Research News

The Genetics of Personality

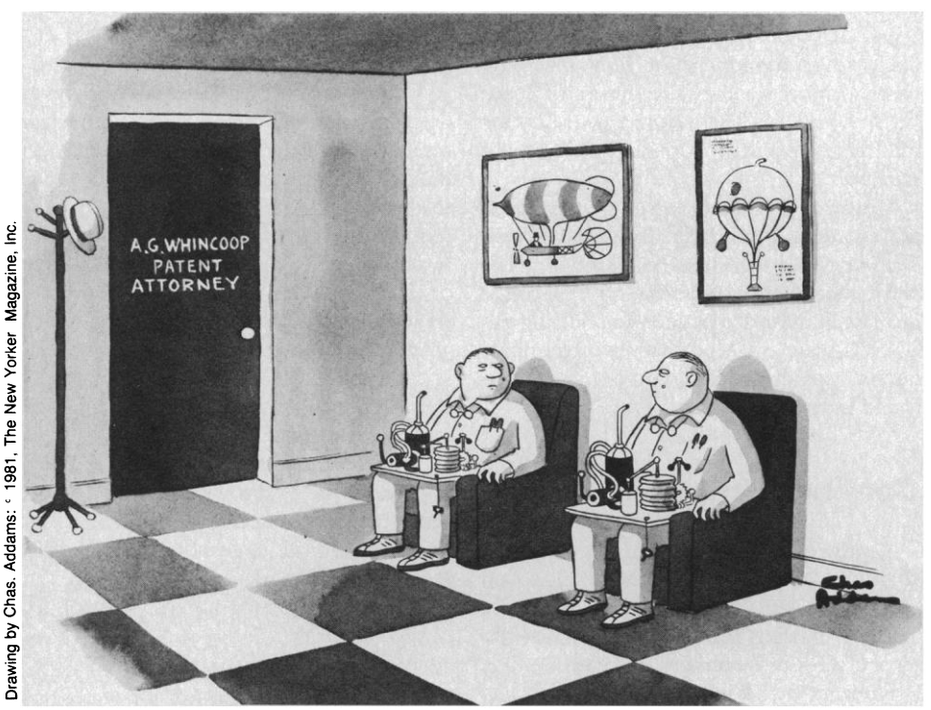
What makes family members alike? Genetic similarity seems to be a far better predictor than environmental factors, according to adoption studies and research on twins

When Oskar Stöhr and Jack Yufe arrived in Minneapolis to participate in University of Minnesota psychologist Thomas J. Bouchard, Jr.'s study of identical twins reared apart, they were both sporting blue double-breasted epauletted shirts, mustaches, and wire-rimmed glasses. Identical twins separated at birth, the two men, in their late 40s, had met once before two decades earlier. Nonetheless, Oskar, raised as a Catholic in Germany, and Jack, reared by his Jewish father in Trinidad, proved to have much in common in their tastes and personalities—including hasty tempers and idiosyncratic senses of humor (both enjoyed surprising people by sneezing in elevators).

The idea that humans can inherit certain behavioral tendencies arouses skepticism among many people, particularly in the United States where it seems to conflict with egalitarian ideals and conjures up a specter of "biological determinism." Yet research in behavioral genetics, particularly within the past two decades, has shown that, as Richard Rose of Indiana University says, "No dimension of behavior seems to be immune to the effects of genetic expression."

Behavioral genetics involves attempts to quantify the relative genetic and environmental contributions to the behavioral differences between individuals through the use of questionnaires and objective tests. The basic tools of the enterprise—adoption studies and studies of identical and fraternal twins—have been in use for more than 100 years, having been first introduced in England by Sir Francis Galton.

Galton's famous statement that within a given stratum of a population, "nature prevails enormously over nurture," would be a naked heresy to most modern social scientists. It does indeed imply a false dichotomy in view of the interrelatedness of genetic and environmental influences. Yet, research suggests that Galton's essential perception is closer to the truth than the overwhelmingly environmentalist interpretations of human behavior that have held sway in the postwar years.



