Intelligence Quotient

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An intelligence quotient, or IQ, is a score derived from one of several different standardized tests designed to assess intelligence. The term "IQ" comes from the German Intelligenz-Quotient. When modern IQ tests are constructed the median score is set to 100 and a standard deviation to 15. Today almost all IQ tests adhere to the assignment of 15 IQ points to each standard deviation but this has not been the case historically. Approximately 95% of the population have scores within two standard deviations of the mean. If one SD is 15 points, then 95% of the population are within a range of 70 to 130.

IQ scores have been shown to be associated with such factors as morbidity and mortality, parental social status, and, to a substantial degree, parental IQ. While the heritability of IQ has been investigated for nearly a century, controversy remains regarding the significance of heritability estimates, and the mechanisms of inheritance are still a matter of some debate.

IQ scores are used in many contexts: as predictors of educational achievement or special needs, by social scientists who study the distribution of IQ scores in populations and the relationships between IQ score and other variables, and as predictors of job performance and income.

The average IQ scores for many populations have been rising at an average rate of three points per decade since the early 20th century, a phenomenon called the Flynn effect. It is disputed whether these changes in scores reflect real changes in intellectual abilities.

History

Early history

The first large scale mental test may have been the imperial examination system in China. Modern mental testing began in France in the nineteenth century. It contributed to separating mental retardation from mental illness and reducing the neglect, torture, and ridicule heaped on both groups.

Englishman Francis Galton, half-cousin to Charles Darwin, created the terms psychometrics and eugenics, and a method for measuring intelligence based on nonverbal sensory-motor tests. It was initially popular but was abandoned after the discovery that it had no relationship to outcomes such as college grades.

French psychologist Alfred Binet, together with Victor Henri and Théodore Simon, after about 15 years of development, published the Binet-Simon test for the practical use of determining educational placement; the score on the Binet-Simon scale would reveal the child's mental age. For example, a 6 year-old child who passed all the tasks usually passed by 6 year-olds--but nothing beyond--would have a mental age that exactly matched his chronological age, 6.0. (Fancher, 1985). Binet was forthright about the limitations of his scale. He stressed the remarkable

diversity of intelligence and the subsequent need to study it using qualitative, as opposed to quantitative, measures. Binet also stressed that intellectual development progressed at variable rates and could be influenced by the environment; therefore, intelligence was not based solely on genetics, was malleable rather than fixed, and could only be found in children with comparable backgrounds (Siegler, 1992). American psychologist Henry H. Goddard published a translation of it in 1910. The eugenics movement in the USA seized on it as a means to give them credibility in diagnosing mental retardation. American psychologist Lewis Terman at Stanford University revised the Binet-Simon scale which resulted in the Stanford-Binet Intelligence Scales (1916). It became the most popular test in the United States for decades. Finally, when Binet did become aware of the "foreign ideas being grafted on his instrument" he condemned those who with 'brutal pessimism' and 'deplorable verdicts' were promoting the concept of intelligence as a single, unitary construct (White, 2000).

Charles Spearman created the theory of a general intelligence factor in 1904. It argued that intelligence is largely a single global ability called g but that there are also smaller, specific factors or abilities for specific areas, labeled s. The theory remains influential and is discussed in a later section.

During World War I a way was needed to evaluate and assign recruits. This caused a rapid development of several mental tests. The testing also caused controversy, misinterpretations of the data such as recent immigrants with poor English being deemed inferior in intellect, accusations of racism, and much public debate. Nonverbal or "Performance" tests were developed for those who could not speak English or were suspected of malingering.

After World War One

However, a great deal of positive post war publicity on army psychological testing helped to make psychology a respected field. Subsequently there was an increase in jobs and funding in psychology. Group intelligence tests were developed for and became widely used in both primary and secondary schools, universities and industry. L.L. Thurstone (1938) argued for a model of intelligence that included seven unrelated factors (verbal comprehension, word fluency, number facility, spatial visualization, associative memory, perceptual speed, reasoning, and induction). While not widely used, it influenced later theories.

David Wechsler produced the first version of his test in 1939. It gradually became more popular and overtook the Binet in the 1960s. It has been revised several times, as is common for IQ tests in order to incorporate new research. One explanation is that psychologists and educators wanted more information than the single score from the Binet. Wechsler's 10+ subtests provided this. Another is that the Binet focused on verbal abilities while the Wechsler also included non-verbal abilities. The Binet has also been revised several times and is now similar to the Wechsler in

several aspects and but the Wechsler continues to be the most popular test in the United States.

J.P. Guilford's Structure of Intellect (1967) model used three dimensions which when combined yielded a total of 120 types of intelligence. It was popular in the 1970s and early 1980s but faded due to both practical problems and theoretical criticisms.

Alexander Luria's earlier work on neuropsychological processes lead to the PASS theory (1997). It argued that only looking at one general factor was inadequate for researchers and clinicians who worked with learning disabilities, attention disorders, mental retardation, and interventions for such disabilities. The PASS model covers four kinds of processes. The (P)lanning processes involve decision making, problem solving, and performing activities and requires goal setting and self-monitoring. The (A)ttention/arousal process involves selectively attending to a particular stimulus, ignoring distractions, and maintaining vigilance. (S)imultaneous processing involves the integration of stimuli into a group and requires the observation of relationships. (S)uccessive processing involves the integration of stimuli into serial order. The planning and attention/arousal components comes from structures located in the frontal lobe, and the simultaneous and successive processes come from structures located in the posterior region of the cortex. It has influenced some recent IQ tests and been seen as a complement to the Cattell-Horn-Carroll theory described below.

