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FRANCIS GALTON LABORATORY FOR NATIONAL EUGENICS

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# The Influence of Defective Physique and Unfavourable Home Environment on the Intelligence of School Children,

## Being a Statistical Examination of the London County Council Pioneer School Survey

BY

DAVID HERON, M.A.
GALTON RESEARCH FELLOW IN NATIONAL EUGENICS
IN THE UNIVERSITY OF LONDON

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# THE INFLUENCE OF DEFECTIVE PHYSIQUE AND UNFAVOURABLE HOME ENVIRONMENT ON THE INTELLIGENCE OF SCHOOL CHILDREN

## (1) Introductory.

The object of the present memoir is twofold: (*a*) to illustrate the difficulties that arise in attempting to make reliable and comparable observations on school children; and (*b*) to indicate the difficulties met with in the statistical treatment of such observations, if they are not made with due regard to the needs of the statistician.

The medical inspection of school children is now a recognized feature of our social life. We have high hopes of what it may effect in the future; but if it is not to disappoint us, if the harvest is to be worth the labour and its cost, we must definitely settle what we expect to learn from it and what we hope to do for the children by its aid. We shall be bitterly disappointed if we anticipate that definite results can be obtained by merely amassing data without much careful thought. We must determine first of all what are the right lines of inquiry and how best to standardize medical inspection and especially the teachers' powers of observation. Above all, we have to remember that the real complexities of the problems before us are very far from being realized at the present time.

Great Britain is a country of many "local races". Such characters of children as stature and weight vary from local race to local race precisely as eye and hair colours do. In the schools of a large town it is quite usual to find significant pigmentation differences in the different districts. No instructed student of anthropometry attributes these differences to the effects of environment; they are due, he knows well, to different racial proportions in the different districts; the Irish, the Jewish, the Scandinavian, and the Anglo-Saxon elements are there in varying proportions, and in many big towns even a study of the children's names is sufficient to show the varying proportions of these or other races.

Now stature and weight are as markedly differentiated among these racial types as are hair colour, eye colour, or shape of head. What is more, their eyesight, their hearing, and their standard of clothing are often widely differentiated as well. No study of the physique of the school child will be of service unless it is associated with some determination of the racial elements in the schools under consideration. Inquiries as to origin of parents and observations on eye and hair colour must accompany the determination of other physical characters. If the children attending a school in a poor neighbourhood are found to be much under the average height and weight, this may be a result of the environment, but it may equally well be found that the pigmentation of the children is differentiated also, and that on further inquiry there is a large number of immigrants, Irish or Italians perhaps, in the district. Indeed the environment itself may be racially selective, driving out the physically superior and attracting a physically inferior population.

The moment these points are fully realized it will be seen how difficult it is to obtain any results of a really helpful nature by comparing height and weight curves of children from different districts, or from schools in the same large town but in different quarters, or of children of different social grades. It is idle, for example, to compare Lancashire and Devonshire children, or either, with a most misleading "British Association Standard",* and to suppose that anything may be learnt from the result as to the influence of factory or rural environment on the physique of the children. To do so may be to attribute to environment differences which are as purely racial as proportions of hair and eye colours.

In drawing up schemes for the medical inspection of school children, these points must eventually be fully recognized. Mere heights, weights, and chest measurements are of little service, and yet these are being obtained at the present time in endless numbers; the percentage growth of these characters per annum in the individual child would probably be more free from racial influence, but even this point has not up to the present received due attention, and records of parental origin and of pigmentation are the most essential needs of the present schemes.

Even where we are certain of uniformity of race, we cannot assert that differences in physique are due to differences in environment. Let us suppose that the mentally and physically inferior child has been shown in some fairly homogeneous material to be associated with the more unsatisfactory surroundings; we have still to ascertain whether this inferior environment may not be the centre to which the physically and mentally inferior parents naturally gravitate. What we really want to know is whether, for a constant type of parent, the environment is a substantial factor in determining the mentality and physique of the child.

* The British Association standard stature and weight for each year of age were based on records obtained from all parts of the country, and possibly gave a fair idea of the average stature and weight of the child population of this country. But when the average heights and weights of the children of any district are found to fall below this standard, it is quite unjustifiable to assume, as has been done so often, explicitly or tacitly, that this is due to some unfavourable conditions in the district. Until we know the average heights and weights of each racial element of the general population and of the particular district selected for comparison, making due allowance for age, we have no means of saying whether the differences are due to environmental conditions or are purely racial.

Now it will be evident that this cannot be ascertained until we have some information about the parents. The school records of children will never meet national demands until they are extended to cover some inquiry as to the parents and the home conditions. This is not a possibility of the present medical inspection scheme, but none the less it cannot be ignored. It is not possible to assert that defective mentality or physique is due to environmental conditions until some study has been made of the home and the parents. There may be a relationship between physique and environment which is merely an indirect effect of heredity resulting from the selective action of environment upon the parents. It would seem that the point we are dealing with here is a vital one; its solution is to be found in supplementary surveys—independent of the school medical survey—carried out by energetic social workers.

Child-life is the most valuable asset of the nation; on what is its fitness principally based? The future of the nation truly depends on an exact answer to that question. The problem is exceedingly complex and subtle; it cannot be fully answered without surveys of homes and parents. The work of Charles Booth has shown that much can be done in this direction by even a single man with the needful resources; the work of the Edinburgh Charity Organization Society shows that still more valuable results can be obtained by the co-operative action of school authorities, medical officers, and social workers.

The legislation of the future is certain to be of a more and more social character, but the value of that legislation will depend on the attention paid to the more weighty factors influencing the fitness of the child. What is the relative importance of heredity, of moral, of economic, and of hygienic environment on the mentality and physical fitness of the child? We have assumed the answers in the past; they must be found in the future by the same type of laborious research as we now give to any physical or biological problem.

Well-planned school medical inspection combined with standardized observation on the part of the teachers will provide the easier portion of the necessary data, but the harder portion must fall to the part of organized social inquiry. The time has come when it is needful for further social progress that we should follow up not only the school child but also the pauper, the mentally defective and the criminal, into their homes, and study from the standpoint of science—that is, without prejudgment and with bridled emotions—the relative importance of the conditions which produce the pauper, the imbecile, and the criminal.

In all these cases the problem before us is: Given a constant type of parent, what effect has environment on the child? Stating the problem analytically we have the following factors: $p$, the measure of any character in the parent; $c$, the measure of that character in the child; and $e$, the environmental factor. We have then $r_{cp}$, the correlation between child and parent for the character under consideration, the intensity of heredity; $r_{ep}$, the correlation between the environment and the character in the parent; and $r_{ec}$, the correlation between the environment and the character in the child.

Now if we wish to find the relationship between the character under consideration in the child and the environment, independently of the measure of the character in the parent, i. e. independently of the influence of heredity, we must use the partial correlation coefficient,

$$_pR_{ec} = \frac{r_{ec} - r_{cp}r_{ep}}{\sqrt{1-r_{cp}^2}\ \sqrt{1-r_{ep}^2}}.$$

This value would be zero if the relationship $r_{ce} = r_{cp}r_{ep}$ held.

Now we are fairly certain that the value $r_{cp}$, the correlation between parent and child for any character, does not differ widely from ·5. What we do not know is the extent to which the environment selects the parents by their physique or mentality. But it is exceedingly probable that the mentally and physically inferior parents gravitate to the inferior environment. If this relationship were only of the order ·2, it would be needful for $r_{ec}$, the observed correlation between the environment and the character in the child, to be greater than ·10 for any definite effect of environment, independent of heredity, to show itself on the child. For values of $r_{ep}$ from ·3 to ·4 we must have $r_{ec}$ greater than ·15 or ·20; and for closer selective action of environment on parental character, we must have still higher values of $r_{ec}$. Now all the values of $r_{ec}$ so far obtained are small quantities of this kind between ·00 and ·20; they are such that we may reasonably suppose $R_{ec}$ small or zero if there be any sensible value for $r_{ep}$. In other words, they are compatible with little or no influence of environment on child for parent of constant type. High values of $r_{ec}$, i. e. values about ·5, would mean that $r_{ep}$, to produce a zero $R_{ec}$, must needs be above unity, which is impossible.

Unless $r_{ec}$ comes out greater than ·5, we cannot argue, without investigating the relationship between parent and environment, that $R_{ec}$ is significant; it *probably* is if $r_{ec}$ is greater than ·3 or ·4. But for such values as ·00 to ·20 actually found in this paper, the only safe conclusion seems to be that environment has very little, if any, influence, and what influence it has may be an indirect effect of heredity acting by environment selecting the parents. As an illustration of this point we may refer to Miss Elderton's result that children of fathers with an "unhealthy" trade have somewhat less stature and weight. This relationship, however, need not depend on the unhealthiness of the father's trade, but on the possibility that the man is a shoemaker, say, and not a blacksmith, because he is physically inferior and will accordingly have physically inferior offspring.

The points discussed above have been referred to because it is needful at present to insist on the fact that school data without home data will not solve the most urgent national problems, and further to explain what interpretation must be placed on our results.

Correlations in material such as the present must be of a marked kind, say at least of ·3 or ·4, and established by several independent investigations, to allow of our asserting that unfavourable home environment or defective physique is influencing the intelligence of the children.

## (2) Material.

We have seen in the above introduction that for the full answer to the questions which concern the eugenist and the philanthropist we can only look to the records of medical inspection supplemented by careful sociological surveys. Such alone can tell us the relative weights of heredity and of environment, and, above all, show us the exact environmental facts which are influential. Much of this search must be of the nature of experiment, of groping for influential environmental factors, and of seeking for practical methods of effective record and observation. It will be a great waste of time, labour, and money, if all the independent educational authorities of this country start individual inquiries without regard to the experience to be gained from the analysis of earlier attempts on the part of the pioneers in this field. Even inquiries which are largely negative in character are of first-class importance as marking out lines of no thoroughfare. It would be the greatest blindness to suppose that such an inquiry as that initiated by the London School Board in 1904 was of little profit because on so many points it has led to negative results. It is, on the contrary, a pioneer investigation, which, if its lessons are properly studied and applied, ought to save the educational authorities of this country many thousands of pounds and much vain labour. The danger is that they will be content to learn from their own experience without appreciating what this inquiry has shown to be possible or profitable.

The Francis Galton Laboratory has examined five distinct school inspection inquiries, dealing with children in London, in Glasgow, two with children in Edinburgh, and one with children in Aberdeen. The staff of that Laboratory feel certain that in all these pioneer investigations each system of observation and record had much to learn from the results of the other systems and from the statistician as to what type of observation can be of service from the mere standpoint of numerical reduction and the safe deduction of conclusions.* Further, no future investigation can afford to neglect the experience of these earlier inquiries. For instance, one of these investigations statistically leads to the conclusion that defective hearing is not sensibly associated with bad teeth. This has either to be accepted as a definite conclusion, or the observations on teeth and ears must be

* Such points as placing 90 per cent. of the children in one class and the remaining 10 per cent. in five or more classes, the choice of only two classes when for statistical purposes three at least are desirable, the use of terms at different centres with wholly different values, and the tendency to club together as over or under a certain value the "tails" of frequency distributions may be noticed as instances in point.

made on a different plan. The pioneer inquiry is one which must not be disregarded if additional observations are to give any new knowledge; and illustrations of this point could be multiplied twenty-fold. Either the negative results obtained from these pioneer inquiries are correct and therefore do not need repetition, or, if doubt be felt with regard to them, the observations must meet the criticisms which can be raised against the first admittedly experimental investigations. It is from this standpoint that we appreciate, and we hope other investigators will appreciate, the generosity with which the Education Committee of the London County Council has placed its data at the disposal of the Laboratory for reduction and criticism. More at present is to be learnt by careful statistical examination of these pioneer inquiries than by any repetition of them until we have determined what exactly is feasible, what lines of research are profitable, and what preliminary standardization and special training are necessary.

The periodical stocktaking of the child-life of the community may turn out to be the most remarkable factor in our future understanding of what tends to strengthen national welfare; or it may simply lead to the accumulation of records from which no real knowledge can be extracted, and which will soon be taken on that very account, in a non-intelligent and perfunctory manner. The success of the medical inspection of schools depends not only on the enthusiasm of the first medical officers, it depends on the co-ordination of many factors, the teacher, the social worker, and the trained statistician. We must, above all, advance slowly, weighing the experience of each new record before starting more elaborate systems.

The history of the material used in this paper is of some interest. In his Report for 1903,* Dr. Kerr says: "We have no trustworthy measurements of the development of London children. The necessity for a very large number of measurements, requiring a considerable time to effect, at present stands in the way. The smallest number of measurements to give trustworthy results for purposes of comparison in different groups or with other standards would amount to many thousands. It is desirable that such should be obtained for boys and girls at each quarter year of age from 5 to 15. All measurements not absolutely necessary being avoided, there would be required:

Sex, standard, school; age in years and months; weight in clothes; height (without shoes); chest girth (full and empty)."

A few months later † this proposal took definite shape, and it was suggested that an investigation should be initiated to show the relations between (*a*) the educational status, (*b*) the physical condition, and (*c*) the social position of the child. It was hoped that this investigation might cover at least 20,000 children.

For those characters which could not be expressed on a quantitative scale, a system of marks, 1, 2, 3, 4, 5, was suggested: one mark indicating a condition

* First Annual Report of the Medical Officer to the School Board of London, p. 2.

† Report of the Medical Officer of the late School Board of London, 1904, p. 4.

which ought not to be allowed to continue and which required immediate relief; two marks indicating a sub-normal, markedly inferior, or poor condition; three marks, a fairly normal state, neither markedly below nor decidedly above the average; four marks, a condition distinctly above the average; and five marks, a condition of high excellence. Doubtful cases were to be marked on the side towards the average. How far such a system of marks has been successful will be considered later.

As an indication of the educational status of the child, it was suggested that the teacher should state the standard and should give an estimate of the all-round mental capacity of each child dealt with. It was proposed that one mark should be given for a very dull and backward child; two marks for one distinctly below the average; three marks for the average child; four marks for a distinctly sharp child; while five marks would be given for a particularly clever and bright child. Doctor, teacher, and school attendance officer were all to co-operate in the work; the doctor was to give the age, height, weight, condition of clothing, and the results of a superficial examination of the hair, cervical glands, eyelids, teeth, &c.; the part to be played by the teacher has already been indicated, and the school attendance officer was to obtain information from which an estimate could be made of the home conditions of the child, such as the number of rooms occupied, the number of individuals living in those rooms, &c.

After considerable discussion, it was decided by the Committee that this inquiry, which would cost, if based upon records of 50,000 children, about £700, or less than 3½*d.* a head, should be indefinitely postponed.

It is very earnestly to be hoped that this investigation may yet be carried out. It is only by a full scheme of the kind suggested that a true picture could be formed of the very varied child-life of London. But the many and manifold advantages that would flow from such a survey of the school children of London need not be further emphasized.

Although this comprehensive scheme could not be carried out, a couple of measuring standards were obtained and the work was started on a small scale and still continues. The present investigation deals with the material so obtained. We have further to thank Dr. Kerr for his ready help and advice in many matters relating to the survey. Various portions of the material have already been analysed and the results published in the Annual Reports of the Medical Officer of the Education Committee of the London County Council; but there has been no systematic attempt to reduce the statistics by modern methods.

The observations dealt with in this paper refer to 14 different schools, but in 1 school the observations on the boys only could be used, and in 2 schools those on the girls only could be used, so that we are really considering 12 boys' schools and 13 girls' schools.

The different schools will throughout the paper be distinguished by numbers, such as *B.* 6 and *G.* 8, *B.* denoting a boys' school and *G.* a girls' school, while *B.* 6 and *G.* 6 refer to the boys and girls of the same school, No. 6.

By the kindness of the head masters and head mistresses of the schools, and of the medical men who carried out the investigation, the following notes on the individual schools have been supplied, in order that some idea of the character of the schools might be obtained.

*B.* 1 and *G.* 1. The children attending this school belong for the most part to families of the casual labour class, and, especially during the winter months, suffer from inadequate feeding and clothing. The housing question presses very severely, rents being high, and the accommodation, mostly provided in high block dwellings, very limited.

*B.* 2 and *G.* 2. This school is situated in a district of a very mixed character. It was built recently, and is attended by the children of the worse section of the population, the better classes going to the older schools in the district. At the time of the investigation there was much unemployment in the district and much drinking, but a characteristic feature of the locality is the rapid changes among the people. This is well shown by the following table, which gives the number of children who were admitted to and who left the school, and the average number on the roll for three years.

TABLE I.

| Year ending. | Number of children admitted. | Number of children left. | Average Number on the Roll. |
|---|---|---|---|
| Jan. 31, 1907 | 158 | 155 | 285 |
| „ „ 1908 | 180 | 188 | 280 |
| „ „ 1909 | 148 | 140 | 274 |

The table shows that more than 50 per cent. of the children left within the year.

*B.* 3 and *G.* 3. This school is situated in a fairly well-to-do neighbourhood; the pupils are the children of city clerks, artizans, and fairly prosperous tradespeople. The neighbourhood is rather low and damp, and there is a fair amount of rheumatism, chorea, &c.

*B.* 4 and *G.* 4. Many of the children attending this school come from very poor homes, and some are of the gutter-children type, but many also are the children of small tradespeople and others in fairly good positions. There are very few, however, of the lowest class. This is shown by the fact that during the winter only 30 cases required feeding out of 330, and never more than 20 at a time. Some of these were fed only for a short time, "while father was out of work". The houses are mostly small, but, though there is still some overcrowding, the worst spots have been cleared away.

*B.* 5 and *G.* 5. This school is situated in the Bethnal Green district. About 25 per cent. of the children are Jews.

*B.* 6 and *G.* 6. This school is situated in a low-lying and damp neighbourhood, and the children suffer from chorea, enlargement of glands, tonsils, and adenoids, and from rheumatism and deafness. The children are of a very well-to-do class ; there are only three or four poor children in each department.

*B.* 7 and *G.* 7. This school is said to be of the same type as *B.* 11 and *G.* 11. Much attention has been paid to physical exercises and organized games, resulting in marked benefit to the physique of the children.

*B.* 8 and *G.* 8. This school is a little below the general average. The parents are artizans, mechanics, and are employed in gas-works, and on the whole have fairly steady work. The attendance is good and there is little sickness among the children, who live within easy distance of large open spaces.

*B.* 9 and *G.* 9. This school is situated in one of the poorest districts of South London. The parents are mostly engaged in riverside work—watermen, dredgers, and casual labourers—and at the time of the inspection there was much unemployment in the district and many of the children were obviously underfed and very badly clothed. Many of the children are bootless even in winter. There is much overcrowding. The school is classed as one of special difficulty by the Education Committee of the London County Council.

*B.* 10 and *G.* 10. Except for the slum element which has lately been introduced by the building of cheap workmen's houses, the majority of the pupils are the children of small tradespeople, clerks, artizans, and shop assistants. The school is surrounded by open spaces and the children are under ideal conditions as regards fresh air and space for physical exercises and organized games. A good deal of time is devoted to hockey, cricket, football, and swimming, under the supervision of the teachers, with the result that a real *esprit de corps* exists among the pupils.

*B.* 11 and *G.* 11. This school is situated in a district where there is no overcrowding and is surrounded by many open spaces. The parents in most cases are in regular employment as small shopkeepers, clerks, gardeners, railway servants, and outdoor labourers.

*G.* 12. This school is situated in a district which is very mixed in character, streets of decent houses being close upon some of the worst slums, and consequently the class of children shows no uniformity. About half of the children come from fairly good homes and live under average conditions, but the proportion of poor and neglected children is steadily increasing.

*G.* 13. About 16 per cent. of the children in this school are extremely poor. At the time of the inspection there were between 30 and 40 children on the roll who lived in a slum close to the school. This, however, has now been demolished. There are a number of gardens and open spaces in the immediate neighbourhood, so that the school gets plenty of fresh air and sunshine.

*B.* 14. This school is situated in one of the poorest districts in London, and the poverty is fairly uniform. From 30 per cent. to 40 per cent. of the children on the roll are given a free mid-day meal during the winter months. There are many cases of overcrowding. Most of the parents belong to the unskilled labour class, but there are few criminals.

These short notes will give some idea of the type of school in each case. They show that the schools differ widely in character and may fairly be considered as representative of the children of the elementary schools of London.

