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Ethical, Legal, Social, and Policy Implications of Behavioral Genetics

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Abstract

The field of behavioral genetics has engendered a host of moral and social concerns virtually since its inception. The policy implications of a genetic basis for behaviors are widespread and extend beyond the clinic to the socially important realms of education, criminal justice, childbearing, and child rearing. The development of new techniques and analytic approaches, including whole-genome sequencing, noninvasive prenatal genetic testing, and optogenetics, has clearly changed the study of behavioral genetics. However, the social context of biomedical research has also changed profoundly over the past few decades, and in ways that are especially relevant to behavioral genetics. The ever-widening scope of behavioral genetics raises ethical, legal, social, and policy issues in the potential new applications to criminal justice, education, the military, and reproduction. These issues are especially critical to address because of their potentially disproportionate effects on vulnerable populations such as children, the unborn, and the incarcerated.

Keywords

genetic testing; ethics; criminal justice; eugenics; commercialization; patient advocacy

INTRODUCTION TO BEHAVIORAL GENETICS

The field of behavioral genetics has engendered a host of moral and social concerns virtually since its inception (82, 84). Although many of these concerns are not unique to behavioral genetics, or even to genetics, there are still good reasons to be aware of them. The policy implications of a genetic basis for behaviors are widespread and extend beyond the clinic to the socially important realms of education, criminal justice, childbearing, and child rearing. Our society has been willing to use scientific as well as pseudoscientific information to control individuals who are perceived to be socially deviant or problematic. In addition, genetic determinism and scientific illiteracy make information about the genetic basis of

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behaviors at once potentially powerful and dangerous, especially with the advent of new genetic technologies and research findings.

Behavioral genetics has been and continues to be interpreted through the lens of several different fallacies that have important policy implications. One is the fallacy of heritability (38, 84)—if a trait is highly heritable, it is unalterable by environmental changes—which was perhaps most infamously presented in Jensen’s 1969 article “How Much Can We Boost IQ and Scholastic Achievement?” (60). The corollary to this fallacy is that biological inequality justifies social inequality or unequal treatment (83). Such biological explanations for behavior facilitate problematizing individuals rather than social policy or environmental factors (99). More than 40 years after Jensen’s article, however, the same erroneous assumptions that genetic contributions to behavior are immutable were being made to justify the dismantling of initiatives such as the Head Start program in the United States (93).

On the flip side, behavioral genetics is also subject to the naturalistic fallacy, the appeal to the goodness of nature—if it is natural, it must be good (89). Optimists have fallen prey to the hope that if behaviors such as homosexuality or mental illnesses are found to have a genetic cause, they will be destigmatized (23, 24). Recent studies suggest that many people with psychiatric disorders, their physicians, and behavioral genetics researchers believe that genetic explanations for mental illness will diminish stigma and discrimination (40, 41).

These fallacies still hold sway, and changes in the social context of behavioral genetics, which we discuss below, may exacerbate their impact. Furthermore, our increased understanding of the enormous complexity of behavioral genetics may also act to reduce our genetic deterministic impulses. In this article, we discuss major ethical, legal, social, and policy issues related to behavioral genetics: the history of the field of behavioral genetics and its relationship to eugenics; the impact of evolving applications and understandings of behavioral genetics and advances in genomics and new technologies; scientific limitations and challenges; the changing social contexts, applications, and perceptions of behavioral genetics; and the growing use of behavioral genetics in law and criminal justice. For the purposes of this article, we define behavior broadly, as the actions and responses of an organism to its environment (17), including not only processes that involve muscular activity and the movement of individuals—the definition typically used in ethology (106)—but also cognitive processes. We define behavioral genetics as research that strives to understand the genetic basis of behavior, whether through twin, family, or population studies; linkage studies; or genome sequencing.

EUGENICS AND THE HISTORY OF BEHAVIORAL GENETICS

The scientific study of behavioral genetics has long been intertwined with eugenics, thus making a discussion of this unfortunate chapter of scientific and social history unavoidable. Eugenics was an attempt to use the study of innate differences of the human species to improve genetic quality and promote “better breeding” during the first four decades of the twentieth century (4). This study was based on early scientific misunderstandings of heredity, Darwinian evolution, and Mendelian genetics, and scientists believed that a single “good” or “bad” gene passed down through a family lineage caused certain desirable or

undesirable complex behavioral characteristics, such as criminality or levels of intelligence (4). Although deeply flawed, the science behind eugenics is the foundation for the modern-day study of behavioral genetics (63, 85). Thus, although the bulk of the eugenics movement occurred almost a century ago, the ethical implications and observations brought by the behavioral science and resulting social movement of that time are pertinent in providing insight into why examining the ethics of behavioral genetics is still important today.

From its beginnings, eugenics was concerned with socially relevant behaviors and differences, and the social traits that were identified as genetic included criminality, insanity, racial differences, and different levels of intelligence, ranging from genius to feeble-mindedness (4). Thus, as varying social traits were tied to “hereditary fitness” (67), Francis Galton suggested that the “gifted” should marry one another and bear as many offspring as possible, whereas the “unfit” should be institutionalized or sterilized to stop the passage of degenerate traits. Galton ultimately defined eugenics as “the study of agencies under social control that may improve or impair the racial qualities of future generations, either physically or mentally” (3, p. 441). This definition was important as it tied together behavior, genetics, race, and social policy as well as value judgments about what types of people were “born well.”

