SCIENCE AND SOCIETY

Applications of behavioural genetics: outpacing the science?

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Abstract | Human behavioural genetics is an established research discipline of the genomic age, and applications for behavioural genetic information are most likely to emerge in areas such as criminal justice, education, employment and insurance. However, behavioural genetic research into personality traits and antisocial behaviour poses several risks; for example, tentative or preliminary research findings might be misused in legal and commercial settings. Scientific caution, public and media education, expert consultation and confidentiality protection are essential for the responsible use of behavioural genetics.

The study of the role of heredity in human behaviour emerged at the end of the nineteenth century, and since then the resulting scientific data has been extremely controversial. Studies that claim to show a genetic basis of low intelligence and antisocial behaviour among immigrants to the United States from southern and eastern Europe in the early 1900s paved the way for restrictive immigration laws. The asserted genetic basis of immorality and mental defects was misused to enact eugenic sterilization laws in most of western Europe and many states of the United States at the beginning of the twentieth century. Behavioural genetics research was also misused to support Nazi claims of racial superiority (and non-Aryan inferiority), which had a direct and important role in the Holocaust[1,2].

As we contemplate the potential for misuse of new behavioural genetics research, it is important to recognize the crucial role that the media has in informing the public of new scientific discoveries. The public has traditionally shown a keen interest in behavioural genetics, and genetic explanations of human behaviours have always been popular in the mass media[3]. Although scientific publications of new findings are usually properly controlled and qualified, descriptions of new research in the popular media are not always as constrained. As one journalist recently explained, "We science reporters occupy a humble niche in the vast news and entertainment industry [and we] must compete fiercely for editors' and readers' attention."[4] The public is increasingly confronted with reports claiming that violence, happiness, impulsivity, religiosity, fidelity and other behaviours are 'hard wired' rather than being caused by many factors[5]. Although the accuracy and effect of media reports of genetic discoveries have been debated in the literature[6,7], public confusion is an expected result[8].

Because many individuals and institutions might act on the basis of these misconceptions, popular misunderstanding of behavioural genetics is of great concern. In this article I summarize recent scientific developments in behavioural genetics, with emphasis on the genetics of mental disorders, aggression, addiction and personality. I discuss the economic and legal pressures that might lead to the misuse of preliminary studies in behavioural genetics. I then analyse the most probable settings for the use of behavioural genetic information — criminal law, education, employment and insurance. I conclude by considering the ethical and legal framework for applications of behavioural genetics.

Scientific developments

The traditional tools of behavioural genetic research consist of animal studies, family studies (including adoption studies), twin studies, LINKAGE ANALYSIS and population studies. Although these studies have revealed a statistical correlation between genetic factors and certain behaviours, they can only predict in a probabilistic way the likelihood that individuals will show a particular behaviour. More recently, the application of genomics to behavioural genetics has been accelerated by the Human Genome Project[9,10], and could provide the means to individualize behavioural genetic assessments in the future. By analysing the genotype of an individual, scientists might be able to make more accurate predictions about the influence of genetic factors on that individual's behaviour.

Genomics — and associated fields such as proteomics, transcriptomics, metabolomics and pharmacogenomics — also holds great promise for understanding how the brain and CNS function. Emerging behavioural genetic insights could have an important role in the prevention and treatment of a wide range of behavioural and psychiatric disorders. These developments might also have a wider application for treating minor anxieties, addictions, phobias and adjustment problems that individuals routinely face in daily life.

Although scientists overwhelmingly agree that human behaviour is affected by genes that is largely as far as agreement on this subject goes. The range of behaviours that are influenced by genes, the effect of the environment on particular behaviours, the methodology for determining heritability, the plasticity of genetic predispositions and

numerous other issues are still under debate. With only a few exceptions, behavioural genetics involves complex interactions of many genes and environmental factors[11]. Furthermore, there is an important distinction between psychopathology and variation within normal bounds. Minor variations in personality and temperament are likely to be more difficult to link with genetic factors than well-characterized mental disorders, although there is no guarantee that even studies that deal with well-studied psychiatric illnesses will be successful[12]. Bearing in mind these caveats, I provide a brief overview of areas of behavioural genetics in which links have been found between genetic components and behaviours that have implications for use in legal, commercial and educational settings.