Raymond Cattell (1941) proposed two types of cognitive abilities in a revision of Spearman's concept of general intelligence. Fluid intelligence (Gf) was hypothesized as the ability to solve novel problems by using reasoning and crystallized intelligence (Gc) was hypothesized as a knowledge-based ability that was very dependent on education and experience. In addition, fluid intelligence was hypothesized to decline with age while crystallized intelligence was largely resistant. The theory was almost forgotten but revived by his student John L. Horn (1966) who later argued that Gf and Gc were only two among several factors and he eventually identified 9 or 10 broad abilities. The theory continued to be called Gf-Gc theory.

John B. Carroll (1993) after a comprehensive re-analysis of earlier data proposed the Three Stratum Theory, which is a hierarchical model with three levels. At the bottom is the first stratum which consists of narrow abilities that are highly specialized (e.g., induction, spelling ability). The second stratum consists of broad abilities. Carroll identified eight second-stratum abilities. Carroll accepted Spearman's concept of general intelligence, for the most part, as a representation of the uppermost third stratum.

More recently (1999), a merging of the Gf-Gc theory of Cattell and Horn with Carroll's Three-Stratum theory has led to the Cattell-Horn-Carroll theory. It has greatly influenced many of the current IQ tests.

Mental age vs. modern method

The IQs of a large enough population are calculated so that they conform to a normal distribution. The term "IQ" comes from German "Intelligenz-Quotient", coined by the German psychologist William Stern in 1912, who proposed a method of scoring children's intelligence tests. He calculated the IQ score as the quotient of the "mental age" (the age group which scored such a result on average) of the test-taker and the "chronological age" of the test-taker, multiplied by 100. Terman used this system for the first version of the Stanford-Binet Intelligence Scales. This method has several problems such as not working for adults.

Wechsler introduced a different procedure for his test that is now used by almost all IQ tests. When an IQ test is constructed, a standardization sample representative of the general population takes the test. The median result is defined to be equivalent to 100 IQ points. In almost all modern tests, a standard deviation of the results is defined to equivalent to 15 IQ points. When a subject takes an IQ test, the result is ranked compared to the results of normalization sample and the subject is given an IQ score equal to those with the same test result in the normalization sample. Although the term "IQ" is still in common use, it is now an inaccurate description, mathematically speaking, since a quotient is no longer involved.

The values of 100 and 15 were chosen in order to get somewhat similar scores as in the older type of test. Likely as a part of the rivalry between the Binet and the Wechsler, the Binet until 2003 chose to have 16 for one SD, causing considerable confusion. Today almost all tests use 15 for one SD. Modern scores are sometimes referred to as "deviation IQs," while older method age-specific scores are referred to as "ratio IQs."

Modern tests

Well-known modern IQ tests include Wechsler Adult Intelligence Scale, Wechsler Intelligence Scale for Children, Stanford-Binet, Woodcock-Johnson Tests of Cognitive Abilities, Kaufman Assessment Battery for Children, and Raven's Progressive Matrices.

Approximately 95% of the population have scores within two standard deviations (SD) of the mean. If one SD is 15 points, as is common in almost all modern tests, then 95% of the population are within a range of 70 to 130. Alternatively, two-thirds of the population have IQ scores within one SD of the mean, i.e. within the range 85-115.

IQ scales are ordinally scaled. While one standard deviation is 15 points, and two SDs are 30 points, and so on, this does not imply that cognitive ability is linearly related to IQ, such that IQ 50 means half the cognitive ability of IQ 100. In particular, IQ points are not percentage points.

The correlation between IQ test results and achievement test results is about 0.7.

Reliability and validity

IQ scores can differ to some degree for the same individual on different IQ tests (age 12-13 years).

Pupil KABC-II WISC-III WJ-III
Asher 90 95 111
Brianna 125 110 105
Colin 100 93 101
Danica 116 127 118
Elpha 93 105 93
Fritz 106 105 105
Georgi 95 100 90
Hector 112 113 103
Imelda 104 96 97
Jose 101 99 86
Keoku 81 78 75
Leo 116 124 102

Psychometricians generally regard IQ tests as having high statistical reliability. A high reliability implies that while test-takers can have varying scores on differing occasions when taking the same test and can vary in scores on different IQ tests taken at the same age, the scores generally agree. A test-taker's score on any one IQ test is surrounded by an error band that shows, to a specified degree of confidence, what the test-taker's true score is likely to be. For modern tests, the standard error of measurement is about 3 points, or in other words, the odds are about 2 out of 3 that a persons true IQ is in range from 3 points above to 3 points below the test IQ. Another description is that there is a 95% chance that the true IQ is in range from 4-5 points above to 4-5 points below the test IQ, depending on the test in question. Clinical psychologists generally regard them as having sufficient statistical validity for many clinical purposes.