### (3) Categories Used.

In determining categories for qualitative classification it is essential that the terms used should be defined as clearly and definitely as possible, and, further, that the definitions selected should be tested by actual practice,* so that the personal equation of the observers may be reduced to a minimum. The use of the word "average" in the categories is to be deprecated, as it does not mark, except in very inexact language, a class, but a definite degree, and where we find 50 per cent. of the children classed as "average", 20 per cent. as "above", and 17 per cent. as "below" the average, the remaining 13 per cent. being put in extreme classes above "above" and below "below" the average, there must arise some danger of a large personal equation, and therefore some difficulty in distinguishing its effects from true environmental effects.

Not only is there some vagueness in the categories used, but, as will be seen when we deal with the various characters, the system used varies considerably in different schools.

For every child there is given a statement of the age, standard, height, and weight, and an estimate by the teacher of the child's mental capacity, while the medical officers give for the children in every school an estimate of the condition of the teeth, in 8 boys' schools and 9 girls' schools an estimate of the state of nutrition, of the condition of the clothing in 7 boys' schools and 6 girls' schools, of the degree of cleanliness in 6 boys' schools and 6 girls' schools, and of the power of hearing, condition of the cervical glands and condition of the tonsils and adenoids in 3 boys' schools and 3 girls' schools.

In all, 4,286 boys and 4,474 girls are dealt with.

### (4) Classification of Intelligence.

Since the main purpose of our investigation is to discuss the effect of various physical conditions on the intelligence of the children, it will be convenient to consider first of all the teachers' estimate of the mental capacity of the children.

Five grades of mental capacity were used: one mark being given to a "very dull and backward" child, two marks to a child "below the average", three marks

* For example, by two observers examining the same group of children independently.

to an "average" child, four marks to a child "above the average", and five marks to a child who could be called "brilliant".

The percentages of children in each school who were placed in each grade of mental capacity are given in Table II.

## TABLE II.

THE PERCENTAGE OF CHILDREN IN EACH GRADE OF MENTAL CAPACITY IN EACH SCHOOL.

| School Number. | Boys. Grade of Mental Capacity. Brilliant. | Above the Average. | Average. | Under the Average. | Very Dull and Backward. | School Number. | Girls. Grade of Mental Capacity. Brilliant. | Above the Average. | Average. | Under the Average. | Very Dull and Backward. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 33 | 35 | 24 | 8 | — | 1 | 33 | 22 | 22 | 19 | 4 |
| 2 | 4 | 13 | 59 | 17 | 7 | 2 | 1 | 11 | 69 | 15 | 3 |
| 3 | 9 | 24 | 44 | 18 | 5 | 3 | 3 | 13 | 62 | 17 | 5 |
| 4 | 3 | 15 | 61 | 21 | — | 4 | 2 | 16 | 69 | 12 | 1 |
| 5 | 16 | 24 | 47 | 13 | 1 | 5 | 15 | 30 | 37 | 14 | 4 |
| 6 | 3 | 19 | 44 | 31 | 3 | 6 | 4 | 19 | 58 | 18 | 2 |
| 7 | 3 | 23 | 50 | 18 | 5 | 7 | 1 | 17 | 41 | 31 | 10 |
| 8 | 11 | 44 | 34 | 9 | 2 | 8 | 5 | 33 | 49 | 11 | 1 |
| 9 | 5 | 17 | 39 | 27 | 11 | 9 | 22 | 27 | 38 | 10 | 3 |
| 10 | 5 | 17 | 57 | 19 | 2 | 10 | 7 | 18 | 60 | 13 | 3 |
| 11 | 13 | 27 | 47 | 9 | 5 | 11 | 9 | 28 | 40 | 16 | 7 |
| 12 | — | — | — | — | — | 12 | — | 4 | 82 | 13 | 1 |
| 13 | — | — | — | — | — | 13 | 1 | 9 | 68 | 18 | 4 |
| 14 | 11 | 23 | 43 | 22 | 2 | 14 | — | — | — | — | — |

This table indicates quite clearly that the estimation by the teachers of the mental capacity of the children on this system is far from satisfactory. We find, for example, that the percentage of children who are classed as "brilliant" varies from 3 per cent. to 33 per cent. among the boys, and from 1 per cent. to 33 per cent. among the girls, while in one boys' school which was not used exactly 50 per cent. of the children were classed as "brilliant", and in Standard III of that school, out of a class of 95, no fewer than 83 were marked "brilliant".

These differences seem much greater than could possibly arise from any real differences between the average intelligence of children in different districts of London, and what is more, the percentages may differ considerably in the boys' and girls' departments of the same school. In School No. 9, for instance, while 22 per cent. of the girls are marked "brilliant", only 5 per cent. of the boys get this mark.

It is desirable that we should be able to express the degree of heterogeneity among the different schools by a single number. To do so we must use Professor Pearson's "Coefficient of Class Heterogeneity".* To find this coefficient we

* See *Biometrika*, vol. v, p. 198.

must form a contingency table, in which the rows are the distributions of mental capacity in each school, so that in the case of the boys we have a five × twelve-fold contingency table, and in the case of the girls a five × thirteen-fold contingency table. If now the contingency coefficients be calculated from these tables, we have two numbers which express the degree of heterogeneity among the boys' and girls' schools respectively.

If the proportions in each grade of mental capacity were the same for all the schools, then this coefficient would be zero, while the maximum amount of divergence would be represented by a coefficient of unity, and the higher the coefficient the greater the degree of heterogeneity.

Actually those coefficients were found to be:

For the Boys' Schools, ·37.
For the Girls' Schools, ·45.

In the face of such divergence as is represented by these numbers we are compelled to assert that either the schools, and each department of the schools, represent highly differentiated grades of intelligence, or that there has been far too much scope left for the play of personal equation. There can be little doubt that personal equation and not local differentiation contributes the bulk of the heterogeneity. No conventional use of the word "brilliant" would admit of our returning 33 per cent. of the scholars—even in a middle-class scholarship preparatory school—as of "brilliant" intelligence. The word has evidently been used in a personal sense peculiar to the head master or mistress. We may be satisfied that the "brilliant" class in this school has intelligence of a higher grade than those classed as "above the average" in the same school, but it is clearly impossible to pool such estimates with those of another school in which the "brilliant" children form only 4 per cent., say, of the population.

It is clear that each school must be dealt with separately, and this immensely increases the labour of reduction and decreases the certainty of and weight to be given to our conclusions. Believing that the heterogeneity above measured is principally due to personal equation, it will not be without interest to observe how far the individual schools differ from the average of all schools in the use of the terms employed by the teachers, by estimating the relative heterogeneity of the individual schools.

To do so we must form a contingency table consisting of two rows only, one row consisting of the mental capacity distribution of a single school, and the other row, of the distribution of all the other schools taken together. The contingency coefficient found from this table gives a measure of the relative agreement of the individual schools with the general "norm". These coefficients are given in Table III.

## TABLE III.

### Coefficients of Divergence for Individual Schools.

| School Number. | Coefficient of Divergence. | |
|---|---|---|
| | Boys. | Girls. |
| 1 | ·25 | ·28 |
| 2 | ·09 | ·08 |
| 3 | ·02 | ·08 |
| 4 | ·11 | ·12 |
| 5 | ·08 | ·13 |
| 6 | ·09 | ·06 |
| 7 | ·09 | ·19 |
| 8 | ·15 | ·11 |
| 9 | ·14 | ·16 |
| 10 | ·07 | ·03 |
| 11 | ·09 | ·10 |
| 12 | — | ·20 |
| 13 | — | ·11 |
| 14 | ·05 | — |
| Mean | ·10 | ·13 |

This table confirms what has already been found from Table II, that the estimation by the teachers of the mental capacity of the children has not been reduced to any standard value. In all probability this is due to the fact that a system of marks such as that adopted and the rather loose categories "average", "under the average", &c., which they represent, did not demand sufficient preliminary thought on the part of the teachers.

Much better results were obtained by Professor Pearson's more elaborate and more definite scale of mental capacity.* But it must be remembered that in Professor Pearson's investigation, all those who sent in returns were volunteers, and the bulk of them secondary school teachers, while in the present case the return was compulsory and was probably resented by a few as an extra, and perhaps in their opinion an unnecessary duty. It is probable also that some teachers imagined that to enter any children as "very dull and backward" would in some way or other be to their disadvantage. A little consultation, however, between head master or head mistress and the members of the staff, followed by a slight examination of the returns, would probably have eliminated some of the greater divergences.

It will be seen at once that from this standpoint this pioneer survey has a most valuable lesson to teach us. There must be a preliminary standardization of the teachers who are called upon to estimate the intelligence of their pupils. It is idle to assert that there is no such thing as "general intelligence"; it may be difficult to find a satisfactory means of measuring it, but measure it we must if we are to obtain any useful facts from these school surveys. In the battle of life

* *Biometrika*, vol. v, p. 107.

it is general intelligence which grades men, and that is what we seek to measure, imperfectly it may be, by the system of examinations or in practical affairs by our experience of men. Under a good system of closely defined categories we believe that two experienced teachers will show only a small percentage of divergence in classifying pupils with whose work they have been familiar for some time. But even without this system, would not the results of general examinations for each standard provide a better test of general intelligence than we have had to deal with above ? It is usual in this country for a child to advance a standard a year, and the place in the standard is usually known each year by examination. We might therefore propose to adopt as our standard the grade of the child, i.e. 100 × place in standard ÷ number examined. This would require correction for age, but this correction might be made once for all by ascertaining the correlation for the same standard between place and age. Thus a child's intelligence would be measured by the deviation of its grade in the standard from the mean grade of children of that age in the standard. This would very considerably reduce the personal equation, especially in the case of teachers who are not apt psychological observers. Some day we may hope that examinations may be skilfully devised for the very purpose of grading the intelligence of school children ; these examinations would be accompanied by various psychological tests, but we are somewhat removed from this at present, and also from being able to base a satisfactory measure of general intelligence even on the results of such mental tests, if they were made. The wisest course at present seems to be to determine place in standard, corrected for age, and compare this with the teacher's estimate of the intelligence of the children obtained by carefully defined verbal categories.

### (5) General Scale of Intelligence.

Even with such heterogeneous material, however, there is some advantage to be gained by a study of the distribution of the mental capacity of all the children of the same sex together. The numbers and percentages of boys and girls in each grade of intelligence are given in Table IV.

### TABLE IV.

The Numbers and Percentages in Five Grades of Mental Capacity.

| Mental Grade. | Boys. | | Girls. | |
|---|---|---|---|---|
| | Number. | Percentage. | Number. | Percentage. |
| Brilliant . . . . . . . . | 419 | 10 | 351 | 8 |
| Above the Average . . . | 1,036 | 24 | 853 | 19 |
| Average . . . . . . . . | 1,941 | 45 | 2,357 | 53 |
| Under the Average . . . | 741 | 17 | 737 | 16 |
| Very Dull and Backward . | 149 | 3 | 176 | 4 |
| Total . . . . . . | 4,286 | | 4,474 | |

It will be seen that the percentages of "brilliant" and "above the average" boys are somewhat higher than in the case of the girls, but the differences are small and not necessarily significant.

If we now make the assumption that mental capacity follows the normal or Gaussian curve of errors, it is possible to express this qualitative scale in quantitative form. Taking first of all as our unit the standard deviation of mental capacity, $\sigma$, we can find the range of each grade of intelligence, the whole range extending from $-\infty$ to $+\infty$. The results are given in Table V, and we see that in the case of the boys the "brilliant" group extends from $+\infty$ to $+1{\cdot}294\,\sigma$, the group "above the average" from $+1{\cdot}294\,\sigma$ to $+{\cdot}414\,\sigma$, the "average" group from $+{\cdot}414\,\sigma$ to $-{\cdot}815\,\sigma$, and so on.

## TABLE V.

Relative Scales of Mental Capacity with the Standard Deviation as Unit and with Means supposed to be identical.

| London County Council Schools. | | | Professor Pearson's Data. | | |
|---|---|---|---|---|---|
| Class. | Boys. | Girls. | Class. | Boys. | Girls. |
| Median Individual. | ·414 σ below top and ·815 σ above bottom of "Average" Group. | ·616 σ below top and ·827 σ above bottom of "Average" Group. | Median Individual. | ·113 σ below top and ·733 σ above bottom of "Slow Intelligent" Group. | ·007 σ below top and ·853 σ above bottom of "Slow Intelligent" Group. |
| Range of "Average". | 1·229 σ | 1·443 σ | Range of "Slow Intelligent". | ·846 σ | ·860 σ |
| | | | Range of "Slow". | ·722 σ | ·642 σ |
| Range of "Under the Average". | σ | ·931 σ | Range of "Slow Dull". | ·725 σ | ·640 σ |
| Range of "Very Dull and Backward". | From 1·815 σ below median to ∞. | From 1·758 σ below median to ∞. | Range of "Very Dull". | From 2·180 σ below median to ∞. | From 2·135 σ below median to ∞. |
| Range of "Above the Average". | ·880 σ | ·8 σ | Range of "Intelligent". | 1·108 σ | 1·033 σ |
| Range of "Brilliant". | From 1·294 σ above median to ∞. | From 1·416 σ above median to ∞. | Range of "Quick Intelligent". | From 1·221 σ above median to ∞. | From 1·040 σ above median to ∞. |

These results may now be compared with a similar distribution found for the school children of Professor Pearson's investigation, which has already been quoted. The results are given in the second part of Table V, and the results are also compared graphically in Fig. 1.

Such a method of comparison, however, assumes that the average intelligence in the two series is the same, and also the variability is the same; but there is no reason for supposing that this is the case. Each series is selected from the

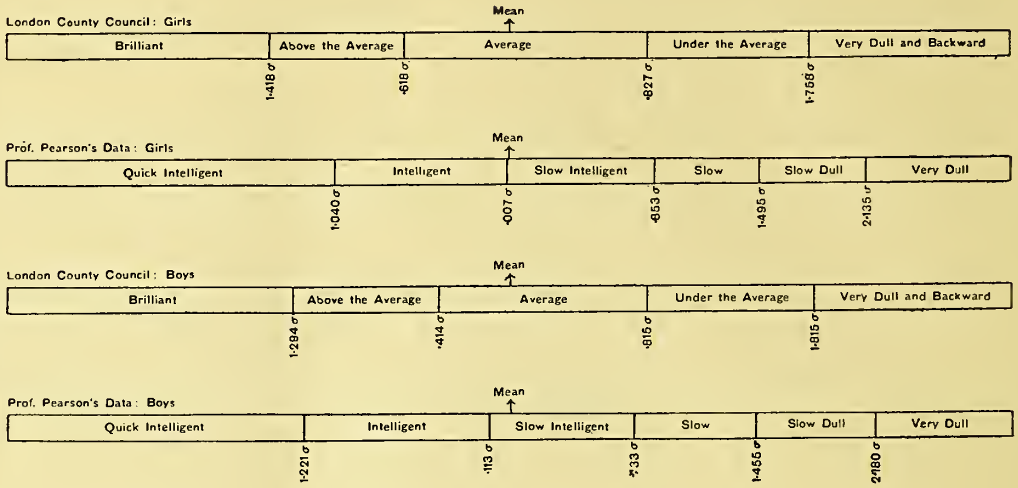



FIG. 1. RELATIVE SCALES OF INTELLIGENCE WITH STANDARD DEVIATION, σ, AS UNIT

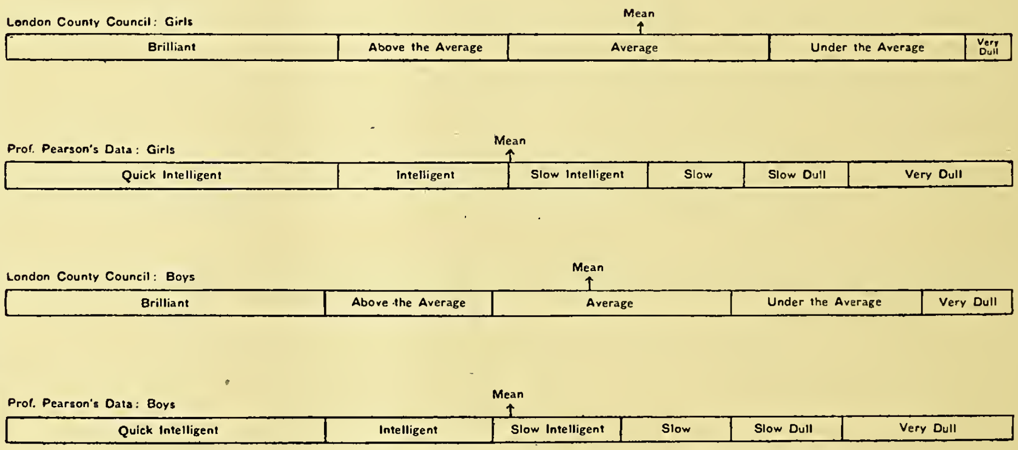



FIG. 2. RELATIVE SCALES OF INTELLIGENCE WITH L.C.C. GROUP "ABOVE THE AVERAGE" AND PEARSON'S "INTELLIGENT" AS EQUIVALENTS

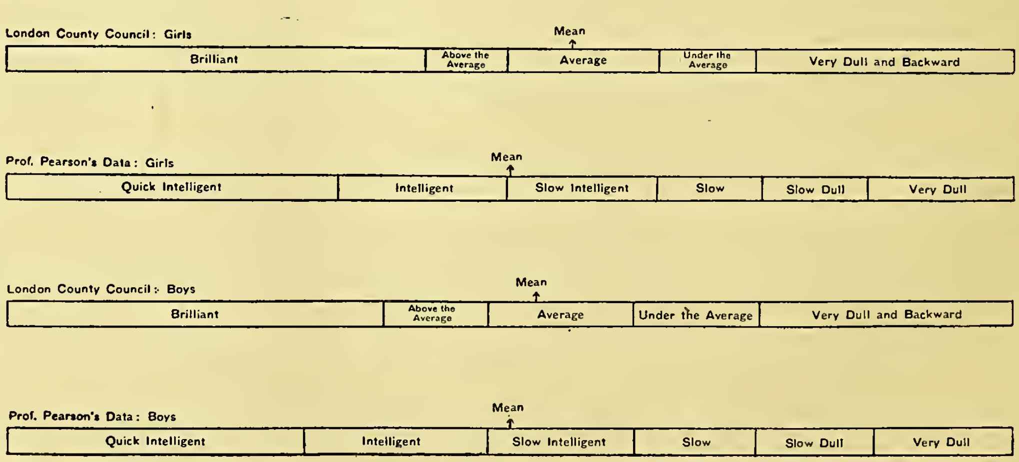



FIG. 3. RELATIVE SCALES OF INTELLIGENCE WITH L.C.C. GROUP "AVERAGE" AND PEARSON'S "SLOW INTELLIGENT", AS EQUIVALENTS

total school children population of the country. Professor Pearson's data include many preparatory schools, with selected scholarship boys, some public schools and higher grade elementary schools in all parts of the country, and also includes some Scottish secondary schools, so that it is very probable that the average intelligence is greater than in the case of the London children, but it is not easy to say which series is the more variable.

A more satisfactory way of investigating the relative intelligence of the two series is to suppose equality in the range of some of the categories.

## TABLE VI.

Relative Scales of Mental Capacity with the "Above the Average" Group and "Intelligent" Group as Equivalents.

| London County Council Schools. | | | Professor Pearson's Data. | | |
|---|---|---|---|---|---|
| Class. | Boys. | Girls. | Class. | Boys. | Girls. |
| Median Individual. | ·470 below top and ·926 above bottom of "Average" Group. | ·770 below top and ·827 above bottom of "Average" Group. | Median Individual. | ·102 below top and ·662 above bottom of "Slow Intelligent" Group. | ·007 below top and ·826 above bottom of "Slow Intelligent" Group. |
| Range of "Average". | 1·397 | 1·804 | Range of "Slow Intelligent". | ·764 | ·833 |
| | | | Range of "Slow". | ·652 | ·622 |
| Range of "Under the Average". | 1·136 | 1·164 | Range of "Slow Dull". | ·654 | ·620 |
| Range of "Very Dull and Backward". | From 2·062 below median to ∞. | From 2·198 below median to ∞. | Range of "Very Dull". | From 1·1967 below median to ∞. | From 2·066 below median to ∞. |
| Range of "Above the Average". | 1·000 | 1·000 | Range of "Intelligent". | 1·000 | 1·000 |
| Range of "Brilliant". | From 1·470 above median to ∞. | From 1·770 above median to ∞. | Range of "Quick Intelligent." | From 1·102 above median to ∞. | From 1·007 above median to ∞. |

In Table VI and in Fig. 2, I have compared the two series on the assumption that the group "above the average" in the case of the London children is the same as the group "intelligent" in Professor Pearson's investigation. We see that the agreement is much closer than before and that we have now some correspondence between the two series. The "average" group has now substantially the same range as the two groups "slow intelligent" and "slow" in Professor Pearson's data. Such a basis of comparison also allows for a considerable difference between the average intelligence in the two series, a result which has already been stated to be very probable.

