



Article scientifique

Article

2017

Accepted version

Open Access

This is an author manuscript post-peer-reviewing (accepted version) of the original publication. The layout of the published version may differ .

---

## The forensic use of behavioral genetics in criminal proceedings: Case of the MAOA-L genotype

---

McSwiggan, Sally; Elger, Bernice Simone; Appelbaum, Paul S

### How to cite

MCSWIGGAN, Sally, ELGER, Bernice Simone, APPELBAUM, Paul S. The forensic use of behavioral genetics in criminal proceedings: Case of the MAOA-L genotype. In: International Journal of Law and Psychiatry, 2017, vol. 50, p. 17–23. doi: 10.1016/j.ijlp.2016.09.005

This publication URL: <https://archive-ouverte.unige.ch/unige:111193>

Publication DOI: [10.1016/j.ijlp.2016.09.005](https://doi.org/10.1016/j.ijlp.2016.09.005)



# HHS Public Access

Author manuscript

*Int J Law Psychiatry*. Author manuscript; available in PMC 2018 January 01.

Published in final edited form as:

*Int J Law Psychiatry*. 2017 ; 50: 17–23. doi:10.1016/j.ijlp.2016.09.005.

## The Forensic Use of Behavioral Genetics in Criminal Proceedings: Case of the MAOA-L Genotype

Sally McSwiggan<sup>1</sup>, Bernice Elger<sup>1,2</sup>, and Paul S. Appelbaum<sup>3</sup>

<sup>1</sup>Institute for Biomedical Ethics, Basel University, Basel, Switzerland <sup>2</sup>Centre for Legal Medicine, University of Geneva, Switzerland <sup>3</sup>Department of Psychiatry, Columbia University, New York, USA

### Abstract

The role of behavioral genetic evidence in excusing and mitigating criminal behavior is unclear. Research has suggested that a low activity genotype of the enzyme monoamine oxidase (MAOA-L) may increase the risk for aggressive and antisocial behavior. By examining criminal proceedings in which MAOA-L genotype evidence was introduced, we explored the forensic uses of behavioral genetic science. Westlaw and LexisNexis legal databases were electronically searched for cases from 1995–2016 to identify court documents from cases involving the MAOA-L genotype. Evidence of the MAOA-L genotype was included in records from **11** criminal cases (**9** U.S. and **2** Italian). In the guilt phase, genotype evidence was ruled admissible in one of **two** cases, and may have contributed to a conviction on a lesser charge. In the sentencing phase, genotype evidence was admissible in four of five cases, one of which ended with a lesser sentence. Five cases used genotype evidence for post-conviction appeals, two of which resulted in sentence reductions. Even when charges or sentences are reduced it is difficult to gauge the effect of evidence of the MAOA-L genotype. Genotype evidence may lack persuasive effect because the impact of the allele on a particular accused is difficult to establish.

### Keywords

Behavioral genetics; MAO-A L; Monoamine oxidase; law; criminal law

### 1. Introduction

Over the last two decades the use of neuroscientific evidence in criminal proceedings has been on the rise worldwide (Presidential Commission for the Study of Bioethical Issues, 2015). Across the U.S., United Kingdom, Canada and The Netherlands audits of criminal cases have shown an upward trend (Catley & Claydon, 2015; Chandler, 2015; de Kogel & Westgeest, 2015; Denno, 2015). The evidence has often included structural brain imaging,

---

Address correspondence to: Dr. Sally McSwiggan, Institute for Biomedical Ethics, Basel University, Bernoullistrasse 28, Basel 4056, SWITZERLAND. Phone: +41 (0) 61 267 17 86, +41 (0) 79 244 75 78, Fax +41 (0) 61 267 17 80, sally.mcswiggan@unibas.ch.

**Disclosure statement: No financial interest or benefit will be derived from this research.** Dr. Appelbaum acknowledges support from the National Human Genome Research Institute (P50HG007257).

electroencephalography (EEG) and neuropsychological assessment (de Kogel & Westgeest, 2015). When behavioral genetic evidence has been introduced, it has most commonly involved expert testimony on the heritability of addictive disorders (including drug and alcohol abuse) and problem gambling, in addition to genetic bases of mental illnesses like depression and psychosis (Denno, 2015). A limited number of experts have introduced evidence of an accused's unique genetic risk in relation to their crime (Bernet, Vnencak-Jones, Farahany, & Montgomery, 2007), most commonly a low activity gene variant, monoamine oxidase A (MAOA-L), which has been linked to aggressive and antisocial behavior (Dorfman, Meyer-Lindenberg, & Buckholtz, 2014).

