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Galtonian Eugenics and the Study of Growth:

THE RELATION OF BODY SIZE, INTELLIGENCE TEST SCORE, AND SOCIAL CIRCUMSTANCES IN CHILDREN AND ADULTS*

GALTON IN 1904 DEFINED eugenics as "the science which deals with all influences that improve the inborn qualities of a race; also with those influences that develop them [these inborn qualities] to the utmost advantage".

In this definition "eugenics" has clearly its older, pre-Batesonian meaning. It refers to the whole span of reproduction and development and not exclusively to events which precede the formation of the zygote. (The usage still persists in the title of the *Journal of Genetic Psychology* which deals with development, not genetics in the modern sense.) Admittedly Galton puts prominently first the phrase about the inborn qualities; "factors developing them" have a place only below the semi-colon. But it seems likely that this just reflects Galton's circumstances and time. In the favoured atmosphere of the upper classes of optimistic expansionist Victorian England, the black squalid back-to-backs, the vast orphanages, the men like pit-ponies must have seemed purely transitory, even when they were noticed at all. Galton's gaze was set on the more distant horizon, a horizon we are beginning to approach in the cold neon light of our meritocratic dawn.

But the eugenic horizon, like the real one, always retreats as we approach it. We are far from providing each zygote with the environment which "develops its inborn qualities to the utmost advantage". And we understand better than the biologists of Galton's day the illusory nature of any division between heredity and environment. Zygote and environment interact, develop together. Galton was, perhaps, more aware of this than the generation of geneticists immediately following him. So in commemorating this very wise, humane and attractive man I want to draw your attention to this interaction by way of an example from my own field of research. I shall describe and try to analyse the way in which mental ability, physical size and social circumstances are related in children and adults. I shall use this example to develop the thesis that it is precisely at the interphase of heredity and environment that positive eugenics may make a significant impact. The positive eugenist's attention, I believe, should be increasingly directed at providing the environmental stimuli most appropriate to evoke and derive from each zygote those potentialities which would best enrich and humanize our present culture.

Let us now turn to my example.

Body Size and Mental Ability

(a) *In Children.* In 1892 William Townsend Porter† (then Professor of Physiology at St. Louis Medical College), organized a survey of

* The Galton Lecture, delivered in London on 1st June 1966.

† Porter (1862–1949) at this time aged thirty, later became a famous figure in American physiology. His work on children caused Henry Bowditch, the first Professor of Physiology at Harvard, and the first serious student of children's growth in America, to call him to Harvard the following year as Assistant Professor of Physiology. He later became Professor of Comparative Physiology at Harvard (1903–28), founder, first editor (1898–1914) and financial sponsor of the *American Journal of Physiology* and founder of the Harvard Apparatus Company. His long obituaries make no mention of his pioneer work on human growth.

the heights and weights and various other measurements of some 33,500 boys and girls in the public schools of St. Louis. The school classes were organized in grades, and a pupil moved up a grade when he had successfully completed the work of the previous grade, irrespective of his age. (The same system was used in England at that time and the schools were known as Grade Schools: furthermore in England the teachers in the schools were paid according to the number of pupils who passed each grade exam each year!) Porter (1893) found that the pupils in the higher grades were taller and heavier than pupils of the same age in the lower grades. (Not only was this true of the average figures: Porter, a close follower of Galton, who invented percentiles, calculated the 20th and 80th percentiles in higher and lower grades and showed that the whole distribution of weight of pupils of the higher grade was shifted upward.)

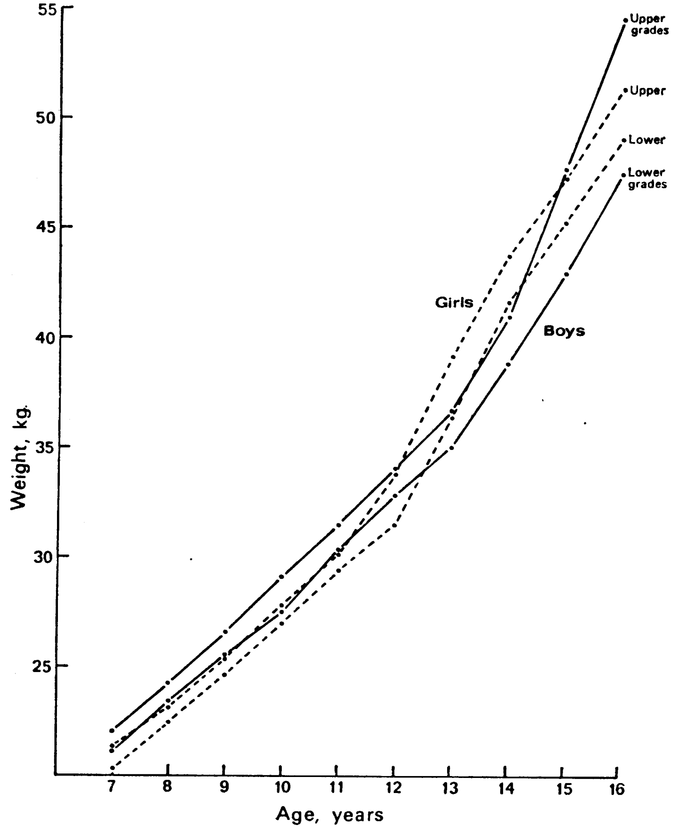

FIGURE 1

Weight of boys and girls of above-average grade and below-average grade in schools of St. Louis in 1892. Cross-sectional data. From Porter (1893).