The only difficulty about this basis of comparison is that it makes the "brilliant" group of the London children equal in range to Professor Pearson's "intelligent" group. Now we see from Table II that in one school as many as 30 per cent. of the children are marked "brilliant", so that the term is applied somewhat freely. If, however, we take a third basis of comparison and make the groups "average" and "slow intelligent" equal in range we get over this difficulty. The result is shown in Fig. 3, and the agreement is now quite satisfactory. The group "brilliant" is now seen to cover about half of the "intelligent" group in addition to the "quick intelligent" group, "under the average" is nearly equal to "slow", and "very dull and backward" has practically the same range as the two groups "slow dull" and "dull".

No very great stress, however, can be laid on any such schemes because of the high personal equation of the teachers; their object is to show the essential importance of a common standard of ability which may be used for comparative purposes in schools of all classes.

We shall use this general scale to illustrate graphically various points, but in the main we must depend upon the examination of the results for individual schools and endeavour to disentangle significant values from the large errors of small samples.

## (6) Relationship of Intelligence to Other Characters.

We can now proceed to the main part of the inquiry and investigate the relationships which exist between mental capacity and the other characters tabulated. These relationships have been worked out in various ways. When both characters are quantitative, e. g. when dealing with the relationships between height, weight, and age, the correlation coefficients have been obtained by the ordinary product moment method. This assumes, of course, that the regression is linear, and where age is concerned this is not strictly true, but the divergence from linearity is small and we obtain results which are sufficiently accurate for our present purpose. When one of the characters is quantitative and the other qualitative we can make use of the correlation ratio, and when the qualitative scale consists of two groups only, Professor Pearson's new method of determining correlation was used.* When both characters are qualitative, contingency tables were used, if at least a three × threefold division of the material could be made; otherwise fourfold tables were used.

* W. Palin Elderton's *Frequency Curves and Correlation* (C. & E. Layton) can be recommended as an excellent introduction to modern statistical methods. Nearly all the processes employed in this paper are illustrated there. For the correlation ratio, see Professor Pearson's *General Theory of Skew Curves and Non-linear Regression*, Drapers' Company Research Memoirs, Biometric Series II (Dulau & Co.); and for the new method of determining correlation indicated above see Professor Pearson's paper in *Biometrika*, vol. vii, p. 96.

Considerable difficulty was experienced in determining the signs of the correlation when contingency coefficients were used. The simplest method is to arrange the contingency table in fourfold form and then assign to the correlation, numerically measured by the contingency coefficient, the sign which would be obtained from the fourfold table. But in many cases, the material is so rough that by changing the lines of division different signs can be obtained. To obtain a unique solution, that division into fourfold form was chosen which most nearly gave four equal compartments. Even this, however, was not always sufficient; in two cases such a division gave zero correlation from the fourfold table, and as the contingency coefficient was not zero in those cases, another method of division had to be used.

This happened, for instance, in the case of *G.* 10, in the table giving the relationship between mental capacity and the condition of the teeth. The original contingency table is given in Table VII, but when we express this in fourfold form,

## TABLE VII.

*G.* 10. The Relationship between Mental Capacity and the Condition of the Teeth.

| | | Mental Capacity. | | | | | |
|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | Totals. |
| Condition of the Teeth. | II | 1 | 1 | 5 | — | — | 7 |
| | III | — | 3 | 29 | 9 | 4 | 45 |
| | IV | 3 | 10 | 39 | 8 | 4 | 64 |
| | V | 1 | 7 | 27 | 13 | 4 | 52 |
| | Totals. | 5 | 21 | 100 | 30 | 12 | 168 |

by taking together groups I + II + III and IV + V in the case of mental capacity, and groups II + III and IV + V in the case of the condition of the teeth, and so obtain Table VIII, the resulting correlation coefficient is zero, and we must take the next

## TABLE VIII.

Table VII arranged in Fourfold Form so as to give Zero Correlation.

| | | Mental Capacity. | | |
|---|---|---|---|---|
| | | I + II + III | IV + V | Totals. |
| Condition of Teeth. | II + III | 39 | 13 | 52 |
| | IV + V | 87 | 29 | 116 |
| | Totals. | 126 | 42 | 168 |

best division by taking II+III+IV together and V alone for the condition of the teeth, and so obtain Table IX, which gives a positive correlation coefficient.

## TABLE IX.

Alternative Arrangement of Table VII.

| | | Mental Capacity. | | |
|---|---|---|---|---|
| | | I+II+III | IV+V | Totals. |
| Condition of Teeth. | II+III+IV | 91 | 25 | 116 |
| | V | 35 | 17 | 52 |
| | Totals. | 126 | 42 | 168 |

The same difficulty was experienced when dealing with the correlation ratio. Like the contingency coefficient it has by its very nature *no* sign, but when it is used as equivalent to a correlation coefficient we must determine what sign the corresponding correlation coefficient would have. In every case the regression line was plotted from the means of the arrays, and in most cases this was sufficient to determine the sign; but here also cases arose which seemed indeterminate, and in such cases the material was divided as equally as possible into two columns, and the slope of the regression line found from these was used to determine the sign of the correlation coefficient, whose *numerical* value was obtained from the correlation ratio.

It ought also to be stated that a *positive* sign has been given throughout when a *greater* value of a quantitative character was associated with a *better* value of a qualitative character, or when the better values of two qualitative characters were associated; thus, when intelligence was found to increase with age, or when the condition of the teeth was found to improve with age; when good hearing was associated with a bad condition of the tonsils and adenoids, a negative sign was given.

Although most of the contingency coefficients found are significant, only 5 out of 59 exceed ·25; but the distribution of magnitudes has a distinctly bimodal form. The actual distribution is given in Table X and graphically in Fig. 4. It

## TABLE X.

Distribution of Magnitude of 59 Contingency Coefficients indicating the Relationship between Mental Capacity and Physical Condition.

| Magnitude . . . | −·2 | −·1 | 0 | +·1 | +·2 | +·3 | +·4 | Total |
|---|---|---|---|---|---|---|---|---|
| Frequency . . . | 6 | 9 | 1 | 16 | 22 | 4·5 | ·5 | 59 |

FIG. 4. FREQUENCY DISTRIBUTION OF 59 CONTINGENCY COEFFICIENTS BETWEEN MENTAL CAPACITY AND PHYSICAL CONDITION.

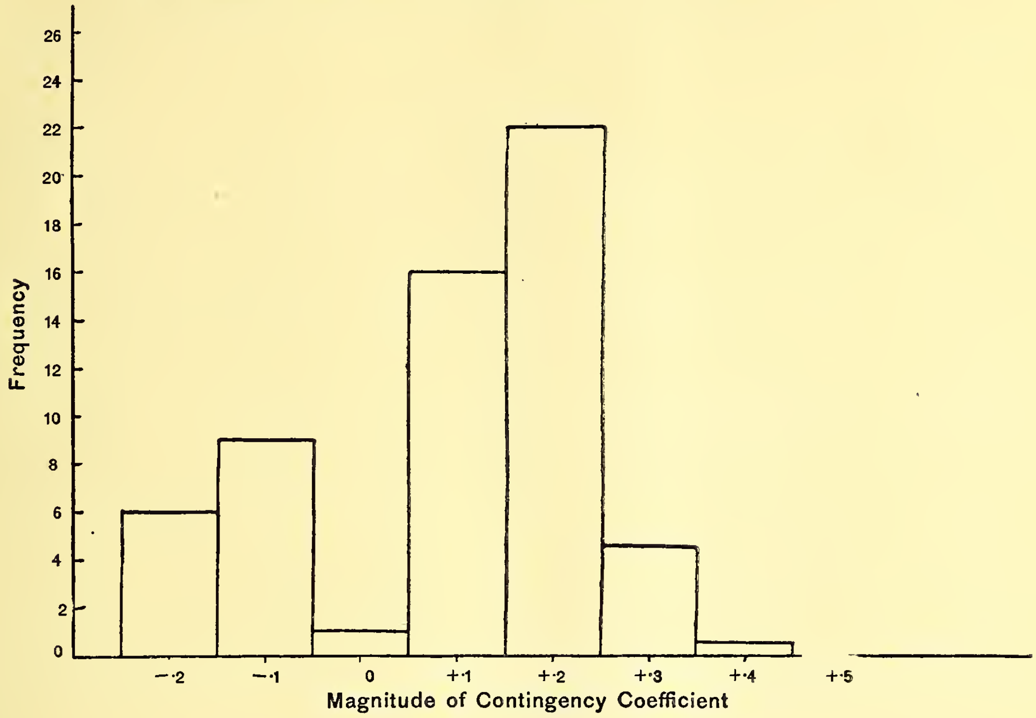
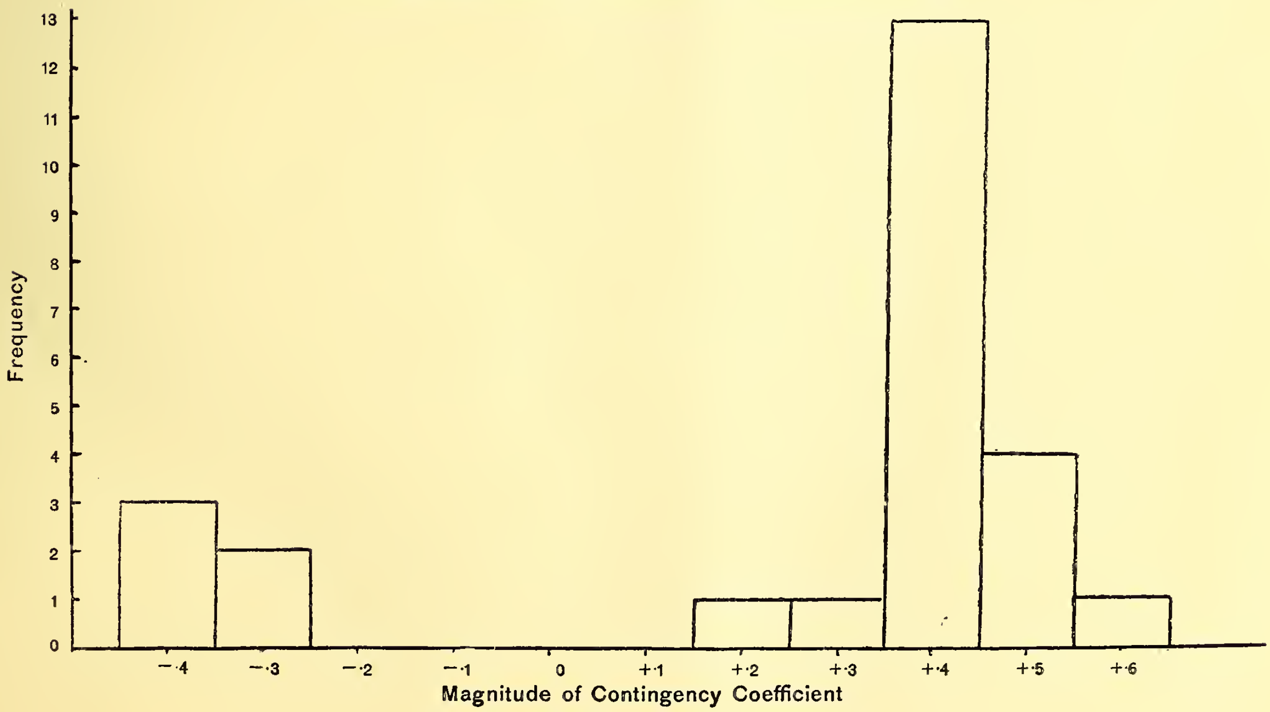



FIG. 5. FREQUENCY DISTRIBUTION OF 25 CONTINGENCY COEFFICIENTS BETWEEN MENTAL CAPACITY AND STANDARD.



will be seen that the distribution consists of two parts, one containing positive contingency coefficients and the other negative contingency coefficients. The bimodal form of the distribution of contingency coefficients is even more clearly shown in Table XI and Fig. 5, which give the relationship between the standard

TABLE XI.

DISTRIBUTION OF MAGNITUDE OF 25 CONTINGENCY COEFFICIENTS INDICATING THE RELATIONSHIP BETWEEN STANDARD AND MENTAL CAPACITY.

| Magnitude . . | −·4 | −·3 | −·2 | −·1 | 0 | +·1 | +·2 | +·3 | +·4 | +·5 | +·6 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency . . | 3 | 2 | — | — | — | — | 1 | 1 | 13 | 4 | 1 | 25 |

and mental capacity for 25 schools. The roughness of the material and the personal equation of the observers seem to increase the contingency coefficients. One would naturally expect a positive correlation between mental capacity and standard, and the existence of five negative correlations must indicate personal equation of teachers, i. e. teachers of low standards have been optimistic and those of high standards have been pessimistic, and they have labelled their children accordingly. The existence of negative correlations between mental capacity and physical conditions may also be due to personal equation; it is quite probable that some teachers have confused "intelligence" with orderly behaviour and quietness, and so have classed some of the weaklings as "intelligent", while the physically active and noisy children were regarded less favourably.*

In view of those difficulties we can only use the average of the values found for individual schools as giving some measure of the actual relationship, and cannot lay any stress on individual results, so long as we have so many evidences of irregularity due to personal equation.

### (7) THE RELATIONSHIP BETWEEN MENTAL CAPACITY AND AGE.

Dealing first of all with the individual schools, we find the 25 correlation ratios given in Table XII. It will be noticed that here also we have considerable positive and negative values, which may occur in the same school, e. g. see Schools Nos. 4 and 5, while the average among both boys and girls is very small. It is not possible to assert on the basis of this table that any definite relationship exists between mental capacity and age. This is strictly in accordance with the results found by Professor Pearson: For boys, $\eta = \cdot 05 \pm \cdot 01$; For girls, $\eta = \cdot 08 \pm \cdot 01$ † where the relationship, though significant, is very small.

* The high correlation found in some cases between mental capacity and standard may in part be due, as Dr. Kerr suggests, to the fact that from the age 7 to age 11, 0·8 % of children are weeded out and sent as mentally defective to special schools. A trace of this is probably noticeable in Fig. 6, p. 24.

† Throughout this paper, when the correlation is obtained by the product moment method, the probable error is calculated by the usual formula; in other cases to determine significance it is calculated on the basis of zero correlation.

## TABLE XII.

### The Relationship between Age and Mental Capacity.

| School Number. | Correlation Ratios. | |
|---|---|---|
| | Boys. | Girls. |
| 1 | + ·03 ± ·04 | − ·26 ± ·04 |
| 2 | + ·21 ± ·04 | + ·12 ± ·05 |
| 3 | + ·07 ± ·03 | + ·26 ± ·04 |
| 4 | + ·24 ± ·04 | − ·18 ± ·03 |
| 5 | + ·27 ± ·04 | − ·28 ± ·03 |
| 6 | − ·20 ± ·03 | + ·19 ± ·04 |
| 7 | + ·13 ± ·03 | − ·27 ± ·03 |
| 8 | + ·08 ± ·04 | + ·17 ± ·04 |
| 9 | + ·15 ± ·04 | + ·16 ± ·04 |
| 10 | + ·11 ± ·04 | + ·29 ± ·05 |
| 11 | − ·23 ± ·03 | − ·12 ± ·03 |
| 12 | − | − ·11 ± ·03 |
| 13 | − | + ·14 ± ·04 |
| 14 | − ·16 ± ·04 | − |
| Mean | + ·06 | + ·05 |

We can also look at the matter in another way by finding the average age of all the boys and all the girls in each grade of mental capacity. These averages with their probable errors are given in Table XIII, and the table shows that there is no significant difference between the average ages of the children in the different intelligence groups.

## TABLE XIII.

### The Relationship between Age and Mental Capacity.

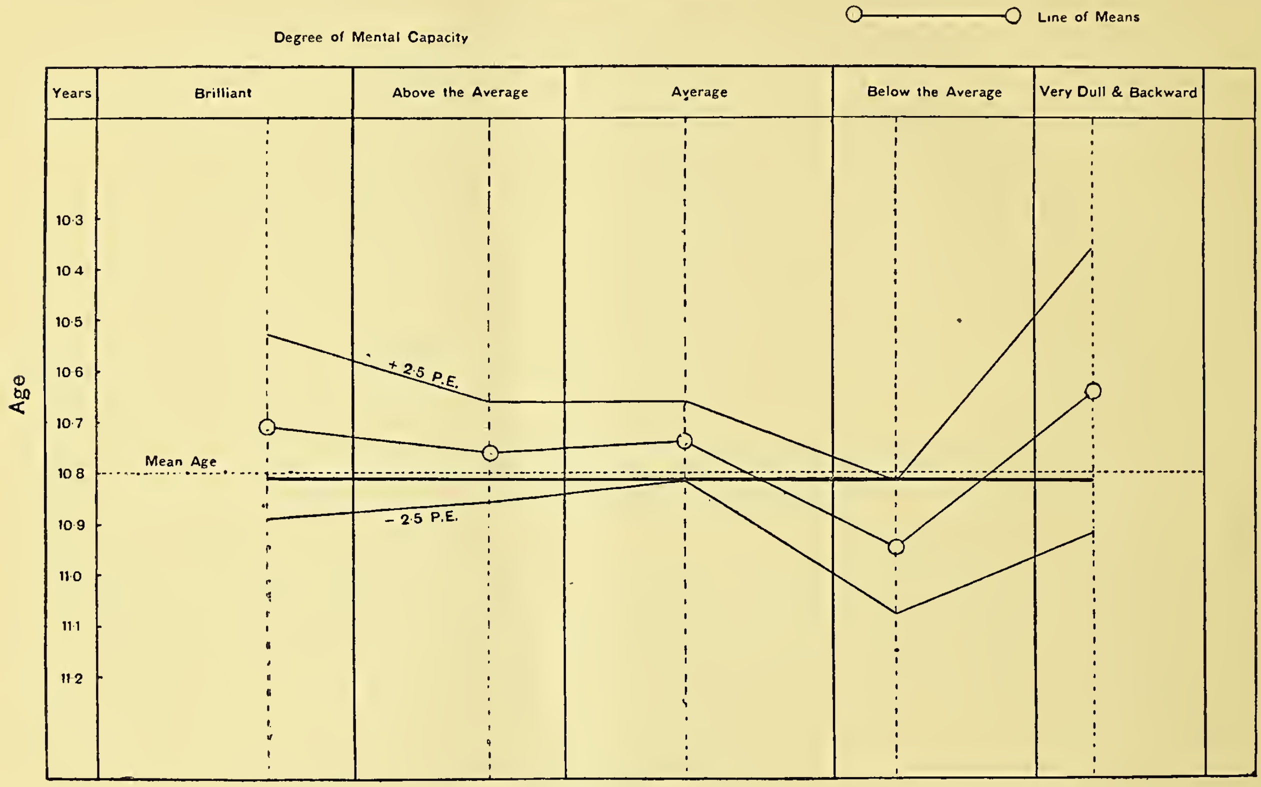
Mean Ages of Children, in Five Groups of Mental Capacity.

| Mental Group. | Mean Ages : Boys. | Mean Ages : Girls. |
|---|---|---|
| Brilliant . . . . . . . | 10·71 ± ·07 | 11·05 ± ·08 |
| Above the Average . . . | 10·76 ± ·04 | 11·04 ± ·05 |
| Average . . . . . . . | 10·74 ± ·03 | 11·14 ± ·03 |
| Under the Average . . . | 10·95 ± ·05 | 11·05 ± ·05 |
| Very Dull and Backward . | 10·64 ± ·11 | 10·98 ± ·11. |
| All groups . . . . . . | 10·80 ± ·02 | 11·10 ± ·02 |

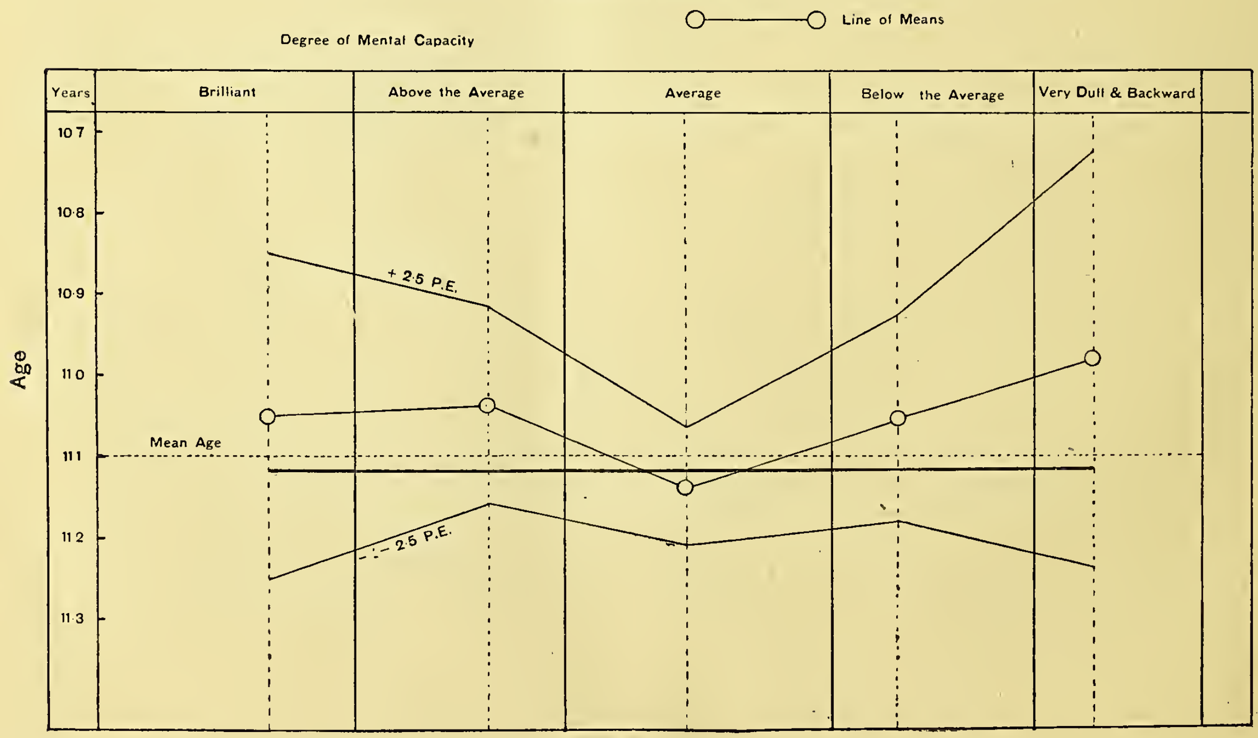
This is shown perhaps more clearly in Fig. 6. Lines are first of all drawn to indicate the average age of each intelligence group. Then above and below those lines are drawn two other lines at a distance of 2·5 times the probable error of each average. In the case of both boys and girls it is possible to draw a *horizontal* line which lies wholly within those bands, indicating clearly that there is no certain relationship between age and intelligence when we take the data in the bulk. The teacher's estimate of the mental capacity of a child ought of course to be relative to children of its own age, i.e. intelligence ought to be independent of age as has just been found.

