The Nature-Nurture Question

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R. Biswas-Diener & E. Diener (Eds), Noba Textbook Series: Psychology.
Champaign, IL: DEF Publishers. DOI: nobaproject.com

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The Diener Education Fund is co-founded by Drs. Ed and Carol Diener. Ed is the Joseph Smiley Distinguished Professor of Psychology (Emeritus) at the University of Illinois. Carol Diener is the former director of the Mental Health Worker and the Juvenile Justice Programs at the University of Illinois. Both Ed and Carol are award- winning university teachers.

Abstract

People have a deep intuition about what has been called the “nature–nurture question.” Some aspects of our behavior feel as though they originate in our genetic makeup, while others feel like the result of our upbringing or our own hard work. The scientific field of behavior genetics attempts to study these differences empirically, either by examining similarities among family members with different degrees of genetic relatedness, or, more recently, by studying differences in the DNA of people with different behavioral traits. The scientific methods that have been developed are ingenious, but often inconclusive. Many of the difficulties encountered in the empirical science of behavior genetics turn out to be conceptual, and our intuitions about nature and nurture get more complicated the harder we think about them. In the end, it is an oversimplification to ask how “genetic” some particular behavior is. Genes and environments always combine to produce behavior, and the real science is in the discovery of how they combine for a given behavior.

Learning Objectives

- Understand what the nature–nurture debate is and why the problem fascinates us.
- Understand why nature–nurture questions are difficult to study empirically.
- Know the major research designs that can be used to study nature–nurture questions.
- Appreciate the complexities of nature–nurture and why questions that seem simple turn out not to have simple answers.

Introduction

Three related problems at the borderline of philosophy and empirical science are fundamental to humans' understanding of our relationship to the natural world: the mind–body problem, the free will problem, and the nature–nurture problem. These great questions have much in common. Everyone, even without reference to science or formal philosophy, can generate intuitions about them via introspection and casual observation of the world. Yet, our intuitions about our relationship with the physical and biological world often feel incomplete and half-seen. We are in control of our actions in some ways, yet bound to our bodies in others; it seems obvious that our consciousness is some kind of property of our physical brains, still it often feels as though our awareness floats free of raw physicality. This peculiar combination of easy, but incomplete access to our relationship with nature leaves us fascinated and a little obsessed, like a cat that climbs into a paper bag and then out again, over and over, mystified every time by a relationship between inner and outer that it can glimpse but can't quite grasp.

That some characteristics are inborn while others are acquired is a fundamental and profound human intuition, and it is worth crediting its importance and validity before we begin to pick it apart. Of the three great questions about humans' relationships with the natural world, only nature–nurture is sometimes called a "debate." In the history of psychology, no other question has generated so much disagreement and moral indignation: The most fundamental reason we are so fascinated with nature–nurture is that our most important moral judgments seem to depend on it. We may admire the athletic skills of a great basketball player, but his height is simply a gift, a payoff in the "genetic lottery" in which we have all been involuntarily entered. For the same reason no one would condemn a short person, much less someone with a real congenital disability: It is, to state the obvious, "not their fault." But we do credit the concert oboist for her skills, and perhaps her parents and community as well; we condemn cheaters, slackers, and the violent.

It only adds to our fascination that most interesting human characteristics aren’t actually like height or oboe-playing, with our nature–nurture intuitions skewed strongly one way or the other. Even the great oboist, we might think, might have some inborn quality—perfect pitch, or long nimble fingers—that support and reward her hard work. When we think about ourselves and our ordinary human qualities, they seem under our control in some respects, yet beyond our control in others. Moreover, many of the traits we wonder about are of much greater personal consequence than our height or musicality. What about how much we drink or worry? What about our honesty, our religiosity, or sexual orientation? They all have that same difficult quality, neither fixed by nature nor totally under our own control.

