The Heritability of Intelligence

In accounting for the causes of the differences among persons in IQ, the genes outweigh the effects of environment by 2 to 1.

Since the dawn of history people have noticed differences in intelligence among individuals and have wondered about the causes of these obvious differences. Intelligence has been described by many different words—brightness, cleverness, reasoning power, judgment, and quickness in learning, in grasping abstract concepts, and in solving problems. Every parent, teacher, and employer has observed differences among children and adults in all these characteristics that we call "intelligence." A few persons appear extremely "bright," a few appear extremely "dull," and the vast majority falls somewhere between these extremes. There is a continuous gradation of mental ability from the one extreme to the other, from idiot to genius. Just as we see a continuous gradation of differences in other characteristics of humans, such as physical stature, so too there is a similar gradation of differences in intellectual ability. Indeed, individual variation is a fundamental aspect of all living things. Without individual variation, biological evolution as we know it could not have occurred.

The question of why people differ in intelligence has been asked for centuries, but a scientifically acceptable answer did not become wholly possible until psychologists devised techniques for measuring intelligence quantitatively and objectively. The first really useful intelligence test was devised in 1905 by the French psychologist Alfred Binet. Binet's early test was later revised and improved by Lewis Terman at Stanford University; the now-famous test that resulted from these efforts is known as the Stanford-Binet Intelligence Scale. It is still the most widely used test of general intelligence.

There are also many other intelligence tests, and although many of them appear to be quite different from one another, all actually measure much the same general ability. That is to say, if we administer several seemingly quite different intelligence tests to a large number of persons, their scores on all the tests will be in pretty much the same rank order. Those who score high on one test will tend to score high on the others, and those who score low on one test will usually score low on all the others. This fact of correlation among all tests of intelligence led Charles Spearman, the famous English psychologist, to conclude that there is a general factor, "*g*," which is common to all tests of intelligence. We know that it is practically impossible to make up a mental test having any degree of complexity which does not involve "*g*." We can perhaps most clearly characterize "*g*" as an ability for abstract reasoning and problem solving, for seeing relationships, and for grasping concepts.

A person's score on an intelligence test is usually expressed as an IQ (for Intelligence Quotient). The test is standardized in the general population in such a way that the average IQ at any age is set at 100, and the middle 50 percent of the population falls within the so-called average range of IQ's going from 90 to 110.

Significance of the IQ

Can the IQ tell us anything of practical importance? Is it related to our commonsense notions about mental ability as we ordinarily think of it in connection with educational and occupational performance? Yes, indeed, and there is no doubt about it. The massive evidence from psychological, educational, and industrial research, and research in the armed forces, is unequivocal. We know, for example, that no other single fact that we are now able to ascertain about a child gives us a better prediction of his future scholastic performance than his IQ obtained after age 5 or 6. (Below this age IQ tests become less accurate indicators of the child's later mental development, and below 2 or 3 years of age test scores have practically no predictive value.)

The IQ obtained after 9 or 10 years of age also predicts final adult occupational status to almost as high a degree as it predicts scholastic performance. When various occupations are ranked for average income and for the general public's average judgment of the occupation's prestige and desirability, this rank order is found to be highly related to the average IQ level of the persons in these occupations. There is of course a wide spread of IQ's in nearly every occupation, but the *average* IQ of persons within a particular occupation is closely related to that occupation's standing in terms of its average income and the amount of prestige accorded to it by the general public.

One of the most convincing demonstrations that IQ is

by Arthur R. Jensen

related to "real life" indicators of ability was provided in a classic study by Terman and his associates at Stanford University. In the 1920's they selected a total of 1,528 children with Stanford-Binet IQ's above 140. The average IQ of the group was 152. These children were investigated periodically over the years up into their adulthood. (Most of them are now in their 50's.) Terman found that for the most part these high-IQ children in later adulthood markedly excelled the general population on every indicator of achievement that was examined: a higher level of education completed; more scholastic honors and awards; higher occupational status; higher income; production of more articles, books, patents, and other signs of creativity; more entries in *Who's Who;* a lower mortality rate; better physical and mental health; and a lower divorce rate. Also, they have much brighter children than the average; their average IQ is 133, a level which is exceeded by only 2 percent of children in the general population.

Findings such as these establish beyond a doubt that IQ tests measure characteristics that are obviously of considerable importance in our present technological society. To say that the kind of ability measured by intelligence tests is irrelevant or unimportant would be tantamount to repudiating civilization as we know it.

The Causes of IQ Differences

The layman usually asks: "Is intelligence due to heredity *or* environment?" The scientist promptly answers: "Both." Without heredity *and* environment there simply is no intelligence. Obviously every person must have had a biological inheritance of genes from his parents and must have grown in an environment, or he wouldn't even be here to take an IQ test. So, of course, both heredity and environment are essential for the existence of the individual or any of his physical and mental characteristics.

But when scientists actually study this problem, we find that they do not even ask the layman's question. The question to which scientists have sought an answer can be stated as follows: How much of the *variation* among persons in a given population is attributable to differences in their environments and how much to differences in their genetic endowments?