Genes and mental disorders. Genetic influences on various mental diseases have been reported in the literature but have not been thoroughly characterized. Studies of depression[13], BIPOLAR DISORDER[14] and schizophrenia[15] have identified genetic loci or regions of genes associated with molecular pathways that lead to diagnosable psychiatric conditions. However, defects in many of these pathways result in various behavioural disorders with a range of severity and presentation, making it even more difficult to make definitive links. For example, there are two isoforms of monoamine oxidase (MAO) in humans — MAOA and MAOB — both of which are encoded on the X chromosome[16]. MAO has an important role in metabolizing and modulating neurotransmitters that are essential for brain function[17,18]. Mutations in the gene that encodes MAOA, although rare, are thought to be associated with certain pathologies and abnormal behaviours, including schizophrenia, bipolar disorder, Parkinson disease, alcoholism and nicotine addiction[19–21]. Variation in MAOA activity has also been associated with depression, aggressiveness, impulsivity and other antisocial behaviours and psychopathologies[22].

In frequently cited research, investigators studied a large Dutch family, including several males with borderline mental retardation who showed abnormal and impulsive behaviours, including aggressive and violent behaviour, arson, exhibitionism, voyeurism, rape and attempted suicide[23]. A complete deficiency of MAOA activity was found to be related to "abnormal aggressive behaviour in affected males"[24]. Other studies, including those with females and adolescents, confirmed the hypothesis that substantially reduced levels of MAOA activity correlate with higher levels of impulsivity, low socialization and vulnerability for criminal behaviour[25,26].

Genes and aggressive behaviour. Studies of the genetics of aggression have been increasingly used in criminal law and other areas, which are discussed below. Serotonin is an important neurotransmitter that has been linked to human aggression[27], and some of the receptor sites for serotonin have known genetic polymorphisms, which might underlie variations in aggressive behaviour[28]. Serotonergic neurons, which are located primarily in the BRAINSTEM and project to almost every part of the CNS, have been implicated in many functions of the CNS, including sleep, arousal, feeding, motor activity, mood and stress resilience[29]. Reduced levels of serotonin metabolites in the cerebrospinal fluid have been found in aggressive psychiatric patients, impulsive violent men and victims of violent suicide[30,31]. Other studies have shown that low levels of these molecules were predictive of RECIDIVISM in violent offenders and arsonists, and they were strongly associated with a family history of paternal violence and alcoholism[32]. Serotonin polymorphisms have also been correlated with panic disorder[33], impulsivity[34] and poor behavioural control[35].

Dopamine, another neurotransmitter, has also been shown to have an effect on behaviour. Six dopamine receptors have been well characterized so far[36]. Dopamine release induces a 'reward cascade' in the brain, which leads to feelings of well-being and stress reduction[37]. Preliminary studies have shown a correlation between dopamine D3 receptor polymorphisms and aggressive behaviour[38,39].

Genes and addictions. Substantial genetic research has established correlations between certain genes and a propensity to addictive behaviour, including gambling and the use of alcohol, tobacco and various licit and illicit substances[18,40]. A polymorphism in the D2 receptor has been associated with craving for a dopamine fix, which is satisfied by ingesting alcohol, cocaine, heroin, marijuana or nicotine[37]. The genetic factors that predispose to addictive behaviour, violence and other antisocial behaviours can be interrelated for several reasons. First, the genetic factors that have been identified as having a causal role in addiction also have causal roles in violent, aggressive or impulsive behaviour[41]. Second, even if these genotypes are not independently linked, merely being addicted is often associated with these other behaviours[42]. Last, the continuing need for large sums of money to satisfy an addiction, which might be partly caused by genetic factors, often causes individuals to engage in aggressive criminal activity.

Genes and personality. If and when behavioural genetic screening begins it will probably grow out of the desire to make an early assessment of a psychopathology or to avoid commercial and other relationships with individuals that are at an increased risk of antisocial behaviours. Nevertheless, research is also being carried out that relates to the non-pathological dimension of behavioural genetics. Researchers have studied, among other things, the genetic influence on happiness[43], intelligence[44], novelty seeking[45], sexual orientation[46], shyness[47], sociability and positive emotionality[48], and memory skills[49]. All these aspects of personality are important in employment, education and other settings, which are discussed below.

Why rely on preliminary studies?

As noted above, media reports that suggest determinative links between genotype and behaviour might lead to the public's overestimation of the role of genes in human behaviour. Various entities with financial interests in the behaviour of certain individuals might then attempt to use genetic information to predict behaviour. For example, employers and insurers might be liable for injuries caused by an impulsive, aggressive or emotionally unstable individual. Many employers undoubtedly believe that learning about potential employee's behavioural proclivities could result in substantial savings. Behavioural genetics might seem appealing because it is more 'high tech' than the use of references that relate to past behaviour, and it operates predictively, rather than relying on phenotypic expression.