In the early 1990s, a Dutch family was identified whose male members demonstrated unusually high rates of aggressive and antisocial criminal behavior, and who shared a rare mutation leading to a complete absence of the enzyme monoamine oxidase A (Brunner et al., 1993). This enzyme is responsible for breaking down key neurotransmitters, including serotonin, in the brain. Although a functionally inactive monoamine oxidase A gene is rare (no other cases have been reported), there are common gene variants of different transcriptional efficiency. The low activity monoamine oxidase (MAOA-L) gene variants are less efficient and therefore result in a higher concentration of serotonin in the brain than the more efficient high activity variants (MAOA-H) (Eme, 2013).

The first study of the MAOA-L genotype, based on a longitudinal follow up of an epidemiologic cohort in New Zealand, found that the MAOA-L genotype predicted an increased risk for aggressive and antisocial behavior in Caucasian males, but only when participants had experienced severe childhood maltreatment (Caspi et al., 2002). There was no direct relationship between the MAOA-L genotype and aggressive or antisocial behavior, although there was between childhood maltreatment and antisocial behavior. Importantly, maltreated participants were not significantly more likely to possess the MAOA-L genotype. This suggests they were not genetically predisposed to being maltreated (e.g., by provoking extreme reactions from their caregivers), but rather the risk gene impacted their resilience to abuse (Baum, 2013). Replication studies have generally shown that there is little direct relationship between carrying the MAOA-L genotype and aggressive and antisocial behavior (Dorfman et al., 2014), although exceptions have been reported (Beaver, Barnes, & Boutwell, 2014; Beaver, DeLisi, Vaughn, & Barnes, 2010). Generally, meta-analyses of this main effect found the direct genetic influence to be very small and heterogeneous across studies (Ficks & Walman, 2014; Vassos, Collier, & Fazel, 2014).

Research following Caspi and colleague's (2002) findings has largely replicated the "gene-environment" interaction for impulsive, aggressive and antisocial behavior with MAOA-L genotype carriers who experienced childhood maltreatment (Armstrong et al, 2014; Åslund et al, 2011; Choe, Shaw, Hyde, & Forbes, 2014; Cicchetti, Rogosch, & Thibodeau, 2012; Edwards et al., 2010; Ferguson, Boden, Horwood, Miller, & Kennedy, 2012; Foley et al, 2004; Frazzetto et al, 2007; Gorodetsky et al, 2014; Nilsson et al, 2006; Widom & Brzustowicz, 2006). Relatedly, carriers of the MAOA-L genotype who experienced adverse childhoods have been shown to have increased rates of other disorders of behavioral dysregulation like attention deficit hyperactivity disorder, depression, and impulsivity (Beach et al., 2010; Enoch, Steer, Newman, Gibson, & Goldman, 2010; Huang et al., 2004;

Kim-Cohen et al., 2006). Several large prospective studies, however, failed to replicate the gene-environment interaction as enhancing risk for aggression (Derringer, Krueger, Irons, & Iacono, 2010; Haberstick et al., 2014; Whelan, Kretschmer, Barker, 2014). Despite this, two meta-analyses of MAOA-L genotype have found the gene-environment interaction to be moderately reliable (Byrd & Manuck, 2014; Taylor & Kim-Cohen, 2007). The magnitude of the gene-environment effect on aggressive and antisocial outcomes remains largely unknown given the immense heterogeneity across MAOA-L genotype study methods, populations and measurements (Byrd & Manuck, 2014). Calculating a mean effect size was considered spurious and misleading, with the authors instead reporting pooled *p* values with limited statistical meaning for the strength of the relationship. Neurobiological studies of the MAOA-L genotype suggest that it may exert its influence by disrupting the corticolimbic circuits controlling emotional arousal and regulation. Neural hypersensitivity to emotional stimuli in low MAOA genotypes has been associated with increased activity in the amygdala and decreased activity in the frontal brain regions (Dorfman et al., 2014).

