Genetics of Childhood Disorders: II. Genetics and Intelligence

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The modern measurement of human intelligence began in England in the latter half of the 19th century when Sir Francis Galton, the half-cousin of Charles Darwin, developed a test from a simplistic theory. People take in information through their senses; therefore, the most intelligent people must have the best developed senses. Galton developed a test composed of sensory, motor, and reaction-time tasks, all of which produced reliable, consistent results. Ultimately, only Galton's emphasis on the genetics of intelligence proved sound; around the turn of the 20th century, his influential tests were shown to be invalid measures of the complex construct.

Binet seized the opening and published the first "real" intelligence test in 1905. Binet's intelligence test, based on "g" or general intelligence theory, comprised many brief tasks of memory, judgment, and reasoning. He focused on language, rather than the nonverbal abilities emphasized by Galton; introduced the mental age concept; and revolutionized testing by insisting that one must be willing to accept measurement error in order to measure complex human intelligence. Lewis Terman of Stanford University, also a believer in "g," translated, adapted, and standardized the Binet-Simon scales in the United States. When he published the Stanford-Binet in 1916, it became the undisputed king of intelligence tests and retained that title for nearly a half-century.

A second great influence on the development of IQ tests in the United States was America's entry into World War I in 1917. The necessity of testing large numbers of recruits quickly led to the development of group-administered intelligence tests: the Army Alpha (a multiple-choice Binet-like test of language abilities) and the Army Beta (composed of nonverbal tasks), to assess the mental abilities of immigrants who spoke English poorly. Ultimately, the individually administered Army Performance Scale Examination was developed for suspected malingerers and for others who could not be tested validly in a group format. The practical outcomes of this war effort were many, including the notion that IQ tests were useful for adults (not just children), they were valid (data from almost 2 million soldiers were analyzed), and they were controversial (thanks to irresponsible misinterpretations of the data by some prejudiced wartime researchers that led to cries of racism and inferiority).

The link between the practical innovations of Binet, Terman, and wartime psychologists and current clinical assessment practices as we approach the 21st century is one man: David Wechsler. A clinical examiner during World War I, Wechsler became aware of the need for fair assessment of people who spoke English poorly. His Wechsler series of scales continues to reign as the worldwide king of IQ tests.

Wechsler blended tasks from the Stanford-Binet and Army Alpha to develop his Verbal scale and from the Army Beta and Army Performance Scale Examination to create his Performance scale. His creativity came from his insistence that everyone be evaluated on both verbal and nonverbal tasks and that multiscore test profiles are more valuable for interpreting human intelligence than is a single global IQ. Conventional wisdom encouraged the administration of relatively brief verbal tasks instead of time-consuming nonverbal items to anyone who spoke English.

Though Wechsler was a firm believer in "g" theory, he was first and foremost a clinician who considered his IQ tests to measure an aspect of personality and to be clinical instruments more than psychometric devices. Although Wechsler developed his tests from practical and clinical considerations, his tests have had important theory-based and neurologically relevant implications. His distinction between Verbal IQ (V-IQ) and Performance IQ (P-IQ) was subsequently related to neuropsychological theory in the 1950s by Ralph Reitan, and to cerebral specialization theory in the 1960s by Roger Sperry. Deficits in V-IQ related to damage to the left hemisphere and deficits in P-IQ were associated with damage to the right hemisphere.

No test is able to measure all abilities that lie within the complex domain of intelligence. Tests measure only a segment of the diverse abilities that define Howard Gardner's theory of intelligence and assess only one dimension of Robert Sternberg's triarchic theory, namely analytic abilities but not creative or practical abilities. Indeed, they measure only a small portion of skills that might rightfully define the domain of intelligent human behavior. Yet they do measure abilities that are able to be assessed objectively and that are stable over time; that are either theory-based or intimately related to well-respected neuropsychological and empirical theories of intelligence; that have demonstrated validity for predicting school achievement; that have diagnostic utility for clinical populations such as those with learning disabilities or Alzheimer disease; that are clinical tools, as Wechsler initially visualized them, to evaluate aspects of one's personality; and that offer insight into diverse real-life issues such as IQ and aging and genetics versus environment. It is to the latter topic that I now turn.

The main way that scientists have studied the role of genetics and environment in determining IQ and other variables has been to investigate individuals who differ in their degree of blood relationship. For example, if genetics plays a role in IQ, then identical twins should have IQs that correlate more highly than the IQs of fraternal twins; siblings' IQs should correlate more highly than those of cousins; and so forth. The results of this aggregation of data can be used either by genetics-oriented or environment-oriented individuals to support their position.

