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THE BIOLOGY OF RELATIONSHIPS: WHAT BEHAVIORAL GENETICS TELLS US ABOUT INTERACTIONS AMONG FAMILY MEMBERS

*Laura A. Baker**

INTRODUCTION

Human behavior is subject to genetic variations. The ways in which individuals differ in their intellectual abilities, personalities, and mental health are, to a large extent, functions of their inherited genetic predispositions. Decades of research on twins, adoptees, and families have led to the inescapable conclusion that most reliably measured psychological characteristics are influenced to some degree by genes. Behavior also shows signs of genetic influence; the way one experiences stressful life events, for example, shows some genetic influence. Even personal aspects of individuals, such as spirituality and political ideology, are affected to an extent by genes.[1] It should come as no surprise, then, that genes influence the ways in which families function and how family members relate to one another.[2] Familial relationships of all kinds—parent-child, sibling, and spousal—can be shown to be at least partially the product of genetic factors.

This Article discusses a behavioral genetic perspective that provides insight into the biological factors that influence family relationships. Part II presents a brief overview of the research methods used to understand both genetic and environmental influences on human behavior. Part III then discusses several key findings from the field of behavioral sciences, particularly how they pertain to the ways in which family members relate to one another. It focuses on the following: (1) characteristics of parents and variations in the ways they treat their own children; (2) characteristics of children and how they may react to

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1. For a review of behavioral genetic methods and results, see ROBERT PLOMIN ET AL., BEHAVIORAL GENETICS (4th ed. 2001). For a recent review of findings in psychological domains, see Thomas J. Bouchard, Jr. & Matt McGue, *Genetic and Environmental Influences on Human Psychological Differences*, 54 J. NEUROBIOLOGY 4 (2003).

2. For a discussion of the genetic and environmental contributions to interactions between family members, see DAVID REISS WITH JENAE M. NEIDERHISER ET AL., THE RELATIONSHIP CODE: DECIPHERING GENETIC AND SOCIAL INFLUENCES ON ADOLESCENT DEVELOPMENT (2000).

their parents' behavior; and (3) the interactive processes that occur between parents and children. While the primary focus of Part III is on parent-child relationships, Part IV considers sibling and spousal relationships. Part V discusses the general interpretation of family relationships from a behavioral genetic perspective.

II. TWIN, FAMILY, AND ADOPTION STUDIES

What is the evidence for the overwhelming influence of genetic factors on human psychological function? What does it mean to say that psychological dimensions of family relations are a function of genes? Answering these questions requires a basic understanding of behavioral genetic studies, which help to separate the effects of genes and environment in human behavior.

The general strategy in behavioral-genetic research designs involves the study of family members with varying degrees of genetic and environmental relatedness.[3] For example, genetic influences in a trait are evident if pairs of monozygotic (MZ) twins (who are genetically identical) are more similar to one another than dizygotic (DZ) twins (who share only about 50% of their genes), or if pairs of biological siblings raised together resemble one another more than unrelated (e.g., adoptive) siblings raised together. In general, if psychological traits and observed behavior have a genetic component, then genetically similar relatives should resemble one another more closely than individuals who share fewer genes.[4]

Regarding environmental influences, researchers in behavioral genetics typically distinguish between two broad classes of effects: (1) environmental factors shared by relatives that cause them to behave similarly; and (2) unique, individual environments that are not shared by relatives, which cause them to be different from one another. These are referred to, respectively, as shared and nonshared environments. Shared environmental influences are evident when greater trait similarity is observed for those relatives who share more experiences (e.g., siblings raised together rather than apart), or when twins are more similar to one another than their genetic relatedness would predict. Evidence for nonshared environment often stems from differences observed between genetic relatives—that is, their lack of resemblance. Differences between MZ co-twins, for example, must stem from nonshared environments. The study of the similarities and differences between relatives of varying degrees of genetic and envi-

3. David M. Evans et al., *Biometrical Genetics*, 61 BIOLOGICAL PSYCHOL. 33 (2002).

4. *See* PLOMIN ET AL., *supra* note 1.

ronmental relatedness provide the basic data for understanding the effects of genes, and thus the influence of shared and nonshared environments on behavior.[5]