There is ample indication that some entities would be willing to use new technologies despite the lack of adequate scientific proof for their validity. For example — in an incident involving medical rather than behavioural genetics — in early 2001 it was disclosed that the Burlington Northern Santa Fe Railroad, the second largest railroad in the United States, carried out genetic testing without the knowledge or consent of employees who had filed compensation claims for CARPAL TUNNEL SYNDROME (see also Online links). A laboratory under contract with the employer used a genetic test for a chromosomal deletion that is associated with HEREDITARY NEUROPATHY WITH LIABILITY TO PRESSURE PALSIES, a rare condition that might predict some forms of carpal

tunnel syndrome. Scientists overwhelmingly asserted that the use of this genetic test was improper and inappropriate because it tested for a rare mutation that was unlikely to have caused the disability of employees with known workplace exposures to repetitive motion and vibration[50]. The company quickly settled lawsuits that were based on the testing and promised not to repeat the genetic test. Because the railroad was willing to use an inappropriate genetic test in an attempt to identify predisposition to a physical condition, and in light of other unproven, non-genetic behavioural tests already in use[51], it can be assumed that other employers would be tempted to use unproven behavioural genetic tests.

The likelihood of preliminary behavioural genetic information being used in courts must be considered in light of the Anglo-American legal system. Each side in a legal case has its own lawyer, who has an ethical duty to assert all plausible claims on behalf of his (or her) client. The ethical mandate of zealous advocacy is especially applicable to defence lawyers in criminal cases, in which the conviction of a client could result in imprisonment or even execution (BOX 1). In 2003 the United States Supreme Court held that it was "ineffective assistance of counsel" for a defence lawyer to fail to investigate the family history of a convicted client before sentencing occurred[52]. In subsequent cases defendants have asserted that genetic predisposition to uncontrollably violent conduct and a family history of uncontrollably violent conduct should mitigate a sentence of death. Various unproven scientific hypotheses have been introduced in support of the defendants' claims.

Box 1 | **Behavioural genetics and the death penalty**

Thirty-eight of the fifty states in the United States provide the death penalty for at least some types of serious crime. In these states, capital punishment is considered to be appropriate on the basis of the severity of the crime and the culpability of the defendant. In *Thompson v. Oklahoma*, 487 US 815 (1988), the US Supreme Court held that execution of individuals who were 15 years old or younger at the time of their crimes violated the ban on 'cruel and unusual punishment' contained in the Eighth Amendment to the US Constitution. In *Atkins v. Virginia*, 536 US 304 (2002), the Supreme Court held that it was unconstitutional to execute mentally retarded offenders on the basis of their diminished culpability.

Most recently, in *Roper v. Simmons*, 125 S. Ct. 1183 (2005), the Supreme Court held that it was unconstitutional to execute individuals who were under 18 years old at the time that they committed their crime. The decision in *Roper v. Simmons* was based largely on "evolving national and international standards of decency" and the consensus that children lack the emotional and mental maturity necessary for the most culpable criminal intent. FRIEND OF THE COURT **briefs submitted on behalf of the defendant emphasized, among other things, that teenagers have "an underdeveloped sense of responsibility." Studies using modern neuroscience imagining techniques were offered to show that the brain does not mature until the age of 20–25 and therefore teenagers do not have fully developed frontal lobes that are capable of impulse control.**

On the basis of this line of reasoning, it is possible that the Supreme Court will be asked to rule on a future defendant's argument that it is cruel and unusual punishment to execute an adult who does not suffer from mental retardation, but whose impulse control has been compromised by a genetic mutation. Such a case would call into question a bedrock assumption of Anglo-American jurisprudence: individuals are assumed to have free will in their actions and therefore are legally responsible for their conduct.

Specific applications

Criminal law. Genetic explanations of antisocial behaviour represent an important area of research and one of the earliest applications of behavioural genetics[53]. Behavioural genetics could potentially be used in several ways — from the earliest stages of a criminal investigation through to almost every aspect of the criminal justice system.