Drawing by Chas. Addams; © 1981, The New Yorker Magazine, Inc.

Separated at birth, the Mallifert twins meet accidentally.

In recent decades twins and adoptees have been used to separate environmental from genetic influences for a wide variety of traits both normal and pathological. As enumerated by J. Philippe Rushton of the University of Western Ontario, traits and conditions for which substantial heritabilities have been detected include "activity level, alcoholism, anxiety, criminality, dominance, extraversion, intelligence, locus of control [personal autonomy], manic-depressive psychosis, political attitudes, schizophrenia, sexuality, sociability, values, and vocational interests."

The subjects of inquiry can roughly be divided into three parts: psychopathology, cognitive abilities, and personality. Family studies have long indicated that genes play a role in the development of mental illnesses, and more recent research in molecular biology has turned up clues as to specific biochemical and genetic causes, as evidenced by the recent identification of one, and possibly two, genes for manic depression. Substantial heritability for cognitive abilities as measured in various IQ tests has also been repeatedly documented by such studies, although this politically controversial area continues to be debated.

Personality is the most recent area of human behavior to be subjected to the methodology of behavioral genetics. As with IQ, the absence of biological indicators means that the evidence boils down to statistics. Psychologist Irving Gottesman of the University of Virginia, who founded the country's first behavioral genetics department at the University of Minnesota in the early 1960s, likens the situation to a trial: "Much of the evidence we are dealing with is circumstantial or indirect, but if you accumulate enough information it will persuade an impartial jury that something indeed did happen."

What studies have revealed in recent years poses a fundamental challenge to conventional wisdom about the importance of childhood environment. It is that the environment shared by members of the same family has little or no role in producing whatever personality similarities they exhibit. Psychologist Robert Plomin of Pennsylvania State University calls this "the single

most important finding in behavioral genetics in the last decade." If that is correct, it means that although environmental influences are important in shaping personality, the nature of those influences is not what has been commonly thought.

Behavioral geneticists are finding that genes account for about 50% of the variance (that is, 50% of the range found in a given study population) in most normally distributed traits. Most of the remaining differences are attributed to environmental influences unique to individuals—ranging from individual parent-child interactions to peer influences to random events. So, although the family environment may influence personality, it does so in a nonuniform and therefore unpredictable way in different individuals.

One of the most recent papers suggesting this comes from Bouchard's ongoing study of identical twins reared apart (part of a larger twin project directed by Minnesota psychologist David T. Lykken). The group has recently produced a paper,* which reports the results of a personality questionnaire (see box) given to four groups of twins, identical and fraternal, reared together and apart.

The sample is relatively small (so far, it includes 44 pairs of identical twins reared apart), but the authors regard the design as powerful because of its built-in redundancy, allowing heritability to be estimated in two ways. One way is by estimating the average correlation (degree of similarity within a twin pair) in a group of identical twins reared apart, where all similarities are presumed genetic since the environment they share is no more similar than that of two individuals selected at random. Another type of estimate can be made with a formula comparing the average correlation of a group of fraternal twin pairs to that obtained from identical twins. Heritability of a given trait (the range of variance attributed to the genes) is estimated by doubling the difference between the two correlations.

In the Minnesota study, the overall heritability of the traits measured came out at about 0.50. The study, whose findings the investigators call "both remarkable and puzzling," showed that the correlations for the identical twins reared apart and those reared together are "remarkably alike" on the 11 personality factors measured. The median correlation was 0.49 for the identical twins reared apart and 0.52 for those reared together. The median correlation for fraternal twins reared together was about 0.23—roughly half the correlation for identical twins and about what would be predicted if calculations were based solely on the proportions of genes shared by twin pairs.