Within a few decades of the earliest twin, family, and adoption studies (which grew immensely from the 1970s onward), genetic factors were implicated in a wide range of human behaviors, such as cognitive ability and personality, as well as most major psychological disorders, such as depression and schizophrenia.[6] Collectively, these studies show that family members who are more closely related genetically demonstrate greater similarity than unrelated individuals for measured aspects of personality (e.g., extraversion or neuroticism), intellectual function (e.g., verbal skills and spatial ability), and likelihood of being diagnosed with a psychological disorder (e.g., depression or schizophrenia).[7]

For a while, it was considered a challenge to find an enduring aspect of behavior that did not appear to be influenced by genes. Constructs such as religious behaviors and political attitudes, which had traditionally been understood to be strictly the product of culture, became the subject of behavioral genetic studies. Somewhat surprisingly, even these culturally defined behaviors appear to be influenced by genetic variations, at least within groups of individuals. For example, although one's religion may be culturally defined and thus independent of genetic influences, the degree to which one engages in the rituals or adheres to the tenets of a particular religion appear to be affected by one's genetic inheritance.[8] Indeed, even the degree to which an individual may endorse highly liberal or conservative ideals (e.g., abortion rights or gay rights) has been shown to be influenced by genetic factors; MZ twins are much more similar than DZ twins, and biological siblings are more similar than adoptive siblings in conservative attitudes from adolescence onward.[9]

Around the same time these culturally defined behaviors became the subject of behavioral genetic research, investigators began to study other variables that were traditionally viewed as entirely "environmental" factors. This research challenged a long-standing social learning perspective in developmental psychology. What were traditionally considered to be "environmental" measures—including as-

5. *Id.*

6. *See id.*

7. *Id.*; *see also* Bouchard & McGue, *supra* note 1.

8. PLOMIN ET AL., *supra* note 1.

9. For a review and recent findings of genetic and environmental influences on social attitudes, see Amy C. Abrahamson et al., *Rebellious Teens? Genetic and Environmental Influences on the Social Attitudes of Adolescents*, 83 J. PERSONALITY & SOC. PSYCHOL. 1392 (2002).

pects of parenting—came to be understood as products of both genes and environment. Thus, we turn back now to the issue at hand: the various aspects of family relationships and how they are influenced by the complex interplay between genes and environment.

III. How the Behavior of Parents and Children Is Influenced by Genes and Environment

Genes influence each individual's behavioral and psychological characteristics, including intellectual ability, personality, and risk for mental illness—all of which have bearing on both parents and children within a family. The ways in which genes and environment can affect parent-child relationships can be seen in Figure 1. This model represents a standard way in which behavioral geneticists think about human behavior in the context of family relationships. Parents' genes influence their own behavior (including the ways they parent their children) and children's genes influence their own behavior (including the ways they respond to their parents). The transmission of genes from parent to child is one important link that will lead to similarities between the behavior of a parent and a child. For example, to the extent that genes predispose an individual toward aggressive behavior, including violence toward others, parents and children will show similarities in this area of behavior. This might offer another explanation for the "cycle of violence" in which abusive parenting is related to aggression and other antisocial behaviors in children.[10] Antisocial behavior does, in fact, show moderate genetic influence in a wide range of studies.[11]

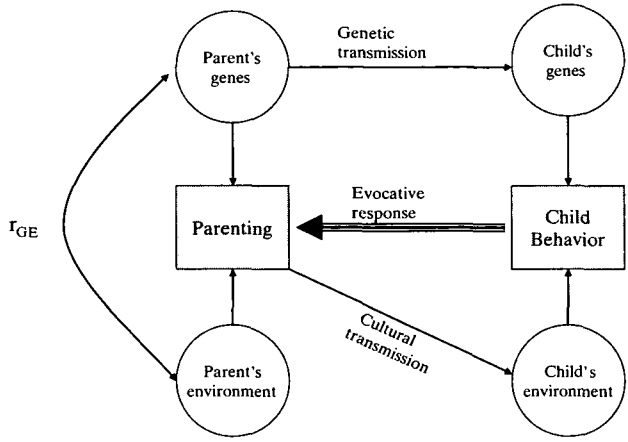
Besides direct genetic transmission, the model in Figure 1 indicates two other important ways in which the behavior of parents and children may be linked. First, parental behavior may itself be an important aspect of the child's environment, which may be considered a form of "cultural transmission." For example, a mother's intelligence, personality, and mental health may have an impact on the child's environment; mothers with higher intelligence and education spend more time reading to their children and engaging them in stimulating activi-

10. Cathy Spatz Widom, *The Cycle of Violence*, 244 Science 160 (1989) [hereinafter Widom, *Cycle of Violence*]; Cathy Spatz Widom, *Does Violence Beget Violence? A Critical Examination of the Literature*, 106 Psychol. Bull. 3 (1989) [hereinafter Widom, *Does Violence Beget Violence*].