Figure 1 is redrawn from one of Porter's papers. It shows the weight at each year of age of children who were above-average in grade and children who were below-average. Though in the Figure the difference does not look very impressive, it corresponds to the amount an average child grows in about six months. The data, of course, are cross-sectional. (The figures for height are similar: for example twelve-year-old girls in Grade II are 5 cm. shorter than twelve-year-olds in Grade V. Ten-year-old boys show the same difference between Grades I and IV.) Size in children, then, appeared to be linked in some way with ability.

Porter was the first to demonstrate this fact, except for two Russians who independently in the previous year wrote theses describing the same phenomenon in Moscow children (Porter very correctly gives them credit in a footnote). Porter's finding raised incredulous but ill-documented opposition then as, sometimes, now. Porter (1893) thought that physical strength, which he equated with size and weight, conditioned the amount of mental effort that a child could make, and wrote "precocious children are heavier and dull children lighter than the mean* child of the same age. This establishes a basis of precocity and dullness". By precocious, however, he did not mean temporarily advanced, but rather the opposite of dull; we might say bright. He pointed out that the growth curves of precocious and dull followed a parallel course and that the adolescent increase in weight occurred at about the same age in the two groups. He thus indirectly inferred (though I cannot find him committing himself so directly as Boas implies) that these differences of size and mental ability would persist into adult life.

To this conclusion Franz Boas, the greatest American anthropologist of his generation and the foremost pioneer of studies of human growth, objected strongly (see Tanner, 1959, p. 82). "I should prefer to call the less favourably developed grade of children *retarded*, not dull" he wrote "and these terms are by no means equivalent, as a retarded child may develop and become quite bright . . . furthermore I do not believe that the facts found by Dr. Porter establish a basis of precocity and dullness, but only that precocious children are at the same time better developed physically. . . . Dr. Porter has shown that mental and physical growth are correlated, or depend upon common causes; not that mental development depends on physical growth" (Boas, 1895). Boas was the first man to realize fully that children developed at different rates; it was he who invented the phrases *tempo of growth* and *developmental age*. Thus naturally he saw the relation between ability and size as probably caused by differences in rate of development, some children being advanced both physically and mentally and others retarded. If so, then by adulthood the "retarded" child would have caught up the "advanced" and there would no longer be any difference between them either in physique or ability.

After seventy years the controversy still continues. Only very recently have we made any substantial progress towards clarifying what, after all, is an important and practical issue, to educationists as well as human biologists. Porter and Boas were writing a decade and more before Binet published his work, yet even now intelligence tests are constructed and usually interpreted entirely on the basis of "bright" and "dull". They do not distinguish between the advanced child who will end up, early, with average ability and the bright child who is not advanced and who will end up, at the average age, with high ability. Worse, they fail to pick out the slowly-developing child of potentially high ability. Such a child may fall through the apple-sorting machinery of an age-linked examination like the eleven-plus, and as a result may not have the educational opportunity to "develop his inborn qualities to the utmost advantage". Modern longitudinal studies of intelligence test scores indicate clearly that differences in rates of maturing occur in mental ability just as they do in height and weight. (Bayley, 1956 and see Tanner, 1961, p. 92).

Porter's factual observations on the relation of body size to school grades have been repeatedly confirmed over the years. Boas himself found that children in Worcester, Mass. who were one grade ahead were on average bigger by about six months'-worth of height growth than their co-evals a grade below. When psychological testing was introduced and the school system reorganized so that promotion was less dependent on passing graded examinations, the

* By mean Porter meant median. In this he followed Galton's terminology, in *Natural Inheritance*, in a way confusing to us nowadays. Our modern mean $\left(\frac{\Sigma X}{N}\right)$ was referred to as the average. Boas also used this terminology in some of his papers prior to 1900.

relevant statistic became the correlation between height* and test score, or IQ, at a given age.

In 1947 a sample of 6,490 pupils drawn at random from all eleven-year-old Scottish school children, gave a correlation of 0·25±0·01 between height and score in a Moray House group test of attainment (the effect of age differences from 11·0 to 11·9 having been allowed for) (Scottish Council, 1953). An approximate conversion of the test scores to Terman-Merrill IQs leads to an average increase of about 0·67 IQ points for each cm. of height or roughly 1½ points of IQ for each inch. In 1959 and 1960 amongst approximately 4,000 ten- and eleven-year-old pupils in London there was a correlation of 0·23 between height and verbal reasoning test score (Moray House Test 61 or NFER Test 9B). The correlation does not look high, but the effects can be very significant for individual children. In the ten-year-old girls there was a 9-point difference in IQ between those whose height was below the 15th percentile and those whose height was above the 75th percentile. This is two-thirds of the standard deviation of the test score, and in the 11+ exam, for instance, corresponds to a difference of about 15 percentile ranks at the level usually used for pass or fail.

The children of the National Survey of Health and Development provide measurements at ages eight, eleven and fifteen. This Survey consists of a stratified sample of all boys and girls born in the first week of March, 1946; the sample considered comprised 2,864 children. At each age four pencil-and-paper tests were given; the heights were taken by school doctors. The correlations between height and the results of these tests were 0·14 at eight years, 0·14 at eleven years and 0·12 at fifteen years (Douglas, Ross and Simpson, 1965). (Actually height was taken at age seven and the first test at age eight, but the results were adjusted for this.)

None of these data tell us, however, whether the correlation represents simply co-advancement in height and in ability and hence will disappear in adult life, (Boas's view) or whether it represents something more persistent (Porter's view).

