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Big Data, Behavioural Genetics and Risk of Future Offending

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Abstract

A convergence of trends in assessing the future risk of reoffending could result in morally questionable inputs into the criminal process. Advances in the analysis of DNA and increases in the availability of information about people gleaned from social media might allow for new inferences to be drawn against offenders during the sentencing process. We explore how developments in forensic DNA analysis methods and law enforcement DNA databases in conjunction with information about an offender's developmental environment could lead the prosecution to postulate a high risk of recidivism and thus argue for a longer sentence. We then consider some reasons why such a prosecution strategy might be troubling. In doing so, we focus on issues related to the inferential process, discrimination, privacy and constitutive luck.

***Keywords**:* Big data; DNA databases; sentencing; behavioural genetics; genetics evidence; social media; privacy.

Introduction

Studies in behavioural genetics have indicated that certain genes (i.e., genotypes) in interaction with environmental factors throughout an individual's development may predispose them to specific characteristics (i.e., phenotypes), including those related to behaviour and psychology.[1] This information might be used as evidence in criminal courts to argue that an offender is less culpable because they are genetically predisposed to issues, such as impaired judgment or a reduced capacity to control their behaviour, or that they are predisposed to be aggressive and pose a danger to society.[2] In practice, it appears that behavioural genetics evidence has been used in several jurisdictions by offenders to argue for a more lenient sentence, but the prosecution very rarely, if at all, introduces behavioural genetics to argue for a longer sentence based on a claim that the offender presents a high risk of future offending.[3] As we will discuss later, this is due to various potential factors, including the cost, the strength of the evidence and the accessibility to DNA data for prosecution. In this paper, we argue that recent DNA analysis technologies, next-generation sequencing, and big data might change the way behavioural genetics evidence is used in sentencing, and the prosecution might introduce this evidence to argue for longer sentences.

This possibility is increased by rapid improvements in genetic sequencing and public genomic databases. In the forensic context, the significance of next-generation sequencing technology may grow, as this technology may allow for crime-scene DNA evidence to be used to guide the investigation by indicating that there is a higher probability that an offender has particular

[1] Plomin, Behavioral Genetics.
[2] See Farahany, "Behavioural Genetics."
[3] See, Denno, "Behavioral Genetics Evidence;" Denno, "Courts' Increasing Consideration;" McSwiggan, "The Forensic Use."

characteristics than individuals in the general population. These characteristics include skin, eye and hair colour, and chronological age.[4] But more importantly for the present purposes, recent developments in genetic analysis technology may expand the use of law enforcement databases into predictions of the risk of future offending.[5]

In conjunction with advances in DNA analysis technologies, socio-technical shifts, perhaps most notably (but not exclusively) those facilitating wider uptake of social media, could play a role in enabling such possibilities. This is because behavioural genetics inferences are made by combining biological and environmental information (i.e., nature and nurture interaction). Combined insights from advances in DNA next-generation sequencing and the increasing availability of data (i.e., big data) on an offender's formative environment may enable the prosecution to make more informed behavioural genetics inferences and raise more compelling arguments regarding an offender's potential future dangerousness. The key practical question is not so much about whether the epistemic basis has been strengthened but whether a court can be persuaded that there is a firmer basis for the inference it is suggested that they make.

An increased prosecutorial capacity to argue for future dangerousness might be advantageous to the prosecution at various stages of the criminal process, including bail hearings and parole decisions.[6] In some jurisdictions (e.g., England and Wales, and Australia), depending on the circumstances of the case specific types of offenders are evaluated at the end of their sentence, and if they pose a risk of serious harm to the community, they may serve post-sentence preventive detention (i.e., be detained beyond their original sentence).[7] In this paper, however, we focus on how recent developments might support the prosecution's claim about an offender's future dangerousness in support of a longer sentence. Of course, the existence and nature of such a legal possibility for the prosecution will vary according to the rules of evidence in different jurisdictions and our intention is not to make a claim about any particular jurisdiction; rather, it is simply our aim to draw attention to a possibility that the prosecution might consider in some jurisdictions.

To investigate the possible prosecution strategy, we first draw on the monoamine oxidase A (MAOA) gene and aggressive behaviour as an example to show how genetic data could potentially be used to assess an offender's future dangerousness in courts. We then outline how evidence derived from behavioural genetics has historically been used in sentencing. Next, we consider how next-generation sequencing might be used to infer an individual's genetic data without their consent. We then discuss some developments in relation to the availability of data pertaining to an offender's formative circumstances from various sources, including their past social media activities. After that, we consider potential novel uses of behavioural genetics evidence with reference to recent developments in next-generation sequencing and big data in sentencing.

Ultimately, we argue that the availability of both next-generation sequencing technology and big data (i.e., nature and nurture data) could make behavioural genetics evidence more appealing to prosecutors. To support the plausibility of our argument, we discuss how law enforcement has previously used public genetic databases to identify suspects, raising many concerns, including those relating to the privacy of individuals. This leads us to the final consideration of the paper; that is, the serious ethical issues are raised if next-generation sequencing is used to infer behavioural genetics evidence. We draw attention to some of the epistemic and ethical issues that result from the prosecution's possible use of such evidence in sentencing, questionable inferential reasoning relating to the kind of data under consideration here, discrimination, privacy and constitutive luck.

Use of Behavioural Genetics in Criminal Courts

Behavioural geneticists have shown that it is possible to infer *the likely* characteristics of an individual from genetic and environmental data. Many behavioural and mental health traits have a significant genetic component, including depression and schizophrenia.[8] In some circumstances, many of these behavioural traits can be of relevance in a criminal proceeding. Aggression can be a significant behavioural factor in deciding sentence length (e.g., it may suggest that an offender is prone to

[4] Plesivkova, "A Review."
[5] Further, in cases of recidivism, such databases might free prosecutors from reliance on the collection of DNA evidence from contemporaneous crime scenes in cases where there is no contemporaneous crime-scene evidence or where it has been lost or tainted.
[6] Similarly, following a successful insanity defence, the prosecution may point out the risk of reoffending and the necessity of detention in a mental health facility.
[7] The preventive detention order may have different forms in different jurisdictions (e.g., indefinite or finite, and renewable), see Ashworth, "Preventive Detention of the Dangerous."
[8] Plomin, Behavioral Genetics.

recidivism and therefore warrants a longer sentence). Further, in various jurisdictions, courts have heard arguments that substantive evidence exists for the genetic and environmental conditions that lead to aggression.[9]

To illustrate how genetic data could be used to influence the assessment of an offender's future dangerousness, we use the connection between the MAOA gene and aggressive behaviour as an example, both because it is widely discussed in the scientific literature and because of the history of its use in courts.

