The grate excitement ocasioned by seeing, for the first tim, a wild best at liberty and in a state of natur, product a sensation of hop and fear that was intens.

Naming colors. The individual measured was required to give out loud the series of color names corresponding to a series of small squares of colored paper arranged upon a sheet of paper.

Opposites tests. Writing as rapidly as possible the opposites of a given set of words. The given words were in the case of the easy opposites—good, outside, quick, tall, big, loud, white, light, happy, false, like, rich, sick, glad, thin, empty, war, many, above, friend.

Part-whole test. Writing as rapidly as possible a word meaning the whole of which the thing meant by a given word was a part.

Parts of speech. Marking nouns, verbs or some other parts of speech wherever they occurred in a page of simple English prose.

r-e test. This was the same as a-t test except that the words to be marked were those containing r and e.

Word test. To write words containing certain given letters (*e. g.* write a word of six letters containing l and o).

Controlled thinking with word relationships. The opposites, genus-species and part-whole tests and their like.

APPENDIX II.

Explanatory Index of Common Measures.

Measurements of General Tendency.

$$\text{The average} = \frac{\text{the sum of the individual measures}}{\text{the number of cases.}}$$

The median = the measure above and below which an equal number of the individual measures lie.

The mode = the most common of the individual measures.

Measures of Variability.

The average deviation (A. D.) = the average (arithmetical) of the deviations of the individual measures from their average.

The probable error of a distribution (P. E.) = the amount of difference from the average such that 50 per cent. of all the individual measures lie between Av.— P. E. and Av.+ P. E.

The standard deviation (σ) of a distribution = the square root of the average of the squares of the deviations of the individual measures from their average.

The coefficient of variability = some measure of variability divided by some measure of the general tendency of the ability; *i. e.*, any one of the following:

Average deviation divided by average.
" " " median.
" " " mode.

Probable error of a distribution divided by average.
" " " " median.
" " " " mode.

Standard deviation divided by average.
" " " median.
" " " mode.

Measurements of Relationship.

The coefficient of correlation (r). Let x_1, x_2, x_3, x_4, x_5, etc., be the deviations from the average of one series of measures; let y_1, y_2, y_3, y_4, y_5, etc., be the corresponding deviations from their average of the second series. Let σ_1 be the standard deviation of the first series and σ_2 be the standard deviation of the second series. Let n be the number of pairs. Then

$$r = \frac{\text{sum of } x_1y_1,\ x_2y_2,\ x_3y_3, \text{ etc.}}{n.\ \sigma_1\sigma_2}$$

Measurements of Reliability (or more properly of unreliability).

These are all measures of the likelihood of a certain difference between the true result (the one that would obtain in the case of our measurement if we had an infinite number of measures) and the one actually obtained from the few measures we have actually made. The measure will thus involve a statement of an amount of difference and of the likelihood of unlikelihood of the existence of one as great or greater than it. Sample formulæ are the following:

The chances are a bit over 2 to 1 that the true average will not deviate from the obtained average by more than the standard deviation of the distribution in question divided by the square root of the number of cases studied. The chances are a bit over 2 to 1 that the true variability will not differ from the obtained variability by more than the standard deviation of the distribution in question divided by the square root of twice the number of cases. The chances are 1 to 1 that the true relationship will not differ from the obtained relationship by over

$$.6745\ \frac{1-r^2}{\sqrt{n(1+r^2)}}.$$

The unreliability of a difference between two things equals the square root of the sum of the squares of the unreliabilities of the two things.

TABLE A.

TABLE OF VALUES OF THE NORMAL PROBABILITY INTEGRAL CORRESPONDING TO VALUES OF $\frac{x}{\sigma}$; OR THE FRACTION OF THE AREA OF THE CURVE BETWEEN THE LIMITS 0 AND $+\frac{x}{\sigma}$ OR 0 AND $-\frac{x}{\sigma}$.

Total area of curve assumed to be 10.000.
x = deviation from mean.
σ = standard deviation.

