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The New Era of Research on Genetic Influences on Human Behavior and Development

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INTRODUCTION

There is a long history of ongoing scientific debate over the function of nature (genetics) and nurture (environmental influences) in determining what makes human beings who they are and what they will become. This is clearest when studying the human brain and its influences on individual thought, personality, and behavior. The fundamental question is: Which (genetics or the environment) has the most influence? There has long been a difference of opinion among psychiatrists, psychologists, geneticists, behavior geneticists, and even sociologists. Among the ongoing scientific debate between nature (genetics) and nurture (environmental influences) in human development, the "genetics of behavior" offers greater opportunities for media sensationalism than does any other domain of current science. Frequent news reports assert that some researchers have found the "gene" for such traits as intelligence, criminality, homosexuality, and even so-called bad luck. Such reports tend to suggest, mostly inaccurately, that there is a direct correspondence between carrying a mutation in a gene and the manifestation of a trait or disorder. Hardly ever is it mentioned that traits involving behavior are likely to have very complex genetic bases. The reason why these kinds of discoveries are reported and noted is probably because most educated laypeople tend to hold a simple, straightforward, single-gene view of genetics. Unfortunately, the truth is that single genes do not determine most human behaviors. Most types of behavior have no clear-cut patterns and depend on the interplay between environmental factors and multiple genes. Scientists regard genes in such multiple-gene systems as quantitative trait loci (QTLs), since they are ordinarily expected to result in a continuous (or quantitative) distribution of phenotypes that underlie vulnerability to behavioral disorders.[1] Among a number of traits, researchers have pointed out that intellectual achievement depends primarily on education.[2] On the other hand, shyness is strongly linked to heredity, and in addition, fears and phobias are also largely inherited.[2] However, even in the most clearly inherited traits, the brain still affects delicately behavior by influencing which environments a person will inhabit, and this in turn determines the expression of behavior.[1,2] For instance, if there really is a person who was born to lead (genetics), he/she may never have the chance to do so if he/she is unfortunately born into a family of poverty and isolation (environmental influences). Many different genetic influences, as well as environmental ones, compete to determine which path such an individual may ultimately follow. As discussed, the path a person born to lead takes depends heavily upon his/her "life chance" to eventually become a "true" leader, or they could end up just like others becoming a layperson. Starting from this exact point of view, many interesting research issues related to genetic influences on the human brain and behavior have rapidly developed. Coincidently, most of the research findings concede that both nature and nurture play a part

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in shaping human behaviors and the outcomes of an individual's life choices.

BACKGROUND AND ISSUES

Human Genome Project

In 1990, the US Human Genome Project (HGP) coordinated by the US Department of Energy and the National Institute of Health, launched an effort to identify all of the 30,000 genes in human DNA and to determine the sequences of the 3 billion chemical base pairs that make up this DNA. To date, several genome maps have already been completed, and a working draft of the entire human genome sequence was made available to the public in June 2000. More than US$3 billion has been spent worldwide on the HGP since its official launch in 1990. Overseers of the HGP understand that the ethical, legal, and social issues that arise as a result of their work need to be addressed as well. What would the social consequences be of revealing an individual's "genetic record" including differences in intelligence, shyness, criminality, risk taking, or even homosexuality? What effect would the discovery of a gene associated with violence have on social systems of justice? If a "particular gene" could be linked to antisocial forms of behavior, would it lead to greater or lesser acceptance of people exhibiting these kinds of actions? Would we recommend that those with this "particular gene" be treated and/or refrain from having children through conventional means? The research engenders very strong responses because of the substantial social consequences that may apply. Therefore, all of these critical research issues need to be worked out before the HGP has proceeded much further.

Gender Development

A rapidly growing body of empirical evidence reflects the importance genetics plays in determining a human's gender development. Direct socialization into gender roles by parents does not appear to be as singular an influence on children's sex-typed preferences and behaviors as social scientists once thought.[3] In the past decades, human development researchers have placed too little emphasis on how genetics interacts with environmental influences to guide children's gender development. Although conventional research on gender development has mapped out how the sexes differ in their preferences, interests, and activities and has tried to uncover the reasons why such differences emerge and why some children are more sex-typed than others, this strategy of seeking to explain gender divergence during childhood through analyzing individual differences in sex-typing has provided little insightful interpretation so far. While children's environments indeed play important roles in their gender development, as is evidenced by studies of cultural differences in gender roles, Maccoby[3] argued that, normally, the daily routines of family life do not have much impact on the strong tendency of children to separate into same-sex groups, or probably also on the distinctive activities enacted by male and female groups. Research has indicated that environmental settings not only directly influence behavior, but also exert indirect effects by altering biological processes. In addition, experiments with nonhuman primates show that administering testosterone to female fetuses late in gestation yields more typically masculine behavior. Furthermore, ethological studies have revealed that gender divergences are not limited to humans, but also appear in other animals. The parallels are sufficiently strong to give us some confidence that there is an evolved, genetic basis for several of the robust gender divergences that have been documented in human children.