Galton’s work spread to the United States, and Harvard scientist Charles Davenport became the face of the American eugenics movement. The advisory board of the Eugenics Record Office, established at Cold Spring Harbor by Davenport as the institutional base of the US movement, represented some of the most highly regarded scientists and academics of the early twentieth century (4). Thus, the science behind eugenics was not conducted by a fringe element, but rather had become the mainstream and accepted hereditary science of explaining human differences in traits and behavior, ultimately leading to the segregation, sterilization, and social labeling that is now known as the eugenics movement.

Although it was overshadowed by the application of eugenic theories to Nazi racial hygiene, one of the major policy initiatives resulting from the movement in the United States was the development of state sterilization programs. By 1935, more than 30 sterilization laws had been passed in the United States and more than 21,000 sterilizations had already taken place. By the end of the 1960s, more than 60,000 sterilizations had taken place (86). Even constitutional challenges to these laws, including the famous *Buck v. Bell* case in Virginia in 1925, were unsuccessful. Many of these laws were not struck down until after the mid-twentieth century.

IQ testing throughout the twentieth century also drew controversy. Building on eugenics’ already strong following, Alfred Binet and Theodore Piaget in France developed the first paper IQ test to separate those who were intelligent enough to succeed in school from those who were not (63). The publication of *The Bell Curve* in 1994 (55) reignited discussions on the hereditary, racial, and social connection to levels of intelligence, and criticisms of that publication’s racist tones prompted the American Psychological Association (APA) to revisit these arguments in the late twentieth century. Concerning the connection between race and intelligence, the APA could conclude only that the genetic factors responsible for intelligence were still not well understood (80).

To learn the lessons from this history, it is critical to make the correct “moral diagnosis.” Buchanan (15) has argued that the “conventional ethical autopsy” of the eugenics movement as a simple violation of autonomy (e.g., through forced sterilization) is a gross misunderstanding of the moral pathology. His argument has direct implications for scientists because it posits that “factual beliefs that were not only false but unjustified on the basis of evidence available at the time, when evaluated according to norms of scientific reasoning then widely recognized, played a role in disabling the moral virtues and distorting the interpretation and application of largely unexceptionable moral principles” (15, p. 24).

For example, the key evidence that “major social ills were the result of strongly genetically determined behavioral traits... was a handful of scandalously unscientific ‘family studies.’ The investigators in these ‘family studies’ steadfastly ignored critics who pointed out that their methodology could not disentangle environmental from genetic influences” (15, p. 28). Buchanan cited as another example the testimony in *Buck v. Bell* that led to the sterilization of Carrie Buck, in which the “expert” diagnosed Carrie’s daughter as feeble-minded because the infant “didn’t quite look right,” despite the fact that she later became an honors student (15, p. 29).

In addition, the educated scientists and experts of the eugenics movement have been accused of promoting their false beliefs because “it was in their interest to do so” (15, p. 30)—it was much easier and more comfortable for these individuals and other members of the bourgeoisie class to attribute major social problems of capitalistic society in the late nineteenth and early twentieth centuries to “biochemical entities” (15, p. 30) than to the social, political, economic, and legal institutions from which these individuals and other members of the upper class benefited.

In no way does this established frame or false belief justify the actions undertaken during the eugenics movement, but it does provide insight into how the social milieu of science affects epistemology and how modern genomic sciences are thus not immune to influences of societal beliefs. After all, the former director of the Human Genome Project, James Watson, has said that “our fate is in our genes” (25, p. 229). This belief is reflected in the optimism scientists feel about their work and its potential application, which can sometimes lead them to overestimate the social or scientific significance of their findings, which in turn is exaggerated by the popular media (25). Genomic scientists and academics are sometimes not aware that “nuanced reports of genetic links to behavior become far more simplistic as reported to and understood by the general public” (25, p. 229). The general public as well as the media “sees scientific information, regardless of the soundness of the methods, as powerfully legitimizing” and assumes that “genetic findings... are immutable” (25, p. 230). Coombs (25) highlighted that this is particularly true where the scientific findings appear to confirm existing prejudices. As the genomic sciences advance and continue to provide explanations for human differences, it is likely that these challenges will persist.

ETHICAL ISSUES RAISED BY ADVANCES IN GENOMICS AND NEW TECHNOLOGIES

Advances in the field of genomics have implications for behavioral genetics and raise new ethical issues. These issues arise because genomics is increasingly used to study a wide range of behaviors (including nonmedical conditions and those associated with human evolution) and because the limitations of the science are not well understood. This is exacerbated by the emergence of new technologies such as massively parallel sequencing for noninvasive prenatal diagnosis and optogenetics.

Genomics of Nonmedical Conditions

Much of the science behind the eugenics movement has been discredited (63), and in retrospect, the research questions posed in that era appear quaint at best, if not plain ludicrous. For example, behaviors that were subjected to pedigree analysis included “interest in carpentry,” “dressmaking skill,” and “thalassophilia” (love of the sea) (21). Nevertheless, interest in the genetics of human behaviors, whether classified as diseases or not, has only become more intense as powerful tools have become available. The substantial evidence for a hereditary component to many normal and disordered human behaviors has fueled research on the molecular bases of these traits.

Furthermore, the universality of genetic and genomic tools has allowed researchers to address an ever-widening scope of traits. For example, scientists have examined the genetic correlates of personality traits (33). Although twin studies identified a heritable component to these traits (13, 59), genome-wide association studies have not been able to reliably point to specific genes (5, 102, 110).

Behavioral genetics has also been recently used to explain voting behavior and political views. Penn State political scientist Peter Hatemi (52) concluded in a 2008 study that there are genetic variances in liberals and conservatives, most of which deal with the cognitive processing of fear. Jost et al. (61) also concluded that members of the two ideologies have genetic differences in dopamine receptors, which according to the authors are tied to “sensation seeking,” the need for less order, and openness to new experiences, qualities that liberals are more likely to have.