Numerous studies conducted by psychologists and geneticists over the last 40 or 50 years provide an answer to this question. The answer is unambiguous and is generally agreed upon by all scientists who have considered all the evidence. This evidence strongly supports the conclusion that genetic factors are much more important than environmental influences in accounting for *individual differences* in IQ. How much more important? The evidence indicates that genetic factors account for at least *twice* as much of the variation in IQ's as environmental factors. This conclusion has one main limitation. Since all of the major studies in this field were conducted with samples of Caucasian European and North American populations, we cannot confidently generalize their conclusions to other populations, especially those with very dissimilar environments.

What are the kinds of evidence that lead to the conclusion that genetic differences outweigh environmental differences in accounting for individual differences in IQ? Most of this evidence, as it is found in the scientific literature, depends upon quite technical methods of analysis developed in a specialty known as quantitative genetics or population genetics. Some of these methods were devised originally to analyze the roles of heredity and environment in agriculture and animal breeding.

Experiments in Animal Breeding

Experiments in which we explicitly try to breed for some specific trait give us the most certain evidence that variation in the trait has a genetic component. Psychologists have bred rats for speed of learning mazes, which is a good indicator of rat intelligence. By always mating the fast-learning males with fast-learning females, and mating slow-learning males with slow-learning females, it is possible, within 6 to 10 generations, to produce two quite distinct strains of rats in respect to maze-learning ability. The slowest learning rat of the "bright" strain will learn mazes faster than the fastest rat of the "dull" strain. The two strains will differ markedly in the number of tries they need to learn how to run through a maze efficiently, avoiding the blind alleys. These experiments definitely prove that not only physical characteristics but some behavioral traits as well are largely inherited through the parental genes. Thus we should not be surprised to find in humans that differences in some behavioral characteristics, including intelligence, are a product of genetic inheritance.

Identical Twins Reared Apart

One of the most important lines of evidence for the inheritance of intelligence in humans comes from studies of identical twins who were separated shortly after birth and reared in different homes. Identical twins originate from a single fertilized ovum which splits in the course of

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early development to form two individuals. Each member of the pair of twins therefore has exactly the same complement of genes. Consequently, any difference between the twins must be due entirely to nongenetic or environmental differences.

Twins separated shortly after birth are often reared in families that differ markedly in social class, and the range of environmental differences observed in their foster homes is fairly typical of the environmental variations seen in the general population.

Four major studies of identical twins reared apart, conducted in England, Denmark, and the United States, and totaling 122 pairs of twins, are in remarkably close agreement in showing that twins reared in different homes are still much more alike in IQ than are *fraternal* twins reared together. Fraternal twins are merely siblings who happen to be conceived and born at the same time, and therefore half of them are of opposite sex. In IQ and other traits they resemble one another no more than do ordinary siblings born at different times.

Identical twins reared apart differ, on the average, by only 6 to 7 IQ points. But even if we test the very same person on two occasions a week apart, we find that his test score will vary, on the average, by 2 or 3 IQ points. This is the test's "measurement error." When we eliminate this error from the twin data, we find that the twins differ only 4 or 5 points in IQ. Identical twins reared *together* differ by only 2 or 3 points, not including measurement error. The largest IQ difference ever found in a pair of identical twins reared apart is 24 points. More than 17 percent of siblings reared together differ by more than 24 IQ points. The same is true of fraternal twins. But siblings (and fraternal twins) have only half of their genes in common, and they differ on the average by 12 IQ points (excluding measurement error), even when reared together.

The studies of identical twins show clearly that individuals who are genetically identical are almost as much alike in mental ability as they are alike in physical traits, and this is true even when they have grown up in different environments.

Unrelated Children Reared Together

The opposite situation to identical twins reared apart is that of genetically unrelated children adopted at birth by foster parents and reared together. Such children differ from one another, on the average, by 15 to 16 IQ points (excluding measurement error). Compare this with the 17 to 18 IQ points difference between unrelated children reared in *different* homes, or the 15 to 16 points difference between unrelated children brought up in different homes but in the same socioeconomic class. We see that unrelated children brought up together in the *same* home differ from one another in IQ at least 3 or 4 times more than genetically identical twins reared in *different* homes. And the unrelated children reared together differ almost as much in IQ as unrelated children simply picked at random from different homes.

The IQ's of adopted children also show little or no relationship to the IQ's of their adopting parents, but they are almost as closely related to the IQ's of their natural parents as we find in the case of children who are reared by their natural parents.

Children reared in the common environment of an orphanage differ from one another in IQ to approximately the same degree as children picked at random from the total population. The IQ's of orphanage children who have never known their own parents show almost the same degree of correlation with their parents' level of ability as we find in the case of children reared by their own parents.