DNA forensic techniques are used by law-enforcement agencies around the world. In the absence of a match between the evidence from a crime scene and the profiles stored in forensic DNA databases, DNA forensic profiling can be used for several purposes — to identify the gender of and make predictions about the race or ethnicity, health status, age, or physical characteristics of the sample source. Behavioural genetic forensic profiling might be increasingly used in law enforcement to predict the perpetrator's behavioural traits and psychiatric conditions, such as learning disabilities and personality traits.

Once a suspect is arrested and charged with a crime, behavioural genetic information could be presented at a bail hearing. Prosecutors might urge that bail should not be granted or should be set at a high amount because of the defendant's genetic predisposition to impulsivity (for example, risk of flight) or aggression (for example, risk of committing further crimes).

At trial, evidence of behavioural genetic variation within the normal range is unlikely to establish an independent basis for acquittal. More extreme deviations might be part of the scientific evidence used to support an insanity defence[54]. Behavioural genetic evidence might also be used to claim that the defendant lacked the mental capacity to form the intent necessary to commit the crime. For example, on this basis a defendant charged with premeditated murder might be convicted of a lesser offence, such as manslaughter.

In many states in the United States it is common for convicted defendants to introduce evidence that relatives across many generations have engaged in violent criminal activities, that the defendant has inexplicably engaged in antisocial activities from a young age, or that the individual has been diagnosed with a neurogenetic disorder. This is then used to assert that defendants who commit crimes caused at least in part by a genetic predisposition or compulsion are not as morally culpable and do not deserve the harshest sentences. It is difficult to determine whether such arguments have had an effect on the sentences imposed, but the willingness of some courts to consider such evidence[55] leaves open the possibility that behavioural genetics could be afforded greater weight in the future.

Behavioural genetic information could also be introduced in parole hearings. Ironically, the positions of the government and the inmate with respect to the behavioural genetic evidence are likely to be the opposite of their arguments at the trial. At a parole hearing, the government might attempt to use genetic predisposition as a basis for denying parole; the inmate might use the absence of genetic predisposition as a basis for release under the theory that he or she is less likely to commit another crime in the future.

Finally, many states in the United States have enacted 'sexual predator laws', which permit the indefinite confinement of individuals who have been convicted of multiple sex crimes against children and who are considered likely to commit further crimes if released[56]. In theory, behavioural genetic evidence might be used to predict the likelihood of the individual committing future sex crimes[57,58].

As a scientific matter, it is difficult to determine the contribution of genetic factors in the criminal activities of any particular individual. When these scientific issues are considered by judges and juries with little or no scientific training, there is a risk that the general public will give too much credence to unproven scientific theories, thereby increasing the likelihood of faulty or premature application of behavioural genetic research.

Education. Behavioural genetic research has shed light on various traits and disorders that are relevant to education, ranging from preschool through to graduate and professional school. Behavioural genetic testing might help to diagnose or identify the cause of mental retardation or other impairments much earlier than current assessment methods. Among the conditions that give rise to identifiable neurodevelopmental and neuropsychiatric disabilities that have an impact on educational development are FRAGILE X SYNDROME (see also Online links), KLINEFELTER SYNDROME, TURNER SYNDROME and WILLIAMS SYNDROME (see also Online links)[59]. Researchers have also attempted to identify the genetic factors in autism[60].

Genetic factors also have an important role in learning disabilities, such as dyslexia[61] and dyscalculia[62]. Furthermore, genetic links have been identified for ATTENTION-DEFICIT HYPERACTIVITY DISORDER[63] (see also Online links) and emotional disorders[64]. The genetic contribution to cognitive ability[44], memory skills[49] and other measures of academic potential could also be applied in educational settings for classroom placement and curriculum development.

Educational programming for students with mental retardation is the area that is most likely to be affected by behavioural genetics. In the past, definitive diagnoses, helped by genetic test results, have been used for several educational purposes. These include student evaluation, assignment of special services and instruction, placement, curriculum development, and determination of appropriate discipline[65]. As research in this field progresses, it is possible that behavioural genetic information could be used for a wider range of students to assess general academic potential and specialized talents.

The use of behavioural genetics by educational institutions raises two main concerns. First, school officials have little expertise in evaluating behavioural genetic technologies and deciding when and how to rely on genetic information. Schools also often lack the privacy safeguards needed to ensure that this sensitive information is not wrongfully disclosed. Second, there is a concern that behavioural genetic information will be given greater weight than it deserves in assessing complex phenotypes such as cognition. An unfortunate result could be to deny educational opportunities to many individuals, to the detriment of both the individuals and society. In most of the developed world, universal public education embodies meritocracy, vertical social mobility and social justice. Actions that limit opportunity, even on the basis of scientific considerations, might demand a social cost. For the near future at least, behavioural genetics is much more likely to be valuable in assessing learning disabilities (in which the influence of genetics is greater than that of the environment) than learning abilities (in which genetic influence is less than that of the environment)[66]. Socioeconomic status and other factors will further complicate this analysis[67].