Traits like aggressiveness can be the product of both nature and nurture. Researchers must find ways to separate the two influences. [Photo: mharrsch]

Another reason we are so fascinated with nature–nurture is that there are difficult obstacles in the way of studying it empirically in humans. In nonhuman animals, experimental methods are available that make finding answers to nature–nurture questions relatively straightforward. Suppose you are interested in aggressiveness in dogs. You could mate a pair of aggressive dogs and a pair of nonaggressive ones, split their litters in half, and switch half of each litter. You now have puppies born to aggressive and nonaggressive dogs, half of them raised by their own parents, the other half raised by the parents of the opposite type to whom they are not biologically related. Which is a more important determinant of aggression in the puppies: being born to aggressive dogs or being raised by them, and how do the two factors combine? Much of the best and most enduring nature–nurture research has been done in this way (Scott & Fuller, 1998), and animal breeders have been doing it successfully for millennia. It is possible, even easy, to breed animals for behavioral traits. In people, however, it is not possible to assign babies to parents at random, or to select parents with certain behavioral characteristics for reproduction. (Although history includes horrific examples of such practices, as part of misconceived attempts at "eugenics," the shaping of human characteristics through intentional breeding.) In typical human families, the children's biological parents also raise them, and as a result, it is very difficult to know whether children resemble their parents for genetic or environmental reasons.

The next reason for our fascination with nature–nurture is the converse of the previous one: Although there are difficult obstacles in the way of scientific analysis of human families, there are also clever methods that provide partial solutions. The empirical science of how genes and environments work together to generate behavior is called **behavioral genetics**. The easiest of these methods to understand is the **adoption study**. When children are put up for adoption, the parents who give birth to them are no longer the same as the parents who raise them. It isn't quite the same as the experiments with dogs—children can't be assigned to adoptive parents at random, or in order to suit some particular interests of a scientist, but adoption still tells us something interesting. If the biological children of tall parents were adopted into a family of short people, what do you think would happen? What about the biological children of a Spanish-speaking family adopted at birth into an English-speaking family? Would this tell you something about the difference between height and language?

Another path around the scientific difficulties of typical human families involves **twin studies**. There are two kinds of twin pairs: Identical, or monozygotic (MZ), twins result from a single zygote and have the same DNA. They are essentially clones. Fraternal, or dizygotic (DZ), twins develop from two zygotes. Fraternal twins are ordinary siblings who happen to have been born at the same time. They share 50% of their DNA. To analyze nature–nurture using twins, we compare the similarity of MZ and DZ pairs. Identical twins, unsurprisingly, are almost perfectly similar for height. The heights of fraternal twins are like any other sibling pairs: more similar to each other than to people from other families, but hardly identical. This difference in similarity tells us something about the role genetics plays in the determination of height. Now consider speaking Spanish. If one identical twin speaks Spanish at home, the co-twin with whom she is raised almost certainly does too. But in this case, the same would be true for a pair of fraternal twins raised together. For language-speaking, fraternal twins are just as similar as identical twins, so it appears that the additional genetic similarity of identical twins isn't making much difference.

Studies using twins can lead to insights about the biological origins of many personality characteristics. [Photo: ethermoon]

Twin and adoption designs have much in common; in fact, they are two instances of a much broader class of methods in which similarity among individuals is analyzed in terms of how biologically related they are, a scientific discipline called **quantitative genetics**. We can do these studies with siblings and half-siblings, cousins, or with twins who have been separated at birth and raised separately (Bouchard, Lykken, McGue, & Segal, 1990; such twins are very rare and play a smaller role than is commonly believed in the science of nature–nurture), or with entire pedigrees of extended families (see Plomin, DeFries, Knopik, & Neiderhiser, 2012, for a complete introduction to research methods relevant to nature–nurture).

For better or for worse, our thinking about nature–nurture has been intensified because the methods of quantitative genetics produce a number, called a **heritability coefficient**, varying from 0 to 1, that appears to provide a single measure of the role of genetics in a trait. In a general way, a heritability coefficient measures how strongly differences among individuals for a trait are related to differences among their genes. But beware: The previous sentences are qualified with appears to and in a general way because heritability coefficients, although simple to compute, are deceptively difficult to interpret. Nevertheless, numbers that seem to provide simple answers to complicated questions have a strong draw on the human mind, and a great deal of time has been spent discussing whether the heritability of intelligence or personality or depression is equal to this number or that.