The general intelligence factor (g)

There are many different kinds of IQ tests using a wide variety of methods. Some tests are visual, some are verbal, some tests only use of abstract-reasoning problems, and some tests concentrate on arithmetic, spatial imagery, reading, vocabulary, memory or general knowledge. The psychologist Charles Spearman made the first formal factor analysis of correlations between the tests in the early 20th century. He found that a single common factor explained for the positive correlations among tests. This is an argument still accepted in principle by many psychometricians. Spearman named it g for "general intelligence factor". In any collections of IQ tests, by definition the test that best measures g is the one that has the highest correlations with all the others. Most

of these g-loaded tests typically involve some form of abstract reasoning. Therefore Spearman and others have regarded g as the perhaps genetically determined real essence of intelligence. This is still a common but not proven view. Other factor analyses of the data are with different results are possible. Some psychometricians regard g as a statistical artifact. The accepted best measure of g is Raven's Progressive Matrices which is a test of visual reasoning.

Cattell-Horn-Carroll theory

Many of the broad, recent IQ tests have been greatly influenced by the Cattell-Horn-Carroll theory. It is argued to reflect much of what is known about intelligence from research. A hierarchy of factors is used. g is at the top. Under it there are 10 broad abilities that in turn are subdivided into 70 narrow abilities. The broad abilities are:

Fluid Intelligence (Gf): includes the broad ability to reason, form concepts, and solve problems using unfamiliar information or novel procedures.
Crystallized Intelligence (Gc): includes the breadth and depth of a person's acquired knowledge, the ability to communicate one's knowledge, and the ability to reason using previously learned experiences or procedures.
Quantitative Reasoning (Gq): the ability to comprehend quantitative concepts and relationships and to manipulate numerical symbols.
Reading & Writing Ability (Grw): includes basic reading and writing skills.
Short-Term Memory (Gsm): is the ability to apprehend and hold information in immediate awareness and then use it within a few seconds.
Long-Term Storage and Retrieval (Glr): is the ability to store information and fluently retrieve it later in the process of thinking.
Visual Processing (Gv): is the ability to perceive, analyze, synthesize, and think with visual patterns, including the ability to store and recall visual representations.
Auditory Processing (Ga): is the ability to analyze, synthesize, and discriminate auditory stimuli, including the ability to process and discriminate speech sounds that may be presented under distorted conditions.
Processing Speed (Gs): is the ability to perform automatic cognitive tasks, particularly when measured under pressure to maintain focused attention.
Decision/Reaction Time/Speed (Gt): reflect the immediacy with which an individual can react to stimuli or a task (typically measured in seconds or fractions of seconds; not to be confused with Gs, which typically is measured in intervals of 2-3 minutes).

Modern tests do not necessarily measure of all of these broad abilities. For example, Gq and Grw may be seen as measures of school achievement and not IQ. Gt may be difficult to measure without special equipment.

g was earlier often subdivided into only Gf and Gc which were thought to correspond to the Nonverbal or Performance subtests and Verbal subtests in earlier versions of the popular Wechsler IQ test. More recent research has shown the situation to be more complex.

Modern comprehensive IQ tests no longer give a single score. Although they still give an overall score, they now also gives scores for many of these more restricted abilities, identifying particular strengths and weaknesses of an individual.

Flynn effect

Since the early 20th century, raw scores on IQ tests have increased in most parts of the world. When a new version of an IQ test is normed, the standard scoring is set so that performance at the population median results in a score of IQ 100. The phenomenon of rising raw score performance means that if test-takers are scored by a constant standard scoring rule, IQ test scores have been rising at an average rate of around three IQ points per decade. This phenomenon was named the Flynn effect in the book The Bell Curve after James R. Flynn, the author who did the most to bring this phenomenon to the attention of psychologists.

Researchers have been exploring the issue of whether the Flynn effect is equally strong on performance of all kinds of IQ test items, whether the effect may have ended in some developed nations, whether or not there are social subgroup differences in the effect, and what possible causes of the effect might be. Flynn's observation has prompted much new research in psychology and "demolish some long-cherished beliefs, and raise a number of other interesting issues along the way."

IQ and age

IQ can change to some degree over the course of childhood. However, in one longitudinal study, the mean IQ scores of tests at ages 17 and 18 were correlated at r=.86 with the mean scores of tests at ages 5, 6 and 7 and at r=.96 with the mean scores of tests at ages 11, 12 and 13.

IQ scores for children are relative to children of a similar age. That is, a child of a certain age does not do as well on the tests as an older child or an adult with the same IQ. But relative to persons of a similar age, or other adults in the case of adults, they do equally well if the IQ scores are the same.

For decades, it has been reported in practitioners' handbooks and textbooks on IQ testing that IQ declines with age after the beginning of adulthood. However, later researchers pointed out that this phenomenon is related to the Flynn effect and is in part a cohort effect rather than a true aging effect.

There have been a variety of studies of IQ and aging since the norming of the first Wechsler Intelligence Scale drew attention to IQ differences in different age groups of adults. Current consensus is that fluid intelligence generally declines with age after early adulthood, while crystallized intelligence remains intact. Both cohort effects (the birth year of the test-takers) and practice effects (test-takers taking the same form of IQ test more than once) must be controlled for to gain accurate data. It is unclear whether any lifestyle intervention can preserve fluid intelligence into older ages.

The peak of capacity for both fluid intelligence and crystallized intelligence occurs at age 26. This is followed by a slow decline.

Heritability of IQ

Environmental and genetic factors play a role in determining IQ. Their relative importance have been the subject of much research and debate.