Employment. Many employers spend substantial sums of money carrying out psychological, personality, intelligence and aptitude tests on applicants and employees[68]. Although there have been questions raised concerning the appropriateness of many of these tests[69], the purpose of the testing is understandable. Inappropriate employee selection and job placement are expensive for employers in terms of increased turnover, decreased morale, losses due to theft, lost productivity and damage to the employer's reputation. Furthermore, employers are concerned about potential legal liability resulting from the negligent or wilful misconduct of employees. Consequently, employers are especially careful in hiring employees for positions of trust, such as law-enforcement officers, day-care workers, teachers, transportation workers and employees who handle large sums of cash or valuables[70].

Some employers are willing to use handwriting analysis, honesty questionnaires and other unproven measures. In the United States, polygraphs were widely used until 1988, when Congress banned their use for most private-sector employment. In the future, some employers almost certainly would be willing to use behavioural genetic testing, providing that the tests were not too expensive. Employers might attempt to identify individuals who are genetically predisposed to sexual predation[23], pathological gambling[71] or poor impulse control[72]. They might also seek to learn about genetic predisposition to shyness, assertiveness, ability to work under stress or other traits that are relevant to the position.

As with the use of behavioural genetics in educational settings, its inappropriate use in employment could result in the wrongful exclusion of individuals from important

Box 2 | **How a lawsuit could spur the growth of behavioural genetic testing**

As an indication of how behavioural genetic information of dubious scientific value could become more widely used, take the theoretical example of a publicized personal-injury lawsuit. Suppose a young boy at an overnight summer camp is seriously injured when he is hit in the head by a rock that is unexpectedly but deliberately thrown by another boy. The injured boy might have substantial medical bills and other expenses and might, through his parents, seek legal compensation. But who should the boy sue? If neither the aggressor's parents nor the camp had any forewarning that such an attack might occur, it is doubtful that a lawsuit would be successful in charging negligent supervision or failure to control the child.

Behavioural genetics might indicate another legal theory. The injured child's lawyer might assert that had the camp required behavioural testing to be carried out, perhaps including behavioural genetic testing of all campers, it would have learned that the aggressor child had a particular genotype that the plaintiff's expert would testify confers a genetic predisposition to violent behaviour. Therefore, as the argument would go, if the camp had required behavioural genetic testing to be carried out, it would have refused to admit the child to camp and the injury would have been averted. In personal-injury cases, defendants, their lawyers and their insurers often attempt to calculate their legal exposure. If the odds of the plaintiff recovering on this theory are 5%, and the potential damages are US$3 million if the plaintiff wins, then the case would have a settlement value of at least $150,000, because the defendant would also save on legal fees. Accordingly, even a scientific explanation with questionable merit could support a substantial settlement.

If the defendants opt to settle and the case receives publicity, there might be a widespread misimpression that behavioural genetic screening has scientific support. Parents might start to demand testing before sending their children to camp, and insurers might pressure camps to adopt testing. Undoubtedly, commercial laboratories would attempt to promote even wider testing, including testing by boarding schools, dormitories and various residential workplaces, such as offshore oil rigs.

Glossary

ATTENTION-DEFICIT HYPERACTIVITY DISORDER
A persistent pattern of inattention and/or hyperactivity or impulsivity that is more frequently displayed and more severe than is typically observed in individuals that are at a comparable level of development.

BIPOLAR DISORDER
A mood disorder that is characterized by periodic swings between exaggerated elation and depression.

BRAINSTEM
A portion of the deep posterior part of the brain that consists of the midbrain, pons and medulla.

CARPAL TUNNEL SYNDROME
Compression of the median nerve as it passes through the carpal tunnel in the wrist, which is often caused by repetitive flexion and extension of the wrist.

FRAGILE X SYNDROME
X-linked mental retardation. It occurs in both genders, but with a higher frequency in males.

FRIEND OF THE COURT
An individual or group that has an interest in a case, but is not a party to it.