Behavioural Genetics: The L-MAOA Gene and Aggression

A relationship between MAOA levels in males and violence was identified as early as the 1990s. MAOA is an enzyme that regulates neurotransmitters in the brain[10] and consequently helps regulate emotional responses to stimuli.[11] In 1989, genes that code MAOA were identified.[12] By 1998, the different forms of the MAOA gene[13] that affect MAOA (enzyme) production were recognised.[14] The low-activity MAOA (L-MAOA) genotype was found to code for lower activity of the MAOA enzyme due to its shorter repeat structure, while the high-activity MAOA (H-MAOA) genotype was found to code for increased MAOA activity. A piece of research that attracted significant attention was the study published by Caspi et al. in 2002, which indicated the importance of the interaction of genes with environmental factors in predisposing males towards certain behavioural traits (i.e., the gene-environment interaction).[15] Specifically, Caspi et al. compared the effect of childhood maltreatment on adult men with L-MAOA genotypes and H-MAOA genotypes. They found that while childhood maltreatment increased the likelihood of antisocial personality disorder in H-MAOA individuals, it more radically increased the risk of antisocial personality disorder in L-MAOA individuals.[16] In the study, 85% of L-MAOA males who suffered severe maltreatment developed some form of antisocial behaviour.[17] Although individuals with L-MAOA and maltreatment only comprised 12% of the male cohort in the study, they committed 44% of the violent crimes in the cohort.[18] Later studies identified how these genes can influence female aggression.[19]

Despite optimism about finding more genetic roots of behavioural traits, the connection between genetics and behaviour is tenuous, as genes do not directly encode behaviour. The outcome of gene-environment interactions is only part of many interactions in the brain shaping the behaviour. As such, behavioural genetics—including identifying correlations between gene-environment interactions and behaviour—is a highly contested field.[20] Despite that, the relationship between aggressive behaviour and L-MAOA, where it is coupled with childhood maltreatment, is supported by some meta-analyses.[21] If it can be established that an individual has both the required environment and genes, then it could be argued that they are likely to be susceptible to acts of impulsive aggression. Of course, in different contexts (e.g., a science laboratory and a court), the probability of this interaction may have different probative values. Nonetheless, this predictive relationship (of MAOA and childhood maltreatment) has been used in some sentencing decisions.[22]

The interaction between MAOA and childhood maltreatment is not the only genetic and environment interplay, which is found to correlate with aggression. Other studies indicate other genetic factors may be linked to risk of aggressive behaviour, such as

[9] Aspinwall, "The Double-Edged Sword;" Farahany, "Behavioural Genetics;" Forzano, "Italian Appeal Court;" McCay, "Behavioral Genetics and Sentencing."
[10] Such as serotonin, ephedrine and dopamine.
[11] Byrd, "MAOA."
[12] Levy, "Localization of Human Monoamine Oxidase-A Gene." These genes are located on the X chromosome, one of the two sex chromosomes.
[13] Different forms of the same gene are called polymorphisms.
[14] Sabol, "A Functional Polymorphism."
[15] Caspi, "Role of Genotype;" Radford, "Scientists Identify Gene."
[16] The data used by Caspi were based on the Dunedin Multidisciplinary Health and Development Study. In this study, a birth cohort of 1,037 children was assessed at different ages. Around half of the cohort were male. The fact that the sample had a well-characterised record of environmental adversity made it suitable for Caspi's research. As Caspi reported, '[b]etween the ages of 3 and 11 years, 8% of the study children experienced "severe" maltreatment, 28% experienced "probable" maltreatment, and 64% experienced no maltreatment': Caspi, "Role of Genotype," 852.
[17] Caspi, "Role of Genotype."
[18] Caspi, "Role of Genotype."
[19] Ducci, "Interaction Between a Functional MAOA Locus."
[20] See, Rose, Neuro.
[21] Byrd, "MAOA."
[22] Bernet, "Bad Nature;" Feresin, "Lighter Sentence."

the oxytocin receptor (*OXTR*) gene,[23] serotonin transporter promoter variant (*5-HTTLPR*),[24] and Catechol-O-methyltransferase (*COMT*) genotype.[25]

Traditional Use of Behavioural Genetics in Criminal Courts: Mitigation of Sentence

In sentencing, behavioural genetics evidence may be used for at least two purposes. For instance, it may suggest that an offender committed the offense while they had a reduced capacity to control their behaviour and that they consequently deserve a more lenient sentence. However, the same evidence may also suggest that an offender has a high risk of recidivism and that the court should increase their sentence to protect the community (this is also known as the double-edged sword effect of biological evidence).[26]

Some studies previously attempted to evaluate the effect of genetic and neuroscientific evidence in mock sentencing decisions. However, the outcomes of these studies were inconsistent; some found the evidence to mitigate the sentence,[27] while others suggested it had no effect on sentencing decisions.[28] A further analysis of these mixed results suggested that one of the moderating factors is the participants' perceived aim of the legal system.[29] For example, those who were of the view that the primary aim of sentencing was retribution found neuroscientific evidence to be a mitigating factor. While those who were of the view that the primary aim of sentencing was the protection of society tended to favour a lengthier sentence.[30]

In practice, however, studies suggest that behavioural genetics has almost always been used by the offender in a plea for mitigation of their sentence, and typically based on their family history, and in other cases by way of genetic testing.[31] In both the United States of America (USA) and Italy, offenders have argued for a shorter sentence by referring to their MAOA status.[32] According to the analysis of Deborah Denno (2011) in the USA, behavioural genetics cases have generally been related to attempts by offenders to avoid the death penalty and have been used primarily in two ways: to provide additional support for a defence claim about an offender's impaired mental state, and to suggest that counsel has been ineffective by failing to have advanced behavioural genetics evidence that might have mitigated the offender's sentence. As Denno notes:

> at the very least, behavioral genetics evidence has no decipherable impact on a defendant's case or, at most, it becomes an effective tool along with a range of other kinds of variables in rendering a defendant ineligible for the death penalty.[33]

Interestingly, Denno found that the use of behavioural genetics evidence by the prosecution to indicate an offender's future dangerousness is rare. In her first behavioural genetics study (2009) (based on decisions between 1994–2007), Denno found that behavioural genetics evidence was used in only three (of 48) cases to highlight the risk of future offending,[34] and in her second study (2011) (based on decisions between 2007–2011), she found that it was not used in any of the 33 cases.[35]

Attributing this outcome in part to improvements in the quality of expert witnesses and evidence, 'which could preclude extreme characterizations or conclusions that a defendant may be "hard-wired" into dangerousness',[36] in her 2011 study, Denno argued that:

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[23] LoParo, "Rigorous Tests."
[24] Tielbeek, "Meta-Analysis."
[25] Tuvblad, "Physical and Verbal Aggressive Behavior." See also, Asherson, "The Genetics of Aggression;" Craig, "Genetics of Human Aggressive Behaviour;" Pavlov, "Genetic Determinants;" Vevera, "Rare Copy Number Variation."
[26] Chandler, "The Use of Neuroscientific Evidence." See Aspinwall, "The Double-Edged Sword;" Farahany, "Behavioural Genetics;" McCay, "Behavioral Genetics and Sentencing."
[27] For studies suggesting the mitigating effect of neurobiological evidence see, Greene and Cahill, "Effects of Neuroimaging Evidence on Mock Juror Decision Making."
[28] For discussions suggesting neurobiological evidence has no effect on sentencing, see, Appelbaum, "Impact of Behavioral Genetic Evidence;" Schweitzer, "Neuroimages as Evidence;" Scurich, "The Blunt-Edged Sword."
[29] Perricone, "The Effect of Neuroscientific Evidence."
[30] Perricone, "The Effect of Neuroscientific Evidence."
[31] See, Denno, "Behavioral Genetics Evidence;" Denno, "Courts' Increasing Consideration;" McSwiggan, "The Forensic Use."
[32] McSwiggan, "The Forensic Use."
[33] Denno, "Courts' Increasing Consideration," 1028.
[34] Denno, "Behavioral Genetics Evidence." In those three cases, it is unclear to the authors of this article whether the prosecution initiated the future dangerousness argument by introducing the behavioural genetics evidence to the court or whether the prosecution pointed out the possibility of future dangerousness following the introduction of behavioural genetics evidence by the offender.
[35] Denno, "Courts' Increasing Consideration."
[36] Denno, "Courts' Increasing Consideration," 997.

> While behavioral genetics evidence is viewed as a double-edged sword, each side of that sword is not the direct flip of the other. The hurdles for the State are substantially different from those for the defense and their evidence and arguments may not be comparably compelling.[37]

There seem to be two possibilities for the prosecution if they want to use behavioural genetics to argue for a longer sentence. One is to use a family history argument that suggests that an offender comes from a family that is genetically predisposed to some criminogenic trait (making use of family trees), and the other is to rely on molecular genetics (genetic testing) and to focus on demonstrating that the offender carries a gene that has been linked with crime, such as L-MAOA. However, prosecutors do not make much use of such arguments.

It is possible that the prosecution might view the family history–based behavioural genetics argument as insufficiently strong to argue that an offender would be a risk to the community some years in the future. This appears to be consistent with Denno's observation on the double-edged sword of behavioural genetics that the prosecution's 'evidence and arguments may not be comparably compelling'.[38]

Alternatively, the prosecution might rely on genetic testing (together with the evidence of defendant's family history). It seems possible that the historical usage of behavioural genetics in courts may have been at least to some extent shaped by the limitations of access to the relevant genetic information. Even if raising behavioural genetics to argue for the future risk of reoffending was a potential strategy for the prosecution in some jurisdictions, it may have been difficult or impossible for the prosecution to obtain the genetic data without the offender's consent. In sentencing practice, genetic data may have generally only been available for the purpose of mitigation when it aligned with the interests of the offender, as only the offender could decide whether or not to make some of their DNA available for analysis. For instance, in an Italian case, the *defendant* appealed against the sentence and requested genetic testing. The results indicated the existence of L-MAOA and the court the court mitigated the sentence based on the expert witness's testimony that such a genetic condition in combination with the offender's adverse early life experience would increase the likelihood of aggression.[39]

At the moment, molecular genetic testing is relatively costly, and the result of DNA identification testing that is usually conducted on the DNA collected from the crime scene is not useful for behavioural genetics evidence purposes.[40] However, these issues may be addressed with the advent of next-generation sequencing, and the prosecution may, at least in some jurisdictions where the rules of evidence make such actions possible, conceivably be the initiators of arguments (supported by behavioural genetics) for the risk of future dangerousness.[41]

DNA Data Analysis and Next-Generation Sequencing

When using current DNA identification technology[42] to determine the origin of an anonymous DNA sample (e.g., one collected at a crime scene), the forensic experts examine the *length* of some parts of the genome and not the DNA sequence.[43] Consequently, this approach does not provide DNA data that indicates whether the person is predisposed to any trait, either physical or behavioural, and as such, this DNA analysis does not allow for inferences to be made for the purpose of a behavioural genetics analysis from DNA obtained from the crime scene.[44] However, through next-generation sequencing, it may be possible to identify DNA data from which behavioural genetics inferences can be made.[45] Further, next-generation