These statistics indicated that their common environment must have contributed very little to the similarity between the twins reared together, since this was the only factor on which they differed from the twins reared apart. The genetic influences, however, appeared to be substantial, with heritabilities on the primary personality dimensions ranging from 0.39 to 0.58.

The study also added to evidence that social attitudes are not purely learned but are affected by deeper personality traits. The heritability estimate for "traditionalism," which is related to conservative political and social attitudes (respect for discipline and authority), was 0.45.

Two recent studies have added some provocative data on the extent to which social and political attitudes appear to be genetically influenced. One is by Australian researcher Nicholas Martin of the Queensland Institute of Medical Research and Lindon Eaves of the Medical College of Virginia, based on twins in England and Australia. Investigators mailed out questionnaires using the Wilson-Patterson conservatism scale, which taps attitudes on a variety of socially and politically controversial matters. Data were obtained on 3810 pairs of identical and fraternal twins.

In most cases the correlations between the identical twins significantly exceeded those for the fraternal pairs. For example, in the most extreme case, male twins' opinions on the death penalty correlated at 0.52 for the identical twins and 0.31 for the fraternal twins, yielding a heritability estimate of 0.51, and 0 for common environment. Eighteen other items, ranging from opinions on disarmament to computer music, showed strong support for the genetic component and little for cultural inheritance. On only three items did the influence of the common environment significantly exceed that of the genes. The investigators found the evidence consistent with the hypothesis that "individuals are influenced by their genotypes in their acquisition of particular opinions from the range current in a given society."

The other study, reported by Rushton of Western Ontario, focuses on the heritability of altruism and aggression, traits that are related to both personality and social attitudes. Rushton and his colleagues adminis-

*"Personality Similarity in Twins Reared Apart and Together," by A. Tellegen *et al.*, in preparation.

Measuring Personality

The measurement of personality is a controversial topic in its own right. It is "a different and more temperamental animal" than IQ, says psychologist Auke Tellegen of the University of Minnesota.

There is wide agreement on the pervasiveness and stability of two "superfactors": extraversion (which includes sociability and impulsivity) and neuroticism (emotional sensitivity and anxiety). But there is no consensus on exactly how the normal personality should be divided up.

The best known major personality dimensions are those described by Hans Eysenck of Maudsley Hospital in London. These are extraversion, neuroticism, and psychoticism (which actually denotes nonconforming or antisocial tendencies and eccentricity).

Other tests correspond roughly to these dimensions. One, used on the Minnesota twins, is the Multidimensional Personality Questionnaire, developed by Tellegen. Based on factor analyses of items from many other tests, it has 300 items that can be distilled into three "higher order" traits: "positive affectivity" (like extraversion), "negative affectivity" (neuroticism), and "constraint" (the opposite of Eysenck's psychoticism).

The content is also broken down into 11 "primary personality dimensions": well-being, social potency, achievement, social closeness, stress reaction, alienation, aggression, control, harm avoidance, traditionalism, and absorption.

Each item relates to one of these dimensions. For example, "I rarely, if ever, do anything reckless" *relates to harm avoidance, which contribute to the superfactor of constraint. "I would be more successful if people did not make things difficult for me" relates to alienation, and the superfactor of negative affectivity. "The crackle and flames of a wood fire stimulate my imagination" relates to absorption, and to both positive and negative affectivity. ■ **C.H.**

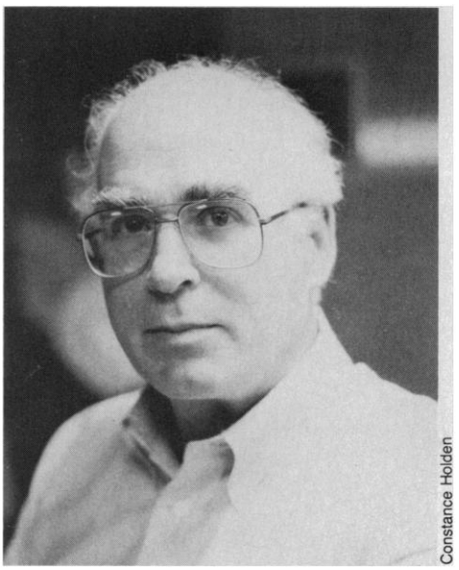
tered questionnaires to 573 pairs of adult twins from the University of London twin register. Five different questionnaires were used, designed to probe behaviors and attitudes related to altruism, empathy, nurturance, aggressiveness, and assertiveness.