$\frac{x}{\sigma}$	0	1	2	3	4	5	6	7	8	9	Δ
0.0	0000	0040	0080	0120	0160	0200	0239	0279	0319	0359	40
0.1	0399	0438	0478	0517	0557	0597	0636	0676	0715	0754	40
0.2	0793	0832	0871	0910	0948	0987	1026	1064	1103	1141	39
0.3	1179	1217	1255	1293	1330	1368	1406	1443	1480	1517	38
0.4	1554	1591	1628	1664	1700	1737	1773	1808	1844	1879	36
0.5	1915	1950	1985	2020	2054	2089	2124	2157	2191	2225	34
0.6	2258	2291	2324	2357	2389	2422	2454	2486	2518	2549	32
0.7	2581	2612	2643	2672	2704	2734	2764	2794	2823	2853	30
0.8	2882	2910	2939	2967	2995	3023	3051	3078	3106	3133	28
0.9	3160	3186	3212	3238	3264	3290	3315	3340	3365	3389	26
1.0	3414	3438	3461	3485	3509	3532	3555	3577	3600	3622	23
1.1	3644	3665	3686	3708	3729	3750	3770	3791	3811	3830	21
1.2	3850	3869	3888	3906	3925	3944	3962	3980	3997	4015	19
1.3	4032	4049	4066	4083	4099	4115	4132	4147	4162	4178	17
1.4	4193	4208	4222	4247	4251	4265	4279	4292	4306	4319	14
1.5	4332	4345	4358	4370	4383	4395	4406	4418	4429	4441	12
1.6	4452	4463	4474	4485	4496	4506	4516	4526	4536	4545	10
1.7	4554	4564	4573	4582	4591	4600	4608	4617	4625	4633	9
1.8	4641	4648	4656	4664	4671	4678	4686	4693	4700	4706	7
1.9	4713	4720	4726	4732	4738	4744	4750	4756	4762	4767	6
2.0	4773	4778	4783	4788	4794	4799	4804	4808	4813	4817	5
2.1	4822	4826	4830	4834	4838	4842	4846	4850	4854	4858	4
2.2	4861	4865	4868	4872	4875	4878	4881	4884	4887	4890	3
2.3	4893	4896	4899	4901	4904	4906	4909	4911	4914	4916	3
2.4	4918	4921	4923	4925	4927	4929	4931	4933	4935	4936	2
2.5	4938	4940	4942	4943	4945	4946	4947	4949	4951	4952	2
2.6	4953	4955	4956	4958	4959	4960	4961	4962	4964	4965	1
2.7	4966	4967	4968	4969	4970	4970	4971	4972	4973	4974	1
2.8	4975	4975	4976	4977	4978	4978	4979	4980	4981	4981	0.5
2.9	4982	4982	4983	4983	4984	4984	4985	4985	4986	4986	0.5
3	4987	4991	4993	4995	4997	4998	4999	4999	4999	5000	.....
∞	5000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Table A, which is quoted from page 55 of Davenport's 'Statistical Methods,' enables one to calculate easily the probability of any given varia-

tion in a normal distribution or the amount of a variation of any given frequency (reckoning from a stated percentile grade) provided the standard deviation of the distribution is known. The probability of any given degree of unreliability of any measure of a distribution can be calculated from the same table provided the mean square error of the measure is known.

Table B, which is quoted from page 203 of Galton's 'Natural Inheritance,' serves the same purpose when the probable error is used in place of the standard deviation and mean square error. To make it comparable with Davenport's table the entries should be halved.

TABLE B.

TABLE OF VALUES OF THE NORMAL PROBABILITY INTEGRAL CORRESPONDING TO VALUES OF $\frac{2x}{P.E.}$; OR THE FRACTION OF THE AREA OF THE CURVE BETWEEN THE LIMITS $\frac{+x}{P.E.}$ AND $\frac{-x}{P.E.}$.

Total area of curve assumed to be 1.
x = deviation from mean.
$P.E.$ = probable error.

Multiples of the Probable Error.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	.00	.065	.11	.16	.21	.26	.31	.36	.41	.46
1.0	.50	.54	.58	.62	.66	.69	.72	.75	.78	.80
2.0	.82	.84	.86	.88	.89	.91	.92	.93	.94	.95
3.0	.957	.964	.969	.974	.978	.982	.985	.987	.990	.992
4.0	.9930	.9943	.9954	.9963	.9970	.9976	.9981	.9985	.9988	.9990
5.0	.9993	.9994	.9996	.9997	.9997	.9998	.9998	.9999	.9999	.9999
infinite	1.0000									

APPENDIX III.