FIG. 6. DIAGRAMS TO SHOW THAT, WITHIN THE LIMITS OF PROBABLE ERRORS, THERE IS NO RELATIONSHIP BETWEEN AGE AND MENTAL CAPACITY.

Boys: All Schools




Girls: All Schools



## (8) The Relationships between Height, Weight, and Age.

We can now proceed to consider the growth curves of these children. In Tables XIV and XV I have given for boys and for girls the mean height of the

### TABLE XIV.

Boys.—Mean Height in Centimetres at each Year of Age.

| School Number. | Age. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 8. | 9. | 10. | 11. | 12. | 13. | 14. |
| 1 | 115·2 | 120·0 | 125·3 | 129·4 | 132·5 | 140·5 | 141·3 |
| 2 | 117·1 | 120·2 | 126·9 | 130·2 | 134·5 | 137·9 | 141·9 |
| 3 | 118·5 | 124·5 | 128·1 | 134·1 | 137·3 | 143·8 | 149·3 |
| 4 | — | — | 129·2 | 132·5 | 135·2 | 140·5 | 144·9 |
| 5 | 117·7 | 122·6 | 127·0 | 130·3 | 135·4 | 140·3 | 142·9 |
| 6 | 118·5 | 123·7 | 130·9 | 134·7 | 137·9 | 144·1 | 149·5 |
| 7 | 117·5 | 123·3 | 127·9 | 133·0 | 135·2 | 140·9 | 146·5 |
| 8 | 114·9 | 123·2 | 128·0 | 133·0 | 136·4 | 141·6 | 143·9 |
| 9 | 117·9 | 122·2 | 125·6 | 129·7 | 135·0 | 138·2 | 142·4 |
| 10 | 117·6 | 124·6 | 129·7 | 132·6 | 138·1 | 141·5 | 147·4 |
| 11 | 118·1 | 122·3 | 126·1 | 132·0 | 136·6 | 139·8 | 142·4 |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | 114·0 | 118·3 | 124·5 | 127·0 | 133·4 | 137·0 | — |
| Mean for all Boys. | 117·1 | 122·3 | 127·3 | 131·6 | 135·7 | 140·7 | 145·0 |

Age 10 includes those between 9 years 6 months and 10 years 6 months.

### TABLE XV.

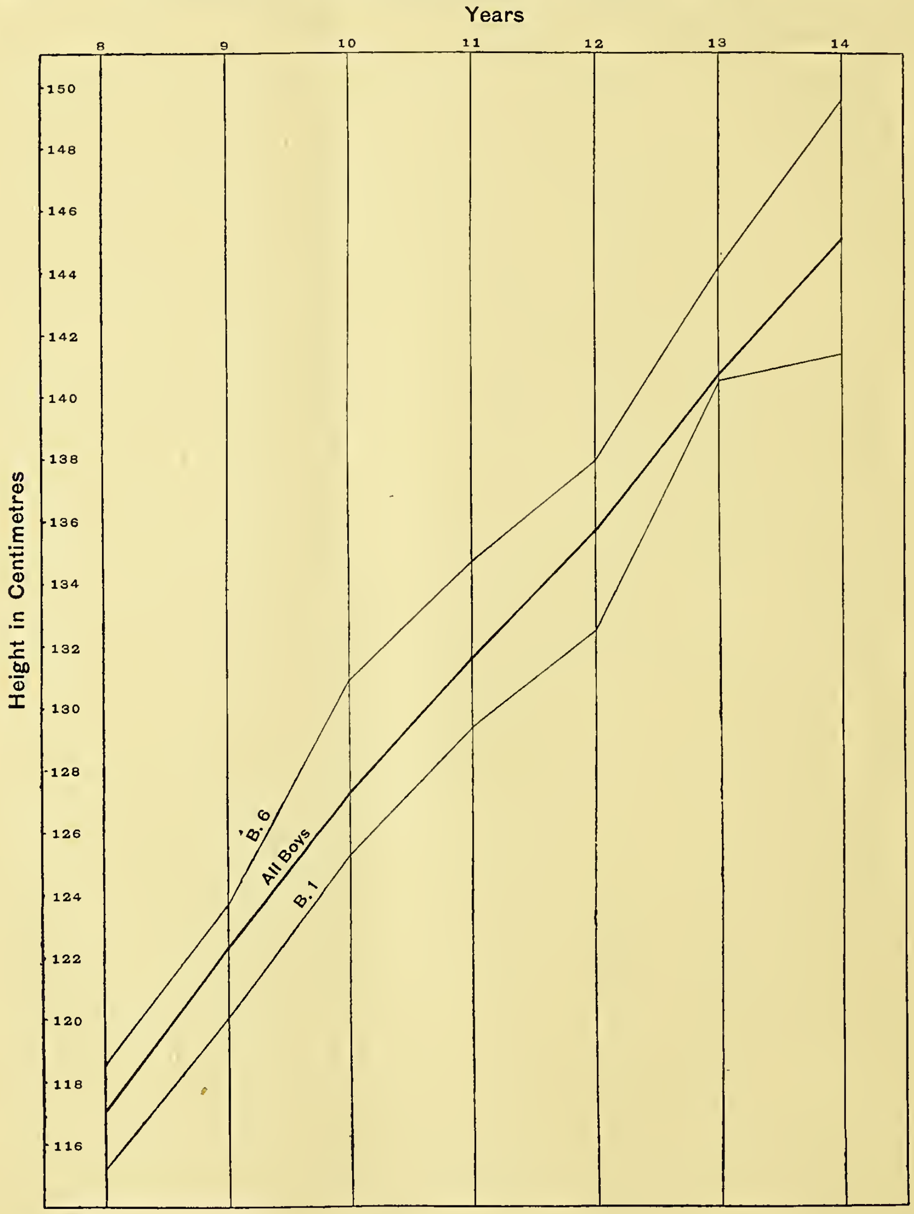
Girls.—Mean Height in Centimetres at each Year of Age.

| School Number. | Age. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 8. | 9. | 10. | 11. | 12. | 13. | 14. |
| 1 | 115·6 | 120·0 | 124·9 | 129·1 | 133·6 | 139·9 | 145·8 |
| 2 | 117·7 | 122·9 | 124·2 | 130·3 | 136·1 | 142·0 | 145·9 |
| 3 | 119·2 | 123·4 | 128·5 | 133·9 | 139·9 | 147·0 | 149·5 |
| 4 | 117·1 | 121·3 | 126·2 | 131·9 | 138·1 | 142·8 | 147·9 |
| 5 | 116·0 | 120·6 | 124·4 | 130·2 | 136·4 | 141·5 | 144·2 |
| 6 | 118·8 | 123·9 | 129·9 | 132·9 | 139·2 | 144·3 | 150·8 |
| 7 | 118·0 | 121·9 | 126·7 | 132·3 | 137·4 | 144·7 | 147·7 |
| 8 | 117·7 | 122·9 | 126·8 | 132·8 | 137·1 | 143·8 | 147·2 |
| 9 | 116·8 | 121·4 | 126·1 | 129·9 | 136·8 | 141·9 | 146·5 |
| 10 | 117·8 | 122·0 | 128·9 | 134·6 | 139·0 | 144·1 | — |
| 11 | 115·3 | 120·5 | 125·4 | 128·9 | 136·5 | 139·9 | 145·0 |
| 12 | 120·2 | 121·4 | 126·6 | 132·7 | 137·0 | 143·2 | 148·7 |
| 13 | 121·1 | 122·3 | 125·2 | 128·7 | 136·2 | 143·1 | 145·0 |
| 14 | — | — | — | — | — | — | — |
| Mean for all girls. | 117·4 | 121·6 | 126·2 | 131·2 | 137·2 | 143·0 | 147·6 |

Age 10 includes those between 9 years 6 months and 10 years 6 months.

children in each school at each year of age, and the tables show very striking differences between the different schools. The probable errors are not given, but have been calculated, and in the extreme cases where the numbers of children on which the means are based are least, they in no case exceed half a centimetre,

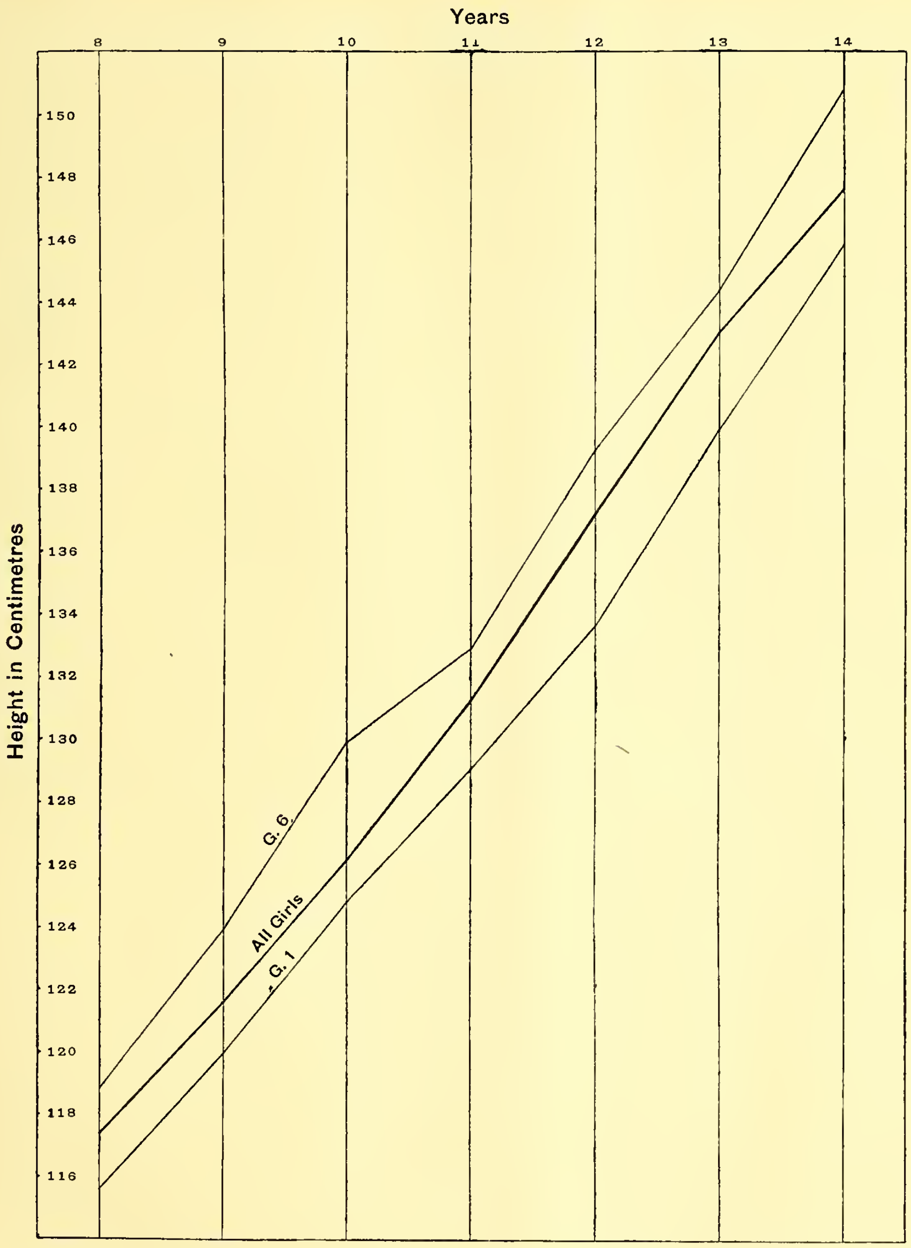
Fig. 7. Diagram to Illustrate the Height of L.C.C. Boys.




so that the differences between the schools with tallest and shortest children is certainly significant. These extreme differences are shown graphically in Fig. 7, where I have plotted the mean height at each year of age for all boys, and also the mean heights in the "best" and "worst" schools so far as stature is concerned, while Fig. 8 gives similar graphs for the girls.

Similarly in Tables XVI and XVII we have the mean weight of the boys and girls in each school at each age, while in Figs. 9 and 10 the extreme differences between the " best " and " worst " schools are shown graphically.

Fig. 8. Diagram to Illustrate the Height of L.C.C. Girls.




How are we to account for those striking differences ? I have already shown the danger of attributing them to purely environmental factors and of neglecting the influence of heredity, and have suggested that a consideration of the hair and eye colours of these children would go far towards settling the question. It has

## TABLE XVI.

Boys.—Mean Weight in Kilograms at each Year of Age.

| School Number. | Age. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 8. | 9. | 10. | 11. | 12. | 13. | 14. |
| 1 | 21·6 | 23·6 | 25·9 | 28·6 | 29·8 | 33·7 | 34·4 |
| 2 | 22·5 | 23·7 | 25·9 | 27·8 | 30·8 | 32·5 | 34·6 |
| 3 | 22·0 | 24·5 | 26·2 | 29·3 | 30·9 | 35·2 | 38·6 |
| 4 | — | — | 27·2 | 29·5 | 30·7 | 34·1 | 36·6 |
| 5 | 23·0 | 24·6 | 27·4 | 29·0 | 31·3 | 34·9 | 36·5 |
| 6 | 22·5 | 25·7 | 27·4 | 29·8 | 31·9 | 35·5 | 40·4 |
| 7 | 22·4 | 24·4 | 27·2 | 29·7 | 30·5 | 34·6 | 38·9 |
| 8 | 22·4 | 24·6 | 26·4 | 29·3 | 31·4 | 34·7 | 36·4 |
| 9 | 23·1 | 25·1 | 26·9 | 28·5 | 30·9 | 32·9 | 35·9 |
| 10 | 20·9 | 24·6 | 28·2 | 28·8 | 30·9 | 35·0 | 38·2 |
| 11 | 22·4 | 24·5 | 26·6 | 29·5 | 31·4 | 33·9 | 35·8 |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | 21·6 | 24·7 | 25·5 | 26·8 | 30·2 | 32·1 | — |
| Mean for all boys. | 22·2 | 24·5 | 26·7 | 28·6 | 30·9 | 34·2 | 37·1 |

Age 10 includes those from 9 years 6 months to 10 years 6 months.

## TABLE XVII.

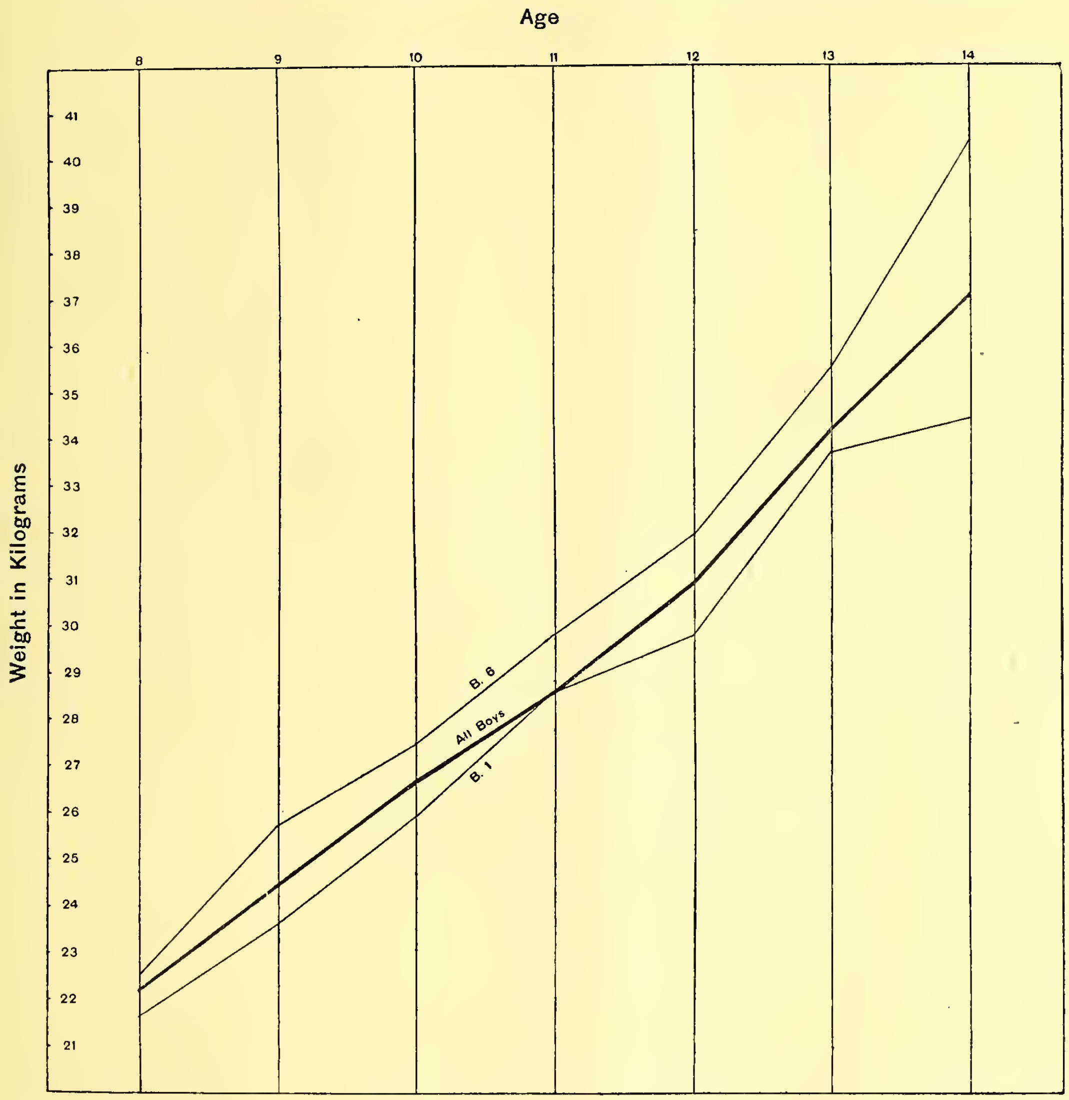
Girls' Schools.—Mean Weight in Kilograms at each Year of Age.