Longitudinal studies have shown that early-maturing children—that is children with an early puberty—do score higher in tests than late-maturing children from at least age six (see Tanner, 1962 p. 211 for references; also Nisbet and Illsley, 1963). They are also, of course, taller since on average children with an early puberty are advanced throughout all their growing period, from early infancy. But for a number of reasons this does not settle the matter. First, the longitudinal data, as so often, become very poor after about age fifteen and for this reason we cannot really be sure what happens at full maturity. Shuttleworth's (1939) data (illustrated in Tanner, 1962 p. 212) suffer from a sharp reduction in numbers at the older ages, due to causes which very probably introduce bias; the same is true of Abernethy's (1936) and Freeman and Florey's (1937) data. The National Survey of Child Health and Development data show the usual higher scores in early maturers, and additionally demonstrate that this holds good even for children matched for occupational category and number of siblings (see below). At age fifteen the difference has not diminished; indeed it is slightly greater, in both boys and girls, than it was in the same children at ages seven and eleven (Douglas, Ross and Simpson, 1965). Thus it is dubious whether the difference between early and late maturers disappears in adulthood. And secondly, even if the difference does disappear completely, that still would not prove that *all* the relation of height and score in childhood was due to co-advancement, only that some of it was.

Most writers on the subject however (including at one time myself) have adopted Boas's view that the correlation probably represented only co-advancement and would disappear at maturity. This view has important consequences for education. According to it, early developers are at an advantage in tests such as the 11 plus, for admission to selective education. Furthermore they obtain an increasing educational advantage thereafter, simply as a result of passing these tests. Hence they would remain always ahead, an example of the classical self-fulfilling prophesy or positive feed-back. This effect would also

* It is likely that the true relationship is with body size rather than height, in children and in adults. Weight, however, is a poor measure of size, since it is so affected by fat.

bias the results of a longitudinal study to maturity, unless allowances could be made for differences in educational opportunity.

However, we might perhaps have thought twice before adopting this view too wholeheartedly, even though Boas's side in an argument very seldom lost. Nancy Bayley, one of the most profound of all students of the development of mental abilities, in 1956 published correlations between height and intelligence test score at each year of age from eleven to sixteen in a group of about forty children followed longitudinally in Berkeley till age twenty-one. The correlations were high, mostly between 0·30 and 0·50, and showed no tendency to drop between seven and sixteen, in either sex. Furthermore Dr. Bayley developed an absolute score for the intelligence test, so that it was possible to compute for each individual the percentage of his final twenty-one-year-old score attained at each age. Similarly the percentage of mature height attained at each age was calculated. The correlation between these two measures, of mental and physical advancement respectively, turned out, in these admittedly limited data, to be slightly negative. There was no evidence that an early-maturing boy or girl in the height-growth sense was early-maturing in the mental attainment sense. Indeed there was a slight suggestion that children who were slower in physical maturing reached their twenty-one-year-old intelligence sooner. Or, put the other way around, the less able, though slow in maturing physically, nevertheless reached their twenty-one-year-old intelligence relatively early, slowing down in mental attainment as they approached adulthood. (This could wholly or partly be a result of poor teaching associated with the poor social circumstances, which could also lead to slow physical growth.) This study, then, provides some evidence against the co-advancement hypothesis.*

(*b*) *In Adults*. However the main argument against co-advancement as the sole cause of the height-ability correlation in children rests on recent data about the same relationship in adults. The older literature,† summarized in Patterson (1930) concerned mainly students. The restricted nature of their intellectual range (in the statistical sampling sense, that is) makes them a poor guide

* Perhaps a model will help clarify this slightly confusing situation.

	CHILDHOOD		ADULTHOOD
Tall children A	↗ advanced-ht. C	→	average ht. G
	↘ tall-as-adult D	→	tall H
High-scoring children B	↗ advanced-test E	→	average IQ I
	↘ high test as adults F	→	high IQ J

Tall children may be divided into those who are advanced and will end up average as adult and those who are tall and will end up tall, as explained above. We can classify the high-scoring children similarly. (In practice no such crude dichotomies can be made of course; the true situation is a continuum.) Our information is that there is a connection (on average) between A and B. This must come about either by connection between C and E, D and F, C and F or D and E. C–E represents the co-advancement or Boas's hypothesis, D–F the adult-persistent or Porter hypothesis. We must assume that C and D, and E and F are independent. We know that this is very nearly true of C and D; in fact advanced children end up very slightly shorter than others, so there is very small negative interaction, larger in girls than boys. About E and F we know nothing, except possibly from Nancy Bayley's study quoted above. This might incline us to think E and F could be if anything negatively interacting too.

What now can we say about these connections? We have to remember, ruefully, that though we can distinguish C and D in childhood (by bone age and pubertal age) we cannot as a rule distinguish E and F. We cannot therefore say anything about the connections except by reference to the situation at adulthood, in the right-hand column. The adult correlations indicate that on average tall adults have high test scores. Thus H is connected with J. This then is evidence that D, the generator of H, is connected with F, the generator of J, since we know C and H are practically independent and we suppose that E and J are likewise. Hence we have, of course, the connection D–B.

The evidence for the C–E or co-advancement connection is, on the whole, less good. In most data the connection C–B exists, though whether it is more or less important than D–B is not clear. In the National Child Health Survey data D–B was probably more important, since the height-ability correlation was scarcely at all lowered by allowing for different stages of puberty, that is eliminating the effect of C (Douglas, Ross and Simpson, 1965). But assuming C–B to exist, our problem is whether this is via C–E, C–F, or both. The evidence on C–F is conflicting. Early maturers may perhaps have persistent high test scores when they are adult. If so, then the connection C–E need not necessarily exist at all. Nancy Bayley's data suggest directly that C and E are independent or slightly negatively related and carry the consequence that in her small series the connection C–F does exist.

