Genetic Influence on Human Psychological Traits

A Survey

Thomas J. Bouchard, Jr.

University of Minnesota, Minneapolis

ABSTRACT—*There is now a large body of evidence that supports the conclusion that individual differences in most, if not all, reliably measured psychological traits, normal and abnormal, are substantively influenced by genetic factors. This fact has important implications for research and theory building in psychology, as evidence of genetic influence unleashes a cascade of questions regarding the sources of variance in such traits. A brief list of those questions is provided, and representative findings regarding genetic and environmental influences are presented for the domains of personality, intelligence, psychological interests, psychiatric illnesses, and social attitudes. These findings are consistent with those reported for the traits of other species and for many human physical traits, suggesting that they may represent a general biological phenomenon.*

KEYWORDS—*behavior genetics; heritability; individual differences*

Among knowledgeable researchers, discussions regarding genetic influences on psychological traits are not about whether there is genetic influence, but rather about how much influence there is, and how genes work to shape the mind. As Rutter (2002) noted, "Any dispassionate reading of the evidence leads to the inescapable conclusion that genetic factors play a substantial role in the origins of individual differences with respect to all psychological traits, both normal and abnormal" (p. 2). Put concisely, all psychological traits are heritable. Heritability (h^2) is a descriptive statistic that indexes the degree of population variation in a trait that is due to genetic differences. The complement of heritability ($1 - h^2$) indexes variation contributed by the environment (plus error of measurement) to population variation in the trait. Studies of human twins and adoptees, often called behavior genetic studies, allow us to estimate the heritability of various traits. The name behavior genetic studies is an unfortunate misnomer, however, as such studies are neutral regarding both environmental and genetic influences. That they repeatedly and reliably reveal significant heritability for psychological traits is an empirical fact and one not unique to humans. Lynch and Walsh (1998) pointed out that genetic influence on most traits, as indexed by estimates of heritability, is found for all species and observed that "the interesting questions remaining are, How does the magnitude of h^2 differ among characters and species and why?" (p. 175).

Address correspondence to Thomas J. Bouchard, Jr., Psychology Department, University of Minnesota, 75 East River Rd., Minneapolis, MN 55455-0344; e-mail: bouch001@umn.edu.

WHY STUDY GENETIC INFLUENCES ON HUMAN BEHAVIORAL TRAITS?

A simple answer to the question of why scientists study genetic influences on human behavior is that they want a better understanding of how things work, that is, better theories. Not too many years ago, Meehl (1978) argued that "most so-called 'theories' in the soft areas of psychology (clinical, counseling, social, personality, community, and school psychology) are scientifically unimpressive and technologically worthless" (p. 806). He listed 20 fundamental difficulties faced by researchers in the social sciences. Two are relevant to the current discussion: heritability and nuisance variables. The two are closely related. Nuisance variables are variables assumed to be causes of group or individual differences irrelevant to the theory of an investigator. Investigators seldom provide a full theoretical rationale in support of their choice of nuisance variables to control. As Meehl pointed out, removing the influence of parental socioeconomic status (SES; i.e., treating it as a nuisance variable) on children's IQ, when studying the causes of individual differences in IQ, makes the assumption that parental SES is exclusively a source of environmental variance, as opposed to being confounded with genetic influence.[1] Meehl argued that this example "is perhaps the most dramatic one, but other less emotion-laden examples can be found on all sides in the behavioral sciences" (p. 810). His point was that knowledge of how genetic factors influence any given measure (e.g., SES) or trait (e.g., IQ) will allow scientists to develop more scientifically impressive and worthwhile theories about the sources of individual differences in psychological traits.

Evidence of genetic influence on a psychological trait raises a series of new questions regarding the sources of population variance for that trait. All the questions addressed in quantitative genetics (Lynch & Walsh, 1998) and genetic epidemiology (Khoury, 1998) become

[1]See Evans (2004, Fig. 1) for a recent commission of this error.

relevant. What kind of gene action is involved? Is it a simple additive influence, with the effects of genes simply adding up so that more genes cause greater expression of the trait, or is the mode of action more complex? Are the effects of genes for a particular trait more pronounced in men or women? Are there interactions between genes and the environment? For example, it has been known for a long time that stressful life events lead to depression in some people but not others. There is now evidence for an interaction. Individuals who carry a specific genetic variant are more susceptible to depression when exposed to stressful life events than individuals who do not carry the genetic variant (Caspi et al., 2003). Are there gene-environment correlations? That is, do individuals with certain genetic constitutions seek out specific environments? People who score high on measures of sensation seeking certainly, on average, tend to find themselves in more dangerous environments than people who score low for this trait. McGue and I have provided an extended list of such questions (Bouchard & McGue, 2003).