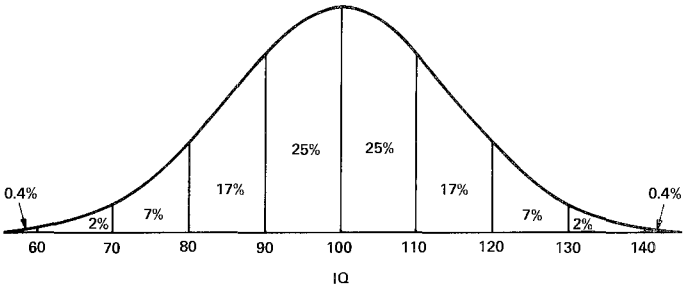
Resemblance Between Parents and Children

Now and then we notice that very bright parents can have an intellectually mediocre child, or that rather dull parents can have an exceptionally bright child. These observations are often pointed to mistakenly as evidence that intelligence is not inherited. But the fact is that genetic theory predicts precisely that we should find such discrepancies between parents and their offspring. For example, parent-offspring differences in height are of about the same relative magnitude as their differences in IQ. Children resemble their parents physically and in mental ability to about the same degree that they resemble their own siblings. The average IQ difference between a parent and his (or her) child is the same as the difference between siblings—that is, about 12 IQ points. The difference between a child and the average of both of his parents' IQ's is about 10 points.

A parent with a high IQ will usually, but by no means always, have children whose IQ's are somewhat lower than his own but are still above the average for the general population. A parent with a low IQ, on the other hand, will usually, but not always, have children whose IQ's are somewhat higher than his own but are still below the average of the population. This phenomenon, discovered by Sir Francis Galton, is called "regression toward the mean," and it holds true for height and other inherited physical traits as well as for IQ.

IQ's of Husbands and Wives

It is interesting that in our society husbands and wives are at least as much alike in IQ as brothers and sisters.



The theoretical normal or Gaussian distribution of IQ's shows the expected percentages of the population in each IQ range. Except at the extremes (below 70 and above 130), these percentages are very close to actual population values. (The percentage figures total slightly more than 100 because of rounding.)

If men and women picked their mates strictly at random, as by a lottery, spouses would differ by an average of 18 IQ points. But in fact men and women choose one another partly for intelligence, and so spouses differ by only 10 or 11 points in IQ.

The Effect of Inbreeding on IQ

Every person harbors a number of mutant, recessive genes. Most of these are defective genes. They are passed on from parent to child, but they usually will not produce any harmful effects to the child unless the other parent also contributes exactly the same defective gene. The reason this usually does not occur is that each parent's normal genes are dominant over the other parent's defective, recessive genes. When mating occurs between a man and a woman who are blood relations, however, the chances are much greater that they will both possess many of the same defective genes. When these defective genes are paired together in the related couple's children, they subtract unfavorably from the traits that are controlled by these genes under normal conditions. This depression due to inbreeding is known to occur in inherited physical traits, such as stature, and the same thing has been found for IQ. It is well established, for example, that cousin marriages produce children who, on the average, have IQ's several points lower than the IQ's of children whose parents are unrelated but are matched with the married cousins on IQ, age, educational level, and socioeconomic status. More extreme are the cases of children who have resulted from incestuous relationships, such as father-daughter and brother-sister matings. These children show a much higher incidence of severe mental retardation than children born to the same parents when they have mated with unrelated persons. These interesting findings are entirely predictable from basic principles of genetics that apply to all living beings. Moreover, it is virtually impossible to explain such facts without concluding that IQ differences are very strongly influenced by genetic mechanisms.

The Relative Effects of Heredity and Environment

How can we summarize briefly what is now known about the relative importance of heredity and environment in causing individual differences in IQ? In the terminology of genetics a summary answer consists of saying that the "heritability" of IQ is close to 0.80. This means that 80 percent of the "variance" in IQ's in the general population is attributable to genetic differences and 20 percent is attributable to nongenetic or environmental differences.

"Variance" is essentially a quantitative index of the total amount of differences that exist among all members of some population. So instead of talking about variance, we can more easily describe our conclusions in terms of average differences.

If we should determine the differences in IQ between every person in the population and every other person, the average of all these differences would turn out to be 18 IQ points. These differences are due both to genetic and to environmental factors. Now we can ask theoretically: What would be the average IQ difference among all persons in the population if everyone had grown up in identical environments from the moment of conception, while genetic differences remained as they are? Under this hypothetical condition of completely equal environments for everyone, the average IQ difference would be 16 points. Thus, there would be a reduction of 2 points in the average difference that now exists. Let us now ask the reverse: What would be the average difference if everyone had exactly the same genetic endowment, but environmental differences remained unchanged? Under this hypothetical condition of complete genetic equality the average IQ difference among persons would be only 8 points, or just half the difference that would exist with equal environments.

So the conclusion we come to—which is certainly valid at least in the white European and North American populations in which the research was conducted—is this: In accounting for the causes of the differences among persons in IQ, the genes outweigh the effects of environment by 2 to 1. As environmental conditions are improved and made more alike for all persons in the society, the average intelligence level of the population will be somewhat increased, and the IQ differences among persons will be slightly reduced. But of course the differences that remain will inevitably be due even more to genetic factors.