The importance of genetics in influencing one's IQ is supported by these results:

1. Identical (monozygotic or MZ) twins' IQs are more similar than those of fraternal (dizygotic or DZ) twins (0.86 versus 0.60).
2. IQs of siblings correlate more highly than IQs of half-siblings (0.47 versus 0.31), which, in turn, correlate higher than IQs of cousins (0.15).
3. Correlations between a biological parent and child living together are higher than correlations between an adoptive parent and child living together (0.42 versus 0.19).

In contrast, the following results support the role of environment in determining one's IQ:

1. IQs of DZ twins correlate more highly than IQs of siblings of different ages (0.60 versus 0.47) despite the same degree of genetic similarity.
2. Unrelated siblings reared together (adoptive/natural or adoptive/adoptive) have IQs that are more similar than do biological siblings reared apart (0.32 versus 0.24).
3. Correlations between IQs of an adoptive parent and a child living together are similar to correlations of a biological parent and a child living apart (0.19 versus 0.22).
4. Siblings reared together have IQs that are more similar than siblings reared apart (0.47 versus 0.24). The same finding holds for parent and child, when they are living together (0.42) or apart (0.22).

The results of data from thousands of subjects indicate that heredity is important in determining a person's IQ, but that environment is also a vital factor. Based on many twin studies, the heritability percentage for IQ is approximately 50, not as high as the value of 80 for height, but comparable in magnitude with the value for weight. The weight comparison is good. In general, overweight people have a genetic predisposition for a large frame and a metabolism that promotes gaining weight, whereas extremely thin people have the opposite predisposition. But for any given individual, lifestyle (eating habits, exercising) has a substantial effect on weight. The analogy to IQ development is self-evident. And, as with weight, genetics and environment interact in determining IQ. People with genetic overlaps (parents, siblings) usually share common environments.

One of fascinating aspect of genetic research provides a caveat regarding all previous data and conclusions discussed. Heritability estimates are based to a large extent on correlations involving MZ versus DZ twins. However, one potentially crucial variable has been ignored in most genetic research, namely a placentation (chorion) effect. Did the MZ twins share a single placenta (monochorionic) or did they have separate placentas (dichorionic)? When the zygote divides within 72 hours after fertilization, the MZ twins are dichorionic but when the division occurs from day 4 to 7, they share one placenta. Data indicate that MZ twins who differ on the chorion effect also differ in birth weight, cord blood cholesterol level, adult personality, and cognition. About two thirds of MZ twins are monochorionic.

Regarding cognitive differences, correlations between IQ tasks may be a function of the chorion effect. Table 1 demonstrates this finding for 2 WAIS subtests, Vocabulary (a prototypical measure of Gc) and Block Design (a measure of Gf). As shown, adult MZ twins scored almost identically on Vocabulary regardless of chorion classification, but on Block Design the close similarity held only for monochorionic twins. Dichorionic twins were no more similar in their test performance than DZ twins. This finding was upheld for 8- to 12-year-old MZ twins in France.

These cross-validated findings from Canada and France (hospitals in the United States do not typically record chorion category) indicate that an infant's earliest environment may influence later IQ. Those adult MZ twins whose intrauterine environment was different (dichorionic) performed more differently on Block Design than those with virtually the same environment. Ironically, the greatest effect seems to be on a nonverbal measure of an ability believed to be closely aligned with neurological development, rather than with the verbal, education-dependent Gc subtest. The results require additional replication and generalization to be accepted as scientific findings; furthermore, some significant findings in the chorion studies indicate greater similarities among dichorionic than monochorionic MZ twins. The findings are, however,

TABLE 1
Adult Monozygotic and Dizygotic Twins and the Chorion Effect: Correlations on the WAIS Vocabulary and Block Design Subtests

Twin Classification	Twin Pair *n*	Vocabulary	Block Design
Monozygotic (identical)			
Monochorionic (1 placenta)	17	0.95	0.92
Diochorionic (2 placentas)	15	0.95	0.48
Dizygotic (fraternal)	28	0.55	0.44

sufficiently provocative to challenge all known heritability estimates pertaining to intelligence and personality because pertinent studies failed to control for the chorion effect.

WEB SITES OF INTEREST

http://hss.cmu.edu/html/departments/history/directory/Daniel_Resnick.html
http://www.stockton-press.co.uk/mp/index.html

ADDITIONAL READINGS

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