[37] Denno, "Courts' Increasing Consideration," 997. The defence might raise behavioural genetics evidence if they are confident that it will result in a more lenient sentence and withhold such evidence if there is a possibility that the behavioural genetics evidence may contribute to a harsher punishment. For a similar argument on neuroscientific evidence in sentencing, see: Alimardani, "An Empirical Study."
[38] Denno, "Courts' Increasing Consideration," 997.
[39] Baum, "The Monoamine Oxidase A (MAOA) Genetic Predisposition."
[40] Kling, "Investigative Genetic Genealogy."
[41] Our aim is merely to raise an emerging legal possibility that might in time be considered and not to conduct a comparative survey of the degree to which the rules of evidence around the world accommodate behavioural genetics based on arguments about dangerousness that might be raised by the prosecution.
[42] Short Tandem Repeat (STR) markers.
[43] Murphy, "Forensic DNA Typing."
[44] Kling, "Investigative Genetic Genealogy."
[45] Murphy, "Forensic DNA Typing.," While a STR analysis considers the length of a section non-coding DNA, a single nucleotide polymorphism (SNP) analysis identifies points of mutation that can be genetically relevant to the formation of phenotypes, including behaviour. To make a *relatively* accurate prediction about an individual's behaviour, there needs to be enough number of SNPs sequenced from a DNA sample. This can now be done with the advent of these next-generation sequencing technologies, particularly the use of SNP microarrays, such as Illumina GSA, which profiles over 600,000 SNPs. Even more accurate is the more recently available whole-genome sequencing, which analyses the entire genetic sequence of an individual. These are currently still too expensive for widespread use but

sequencing can be used to indicate that there is a higher probability that the offender has certain characteristics, such as specific eye, skin and hair colours, than the general population,[46] and this technology can also be used to identify the accused through the crime-scene DNA.

As this technology might become cheaper[47] and more prevalent,[48] it might be possible for prosecutors to submit DNA evidence collected from the crime scene to a third party or a forensic laboratory to be analysed to both identify the individuals and make behavioural genetics inferences, including those related to future dangerousness, and argue for a longer sentence. By storing the DNA data in the police database, law enforcement could reuse this evidence in the future. This is potentially significant, as in the future, more genetic markers may be identified as those that may predispose an individual to aggressive behaviour, and the prosecution may be able to use that knowledge in the court without going to the trouble of conducting DNA testing via next-generation testing again. These developments support our claim that there may be new uses and possibilities for the prosecution in the context of the legal system, perhaps including predictions of an offender's future danger to society.

Genetic profiles might inform predictions about behaviour; however, more information is required than just genes. As the MAOA example shows, data about the environment in which an individual was raised will be required to make more accurate behavioural predictions, and these data will need to be sourced from somewhere. If the prosecution intends to make use of the behavioural genetics research described earlier to establish a link between L-MAOA in an offender and likely impulsivity and aggression, they must also establish that the offender was subjected to childhood maltreatment.

Big Data and Behavioural Genetics Evidence

Like many characteristics inferred by behavioural genetics, impulsivity and aggression are influenced by both genes and environment, so the prosecution requires environmental data showing that the individual was subject to childhood maltreatment. At least in some jurisdictions, the introduction of evidence of childhood maltreatment into sentencing matters is not novel—such evidence can already have a role in assessing an offender's moral culpability.[49] While the sources for identifying and introducing the environmental evidence of maltreatment are well established—such evidence is usually introduced through social workers, medical records or the offender[50]—the environmental evidence for establishing the formation of other phenotypes may be derived from new sources and thereby bolster predictions of the offender's risk of reoffending based on behavioural genetics evidence for the prosecution.

There are longstanding repositories of information that might conceivably be used to establish environmental data more comprehensively. Platforms like Facebook and Google accumulate much of the data that may suggest the type of environment in which an individual was raised.[51] These large companies collect information about a person's location, interests, purchases and pastimes.[52] Increasingly, parents post information about their children on these sites, and schools encourage their students to create profiles early in life.[53]

At least in some cases, this recorded information might have a role in predicting environmental triggers for behavioural phenotype production. For instance, studies have shown that by collecting users' mouse-cursor tracking data, it is possible to predict users' demographic information.[54] Of course, corporate data collection goes way beyond mouse-cursor tracking data. By collecting and aggregating users' data from various sources, data brokers create digital consumer profiles.[55] This information

would provide a more accurate picture of an individual's genome if they became prevalent: Kling, "Investigative Genetic Genealogy;" Murphy, "Forensic DNA Typing."

[46] Plesivkova, "A Review."

[47] Elkins, Next Generation Sequencing; Murphy, "Forensic DNA Typing," Dorrier, "Ultima Genomics Claims the $100 Genome and Raises $600M to Go Even Lower."

[48] Pells, "Everything You Need to Know."

[49] For instance, in *Bugmy v R* (2013) 249 CLR 571, the High Court of Australia explained that an offender's deprived background could reduce their moral culpability and their sentence: 'An offender's childhood exposure to extreme violence and alcohol abuse may explain the offender's recourse to violence when frustrated such that the offender's moral culpability for the inability to control that impulse may be substantially reduced' (at [44]). See also, McCay, "Mitigation Is Difficult."

[50] See Howard, Crime and Mental Health Law.

[51] Ferguson, "Big Data."

[52] Bagley, "Don't Be Evil;" Rahbar, "Laundering Data."

[53] Singer, "How Google Took Over the Classroom.,"

[54] Leiva, "My Mouse, My Rules."

[55] Rostow, "What Happens When an Acquaintance Buys Your Data."

is not only sold to commercial entities; some data brokers also provide it to individual customers without the owner's knowledge or consent.[56]

Similar to data brokers, some may argue that future coordination between various data-gathering institutions is a real possibility. This could allow for the automation of behavioural profiles, in which data from the next-generation DNA analysis of law enforcement is combined with relevant environmental information (e.g., on social factors that express genes predisposed to aggression) to make behavioural predictions.

The ascension of big data and the collection of data by technology companies make increased access to environmental data about the public more and more feasible. This will all facilitate a possible future in which the prosecution can gain access to more data about an offender's background,[57] which, combined with the genetic data inferred from crime-scene DNA by using next-generation sequencing technology, could help them make behavioural genetics inferences without the offender's consent. To support the plausibility of our argument, in the next section, we will discuss how law enforcement has previously used public genetic databases to identify suspects.

A Recent History of Public Genetic Databases and Law Enforcement

We have indicated that both genomic data and socio-behavioural data may become more accessible, and that this accessibility could foster new uses of these data in the legal system. This dynamic can already be seen in the rapid utilisation of online genetic genealogical databases in the identification of criminals and their prosecution. Law enforcement has gained access to the genetic information of individuals from online genetic genealogy databases to prove guilt at the criminal liability stage in a rather unorthodox fashion.