† Galton's views on this subject were characteristically vigorous. In *Hereditary Genius* (1869) he wrote "I do not deny that many men of extraordinary mental gifts have had wretched constitutions, but deny them to be an essential or even the usual accompaniment. . . . A collection of living magnates in various branches of intellectual achievement is always a feast to my eyes; being as they are, such massive, vigorous, capable-looking animals".

to the population as a whole. There is certainly a difference in height between individuals belonging to different socio-economic groups, and there is also a similar difference in intelligence test scores. Thus one might expect to find a positive correlation between height and test score in the population at large. This seems indeed to be the case. Husen (1951) reported a figure of 0·22 for 2,250 Swedish conscripts; Schreider (1956) 0·29 for 566 French conscripts and a similar figure for industrial workers; Scott, Illsley and Thomson (1956) 0·24 for a random sample of Aberdeen women pregnant for the first time (Wechsler test); Udjus (1964) 0·16 for twenty-year-old Norwegian conscripts.

These figures undoubtedly reflect to a large extent the association between occupation, or socio-economic class, and both height and intelligence (Udjus, 1964; Schreider, 1964). But even within a given occupational group the relation persists to a significant degree. In Udjus's data high school graduates averaged 179·7 cm. in height, compared with a general mean of 177·5 cm. Nearly all were in the top three out of the nine ranks given by the intelligence tests. But those in the top two ranks of the test were still about 2 cm. taller than those in the third and lower divisions. (Indeed the regression within this educational group was no different from the general regression though its members contributed only about 50 per cent of the top two divisions and 17 per cent of the third one.) When the Aberdeen women are classified by husband's occupation, the height-ability correlation disappears in Registrar General's Groups I+II; but it persists significantly in the less well-off occupational groups, being 0·16 in Group III, and 0·25 in Groups IV+V.

We can fairly confidently assert, then, that there is currently a small but significant tendency for taller adults in the population to score higher in some intelligence tests than short adults of the same sex, even within certain, if not all, crude occupational categories, such as "unskilled and semi-skilled workers".

It is at this point necessary to dispose of an objection sometimes raised by tall men on behalf of their shorter, and admittedly brighter friends. Hard cases make bad law, and soft friends make worse statistics. Just because on average large boys do well in school it does not follow that every large boy is a paragon of educational virtue. On the contrary schoolteachers frequently query the statistical relationship because they have had the experience of a large, unintellectual uninhibited boy who remains obstinately in the memory when the visions of more tractable pupils have long faded. Similarly with adults: the correlation is far too low, of course, for it to indicate anything as applied to individuals. Perhaps the best analogy is with accident statistics. No-one can tell if he personally will be killed driving on the road next week; yet the total number of people who will be killed in this period can be rather accurately predicted. Equally the correlation we are discussing, like road deaths, tells us something of sociological but nothing of individual importance. It is a sociological symptom calling for diagnosis and perhaps treatment.

We may sum up the situation to date by saying that probably in most data both the Boas and Porter links between height and ability exist; both the co-advancement link and the adult-persistent link. Their relative importance probably varies according to circumstances. We have now to clarify these circumstances and at the same time to consider how each of the links is brought about.

The Number of Children in the Family

One factor that is clearly associated with the height-ability relationship in childhood is the number of children in the family. In all surveys reported, children are taller if they have few sibs* and shorter if they have many. This is illustrated for data from the London County Council (Scott, 1962, Table 1) in Figure 2. The data are also quite consistent on the subject of intelligence test results; here again children with fewer sibs score higher, as shown in Figure 3 (LCC data, Scott, 1962, Table 1: the test was Moray House Test 61, standardized to a mean of 100 and SD 15).

Hence all or part of the childhood correlation between height and ability might be associated

* By "sibs" most surveys in fact mean children living in the same household, whether or not they are brothers and sisters.

with differences in number of sibs. In fact in the LCC data about half of the correlation is so associated and half is not. Figure 4 shows the regression in families with one, two, three, four and more children (Scott, 1962, Table 4).

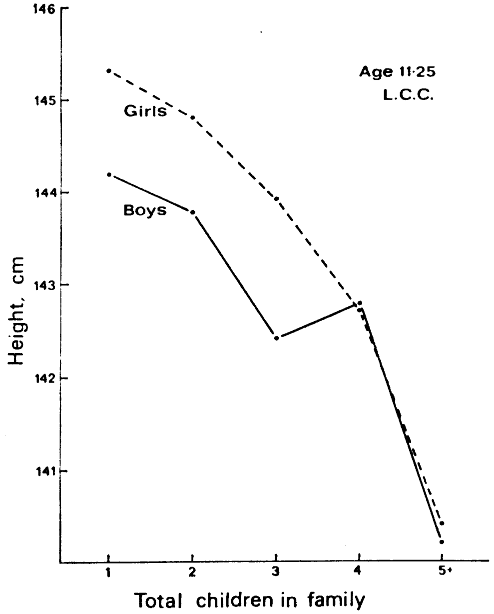

FIGURE 2

The relation of height and number of children in the family in boys and girls aged 10¾ to 11¾. London County Council 1959. (From Scott, 1962, Table 1.)

Figure 5 shows the regression of height on test score in families of one or two children only. (Scott, 1962, Table 3). The average correlation in these data is 0·17, in comparison with the correlation of 0·23 in all children irrespective of sib number.

The association with number of sibs certainly seems unlikely to spring from factors present in the zygote. Probably it reflects differences in nutrition affecting height, and differences either in nutrition or, more likely, in parental attention affecting attainment. The height relationship is established probably by 4½ (Douglas and Blomfield, 1958), and certainly by six (Grant, 1964). The National Survey of Child Health and Development data show a difference of height between girls with no sibs and girls with three or more amounting to 3·6 cm. at seven, 3·2 cm. at eleven and 1·3 cm. at fifteen, suggesting that by full maturity the association might have disappeared. But for boys the figures were 1·6, 2·5 cm. and 2·3 cm. (Douglas and Simpson, 1964).