Heritability

Heritability is defined as the proportion of variance in a trait which is attributable to genotype within a defined population in a specific environment. A heritability of 1 indicates that all variation is genetic in origin and a heritability of 0 indicates that none of the variation is genetic. There are a number of points to consider when interpreting heritability. Some examples:

Heritability measures the proportion of variation in a trait that can be attributed to genes, and not the proportion of a trait caused by genes. Thus, if the environment relevant to a given trait changes in a way that affects all members of the population equally, the mean value of the trait will change without any change in its heritability (because the variation or differences among individuals in the population will stay the same). This has evidently happened for height: the heritability of stature is high, but average heights continue to increase. Thus, even in developed nations, a high heritability of a trait does not necessarily mean that average group differences are due to genes. Some have gone further, and used height as an example in order to argue that "even highly heritable traits can be strongly manipulated by the environment, so heritability has little if anything to do with controllability." However, others argue that IQ is highly stable during life and has been largely resistant to interventions aimed to change it long-term and substantially.

A common error is to assume that a heritability figure is necessarily unchangeable. The value of heritability can change if the impact of environment (or of genes) in the population is substantially altered. If the environmental variation encountered by different individuals increases, then the heritability figure would decrease. On the other hand, if everyone had the same environment, then heritability would be 100%. The population in developing nations often have more diverse

environments than in developed nations. This would mean that heritability figures would be lower in developing nations. Another example is phenylketonuria which previously caused mental retardation for everyone who had this genetic disorder and thus had a heritability of 100%. Today, this can be prevented by following a modified diet which has lowered heritability.

A high heritability of a trait does not mean that environmental effects such as learning are not involved. Vocabulary size, for example, is very substantially heritable (and highly correlated with general intelligence) although every word in an individual's vocabulary is learned. In a society in which plenty of words are available in everyone's environment, especially for individuals who are motivated to seek them out, the number of words that individuals actually learn depends to a considerable extent on their genetic predispositions and thus heritability is high.

Since heritability increases during childhood and adolescence, and even increases greatly between 16-20 years of age and adulthood, one should be cautious drawing conclusions regarding the role of genetics and environment from studies where the participants are not followed until they are adults. Furthermore, there may be differences regarding the effects on g and on non-g factors, with g possibly being harder to affect and environmental interventions disproportionately affecting non-g factors.

Various studies have found the heritability of IQ to be between 0.7 and 0.8 in adults and 0.45 in childhood in the United States. It may seem reasonable to expect that genetic influences on traits like IQ should become less important as one gains experiences with age. However, the opposite occurs. Heritability measures in infancy are as low as 0.2, around 0.4 in middle childhood, and as high as 0.8 in adulthood. One proposed explanation is that people with different genes tend to seek out different environments that reinforce the effects of those genes. There is an ongoing debate, as discussed in the Heritability of IQ article, regarding if these high heritability estimates are too high due to not adequately considering factors such as that the environment may be relatively more important in families with low socio-economic status or the effect of the maternal (fetal) environment.

Shared family environment

There are aspects of environments that family members have in common (for example, characteristics of the home). This shared family environment accounts for 0.25-0.35 of the variation in IQ in childhood. By late adolescence it is quite low (zero in some studies). There is a similar effect for several other psychological traits. These studies have not looked the effects of extreme environments such as in abusive families.

Non-shared family environment and environment outside the family

Although parents treat their children differently, such differential treatment explains only a small amount of non-shared environmental influence. One suggestion is that children react differently to the same environment due to different genes. More likely influences may be the impact of peers and other experiences outside the family.

Individual genes

A number of individual genes have been reported to be associated with IQ. Examples include CHRM2, microcephalin, and ASPM. However, Deary and colleagues (2009) argued that there are still almost no replicated evidence. About 20,000 genes are thought to have an impact on the development and functionality of the brain.

Regression toward the mean

Regression towards the mean is a statistical phenomenon that occurs when an outcome is determined by many independent factors. If an outcome is extreme, then this occurred because most of the independent factors agreed by chance. This is unlikely to occur again so to the next outcome is likely to be less extreme. If IQ is determined by many factors, genetic and/or environmental, then they must mostly agree in the same direction in order to produce an extreme IQ. The child of a person with an extreme IQ is unlikely to have all the factors agree so similarly so the child is on average likely to have a less extreme IQ.

People in professional occupations have on average 25 points higher IQ than unskilled workers. For their children the difference is 21 points. This is in itself not evidence for genetics or environment since the environment for the children likely differs greatly with it on average being more stimulating for the children of professionals.

Gene-environment interaction

Dickens and Flynn (2001) argued that the "heritability" figure includes both a direct effect of the genotype on IQ and also indirect effects where the genotype changes the environment, in turn affecting IQ. That is, those with a higher IQ tend to seek out stimulating environments that further increase IQ. The direct effect can initially have been very small but feedback loops can create large differences in IQ. In their model an environmental stimulus can have a very large effect on IQ, even in adults, but this effect also decays over time unless the stimulus continues (the model could be adapted to include possible factors, like nutrition in early childhood, that may cause permanent effects). The Flynn effect can be explained by a generally more stimulating environment for all people. The authors suggest that programs aiming to increase IQ would be most likely to produce long-term IQ gains if they taught children how to replicate outside the program the kinds of

cognitively demanding experiences that produce IQ gains while they are in the program and motivate them to persist in that replication long after they have left the program.

Interventions

Interventions such as the Head Start Program have not produced lasting gains, although the more intensive Abecedarian Project have. In general, many interventions, as those described below, have shown short-term effects on IQ, but long-term follow-up is often missing.