Scientists have also explored genetic underpinnings of other behaviors, such as moral judgments (51, 73), as well as the size and cognitive function of brain centers involved in language, memory, decision making, and judgment (87, 104). A 2011 study (68) even found a connection between “innate number sense” before formal mathematics instruction and success in formal mathematics coursework, potentially showing that mathematics ability is at least partially genetically determined. Hence, genomic science no longer belongs exclusively in the laboratory or the clinic; it is now often discussed in the mainstream media and has been applied to at least partially explain the causes for a range of familiar, everyday behaviors. In addition, behavioral genetics has important policy implications because the results will not be applied for the benefit of individuals in the way that research on “medical” conditions is—many of these findings are relevant primarily to social institutions

and policy, and they can be used for the purposes of social or political control, especially of those seen as deviant.

Human Evolution

New studies related to the genetics of cognitive abilities continue to raise controversy. One set of widely debated studies examined two genes associated with microcephaly, which is associated with cognitive function. This research found evidence of relatively recent positive selection at these loci in human populations (42, 74). That is, specific variants of the two genes—*MCPH1* (*microcephalin*) and *ASPM* (*abnormal spindle-like microcephalin associated*)—were found at much higher frequency than other variants in a diverse sample of human genomes. The ancestral polymorphisms were assigned by sequencing the chimpanzee genome.

One point of controversy raised by this finding was that the polymorphisms thought to be the target of positive selection (presumably because they conferred selective advantage owing to larger brain size and thus higher intelligence) were found at lower frequency in samples taken from African populations. The potential implication was that modern African populations (from as recent as 5,000 years ago) are less cognitively evolved than other populations. Arguing that scientists should not shy away from un–politically correct conclusions, John Derbyshire (34) wrote in the *National Review*,

Of course, nobody ever supposed that to mean that we are all equally tall, equally strong, or equally clever; but if different human *groups*, of different common ancestry, have different frequencies of genes influencing things like, for goodness' sake, brain development, then our cherished national dream of a well-mixed and harmonious meritocracy with all groups equally represented in all niches, at all levels, may be unattainable.

Perhaps because of the potentially serious societal and policy implications, scientists joined in the debate by engaging on the validity of the science. Some questioned whether these genes were selected because of their effects on brain size. Woods et al. (118) genotyped variants in *MCPH1* and *ASPM* in 120 individuals and found no association with brain volume as determined by MRI. Similarly, Timpson et al. (105) genotyped and examined 9,000 children and found no association with either head circumference or cognitive measures such as verbal and performance IQ, working memory, and attention span. Indeed, the senior author of the Mekel-Bobrov et al. (74) and Evans et al. (42) studies collaborated on a study that found no association between these two genes and general mental ability (e.g., as measured by the Multidimensional Aptitude Battery), social intelligence (e.g., as measured by the Arizona Mini-K Scale), or head circumference (94).

Another point of debate was whether it was necessary to invoke positive selection to explain these findings. Currat et al. (26) argued that simple founder effects and population expansion were more plausible scenarios. Yu et al. (119) examined a large number of other loci and found similar patterns of variation, suggesting that these patterns are not unusual and not necessarily the result of selection.

This flurry of scientific activity suggests that core questions about the study of behavioral genetics remain unanswered, such as how best to approach the identification of genetic contributions to complex traits and how best to interpret findings. Even more fundamentally, we do not have an adequate ethical framework in which to consider whether there are some research questions that should not be asked at all. However, the actions of scientists suggest that they are more willing to participate in open scholarly critique of research that has important societal implications. Such participation is welcome in an era that now sees news headlines on a daily basis claiming that scientists have found the “warrior gene,” “crime gene,” “poverty gene,” or “liberalism gene.” Scientists still disagree about the extent to which they should take responsibility for such media coverage (53, 88). Although this issue has not been resolved, it is encouraging that scientists are actively debating it (112).

Noninvasive Prenatal Testing

Other genetic technologies have also raised ethical concerns regarding their application to behavior. One of these is the development of noninvasive prenatal testing that is conducted on maternal serum to detect cell-free fetal DNA (70). Unlike current forms of prenatal genetic testing, it does not pose physical risks to the fetus and theoretically can be performed at earlier stages of pregnancy. Unlike current maternal serum screening methods, it examines DNA directly and appears to be less prone to false-positive results (11, 97). This type of test is currently available only through commercial laboratories and only for trisomies 21 (Down syndrome), 13 (Patau syndrome), and 18 (Edwards syndrome). Most of these labs conduct some type of massively parallel DNA sequencing of fetal DNA (97). Therefore, it does not at this stage detect other conditions currently screened for, such as spina bifida, and professional societies such as the National Society of Genetic Counselors (35) and the International Society for Prenatal Diagnosis (58) do not support its use as a first-tier aneuploidy test.

Nevertheless, the potential combination of early gestation, noninvasive testing, and the ability to analyze whole genomes (64) or specific genes (69) raises the specter of eugenics again. Although this form of eugenics is not state sponsored, more concerns are raised because of the potential widespread availability through commercial sources and relative lack of regulation and quality control. Patient advocacy groups such as the National Down Syndrome Society have raised their concerns about the use of noninvasive prenatal testing because of the potential for encouraging discrimination against those with Down syndrome, both by enabling greater termination rates of fetuses identified with Down syndrome and by reducing incentives to develop treatments for existing patients with Down syndrome (79).