Udjus's Norwegian data show that at age nineteen men with no sibs or one sib averaged 178·0 cm. tall, those with two or three sibs 177·7 cm. and those with four or five sibs 176·9 cm. The regression is therefore small. Further, a follow-up study showed that on average the conscripts grew about a further 0·8 cm. to maturity; hence it could well be that the many-sibbed conscripts were a little delayed and caught up the 1·1 cm. deficit in the ensuing

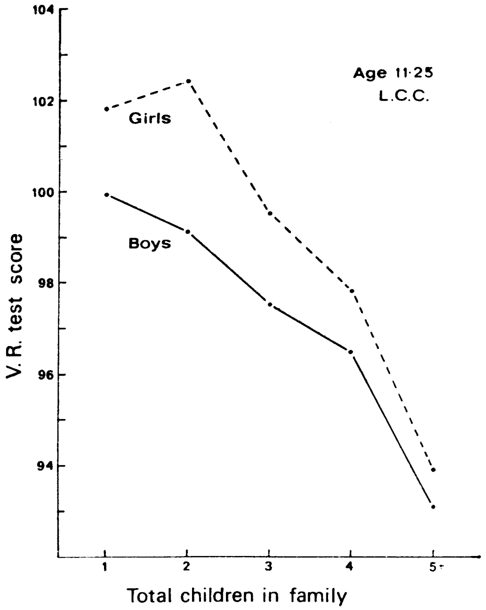

FIGURE 3

The relation between verbal reasoning test score and number of children in the family in boys and girls aged 10¾ to 11¾. London County Council 1959. (From Scott, 1962, Table 1.)

years. In twenty-year-old French army recruits in 1946–48 there was still a difference of 2 cm. in height between those from families of one or two children and those from families of five or more (Trémolières and Boulanger, 1960). But at this time probably full adult height was not reached by age twenty, owing to the years of war.

The intelligence test score relations with number of sibs are established by age eight (Douglas and Simpson, 1964; Douglas, 1964) and probably persist into adult life (Vernon, 1951).

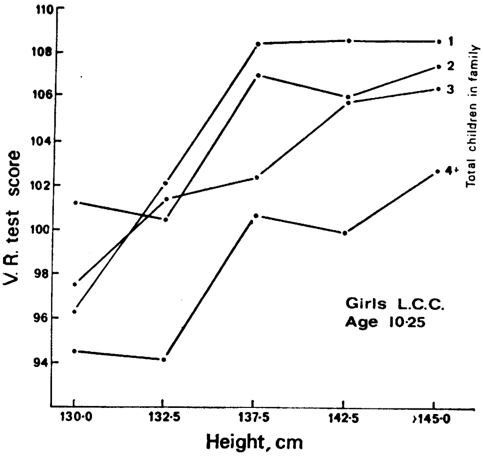

FIGURE 4

Regression of verbal reasoning test score on height for children in 1-child, 2-child etc. families. London County Council 1959. (From Scott, 1962, Table 4.)

All in all, it seems likely that the sib-number effect is concerned chiefly or entirely with the co-advancement link of height and ability and not with the adult-persistent link. If the effect is purely environmental in origin, as we suppose, then it ought to be less in the well-off than in the poor. This appears to be the case. The children of the upper middle class families in the National Survey of Child Health and Development showed no relation at all between height and number of sibs, either at seven, eleven or fifteen. In girls the regression was present to much the same degree in lower middle, upper manual and lower manual groups, but in boys it became progressively greater as parent's social class declined. In the same data the regression of intelligence test score on sib number in the upper middle classes is about half the amount that it is in the other three groups, between which there is again little difference. This is at ages eight and eleven (Douglas, 1964). In the Scottish eleven-year-olds it is striking that the only occupational group besides the professional-managerial not to show a decline of height and weight with increasing numbers of children were the farmers and agricultural labourers (Scottish Research Council 1953, Tables 32 and 33).

Ministry of Food Statistics show that families in the UK spend less per head on food as the number of children in them increases. Recently Abel-Smith and Townsend (1965) have produced data which challenge the widely held notion that in the UK poverty, and particularly poverty in children, is a thing of the past. Defining "poverty" as the level of living of National Assistance Board applicants, they showed that one-third of all the poor were children. As many as 25 per cent of households with four children or more were poor, 10 per cent of households with three children and only 6 or 7 per cent of households with one or two children. Thus there is ample reason for supposing that a substantial number of children in large families in the poorer classes are not adequately fed. Children in these circumstances also have a higher incidence of childhood disease such as bronchitis, though whether this causes a retardation of growth is in dispute (for discussion see Tanner, 1962, p. 130).

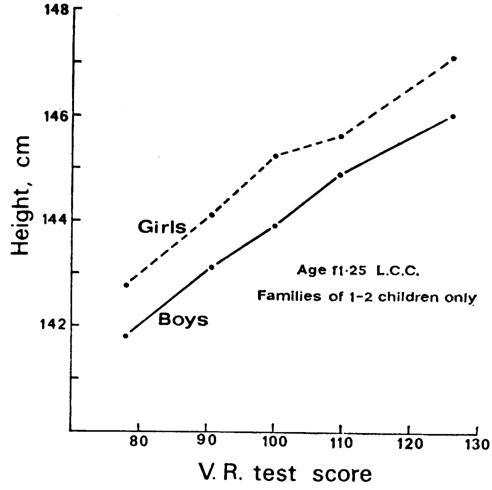

FIGURE 5

Regression of height on verbal reasoning test score in boys and girls of 1-child or 2-child families only. London County Council 1959. (From Scott, 1962, Table 3.)

The under-nutrition and possibly the disease may well account for retardation of growth in height, and even, perhaps, for smallness at maturity.