The final reason nature–nurture has continued to fascinate us is that we live in an era of great scientific discovery in genetics, the equal, certainly, of the time of Galileo, Copernicus, and Newton with regard to astronomy and physics. When Francis Galton first started thinking about nature–nurture in the late-19th century he was very influenced by his cousin, Charles Darwin, but genetics per se was unknown. Mendel's famous work with peas, conducted at about the same time, went undiscovered for 20 years; quantitative genetics was developed in the 1920s; DNA discovered by Watson and Crick in the 1950s; the human genome was completely sequenced at the turn of the 21st century; and we are now on the cusp of a time when it will be possible to obtain the DNA sequence of anyone at relatively low cost. No one knows what this new genetic knowledge will mean for the study of nature–nurture, but as we will see in the next section, answers to nature–nurture questions have turned out to be far more difficult and mysterious than anyone imagined.

People still hold strong opinions about the role of nature versus nurture. As science becomes more sophisticated we are able to better understand the interaction of these two influences. [Photo: Shohei Hanazaki]

What Have We Learned About Nature–Nurture?

It would be satisfying to report that the proliferation of scientific nature–nurture studies has produced a finely articulated set of results, with some traits turning out to be under strong genetic control, leading to clear genetic explanations of their development, while others turned out to be relatively independent of genes, in the domain of parental childrearing practices and the force of our personal will; but that is not what has occurred. Instead, everything has turned out to be related to genetics, in this sense: The more genetically related people are, the more similar they are, and for everything—height, weight, intelligence, personality, mental illness. Adopted children resemble their biological parents even if they have never met them; identical twins are more similar than fraternal twins. This finding is true, it is important to emphasize, not only for the classical psychological traits such as personality and psychiatric categories such as schizophrenia: It is also true for political attitudes, how much television people watch (Plomin, Corley, DeFries, & Fulker, 1990), and whether or not they are divorced (McGue & Lykken, 1992).

People have grown accustomed to the idea of genetic influence on behavioral characteristics, and it may be difficult to imagine how shocking it was when these discoveries were first made. In the middle of the 20th century, psychology was dominated by the doctrine of behaviorism, which held that the behavior of organisms could be explained only in terms of environmental contingencies, without reference to internal states. Psychiatry was dominated by psychoanalysis, which sought explanations of behavior in the early life-histories of individuals. In fact, neither behaviorism nor psychoanalysis is incompatible with genetic influences on behavior, and neither Freud nor Skinner was naive about the importance of organic processes in the genesis of behavior. Nevertheless, it was widely thought at the time that children's personality was shaped by modeling the observed behavior of their parents and that schizophrenia was caused by certain kinds of pathological mothering. Whatever the outcome of our broader discussion of nature–nurture, the simple compelling fact that the best predictors of an adopted child's personality or mental health are to be found in the biological parents he or she has never seen, rather than in the adoptive parents who raised him or her, presents a significant challenge to purely environmental explanations of personality or psychopathology. To this extent the outcome of nature–nurture has been clear: You can't leave out genes. Of course, no human behavioral traits are perfectly heritable, so the converse is also true: You can't leave out the environment.

In what follows, we will hear a great deal about the complexities of sorting nature and nurture as influences on human behavior, so at the outset we should emphasize one very concrete consequence of behavioral genetics that has changed the scientific study of psychology for good. However complicated relations among genes, environments, and behavior may turn out to be, it is never possible to interpret an association between the behaviors of biologically related individuals as causal and environmental in origin without further evidence. This may seem obvious, but it is always very tempting to observe that mothers who read more to their children have children with better reading scores in the third grade and to conclude that reading out loud is important to success in school. It may well be, but the study as described is inconclusive, because there are genetic as well as environmental pathways between the parenting practices of mothers and the abilities of children. To establish that reading aloud causes success, a scientist can either study the problem in adoptive families in which the genetic pathway is absent or by finding a way to assign children at random to oral reading conditions.