Suggestions for Investigations in Educational Science.

It is often as profitable to learn what ought to be and can be, as what has been, found out about any body of facts. I therefore make no apology for the addition of this chapter.

The problems that will be suggested are such as any trained student who possesses ingenuity and a knowledge of elementary statistics can attack with fair promise of success.

The Discovery of Units of Mental Measurement.

Educational science needs lists of words in spelling, of examples in arithmetic, algebra and geometry, of questions in geography, history and grammar, exercises in Latin, French and German, etc., so chosen that any one will be of approximately the same difficulty as any other, or at least so that a given group of two or three or four will be of equal difficulty with other given groups. The service rendered to physical science by the inch, the ounce, the ohm, the ampere, the calorie, etc., should be duplicated in mental science.

Such commensurate units of measurement may be at least roughly determined by taking as equal those tasks which are done by equal percentages of a group of individuals in a constant time. Thus if with the examples printed below, out of 1,000 eighth-grade children chosen at random 761 do example 1 correctly in 1 minute and 759 do example 2 correctly in the same time we may say with fair surety that accomplishment of 1 equals accomplishment of 2.

1. How much is $\frac{7}{5} + \frac{8}{4} - \frac{5}{8} + \frac{2}{3} - \frac{7}{6}$?
2. How much is $\frac{96}{45} \times \frac{22}{13} \times \frac{52}{16} \times \frac{18}{44}$?
3. How much is $\frac{81}{42} \times \frac{14}{27} \div \frac{65}{9} \times \frac{7}{26}$?
4. To $\frac{9}{4}$ add $\frac{3}{7}$; divide by $\frac{16}{56}$; add $\frac{12\frac{1}{2}}{8}$; multiply by $\frac{4}{5}$.

If we find a score of examples for all of which the percentages of correct answers are practically identical we can say, for eighth-grade children $1 = 2 = 3 = 4 = 5 = 6 = 7 = 8 = 9$, etc., and use all the examples as duplicates of a common unit, just as we use all inches or ounces.

Until we have such units all our investigations rest on insecure foundations.

The Distribution of Mental Traits.

Arguing from the average condition instead of from the total condition of affairs is a well-nigh universal fallacy in educational theory. For instance, the average income of the American universities and colleges for men and for both sexes listed in the '99–1900 report of the U. S. Commissioner of Education was about $50,000; yet there were only 10 per cent. of the colleges which had within $15,000 of that amount. A foreigner knowing nothing of conditions here would never imagine that 37½ per cent. of these so-called colleges had less than $10,000 income per year, nor that we possessed colleges with an income twenty times the average.

Only in a few cases do we know the exact distributions of the facts about which we argue. Yet nothing is needed beyond time, thought and energy to discover the distributions of—

The age of entrance to school;
The age of leaving school;
Length of attendance upon school;
The age of college graduation;
The ability of children of any given age or amount of training in any form of school work that can be measured in units of amount, e. g., spelling, arithmetical work, reading, writing;
The cost per pupil for elementary education;
The cost per pupil for secondary education.

These and many other variable facts have not been fully described and measured but they could be from records available in reports or in superintendents' offices or from tests easily made.

The Relationships of Mental Traits.

(1) Almost any measurement of relationships is important from the point of view of general psychological theory. (2) Measurements of the relationships between school abilities by means of objective tests are needed to compare with the results found in the case of the teachers' marks. (3) Measurements of the relationships of various simple tests to more complex

and general abilities will help us to diagnose the general conditions more easily. For instance, we may expect some time to find eight or ten tests capable of being given in an hour or two which will inform us precisely of a pupil's degree of mental maturity. (4) The relationships of success in the early years of school to success in later years, of success in school to success in life, and of early tastes to later career, are of the utmost practical importance. Yet the record books of a single school system and the school marks of 200 adults whose relative success in life was roughly known would provide answers to the first two questions and a moderate amount of investigation of the boyhood of selected adults would go far toward answering the third.

Original and Acquired Traits.

A comparison of the variability in school abilities of orphans brought up in an institution under the same rules, with the same habitat, etc., with children of the same general social group brought up in a variety of homes with different ideals, models and requirements influencing them. Such a study well done would be worth thousands of pages of opinion about home training or the potency of the germ plasm.