Direct-to-consumer genetic testing (e.g., 23andMe and Ancestry.com) has created an enormous new data set of genetic information that the public has freely submitted to genealogy databases (e.g., GEDmatch and FamilyTreeDNA). These data have been used to identify close relatives, up to second cousins, in the search for suspects of crime.[58] This was made possible because the public now produces and provides their genetic and familial data, creating detailed genealogies to contact relatives or understand their family's history and heritage. According to one estimate, 90% of all Americans of European descent can currently be identified using genetic genealogy databases due to the availability of data submitted by their relatives.[59] Police have realised the power of this technology and famously used it in the case of the Golden State Killer.[60] Police analysed a DNA sample left at the crime scene and submitted the sequence into a genetic genealogy database under a pseudonym. The similarity of the DNA sample to distant relatives of the Golden State Killer allowed the police to identify him.[61] When the killer was identified, it was through a first cousin once removed; however, more distant relatives can also be used.[62] In another case, the mother of a deceased child abandoned in a ditch in 1981 was identified using the same methodology.[63]

The effectiveness of these techniques has led police and courts in the USA to pursue their use. Private companies tend to aim to preserve clients' privacy, but these policies usually include the clause 'except as required by law', and such exceptions may be common.[64] In response to the increased use of these sites by police, private companies have tried to shore up their privacy security. GEDmatch offered individuals the option to opt in to having their data used by police. Of the 1.3 million users registered, fewer than 200,000 consented to having their data used by law enforcement. However, in late 2019, a Florida court overturned this policy, serving a warrant to obtain information from the website, countering its users' explicit consent.[65] Given that GEDmatch is an international database, the privacy of individuals around the globe was compromised by the local laws of the Florida warrant. This constitutes a removal of the safeguards against the non-consensual use of these data by police, directly

[56] Minkus, "The City Privacy Attack;" Ramirez, "A Call for Transparency and Accountability;" Rostow, "What Happens When an Acquaintance Buys Your Data."
[57] Ferguson, "Big Data."
[58] To identify more distant relations, the data must be analysed through models that represent the genealogical structure of family relationships. To calculate this structure, the data are submitted to genealogical databases that use other historical sources, such as public registries and records, to create family trees. With this information, large genealogies can be constructed and further structure or possible relatives can be inferred through methods that identify the genetic relatedness of individuals: Kennett, "Using Genetic Genealogy Databases."
[59] Edge, "Attacks on Genetic Privacy."
[60] Fuller, "How a Genealogy Site;" Guerrini, "Should Police Have Access."
[61] Phillips, "The Golden State Killer Investigation."
[62] Zhang, "How a Genealogy Website."
[63] Zhang, "An Abandoned Baby's DNA."
[64] Kennett, "Using Genetic Genealogy Databases."
[65] Tiller, "If You've given Your DNA."

contravening the will of the individuals who submitted that data.[66] This shows that, based on the circumstances, the law can be volatile and amended to fit the needs of law enforcement, even if that means violating the rights of owners of genetic data.

Previous uses of such databases support our claim that it is plausible that law enforcement is interested in establishing DNA databases that can not only help to identify individuals based on their physical characteristics but can also be used to support arguments of future dangerousness for different purposes, including sentencing. More importantly, if such databases are created by law enforcement instead of third parties, they would no longer encounter certain difficulties, such as requesting a warrant to access an individual's DNA information.

Reflection on this Novel Use of Behavioural Genetics

Before proceeding to a reflection on some concerns about the possible prosecution strategy under consideration, it is worth first briefly recapping what has been said thus far. As mentioned above, in jurisdictions in which behavioural genetics has been used as a factor in sentencing, in most cases, the evidence has been used by the offender to attempt to mitigate the sentence. However, this framing of behavioural genetics is not favourable to any prosecution case, and the prosecution may prefer to emphasise the community's need for protection from a dangerous offender to urge for a longer sentence.

Prosecutors may determine that behavioural genetics evidence is not persuasive enough based on family history and may be reluctant to use it. They may also have trouble gaining an offender's consent to conduct DNA testing or finding legal means to compel the offender to provide a sample of DNA for the purposes of *sentencing* (rather than, say, for the purposes of identification). It is also possible that the relatively high cost and inaccessibility of resources to conduct molecular genetic testing have impeded using the crime scene evidence. However, with the advent of next-generation sequencing, it may become possible to access and analyse DNA data from a crime scene. Law enforcement may have already gained access to the genetic data of individuals from the crime scene for the purpose of identifying the accused person. It seems possible that we might eventually observe the use of genetic data by the prosecution for the purpose of making behavioural genetics claims at sentencing. A behavioural geneticist could then provide expert evidence to a court that the offender had, for example, the L-MAOA gene variant. If the prosecution could also obtain information about the offender's childhood maltreatment, either through traditional methods (e.g., social workers) and/or big data (e.g., Facebook and Google), they would be able to emphasise the community's need for protection from a dangerous offender.

Given the changing possibilities for the analysis of crime-scene data by the prosecution, a new trend could conceivably emerge where behavioural genetics evidence becomes part of the prosecution's strategy to support the argument that the offender poses a risk to society. As indicated earlier, such a strategy might well be bolstered by increased access to environmental data. However, this strategy is troubling.

There has been much scholarly discussion of the epistemic and ethical concerns relating to the use of behavioural genetics in sentencing. In relation to the epistemic concerns, McCay (2020) notes that there is doubt as to whether the science is sufficiently conclusive for the courts to rely on it.[67] McCay also discusses ethical concerns, including the potential for genetic stigmatisation of particular offenders or races and the possibility that behavioural genetics may lead to a view of crime that is unduly focused on problematic individuals and pays insufficient attention to the role of society in relation to criminalisation and the creation of conditions conducive to criminal activity.[68] However, the possibility of non-consensual use by the prosecution of evidence derived from next-generation sequencing raises some further issues.

There are several concerns relating to the use of behavioural genetics evidence to support claims about the risk of future offending through next-generation sequencing that we will discuss below.

