Genes, Environment, and Personality

Thomas J. Bouchard Jr.

The idea that genetic factors influence behavior, including personality, is very old. The most compelling evidence has always been, as Darwin (*1*) noted, the successful domestication of animals.

> So in regard to mental qualities, their transmission is manifest in our dogs, horses and other domestic animals. Besides special tastes and habits, general intelligence, courage, bad and good tempers, etc., are certainly transmitted.

Unlike genetic influences on the intelligence quotient, which have been studied continuously since the time of Galton a century ago, the study of genetic influences on personality has had a much briefer history. Although Galton discussed genetic influence on personality, the lack of reliable and valid measures of personality qualities hampered progress. In addition, until recently, psychologists could not agree on which were the important traits of personality. Currently there is a modest consensus that five broad traits or "super factors" are necessary to describe personality—extraversion, neuroticism, conscientiousness, agreeableness, and openness (*2*) (see table).

Until the early 1980s, the evidence for genetic influence on personality derived almost exclusively from twin studies that utilized very modest sample sizes and measured different variables. Heritability was estimated as twice the difference between the correlation for identical or monozygotic (MZ) twins and that for fraternal or dizygotic (DZ) twins. The typical conclusion was that about 50% of the observed variance in personality is due to genetic factors (*3*). The influence on personality of the shared home environment (estimated as twice the DZ correlation minus the MZ value) was concluded to be small or even negligible. These simple equations make a number of assumptions, including (i) on average DZ twins share half as many genes in common by descent as MZ twins, (ii) the genes act additively, and (iii) MZ and DZ twins experience the same shared environmental influences. If the assumptions are correct, the difference between the two types of twins reflects one-half the genetic influence on the trait being studied.

The conclusion that 50% of the variation in personality is genetic was not universally embraced. Many psychologists questioned that MZ and DZ twins experience the same home environment and ascribed much of the greater similarity of MZ twins over DZ twins to more similar environmental treatment of the MZ than the DZ twins. It also seemed implausible to psychologists that being reared in the same home would have so little influence on sibling similarity. Consequently these findings were not generally accepted outside of behavioral genetics.

In recent years, three trends have converged to transform our understanding of genetic and environmental influences on personality traits. First, studies of twins reared together with very large sample sizes, in some instances over 2000 pairs of each sex and zygosity, have been carried out. Second, data have been gathered from monozygotic and dizygotic twins reared apart (MZA and DZA), as well as from both biological and adoptive families. Third, powerful methods of model fitting have been introduced that allow full utilization of the available information and statistical testing of competing hypotheses (*4*, *5*).

The figure compares the results of the early twin studies, an analysis of an extremely large data set assembled by Loehlin (*6*), and our own analysis of MZA (n = 59) and DZA (n = 47) data from the Minnesota study of twins reared apart (MISTRA) and MZT (n = 522) and DZT (n = 408) twins from the Minnesota Twin Registry (*7*). The Loehlin analysis yields an estimated genetic influence of 42% (with a sizable contribution from nonadditive genetic factors—influences that are configural and not inherited in a simple additive manner) and a very modest contribution of the shared environment. The most parsimonious fit to the Minnesota data is a simple additive genetic model for all five traits with an estimate of genetic influence of 46%. Addition of nonadditive genetic and shared environmental parameters do not, however, significantly change the fit of the model, and those data are shown in the figure for comparison with the Loehlin analysis. Both approaches yield estimates of genetic influence of just over 40% and modest estimates of shared environmental influence (7%). Of the remaining variance, about half is due to nonshared environmental influences and half to error of measurement. Thus, about two-thirds of the reliable variance in measured personality traits is due to genetic influence.