A placebo controlled double-blind experiment found that vegetarians who took 5 grams of creatine per day for six weeks showed a significant improvement on two separate tests of fluid intelligence, Raven's Progressive Matrices, and the backward digit span test from the WAIS. The treatment group was able to repeat longer sequences of numbers from memory and had higher overall IQ scores than the control group. The researchers concluded that "supplementation with creatine significantly increased intelligence compared with placebo." A subsequent study found that creatine supplements improved cognitive ability in the elderly. A study on young adults (0.03 g/kg/day for six weeks, e.g., 2 g/day for 150-pound individual) failed, however, to find any improvements.

Musical training in childhood has also been found to correlate with higher than average IQ. Recent studies have shown that training in using one's working memory may increase IQ. A study on young adults published in April 2008 by a team from the Universities of Michigan and Bern supports the possibility of the transfer of fluid intelligence from specifically designed working memory training. Further research will be needed to determine nature, extent and duration of the proposed transfer. Among other questions, it remains to be seen whether the results extend to other kinds of fluid intelligence tests than the matrix test used in the study, and if so, whether, after training, fluid intelligence measures retain their correlation with educational and occupational achievement or if the value of fluid intelligence for predicting performance on other tasks changes. It is also unclear whether the training is durable of extended periods of time.

IQ and brain anatomy

Some studies have not found a correlation between some measures of brain size and IQ. Thus, Jensen and Reed in a 1993 study found no correlation between cranial capacity and IQ in nonpathological subjects (N=211). However, more recent meta-analyses and reviews find such a correlation. Rushton and Ankney (2009) in a literature review write that in 28 samples using brain imaging techniques the mean brain size/g correlation was 0.40 (N = 1,389). In 59 samples using external head size measures it was 0.20 (N = 63,405). In 6 studies that corrected for that different IQ subtests measure g unequally well, the mean correlation was 0.63. Some studies have found the whole brain to be important for g while others have found the frontal lobes to be particularly

important. Two studies founds correlations of 0.48 and 0.56 between brain size and the number of neurons in the cerebral cortex (based on counting in representative areas.

Luders and colleagues in a literature review (2009) write that the majority of data shows that both gray matter and white matter volume correlate with IQ but the correlation is stronger for gray matter. Increased number of neurons in the gray matter may explain the higher correlation but not necessarily so since glucose consumption and intelligence measures correlate negatively which may mean intelligent individuals use their neurons more efficiently, such as being more efficient in their formation of synapses between neurons which help to create more efficient neural circuitry. The white matter correlation may be due to more myelination or better control of pH and thus enhanced neural transmission. For more specific regions, the most frequently replicated positive correlations appear localized in the lateral and medial frontal lobe cortex. Positive correlations are also found with volume in many other areas. Cortical thickness may be a better measure than gray matter volume although this may vary with age with an initially negative correlation in early childhood becoming positive later. The explanation may again be that more intelligent individuals manage their synapses better. During evolution not only brain size but also brain folding has increased which has increased the surface area. Convolution data may support the "The Parieto-Frontal Integration Theory" which see medial cortex structures as particularly important. Volume of the corpus callosum or subareas were found to be important in several studies which may be due to more efficient inter-hemispheric information transfer.

Brain injuries at an early age isolated to one side of the brain typically results in relatively spared intellectual function and with IQ in the normal range.

Health and IQ

Proper childhood nutrition appears critical for cognitive development; malnutrition can lower IQ. For example, iodine deficiency causes a fall, in average, of 12 IQ points. It is expected that average IQ in third world countries will increase if malnutrition of various kinds is eradicated.

One recent study found that a group of children with the C" version of the FADS2 gene who were breastfed acquired on average 7 IQ points higher than to those with the "G" allele of the gene. Other studies have failed to replicate any correlation between the FADS2 gene, breastfeeding and IQ, while others show a negative effect on IQ when combining bottledfeeding, and the "G" version of FADS2 .

People with a higher IQ have generally lower adult morbidity and mortality. Post-Traumatic Stress Disorder and schizophrenia are less prevalent in higher IQ bands. People in the midsts of a major depressive episode have been shown to have a lower IQ than when without symptoms and lower cognitive ability than people without depression of equivalent verbal intelligence.

A study of 11,282 individuals in Scotland who took intelligence tests at ages 7, 9 and 11 in the 1950s and 1960s, found an "inverse linear association" between childhood IQ scores and hospital admissions for injuries in adulthood. The association between childhood IQ and the risk of later injury remained even after accounting for factors such as the child's socioeconomic background. Research in Scotland has also shown that a 15-point lower IQ meant people had a fifth less chance of living to 76, while those with a 30-point disadvantage were 37% less likely than those with a higher IQ to live that long.

A decrease in IQ has also been shown as an early predictor of late-onset Alzheimer's Disease and other forms of dementia. In a 2004 study, Cervilla and colleagues showed that tests of cognitive ability provide useful predictive information up to a decade before the onset of dementia. However, when diagnosing individuals with a higher level of cognitive ability, in this study those with IQs of 120 or more, patients should not be diagnosed from the standard norm but from an adjusted high-IQ norm that measured changes against the individual's higher ability level. In 2000, Whalley and colleagues published a paper in the journal Neurology, which examined links between childhood mental ability and late-onset dementia. The study showed that mental ability scores were significantly lower in children who eventually developed late-onset dementia when compared with other children tested.