| School Number. | Age. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 8. | 9. | 10. | 11. | 12. | 13. | 14. |
| 1 | 22·4 | 23·5 | 26·0 | 27·8 | 30·5 | 34·7 | 38·5 |
| 2 | 21·9 | 23·8 | 25·1 | 27·7 | 31·3 | 34·7 | 35·4 |
| 3 | 21·5 | 22·7 | 24·8 | 28·0 | 32·3 | 36·4 | 39·0 |
| 4 | 21·6 | 23·7 | 26·2 | 28·7 | 32·8 | 36·0 | 42·5 |
| 5 | 22·1 | 23·7 | 25·6 | 29·3 | 32·0 | 35·9 | 37·5 |
| 6 | 21·2 | 24·3 | 27·4 | 28·8 | 33·1 | 36·0 | 40·6 |
| 7 | 22·1 | 24·3 | 26·0 | 28·8 | 31·2 | 36·9 | 38·2 |
| 8 | 21·8 | 23·7 | 25·7 | 28·1 | 32·3 | 35·2 | 39·9 |
| 9 | 21·8 | 23·7 | 26·3 | 28·0 | 31·3 | 34·6 | 37·8 |
| 10 | 23·1 | 23·7 | 26·8 | 29·2 | 32·4 | 35·8 | — |
| 11 | 21·3 | 23·6 | 26·4 | 28·2 | 31·7 | 34·8 | 37·2 |
| 12 | 22·8 | 23·7 | 26·1 | 28·8 | 31·5 | 35·7 | 40·0 |
| 13 | 23·4 | 24·2 | 26·4 | 27·5 | 31·2 | 35·6 | 36·2 |
| 14 | — | — | — | — | — | — | — |
| Mean for all girls. | 21·9 | 23·7 | 26·0 | 28·4 | 31·8 | 35·6 | 37·9 |

Age 10 includes those from 9 years 6 months to 10 years 6 months.

has already been pointed out that the racial differences between the various districts of London are very great, and that the fair-haired elements of the population are generally taller than the dark-haired elements, while Tocher has found very striking differences in the distribution of hair and eye colour in different districts

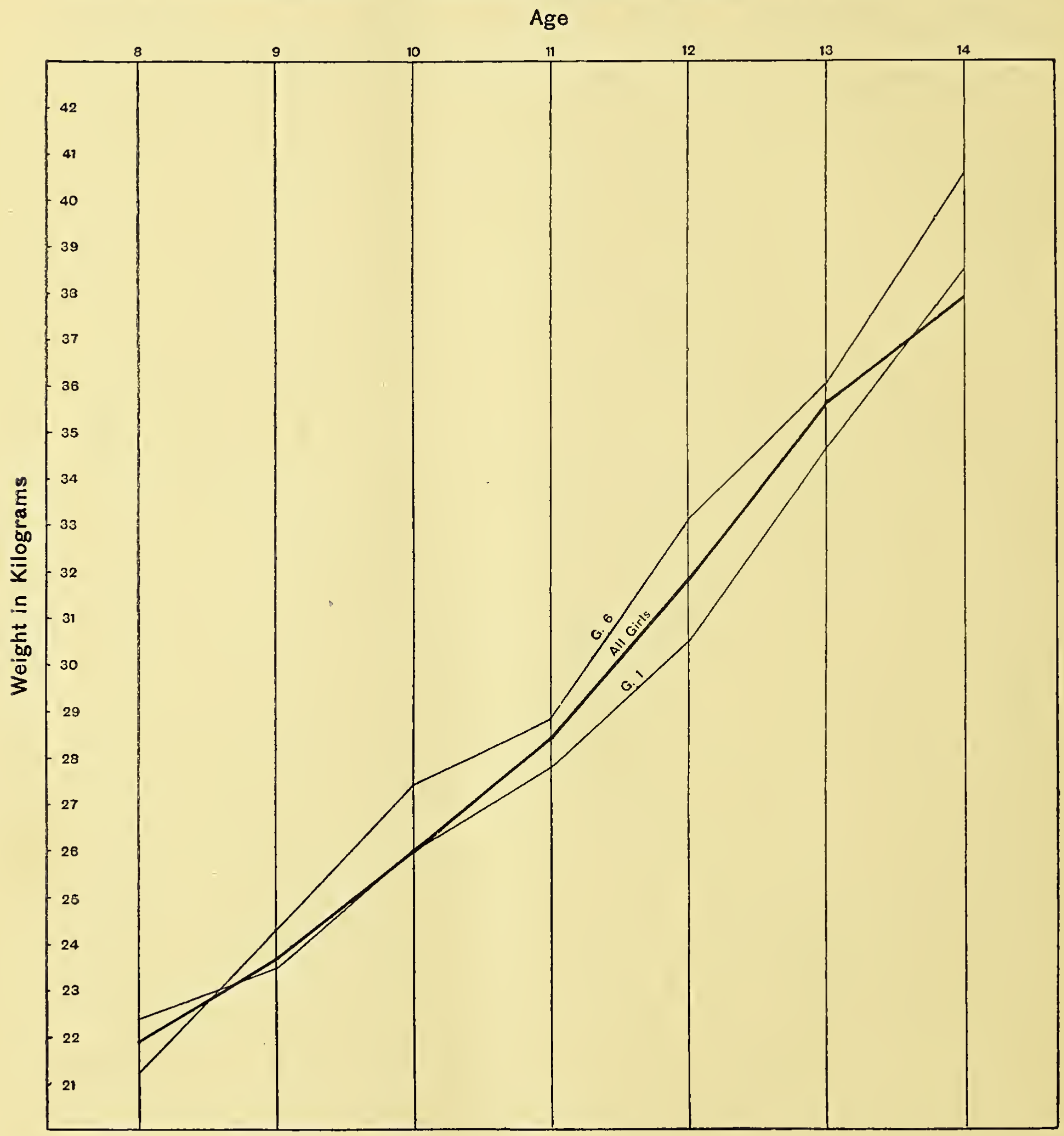
FIG. 9. DIAGRAM TO ILLUSTRATE THE WEIGHT OF L.C.C. BOYS.




in Glasgow. It is therefore desirable that further surveys should include this very useful information.

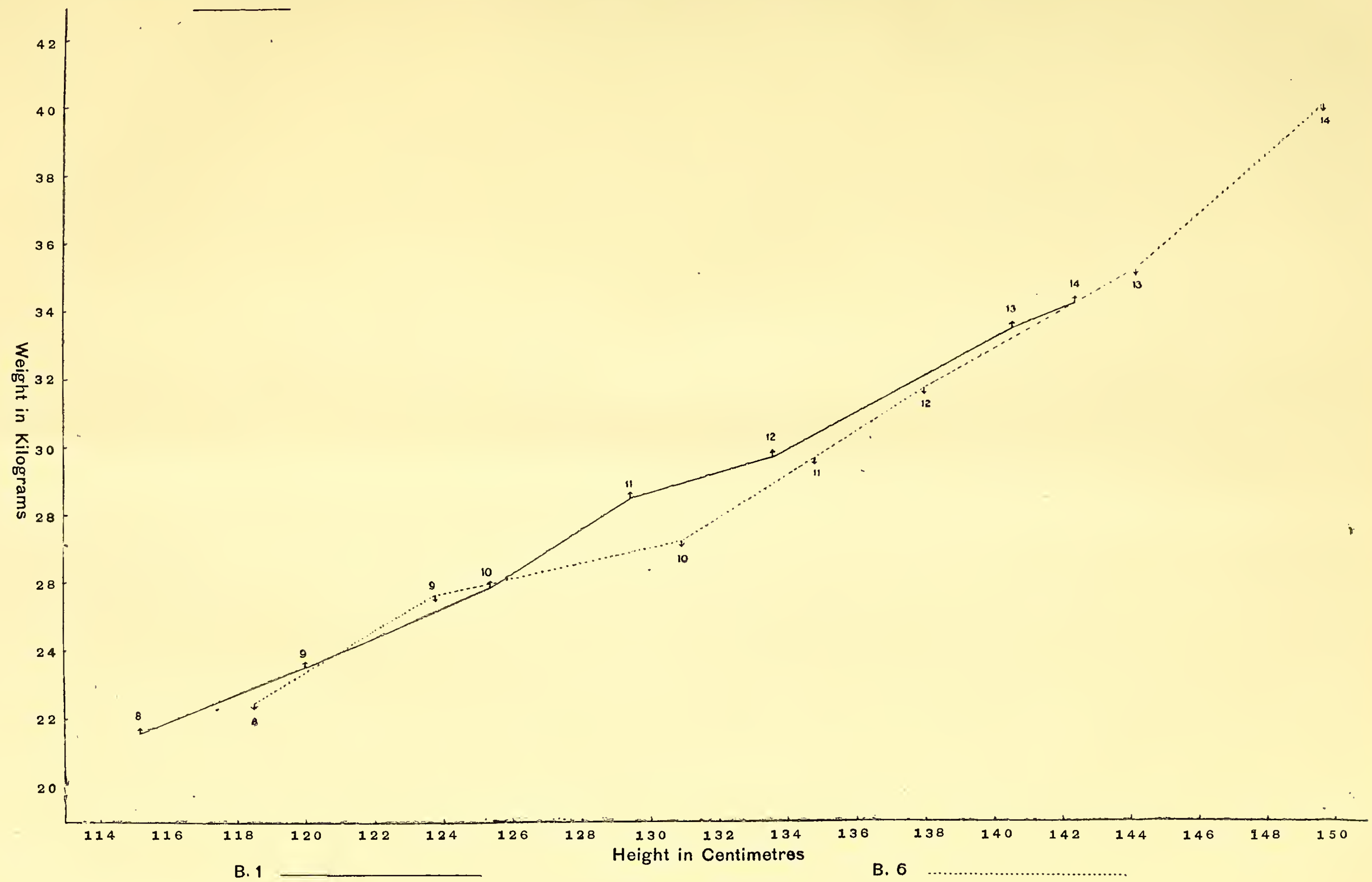
We have seen that children of the same age from different districts of London differ very considerably in stature and weight. It is of some interest to consider the differences in weight between boys of the same stature. I have treated the matter graphically in Fig. 11. Taking the two boys' schools in which the children are on the whole tallest and shortest respectively, we can from Tables XIV and XVI obtain curves which give the relationship between height and weight in those schools. Now the diagram shows that both in stature and in weight the one school is practically a year ahead of the other, and yet for a given stature the

Fig. 10. Diagram to Illustrate the Weight of L.C.C. Girls.




boys of the two schools are practically of the same weight; and if, as has been suggested, we measure the state of nutrition by the weight in proportion to the height, then the state of nutrition in the two schools is practically the same, and it would seem that the provision of free meals at school and other forms of charitable relief has been sufficient to bring the one school up to the level of the other as far as weight in proportion to stature is concerned.

Fig. 11. Diagram giving the Age, Height, and Weight of Boys in two selected Schools, B 1 and B 6. To show that, while for a Given Age, the Boys of B 6 are much Taller and Heavier than the Boys of B 1, for a Given Height they are practically equal in Weight.



In comparing the children of different schools in respect of height and weight, we obviously cannot put the average height of all the children of one school against a similar average for another school, unless the age distribution in the two schools is precisely the same, and in general that is not the case. In particular, when the social conditions of the children of two schools are widely different, it will be found that the age distributions of the two schools are also different; among the better class children the proportion of older children is higher because there is less tendency to leave school at the earliest possible age.

We must, then, as in Tables XIV to XVII, compare the heights and weights of children of the same ages. But it is so very convenient to have a single number to represent the stature of the children of all ages in a school, that the following method of obtaining a "School Height" is given, so that, instead of comparing eight or nine sets of means (according to the number of age groups used) we can deal with a single coefficient for each school.

The method by which the Registrar-General allows for differences of age distribution among men engaged in different occupations is well known; the occupational death-rates are based on a population with a "Standard Age Distribution", which is that of all occupied males. The death-rate among clergymen, for instance, is based, not directly on the number of deaths which occur among clergymen, but on the number of deaths which *would* occur if the age distribution among clergymen were the same as that of all occupied males.

An exactly analogous method can be used to obtain a single number to represent the mean height of a school; this may be called the "School Height". In all the schools under consideration let there be $m_5$ boys aged 5, $m_6$ boys aged 6, and so on, so that the age distribution of all boys is $M = m_5 + m_6 + \&c.$ In any individual school, let $h_5$ be the mean height of the boys aged 5, $h_6$ the mean height of all boys aged 6, and so on, then the individual "School Height" is given by

$$\text{S.H.} = \frac{m_5 h_5 + m_6 h_6 + \&c.}{\text{M}} = \frac{\Sigma mh}{\text{M}}$$

In exactly the same way, if $w_5$ be the mean weight of boys aged 5, then the "School Weight" is given by

$$\text{S.W.} = \frac{m_5 w_5 + m_6 w_6 + \&c.}{\text{M}} = \frac{\Sigma mw}{\text{M}},$$

and this principle can be extended to chest measurements, head measurements, or any quantitative measurements.

In the case of the London County Council Schools, the "School Heights" and "School Weights" were calculated for eleven boys' schools and thirteen girls' schools. School No. *B*. 4 was not used owing to there being no boys aged 8 included in the record.

The Standard Age Distributions on which those coefficients are based are given in Table XVIII.

## TABLE XVIII.

STANDARD AGE DISTRIBUTIONS FOR L.C.C. SCHOOLS.

| Age. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | Totals. |
|---|---|---|---|---|---|---|---|---|
| Boys . | 130 | 159 | 169 | 145 | 144 | 156 | 97 | 1000 |
| Girls . | 106 | 147 | 176 | 160 | 159 | 152 | 100 | 1000 |

There appears to be a significant difference between the age distributions, but the results would not have been materially altered had the coefficients been based on an age distribution formed from the totals of both sexes, and we should have had the advantage of being able to compare directly boys and girls of the same school.

The values found for the "School Heights" and "School Weights" are given in Table XIX.

## TABLE XIX.

"SCHOOL HEIGHTS" AND "SCHOOL WEIGHTS".

| School Number. | School Heights (cms.). | | School Weights (kgms.). | |
|---|---|---|---|---|
| | Boys. | Girls. | Boys. | Girls. |
| 1 | 128·7 | 129·6 | 28·0 | 28·8 |
| 2 | 129·3 | 131·1 | 28·0 | 28·5 |
| 3 | 133·0 | 134·4 | 29·1 | 29·0 |
| 4 | — | 132·0 | — | 29·9 |
| 5 | 130·4 | 130·4 | 29·2 | 29·3 |
| 6 | 133·6 | 134·1 | 30·0 | 30·0 |
| 7 | 131·4 | 132·5 | 29·3 | 29·5 |
| 8 | 131·1 | 132·5 | 29·0 | 29·3 |
| 9 | 129·6 | 131·2 | 28·7 | 28·9 |
| 10 | 132·5 | 133·3 | 29·2 | 29·5 |
| 11 | 130·6 | 130·1 | 28·9 | 28·9 |
| 12 | — | 132·5 | — | 29·5 |
| 13 | — | 131·4 | — | 29·1 |
| 14 | 127·4 | — | 27·7 | — |

We see that the maximum differences are in the case of the boys 6·2 cms. and 2·3 kgms.; in the case of the girls they are 5·8 cms. and 1·5 kgms. These differences are certainly significant.

We can also look at the matter in another way. For ten schools we have the "School Heights" and "School Weights" both for boys and for girls. Let us arrange the schools according to the values given for "School Heights" and "School Weights" as shown in Table XX.

## TABLE XX.

Place Order of Ten Schools for Height and Weight.

| | Boys. | | Girls. | |
|---|---|---|---|---|
| Order of Merit. | Height. | Weight. | Height. | Weight. |
| 1 | No. 6 | No. 6 | No. 3 | No. 6 |
| 2 | „ 3 | „ 7 | „ 6 | „ 7 |
| 3 | „ 10 | „ 5 | „ 10 | „ 10 |
| 4 | „ 7 | „ 10 | „ 7 } | „ 5 |
| 5 | „ 8 | „ 3 | „ 8 } | „ 8 |
| 6 | „ 11 | „ 8 | „ 9 | „ 3 |
| 7 | „ 5 | „ 11 | „ 2 | „ 9 } |
| 8 | „ 9 | „ 9 | „ 5 | „ 11 } |
| 9 | „ 2 | „ 2 } | „ 11 | „ 2 |
| 10 | „ 1 | „ 1 } | „ 1 | „ 1 |

It is quite clear from this table that there is a close relationship between height and weight in the schools. No. 6 clearly stands at one end of the scale and No. 1 at the other. School No. 5 takes a higher place for weight than for height, both among boys and girls. Now School No. 5 contains 25 per cent. of Jewish children. It may be that Jewish children are heavier in proportion to their height than the average London child, but further evidence of this is desirable before asserting it. School No. 3, on the other hand, takes a higher place for height than for weight, but the notes on the school do not suffice to explain this result.

We cannot go any further with the present material, but it must be pointed out that the "School Heights" so found take no account of racial differences, and the necessity of allowing for the effects of race has already been insisted on in the introduction to this paper. To do so we require some indication of the nationality of the parents. In practice this is not easy. Failing a definite statement of nationality, we may reach some approximation to the racial constitution of the population by an examination of the children's surnames, especially in towns with large foreign elements. It must be remembered, of course, that the mother's surname disappears, and that many foreigners adopt English names, so that the number of foreigners would probably be considerably underestimated by this method. The better method, however, is to consider hair colour and eye colour as indicating the racial elements of the population.* Whichever method be adopted a simple extension of the process just given will enable us to find a "School Height" or "School Weight" independent of age distribution and of racial mixture, just as the Registrar-General's method can be extended to correct for differences of sex constitution as well as of age distribution. The use of a single coefficient to represent the stature or weight of a school is even more necessary here, because the only other way available for comparing two schools in respect of stature is to

* It will probably be necessary to classify by both hair and eye colours, either alone being found insufficient to determine the racial constitution of a district.

compare the average height of each race represented, or of each hair colour group, at each year of age, so that from thirty to forty averages would be necessary to represent adequately the stature of a single school. If we divide the children at each age directly into nationalities, or indirectly by classifying hair colour, and define ${}_am_5$ as the number of children of age 5 and nationality or hair colour "$a$", then the standard age distribution will still be $M=m_5+m_6+m_7\dots$ where $m_5={}_am_5+{}_bm_5+\dots$, and similarly, if ${}_ah_5$ be the average height of children aged 5, and of nationality or hair colour "$a$", then the number which represents the average height of the school, corrected for differences in age and racial distribution, will be

$$S.H.=\frac{h_5\,m_5+h_6\,m_6+\&c.}{M}=\frac{\Sigma hm}{M}$$

where $h_5\,m_5={}_ah_5\times{}_am_5+{}_bh_5\times{}_bm_5+{}_ch_5\times{}_cm_5+\&c.$ In the same way we can obtain a "School Weight" which will be independent of age and racial distribution. Only when this has been done shall we be in a position to compare the stature and weight of children of different schools or areas, or to test whether there is any relationship between stature, independent of age and race, and any environmental factors, such as the amount of pauperism in a district, the density of population, and other measures of social condition, just as has been done with the birth-rate in the Metropolitan Boroughs of London by the present writer * ; only when those corrections have been made can we test whether the differences found between schools and districts are due to underfeeding and the like.

These coefficients for height and weight might usefully have been employed in the valuable Report on the Physical Condition of Glasgow School Children, by Dr. W. Leslie Mackenzie and Captain A. Foster,† who have analysed records of stature and weight of 72,857 children, and discussed the relation of stature and weight to the housing of the children. The result reached is that boys who live in one-roomed houses are 11·7 lb. lighter and 4·7 inches smaller than boys who live in four-roomed houses, while girls from one-roomed houses are 14 lb. lighter and 5·3 inches shorter than the girls from four-roomed houses. These figures are based on the average height and weight of children of all ages, and no correction is made for differences of age distribution.

I have calculated, from these Scottish statistics, the average height and weight, independent of age distribution, i.e. the "Class Height" and "Class Weight", for children in houses with one, two, three, and four rooms. These and the averages given in the Report are given in Table XXI.

* On the Relation of Fertility in Man to Social Status, and on the changes in this Relation that have taken place in the last fifty years. Drapers' Company Research Memoirs. Studies in National Deterioration I. Dulau & Co.