A number of additional ethical issues have also been raised regarding noninvasive prenatal testing that are not specific to behavioral genetics, including the difficulty of conducting fully informed consent on the accelerated time frame of prenatal testing that adequately discusses the vast amounts of information about the fetus and family members (especially information of uncertain clinical significance) that would undoubtedly be obtained if whole-genome sequencing were applied to fetal DNA (29, 49, 81). However, these issues are exacerbated for complex traits such as behaviors, for which the genetic bases may be weak and lead to significant uncertainty.

Optogenetics

Another new technology, optogenetics, has revived concerns about the manipulation of the human brain. Viral vectors containing light-responsive genes are injected into tissue, sometimes into single neurons in the brain, and activated by light supplied by optical fibers inserted in the tissue near the site where the genes were injected (27, 45). Optogenetics is particularly well suited for neuroscience because of its power to examine the activity of single genes in single cells with precision and exquisite control. The first clinical trials in humans will likely be for highly targeted applications such as treatments in the optic nerve or in the eye (e.g., for retinitis pigmentosa). However, early research has examined addiction (18), aggression (6), and Parkinson disease (108) and has been proposed to study a wide range of psychiatric conditions, including anxiety, depression, and memory deficits (28).

Like cell-free fetal DNA testing, this technology is predicted to also be used for an even broader range of applications. Most of the clinical applications envisioned so far have been to treat conditions that are widely considered to be diseases. However, studies of aggression raise the possibility that conditions that might be better characterized as social pathologies could be manipulated. Whereas many would consider it desirable to use a technology such as optogenetics to decrease aggression, others, such as the military, might seek out such technologies for the purposes of increasing aggression. Optogenetics could also easily fit into other military research programs such as augmented cognition. As an example of such a program, the Defense Advanced Research Projects Agency (DARPA) has funded research on the use of the drug modafinil, which creates a wakeful, alert mental state, to increase cognitive and physical performance in soldiers. Although the US Food and Drug Administration has approved modafinil for specific conditions such as narcolepsy, it is thought to be widely used by people without sleep disturbances for its performance-enhancing properties. This highlights the thin line between treatment and enhancement, which new technologies such as optogenetics can easily cross.

The ethics of human enhancement has been discussed at length elsewhere (16, 96), with compelling arguments presented both for and against it. Enhancement of behavioral traits magnifies the importance of some of these arguments. Although it is assumed by most that the benefits of enhancement will accrue at least to the individuals who receive the enhancements, there is debate about the extent to which society as a whole will benefit (16). However, there are some indications that the complexity of behavior may make it more likely that attempts to enhance a specific characteristic will backfire (117). For example, mice that were engineered to have an increased ability to perform learning tasks (101) also appeared to have a greater sensitivity to pain (115). Similarly, there is concern that increasing memory capacity may have unintended consequences because the ability to filter and delete memories, especially traumatic ones, may have value as a coping mechanism (117). Or, if soldiers receive interventions that make them more aggressive and less fearful in combat, what happens to them and those around them when they are in peacetime situations? Can these effects be made reliably and completely reversible? Furthermore, do the risks of war or terrorism justify such interventions and conducting research to develop them?

SCIENTIFIC LIMITATIONS AND CHALLENGES

The development of new techniques and analytic approaches has clearly changed the study of behavioral genetics and provided tantalizing clues to the role of the genome in a whole host of behaviors and cognitive skills. For example, recent whole-genome scans have identified at least two loci associated with cognitive abilities such as reading ability, word recognition, and IQ as well as with autism and dyslexia (90). Genome-wide association studies have also identified genes associated with depression (20), schizophrenia (47), and antisocial behavior (19), among other behavioral traits.

However, researchers are still struggling to identify definitive genetic causes of behavior. Given the broad policy ramifications of behavioral genetics, it is important that policy makers and the general public understand the limitations of these findings. For example, genomic studies of behavior have typically accounted for very small amounts of individual variance, usually 1% or even less (48). Findings of genes associated with behaviors ranging from mood disorders to personality traits have been notorious for their unreplicability (48, 107, 110). This is also true for nonbehavioral traits such as human height. For example, three separate studies published in 2008 identified 54 variants affecting height in a total sample of more than 63,000 individuals, but these studies could account for only 2–3.7% of variation in height (111). Visscher (111) argued that even studies with sample sizes of 10,000 individuals were underpowered to detect very small effects of single loci, which might be expected for behavioral traits.

The inability of even very large studies to obtain robust and replicable findings has led to thinking about alternative study designs. A different approach has expressly addressed the complexity of behavioral traits by examining gene-environment interactions (76). A series of studies suggested interactions between the *5HTT* gene and life stress (influencing depression), the *COMT* gene and cannabis use (influencing adult psychosis), and fatty-acid metabolism genes and breast-feeding (influencing IQ) (95). However, this approach has also been challenged—a large meta-analysis found no association between *5HTT* and life stress in depression (92), suggesting that causation of behavioral traits and the solution to the “missing heritability” and the “dark matter” of the genome (72) will remain elusive.

Studies of copy-number variation and rare variants have been especially illuminating for the study of behavioral traits such as schizophrenia, bipolar disorder, and autism (71). Even more recently, the ENCODE (Encyclopedia of DNA Elements) project has revealed that the vast majority of the noncoding portions of the genome are busy places, with more than 80% participating in “at least one biochemical RNA- and/or chromatin-associated event in at least one cell type” (37, p. 57), suggesting that light may eventually be shed on the dark matter where behavioral genetics is concerned. However, projects such as ENCODE also highlight how much we still have to learn about the genetics of complex traits.