Questionable Inferential Reasoning and Behavioural Genetics Evidence

Even if the prosecution can access the DNA data of the offender, there is still the problem of linking the DNA to the behaviour (e.g., the violent behaviour), and this might be thought to be of particular ethical concern where the evidence is to be used *against* the offender. This is in many ways the most contested step. Behavioural genetics is a deeply fraught and controversial

[66] Tiller, "If You've given Your DNA." In 2019, GEDmatch was sold to the forensic genomics company Verogen, which aids police in solving crimes: Vaughan, "DNA Site GEDmatch Sold."
[67] McCay, "Behavioral Genetics and Sentencing."
[68] McCay, "Behavioral Genetics and Sentencing."

science.[69] Persistent issues have dogged the study of the role of genes in behaviour; for example, even when traits appear to be highly heritable, few genes have strong causal effects, leading to 'missing heritability'; that is, single variations in the genome do not lead to specific types of behaviour, as the interaction of variations with other genes and environmental factors can change the outcome (e.g., behaviour or illnesses).[70] This makes strong relationships between traits and genes contestable and subject to revision given developments in the science of behavioural genetics. Even when there is evidence of a strong correlation between identified genes and a trait, such as L-MAOA and aggression, the person carrying the genetic predisposition in question does not necessarily have the behavioural feature. Based on the high estimates of the relationship between reactive aggression and L-MAOA*Childhood Maltreatment, still close to one in five of these men will not have this phenotype.[71] It is by no means a foregone conclusion that the individual will have the phenotype of question even if there is evidence for its presence that has been derived from behavioural genetics.

This evidence must be considered with caution, and in the case of sentencing, we are reliant on judges' conclusions about the validity of the scientific evidence presented. In practice, however, there is some evidence that courts do not solely rely on behavioural genetics evidence, nor do they appear to treat it with excessive deference. Previous biolaw studies about the use of biological evidence (i.e., behavioural genetics and neuroscience) in some jurisdictions suggest that when drawing conclusions about the mental state of offenders, courts consider such evidence along with other evidence and as part of a bigger picture[72] and rely on biological evidence where it is consistent with other forms of evidence, such as psychological assessment.[73] As such, even if the evidence suggests that there is a strong likelihood of impulsive aggression due to L-MAOA*Childhood Maltreatment, it is likely that courts would assess whether behavioural and other forms of evidence (e.g., psychiatric reports) are consistent with this inference. It should be noted that this is a conclusion with respect to the jurisdictions of biolaw studies mentioned above, and in other jurisdictions, there is a possibility of excessive reliance on behavioural genetics evidence.

The convergence of behavioural genetics evidence with other forms of evidence (e.g., psychiatric reports) *may* address concerns about the reliability of this evidence. The law does not require every single piece of evidence to determine the court's position on a fact in issue. Instead, different pieces of evidence and factual matters determine whether the standard of proof is met.[74] As such, if behavioural genetics evidence is convergent with other forms of evidence, it may have probative value for the court. Caution over the inferences made on the basis of various forms of behavioural genetics evidence is warranted; however, perhaps there is reason to suggest that the courts will display appropriate caution, at least in some jurisdictions. One may hope they will be similarly cautious with respect to any evidence that is of the kind under consideration in this paper. This is not to suggest that courts should rely on such evidence; claims about future dangerousness are notoriously inaccurate,[75] and even with new technological insights they might remain that way.

Further, at least in some quarters, there is a significant interest in the *rehabilitation* of offenders among other aims of sentencing and the protection of society by aggravating the sentence should perhaps not be considered as the sole or primary measure to address dangerous offenders with risk genes.[76]

Discrimination

Regardless of the reliability of these data, one could reject their use on another ground. Failing to treat a person as an individual and instead judging them according to generalisations about a demographic category they belong to might be considered a form of discrimination,[77] at least, in instances in which it leads to adverse treatment. Similarly, the use of genetic data might also be viewed as a form of discrimination or as a basis for biased decisions, and some may argue against the use of such data. For instance, in a child pornography case, a federal district court in the USA sentenced an offender to six-and-a-half years' imprisonment. The court assumed the offender would reoffend based on an undiscovered gene. The court rejected two

[69] Hayden, "Ethics: Taboo Genetics."
[70] Matthews, "Across the Great Divide."
[71] Caspi, "Role of Genotype."
[72] See, Denno, "Courts' Increasing Consideration."
[73] Alimardani, "An Empirical Study;" Alimardani, "Neurolaw in Australia."
[74] Aggarwal, "The Neuroethics and Neurolaw of Brain Injury."
[75] For example, see Fazel, "Use of Risk Assessment Instruments."
[76] Brazão, "From Multimodal Programs" Also see, Cozolino, The Neuroscience of Psychotherapy; Eagleman, The Brain; Hodgson, "Guilty Mind or Guilty Brain?" Hodgson encourages the use of new scientific technologies for rehabilitative purposes: "It is to be expected that increasing knowledge of how the brain works will assist in devising programs for rehabilitation of offenders and programs for addressing genetic and environmental factors contributing to criminal conduct, and will contribute to the development and implementation of educational strategies to discourage criminal conduct:" Hodgson, Rationality+ Consciousness = Free Will, 255.
[77] Lippert-Rasmussen, Born Free and Equal.

psychological evaluations that found that the risk of reoffending was low to moderate and that this was a gene that the offender was born with and could thus not rid themselves of, stating, 'You are what you're born with. And that's the only explanation for what I see here'.[78] In 2011, the district court's decision was overturned by the United States Court of Appeals for the Second Circuit based on the inappropriate reliance on genetic proclivities.[79]

Such cases appear to be rare, and as the empirical biolaw studies reported, such evidence is mostly used to mitigate punishment[80] and does not support the discrimination claim (at least, if the discrimination claim is thought to relate to *adverse* treatment on the grounds of one's membership of a group). Even if the next-generation sequencing data are used in conjunction with evidence of formative environment as a basis suggesting the offender is a risk to society, the same evidence might be used to argue why their punishment should be more lenient. As such, it is not clear that this evidence necessarily leads to discrimination *against* the offender. Some may still wish to argue that the evidence may be used as a tool to discriminate against specific people or groups of people. However, there are many other forms of evidence that may support a more severe sentence, and their use is not necessarily considered to be discriminatory in an unacceptable way. Generally, sentencing decisions are rife with demographic-based decisions. Whether the offender is young, has a mental condition, has a support group or comes from a disadvantaged background are only some examples of many demographic factors used in sentencing that might be thought to be similar to the sentencing factors that result from behavioural genetics analyses.