In many other ways, however, the outcomes of nature–nurture studies have been less decisive. The most disappointing outcome has been that the sorting of traits from more to less genetic hasn't worked out. In fact, everything has turned out to be at least moderately heritable, and nothing has turned out to be perfectly so, without much consistency as to which traits are more heritable and which are less, once other considerations (such as how accurately the trait can be measured) are taken into account (Turkheimer, 2000). The problem is conceptual. The heritability coefficient, and, in fact, the whole quantitative genetic apparatus that underlies it, does not do what our nature–nurture intuitions want it to do. We want to be informed about how "important" genes and environment are to the development of a trait, but that turns out to be a poorly specified question. First of all, both genes and environment are absolutely important to every trait: No genes can develop in a vacuum, and without genes the environment has nothing to work on. Even more important, because nature–nurture questions are always about differences among people, the answer we obtain for a given trait depends not only on the trait itself, but also on how and how much people differ on the trait in the population being studied.

Examining the ways in which people differ can help us understand the role of environmental and genetic influences. [Photo: Oude School]

The classic example is the trait of having two arms. No one would doubt that the development of arms is a profoundly biological and genetic process. But fraternal twins are just as similar for two-armedness (that is to say, nearly perfectly similar) as identical twins, and as a result the heritability of having two arms is essentially zero. This result is not a tip-off that arm development is less genetic than we had imagined, rather it occurs because people do not vary in the genes related to arm development. To the extent people do differ in arm number, it is likely the result of accidents and, therefore, environmental. For this reason, we always have to be very careful when asking nature–nurture questions and especially when we try to express the answer in terms of a single number. The heritability of a trait is not a property of that trait, it is a property of the trait in a particular context in which relevant genes and environments vary in some ways but not in others.

Another difficulty with the heritability coefficient as an outcome of nature–nurture studies is that it presumes that it is meaningful to divide up differences in a trait into two portions, genes and environment, which can be added together to obtain the total variability. Conceptually, this is a little like asking how much of the experience of a symphony is attributable to the horns and how much to the strings—the ways in which instruments or genes combine is more complicated than that. More formally, it turns out to be the case that for many traits genetic differences affect behavior under some environmental circumstances but not others, a phenomenon called gene-environment interaction, or G x E. In one well-known example, Caspi et al. (2002) showed that among maltreated children, those who carried a particular allele of the MAOA gene showed a predisposition to violence and antisocial behavior, while those with other alleles did not. The gene had no effect in children who had not been maltreated. Making matters even more complex are very recent studies of what is known as epigenetics (see module, “Epigenetics”), a process in which the DNA itself can modified by environmental events, and those changes transmitted to children.

Another question we sometimes want to answer when we think about nature–nurture is how susceptible a trait is to being changed, how malleable it is, or whether we “have a choice” about it. But, these questions are also much more complex than they appear at first. Phenylketonuria is an inborn error of metabolism caused by a single gene; it prevents the body from metabolizing phenylalanine. Untreated it causes mental retardation and death, but it can be treated effectively by a straightforward environmental intervention: avoiding foods containing phenylalanine. Height seems like a trait about which we have no choice, something that is firmly rooted in our nature, but the average height of many populations of people in Asia and Europe has increased massively in the past 100 years. Such rapid change cannot be genetic; instead it is the result of changes in diet and alleviation of poverty. Even the most modern genetics has not provided definitive answers to nature–nurture questions. When it was first becoming possible to measure the DNA sequences of individual people, it was widely thought that we would quickly progress to finding the specific genes that account for the heritability of behavioral characteristics, but it hasn't happened. For most traits, there are a few rare genes with large (almost always negative) effects, such as the single gene that causes Huntington's disease or the Apolipoprotein gene that causes early dementia in a small percentage of cases of Alzheimer's disease. Beyond these rare genes of large effect, however, genetic effects on behavior are broken up over many genes, each with very small effects. For most behavioral traits, the effects are so small and distributed across so many genes that we have not been able to catalog them in a meaningful way. In fact, the same is true of environmental effects. We know that extreme environmental deprivation causes catastrophic effects for many behavioral outcomes, but fortunately extreme environmental deprivation is very rare. The environmental events responsible for differences in the normal range—why some children in a suburban third-grade classroom perform better than others—are much more difficult to discern.