IQ is also negatively correlated with certain diseases. Several factors can lead to significant cognitive impairment, particularly if they occur during pregnancy and childhood when the brain is growing and the blood-brain barrier is less effective. Such impairment may sometimes be permanent, or may sometimes be partially or wholly compensated for by later growth. Several harmful factors may also combine, possibly causing greater impairment.

Developed nations have implemented several health policies regarding nutrients and toxins known to influence cognitive function. These include laws requiring fortification of certain food products and laws establishing safe levels of pollutants (e.g. lead, mercury, and organochlorides). Comprehensive policy recommendations targeting reduction of cognitive impairment in children have been proposed.

In terms of the effect of one's intelligence on health, in one British study, high childhood IQ was shown to correlate with one's chance of becoming a vegetarian in adulthood. In another British study, high childhood IQ was shown to inversely correlate with the chances of smoking. There is also a relationship between longevity and intelligence.

Social outcomes

Outside of academic research and medicine, IQ testing is often done due to its ability to predict future job performance, social pathologies, or academic achievement. Academic research has also

examined these associations, as well as the effect of IQ on other social outcomes, such as income and wealth.

Many of the arguments and criticisms assume that explained variance can be calculated as the square of the correlation coefficient. This way of calculating explained variance has been criticized as inappropriate for most social scientific work. Also, as for the heritability figure, the explained variance only refers to the proportion of variation in an outcome that is explained by a factor, and not the proportion of an outcome that is explained by a factor.

Other tests

One study found a correlation of 0.82 between g (general intelligence factor) and SAT scores; another has found correlation of 0.81 between g and GCSE scores.

Correlations between IQ scores (general cognitive ability) and achievement test scores are reported to be 0.81 by Deary and colleagues, with the explained variance ranging "from 58.6% in Mathematics and 48% in English to 18.1% in Art and Design".

School performance

The American Psychological Association's report "Intelligence: Knowns and Unknowns" states that wherever it has been studied, children with high scores on tests of intelligence tend to learn more of what is taught in school than their lower-scoring peers. The correlation between IQ scores and grades is about .50. This means that the explained variance is 25%. Achieving good grades depends on many factors other than IQ, such as "persistence, interest in school, and willingness to study" (p. 81).

Job performance

According to Frank Schmidt and John Hunter, "for hiring employees without previous experience in the job the most valid predictor of future performance is general mental ability." The validity of IQ as a predictor of job performance is above zero for all work studied to date, but varies with the type of job and across different studies, ranging from 0.2 to 0.6. The correlations were higher when the unreliability of measurement methods were controlled for. While IQ is more strongly correlated with reasoning and less so with motor function, IQ-test scores predict performance ratings in all occupations. That said, for highly qualified activities (research, management) low IQ scores are more likely to be a barrier to adequate performance, whereas for minimally-skilled activities, athletic strength (manual strength, speed, stamina, and coordination) are more likely to influence performance. It is largely mediated through the quicker acquisition of job-relevant knowledge that IQ predicts job performance.

In establishing a causal direction to the link between IQ and work performance, longitudinal studies by Watkins and others suggest that IQ exerts a causal influence on future academic achievement, whereas academic achievement does not substantially influence future IQ scores. Treena Eileen Rohde and Lee Anne Thompson write that general cognitive ability but not specific ability scores predict academic achievement, with the exception that processing speed and spatial ability predict performance on the SAT math beyond the effect of general cognitive ability.

The US military has minimum enlistment standards at about the IQ 85 level. There have been two experiments with lowering this to 80 but in both cases these men could not master soldiering well enough to justify their costs

The American Psychological Association's report "Intelligence: Knowns and Unknowns" states that since the explained variance is 29%, other individual characteristics such as interpersonal skills, aspects of personality etc. are probably of equal or greater importance, but at this point there are no equally reliable instruments to measure them.

Income

Some researchers claim that "in economic terms it appears that the IQ score measures something with decreasing marginal value. It is important to have enough of it, but having lots and lots does not buy you that much."

Other studies show that ability and performance for jobs are linearly related, such that at all IQ levels, an increase in IQ translates into a concomitant increase in performance. Charles Murray, coauthor of The Bell Curve, found that IQ has a substantial effect on income independently of family background.

Taking the above two principles together, very high IQ produces very high job performance, but no greater income than slightly high IQ. Studies also show that high IQ is related to higher net worth.

The American Psychological Association's 1995 report Intelligence: Knowns and Unknowns stated that IQ scores accounted for (explained variance) about one-fourth of the social status variance and one-sixth of the income variance. Statistical controls for parental SES eliminate about a quarter of this predictive power. Psychometric intelligence appears as only one of a great many factors that influence social outcomes.

Some studies claim that IQ only accounts for (explained variance) a sixth of the variation in income because many studies are based on young adults (many of whom have not yet completed their education). On pg 568 of The g Factor, Arthur Jensen claims that although the correlation between IQ and income averages a moderate 0.4 (one sixth or 16% of the variance), the relationship increases with age, and peaks at middle age when people have reached their maximum career

potential. In the book, A Question of Intelligence, Daniel Seligman cites an IQ income correlation of 0.5 (25% of the variance).

A 2002 study further examined the impact of non-IQ factors on income and concluded that an individual's location, inherited wealth, race, and schooling are more important as factors in determining income than IQ.