† Scotch Education Department, Cd. 3637. 1907.

## TABLE XXI.

THE CHANGES MADE BY CORRECTING FOR DIFFERENCES IN AGE DISTRIBUTION ON AVERAGES OF HEIGHTS AND WEIGHTS OF GLASGOW CHILDREN.

| Number of Rooms in House. | Averages before Correction.* | | | | Averages after Correction. | | | |
|---|---|---|---|---|---|---|---|---|
| | Height (inches). | | Weight (lbs.). | | Height (inches). | | Weight (lbs.). | |
| | Boys. | Girls. | Boys. | Girls. | Boys. | Girls. | Boys. | Girls. |
| One. | 46·6 | 46·3 | 52·6 | 51·5 | 47·6 | 47·6 | 54·9 | 54·4 |
| Two. | 48·1 | 47·8 | 56·1 | 54·8 | 48·4 | 48·2 | 56·9 | 56·0 |
| Three. | 50·0 | 49·6 | 60·6 | 59·4 | 49·4 | 49·1 | 59·0 | 57·8 |
| Four. | 51·3 | 51·6 | 64·3 | 65·5 | 50·0 | 49·8 | 60·4 | 59·8 |
| Range. | 4·7 | 5·3 | 11·7 | 14·0 | 2·4 | 2·2 | 5·5 | 5·4 |

It will be seen from this table that the range is now *less than half* what it was before correction. Instead of boys from one-roomed houses being 11·7 lb. lighter and 4·7 inches smaller than boys from four-roomed houses, these differences are now only 5·5 lb. and 2·4 inches; instead of differences among the girls of 14 lb. and 5·3 inches we get differences of 5·4 lb. and 2·2 inches. The explanation of the marked change in these results is that among one-roomed boys only 2·4 per cent. are aged 14 and upwards, while among four-roomed boys the percentage is 11·9; among one-roomed girls only 2·3 per cent. are aged 14 and upwards, while among four-roomed girls the percentage rises to 14·8. As the number of children in a family increase they require of course more accommodation, even though there be no improvement in their circumstances. The housing conditions of children cannot be estimated accurately from a knowledge of the number of rooms alone; we require also the number of persons who occupy those rooms, so as to obtain the number of persons per room, which gives a far better idea of the home conditions of the children.

Can we say, then, that even these smaller differences are certainly due to bad home conditions? By no means. Mr. Tocher † has shown how widely divergent are the different districts of Glasgow in regard to hair and eye colour, and until we have allowed for these racial differences we cannot definitely assert that bad home conditions have any influence on the stature and weight of the children.

The correlation coefficients which indicate the relationship between age and height and between age and weight are given in Table XXII. There are obviously significant differences between the schools, but in the most divergent case this is due to an arbitrary age selection of the children, Standards I and II not being available. The regression coefficients, on the other hand, are practically equal, i. e. the slope of the regression lines are nearly the same in the different schools

* Extracted from Mackenzie and Foster's Report, p. 56, Table 61.

† *Biometrika*, vol. vi, p. 129.

## TABLE XXII.

### The Relationship between Age and Height and between Age and Weight.

| School Number. | Correlation Coefficients. | | | |
|---|---|---|---|---|
| | Boys. | | Girls. | |
| | Age and Height. | Age and Weight. | Age and Height. | Age and Weight. |
| 1 | +·79±·01 | +·78±·01 | +·81±·01 | +·75±·02 |
| 2 | +·80±·02 | +·76±·02 | +·70±·02 | +·73±·02 |
| 3 | +·86±·01 | +·78±·01 | +·86±·01 | +·81±·01 |
| 4 | *(+·64±·02) | (+·60±·02) | +·82±·01 | +·79±·01 |
| 5 | +·80±·01 | +·76±·01 | +·81±·01 | +·77±·01 |
| 6 | +·86±·01 | +·84±·01 | +·87±·01 | +·82±·01 |
| 7 | +·83±·01 | +·83±·01 | +·88±·01 | +·81±·01 |
| 8 | +·83±·01 | +·81±·01 | +·88±·01 | +·80±·01 |
| 9 | +·82±·01 | +·76±·01 | +·83±·01 | +·79±·02 |
| 10 | +·85±·01 | +·83±·01 | +·80±·02 | +·77±·02 |
| 11 | +·88±·01 | +·79±·01 | +·84±·01 | +·75±·01 |
| 12 | — | — | +·83±·01 | +·79±·01 |
| 13 | — | — | +·78±·02 | +·72±·02 |
| 14 | +·84±·01 | +·81±·01 | — | — |
| Mean | +·83 | +·80 | +·82 | +·77 |

when we compare age and height among boys or among girls, or age and weight among boys or among girls.

Similarly in Table XXIII are given the correlation coefficients indicating the relationship between height and weight. The maximum difference between two

## TABLE XXIII.

### The Relationship between Height and Weight.

| School Number. | Correlation Coefficients. | |
|---|---|---|
| | Boys. | Girls. |
| 1 | +·94 | +·87 |
| 2 | +·92 | +·89 |
| 3 | +·93 | +·92 |
| 4 | +·88 | +·89 |
| 5 | +·90 | +·93 |
| 6 | +·94 | +·90 |
| 7 | +·92 | +·93 |
| 8 | +·89 | +·95 |
| 9 | +·92 | +·91 |
| 10 | +·95 | +·94 |
| 11 | +·93 | + 92 |
| 12 | — | +·91 |
| 13 | — | +·91 |
| 14 | +·94 | — |
| Mean | +·92 | +·91 |

Note.—The numbers on which those correlation coefficients are based range from 168 to 545. The probable error is thus in every case of the order ·01.

* In this school Standards I and II are not available.

schools is eight times its probable error, and thus is certainly significant, but the regression lines are even more divergent, so that there seem to be significant differences between the schools in this respect; this is probably due to the influence of the selection of age already indicated.

(9) THE RELATIONSHIPS BETWEEN MENTAL CAPACITY AND HEIGHT AND WEIGHT.

In considering these relationships, we must of course allow for the influence of age on height and weight. This is done by means of partial correlation coefficients. If $r_{MH}$, $r_{MA}$, $r_{HA}$, be the direct correlation coefficients between mental capacity and height, mental capacity and age, and height and age, then the correlation between mental capacity and height for a constant age is given by

$$_{A}R_{MH} = \frac{r_{MH} - r_{MA} r_{HA}}{\sqrt{1 - r_{MA}^2}\ \sqrt{1 - r_{HA}^2}}$$

and a similar formula holds for the correlation between weight and mental capacity for a constant age. The values of $r_{MA}$, $r_{HA}$, $r_{WA}$ have already been given in Tables XII and XXII, and in Table XXIV and XXV I have given $r_{MH}$, $r_{WH}$, $_{a}R_{MH}$, $_{A}R_{MW}$ for the individual schools. It will at once be noticed that to allow for the influence of age makes no significant difference on the *average* of the correlation coefficients, but that the effect is really that of a reducing factor on the separate correlations. We have, for instance, twenty-five correlation coefficients between mental capacity and height, with a range of from $-\cdot 24$ to $+\cdot 29$, and a standard deviation of $\cdot 17$, while the partial correlation coefficients have a range of from $-\cdot 03$ to $+\cdot 18$, and their standard deviation is only $\cdot 05$, less than a third of the former value. Exactly the same result is obtained from the correlations between mental capacity and weight. The range of the direct correlation coefficients is from $-\cdot 21$ to $+\cdot 28$, and the standard deviation is $\cdot 16$, while the range of the partial correlation coefficients is from $-\cdot 04$ to $+\cdot 13$, and the standard deviation is $\cdot 05$. The effect of allowing for the influence of age is thus to leave the *average* correlation practically unaltered while materially reducing the range and variability of the correlation coefficients. The mean values are in all cases positive, but are very small, and no marked stress can be laid upon these relationships. In other words, if the height and weight of the children be primarily a result of their home environment and not largely due to racial differences, this environmental influence does not substantially affect their mental capacity.

This result is confirmed by examination of the individual returns, which are very irregular. Thus in the School *B*. 5 and *G*. 5, the boys show one of the relatively high relationships between height and mental capacity, while the girls show no relationship; a similar difference between the sexes is found in School No. 9 when dealing with the relationship between weight and mental capacity. It may be presumed that the home environment is the same for both boys and girls, and yet if mental capacity be affected by the state of nutrition,

## TABLE XXIV.

### The Relationship between Height and Mental Capacity.

| School Number. | Boys. | | Girls. | |
|---|---|---|---|---|
| | Correlation Ratios. Height and Mental Capacity. | Partial Correlation Coefficients. Height and Mental Capacity for a constant Age. | Correlation Ratios. Height and Mental Capacity. | Partial Correlation Coefficients. Height and Mental Capacity for a constant Age. |
| 1 | +·06±·04 | +·06±·04 | +·25±·04 | +·08±·04 |
| 2 | +·19±·04 | +·04±·04 | +·16±·05 | +·11±·05 |
| 3 | +·14±·03 | +·15±·03 | +·28±·04 | +·12±·04 |
| 4 | +·25±·04 | +·13±·04 | −·14±·03 | +·01±·03 |
| 5 | +·26±·04 | +·08±·04 | −·24±·03 | −·03±·03 |
| 6 | −·11±·03 | +·07±·03 | +·21±·04 | +·08±·04 |
| 7 | +·20±·03 | +·18±·03 | −·16±·03 | +·16±·03 |
| 8 | +·12±·04 | +·08±·04 | +·20±·04 | +·11±·04 |
| 9 | +·21±·04 | +·15±·04 | +·18±·04 | +·07±·04 |
| 10 | +·15±·04 | +·11±·04 | +·29±·05 | +·11±·05 |
| 11 | −·21±·03 | +·02±·03 | −·12±·03 | −·02±·03 |
| 12 | — | — | −·11±·03 | +·03±·03 |
| 13 | — | — | +·16±·04 | +·08±·04 |
| 14 | −·07±·04 | +·11±·04 | — | — |
| Mean | +·10 | +·10 | +·07 | +·07 |

## TABLE XXV.

### The Relationship between Weight and Mental Capacity.

| School Number. | Boys. | | Girls. | |
|---|---|---|---|---|
| | Correlation Ratios. Weight and Mental Capacity. | Partial Correlation Coefficients. Weight and Mental Capacity for a constant Age. | Correlation Ratios. Weight and Mental Capacity. | Partial Correlation Coefficients. Weight and Mental Capacity for a constant Age. |
| 1 | +·06±·04 | +·06±·04 | +·27±·04 | +·13±·04 |
| 2 | +·21±·04 | +·09±·04 | +·15±·05 | +·09±·05 |
| 3 | +·13±·03 | +·12±·03 | +·28±·04 | +·12±·04 |
| 4 | +·14±·04 | −·00±·04 | −·14±·03 | −·00±·03 |
| 5 | +·20±·04 | −·01±·04 | −·20+·03 | +·01±·03 |
| 6 | −·15±·03 | +·03±·03 | +·21±·04 | +·10±·04 |
| 7 | +·18±·03 | +·13±·03 | −·18±·03 | +·07±·03 |
| 8 | +·10±·04 | +·05±·04 | +·18±·04 | +·07±·04 |
| 9 | +·18±·04 | +·10±·04 | +·12±·04 | −·01±·04 |
| 10 | +·11±·04 | +·04±·04 | +·19±·05 | −·04±·05 |
| 11 | −·21±·03 | +·05±·03 | −·10±·03 | −·01±·03 |
| 12 | — | — | −·11±·03 | +·03±·03 |
| 13 | — | — | +·08±·04 | −·03±·04 |
| 14 | −·11±·04 | +·03±·04 | — | — |
| Mean | +·07 | +·06 | +·05 | +·03 |

and this by home conditions, the effect is quite different for boys and girls. If it be suggested that the bigger girls reach puberty sooner and that their mental energies may be thus lessened, some solution must be offered to the difficulty that these relationships rise to their highest positive values in *G.* 1 and *G.* 3 for weight, and in *G.* 3 and *G.* 7 for height. Further, not more than some eight of the fifty partial correlation coefficients can be considered significant, having regard to their probable errors. In other words, unless we are to consider the mental capacity scale as wholly valueless *relatively* as well as absolutely, i. e. unless we are to assume that no reliance is to be placed on the teachers' classification into intelligence groups in the individual schools, there is really no basis for the belief that mental capacity is substantially associated with the height and weight of the children.

### (10) The Relationship between Mental Capacity and Qualitative Characters.

Having discussed the relationship between mental capacity and those characters which can be expressed on a quantitative scale, we must now deal with purely qualitative characters, such as the condition of the teeth and of the clothing, the state of nutrition, cleanliness, &c.

Two methods only are available for determining the relationship between mental capacity and any one of those characters, by forming a contingency table or a fourfold table. The contingency table was used in all cases where at least a twelvefold division, i.e. a three × fourfold division of the material could be made, and where this could not be done the fourfold table was used.

But before discussing in detail those relationships it will perhaps be profitable to look at the question in quite another way. Let us assume again that the distribution of mental capacity obeys the Gaussian law, and let us find for each grade of intelligence the centroid vertical and plot up on those verticals the percentages of children who possess in a given degree a certain character. To take an example, we find that in *B.* 7, of those children who are classed as brilliant 90 per cent. obtain marks IV or V for the condition of the clothing, i. e. in those cases the condition of the clothing is at least above the average. Of the children who are above "the average" in intelligence 91 per cent. reach the standard "above the average" for the condition of the clothing; while in the "average", "under the average", and "very dull and backward" groups of intelligence, the percentages are 84, 72, and 44 respectively. It is clear then that, *so far as this school is concerned,* there is some relationship between mental capacity and the condition of the clothing, and, further, that this relationship is *positive,* i. e. the higher the intelligence the better the condition of the clothing. If these numbers are expressed graphically we obtain a diagram which Professor Pearson has termed an *analograph.**

* See *Biometrika,* vol. v, p. 129.

If the percentages increase or decrease uniformly with mental capacity, a more or less close relationship between mental capacity and the character under consideration is indicated. In such cases the analograph is said to be " homoclinal ", while if the percentage does not reach its maximum with the maximum or minimum of intelligence it is said to be " heteroclinal ".

The analograph is also useful in another way ; as has already been pointed out, the contingency coefficient has essentially no sign, but if we are to consider the correlation between two characters to be determined by a contingency coefficient we must prefix a positive or negative sign to the arithmetical value found from the contingency table, and this sign can usually be determined from the analograph. The procedure to be adopted in doubtful cases has already been discussed.

Analographs have been constructed to show the relationship between mental capacity and seven other characters for the boys' and girls' departments of School No. 7, and these are given in Fig. 12.

It should be noted that the deductions drawn from these analographs apply only to those two schools, and in general cannot be extended to the other schools where the analographs may show actually reversed conditions.

In the boys' department, five groups of mental capacity are used, but in the girls' department there are only six girls who are classed as " brilliant ", so that here the two groups " above the average " and " brilliant " have been combined, another illustration of the difficulties of the investigation.

To take individual cases there is clearly, as has been stated, some relationship between intelligence and the condition of the clothing, and this is seen to be true both for the boys and the girls of this School, No. 7.

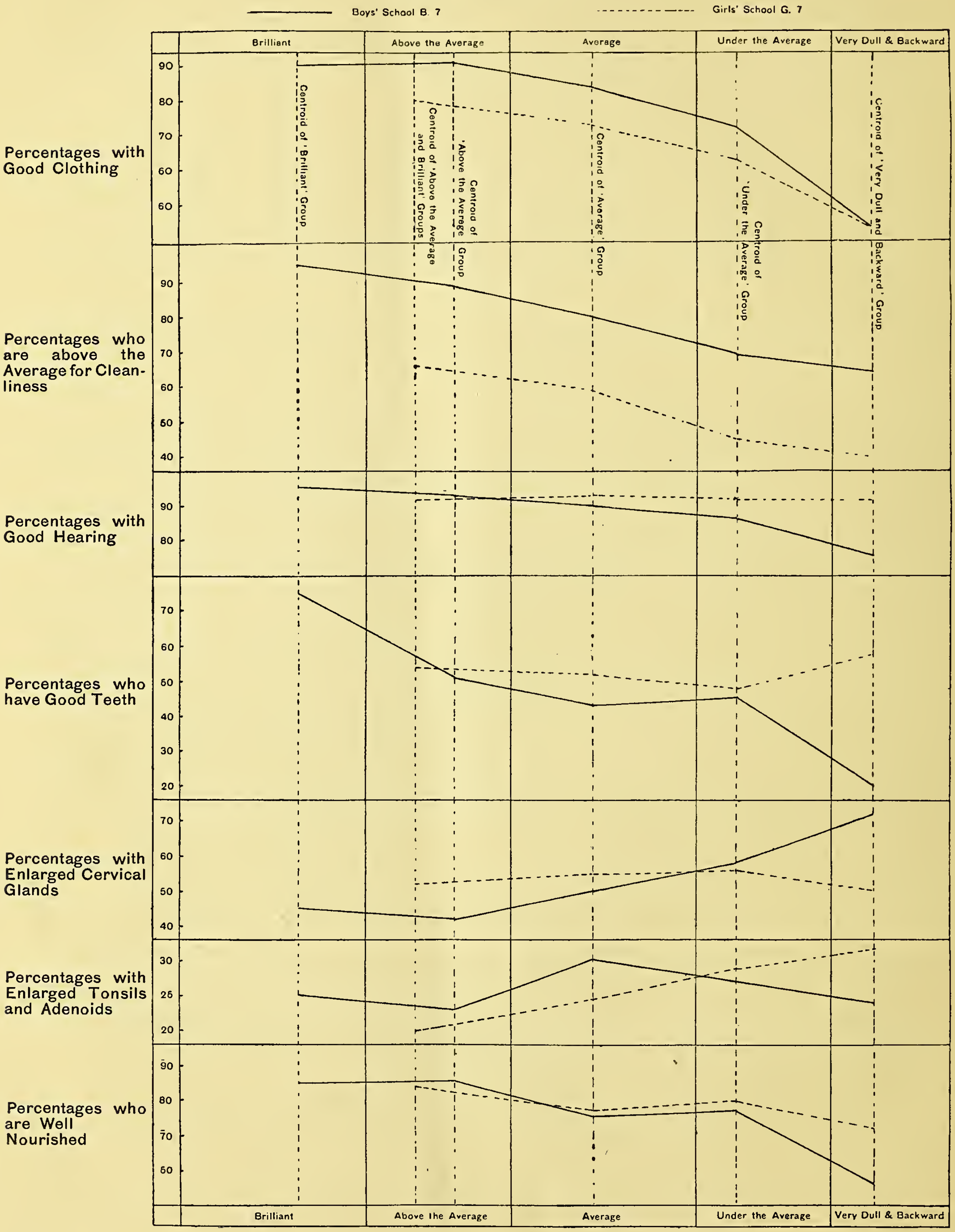
Similarly, I have plotted on the centroid verticals of the mental capacity groups, the percentage of children who obtain the marks IV or V for their state of cleanliness. Here, again, the relationship is homoclinal and the percentage decreases as we pass from the " brilliant " to the " dull ".

The percentage of boys who have normal hearing decreases slightly with decreasing intelligence ; among the girls there is no sensible difference between the groups.

The relationship between the condition of the teeth and mental capacity is more marked among the boys than among the girls ; similarly the percentages of boys whose glands are enlarged increase from 45 to 72 as we pass from the " brilliant " group to the " dull ", i.e. with increased intelligence the condition of the glands improves ; among the girls, on the other hand, the differences are hardly significant and the relationship is heteroclinal.

The condition of the tonsils and adenoids, again, is slightly correlated with mental capacity in the case of the girls, and not at all in the case of the boys.

FIG. 12. ANALOGRAPHS OF VARIOUS CHARACTERS FOR EACH GRADE OF MENTAL CAPACITY.



Unfortunately there is no uniformity among the different schools, and we find that the percentages sometimes increase and sometimes decrease with intelligence, just as we have found correlation coefficients to be sometimes positive among the boys and negative among the girls of the same school.

### (11) The Relationship between Mental Capacity and the Condition of the Teeth.

We can now investigate the relationships between mental capacity and the physical conditions of the children for individual schools.

In every school there is given an estimate of the children's teeth. Unfortunately the system of classification adopted varies very considerably from one school to another. In each case the marks I, II, III, IV, V, are used, but in different schools they represent very different conditions. Thus in the Schools *B*. 2 and *G*. 2 and *G*. 12 the scale used was:

I. Several (more than four) carious teeth.
II. Two to four carious teeth.
III. Average, not more than two slightly carious.
IV. One or more carious.
V. Perfect set, clean, and no caries.