11. *See, e.g.*, Soo Hyun Rhee & Irwin D. Waldman, *Genetic and Environmental Influences on Antisocial Behavior: A Meta-analysis of Twin and Adoption Studies*, 128 Psychol. Bull. 490 (2002).

ties.[12] Importantly, however, these characteristics may each be influenced by the mother's genetic makeup, and thus it can be seen how the mother's genotype may ultimately be associated with the child's environment. The association between genes and environment is generally referred to as a genotype-environment correlation (r^{GE}). One way in which r^{GE} may arise is through this passive form of cultural transmission, which is referred to as a passive r^{GE}.[13]

FIGURE 1: BEHAVIORAL GENETIC MODEL OF PARENT-CHILD BEHAVIOR



The third link between the behavior of parents and children is established through the "evocative responses" that children's behavior may elicit from their parents. Because a child's behavior is itself influenced by the child's genes, genetically different children living in the same family may elicit different parenting responses. This may result in another form of a genotype-environment correlation, an r^{GE} of an evocative form.[14] That is, genetically based differences among children (e.g., temperament characteristics) may evoke different responses from their parents (e.g., disciplinary styles). Thus, genes and environment may be intertwined in complex ways within parent-child relationships.

These complexities can be unraveled by twin, family, and adoption studies. Genetic influences on parenting behavior can be understood

12. Stacey S. Cherny, *Home Environmental Influences on General Cognitive Ability*, *in* JOHN C. DEFRIES ET AL., NATURE AND NURTURE DURING MIDDLE CHILDHOOD 262 (1994).

13. For a detailed description of the gene-environment correlation and its different forms, see PLOMIN ET AL., *supra* note 1 and Evans et al., *supra* note 3.

14. *See* Evans et al., *supra* note 3.

by examining the similarities and differences in adult twins' parenting styles. The parenting styles of adult twins—as measured by positivity, negativity, and monitoring of their children—were more highly correlated for MZ than DZ twins.[15] Reviews of other studies show similar patterns, in which parents' genes influence the ways in which they parent their children.[16]

Evidence of parental behaviors evoked by children has been demonstrated by studying how parents respond differently to two or more children in the same family, such as twins and other siblings. DZ twin children, for example, have reported more differences than MZ twins in levels of affect and warmth received by their parents,[17] a finding that has been replicated by using reports from parents about their own behavior, as well as by observing parents interacting with their different children.[18] Studies of adopted children have also revealed evocative responses in the rearing parents as a function of the child's genetic predispositions, as measured by characteristics in their birth parents. More coercive parenting and negative affect were reported by the adoptive parents of children born to more antisocial parents.[19] These genetically high risk children displayed more conduct problems as children and adolescents,[20] and thus may have elicited more negative parenting. The key point is that the direction of causality may not necessarily run from parent to child; when children elicit parental behaviors, it can move in the reverse direction.

Passive r^{GE} effects are best understood in studies comparing parent-child relationships in adopted and nonadopted children. Since adopted children are not genetically related to their rearing parents, the passive r^{GE} does not influence their similarity, because the parents' genes are not linked to the children's environments. If passive r^{GE} effects arise, whether through cultural transmission effects or other mechanisms,[21] correlations between parenting characteristics and

15. Jenae M. Neiderhiser et al., *Genetic and Environmental Influences on Mothering of Adolescents: A Comparison of Two Samples*, 40 DEVELOPMENTAL PSYCHOL. 335, 342 tbl.4 (2004).

16. *See* Hilary Towers et al., *Genetic and Environmental Influences on Parenting and Marital Relationships: Current Findings and Future Directions*, 33 MARRIAGE & FAM. REV. 11, 16–18 (2001).

17. David C. Rowe, *Environmental and Genetic Influence on Dimensions of Perceived Parenting: A Twin Study*, 17 DEVELOPMENTAL PSYCHOL. 203 (1981).