The discussion in this section is based on the way in which genetic evidence is currently being used in practise. Currently, when behavioural genetics evidence is introduced in criminal proceedings, it is almost always submitted by the defence to mitigate the punishment. However, in light of the developments described in this paper, we may see the introduction of behavioural genetics evidence by prosecutors to argue for future dangerousness. This shift could change some of the assumptions we have made in this section and lead to new and perhaps unexpected trends that could potentially be thought of as being discriminatory against the offender.

Privacy

Over the last decade or so, there has been an increasing emphasis on big data in different sectors of society. However, the growing availability and use of such data have raised many ethical challenges.[81] In this section, we draw attention to the privacy concerns with respect to the collection of genetic data.

In 2003, a New York State Supreme Court discussed the issue of the collection and abuse of DNA samples in the criminal justice system and privacy rights.[82] The court ruled that an offender's DNA sample should only be used for that criminal proceeding and should not be stored in a database to be tested for other unsolved crimes. The court further noted that the offender has the '"exclusive property right" to control dissemination of his genetic makeup'.[83]

There has been considerable progress in the field of genetics and DNA analysis technology since 2003 and the concern about genetic databases might go beyond identifying individuals. The ability to access an offender's genetic data from the crime scene, without that individual's consent, to infer something about their mental condition (e.g., their attitudes, capacities and personality) raises further concerns about privacy. Some scholars have voiced concerns about 'mental privacy' in the context of neurotechnologies that read directly from the brain,[84] and this might be seen as forming part of a larger concern about the potential of emerging technologies to infringe on individual's privacy.[85]

[78] Denno, "Courts' Increasing Consideration," 1020.
[79] Denno, "Courts' Increasing Consideration." In another case in the USA, the court made a speculative and questionable observation about the ethnicity of the defendant (American Indian) and their genetic predisposition to alcoholism: Denno, "Behavioral Genetics Evidence." There are many other extra-legal factors that may affect judges' decision making. For instance, extra-legal factors, such as socio-political ideologies, educational background and media, may affect judges' sentencing decisions on criminal responsibility, the treatment prospects and the future dangerousness of individuals based on their specific type of mental disorders or in general mental disorder diagnosis: Thomaidou, "Mental Illness as a Sentencing Determinant."
[80] Alimardani, "An Empirical Study;" Denno, "Behavioral Genetics Evidence;" Denno, "The Myth of the Double-Edged Sword." See also, Snead, "Neuroimaging."
[81] See, Ajunwa, "Health and Big Data;" Collmann, Ethical Reasoning in Big Data; Kellmeyer, "Big Brain Data;" Paulson, "Legal and Ethical Concerns of Big Data."
[82] *People v. Rodriguez*, 764 N.Y.S.2d 305 N.Y. Sup. Ct. [2003], discussed in Denno, "Behavioral Genetics Evidence."
[83] *People v. Rodriguez*, 764 N.Y.S.2d 305, 311 (N.Y. Sup. Ct. 2003), quoted in Denno, "Behavioral Genetics Evidence," 331.
[84] Ienca, "Towards New Human Rights." See also, McCay, "Neurotechnology."
[85] See, Inglese, "What Should We Do?;" Ligthart, "'Brain-Reading.'"

One might wonder whether an offender who has been inferred by a court to be impulsive and aggressive in the manner described in this paper has lost some mental privacy in a way that is of moral concern. McCarthy-Jones defines mental privacy as 'our ability to determine for ourselves when, how and to what extent information about our thoughts is communicated to others'.[86] Perhaps the term 'thoughts' is a little vague and may not extend to psychological dispositions; however, arguably, psychological dispositions, such as impulsivity, might be included in the private sphere that are worthy of moral protection. If that is so, then the legal possibility we envisage has the potential to infringe on an offender's mental privacy in a way that is arguably of moral concern or should at least be considered further before it is viewed as morally unproblematic.

However, there seems to be a competing ethical concern relating to the public's interest in being protected from the dangerous. If behavioural genetics were to be of value in predicting recidivism, then in protecting the community, it might be of value to put this goal in tension with the ethical concern about mental privacy.

As noted above, concerns about the secondary use of DNA data for the purpose of identification were raised around two decades ago in the 2003 New York State Supreme Court. However, the secondary use of DNA data to predict the future behaviour of individuals may be of even greater concern. It might be the case that the legal possibility we envisage in this paper does not exist in many jurisdictions around the world. This might be because the relevant rules of evidence do not allow the prosecution to use the crime-scene evidence in the manner we suggest or because privacy laws do not permit the creation and maintenance of genetic databases that not only identify individuals but also help to predict their behaviour, and thus worries about mental privacy are not currently warranted in those jurisdictions.

However, the lack of a current legal option for the prosecution to use evidence in the manner considered in this paper may not be a reason to dismiss the issue, as penal populism may change the way law and society view the use of genetic analysis in sentencing. For example, one could imagine a high-profile case in which the prosecution uses next-generation sequencing, obtains the offender's genetic profile and submits to the court that they are a great risk to society. However, the court does not admit the behavioural genetics evidence because it is provided non-consensually and invades the individual's privacy. Once that offender is released from prison, they commit a serious violent offense, and the media criticises the court for not keeping the offender away from society for a longer period. Such a case could lead to a legislative relaxation of the relevant evidence and privacy laws (if they were also a legal impediment for the prosecution), thereby giving rise to concerns of the type raised earlier in this section. In such instances, perceived public interest will directly conflict with an individual's right to privacy, whether it be genetic or mental privacy.

In the next section, we examine how the developments we have considered seem to draw further attention to an ethical issue that already exists for the law; that is, constitutive luck.

Constitutive Luck

There is something a bit unsettling about making inferences about how an offender may behave in the future based on whether or not they have been maltreated and their genetic constitution. It seems particularly unpalatable in the moral context of impending punishment if such inferences are going to be used *against* them to increase the severity of punishment. This is because these factors just seem to be a matter of luck. When considering this issue, the philosophical idea of 'constitutive luck' is useful.