Comparison of the identical and fraternal twin pair correlations yielded heritability estimates ranging from 0.56 to 0.72. Virtually no influence was detected from twins' common environment. "It is of interest to find similar results for altruism and aggression," write the authors, "because these are traits that parents might be expected to socialize heavily."

The first authoritative study to document a strong genetic influence across a wide array of personality characteristics was conducted by psychologists John C. Loehlin and Robert C. Nichols at the University of Texas in 1976. This was an assessment of 514 pairs of identical twins and 336 pairs of fraternal twins who had taken the 1962 National Merit Scholarship Qualifying Test. All the personality traits measured yielded median heritabilities of about 0.50. No effect of shared environment could be detected. "As far as personality and interests are concerned," wrote the authors, "it would appear that the relevant environments of a pair of twins are no more alike than those of two members of a population paired at random."

Research by Sandra Scarr of the University of Virginia and Richard A. Weinberg of the University of Minnesota tends to support Loehlin's conclusion that "shared family life tends to make biologically unrelated individuals a little bit alike, but it is a very little bit indeed." Scarr, a developmental psychologist, says "my views have really changed," particularly with the results of a Minnesota study, which looked at the cumulative effects on personality, by the end of the child-rearing period, of young people who were adopted at infancy. Although there was some family resemblance at early ages, the ultimate finding was that the biological children of a family and their adopted siblings "didn't resemble each other at all in anything"—including IQ and a scale measuring "authoritarian" attitudes. It was "not what we expected to find," says Scarr.

A major study that is attempting to explore in more detail the salient aspects of early environment is the Colorado Adoption Project, begun in 1975. This study covers 245 adoptees and their families matched with 245 nonadoptive control families. It also includes data about the adoptees' biological mothers. Tests include measures of cognition, temperament, language development, and behavior problems as well as physical development from infancy. Tests



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Thomas Bouchard. *Amazed at the similarities between identical twins reared apart.*

are particularly designed to illuminate one of the trickiest areas of uncertainty: the nature and extent of genotype-environment correlations.

According to Robert Plomin, co-founder of the project, it is becoming increasingly clear that the impacts of many environmental influences are genetically mediated. This is indicated by the fact that for a number of measures used in the study, the correlations between infant environment and development—that is, "good" environments correlating with "good" developmental outcomes—were higher in the biological than the adoptive families.

Findings such as these, says Plomin, point to the need for "a dramatic reconceptualization of how developmental psychologists think about the environment."

One of the most important aspects of genetics being illuminated by the field of behavioral genetics is the changing influences exerted by genes over an individual's development. The longest running project to explore this is the Louisville Twin Study, started in the 1950s by the late Ronald Wilson of the University of Louisville. According to his colleague Adam P. Matheny, Jr., Wilson was the one to come up with a "basic model to document the possibility that changes over development are not necessarily owing to environment but are part of the individual's genetic endowment."

The subjects are twins from birth to age 15, who are subjected to detailed laboratory observations up to the age of 24 months on measures related to temperament: activity level, sociability, and emotionality. The chief finding has been that, in Wilson's words, "behavioral development is guided by a genetic strategy analogous to that for biological development." This influence on temperament "may be inferred not just from stabilities over age, but also from synchronized patterns of change"—as demonstrated by the high correspondence between the developmental courses of identical, compared with fraternal, twins (*Science*, 1 December 1978, p. 939).