18. Thomas G. O'Connor et al., *A Twin-Sibling Study of Observed Parent-Adolescent Interactions*, 66 CHILD DEV. 812 (1995).

19. Thomas G. O'Connor et al., *Genotype-Environment Correlations in Late Childhood and Early Adolescence: Antisocial Behavioral Problems and Coercive Parenting*, 34 DEVELOPMENTAL PSYCHOL. 970, 971 (1998).

20. *Id.* at 977.

21. *See* Evans et al., *supra* note 3, at 41–42.

child outcomes should be stronger when parents are raising their own genetic children. In fact, one study of adoptive and nonadoptive families found that parents' ratings of family cohesion, low conflict, and open communication about feelings in early childhood were associated with lower ratings of aggression at age seven, but only for nonadopted children.[22] This link between early environment and child outcome was not found for adopted children, suggesting that passive gene-environment correlations may exist in nonadoptive families that have increased similarity compared to adoptive families.[23]

Like other areas of human behavior, parenting itself is subject to genetic influence. This means that "bad parenting" may itself be influenced by the parents' genetic inheritance. Negative affect, overcontrol, and even abuse and neglect could be related to the genetic makeup of the parents. This does not mean that environmental factors are unimportant, nor does it make such behavior excusable. It just means that genes can explain parenting behavior to some degree.

It is almost certain that parenting has an environmental influence on children. The fact that parental behavior—including parenting style—may be influenced by genes does not imply that such behaviors have no environmental impact on the children that receive such parenting. What are the best methods for testing the true environmental mediation of the relationship between parent and child behavior? Behavioral genetic designs—adoption and extended twin studies—actually provide the ideal methods for identifying environmental effects while controlling for genetic factors.[24] Behavioral genetic studies have helped resolve the issue of genetic and environmental effects in abusive parenting and its relationship to later behavior problems in children by studying, for example, differences in the physical maltreatment of co-twins. Twin resemblance for maltreatment was substantial and equal for MZ pairs and DZ pairs, suggesting that children's genetic differences did not elicit abusive parenting. This does not rule out the possibility, however, that parents' genes may have influenced their abusive parenting. Most importantly, associations between abusive parenting and a child's later antisocial behavior remained significant even after controlling for ge-

22. Jenae M. Neiderhiser, *Family Environment in Early Childhood and Outcomes in Middle Childhood: Genetic Mediation*, *in* JOHN C. DEFRIES ET AL., NATURE AND NURTURE DURING MIDDLE CHILDHOOD, *supra* note 12, at 249.

23. *Id.*

24. For a good articulation of the confound between genetic and environmental factors in family studies and solutions using genetically controlled designs, see Terrie E. Moffitt, *The New Look of Behavioral Genetics in Developmental Psychopathology: Gene-Environment Interplay in Antisocial Behaviors*, 131 PSYCHOL. BULL. 533 (2005).

netic differences in the children.[25] It is noteworthy that this genetically informative study provided convincing evidence of an environmental effect of abusive parenting on child outcomes.

The environmental effects of abuse on child development have also been shown to be exacerbated by a child's genetic predispositions. Children who inherited a deleterious gene that causes a deficiency in monoamine oxidase (MAO-A) appear particularly vulnerable to physical maltreatment, compared to children with a normal MAO-A gene.[26] These findings underscore the importance of genotype X environment interactions,[27] in which genetic predispositions amplify environmental vulnerabilities and vice versa. We can expect that a more detailed understanding of this complex interplay between specific genetic mechanisms and measured environments will emerge over the next few years, as more studies begin to obtain DNA markers of genetic variations.

IV. Other Family Relationships

Behavioral geneticists have also studied family relationships beyond that of the parent and child. Sibling interactions, for example, have been examined in both twin and non-twin siblings. Unlike parents and children, who always share exactly half of their genes, siblings vary in their degree of genetic relatedness. MZ twins are genetically identical; DZ twins and non-twin siblings share about half of their genes, although some pairs may share more or less genetic material. This variation in genetic relatedness could explain why some siblings have a more cooperative and close relationship than others. Genetic similarity among siblings has been shown to affect both their positive and negative interactions with one another,[28] as well as levels of mutual competition and cooperation.[29] In general, siblings who share a stronger genetic makeup demonstrate a closer, more cooperative and positive relationship with one another.