IQ and crime

The American Psychological Association's 1995 report Intelligence: Knowns and Unknowns stated that the correlation between IQ and crime was -0.2. It was -0.19 between IQ scores and number of juvenile offenses in a large Danish sample; with social class controlled, the correlation dropped to -0.17. A correlation of 0.20 means that the explained variance is less than 4%. It is important to realize that the causal links between psychometric ability and social outcomes may be indirect. Children with poor scholastic performance may feel alienated. Consequently, they may be more likely to engage in delinquent behavior, compared to other children who do well.

In his book The g Factor (1998), Arthur Jensen cited data which showed that, regardless of race, people with IQs between 70 and 90 have higher crime rates than people with IQs below or above this range, with the peak range being between 80 and 90.

The 2009 Handbook of Crime Correlates stated that reviews have found that around eight IQ points, or 0.5 SD, separate criminals from the general population, especially for persistent serious offenders. It has been suggested that this simply reflects that "only dumb ones get caught" but there is similarly a negative relation between IQ and self-reported offending. That children with conduct disorder have lower IQ than their peers "strongly argue" against the theory.

Other correlations with IQ

In addition, IQ and its correlation to health, violent crime, gross state product, and government effectiveness are the subject of a 2006 paper in the publication Intelligence. The paper breaks down IQ averages by U.S. states using the federal government's National Assessment of Educational Progress math and reading test scores as a source.

The American Psychological Association's 1995 report Intelligence: Knowns and Unknowns stated that the correlations for most "negative outcome" variables are typically smaller than 0.20, which means that the explained variance is less than 4%.

Tambs et al. found that occupational status, educational attainment, and IQ are individually heritable; and further found that "genetic variance influencing educational attainment ... contributed approximately one-fourth of the genetic variance for occupational status and nearly half the genetic

variance for IQ." In a sample of U.S. siblings, Rowe et al. report that the inequality in education and income was predominantly due to genes, with shared environmental factors playing a subordinate role. There are also other correlations such as those between religiosity and intelligence and fertility and intelligence.

Real-life accomplishments

Average adult IQs associated with real-life accomplishments:

Neurosurgeons, research scientists, university professors 135+
MDs or PhDs 125
College graduates 115
1-3 years of college 105-110
Clerical and sales workers 100-105
High school graduates, skilled workers (e.g., electricians, cabinetmakers) 100
1-3 years of high school (completed 9-11 years of school) 95
Semi-skilled workers (e.g., truck drivers, factory workers) 90-95
Elementary school graduates (completed eighth grade) 90
Elementary school dropouts (completed 0-7 years of school) 80-85
Have 50/50 chance of reaching high school 75

Average IQ of various occupational groups:

Professional and technical 112
Managers and administrators 104
Clerical workers; sales workers; skilled workers, craftsmen, and foremen 101
Semi-skilled workers (operatives, service workers, including private household; farmers and farm managers) 92
Unskilled workers 87

Type of work that can be accomplished:

Adults can harvest vegetables, repair furniture 60
Adults can do domestic work, simple carpentry 50
Adults can mow lawns, do simple laundry 40

There is considerable variation within and overlap between these categories. People with high IQs are found at all levels of education and occupational categories. The biggest difference occurs for low IQs with only an occasional college graduate or professional scoring below 90.

Group differences

Among the most controversial issues related to the study of intelligence is the observation that intelligence measures such as IQ scores vary between ethnic and racial groups and sexes. While there is little scholarly debate about the existence of some of these differences, their causes remain highly controversial both within academia and in the public sphere.

Sex

Men and women have statistically significant differences in average scores on tests of particular abilities. Studies also illustrate consistently greater variance in the performance of men compared to that of women.

IQ tests are weighted on these sex differences so there is no bias on average in favor of one sex, however the consistent difference in variance is not removed. Because the tests are defined so there is no average difference it is difficult to put any meaning on a statement that one sex has a higher intelligence than the other. However some people have made claims like this even using unbiased IQ tests. For instance, there are claims that men tend to outperform women on average by three to four IQ points based on tests of medical students where the greater variance of men's IQ can be expected to contribute to the result, or where a 'correction' is made for different maturation ages.

Race

The 1996 Task Force investigation on Intelligence sponsored by the American Psychological Association concluded that there are significant variations in IQ across races. The problem of determining the causes underlying this variation relates to the question of the contributions of "nature and nurture" to IQ. Psychologists such as Alan S. Kaufman and Nathan Brody and statisticians such as Bernie Devlin argue that there are insufficient data to conclude that this is because of genetic influences. One of the most notable researchers arguing for a strong genetic influence on these average score differences is Arthur Jensen. In contrast, other researchers such as Richard Nisbett argues that environmental factors can explain all of the average group differences.

Nations

A number of literature reviews have found differences in average national IQs. Other studies have found many factors such economic growth, democracy, crime, fertility, or atheism to be associated with average national IQs. In particular for developing nations environmental factors such as malnutrition and diseases likely affect average national IQs.

Public policy

In the United States, certain public policies and laws regarding military service, education, public benefits, capital punishment, and employment incorporate an individual's IQ into their decisions. However, in the case of Griggs v. Duke Power Co. in 1971, for the purpose of minimizing employment practices that disparately impacted racial minorities, the U.S. Supreme Court banned the use of IQ tests in employment, except in very rare cases. Internationally, certain public policies, such as improving nutrition and prohibiting neurotoxins, have as one of their goals raising, or preventing a decline in, intelligence.

A diagnosis of mental retardation is in part based on the results of IQ testing. Borderline intellectual functioning is a categorization where a person has below average cognitive ability (an IQ of 71-85), but the deficit is not as severe as mental retardation (70 or below).