But whether sub-optimal feeding can have any effect on either the rate of development of mental ability or on the level of mature ability is really quite unknown. Opinion has for many years been quite against any such notion, except perhaps in cases of extreme starvation in early infancy. However, opinion is a poor guide and controlled observations are lacking.

To summarize then: according to present data, children with many sibs in the house are retarded in their height growth from an early age compared with children of the same social class with few sibs. This is especially true of children in poorly-off families. They also score lower in tests of intelligence or attainment. By the time adulthood is reached they have caught up, or very nearly caught up in height; they have not caught up in intelligence tests (Vernon, 1951) but this may be the result only of the vicious circle in educational opportunity described above. The sib number effect on height seems to be due to sub-optimal nutrition. The effect on intelligence in childhood may be a direct consequence of the retardation of physical growth rate, factors underlying mental development being perhaps to a small extent linked with rate of development of body size; or it may be simply due to the influence of parental contact, this being less in many-sibbed families. The sib number effect explains to some extent that part of the height-ability relationship present in childhood and due to co-advancement, but it does not explain that part which persists into adulthood.

Occupational or Socio-economic Class

To explain this we must examine the association of height and intelligence test score with occupational, or socio-economic class. (We have never to forget, in this section, that occupational groups are enormously heterogeneous in terms of income and of social behaviour, which is what chiefly matters. Occupational classifications really need supplementing with assessments of maternal efficiency, child-centredness and sociological affiliations, but these are not available for large-scale data.) Here we have a different situation from sib number, for occupational class differences clearly persist into adult life. They begin in early childhood. In the five West European longitudinal studies co-ordinated by the International Children's Centre (at London, Paris, Brussels, Zurich and Stockholm) children in the better-off classes were already a little longer at age one, (though not at one month), and by age five the difference in height between those in the top two and those in the bottom two out of five classes amounted on average to some 3 cm. in boys and 1½ cm. in girls (Graffar and Corbier, 1966; Graffar, Asiel and Emery-Hauzeur 1961).* In the 1947 Scottish eleven-year-old boys this difference rises to about 6 cm.; it is independent, or nearly so, of the number of sibs. Not all of it persists into maturity; some is due to advancement in height growth in the better-off classes. But some part does persist (for reference see Tanner, 1962, pp. 139, 140). Udjus's nineteen-year-old conscripts, for example, show a difference of about 3 cm. between sons of fishermen, farmworkers and unskilled labourers on the one hand and sons of white-collar executives on the other. This difference is clearly too great to be eliminated by growth after nineteen.

The same difference arises and persists in intelligence test scores. In the International Children's Centre Studies, Terman-Merrill IQ's at three and five already showed a marked differential (Graffar and Corbier, 1966). At age seven clear differences in reading and arithmetic attainment tests are present in the children of the National Child Development Study 1958 Cohort (whose yet unpublished data are quoted by kind permission of Professor N. Butler and Dr. M. Kellmer-Pringle, Co-directors, and Mr. H. Goldstein, of my department, statistician to the study). They are also present at this age in the Aberdeen children (Illsley, 1966).

Social Stratification and the Steady State

A good deal of the adult-persistent correlation between height and ability is associated, then, with differences in social class. We now have to

* Numerous studies, including the Perinatal Mortality Survey, have shown small differences in birth weight between classes to exist. But in the International Children's Centre studies the weight differential at one month was insignificantly small. In most data there is a significant correlation between birth weight and later (e.g. age seven) IQ (Illsley, 1966)

consider two further curious facts. (1) People who migrate from one part of the country to another as children or as young adults are taller, and score higher in tests of mental ability than the stay-at-homes. (2) Women who migrate upwards in social class on marriage are taller, as well as brighter (and perhaps prettier too?) than those who do not.

Concerning the first of these facts the major reports are those of Martin (1949), and Vernon (1951); (see also Lee, 1957 and Scottish Council, 1953). Martin showed an average difference of 0·8 cm. between soldiers who on call-up in 1939 resided outside their county of birth and those who still resided in it. Vernon showed a corresponding difference of about three points in intelligence test score. People who move away from their place of birth are evidently taller and more intelligent, on average.

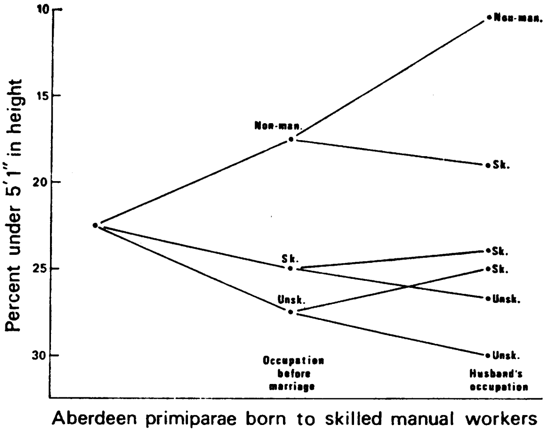

FIGURE 6

Percentage of daughters of skilled manual workers under 5 ft. 1 in. tall taking non-manual and manual jobs, and marrying men in non-manual, skilled manual and unskilled manual occupations. (Redrawn from Thomson, 1959.)

Concerning the second fact the classical demonstration is that of Baird and his associates in Aberdeen (Scott, Illsley and Thomson, 1956; Thomson, 1959). In 1950–57 they measured the height of some seven and a half thousand women pregnant for the first time and showed that whatever the occupation of the father, the taller women take before marriage a more skilled job and the shorter a less skilled job; and whatever the job before marriage the taller women marry husbands with more skilled jobs and the shorter women husbands with less skilled jobs. At each choice-point, so to speak, the tall rise in the social scale and the short sink. The effect is best shown in the daughters of skilled manual workers (Figure 6). Of these 23 per cent were below 5 ft. 1 in. in height. Of those who before marriage took unskilled jobs 28 per cent were under 5 ft. 1 in. contrasted with only 17 per cent of those who took non-manual jobs. Some of these girls in non-manual jobs married men in similar jobs, and others married skilled manual workers. Of the former only 10 per cent were under 5 ft. 1 in. in height; of the latter 19 per cent.