HEREDITARY NEUROPATHY WITH LIABILITY TO PRESSURE PALSIES
A disorder of the peripheral nerves that results in unusual sensitivity to touch, numbness and loss of muscle strength.

KLINEFELTER SYNDROME
A disorder in which males have an XXY-chromosomal constitution. It is associated with a predisposition to learning disabilities and other symptoms.

LINKAGE ANALYSIS
A method for tracking the transmission of genetic information across generations to identify the map location of genetic loci on the basis of co-inheritance of genetic markers and discernable phenotypes in families.

RECIDIVISM
The tendency to relapse into a behavioural condition, especially criminal behaviour.

TURNER SYNDROME
An aneuploidy disorder in which females have a single X-chromosome constitution. It is associated with a diminution in perceptual abilities.

WILLIAMS SYNDROME
A disorder that is caused by deletion in chromosome 7, resulting in mental retardation, aortic stenosis and other symptoms.

opportunities[73]. Behavioural genetics might implicate various laws, including statutes that specifically prohibit genetic discrimination in employment and more general laws that prohibit discrimination based on physical or mental disability[74]. Similar to criminal law, the use of behavioural genetics in employment law could challenge courts to understand the findings and limitations of new scientific discoveries and also to rule on the relative rights of employers and workers in hiring decisions.

Insurance. Behavioural genetic information could be used in establishing eligibility and setting rates for various insurance products. The most obvious use of behavioural genetics would be in private health insurance to predict which applicants for individually underwritten insurance might require mental health services for psychiatric conditions[75] or addictions[76]. Disability insurance companies might also want to predict which applicants for insurance were at increased risk of temporary or permanent disability from behavioural health problems.

A less obvious, but possible future use of behavioural genetic information, at least in the United States, is in life insurance[77], where a genetic predisposition to risk-taking[78], novelty-seeking[79], depression[80] or impulsivity[81] could be considered a risk for premature mortality. In the United Kingdom and other countries, voluntary or mandatory restrictions have been applied to the use of genetic information in life-insurance underwriting[82]. In addition, behavioural genetic traits might be considered to establish a high risk of claims being filed in the context of automobile, household or property insurance. Behavioural genetic screening could be used in an attempt to avoid the liability caused by the intentional or negligent acts of mentally unstable individuals (BOX 2).

The use of behavioural genetic information in any insurance product raises two fundamental questions. First, how accurate is the scientific information on which actuarial predictions are based? Second, assuming that the predictions are accurate, what is the social role of private insurance? Does medical underwriting of the insurance product further societal interests, such as access to health care and financial security for families after the death of the primary bread-winner? Policy decisions that relate to behavioural genetics and insurance should be attuned to overall policies for the use of genetic information in insurance.

Conclusions

The Human Genome Project has led to greater public awareness of the role of genes in disease and behaviour, but it has also led to an increase in popular ideas of behavioural genetic determinism. Despite the preliminary or qualified nature of some associations between genes and behaviour, the applications of behavioural genetic information in everyday life will probably increase. The adversary legal system and the inclination of employers and other institutions to embrace new technologies in the absence of scientific proof of their efficacy are both likely to encourage the proliferation of behavioural genetic testing and genetic explanations of behaviour. This is supported by the economic incentives of insurers and other institutions to avoid commercial relations with individuals who are believed to be at an increased risk of costly behavioural problems. Although the type of scientific data and the reason for its possible use differ for each of the areas in which behavioural genetics might be applied, some common societal challenges emerge. First, there is great potential for misinterpreting and misusing behavioural genetic information, therefore researchers need to be careful in public pronouncements and should temper their enthusiasm for the potential implications of preliminary studies[83]. Second, public and media education programmes need to devote more attention to behavioural genetics, including learning about past abuses and the scientific limitations of research findings. Third, commercial and social institutions need to deliberate carefully and consult with experts before applying behavioural genetics to avoid limiting opportunities for individuals or stigmatizing them. Fourth, because behavioural genetic information is extremely sensitive, those who hold such information must ensure that it is kept confidential. Unless these concerns are addressed there is a real risk that the legal and commercial applications of behavioural genetics will outpace the science to the detriment of us all.

Even assuming the validity of the research findings, behavioural genetics raises important ethical issues and societal challenges. Behavioural genetic information might call into question individual and social ideas of equality of opportunity, discrimination and personal responsibility[84]. As we consider the legal and policy implications of behavioural genetics it is important to undertake further social scientific research on the effect of genetic explanations of behaviour on individuals and society.

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