THE CHANGING SOCIAL CONTEXTS, APPLICATIONS, AND PERCEPTIONS OF BEHAVIORAL GENETICS

The social context of biomedical research has changed profoundly over the past few decades, and in ways that are especially relevant to behavioral genetics. These changes have shaped how and what behavioral genetics research is conducted, how it is funded, and how it will be applied. These broad social shifts also raise ethical, legal, social, and policy questions.

The Rise of Patient Advocacy

One of the major changes to the social context of behavioral genetics is the rise of patient advocacy. Social movements that had a major impact on biomedical research were perhaps first evident with the formation of advocacy groups for AIDS and breast cancer patients in the 1980s and 1990s (14, 39). Since then, thousands of disease-focused advocacy groups have formed, and some have had significant influence on biomedical research, including a sharpening of focus on identifying genes related to diseases and developing genetic diagnostic tests (103). Notably, advocacy groups for autism have considerably changed research funding and priorities. A major proportion of biomedical research support in the United States currently comes from such groups, and advocacy was largely responsible for the passage of the Combating Autism Act (22), which authorized nearly \$1 billion of federal funding over five years for autism research.

However, advocates have also fundamentally challenged some of the premises of biomedical research, including the categorization of some behavioral conditions as diseases. Individuals who have been classified as “diseased” have questioned the biomedicalization of a range of neurological states, from manic depression to dyslexia (7). In 1998, Harvey Blume (12) argued, “Neurodiversity may be every bit as crucial for the human race as biodiversity is for life in general. Who can say what form of wiring will prove best at any given moment?” and described a new condition, “neurotypical syndrome,” as “a neurobiological disorder characterized by preoccupation with social concerns, delusions of superiority, and obsession with conformity.” In addition, parent-run advocacy groups for childhood-onset conditions such as autism have different priorities for research and services than self-advocacy groups do (43) and thus place different emphasis on the necessity for or importance of genetics, and have challenged researchers’ definition of phenotypes. Thus, although patient advocates have fought for increased funding for research on behavioral conditions, they have also raised questions about what this funding should be used for.

The Commercialization of Genetic Testing

One of the other major changes to the context of behavioral genetics is the growth of commercial genetic testing that makes personal genomics available directly to consumers. Dozens of companies have cropped up to provide a variety of services (56). A concern about commercialization is that making such tests available directly to consumers without a clinician’s involvement or physician’s order will lead to harm to people who are not aware of the meaning or limitations of the test results. Because such services are essentially unregulated in the United States if they are considered laboratory-developed tests, there are

no minimum standards of clinical validity. The analytic validity of laboratory tests is regulated by the Centers for Medicare and Medicaid Services under the Clinical Laboratory Improvement Amendments, but genetic targets are not currently included in proficiency testing (98).

However, an investigation of direct-to-consumer genetic testing companies conducted by the US Government Accountability Office found that test results were “misleading and of little or no practical use” (65, p. 4). This investigation included major companies such as 23andMe and Navigenics. Identical samples sent to different companies yielded varied results. For example, a single sample sent to four companies was identified as indicating average, below-average, and above-average risk for prostate cancer and hypertension. The investigation also found several instances of deceptive marketing, including claims that customers’ DNA could be used to create supplements that would cure disease, fraudulent use of celebrity endorsements, and statements that implied that the results were diagnostic. Furthermore, two companies urged a fictitious consumer to secretly test her fiancé’s DNA to “surprise” him despite this practice being restricted in 33 states.

Recently, one company, 23andMe, requested FDA clearance for seven of its tests even though such approval is not required (1). However, other companies have not followed suit, leaving the validity of most commercial testing services in question. Tests related to behavior for which genetic correlates are still uncertain are nevertheless available from 23andMe for bipolar disease and schizophrenia as well as for nonmedical behavioral traits such as “measures of intelligence” (2). Other companies, such as Psynomics (<http://www.psynomics.com>) and the now-defunct NeuroMark Genomics, have also claimed to offer tests for psychiatric conditions, but these tests have been withdrawn. One company called My Gene Profile claimed to provide full profiles of children that included a genetic assessment of character, intelligence, emotion, artistic and sports abilities, and addiction; the company’s website was recently taken down, but its offerings demonstrated how vulnerable consumers could be in the absence of regulation. This commercial stumbling also reflects the lack of clear genetic markers of behavioral traits.

Perceptions of Genetic Tests for Behavior

However premature genetic tests for complex traits such as behavior may be at this time, there is broad interest in them, at least hypothetically. A 2009 survey of more than 2,000 patients visiting a prenatal genetic counseling clinic found that 75% indicated a desire to use prenatal genetic testing for “mental retardation” and 13% indicated a desire to test for “superior intelligence” (54). However, this interest is guarded and tempered somewhat by concerns about stigmatization, discrimination, and privacy. A 2010 focus group study of 36 participants unselected for a personal or family history of psychiatric conditions (but of whom 14 reported having such a personal or family history) found that approximately two-thirds of the participants were initially interested in genetic testing to predict risk of major depression, but only one-third were still interested after the discussion (116). Participants especially saw benefits of testing for people with a family history of depression. Some saw the potential for decreased stigma, whereas others were concerned about increased stigma and discrimination based on genetic test results. All participants who commented about

direct-to-consumer testing objected to it because of concerns about credibility and privacy of results. A survey of 397 individuals diagnosed with depression, bipolar disorder, schizophrenia, or anxiety disorder found that 92% expressed positive attitudes toward psychiatric genetic research and 84% expressed trust in researchers, although 50% had concerns about discrimination against those found to be at risk of a psychiatric condition (66).