It is a pity of course that it was not possible to measure and test the sisters of these women, to see what happened to taller or shorter women brought up in the same family surroundings. A greater proportion of the height differences between sisters is genetically controlled than differences between women in different families, naturally. Thus if the taller sib rose socially more than the shorter one, we could more clearly infer, at least in the absence of prenatal differences, that this was due to something associated with the inherited element in height, if not to simple height itself.*

Recently Schreider (1964) in an excellent discussion of the whole problem, has tabulated the results of the country-wide Perinatal Mortality Survey (Butler and Bonham, 1963) to show the same thing. Figure 7 shows the percentage of women 5 ft. 5 in. and over in height according to the occupations both of father and husband. Height increases as husband's occupation is more skilled. Furthermore this occurs in women of all social origins, judged by father's occupation. Thirty-one per cent of women coming from unskilled labouring

* Recently this approach has been used by Laycock and Caylor (1964) in relation to the height-ability relation in children. They studied children of IQs 120 or over who had an older or younger sib with an IQ at least 20 points less. The gifted sibs were bigger in all five body measurements taken, but the differences were insignificantly different from zero. The average height difference was the equivalent of about 0·5 cm. for instance. Some objections can be raised to the details of this study—for example the sibs should ideally be measured each at the same age—but it does support the notion that much of the height-ability correlation is due to factors operating between, rather than within, families.

homes (throughout the whole country) who married professional husbands were 5 ft. 5 in. or over in height. Only 24 per cent who married in their class or origin were this height. On the other hand, of the women born into professional homes who married semi-skilled or unskilled labourers only 32 per cent were 5 ft. 5 in. or over compared with 46 per cent of those who married in their class of origin.

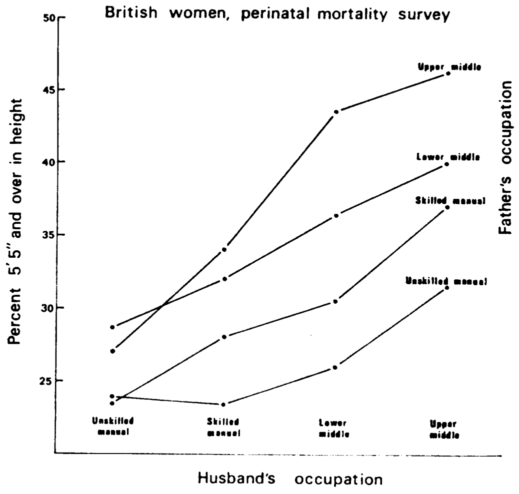

FIGURE 7

Percentage of British women 5 ft. 5 in. and over in height according to occupations of father and husband. Data of Perinatal Mortality Survey (Butler and Bonham 1963) tabulated by Schreider (1964).

The same process is reflected in the data on the weights of fourteen-year-old school boys reported by Berry and Cowin (1954). There were consistent weight differences associated with parents' social class amongst boys in grammar schools and amongst boys in secondary modern schools in the same town. But still larger differences existed between grammar and secondary modern school boys whose fathers had the same type of occupation. The process of social selection had apparently begun. Similarly Parnell (1954) showed that Oxford University students from state schools were not only considerably taller than the average of young men from such schools, but actually a little taller even than the private school ex-pupils who failed to get to University.

One must evidently think of social migration or selection acting for body size as it does for intelligence. Gibson and Young (1965) quote data showing that some 30 per cent of persons per generation now move from one broad division of class into another and that it is the less intelligent who move down and the more intelligent who move up. Evidently the same is true of height. We have a steady state in the population such that the mean height rises only very slightly at present from one generation to another, while the persons contributing to that mean reassort themselves so that a social class gradient is always maintained.

There are probably other examples of such a steady-state process in social selection. Some years ago Morris and Heady (1955), Morris (1959) pointed out that though since 1911 infant mortality had greatly decreased in all social classes, the gap between the classes had, surprisingly, not narrowed. At the same time, while the overall incidence of various adult diseases had risen or fallen, their social class affinities had not changed at all.

It is easy to understand why people who are clever tend to rise in the social scale, but much harder to see why tall people do so. Surely tallness of itself carries no social cachet. It is true that the perinatal mortality in tall mothers is less than that in short ones, even of the same social class (Illsley, 1966), so that there is selection at birth acting in favour of the tall. The effect may well be balanced by an excess of tall women who do not produce children; in any case it would only influence the general level of height in the next generation and not the ability of a given tall child to rise in the social scale.

It seems likely in fact that tall people rise because they are marginally better at certain mental tasks. Schreider (1964) puts this accurately when he stresses that the height correlation is probably with certain aptitudes only, not with some measure of global intelligence. The Aberdeen women showed a higher correlation between height and Wechsler score than between height and the score on the Progressive Matrices, (Scott, Illsley and Thomson, 1956) perhaps because the Wechsler is more verbal. In the National Child Development Survey 1958 Cohort preliminary results suggest that there is a significant relation at age seven between height and reading ability, independently of sex, sib number and social class; but none at all between height and skill at arithmetic.

All this may be interesting, but still leaves us in the dark about whether the tall bright upward-moving children are this way chiefly because of excellence of antenatal and postnatal care, and of intelligent and responsible feeding and upbringing, or chiefly because they inherited a gene complex which was predisposed towards developing in this direction.