ESTIMATES OF THE MAGNITUDE OF GENETIC INFLUENCE ON PSYCHOLOGICAL TRAITS

Table 1 reports typical behavior genetic findings drawn from studies of broad and relatively representative samples from affluent Western societies. In most, but not all, of these studies, estimates of genetic and environmental influences were obtained from studies of twins. Because the studies probably undersampled people who live in the most deprived segment of Western societies, the findings should not be considered as generalizable to such populations. (Documentation for most of the findings can be found in Bouchard & McGue, 2003.)

Personality

Psychologists have developed two major schemes for organizing specific personality traits into a higher-order structure, the Big Five and the Big Three. As Table 1 shows, the findings using the two schemes are much the same. Genetic influence is in the range of 40 to 50%, and heritability is approximately the same for different traits. There is evidence of nonadditive genetic variance. That is, genes for personality, in addition to simply adding or subtracting from the expression of a trait, work in a more complex manner, the expression of a relevant gene depending to some extent on the gene with which it is paired on a chromosome or on genes located on other chromosomes. Research has yielded little evidence for significant shared environmental influence, that is, similarity due to having trait-relevant environmental influences in common. Some large studies have investigated whether the genes that influence personality traits differ in the two sexes (sex limitation). The answer is no. However, sometimes there are sex differences in heritability.

Mental Ability

Early in life, shared environmental factors are the dominant influence on IQ, but gradually genetic influence increases, with the effects of shared environment dropping to near zero (see the twin studies in Table 1). Although not reported here, adoption studies of (a) unrelated individuals reared together and (b) adoptive parents and their adopted offspring have reported similar results—increasing genetic influence on IQ with age and decreasing shared environmental influence. Results from two twin studies of IQ in old age (over 75) are reported in Table 1. Both studies found a substantial level of genetic influence and little shared environmental influence. The results do, however, suggest some decline in heritability when compared with results for earlier ages. There is no evidence for sex differences in heritability for IQ at any age.

Psychological Interests

Heritabilities for psychological interests, also called vocational or occupational interests, are also reported in Table 1. These heritabilities were estimated using data gathered in a single large study that made use of a variety of samples (twins, siblings, parents and their children, etc.) gathered over many years. All respondents completed one form or another of a standard vocational interest questionnaire. There is little variation in heritability for the six scales, with an average of .36. As with personality traits, there is evidence for nonadditive genetic influence. Unlike personality, psychological interests show evidence for shared environmental influence, although this influence is modest, about 10% for each trait.

Psychiatric Illnesses

Schizophrenia is the most extensively studied psychiatric illness, and the findings consistently suggest a very high degree of genetic influence (heritability of about .80), mostly additive genetic influence, with no shared environmental influence. There do not appear to be gender differences in the heritability of schizophrenia. Major depression is less heritable (about .40) than schizophrenia. Men and women share most, but not all, genetic influences for depression. Panic disorder, generalized anxiety disorder, and phobias are moderately heritable, and the effect is largely additive, with few if any sex differences. The heritability of alcoholism is in the range of .50 to .60, mostly because of additive genetic effects. Findings regarding the possibility of sex differences in the heritability of alcoholism are mixed.

Antisocial behavior has long been thought to be more heritable in adulthood than childhood. The results of a recent analysis do not support that conclusion. The genetic influence is additive and in the range of .41 to .46. Shared environmental influences decrease from childhood to adulthood, but do not entirely disappear in adulthood. There are no sex differences in heritability.

Social Attitudes

Twin studies reveal only environmental influence on conservatism up to age 19; only after this age do genetic influences manifest themselves. A large study (30,000 adults, including twins and most of their first-degree relatives) yielded heritabilities of .65 for males and .45 for females. Some of the genetic influence on conservatism is nonadditive. Recent work with twins reared apart has independently replicated these heritability findings. Conservatism correlates highly, about .72, with right-wing authoritarianism, and that trait is also moderately heritable.