A comparison of the similarities of identical with those of unlike twins. In both cases we have for the two members of each pair closely similar training. Consequently whatever greater similarity is found in the identical twins must be due to original nature.

Measurements can be easily obtained of the following traits:

Grade reached in school,
School marks,
Musical ability,
Athletic ability,
Handwriting,
Rate of reading,
Rate of writing,
Spelling,
Addition,
Multiplication,
A test (give 60 seconds time),
a-t test (give 60 seconds time).
Other simple tests can be readily devised.

Heredity.

The exact study of family resemblances is statistically somewhat intricate, but the collection of records of mental traits in related individuals which a trained statistician may later subject to careful examination is a useful and interesting study.

For the student of the mental progress of the race perhaps the most important question of all concerns the correlation between fertility (or more exactly reproductivity) and intellectual and moral traits. The correlation in women between fertility and stature is for mothers and daughters .18. This is sufficient to bring about a sensible increase in the stature of the race in a century. In so far as intellectual gifts and moral virtues are correlated with fertility we have surety of racial progress apart from any action

of natural selection in the strict sense. The exact treatment of this question needs much statistical care, but the collection of the statistics of marriage and offspring in the case of individuals of known mental makeup is not difficult. One of the most useful contributions to education in the broadest sense would be a document presenting such figures for ten or more individuals chosen at random from the following groups: bishops and high church officers, clergymen of fifty years and over who have remained undistinguished by large salaries, published writings or great esteem for intellect amongst their fellow clergymen; bankers, heads of factories, heads of commercial enterprises, small grocerymen and butchers, clerks, janitors; judges of the supreme court of the United States, eminent lawyers of lower courts, professors of law in universities, petty lawyers in country towns; members of cabinets, senators, congressmen, members of state legislatures, small office-holders in cities; professors in universities, teachers in high schools, book-keepers; superintendents of factories, foremen of construction gangs, builders, carpenters and other mechanics, unskilled laborers. Though the statistics are still more important in the case of women it is harder here to measure intellect by achievement. It should, however, be easy to rank in rough order for intellect a hundred women whose work or households or personalities were well known to the observer. Notes of relevant facts in each case would make the facts capable of treatment later.

The Influence of the Environment.

Although, as was noted in the text, it is difficult to get two groups, one characterized by the presence, the other by the absence of a given training and still have the condition of the groups *before the training* alike, still it is possible with proper care to get such groups with and without kindergarten training; with the trainings of a 3-, a 4- and a 5-hour session; with coeducation and with separate classes, etc.

The influence of special forms of discipline upon more general capacities and habits can be studied with advantage in the case of almost any function.

The Influence of Selection.

If the members of the grammar school population of the age of twelve or thirteen were measured for intellect, for social position of parents, for physique and for any other traits of importance and if later it was noted which of them went to high school we should know how far the high school has the pick of the intellect or of the wealth or of the physique or whatever the trait might be, of the general population. If we recorded these same facts again in the first year of high school and then noted which ones graduated we could tell the extent to which high-school graduation means a particularized selection. So also by following groups to college and to professional schools. The result of a careful tracing of a thousand children from the last year of compulsory attendance up through the higher schools would to my mind be one of the most brilliant reports in educational literature.

Mental Growth.

Although almost any repeated measurements upon children would be worth while, the precautions necessary to avoid a mixture of practice effect, to get tests suited for use over a period of years, and to treat the problems of

measurement of change adroitly, are so numerous that the student should have thorough training in making mental measurements and in their statistical treatment.

Sex Differences.

The comparative variability of adult men and women is not known with anything approaching completeness or precision. College students in colleges where men and women students are selected from groups of the same intellectual quality will offer an abundance of material. Their marks in college courses and their abilities in mental tests can be readily ascertained. Differences in the amounts of various abilities can be measured at the same time. In the case of school children the results stated in Chapter XI. need to be confirmed or replaced by more accurate ones.

The investigations suggested above are only a few samples of the hundreds of promising studies that await him who chooses to study the facts at first hand. They, rather than others, have been chosen for mention chiefly because of their practicability and freedom from excessive requirement of technical psychological training.

INDEX.