Criticism and views

Relation between IQ and intelligence

IQ is the most researched approach to intelligence and by far the most widely used in practical setting. There are critics, who do not dispute the stability of IQ test scores or the fact that they predict certain forms of achievement rather effectively. They do argue, however, that to base a concept of intelligence on IQ test scores alone is to ignore many important aspects of mental ability.

Criticism of g

Some scientists dispute IQ entirely. In The Mismeasure of Man (1996), paleontologist Stephen Jay Gould criticized IQ tests and argued that that they were used for scientific racism. He argued that g was a mathematical artifact and criticized:

...the abstraction of intelligence as a single entity, its location within the brain, its quantification as one number for each individual, and the use of these numbers to rank people in a single series of worthiness, invariably to find that oppressed and disadvantaged groups--races, classes, or sexes--are innately inferior and deserve their status.(pp. 24-25)

Psychologist Peter Schönemann was also a persistent critic of IQ, calling it "the IQ myth". He argued that g is a flawed theory and that the high heritability estimates of IQ are based on false assumptions.

Psychologist Arthur Jensen has rejected the criticism by Gould and also argued that even if g was replaced by a model with several intelligences this would change the situation less than expected. All tests of cognitive ability would continue to be highly correlated with one another and there would

still be a black-white gap on cognitive tests. James R. Flynn, an intelligence researcher known for his criticisms of racial theories of intelligence, similarly argued that "Gould's book evades all of Jensen's best arguments for a genetic component in the black-white IQ gap by positing that they are dependent on the concept of g as a general intelligence factor. Therefore, Gould believes that if he can discredit g no more need be said. This is manifestly false. Jensen's arguments would bite no matter whether blacks suffered from a score deficit on one or 10 or 100 factors."

Test bias

The American Psychological Association's report Intelligence: Knowns and Unknowns stated that in the United States IQ tests as predictors of social achievement are not biased against African Americans since they predict future performance, such as school achievement, similarly to the way they predict future performance for Whites.

However, IQ tests may well be biased when used in other situations. A 2005 study stated that "differential validity in prediction suggests that the WAIS-R test may contain cultural influences that reduce the validity of the WAIS-R as a measure of cognitive ability for Mexican American students," indicating a weaker positive correlation relative to sampled white students. Other recent studies have questioned the culture-fairness of IQ tests when used in South Africa. Standard intelligence tests, such as the Stanford-Binet, are often inappropriate for children with autism; the alternative of using developmental or adaptive skills measures are relatively poor measures of intelligence in autistic children, and may have resulted in incorrect claims that a majority of children with autism are mentally retarded.

Outdated methodology

A 2006 article stated that contemporary psychologic research often did not reflect substantial recent developments in psychometrics and "bears an uncanny resemblance to the psychometric state of the art as it existed in the 1950s." However, it also states that an "increasing number of psychometrically informed research papers that have been appearing in the past decade."

"Intelligence: Knowns and Unknowns"

In response to the controversy surrounding The Bell Curve, the American Psychological Association's Board of Scientific Affairs established a task force in 1995 to write a report on the state of intelligence research which could be used by all sides as a basis for discussion, "Intelligence: Knowns and Unknowns". The full text of the report is available through several websites.

In this paper the representatives of the association regret that IQ-related works are frequently

written with a view to their political consequences: "research findings were often assessed not so much on their merits or their scientific standing as on their supposed political implications".

The task force concluded that IQ scores do have high predictive validity for individual differences in school achievement. They confirm the predictive validity of IQ for adult occupational status, even when variables such as education and family background have been statistically controlled. They stated that individual differences in intelligence are substantially influenced by both genetics and environment.

The report stated that a number of biological factors, including malnutrition, exposure to toxic substances, and various prenatal and perinatal stressors, result in lowered psychometric intelligence under at least some conditions. The task force agrees that large differences do exist between the average IQ scores of blacks and whites. "The cause of that differential is not known; it is apparently not due to any simple form of bias in the content or administration of the tests themselves. The Flynn effect shows that environmental factors can produce differences of at least this magnitude, but that effect is mysterious in its own right. Several culturally based explanations of the Black/ White IQ differential have been proposed; some are plausible, but so far none has been conclusively supported. There is even less empirical support for a genetic interpretation. In short, no adequate explanation of the differential between the IQ means of Blacks and Whites is presently available."

The APA journal that published the statement, American Psychologist, subsequently published eleven critical responses in January 1997, several of them arguing that the report failed to examine adequately the evidence for partly genetic explanations.

High IQ societies

There are social organizations, some international, which limit membership to people who have scores as high as or higher than the 98th percentile on some IQ test or equivalent. Mensa International is perhaps the most well known of these. There are other groups requiring a score above the 98th percentile.

Popular culture usage

Many websites and magazines use the term IQ to refer to technical or popular knowledge in a variety of subjects not related to intelligence, including sex, poker, and American football, among a wide variety of other topics. These tests are generally not standardized and do not fit within the normal definition of intelligence. Modern Intelligence tests are not merely placing a test taker's score within the norm, as presumably are the thousands of alleged "IQ Tests" found on the internet, but they are also testing factors (e.g., fluid and crystallized intelligence, working memory,

and the like) that were previously found to represent pure measures of intelligence using factor analysis. This claim may not be made for the hundreds of online tests marketing themselves as IQ Tests, a distinction that may be unfortunately lost upon the public taking them.