Thomas Nagel is a philosopher who has studied the role of 'constitutive luck' in our lives; that is, where luck influences the way we are constituted thereby influencing our inclinations and capacities.[87] In a seminal paper on 'moral luck' (a broader concept that encompasses constitutive luck), Nagel considers the problematic issue of how the view that one should not be morally assessed in relation to the issues that flow from factors that are a matter of luck can be reconciled with moral practices that *do* in fact engage in such assessments.[88] In the course of this project, he draws attention to the concept of 'constitutive bad

[86] McCarthy-Jones, "The Autonomous Mind," 6.
[87] Nagel, Mortal Questions, 32–33.
[88] One example of moral luck is what he calls 'resultant luck': Nagel, 28. A way of understanding 'resultant luck' in the context of the law might be to note that an attempted murderer is treated differently from a murderer; both may have pointed a gun with intent to kill a person, but one luckily missed and the other killed their intended victim. In this paper, it is not our intention to give an overview of the various categories of moral luck that Nagel describes or to consider behavioural genetics in the context of other categories, but for a full discussion of this, see Nagel, 24–38.

fortune',[89] and that aspect of his paper is the one that seems relevant to the topic under consideration. 'Constitutive bad fortune' is an unfortunate constitution owing to bad luck, because the constitution does not result from the agent's earlier decisions.[90] Factors that we have no control of, such as our genetic constitution and how we were treated by others when we were young, appear to have a significant effect on our inclinations and capacities, and since we have no control over these factors, they are a matter of luck. Nagel did not focus his attention on behavioural genetics; however, where an offender has a genetic constitution, such as a L-MAOA gene, which has interacted with their formative environment, such that the offender has been left impulsive, aggressive and more likely to engage in criminal behaviour and be caught up in the criminal justice system, that might be thought of as 'constitutive bad fortune'.

As we discussed earlier, in some jurisdictions, the defence has already used behavioural genetics in pleas in mitigation in sentencing matters. Such pleas draw attention to the fact that the way that an offender is constituted affects the behaviour that the court is about assess, and in a jurisdiction in which the 'moral culpability' of the offender is relevant to the retributive aim of sentencing, the discussion of the MAOA-environment interaction seems to implicitly (but not expressly) raise the moral issue of 'constitutive bad fortune' (but with a view to obtaining favourable treatment; that is, a shorter sentence or a less onerous type of sentence). The offender might be thought of as trying to convince the court that their bad luck should lead to a reduced sentence.

However, even when used in mitigation, the idea of constitutive luck is somewhat disconcerting in a legal context. Generally, criminal justice systems presume that offenders in sentencing matters have free will and in some way deserve their punishment.[91] The whole project of behavioural genetics raises questions about the extent to which agents are free and deserving of punishment by drawing attention to the role of luck in shaping their dispositions, traits and ultimately their moral behaviour. It is not our intention to take a position on the free will problem here, and some may be less troubled by the role of luck in shaping moral behaviour than others. However, the kind of use of behavioural genetics in sentencing envisaged here seems to make this issue particularly *vivid* in a way that might be confronting (or at least a bit more confronting than in a more orthodox behavioural genetics case).

We envisage the possibility of the prosecution using evidence about how an offender was treated by others during their childhood in conjunction with evidence of some biological material found at the crime scene (e.g., some of the offender's DNA) to make a decision about the amount of punishment the offender is to receive. The offender as a person seems to be *out of the loop* in all of this. The constitution of the offender is non-consensually inferred entirely from a substance found at the crime scene, and this seems to underscore the role of luck in the offender's life insofar as it has a role in determining what they are made of. The role of luck is even more striking, as unlike the more standard use of behavioural genetics in sentencing, it is used *against* the offender.

Ultimately, there might be a moral argument for using genetic evidence in the orthodox behavioural evidence case while rejecting its use in the case we develop. This moral argument, however, requires further development. The possibilities we have considered here may force the law to confront the problem of constitutive luck by highlighting, underscoring and making its role a little more difficult to underplay than was previously the case.

As we have seen, these new possibilities raise several ethical concerns, including overreliance on questionable inferences, discrimination, privacy and constitutive luck. Some of these issues are not entirely new to criminal justice; however, one of the things that is striking in the case we raise is that when this genetic evidence is used *against* a defendant, it seems to be particularly troubling. When provided by the defence, the defendant generally has the choice of this evidence being used, albeit in a somewhat coercive set of circumstances given that the punitive power of the state is pitted against them.

The enquiry into the nature of an individual's constitution, without their consent and in circumstances in which the assumption is that it will support their removal from society, may strike many as undesirable. It seems to underscore that this appears to involve punishment for crimes that might not be committed, obscuring their agency and even the offender *as a person*. The legal system is a social institution. We have suggested in our discussion of privacy that penal populism could foster the inclusion of this type of evidence but equally the invasiveness of this type of evidence could drive ethical concerns about its use. The liberty of the individual against large institutions, both legal and scientific, should rightfully be considered as part of the socio-political debate of what constitutes a just society.

[89] Nagel, Mortal Questions, 33.
[90] Nagel, Mortal Questions, 33.
[91] McCay, Free Will and the Law.

Conclusion

Behavioural genetics evidence has traditionally been used by offenders for the purpose of mitigating their sentences. However, it seems that the kind of information required to make behavioural genetics inferences is becoming more accessible, and it may be that in some jurisdictions, prosecutors may not need an offender's permission to conduct genetic testing to make an argument based on behavioural genetics. We suggest that a new legal possibility could emerge where behavioural genetics evidence becomes part of the prosecution's strategy and is used to argue that the offender's genetic profile, in conjunction with their formative circumstances, indicates they are a risk to society. Other than sentencing, this evidence might also be raised at other stages of the criminal process, such as bail hearings and parole decisions.

To date, crime scene DNA evidence has been used in the context of policing and for the purposes of identification, but given the recent developments in DNA analysis, it is not much of a stretch to consider the possibility that other parts of the legal system might start similarly using this data. Whether or not this will eventuate, of course, depends on the rules of evidence in place in the particular legal system in which the prosecution attempts to introduce the evidence. In raising this possibility, we hope to highlight the ethical risks associated with such a development to foster engagement with this issue and shape the ethical use of evidence.

There are also many epistemic sources of error in inferences in relation to behavioural genetics, and it is a highly contested field of research. However, some objections to this kind of evidence might be indexed to this point in time. If the science were to further, strengthening the inference, this might undermine some objections. Nonetheless, the use of this evidence in this way by the prosecution is troubling in the sentencing context and may also be problematic in the context of other stages of the criminal justice process. The moral objection might even be thought of as part of a more general concern—a political objection to institutions having too much power to identify people and make inferences about their behaviour and state of mind.

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