Although behavioral geneticists quibble about each others' methodologies, most appear to be in accord with the conclusion that the common environment seems to have a negligible role in creating personality similarities among family members. From the standpoint of the organism, it seems, there may be no such thing as a common environment for two given individuals unless those individuals also have all their genes in common.

One researcher, however, Rose of Indiana University, thinks it is premature to "close the door" on common environment. He says that a large Finnish survey—of 4640 adult identical twins—has demonstrated that the frequency of social contact between members of a pair is closely related to their degree of similarity on measures of neuroticism—indicating that the experiences they share are influencing at least some aspects of their personalities. The same held true for females, but not males, on measures of extraversion.†

Evidence that the genes play a strong hand in personality development is greeted by many people outside the field with skepticism, but those who are familiar with the studies in question tend to think the findings make sense. "The more familiar you are with the evidence the more persuasive it becomes," says Elliot Gershon, a psychiatric geneticist at the National Institute of Mental Health.

An exception is Stanford geneticist L. L. Cavalli-Sforza who has done work on "vertical cultural transmission" of certain attitudes

†Extraversion is an especially tricky trait for behavioral geneticists, as it raises the possibility of "nonadditive" gene action. Most traits appear to be inherited according to the simple additive model first posited by Mendel. This means that individuals who share 50% of their genes in common will correlate for a given trait about half as well as identical twins. But with some traits, including extraversion, the correlation for identical twins is more than twice as high as for fraternal twins.

This raises several possible interpretations—for example, that there is something special about the identical twin environment that causes them to be more similar. Another possibility is that there are gene interactions that are unique to individuals that have all their genes in common—an assumption that would explain traits that may be strongly genetic but, because they rely on unique configurations of genes, do not run in families. Some concept of gene interaction may be needed to explain the fact that estimates of heritability based on parent-child or (nontwin) sibling-sibling correlations are commonly lower than they are for twins. According to Tellegen, if nonadditive effects are operative "the twin data may tell a truer story, and the data based on nontwins may underestimate the actual impact of genetic factors."

and behaviors. In one study, he and geneticist Marcus W. Feldman claimed strong evidence for cultural transmission of political and religious attitudes in a survey of college students, their parents, and friends (*Science*, 1 October 1982, p. 19). The study was not designed to separate out genetic influences, but the researchers cited work by Loehlin and Nichols showing that there was little difference between the identical and fraternal twin correlations on religious, political, and social attitudes. They therefore concluded that transmission of these traits had "little or no genetic basis."‡

Cavalli-Sforza is skeptical of the data in the Martin-Eaves paper on transmission of social attitudes. He believes the model used is "extremely rigid" and fails to account for genotype-environment interaction, which means that people with different genotypes have different patterns of sensitivity to environmental influences.

Lindon Eaves counters that a model based on genotype-environment interaction would fail to account for the fact that identical twins are similar whether or not they are reared together, because it would predict very low correlations for twins reared apart resulting from the lack of correlation between their environments. Says Eaves, with regard to Cavalli-Sforza's research, "As long as you stick to nuclear families, the effects of genes and culture are inextricably bound up . . . the only way to unbind them is to look at twins and adoptions."

Behavioral geneticists believe their field offers the most promising methods for detecting which environmental factors do in fact influence personality—a quest that has provided sometimes meaningless results in studies that make no provision for genetic factors.

Researchers in various substantive areas are attempting to forge links with other fields in several directions. With psychopathology, the greatest promise is in the field of molecular genetics and neurochemistry. Among those interested in antisocial behavior (which straddles the line between personality and psychopathology), some believe it will be possible to find neurophysiological and neurochemical correlates with traits such as lack of impulse control.