Religiousness is only slightly heritable in 16-year-olds (.11 for girls and .22 for boys in a large Finnish twin study) and strongly influenced by shared environment (.60 in girls and .45 in boys). Religiousness is moderately heritable in adults (.30 to .45) and also shows some shared environmental influence. Good data on sex differences in heritability

TABLE 1

Estimates of Broad Heritability and Shared Environmental Influence and Indications of Nonadditive Genetic Effects and Sex Differences in Heritability for Representative Psychological Traits

Trait	Heritability	Nonadditive genetic effect	Shared environmental effect	Sex differences in heritability
Personality (adult samples)				
Big Five				
Extraversion	.54	Yes	No	Perhaps
Agreeableness (aggression)	.42	Yes	No	Probably not
Conscientiousness	.49	Yes	No	Probably not
Neuroticism	.48	Yes	No	No
Openness	.57	Yes	No	Probably not
Big Three				
Positive emotionality	.50	Yes	No	No
Negative emotionality	.44	Yes	No	No
Constraint	.52	Yes	No	No
Intelligence				
By age in Dutch cross-sectional twin data				
Age 5	.22	No	.54	No
Age 7	.40	No	.29	No
Age 10	.54	No	.26	No
Age 12	.85	No	No	No
Age 16	.62	No	No	No
Age 18	.82	No	No	No
Age 26	.88	No	No	No
Age 50	.85	No	No	No
In old age (> 75 years old)	.54–.62	Not tested	No	No
Psychological interests				
Realistic	.36	Yes	.12	NA
Investigative	.36	Yes	.10	NA
Artistic	.39	Yes	.12	NA
Social	.37	Yes	.08	NA
Enterprising	.31	Yes	.11	NA
Conventional	.38	Yes	.11	NA
Psychiatric illnesses (liability estimates)				
Schizophrenia	.80	No	No	No
Major depression	.37	No	No	Mixed findings
Panic disorder	.30–.40	No	No	No
Generalized anxiety disorder	.30	No	Small female only	No
Phobias	.20–.40	No	No	No
Alcoholism	.50–.60	No	Yes	Mixed findings
Antisocial behavior				
Children	.46	No	.20	No
Adolescents	.43	No	.16	No
Adults	.41	No	.09	No
Social attitudes				
Conservatism				
Under age 20 years	.00	NR	Yes	NR
Over age 20 years	.45–.65	Yes	Yes in females	Yes
Right-wing authoritarianism (adults)	.50–.64	No	.00–.16	NA
Religiousness				
16-year-olds	.11–.22	No	.45–.60	Yes
Adults	.30–.45	No	.20–.40	Not clear
Specific religion	Near zero	NR	NA	NR

Note. NA = not available; NR = not relevant.

of religiousness in adults are not available. Membership in a specific religious denomination is largely due to environmental factors.

A Note on Multivariate Genetic Analysis

In this review, I have addressed only the behavior genetic analysis of traits taken one at a time (univariate analysis). It is important to recognize that it is possible to carry out complex genetic analyses of the correlations among traits and compute genetic correlations. These correlations tell us the degree to which genetic effects on one score (trait measure) are correlated with genetic effects on a second score, at one or at many points in time. The genetic correlation between two traits can be quite high regardless of whether the heritability of either trait is high or low, or whether the correlation between the traits is high or low. Consider the well-known positive correlation between tests of mental ability, the evidentiary base for the general intelligence factor. This value is typically about .30. The genetic correlation between such tests is, however, much higher, typically closer to .80. Co-occurrence of two disorders, a common finding in psychiatric research, is often due to common genes. The genetic correlation between anxiety and depression, for example, is estimated to be very high. Multivariate genetic analysis of behavioral traits is a very active domain of research.

CONCLUDING REMARKS

One unspoken assumption among early behavior geneticists, an assumption that was shared by most for many years, was that some psychological traits were likely to be significantly influenced by genetic factors, whereas others were likely to be primarily influenced by shared environmental influences. Most behavior geneticists assumed that social attitudes, for example, were influenced entirely by shared environmental influences, and so social attitudes remained largely unstudied until relatively recently. The evidence now shows how wrong these assumptions were. Nearly every reliably measured psychological phenotype (normal and abnormal) is significantly influenced by genetic factors. Heritabilities also differ far less from trait to trait than anyone initially imagined. Shared environmental influences are often, but not always, of less importance than genetic factors, and often decrease to near zero after adolescence. Genetic influence on psychological traits is ubiquitous, and psychological researchers must incorporate this fact into their research programs else their theories will be "scientifically unimpressive and technologically worthless," to quote Meehl again.