Similarly, a survey of psychiatrists found that the vast majority (95%) felt that it was their role to discuss genetic information about psychiatric illness with their patients, but only 70% felt competent to do so and only 9% felt competent to actually offer genetic tests and interpret them (57). Interviews of psychiatric genetic researchers who study mood disorders found that researchers share the concerns of patients, families, and clinicians. Researchers articulated six ethical concerns: stigma, prenatal testing and eugenics, the ethics of genetics research, a lack of genetic risk education among the general public and health care professionals, premature commercialization and direct-to-consumer testing, and lack of criteria for when to utilize psychiatric genetic tests (40).

USE OF BEHAVIORAL GENETICS IN LAW AND CRIMINAL JUSTICE

Behavioral genetics to date has been used in an evidentiary capacity in the courtroom but has not yet fundamentally affected the key elements that underlie our legal and criminal justice systems. However, the use of behavioral genetics in these arenas exposes a host of additional ethical issues, including criminal responsibility, biological determinism, and defining “risk” in a bioscientific age, all of which have the potential to alter not only the criminal justice process but also the fundamental ways in which we define, prevent, react to, predict, and punish criminal behavior.

Uses of Behavioral Genetics Evidence in Criminal Trials

In the criminal trial process, there are two comprehensive areas in which behavioral genetics evidence could be offered: when determining criminal responsibility and during the sentencing process. When determining responsibility, two elements of a crime must be established: *actus reus*, the guilty act, and *mens rea*, the guilty mind. This means that there must be evidence beyond a reasonable doubt that the defendant committed a guilty act with guilty intention to establish criminal liability. Genetic evidence could be used during this phase of the trial to try to negate *actus reus*, by claiming that the act was not guilty (e.g., self-defense or involuntariness), or to disprove or mitigate *mens rea*, by claiming that the defendant’s intention was not guilty (e.g., establishing insanity or a diminished or lack of capacity). Correspondingly, in sentencing, behavioral genetics evidence could be offered in an attempt not to negate responsibility but rather to mitigate it, such as by claiming a genetic predisposition to an impulsive behavior. The goal of this would be to use behavioral genetics evidence to lessen criminal responsibility and therefore lessen the amount or type of punishment given.

The actual use of behavioral genetics evidence in criminal trials has been uncommon. Denno (33) noted that from 1994 to 2011, only 81 known cases used behavioral genetics evidence in some capacity. The few cases where defenses have been partially built using behavioral

genetics to negate or lessen the *mens rea* of the defendant through evidence of diminished capacity or lack of intentionality have been unsuccessful. Instead, defenses have generally focused on using behavioral genetics evidence to try to prove the legal insanity of the defendant rather than diminished capacity or lack of intentionality (8, 44). Some early instances in which behavioral genetics evidence was offered to support a plea of insanity began in the 1960s, when research and studies of penal populations suggested that males with an extra Y chromosome were prone to violence and more likely to end up in the criminal justice system (58a). Several XYY defendants in the 1970s unsuccessfully attempted to use this research in court to establish insanity based on “chromosomal abnormality.” In most states, the burden of proof for an insanity defense lies with the defense rather than the state. Thus, these cases were never able to establish proof that the defendant suffered a mental disease or disorder that affected his ability to understand or perceive reality or right and wrong. The 2004 case *State v. Thompson* (100) clarified that the XYY insanity defenses had been rejected because the court had drawn a line between evidence that an individual *could* be predisposed or likely to exhibit certain types of behavior and evidence that a person acted in a certain way *because of* this predisposition.

Other defendants have used genetic evidence to build a defense based on the idea that a genetic predisposition to impulsivity or addiction or a genetic condition superseded their free will to act (44, 77). In the 1973 case *United States v. Moore* (109), a defendant’s criminal act was presented as “involuntary” owing to a serious compulsion for drugs that overrode moral standards and self-control. From this perspective, anyone who could show a predisposition to drug or alcohol abuse could claim to have acted involuntarily in an attempt to evade responsibility for criminal actions. Thus, the court rejected this reasoning. Although *Moore* and other cases involving impulse control have not yet produced successful defense strategies, opinions in other cases (30) suggest some receptivity, at least by judges, to arguments based on biological predispositions to types of involuntary behavior.

Despite these early attempts to negate criminal responsibility, behavioral genetics evidence is now most often presented during sentencing to mitigate punishment. In 1994, attorneys for convicted murderer Stephen Mobley attempted to use a family history of behavioral disorders and a positive test for *MAOA* gene mutation to show a genetic propensity for violence while appealing Mobley’s death sentence for the murder of a pizza store manager (75). Although the Georgia Supreme Court rejected this appeal (75), its use opened the doors for behavioral genetics to be used in a myriad of other sentencing cases. Of the 81 cases since 1994 that have employed genetic evidence (33), most have presented this evidence during sentencing in capital cases (33, 44). During sentencing, the claim is often that genetic predisposition is a mitigating factor that led the defendants to act as they did, either by causing them to act involuntarily (potentially because of a propensity for alcoholism or other substance abuse) or by inhibiting them from grasping the intention or consequence of their actions (33, 44). Defendants have also presented genetic evidence during sentencing to establish the “ineffective assistance” of their attorneys, who, according to the defendants, did not properly use or present genetic evidence during responsibility determination (31–33).