We have no formal estimate of the proportions to which heredity and environmental factors are concerned. There is the curious fact that in all countries students are the tallest group in the population (Parnell, 1954) and mental defectives are the shortest (Mosier, Grossman and Dingman, 1965). Amongst the latter the degree of shortness and the degree of mental defect are correlated. This does seem to argue that on average lack of complexity of brain is linked with lack of skeletal growth. (Perhaps it is significant that in Figure 4 above, there may be indications of a threshold for test score above a height of 137·5 cm. in families with few children. The relationship may be chiefly that a significant number of small children are low in ability.) We are totally unable to say whether such a link reflects genetic factors or minimal brain damage during intra-uterine development. Certainly what Sir Alan Moncrieff has recently called "Antenatal paediatrics" may have great importance in this field. In principle intra-uterine damage could provide a phenocopy of any genetic predisposition; but to what extent the small, not very bright and socially-sinking persons in the community represent phenocopies and to what extent the workings out of gene complexes we cannot yet tell. We are ignorant too, to what extent bad maternal care in the early years can irrevocably fix the constitution of the infant.

We can, I think, say that some of the effect must be genetic. Consider those small unintelligent women who fall from grace to marry two social classes below: they cannot all be daughters of drunken eccentric academics whose homes are in squalor and whose wives are incompetent. Many must have received excellent childhood care, but were unable to benefit fully from it. On the other side, there are plenty of persons—academics especially—who, born into squalor and penury, yet emerged not only with outstanding minds but outstanding physiques as well.

These two examples lie at the end of the spectrum of genetic/environmental interaction. As humanists and eugenists we can perhaps do little to help the first extreme, and need only admire the second. But the vast majority of persons lie between the extremes. For genetic reasons alone, numerous children would be a little smaller and a little less bright than average, but from conception onwards the environment may also be hostile to physical and mental growth and thus even their genetic potentialities fail to be realized. Heredity and environment interact positively in a vicious circle. It is these children, and even more the genetically gifted child born into similar surroundings, whom we can help, by locating the areas and families concerned. Once located, these children should be given nutritional and educational opportunities sufficient to offset their home environment. This is, of course, the philosophy behind the maternity services, the school meals service and that part of the nursery school movement which particularly concerns itself with socially deprived children. In its latest and perhaps most practical form this approach is manifested in a proposal to designate certain areas as educational priority areas and to give these areas better teacher-pupil ratios and more nursery schools.

Finally, I want to develop the thought that such action may be genetically advantageous as well as socially imperative. Development consists of an intricate sequence of interactions some between one part of the animal and another part, others between the animal and its environment. Some sequences are critical so that animals may only develop properly if the environment can be relied on to provide the right stimulus at the right time. In this sense, animals are born into "expected", indeed into "required" environments. A duckling will follow the first large object seen at a certain time after hatching. This is usually the mother; if it happens to be Professor Konrad Lorenz the duckling follows him and remains pathologically attached to humans for the remainder of its life.

We do not yet know to what extent such critical periods occur in the development of children. At least cuddling and optical stimulation are probably essential in early infancy for proper development to occur. And it needs little extension of this notion to lead to the whole of the modern concept of education. Clearly as eugenists we have the duty to seek to improve not only the gene complex, but also the quality and reliability of this interaction. But can we go further, and assert that improving this interaction will result in an actual improvement in the gene pool, through the mechanism of assimilation so elegantly described by Waddington?

I think perhaps we may. Consider a desirable quality (such as the capacity to do differential equations) which though based on certain genetic foundations becomes developed only if certain optimal stimulation is provided by the environment. The genetic bases may be present in only a few persons; when the stimulation is not provided the result is nil. But when the stimulation becomes frequent—that is, when modern mathematical notation is invented and taught—then the quality becomes apparent in a number of people. Classically, in animal genetics, the quality must then confer a selective advantage; if so, then its basis will be gradually assimilated into the gene complexes of a large number of the species.

This can only occur when the more gifted members of the community leave more viable offspring than the less gifted; but my point about interaction refers, I believe, to the definition and ascertainment of the gifted. Positive eugenics is most effective against a background of the optimal environment, for only in the optimal environment can ascertainment be complete. We all, I think, are searching for some effective way to contribute to the improvement of human quality, to become positive eugenists as well as merely negative ones. The study of genetic-environmental interaction may provide one of the means by which we can realize this aim.

Summary

1. Amongst children of school age there is a significant though low correlation between body size and scores in various tests of ability and attainment, such that larger children score more highly than smaller children of the same age. Though the correlation between height and test score is only 0·15 to 0·25 the chance of a large child passing an exam such as the 11+ is substantially greater than that of a small child.

2. This correlation diminishes when maturity is reached but does not disappear entirely. In samples of young adults representing the whole population correlations of up to 0·2 remain. Thus the height-ability relation in children is partly due to co-advancement in both physical and mental growth, but it is also partly adult-persistent.

3. The greater the number of children in the family the lower their height and the less their scores in mental tests. This effect is probably entirely due to co-advancement and disappears when maturity is reached. It is greater in poor families than in rich ones.

4. There are also differences in height and mental ability between children in different socio-economic groups and these persist to a large degree into adulthood.

5. On average taller women tend to rise in the social scale, both in getting jobs and in marriage; and shorter women, on average, tend to sink. This is probably due to height being related to ability. The social structure represents a steady state in which socio-economic group differences remain while individuals change from one group to another.

6. We do not know in what proportions heredity and environment contribute to these effects. Minimal intra-uterine damage may well be important. It is argued that positive eugenics should pay increasing attention to the interphase between heredity and environment, that is to those factors necessary to evoke and derive the full potentialities from the zygote. More efficiency in doing this might also result in changes for the better in the gene pool, by a process of assimilation.

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