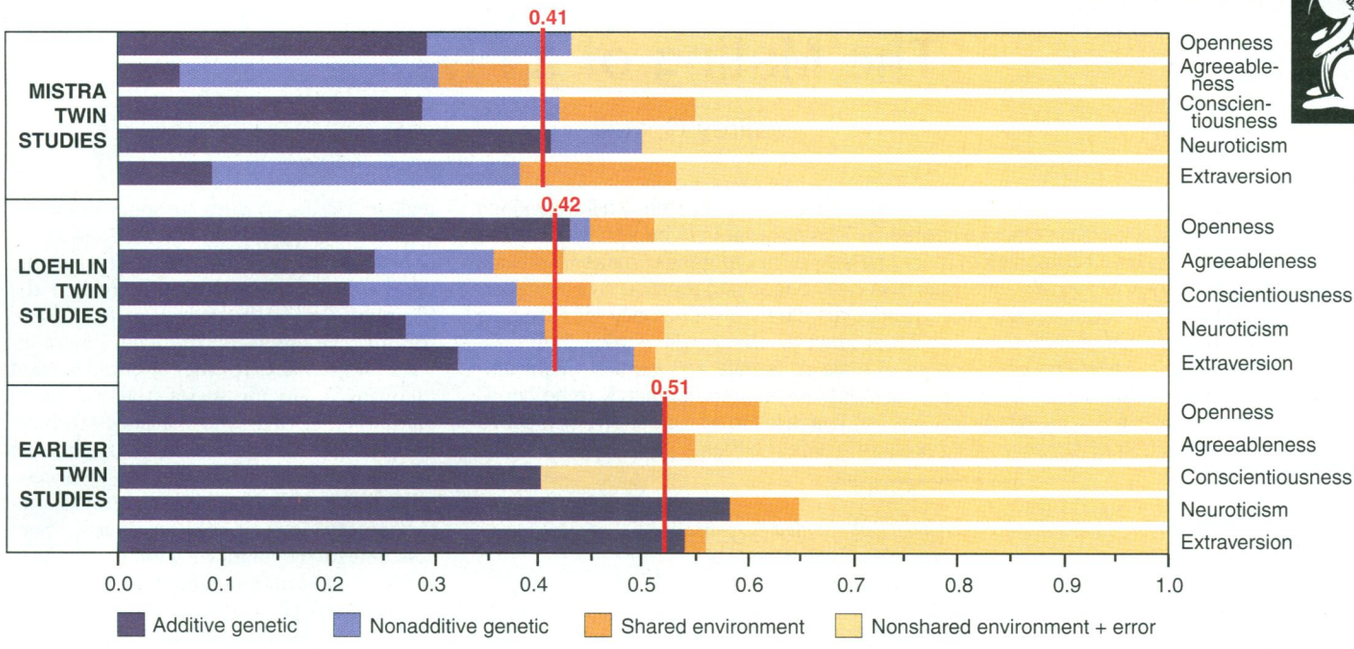
The early studies of twins appear to have only slightly overestimated the degree of genetic influence on personality variation, and the main contribution of the more sophisticated recent analyses is that some of the genetic influence seems to be due to

Five Main Determinants of Personality

Extraversion: Surgency, Introversion-Extraversion (–), Dominance, *Positive Emotionality*	
Is outgoing, decisive, persuasive, and enjoys leadership roles	Is retiring, reserved, withdrawn, and does not enjoy being the center of attention
Neuroticism: Anxiety, Emotional Stability (–), Stress Reactivity, *Negative Emotionality*	
Is emotionally unstable, nervous, irritable, and prone to worry	Quickly gets over upsetting experiences, stable, and not prone to worries and fears
Conscientiousness: Conformity, Dependability, Authoritarianism (–), *Constraint*	
Is planful, organized, responsible, practical, and dependable	Is impulsive, careless, irresponsible, and cannot be depended upon
Agreeableness: Likability, Friendliness, Pleasant, *Aggression (–)*	
Is sympathetic, warm, kind, good-natured, and will not take advantage of others	Is quarrelsome, aggressive, unfriendly, cold, and vindictive
Openness: Culture, Intellect, Sophistication, Imagination, *Absorption*	
Is insightful, curious, original, imaginative, and open to novel experiences and stimuli	Has narrow interests, is unintelligent, unreflective, and shallow

Negative signs indicate trait names that characterized to opposite end of the dimension. The italic trait terms indicate the Multidimensional Personality Questionnaire factors or scales used to measure these five characteristcs in the Minnesota study of twins reared apart.

The author is in the Department of Psychology, University of Minnesota, Minneapolis, MN 55455–0344, USA.