For example, during a 2009 murder trial, a defense attorney presented expert testimony and evidence to a jury during sentencing that his client had the “warrior gene” as well as an extensive history of abuse. Therefore, his client had been predisposed to this type of aggressive behavior and a lack of impulse control and had not premeditated the murder he was guilty of committing (50). This unique defense successfully convinced a jury to forgo first- and second-degree murder convictions, including the possibility of the death penalty, and the defendant was convicted on manslaughter charges. Although the defendant was sentenced to 32 years in prison for his crime, the genetic evidence presented had significantly swayed the jury to believe that the defendant had not possessed the intent to kill, with one jury member even commenting, “Some people without this would react totally different than he would. ... A bad gene is a bad gene” (50). No matter the outlook on the outcome of this case, such examples provide insight into the different types of platforms and settings in which behavioral genetics and genomic science are likely to be influential in the future.

Although behavioral genetics has gained some traction and influence, it has not yet substantially changed the legal system, and the number of cases in which behavioral genetics evidence has been presented represents only a small percentage of the total. Nevertheless, these cases still raise contentious issues of determinism, free will, intention, predisposition, stereotyping, disease, essentialism, the idea of the “self,” prediction, and a whole host of related concepts and disciplines, especially neuroscience. In 1992, the National Institutes of Health had to reschedule a conference called “Genetic Factors in Crime: Findings, Uses, and Implications” that was to focus on the current research and findings on the genetic underpinnings of violence, owing to the outcry on the provocative nature of the topic and arguments that the conference smacked of eugenics and racism (113). Although dialogue has increased following the Human Genome Project’s completion in 2003, it is still an uncomfortable subject for many, including the behavioral genetics community. Still, as behavioral genetics research continues to progress, many of these questions and potential implications for the legal and criminal justice systems must also be addressed by mainstream academia and policy makers. In fact, criminal cases in the past four years have shown a slow but prominent shift in judicial opinion to favor the allowance of behavioral genetics evidence into court proceedings (33), showing that these potential policy questions and implications will need answers and analysis much sooner than anticipated.

Future Implications for Law and Criminal Justice

In addition to its use in court evidence, current and future behavioral genetics research has the potential to permanently affect a host of specific arenas within the legal and criminal justice fields. Although innumerable issues can emerge from this type of research, this article focuses on (a) perceptions of legal and biological free will and responsibility; (b) issues arising from the concept of genetic essentialism, such as public, jury, and judicial understandings of genetic evidence as well as potential biological interventions or medications to alter behavior; (c) redefinition of the concepts of risk, prediction, and dangerousness; and (d) possible effects on privacy and discrimination.

Current and future behavioral genetics research may spur questions of whether and (if so) how individuals' free will can be affected by their genes or biology, including their responsibility for their actions if they were not able to govern their own will at the time of the action. This idea of genetic determinism—the idea that our biology causes factors that are responsible for the decisions we make—is consistent with how defenses have been formulated in conjunction with behavioral genetics in the past, attempting to show that a defendant's ability to exercise free will was compromised by his or her biology. Recent advances in neuroscience and other biological fields involved in researching the origins of human behavior have added new dimensions to age-old debates (46, 78, 114). However, they do not determine how free will should or will be defined in the legal process.

Farahany & Coleman (44) argued that the concept of “legal free will” is not compatible with the metaphysical, philosophical, or biological (among many other disciplines) notions of free will and agency. The criminal justice system, based on sets of standards, laws, and principles, relies on actors to choose to either violate or not violate those standards, lest they be assigned fault and subsequently punished. The very idea of legal free will is based on the choice to disobey these principles, knowing the repercussions of these actions (44). There are certain mental or psychotic disorders, such as schizophrenia, that cause an actor to lose reason and the ability to make the choice to violate these principles or to understand the repercussions of his or her actions; this is the reason that the insanity defense exists. However, the idea that an individual lacks the ability to make this choice owing to a genetic predisposition or propensity to act a certain way, one that does not also remove one's sense of reason or reality (such as addiction, impulsivity, or aggressive behavior), is difficult to reconcile with the criminal justice process. In addition, looking at individual cases and circumstances involving human behavior—especially when it comes to subjectively evaluating individual instances of genetic predisposition and how that propensity contributed to the criminal act at hand—would make it impossible to successfully use universal legal principles (such as proving proximate or actual cause, establishing the burden of proof, and establishing the elements of the crime) across the system when dealing with responsibility or punishment.

The concept of genetic essentialism, emerging from the notions of free will and responsibility, will also surely be affected by current and future behavioral genetics research. This notion of essentialism breaks down an individual's identity to some specific element, in this case one's innate genetic self. Genetic essentialism is an exceedingly difficult concept because it paints a nebulous portrait of what defines a person as *that* person and how much of that identity and the corresponding actions stemming from that identity are determined by genetic or biological influence. Two major issues arise from this idea. The first is the public, jury, and judicial understandings, or misunderstandings, of genetic evidence as it applies to the self, identity, and behavior. There is concern that in court, jury members and judges do not possess the types of knowledge or expertise to make legal decisions based on genetic claims or to recognize the scientific validity of an argument (36a). Juries and judges might overestimate how influential a defendant's genes or biology are on his or her behavior and to what level those biological factors contribute to that person's identity or sense of self. This becomes complicated even further when a

psychiatrist or scientist gives expert testimony on genetic evidence in court to a jury or judge who, trusting those labeled “experts,” might take opinions expressed in testimony very seriously or at face value without knowing the scientific soundness or depth of the evidence presented. This was recently seen in a hypothetical case study showing that, on average, surveyed judges gave a lighter, mitigated prison sentence to a criminal when evidence was presented that he was biologically predisposed to psychopathy (9).