Behavioral problems in children from divorced families have been partially attributed to family conflict and parental maladjustment. Newly reported research findings, coincidentally, have found that both genetic and environmental factors mediate how well or poorly a child will perform after the parents divorce. From a longitudinal study of 398 adoptive and biological families (the Colorado Adoption Project), researchers examined how much children's self-concept, social competence, academic achievement, behavioral and emotional health, and likelihood of early drug use were influenced by stress associated with divorce. In the biological family sample, 28 % of the parents had divorced by the child's 12th birthday. Following the divorce, these children had more behavioral and emotional problems (aggressive behavior, delinquency, depression, anxiety, and withdrawal), lower levels of academic achievement, and poorer social adjustment as reported by their teachers. The children also reported earlier drug use more than did children whose parents were not divorced.

Among the adoptive families, 13 % of the parents had divorced before their children turned 12. These children also had more behavioral problems and earlier drug use than did the adopted children whose parents stayed married. Interestingly, the researchers found no difference in academic achievement or social competence in the adopted children from either the divorced or intact families. The results strongly suggest that parental divorce and measures of children's self-esteem, social competence, and academic achievement may be partly genetically influenced, enforced by the fact that adopted children from broken homes and intact homes showed no difference in these attributes.[4] Future studies should examine the possible genetic influence of long-term life-course outcomes associated with divorce, including premature termination of education and the likelihood of divorce in adulthood to resolve this enigma.

Research Issues

Human society, also, has to be alert so that discoveries in behavioral genetics are not viewed unconditionally as unquestionable until there has been substantial scientific corroboration. Behavior is, after all, the product of the human's most complicated organ, the brain, and is hardly ever capable of being accounted for by straightforward causal interpretations.

Scientists have suggested that research questions should be asked not as "either/or," but in the context of a "developmental system" in which nature embodies the product, and nurture encompasses the process and matters of essence and incidence. In other words, the question which should be asked most often, then, is not whether or not to accept the role of genes in explaining human behavior, but rather how genes, existing in a complex environment, influence human behavior and development.

In summary, current advances in genetic research suggest that the old dichotomy between "genes" and "environment" is done with. "Genes" and "environment" do not act as independent influences on human development. Many environmental influences initiate changes in genes. For example, in rats, effective maternal care changes the expression of genes in the brain that respond to stress hormones. Likewise, many genes require changes in the social environment in order to exert their influence. Human and animal studies have implied that effective parental care may thwart the expression of adverse genes for aggressive behavior through a complicated process in young children.[5]

Methodology Issues

Change, particularly developmental change, is difficult to study empirically. Traditionally, methods used to explore developmental change are predicated on theoretical specifications of the nature of development and on the assumptions one derives from theory related to: (1) the unit of analysis (e.g., individual's psychological variables or relations between variables from different levels of analysis; (2) levels of organization involved in developmental change (e.g., genes, organism, social relationships, culture, etc.), and (3) the role of time and temporality (history) in indexing such change.[6] In other words, traditional research methods vary in regard to the units of analysis and the levels of organization used to study subjects across time. These variations are linked to differences in the approach to research taken by scientists following different philosophies of methodology. Thus, it is necessary to illustrate the linkage between research questions and research methods.

There is a speedily growing volume of evidence which refers to a significant portion of genetics in the determination of human pathology and psychopathology. Many instances of serious psychopathology have been determined to run within families. The hazard of manic-depressive psychosis for those with a manic-depressive parent is about 10 times as high as that for those without such a parent.[7] Alternatively, compared with pathology and psychopathology, it is argued that complex human behavior should appear much more environmentally determined; interestingly, in recent years, behavioral geneticists have reported genetic effects on such seemingly environmentally determined behavior as parenting style, television viewing habits, peer selection, marital disruption, and even educational achievement. However, for several decades, doing research on the effects of genetics upon human development was further hampered by the scarcity of highly integrated statistical methods which can organize multilevel variables into mixed models for behavioral genetic analysis. As discussed earlier, research on the genetic influences on human behavior and development requires complicated statistical models to single out the effects of genetics from those of environmental factors. Unfortunately, traditional statistical analysis, for exam-