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25. *See* Sara R. Jaffee et al., *Physical Maltreatment Victim to Antisocial Child: Evidence of an Environmentally Mediated Process*, 113 J. Abnormal Psychol. 44 (2004).

26. Avshalom Caspi et al., *Role of Genotype in the Cycle of Violence in Maltreated Children*, 297 Science 851 (2002).

27. Gene X environment interactions are conceptually and statistically distinct from GE correlations, although both represent ways in which genes and environment may influence behavior in combination. *See generally* Evans et al., *supra* note 3 (providing a detailed presentation of both gene X environment interactions and GE correlations and how they can be detected in genetically informative studies).

28. Robert Plomin et al., *Nature and Nuture: Genetic Contributions to Measures of the Family Environment*, 30 Developmental Psychol. 32 (1994).

29. Nancy L. Segal, *Twin, Sibling, and Adoption Methods: Tests of Evolutionary Hypotheses*, 48 Am. Psychologist 943 (1993).

Genetic variations among siblings living in the same family have also been suggested as an important source of differential parenting. The differential parenting of two siblings, albeit stemming originally from their genetic differences, has an environmental effect on the children's psychological outcomes and may amplify sibling differences over time.

The quality of the relationship between marital partners has also been a subject of behavioral genetic studies. Twin similarity for marital satisfaction has been reported to be greater for MZ pairs than for DZ pairs,[30] suggesting the importance of individual genetic factors in determining the success of a marriage. Indeed, twin studies have also shown significantly greater concordance for divorce among MZ pairs than among DZ pairs, suggesting a substantial genetic effect on the likelihood of a failed marriage.[31] Genetically influenced personality traits, such as negative emotionality (i.e., neuroticism), are also predictive of divorce, and may explain much of the genetic risk for divorce.[32]

V. CONCLUSION

One lesson to be learned from behavioral genetic studies of parenting and other types of family relationships is that one must be careful in drawing conclusions based on findings of family resemblance in nuclear, nonadoptive families. Consider the well-known finding that children of abusers are likely to become aggressive and violent, and perhaps even become abusive parents themselves later in life.[33] Although it is tempting to assume such resemblance is a function of learning and experience, it is possible that inherited genetic factors could explain the transmission of abuse across generations. Family resemblance for a given characteristic does not necessarily imply either genetic or environmental influence, since either could explain observed similarity among family members. Thus, the mere fact that children who are abused by their parents are more likely to become abusive themselves does not prove a causal relationship between parenting behaviors and child outcome. Through genetically controlled studies, we have come to understand that both genes and envi-

30. Erica L. Spotts et al., *Genetic and Environmental Influences on Marital Relationships*, 18 J. FAM. PSYCHOL. 107 (2004).

31. Matt McGue & David T. Lykken, *Genetic Influence on Risk of Divorce*, 3 PSYCHOL. SCI. 368 (1992).

32. Victor Jockin et al., *Personality and Divorce: A Genetic Analysis*, 71 J. PERSONALITY & SOC. PSYCHOL. 288 (1996).

33. *See* Widom, *Cycle of Violence*, *supra* note 10; Widom, *Does Violence Beget Violence*, *supra* note 10.

ronment play a role in the cycle of violence.[34] Genes may predispose certain adults toward violence and aggression, even toward their own children. Such behaviors can in turn have a real environmental impact on the child's mental health and on behavioral outcomes. Children's genes may also predispose them toward oppositional and other antisocial behaviors, which may elicit negative parenting from the adults who are raising them.

The fact that genetic influences are crucially important for most areas of behavior does not mean that environmental influences are unimportant. Genes typically account for no more than one-half to two-thirds of the variation seen in most individual's psychological traits. But most environmental influences are based on individual experiences and exposures that are not shared by family members. The implication for families is that most observed resemblance among its individual members is a function of their genetic similarity—not their shared experiences.

Finally, behavioral genetic studies of family relationships provide the valuable information required to develop effective programs of intervention and prevention of serious mental health and behavioral problems. Establishing that environmental effects unequivocally mediate links between parents' and children's behavior is a step toward ensuring the success of treatment programs that target either parents or children.

34. *See* Jaffee et al., *supra* note 25.