The difficulties of finding unified solutions to nature–nurture problems brings us back to the other great questions about humans' relationships with the natural world. Detailed examination of what we mean when we say that we are conscious of something or that we have free will to choose something reveals that consciousness is not a simple entity that we can find in the brain somewhere, and that choice is not a unified activity that we can apply to some behaviors but not others. So it is with nature and nurture. What at first appears to be a straightforward distinction that might be indexed with a single number becomes more and more multifaceted the closer we examine it. The many questions we can ask about the relationships among genes, environments, and human traits—how sensitive are traits to environmental change, and how common are the environments to which they are sensitive; whether parents or the broader cultural environment are more relevant; how sensitive traits are to differences in genetic endowment, and how much do the relevant genes vary in a particular population; whether a single gene or a great many genes are involved; whether a trait is more easily described in genetic or more complex behavioral terms—all these questions may have different answers, and the answer to one tells us little about the answers to the others.

Once we learn the profound and wide-ranging effects of genetic differences on all human characteristics, especially behavioral ones, it is tempting to conclude that our cultural, ethical, legal, and personal ways of thinking about ourselves will have to undergo profound changes to take genetic effects into account. Perhaps criminal proceedings will have to consider genetic background. Parents, presented with the genetic sequence of their children, will be faced with difficult decisions about reproduction. These hopes or fears are often exaggerated. In some ways, our thinking may need to change, especially if it was once informed by a superficially empirical reading of the great American principle that all men are created equal. Human beings differ, and like all evolved organisms they differ genetically. The Declaration of Independence predates Darwin and Mendel, but it is hard to imagine that Jefferson-- whose genius encompassed botany as well as moral philosophy-- would have been alarmed to learn about the genetic diversity of organisms. It must be remembered that for almost all human behavioral characteristics, modern genetics has taught us that the genesis of human behavior is too complex to be predicted from even the most complete genetic information, unless one happens to have an identical twin. The science of nature and nurture has demonstrated that genetic differences among people are integral to human moral equality, freedom, and self-determination, not opposed to them. As Mordecai Kaplan said about the role of the past in Jewish theology, genetics gets a vote, not a veto, in the determination of human behavior. We should indulge our fascination with nature–nurture while resisting the temptation to oversimplify it.

Outside Resources

Web: Institute for Behavioral Genetics

http://www.colorado.edu/ibg/

Discussion Questions

1. Is your personality more like one of your parents than the other? If you have a sibling, is his or her personality like yours? In your family, how did these similarities and differences develop? What do you think caused them?

2. Can you think of a human characteristic for which genetic differences would play almost no role? Defend your choice.

3. Do you think the time will come when we will be able to predict almost everything about someone by examining their DNA on the day they are born?

4. Identical twins are more similar than fraternal twins for the trait of aggressiveness, as well as for criminal behavior. Do these facts have implications for the courtroom? If it can be shown that a violent criminal had violent parents, should it make a difference in culpability or sentencing?

Vocabulary

Adoption study
A behavior genetic research method that involves comparison of adopted children to their adoptive and biological parents.

Behavioral genetics
The empirical science of how genes and environments combine to generate behavior.

Heritability coefficient
An easily misinterpreted statistical construct that purports to measure the role of genetics in the explanation of differences among individuals.

Quantitative genetics
Scientific and mathematical methods for inferring genetic and environmental processes based on the degree of genetic and environmental similarity among organisms.

Twin studies
A behavior genetic research method that involves comparison of the similarity of identical (monozygotic; MZ) and fraternal (dizygotic; DZ) twins.

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Acknowledgments

The Diener Education Fund would like to acknowledge the following individuals and companies for their contribution to the Noba Project: The staff of Positive Acorn, including Robert Biswas-Diener as managing editor and Jessica Bettelheim as Project Manager; Sockeye Creative for their work on brand and identity development, web design, and digital strategy; Experience Lab for digital user experience design; The Other Firm for web and software development; Arthur Mount for illustrations; Dan Mountford for artwork; Chad Hurst for photography; EEI Communications for manuscript proofreading; Marissa Diener, Shigehiro Oishi, Daniel Simons, Robert Levine, Lorin Lachs, and Thomas Sander for their feedback and suggestions in the early stages of the project.

Thank you all!