The second issue arising from genetic essentialism concerns therapeutic interventions or medication that could potentially alter one’s genes or biology and consequently one’s behavior. It is incredibly challenging to decide whether it would be ethical to therapeutically treat or medicate a genetic or other biological disorder or predisposition of a person if that would prevent him or her from exhibiting certain criminal behaviors. An example of this would be a hypothetical medication to reduce pedophiles’ sexual attraction to children—would it be ethical to involuntarily medicate them to rid them of this sexual attraction, even if they had been born with it? One view is that, although acting on that sexual attraction encompasses violations of moral and legal principles, forcibly changing that person’s essential genetic or biological attributes is in fact changing that person’s identity or sense of self, even if the person is more inclined to commit certain criminal or immoral acts. This issue also highlights the relevance and potential uses of two established powers of the state: *parens patriae* power (the legal power of the state to take control of a person for that person’s own good) and police power (the legal power of the state to protect its members from danger). Thus, according to these powers, when is it ethical to intervene or regulate the behavior of individuals “for their own good,” and correspondingly, what are the legal and ethical thresholds for a state to intervene to protect its members from harm? In regard to potential interventions, these questions would be impossibly difficult to address.

Advances in behavioral genetics also create the potential to redefine the concepts of prediction, risk, and future dangerousness in our criminal justice system. Currently, the criminal justice system assesses the risk of an individual’s future dangerousness in several areas, such as in juvenile law, capital sentencing, competency hearings, civil commitment proceedings for sex offenders, and parole hearings. Most of the time, these predictions are made using clinical assessment scales as well as testimony from forensic psychiatrists or clinicians. In general, the use of predictions of future dangerousness has been highly controversial. Many scholars argue that these clinical risk assessments are not accurate in evaluating risk and that using personal clinician opinion based on these methods to sentence or commit someone is far too subjective and incomplete to make such important judgments, especially decisions that could detain an individual for an indeterminate amount of time (81).

However, future behavioral genetics research could provide a different and possibly more accurate mode of criminal prediction, hypothetically using data about the genetic makeup of a person to determine that individual’s propensity or “biological risk” for future dangerous behavior in instances like those listed above (10). From there, one could also extrapolate to say that using genetic or biological information to predict future dangerousness could also be applied to individuals who have not yet committed criminal acts, thereby “preventing” future acts from happening and saving individuals from being victimized.

Finally, issues surrounding privacy and discrimination are affected by behavioral genetics research. Questions concerning criminal DNA databases have recently surfaced, such as the extent to which DNA from criminals or those arrested but not convicted of crimes should be retained in state and federal databases, and if so, whether that DNA should be used to study specific traits or markers in behavioral science research without the consent of those individuals (62). There is concern that DNA will be used to discriminate against or label certain populations that are disproportionately represented in these databases (62). Regarding discrimination, the Genetic Information Nondiscrimination Act (GINA), which prohibits employers from genetically discriminating against employees regarding health insurance and employment, is an important piece of federal law that protects individuals from being discriminated against based on their genetic propensity for certain disorders. However, GINA does not cover or regulate the newest mode and future of genetic testing: genetic testing at home by consumers, which has begun to cover everything from medical testing to identification of ancestry (91). Thus, as stated above, the number of ways that behavioral genetics research can influence the legal and criminal justice systems is ever growing.

THE FUTURE OF BEHAVIORAL GENETICS RESEARCH: ETHICAL, LEGAL, SOCIAL, AND POLICY IMPLICATIONS

As technologies and our understanding of behavioral genetics develop, research continues to raise ethical, legal, social, and policy issues, especially as the scope of potential genetic testing expands to the legal and criminal justice systems and to unregulated at-home testing. Furthermore, there are many other areas in which issues will surely arise in the future. First, the field of behavioral neurogenetics is constantly expanding in its scope of study, and the convergence of neuroscience and behavioral genetics research, paired with new technologies and cutting-edge research techniques in neurogenetics, has the potential to affect the concepts and understandings of free will and morality.

Second, it is also likely that military use of behavioral genetics research will increase in the study of areas like posttraumatic stress disorder, the genetic likelihood of suicidal behavior, soldier adaptation, mental resilience and decision making, and improvement and prediction of soldier performance, all of which could produce unique moral challenges because of the lack of autonomy of military personnel. Manipulation of behavior through genes poses even more difficult ethical challenges. Finally, as technologies allow for prenatal genetic testing and prices continue to fall for whole-genome sequencing, an inordinate amount of prenatal genetic data will be generated that could be misused or misunderstood by clinicians, parents, or the children themselves and could permanently alter the raising, or even the existence, of those children (36).

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SUMMARY POINTS

1. The development of new techniques and analytic approaches, including genome-wide association studies and examination of gene-environment interactions, has clearly changed the study of behavioral genetics.
2. The potential new and future uses of behavioral genetics research continue to raise important ethical, legal, social, and policy issues.
3. The universality of genetic and genomic tools has allowed researchers to address an ever-widening scope of phenotypes, including personality traits, voting behavior, and moral judgment.
4. Researchers have yet to identify definitive genetic causes of behavior, but the commercialization of genetic testing has created a venue for making such tests available for characteristics such as schizophrenia, bipolar disorder, and intelligence.
5. Other technologies, such as cell-free fetal DNA analysis for prenatal testing and genetic manipulation through optogenetics, raise ethical and social issues about the appropriate application of technologies, especially regarding behaviors.
6. Behavioral genetics research is now starting to be used in criminal trial procedures, including as a strategy to mitigate punishment, which has been successful in a few cases.
7. Behavioral genetics could also be used in many other facets of the criminal justice system, including prediction of future dangerousness and determining prophylactic intervention to prevent future dangerous acts.