It is not clear what is the distinction between groups 3 and 4, and this makes the scale somewhat unsatisfactory.

In *B*. 3 and *G*. 3, *B*. 6 and *G*. 6, the scale adopted is very vague:

I. Very bad.
II. Fairly bad.
III. Medium.
IV. Good.
V. Very good.

This is practically the general scale of marks given in the introduction, and seems to have been adopted in most of the schools.

In *B*. 5 and *G*. 5 the scale used was much better, and might well be adopted as a standard scale:

I. Practically edentulous; no teeth capable of performing useful mastication.
II. Capable of masticating food but no sound teeth.
III. Good serviceable set with two or three decayed or lost.
IV. One tooth only decayed or lost.
V. A perfect set of teeth.

Now it is clear that the mark I in *B*. 2, *G*. 2, and *G*. 12, given to children who have more than four carious teeth stands for a condition very different from that to which the mark I is given in *B*. 5 and *G*. 5—to children who have no teeth capable of performing useful mastication, and we have no means of comparing either classification with a vague term such as "very bad". Accordingly, a comparison between the numbers who are placed in the various classes in the different schools loses much of its value, and we cannot estimate the general condition of the teeth in the different schools, but can only compare the boys' and girls' departments of the same schools.

The percentages in each grade in each school are given in Table XXVI, but we can only say that on the whole the condition of the teeth is nearly the same among the boys and girls of the same school; the only exception is in *B.* 1 and *G.* 1, where the boys seem to have worse teeth than the girls. We see that the percentage of children who get the highest mark for the condition of their teeth varies from 0 to 31, but we cannot tell how much is real and how much is due to the use of different scales.

## TABLE XXVI.

The Variation in the Condition of the Teeth in the Individual Schools.

| School Number. | Boys. | | | | | Girls. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Condition of Teeth. | | | | | Condition of Teeth. | | | | |
| | Percentages in Each Grade. | | | | | Percentages in Each Grade. | | | | |
| | I. | II. | III. | IV. | V. | I. | II. | III. | IV. | V. |
| 1 | — | 7 | 62 | 24 | 7 | 1 | 15 | 46 | 24 | 15 |
| 2 | 1 | 15 | 57 | 26 | 1 | — | 23 | 57 | 19 | — |
| 3 | — | 29 | 61 | 9 | 1 | 2 | 41 | 48 | 9 | — |
| 4 | — | 7 | 53 | 26 | 15 | — | 16 | 46 | 19 | 19 |
| 5 | — | 21 | 50 | 22 | 7 | 1 | 13 | 58 | 21 | 7 |
| 6 | 3 | 37 | 46 | 13 | 2 | 1 | 36 | 56 | 6 | 1 |
| 7 | 1 | 20 | 35 | 21 | 24 | 1 | 14 | 34 | 22 | 30 |
| 8 | — | 13 | 54 | 19 | 14 | — | 8 | 55 | 21 | 16 |
| 9 | — | 17 | 45 | 28 | 10 | — | 8 | 52 | 27 | 13 |
| 10 | — | 10 | 28 | 31 | 31 | — | 4 | 27 | 38 | 31 |
| 11 | — | 27 | 20 | 25 | 28 | — | 20 | 21 | 28 | 31 |
| 12 | — | — | — | — | — | 12 | 30 | 42 | 16 | — |
| 13 | — | — | — | — | — | — | 17 | 52 | 20 | 12 |
| 14 | 3 | 14 | 54 | 19 | 10 | — | — | — | — | — |

That the teeth of children are extraordinarily susceptible to treatment is clearly indicated by an interesting example of the immense improvement in the condition of the teeth that can be effected by dental care given in Dr. Kerr's Report for 1906.*

Among the pupils attending Dulwich Schools are a number of children from Lambeth Workhouse. Each of those children is inspected twice yearly by a dentist and the result is that 70 per cent. of those workhouse children are free from obvious

* Report of the Education Committee of the London County Council, submitting the Report of the Medical Officer (Education) for the year ending March 31, 1906, pp. 16 et seq.

dental disease, while among the other Dulwich school children only 30 per cent. are free from obvious dental disease. It is probable, too, that the more reasonable diet of the workhouse children was not without its own influence.

The contingency coefficients indicating the relationship between mental capacity and the condition of the teeth are given in Table XXVII.

## TABLE XXVII.

### The Relationship between the Condition of the Teeth and Mental Capacity.

| School Number. | Boys. | | Girls. | |
|---|---|---|---|---|
| | Direct Correlation between Mental Capacity and the Condition of the Teeth. | Correlation between Mental Capacity and the Condition of the Teeth for a constant Age. | Direct Correlation between Mental Capacity and the Condition of the Teeth. | Correlation between Mental Capacity and the Condition of the Teeth for a constant Age. |
| 1 | +·17±·04 | +·17±·04 | +·14±·04 | +·18±·04 |
| 2 | +·13±·04 | +·08±·04 | +·15±·05 | +·12±·05 |
| 3 | +·13±·03 | +·12±·03 | +·22±·04 | +·18±·04 |
| 4 | +·16±·04 | +·12±·04 | +·14±·03 | +·18±·03 |
| 5 | +·16±·04 | +·13±·04 | −·13±·03 | −·07±·03 |
| 6 | +·09±·03 | +·12±·03 | +·14±·04 | +·11±·04 |
| 7 | +·17±·03 | +·16±·03 | +·11±·03 | +·17±·03 |
| 8 | −·12±·04 | −·14±·04 | +·18±·04 | +·15±·04 |
| 9 | −·17±·04 | −·21±·04 | +·12±·04 | +·09±·04 |
| 10 | +·26±·04 | +·24±·04 | +·23±·05 | +·17±·05 |
| 11 | −·10±·03 | −·05±·03 | −·20±·03 | −·19±·03 |
| 12 | — | — | +·15±·03 | +·20±·03 |
| 13 | — | — | −·13±·04 | −·17±·04 |
| 14 | +·19±·04 | +·16±·04 | — | — |
| Mean | +·08 | +·08 | +·08 | +·09 |

There is again a large variation in those coefficients, and although the average of both boys' and girls' schools is positive, in both cases it is small and does not indicate any marked relationship between mental capacity and the condition of the teeth.

The possibility of the condition of the teeth being highly correlated with the age of the child makes it necessary that we should correct for age by means of a partial correlation coefficient, just as in the cases of height and weight. Here the correlation between intelligence and the condition of the teeth for a constant age

$$_AR_{TM} = \frac{r_{TM} - r_{TA} r_{MA}}{\sqrt{1 - r_{TA}^2}\ \sqrt{1 - r_{MA}^2}}$$

The values of $r_{MA}$, the relationship between mental capacity and age have already been given, and those of $r_{TA}$ will be given later, when we consider the influence of age on various physical conditions. Both $r_{TA}$ and $r_{MA}$ are small, so that we find that the correction for age makes very little difference in the result. The partial correlation coefficients for every school are also given in Table XXVII, and the differences between the corrected and uncorrected values are very small. We must conclude then that the condition of the teeth is not associated in any marked degree with intelligence.

### (12) The Relationship between Mental Capacity and the Condition of the Clothing.

In seven boys' schools and six girls' schools there is given an estimate of the condition of the children's clothing. In the original memorandum which outlined the scheme of inspection a very definite classification of the condition of the clothing was given :

I. The clothing of the scantiest possible, e.g. one ragged coat, buttoned up, and practically nothing found beneath it; boots either absent or represented by a mass of rags tied upon the feet.

II. Clothing insufficient to retain animal heat and needing urgent remedy, boots leaking.

III. Clothing poor, but passable; an old and perhaps ragged suit, with some attempt at proper underclothing, usually of flannelette.

IV. Well clad, stuff suit, good boots, and a flannel undergarment or a jersey; poor but sufficient.

V. Very well clad.

This is a very definite scale and might be expected to give good results, but when we look at the percentages of children in each of these classes for each school, as given in Table XXVIII, we see that again we have extraordinary variation in

TABLE XXVIII.

The Variation in the Condition of the Clothing in the Individual Schools.

| School Number. | Boys. Condition of Clothing. Percentage in each Grade. | | | | | Girls. Condition of Clothing. Percentage in each Grade. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | I. | II. | III. | IV. | V. | I. | II. | III. | IV. | V. |
| 1 | 1 | 20 | 49 | 27 | 2 | — | 5 | 24 | 36 | 35 |
| 2 | — | 19 | 41 | 40 | 1 | — | — | — | — | — |
| 4 | — | 18 | 26 | 39 | 18 | — | 3 | 12 | 37 | 48 |
| 7 | — | 4 | 13 | 32 | 50 | — | 1 | 10 | 20 | 68 |
| 10 | — | 3 | 7 | 36 | 54 | — | 2 | 15 | 45 | 38 |
| 11 | — | 3 | 11 | 26 | 61 | — | — | 5 | 11 | 84 |
| 13 | — | — | — | — | — | 1 | 22 | 11 | 17 | 48 |
| 14 | 6 | 29 | 53 | 12 | — | — | — | — | — | — |

the percentages. Now it is only to be expected that the condition of the clothing will vary considerably from one school to another, but surely this cannot be the case when we compare the boys' and girls' departments of the same school. Take, for instance, School No. 1. Of the boys only 2 per cent. obtain the highest mark, while 35 per cent. of the girls obtain this mark. In no school is the condition of the clothing even approximately the same for boys as for girls.

Now the condition of the clothing is one of the characteristics by which several authorities have hoped to measure the home environment, and yet this table seems to show that sex produces fundamental differences.

The same sexual differences are seen when we consider the relationships between mental capacity and the condition of the clothing. The results are given in Table XXIX. Thus in School No. 10, the better clothed boy is on the average

TABLE XXIX.

The Relationship between the Condition of the Clothing and Mental Capacity.

| School Number. | Boys. | | Girls. | |
|---|---|---|---|---|
| | Method. | Correlation. | Method. | Correlation. |
| 1 | Contingency | +·17±·04 | Contingency. | +·23±·04 |
| 2 | ,, | −·23±·04 | | |
| 4 | ,, | +·14±·04 | ,, | +·30±·03 |
| 7 | ,, | +·35±·03 | ,, | +·26±·03 |
| 10 | ,, | −·19±·04 | ,, | +·21±·05 |
| 11 | Fourfold Table | +·03±·03 | Fourfold Table | +·22±·03 |
| 13 | | | Contingency | +·20±·04 |
| 14 | Contingency | +·03±·04 | | |
| Mean | | +·04 | | +·24 |

less intelligent, while the better clothed girl is on the average *more* intelligent and to the same degree. It is possible that in measuring mental capacity in the girls, neatness of dress has been invariably included as a factor, while with the boys this depends on the individual teacher. It seems impossible therefore to use the condition of the clothing as an effective test of home environment so long as the source of these inconsistencies is undetermined. It seems more reasonable to suppose that mental capacity (either directly or because the abler child is the child of abler parents) produces neater clothes and that this is far more the rule with girls than with boys. It would be difficult even with the steady values obtained for girls to assert that good clothing was a sign of good home environment and that that was associated with intelligence. The orderly-minded parents may produce an orderly-minded child as well as provide orderly attire for their children, and the fact that even intelligent and mentally active boys will "tear their clothes to pieces" may explain this sex difference and show how little service a school appreciation of clothing may sometimes be as a measure of home environment. The actual survey of the homes is the only way to reach the truth on this question of the use of the condition of the clothing as a measure of home environment, and the influence of the latter, apart from heredity, on mental capacity.

### (13) The Relationship between Mental Capacity and the State of Nutrition.

The estimation of the state of nutrition of a child presents peculiar difficulties. There seems to be no certain method by which the underfed child may be distinguished, and no satisfactory scale of nutrition has yet been evolved.

In the present investigation no fewer than *five* different scales were used, and even the best is somewhat indefinite, and probably no two medical men would classify under it in exactly the same way. The scale which seems most satisfactory is that used in *B.* 5 and *G.* 5 :

I. Very poor muscular development with little or no subcutaneous fat.

II. Either very poor muscular development with fair amount of fat, or vice versa.

III. Fair all round development.

IV. Very good muscular development with only fair general nutrition, or vice versa.

V. The " pink of condition ".

This scale is fairly definite and ought to give satisfactory results, but three other scales are used which are exceedingly vague. The second scale given is used in Schools Nos. 2 and 12, the third in Schools Nos. 3 and 6, and the fourth in Schools Nos. 8 and 9.

| Mark. | 2nd Scale. | 3rd Scale. | 4th Scale. |
|---|---|---|---|
| I | Very thin. | Very bad. | Emaciated. |
| II | Thin. | Fairly bad. | Badly nourished. |
| III | Average. | Medium. | Fairly well nourished. |
| IV | Well nourished. | Good. | Well nourished. |
| V | Stout. | Very good. | Excellently well nourished. |

In Schools Nos. 7 and 11, a fifth scale is used in which only the marks I, II, III are used, thus rendering impossible any comparison between these and the rest of the schools. The scale is :

I. A child of very inferior physique.

II. A child below the normal.

III. A well-nourished child.

Of course any one of these scales would probably work quite satisfactorily in the hands of the medical man who drew it up, but what is required is some scale which leaves little or no room for individual idiosyncrasies, that is, it must approximate as closely as possible to the quantitative, but the problem is no doubt a very difficult one.

The percentage of children who are placed in the different grades are given in Table XXX. There seems to be on the whole rather better agreement between the boys and girls of the same school.

## TABLE XXX.

### The Variation in the State of Nutrition in the Individual Schools.

| School Number. | Boys. State of Nutrition. Percentage in each Grade. I. | II. | III. | IV. | V. | Girls. State of Nutrition. Percentage in each Grade. I. | II. | III. | IV. | V. |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | — | 5 | 64 | 30 | — | 1 | 12 | 54 | 31 | 1 |
| 3 | — | 4 | 75 | 19 | 1 | — | 12 | 56 | 29 | 3 |
| 5 | — | 11 | 51 | 31 | 8 | 1 | 13 | 60 | 20 | 4 |
| 6 | — | 13 | 67 | 17 | 2 | — | 16 | 63 | 20 | 2 |
| 7 | 2 | 24 | 74 | — | — | — | 21 | 79 | — | — |
| 8 | — | 1 | 61 | 33 | 5 | — | 1 | 48 | 43 | 8 |
| 9 | — | 3 | 57 | 36 | 4 | — | 3 | 55 | 33 | 9 |
| 11 | — | 9 | 91 | — | — | — | 14 | 85 | — | — |
| 12 | — | — | — | — | — | 1 | 14 | 61 | 21 | 2 |

If all the schools had been examined in the same way, using the same uniform scale, the question of how to classify the schools, in respect of the state of nutrition of the children, would have arisen. It is useful in such cases to obtain a single number which will sum up all the observations relating to a single school or area just as we have done in the cases of height and weight.

Nutrition, of course, must be expressed on a qualitative scale, but by assuming, as in the case of mental capacity, that the distribution of nutrition follows the normal curve of error, we can reduce this qualitative scale to a quantitative one, and so obtain an Index of Nutrition by which all the schools in a district can be compared *inter se*. The method can, of course, be applied to any character which is expressed on a qualitative scale. If the children of all the schools under consideration taken together are arranged in five groups in respect of nutrition, and the numbers in each group are $n_1+n_2+n_3+n_4+n_5=N$, then, on the assumption that the distribution of nutrition is normal, we can find the distances of the centroid verticals of each group from the mean of the whole. Let these distances be $h_1$, $h_2$, $h_3$, &c., then $\Sigma nh=0$. If now $m_1+m_2+m_3+m_4+m_5=M$ be the distribution of nutrition in any individual school, $\frac{\Sigma mh}{M}$ will measure the state of nutrition in that school relative to the whole of the schools considered. It will be convenient to take as our Index of Nutrition,

$$I.N.=100\ \frac{\Sigma mh}{M}$$

This coefficient will be positive when the state of nutrition in the school is above the average, zero when it is exactly the same as in the whole, and negative when below the average.

Such a scale will not, of course, allow for racial differences. We can do so on the basis of hair and eye colour, for instance, by finding this coefficient for each hair and eye colour group, but it is better in many ways to get a single coefficient to represent for a single school the general state of nutrition therein. A simple extension of the method just given will enable us to do so. As before, we require to base our Index on a standard distribution of hair and eye colour. Let the hair and eye colour groups necessary for classifying the children into racial groups be *a*, *b*, *c* . . ., let the state of Nutrition in a single school for hair and eye colour "*a*" be $N_a$ as measured by the above method, and let the total number of children in all the schools be $p_a$, then the Index of Nutrition for the school under consideration, which will be independent of racial distribution, will be

$$I.N._H = \frac{N_a p_a + N_b p_b + N_c p_c + \&c.}{N}$$

and if a few hair and eye colour groups are sufficient, the extra labour is not prohibitive. We can thus obtain for a school or an area a single coefficient which will serve for comparison with the other schools or areas included in the observations, and which will be independent of racial distribution. It is assumed here that age has no effect on nutrition; if it has (see p. 57), the method must then be extended to allow for this.

This process has been carried out in the case of six boys' departments and seven girls' departments (all the schools in which the marks I, II, III, IV, V have been used), but the result must be regarded solely as an illustration of method, because no fewer than four different scales are used in those schools, and also because we have no means of estimating the racial elements in the schools. The results are given in Table XXXI.

TABLE XXXI.

INDEX OF NUTRITION FOR SEVEN SCHOOLS.

| School Number. | Index of Nutrition. | |
|---|---|---|
| | Boys. | Girls. |
| 2 | + ·3 | − 9·2 |
| 3 | −11·3 | − 4·7 |
| 5 | +11·0 | −13·6 |
| 6 | −23·8 | −26·1 |
| 8 | +22·8 | +41·0 |
| 9 | +17·9 | +28·5 |
| 12 | — | −23·4 |

It will be seen that, except No. 5, there is at least a fair agreement between the boys and girls of the same school. Schools Nos. 8 and 9 are clearly much above the average, and No. 6 below it. If, however, we compare these results with the "School Heights" and "School Weights" already given, we find in Table XXXII that while No. 6 gets the lowest place for nutrition it gets the highest place for height and weight. It is of course quite reasonable to suppose that the state of nutrition is quite independent of height and weight, but if so, school or class height and weight differences have not the significance which is sometimes attributed to them. Until all the schools are examined on the same basis we cannot go further.

## TABLE XXXII.

### Place Order for Height, Weight, and Nutrition for the Boys and Girls of Six Schools.

| Place Order. | Nutrition. | | Height. | | Weight. | |
|---|---|---|---|---|---|---|
| | Boys. | Girls. | Boys. | Girls. | Boys. | Girls. |
| 1 | No. 8 | No. 8 | No. 6 | No. 3 | No. 6 | No. 6 |
| 2 | ,, 9 | ,, 9 | ,, 3 | ,, 6 | ,, 5 | ,, 5 |
| 3 | ,, 5 | ,, 3 | ,, 8 | ,, 8 | ,, 3 | ,, 8 |
| 4 | ,, 2 | ,, 2 | ,, 5 | ,, 9 | ,, 8 | ,, 3 |
| 5 | ,, 3 | ,, 5 | ,, 9 | ,, 2 | ,, 9 | ,, 9 |
| 6 | ,, 6 | ,, 6 | ,, 2 | ,, 5 | ,, 2 | ,, 2 |

The degree of relationship between mental capacity and the state of nutrition is indicated in Table XXXIII, where the various contingency and correlation coefficients are given. We have here, as before, positive and negative coefficients; the average, however, among both boys and girls is very small, and we must conclude that there is no relationship between mental capacity and the state of nutrition, but that the roughness of the material and the difficulties of classification combine to make some of the coefficients sensible as compared with their probable errors.