At a fundamental level, a scientifically impressive theory must describe the specific molecular mechanism that explicates how genes transact with the environment to produce behavior. The rudiments of such theories are in place. Circadian behavior in humans is under genetic influence (Hur, Bouchard, & Lykken, 1998), and some of the molecular mechanisms in mammals are now being revealed (Lowrey & Takahashi, 2000). Ridley (2003) and Marcus (2004) have provided additional examples of molecular mechanisms that help shape behavior. Nevertheless, the examples are few, the details are sparse, and major mysteries remain. For example, many behavioral traits are influenced by nonadditive genetic processes. These processes remain a puzzle for geneticists and evolutionists, as well as psychologists, because simple additive effects are thought to be the norm (Wolf, Brodie, & Wade, 2000). We also do not understand why most psychological traits are moderately heritable, rather than, as some psychologists expected, variable in heritability, with some traits being highly heritable and others being largely under the influence of the environment. It seems reasonable to suspect that moderate heritability may be a general biological phenomenon rather than one specific to human psychological traits, as the profile of genetic and environmental influences on psychological traits is not that different from the profile of these influences on similarly complex physical traits (Boomsma, Busjahn, & Peltonen, 2002) and similar findings apply to most organisms.

Recommended Reading

Bouchard, T.J., Jr., & McGue, M. (2003). (See References)

Carey, G. (2003). *Human genetics for the social sciences*. Thousand Oaks, CA: Sage.

Plomin, R., DeFries, J.C., Craig, I.W., & McGuffin, P. (Eds.). (2003). *Behavioral genetics in the post genomic era*. Washington, DC: American Psychological Association.

Rutter, M., Pickels, A., Murray, R., & Eaves, L.J. (2001). Testing hypotheses on specific environmental causal effects on behavior. *Psychological Bulletin*, *127*, 291–324.

REFERENCES

Boomsma, D.I., Busjahn, A., & Peltonen, L. (2002). Classical twin studies and beyond. *Nature Reviews: Genetics*, *3*, 872–882.

Bouchard, T.J., Jr., & McGue, M. (2003). Genetic and environmental influences on human psychological differences. *Journal of Neurobiology*, *54*, 4–45.

Caspi, A., Sugden, K., Moffitt, T.E., Taylor, A., Craig, I.W., Harrington, H., McClay, J., Mill, J., Martin, J., Braiwaite, A., & Poulton, R. (2003). Influence of life stress on depression: Moderation by a polymorphism in the 5-HTT gene. *Science*, *301*, 386–389.

Evans, G.W. (2004). The environment of childhood poverty. *American Psychologist*, *59*, 77–92.

Hur, Y.-M., Bouchard, T.J., Jr., & Lykken, D.T. (1998). Genetic and environmental influence on morningness-eveningness. *Personality and Individual Differences*, *25*, 917–925.

Khoury, M.J. (1998). Genetic epidemiology. In K.J. Rothman & S. Greenland (Eds.), *Modern epidemiology* (pp. 609–622). Philadelphia: Lippincott-Raven.

Lowrey, P.L., & Takahashi, J.S. (2000). Genetics of the mammalian circadian system: Photic entrainment, circadian pacemaker mechanisms, and postranslational regulation. *Annual Review of Genetics*, *34*, 533–562.

Lynch, M., & Walsh, B. (1998). *Genetics and analysis of quantitative traits*. Sunderland, MA: Sinauer.

Marcus, G. (2004). *The birth of the mind: How a tiny number of genes creates the complexities of human thought*. New York: Basic Books.

Meehl, P.E. (1978). Theoretical risks and tabular asterisks: Sir Karl, Sir Ronald, and the slow progress of soft psychology. *Journal of Consulting and Clinical Psychology*, *46*, 806–834.

Ridley, M. (2003). *Nature via nurture: Genes, experience and what makes us human*. New York: HarperCollins.

Rutter, M. (2002). Nature, nurture, and development: From evangelism through science toward policy and practice. *Child Development*, *73*, 1–21.

Wolf, J.B., Brodie, E.D.I., & Wade, M.J. (Eds.). (2000). *Epistasis and the evolutionary process*. New York: Oxford University Press.