Sources of variation in personality in three sets of data. Percentages of variance accounted for by various genetic and environmental influences in personality traits. The solid lines indicate the mean Falconer heritability for the twin data from earlier studies and the mean broad heritability from model fitting for the other data sets.

nonadditive genetic variance for all five traits. All three analyses yield quite small estimates of shared environmental influence. This is now a well-replicated finding in behavior genetics, and its implications are straightforward. The similarity we see in personality between biological relatives is almost entirely genetic in origin. If we wish to study environmental influences on personality development in families, we must look for influences that operate differentially among children in the same family (*8*).

However, simply demonstrating that systematic differences in treatment within the family exist does not suffice to prove that such treatments explain personality differences. First, the treatment may have no effect. For example, differences in socialization due to birth order exist, but contrary to widespread belief (*9*), they do not influence personality (*10*). Second, as Lytton (*11*) has demonstrated, the differential behavior of children is often the cause of differential parental behavior rather than a consequence. Third, arguments as to the purported importance of environmental factors in shaping personality, though superficially plausible, often fail to stand up to scrutiny when subjected to quantitative analysis. Consider physical attractiveness. It is often argued that because twins reared apart are similar in physical attractiveness they must be treated alike, and therefore this is an important source of their similarity in personality (*9*, *12*). The problem with this argument is that physical attractiveness is so poorly correlated with personality traits that, when numbers are fit to the model implied by the argument, it can explain only a trivial portion of the similarity between MZA twins (*8*, *10*). In truth, how nontraumatic environmental determinants influence the normal range of variance in adult personality remains largely a mystery. This variation may even turn out to be the equivalent of noise (*13*).

Current thinking holds that each individual picks and chooses from a range of stimuli and events largely on the basis of his or her genotype and creates a unique set of experiences—that is, people help to create their own environments (*14*). This view of human development does not deny the existence of inadequate and debilitating environments nor does it minimize the role of learning. Rather, it views humans as dynamic creative organisms for whom the opportunity to learn and to experience new environments amplifies the effects of the genotype on the phenotype. It also reminds us of our links to the biological world and our evolutionary history. This brings us to the core problem of the genetics of personality—the function of the variation in personality traits. The purpose of this variation is undoubtedly rooted in the fact that humans have adapted to life in face-to-face groups (sociality). Unraveling the role human individual differences play in evolution is the next big hurdle (*15*), and its solution will turn the behavior genetics of human personality from a descriptive discipline to an explanatory one.

References

1. C. Darwin, *The Descent of Man and Selection in Relation to Sex* (Murray, London, 1871; reprinted by Modern Library, New York, 1967).
2. L. R. Goldberg, *Am. Psychol.* **48**, 26 (1993).
3. R. C. Nichols, *Homo* **29**, 158 (1978).
4. L. J. Eaves, H. J. Eysenck, N. G. Martin, *Genes, Culture and Personality: An Empirical Approach* (Academic Press, New York, 1989).
5. M. C. Neale and L. R. Cardon, Eds., *Methodology for Genetic Studies of Twins and Families* (Kluwer Academic, Dordrecht, 1992).
6. J. C. Loehlin, *Genes and Environment in Personality Development* (Sage, Newbury Park, CA, 1992).
7. T. J. Bouchard Jr., D. T. Lykken, M. McGue, N. L. Segal, A. Tellegen, *Science* **250**, 223 (1990).
8. D. Rowe, *The Limits of Family Influence: Genes, Experience, and Behavior* (Guilford, New York, 1994).
9. L. W. Hoffman, *Psychol. Bull.* **110**, 187 (1991).
10. T. J. Bouchard Jr., in *Basic Issues in Personality*, I. Deary and J. Hettema, Eds. (Kluwer Academic, Dordrecht, 1993).
11. H. Lytton, *Dev. Psychol.* **26**, 705 (1990).
12. B. D. Ford, *Am. Psychol.* **48**, 1294 (1993).
13. P. C. M. Molenar, D. I. Boomsma, C. V. Dolan, *Behav. Genet.* **6**, 519 (1993).
14. S. Scarr, *Child Dev.* **63**, 1 (1992).
15. D. M. Buss, in *Twins as a Tool of Behavioral Genetics*, T. J. Bouchard Jr. and P. Propping, Eds. (Wiley, Chichester, 1993).