‡These were the best data available at the time. However, subsequent studies are in harmony with Martin's findings on political and social attitudes. A possible explanation for the discrepancy relates to assortative mating, which exists when people choose mates who share similar traits. Allowance for this phenomenon must be made in heritability estimates; otherwise, the apparent effect of family environment will be higher than would be predicted from random mating, because the correlations for fraternal twins will be more than half those for identical twins. Although assortative mating appears to be negligible for personality characteristics, it is quite strong for both IQ and attitudes. The Loehlin and Nichols study made no allowances for it; the Martin study does.

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Lindon Eaves. *Cultural transmission cannot be studied without looking at twins and adoptions.*

With regard to IQ, some researchers are circumventing the controversial nature of their subject by focusing on narrow traits related to general intelligence—such as reaction times, spatial abilities, and infant behaviors that correlate with adult IQ.

Developmental behavioral geneticists are heading in a different direction as they seek to forge ties with developmental psychology by introducing the genetic dimension to a field that emphasizes generalizations about development rather than examining individual differences.

Another attempt at outreach is personified by Rushton of Western Ontario, who believes the principles of sociobiology, which apply to differences between species, could well be applied to differences among humans. He believes that findings such as those on the heritability of altruism and aggression may yield important clues on how the interplay of cultural and genetic modes of transmission operates on natural selection.

The political climate for behavioral genetics has changed quite dramatically in the past decade, primarily because of the biological revolution in psychiatry. But general criticisms of the methodology remain the same as they were at the peak of the heredity-IQ controversy. Psychologist Leon Kamin of Princeton, who has accused researchers of biological determinism, says that the same old problems remain: it is difficult to eliminate the effects of selective placement in adoption studies, and the effects of "twinness" artificially raise apparent heritabilities.

Gershon believes behavioral geneticists are working with a proven methodology. He points out that "for many years the evidence on genetic contributions to major psychiatric disorders was all found in the statistics of twin studies, family studies, and adoption studies." Now, he says, "the validity of these approaches has been confirmed" by the recent genetic findings in disorders such as Huntington's disease and manic depression. Theodore Reich, a psychiatric geneticist at the Washington University, St. Louis, points out that it should be no surprise that the genes influence personality traits—animal breeders, who breed farm and hunting animals not only for temperament but for specific behaviors, have known it for centuries.

Critics of behavioral genetics fear that findings will be construed as explaining race differences, particularly when it comes to discussions of crime and IQ. But researchers stress that their field is designed primarily for the examination of individual rather than group differences. They emphasize that differences between individuals are far greater than differences between racial or gender groups (although some significant sex differences have been identified in traits related to aggression and antisocial behavior). Almost all study populations, moreover, have been composed of whites whose rearing environments are in the normal range; the more homogeneous the environment, the stronger the genetic contribution to behavior will appear. Thus, heritabilities cannot necessarily be generalized to groups subjected to severely deprived environments.

The biggest question that remains to be answered is: what are the mechanisms by which genes influence behavioral characteristics? No one expects to get far, at least in the near future, in identifying specific genes for normal traits. Although single defective genes can produce lowered IQs as well as psychopathology, behavior geneticists say normal traits result from combinations of hundreds of genes. Says medical geneticist Arno Motulsky of the University of Washington: "The biological substrate is still a black box."

At this point, probably nothing more explicit can be said than what has been written by Harvard sociobiologist E. O. Wilson in *On Human Nature*: "The behavioral genes . . . probably influence the ranges of the form and intensity of emotional responses, the thresholds of arousals, the readiness to learn certain stimuli as opposed to others, and the pattern of sensitivity to additional environmental factors that point cultural evolution in one direction as opposed to another." ■ **CONSTANCE HOLDEN**

SUGGESTED READING

J. C. Loehlin and R. C. Nichols, *Heredity, Environment, and Personality* (Univ. of Texas Press, Austin, 1976).

R. Plomin and D. Daniels, "Why are children in the same family so different from one another?" *Behav. Brain Sci.* **10**, 1 (1987).

N. G. Martin *et al.*, "Transmission of social attitudes," *Proc. Natl. Acad. Sci. U.S.A.* **83**, 4364 (1986).