ple, the commonly used correlation analysis, has failed to discriminate the "genuine" effects of genetics on human behavior and development from the mixed influences of environmental factors. This obstacle was not resolved until recent years. In their groundbreaking work, Guo and Wang[8] proposed a newly constructed mixed or multilevel statistical model as a possible resolution to the much-needed behavioral genetic analysis. In the field of behavioral genetic analysis, the truth is that overt measures of genes are normally unavailable. This usually forces the behavioral genetic researcher to resort to genetically related members clustered into families. The newly developed mixed model is able to readily handle families of behavioral genetic data, which include paired sibling data (especially twin data) and clustered siblings' data (a family with more than 2 biological siblings). Not only can a family of behavioral genetic data contain more than 2 siblings, it can also possibly contain multiple types of siblings. In contrast to traditional statistical approaches, the mixed model is insensitive to the order of the siblings in a sibling cluster. These exclusive characteristics enable the mixed model to readily deal with behavioral genetic data appropriately, while the traditional correlation analysis appears unable to handle clustered or families of behavioral genetic data.

In addition, in further evolution of research on the genetic effects on human behavior and development, studies devoted to prediction of human development must be conducted simultaneously with an appreciation of the dynamic relations between a specific person and a specific display of distinct family, community, and socialcultural settings constituting the person's individual developmental trajectory. As a consequence, such studies have to involve individual differences (diversity) and change-sensitive measures, research design, and analytical strategies. Together, such studies should incorporate both structural and measurement models that include indices of personal-contextual relations.

All in all, any interpretation of human behavior and development has to be tied to the inspection of empirical data in order for it to have a function in science. It is essential, then, to comprehend the character of the research methods available to behavioral genetic researchers to be able to examine the genuine effects of genetics on a specific developmental mechanism. This has been a major obstacle in the past for studies of genetic influences on human behavior and development, since too many latent factors have to be taken into account for a specific developmental mechanism. Advantageously, based on the development of computer and statistical sciences, researchers nowadays are able to conduct more-complicated research to reveal specific developmental mechanisms assisted by the new power of computing and advanced statistical models. As pointed out in the title of this paper, a new era of research in to genetic influences on human behavior and development is about to begin.

CONCLUSIONS

In general, current advances in genetic research have suggested that the era of or, more appropriately, the error of genetic reductionism is completely over. Although genes influence behavior, this neither justifies the behavior, nor means that it is inevitable. Even very high heritability of a behavioral trait does not imply inevitability, as reciprocal influences between the environment and phenotype can amplify either genetic or persistent environmental differences.[9] In fact, high heritability may be a signal that reciprocal influences are multiplied so that persistent environmental stresses can have very large effects on phenotypes.[10] The scientific evidence has made it clear that genes do not constrain human development but rather, as parts of a dynamic, developmental system, are plastic entities that simultaneously influence and are influenced by other levels or organization (cells, tissues, organs, and the physical, social, and cultural ecology) within this system.[6] In other words, human behavior can influence genetic inheritance as well. For instance, restricted mate selection due to belief systems or ethnic conflicts can enhance genetic differences between groups of people living in the same geographic area. Furthermore, flexibility programmed into the human genome can result in environmentally influenced behavior that in turn affects inheritance of genetically encoded behavioral traits.[11]

One thing that all of the researchers should keep in mind is that when identical twins who are reared apart are both found to whistle in the restroom, it is not just because they share the same genes. Genes in and of themselves do not make people whistle in the restroom or do they make people do anything at all. That is why

the concordance for schizophrenia in identical twins is only about 28% instead of 100%.[12]

In summary, even though state-of-the-art research is now widely available, recent highly visible work continues to portray a distorted view of the role of genetics in human behavior and development with erroneous implications for public policy. Distinguished scholars from developmental and comparative psychology, molecular biology, psychiatry, economics, ethics, and so on have used their research to advocate an inclusive yet highly dynamic view of the interplay between nature (genetics) and nurture (environment). Conventional questions of how much variance is attributable to genetics or to the environment, or the prevalence of one versus the other, are seen as inadequate or irrelevant to these illustrious researchers. Their concerns represent a timely contribution to a highly visible and controversial research field with very important policy implications.[13]

Today, we face a significant opportunity to impact the life chances of future generations and to build on what is currently already known to us. Crucial to the research work must be the goal of effecting how this information can be used to promote health, hope, and independence and to prevent unhealthy outcomes for our children. For sure, we are willing to offer a bright future to our offspring in which fatal diseases will be just like controllable infections. Answers to how we use what we currently know to promote health will likely be dissimilar for every discipline, however, the questions must be correctly asked, and then acted upon with good judgment, principles, and collaboration.

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