## TABLE XXXIII.

### The Relationship between the State of Nutrition and Mental Capacity.

| School Number. | Boys. | | Girls. | |
|---|---|---|---|---|
| | Method. | Correlation. | Method. | Correlation. |
| 2 | Contingency | $-\cdot16\pm\cdot04$ | Contingency | $+\cdot22\pm\cdot05$ |
| 3 | ,, | $+\cdot13\pm\cdot03$ | ,, | $+\cdot23\pm\cdot04$ |
| 5 | ,, | $-\cdot19\pm\cdot04$ | ,, | $-\cdot12\pm\cdot03$ |
| 6 | ,, | $+\cdot10\pm\cdot03$ | ,, | $+\cdot11\pm\cdot04$ |
| 7 | Fourfold Table | $+\cdot12\pm\cdot03$ | Fourfold Table | $+\cdot03\pm\cdot03$ |
| 8 | Contingency | $-\cdot12\pm\cdot04$ | Contingency | $+\cdot15\pm\cdot04$ |
| 9 | ,, | $+\cdot15\pm\cdot04$ | ,, | $+\cdot20\pm\cdot04$ |
| 11 | Fourfold Table | $+\cdot03\pm\cdot03$ | Fourfold Table | $+\cdot16\pm\cdot03$ |
| 12 | | — | Contingency | $-\cdot14\pm\cdot03$ |
| Mean | | $+\cdot01$ | | $+\cdot08$ |

### (14) The Relationship between Mental Capacity and the State of Cleanliness.

In the original memorandum the scale proposed to be used in estimating the state of cleanliness of the children is as follows :

I. Very dirty and verminous. II. Clothes and body dirty, but not verminous. III. Passably clean for boys (or girls). IV. Clean (above the average) for boys (or girls). V. Unexceptionable.

The percentages of children who are placed in each of these groups are, however, very irregular, as shown in Table XXXIV. Thus, in *G.* 7 and *G.* 11 groups II and V are very large, while groups III and IV are very small. In *G.* 11, for instance, 38 per cent. of the girls are placed in group II, none in group III, only 8 per cent. in group IV, and 52 per cent. in group V. Similarly, in *B.* 4, 17 per cent. get the mark V, while in *G.* 4, the girls' department of the same school, 47 per cent. of the girls get this mark. So also in School No. 1, only 1 per cent. of the boys get the mark V, while 33 per cent. of the girls get this mark. It is not easy to understand how such distributions could arise, nor to explain such differences between the boys and girls of the same schools, and this furnishes an excellent example of the difficulties of dealing with the material.* All we can do is to treat each school separately and take the average of the results.

### TABLE XXXIV.

The Variation in the State of Cleanliness in the Individual Schools.

| School Number. | Boys. State of Cleanliness. Percentage in each Grade. | | | | | Girls. State of Cleanliness. Percentage in each Grade. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | I. | II. | III. | IV. | V. | I. | II. | III. | IV. | V. |
| 1 | 5 | 22 | 50 | 22 | 1 | 2 | 18 | 28 | 19 | 33 |
| 4 | 3 | 7 | 28 | 45 | 17 | — | 14 | 22 | 16 | 47 |
| 7 | 1 | 11 | 8 | 38 | 42 | 2 | 41 | 4 | 15 | 38 |
| 10 | — | 3 | 10 | 23 | 64 | 1 | 1 | 4 | 18 | 77 |
| 11 | — | 4 | 5 | 47 | 43 | 1 | 38 | — | 8 | 52 |
| 13 | — | — | — | — | — | 2 | 12 | 21 | 17 | 48 |
| 14 | 8 | 31 | 50 | 11 | — | — | — | — | — | — |

The amount of relationship between mental capacity and the state of cleanliness is shown in Table XXXV. The average correlation is larger among the boys than among the girls, but the averages are small. Here, again, we meet the difficulty that boys and girls from the same school, and apparently from the same home environment, show quite contradictory results. Further, the results found

* Dr. Kerr, however, says that there are marked differences between boys and girls with regard to the character of their cleanliness. While the girls' clothing may be clean and tidy, the boys' is often torn and dirty. The girls' hair, on the other hand, is more frequently dirty and verminous.

when estimating home conditions by the state of cleanliness of the children are sometimes opposed to those found when we estimated (p. 46) home conditions by the condition of the clothing.

TABLE XXXV.

THE RELATIONSHIP BETWEEN THE STATE OF CLEANLINESS AND MENTAL CAPACITY.

| School Number. | Boys. | | Girls. | |
|---|---|---|---|---|
| | Method. | Correlation. | Method. | Correlation. |
| 1 | Contingency | $+\cdot14\pm\cdot04$ | Contingency | $+\cdot15\pm\cdot04$ |
| 4 | ,, | $+\cdot19\pm\cdot04$ | ,, | $+\cdot15\pm\cdot03$ |
| 7 | ,, | $+\cdot26\pm\cdot03$ | ,, | $+\cdot21\pm\cdot03$ |
| 10 | ,, | $+\cdot18\pm\cdot04$ | Fourfold Table | $-\cdot08\pm\cdot05$ |
| 11 | Fourfold Table | $+\cdot16\pm\cdot03$ | ,, ,, | $+\cdot06\pm\cdot03$ |
| 13 | — | — | Contingency | $-\cdot10\pm\cdot04$ |
| 14 | Contingency | $-\cdot12\pm\cdot04$ | | — |
| Mean | | $+\cdot14$ | | $+\cdot07$ |

(15) THE RELATIONSHIPS BETWEEN MENTAL CAPACITY AND THE CONDITION OF THE CERVICAL GLANDS, TONSILS AND ADENOIDS, AND POWER OF HEARING.

In the case of the boys' and girls' departments of three schools, we are given an estimate of the condition of the cervical glands, of the tonsils and adenoids, and of the power of hearing. These children seem to have been examined by the same medical man, and so more stress can be laid upon a comparison between the schools. Dealing first of all with the condition of the cervical glands, we find unfortunately that two different scales have been used. In schools Nos. 7 and 11, the scale used is:

I. The cervical glands cannot be felt.
II. The cervical glands can just be felt.
III. The cervical glands are enlarged to the size of hazel nuts.
IV. The cervical glands are enlarged to double the size of hazel nuts.
V. Abscess.

In the case of No. 10, on the other hand, the only marks used are 0 and +, 0 denoting that the glands are not enlarged, and + that they are. Probably classes II, III, IV, and V in the first scale taken together are nearly the same as + in the second, and from Table XXXVI we see that we have excellent agreement between the boys and girls of the same school, and that the schools do not differ widely from each other. A reference to the short notes on those schools on p. 8 shows, however, that they are very alike in general conditions, and that large differences are not to be expected.

## TABLE XXXVI.

The Variation in the Condition of the Cervical Glands in the Individual Schools.

| School Number. | Boys. Condition of Cervical Glands. Percentage in each Grade. | | | | | Girls. Condition of Cervical Glands. Percentage in each Grade. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | + | I | II | III | 0 | + | I | II | III | IV |
| 7 | 8 | — | 41 | 46 | 4 | 11 | — | 35 | 53 | 1 | — |
| 10 | 7 | 92 | — | — | — | 8 | 92 | — | — | — | — |
| 11 | 15 | — | 57 | 27 | 1 | 10 | — | 59 | 31 | — | — |

The contingency and correlation coefficients indicating the relationship between mental capacity and the condition of the cervical glands are given in Table XXXVII. They show in every case a small positive correlation, but the averages are small and afford no means of predicting any appreciable variation of intelligence from the condition of the glands.

## TABLE XXXVII.

The Relationship between the Condition of the Cervical Glands and Mental Capacity.

| School Number. | Boys. | | Girls. | |
|---|---|---|---|---|
| | Method. | Correlation. | Method. | Correlation. |
| 7 | Contingency | $+\cdot 20 \pm \cdot 03$ | Fourfold Table | $+\cdot 08 \pm \cdot 03$ |
| 10 | Fourfold Table | $+\cdot 01 \pm \cdot 04$ | ,, ,, | $+\cdot 06 \pm \cdot 05$ |
| 11 | ,, ,, | $+\cdot 05 \pm \cdot 03$ | ,, ,, | $+\cdot 09 \pm \cdot 03$ |
| Mean | | $+\cdot 09$ | | $+\cdot 08$ |

In estimating the condition of the tonsils and adenoids, two marks only were used, 0 and +. "0" was used to indicate that the tonsils were not enlarged nor adenoids present, and "+" to denote that they were. The proportions falling in each class in each school are given in Table XXXVIII, and show that while

## TABLE XXXVIII.

The Variation in the Condition of the Tonsils and Adenoids in the Individual Schools.

| School Number. | Boys. Condition of Tonsils and Adenoids. Percentage in each Grade. | | Girls. Condition of Tonsils and Adenoids. Percentage in each Grade. | |
|---|---|---|---|---|
| | 0 | + | 0 | + |
| 7 | 72 | 28 | 74 | 26 |
| 10 | 59 | 41 | 59 | 41 |
| 11 | 71 | 29 | 73 | 27 |

Schools Nos. 7 and 11 are substantially the same, the state of affairs in No. 10 is not quite so good, 41 per cent. of the children in this school having enlarged tonsils compared with from 26 per cent. to 29 per cent. in the other two schools. There are no differences between the sexes in any of the schools.

Since two groups only are used in estimating this condition, fourfold tables must be used to determine the relationship between mental capacity and the condition of the tonsils and adenoids, and the results are given in Table XXXIX. The correlation coefficients are small, though consistently positive, among the girls, but not large enough to enable us to say that any definite relationship does exist.

## TABLE XXXIX.

The Relationship between the Condition of the Tonsils and Adenoids and Mental Capacity.

| School Number. | Boys. | | Girls. | |
|---|---|---|---|---|
| | Method. | Correlation. | Method. | Correlation. |
| 7 | Fourfold Table | $+\cdot03\pm\cdot03$ | Fourfold Table | $+\cdot12\pm\cdot03$ |
| 10 | ,, ,, | $-\cdot05\pm\cdot04$ | ,, ,, | $+\cdot16\pm\cdot05$ |
| 11 | ,, ,, | $-\cdot01\pm\cdot03$ | ,, ,, | $+\cdot04\pm\cdot03$ |
| Mean | | $-\cdot01$ | | $+\cdot11$ |

In estimating the condition of the power of hearing the mark III has been given to the usual condition of that faculty, II to slightly impaired hearing, I to considerably impaired hearing, while 0 denotes a very bad condition. The marks IV and V were given to those who had a very acute sense of hearing, but the numbers who obtain those marks do not amount to 1 per cent. From Table XL it will be seen that No. 11 is somewhat better than the others, but that the differences between the schools are small, and that there are no sexual differences. When we turn to the relationship between mental capacity and the power of hearing, as given in Table XLI, we find great diversity not only between different schools but between the boys and girls of the same school; thus in the case of School No. 11,

## TABLE XL.

The Variation in the Hearing Power in the Individual Schools.

| School Number. | Boys. Percentage in each Grade. | | | | | Girls. Percentage in each Grade. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | I. | II. | III. | IV. | V. | O. | I. | II. | III. | IV. | V. |
| 7 | — | 10 | 89 | — | — | — | 1 | 7 | 92 | — | — |
| 10 | — | 14 | 85 | — | — | 1 | 1 | 11 | 88 | — | — |
| 11 | — | 4 | 96 | — | — | — | — | 4 | 95 | — | — |

among the boys the correlation is $-\cdot 13$, while among the girls it is $+\cdot 28$. Little stress must be laid on those results because the division into fourfold form is very unsatisfactory, the displacement of one child into an adjoining compartment of the fourfold table would make a considerable difference to the value found for the correlation.

### TABLE XLI.

The Relationship between the Hearing Power and Mental Capacity.

| School Number. | Boys. | | Girls. | |
|---|---|---|---|---|
| | Method. | Correlation. | Method. | Correlation. |
| 7 | Fourfold Table | +·23±·03 | Fourfold Table | +·03±·03 |
| 10 | ,, ,, | −·01±·04 | ,, ,, | +·21±·05 |
| 11 | ,, ,, | −·13±·03 | ,, ,, | +·28±·03 |
| Mean | | +·03 | | +·17 |

### (16) The Relationship between Age and Various Physical Characters.

I have already dealt with the influence of age on mental capacity, height, and weight, and the correlations between age and the condition of the teeth have been used to find the relationship between mental capacity and the condition of the teeth, independent of age. These correlations are now given in Table XLII.

### TABLE XLII.

The Relationship between Age and the Condition of the Teeth.

| School Number. | Boys. | Girls. |
|---|---|---|
| 1 | +·17±·04 | +·12±·04 |
| 2 | +·27±·04 | +·32±·04 |
| 3 | +·27±·03 | +·21±·03 |
| 4 | +·17±·04 | +·19±·03 |
| 5 | +·13±·03 | +·23±·03 |
| 6 | +·15±·03 | +·17±·04 |
| 7 | +·12±·03 | +·20±·03 |
| 8 | +·19±·03 | +·18±·04 |
| 9 | +·22±·04 | +·18±·04 |
| 10 | +·20±.04 | +·25±·05 |
| 11 | +·24±·03 | +·14±·03 |
| 12 | — | +·25±·04 |
| 13 | — | +·32±·03 |
| 14 | −·25±·04 | — |
| Mean | +·16 | +·21 |

They were calculated as correlation ratios. In every case but one the correlation is positive, and in the exceptional case, *B.* 14, it is exceedingly difficult to say whether the sign should be + or −, the regression line being very far from linear. It is clear, then, that there is a definite relationship between age and the condition of the teeth, but the medical officers do not appear to have made any distinction between permanent and temporary teeth, so that a positive sign is to be expected. At higher ages the teeth would of course deteriorate, and the sign to be given to this relationship when older children are included would probably be a negative one.

In Table XLIII I have given the correlations between age and the remaining physical characters for both boys' and girls' departments of two schools.

## TABLE XLIII.

The Relationship between Age and Various Physical Characters.

| Character correlated with Age. | Method. | School Number. No. 7. Boys. | School Number. No. 7. Girls. | School Number. No. 11. Boys. | School Number. No. 11. Girls. |
|---|---|---|---|---|---|
| Teeth | Correlation Ratio | +·12±·03 | +·20±·03 | +·24±·03 | +·14±·03 |
| Condition of Clothing | ,, ,, | +·25±·03 | +·19±·03 | +·11±·03 | −·02±·03 |
| State of Cleanliness | ,, ,, | +·24±·03 | +·18±·03 | −·07±·03 | +·06±·03 |
| Hearing | Fourfold Table | +·18±·03 | +·43±·03 | −·00±·03 | −·25±·03 |
| | Two-row Method | +·08±·03 | +·35±·03 | +·10±·03 | −·23±·03 |
| Nutrition | Fourfold Table | +·53±·03 | +·25±·03 | +·41±·03 | +·04±·03 |
| | Two-row Method | +·46±·03 | +·22±·03 | +·35±·03 | +·06±·03 |
| Tonsils and Adenoids | Fourfold Table | +·14±·03 | −·18±·03 | +·21±·03 | −·03±·03 |
| | Two-row Method | +·08±·03 | −·14±·03 | +·12±·03 | −·09±·03 |
| Cervical Glands | Correlation Ratio | +·27±·03 | +·07±·03 | +·06±·03 | +·24±·03 |

In the case of the power of hearing, the state of nutrition and the condition of the tonsils and adenoids, these have been worked out by two methods, the fourfold table and Professor Pearson's new two-row method already referred to. There is, however, very little significant difference between the results found by the two methods.

The interpretation of the results given in Table XLIII is by no means easy. Throughout, a positive sign indicates that, with increasing age, the condition of the character under consideration improves, while if greater age is associated with a worse condition a negative sign is prefixed. In no case are the correlations found consistent among the four departments considered, and in several cases we find significant positive values in the boys' department of a school, and significant negative values in the girls' department of the same school. Thus for the relationship between age and the condition of the tonsils and adenoids, in School No. 7, we get a correlation of +·14 among the boys, and −·18 among the girls. The correlation between age and the power of hearing is +·43 among the girls of school No. 7, and −·25 among the girls of No. 11. It is not safe, then, in view of these contradictory results to attempt to draw any deductions from them at present.

## (17) Conclusions.

In starting this investigation I expected to find that the correlations which measured the influences of physique and home on mental capacity would be large, possibly exceeding ·5. I anticipated that stunted growth, as measured by height and weight less than the average, that defective nutrition, and that bad home environment, as measured by uncleanliness and defective clothing, would be found to be seriously detrimental to the growth of intelligence. I expected that physical defect, as measured by swollen glands, enlarged tonsils and adenoids, bad teeth, and poor hearing, would be closely associated with poorer intelligence. The mean values found for all those cases are given in Table XLIV. It is impossible on the basis of the

### TABLE XLIV.

Mean Values of Correlations between Mental Capacity and Characters measuring Physique and Home Environment.

| Character correlated with Mental Capacity. | Boys. | Girls. | Character correlated with Mental Capacity. | Boys. | Girls. | Character correlated with Mental Capacity. | Boys. | Girls. |
|---|---|---|---|---|---|---|---|---|
| Height | +·10 | +·07 | Clothing | +·04 | +·24 | Glands | +·09 | +·08 |
| Weight | +·06 | +·03 | Cleanliness | +·14 | +·07 | Tonsils, &c. | −·01 | +·11 |
| | | | Nutrition | +·01 | +·08 | Teeth | +·08 | +·09 |
| | | | | | | Hearing | +·03 | +·17 |

present statistics to assert that defective intelligence has largely its source in unfavourable home environment or in defective physique. The mean values are somewhat larger for girls than for boys, but they are so small for both that it is quite impossible to assert that the conditions dealt with in this investigation are the sources of the differentiation as to intelligence which we find between one child and another. Even the small values we have found for the average of all the schools become less satisfactory when we follow them up into their component values in the individual schools. There we see a great want of steadiness in the values. Many of the correlations found are not sensible (say less than two or three times their probable errors), others are sensible but small, but the signs are very irregular, and often in the same school the boys will show increased intelligence and the girls less intelligence with bettered environmental factors or physique, or vice versa. It might be said that this is due to personal equations of teacher and medical man; some of it may be so, but results, yet unpublished, of somewhat similar surveys, by different men and with different methods, at Edinburgh, Glasgow, and Aberdeen, which have been reduced in the Francis Galton Laboratory, point to identical conclusions. There is little sensible effect of nurture, environment, and physique on intelligence. Some such effect probably does exist, but it is clearly so small that only very accurate and extremely numerous observations based on homogeneous material are likely to lead to results persistently sensible having regard to their probable errors.

Accordingly we may sum up the results of this pioneer survey as follows :

(i) There is evidence of much personal equation in both teachers and medical officers. This would be of little importance if the numbers examined by each pair were sufficiently large to obtain results sensible with regard to their probable errors. They are not, however, and the results show small average values with much instability.

Standardization of teachers' judgement and of medical officers' classification is absolutely needful if homogeneous material is to be obtained in sufficient quantity to demonstrate the existence of small associations between mental capacity, physique, and environment.

(ii) There is an urgent necessity in future surveys for a better and more absolute measure of intelligence. It is suggested that a careful verbal definition of each category should be given, and that this should be correlated with place in standard corrected for age. If this correlation were high, we should reach a satisfactory measure of general intelligence. The use of numbers as a scale of order without a very careful definition of the categories is not to be recommended, because it seems likely to lead to hasty classification. A great improvement would probably be effected if the teacher, when classifying for intelligence, were to place all the children of the same degrees of intelligence in groups so as to use the relative intelligence of the children as a check.

(iii) It is extremely doubtful whether the condition of the clothing or the cleanliness of a child are satisfactory measures of its home environment; the fact that when we correlate those conditions with intelligence we find a difference of *sign* between the boys and girls of the same school seems to indicate that the common factor, home environment, is not accurately measured by them, or that some, at present unknown, sex correction must be made.

There can be no doubt that the problem of the influence of home environment on the mentality and physique of the child can only be satisfactorily dealt with when the school survey by teachers and medical men is accompanied by a home survey by competent sociological observers.

It seems then that these facts are themselves sufficient to demonstrate the value of this pioneer survey. If they are disregarded in future surveys it is quite certain that much effort will be wasted if these lessons have to be relearnt.

(iv) But, further, the diversity of the recording systems used in this pioneer survey are not opposed to but provide data which justify us in our general conclusion that no close and significant relationship holds between mental capacity and the factors discussed.

Home environment, as measured by clothing, cleanliness, nutrition, stature, and weight, cannot be the chief determining cause of the differentiation of intelligence; nor is defective physique its source. Some contribution unfavourable home environment and defective physique may make to the degree of intelligence, but even if finally demonstrated, it will be found to be a "second order" contribution, possibly even an indirect effect of race and stock, the abler children being those of fitter parents who give them better homes and better physique. Other factors of environment have yet to be discussed, but so far—and this generalization covers much more than the 400 coefficients calculated in this memoir disclose—there is no sign of an environmental condition producing an effect on the mentality of the child at all comparable with the known influences of heredity.

In conclusion, I must acknowledge the friendly assistance given by Miss Elderton and Miss Barrington in calculating some of the coefficients here recorded.

To Professor Pearson it is more difficult to express adequately my gratitude for his constant advice and assistance during the work on this paper.