Although Caspi et al. (2002) did not examine the effect of the MAOA-L genotype on risk for aggressive and antisocial behavior in females who experienced childhood adversity, subsequent work has shown little effect (Frazzetto et al., 2007; Huang et al., 2014; Kiive et al., 2014; Reti et al., 2011; Verhoeven et al., 2012). Instead the reverse relationship, with the high activity variant (MAOA-H) predicting a risk of aggressive and antisocial behavior, has been a common finding among female cohorts (Åslund et al., 2011; Enoch et al., 2010; McGrath et al., 2012; Prom-Wormley et al., 2009; Sjöberg et al., 2007). Having an extra X chromosome may help females to compensate for the detrimental effects of the MAOA-L variant, since the gene is X-linked; thus, females have two copies, while males have only a single copy (Eme, 2013). Gender differences in childhood abuse and expression of aggression and antisocial behavior also may have contributed to the gender specific findings (Choe et al., 2014). In addition, findings regarding aggressive and antisocial behavior risk of non-Caucasian males carrying the MAOA-L genotype have been equivocal, with mixed race samples often failing to show the expected gene-environment interaction (Kieling et al., 2013; Kolla, Attard, Craig, Blackwood, & Hodgins, 2014; Stetler et al., 2014; Widom & Brzustowicz, 2006; Young et al., 2006). Although Caucasians have a MAOA-L genotype rate of around 30% to 40%, African Americans' and Asians' frequency distribution for the MAOA-L genotype is considerably higher at around 60%, perhaps confounding the expected findings (Beaver et al., 2014). Taken as a whole, the research suggests MAOA-L mediation of the risk for impulsive aggressive and antisocial behavior may be specific to Caucasian males who have experienced severe childhood maltreatment.

### 1.1. Purpose of study

With increasing use of genome-wide testing in research and clinical settings, the introduction of MAOA-L genotype evidence in criminal proceedings is predicted to grow (Gonzalez-Tapia & Obsuth, 2015). However, there is a lack of consensus on the merits of introducing evidence of an accused's MAOA-L genotype into a criminal proceeding. Compared with a group of U.S. trial judges who, on average, imposed significantly (but modestly) lighter sentences when exposed to MAOA-L genetic evidence (Aspinwall, Brown, & Tabery, 2012), German judges surveyed using the same vignettes ordered more

involuntary psychiatric hospitalisations (23% versus 6%) with indeterminate periods of confinement rather than shorter sentences (Fuss, Dressing, & Briken, 2015). Surveys of representative samples of the general population in the U.S. have found no changes in views on guilt or punishment with the addition of behavioral genetic evidence, but in some cases subjects reported being more fearful of the accused (Appelbaum & Scurich, 2014; Appelbaum, Scurich, & Raad, 2015). These inconsistencies suggest behavioral genetic evidence can evoke a range of responses in legal settings. Given the predicted increase in use of MAOA-L genotype evidence before the criminal courts and the uncertainty about legal decision-makers' reactions to this evidence, the use of behavioral genetic profiles in criminal proceedings requires careful examination. By examining criminal proceedings involving attempts to introduce evidence of the MAOA-L genotype, the forensic use of behavioral genetics can be explored.

## 2. Methods

Westlaw and LexisNexis legal databases were electronically searched for cases from 1995 to March 1, 2016 to identify court documents from criminal proceedings referencing the MAOA-L genotype. The search began with 1995 because that is the first known use of legal arguments related to MAOA, coming just 2 years after the report of the Dutch kindred in which MAOA was completely absent. The legal databases searched contain selected trial and appellate court filings from state and federal jurisdictions from the U.S., United Kingdom, Australia, Hong Kong and Europe. Documents include reported and unreported judicial opinions and appellate briefs. Westlaw and LexisNexis note that the court documents contained in their respective databases are not complete. Courts vary in practices for release and publication of documents across jurisdictions and types of proceedings. Appellate briefs and judgments constitute the majority of trial court documents contained in these legal databases. Interpretation of these documents, though, often requires the context provided by previous trial proceedings and opinions.

Additional electronic searches were conducted using Ovid MEDLINE, PsychINFO and Embase from 1995 to March 1, 2016 to identify articles citing legal proceedings referencing MAOA-L genotype evidence that were not published by Westlaw or LexisNexis. The individual cases were then verified by searching for court or other records related to the case from the jurisdiction.

## 3. Results

Evidence of the MAOA-L genotype was included in records from **11** criminal cases (**9** U.S. and 2 Italian). Although criminal procedures vary across jurisdictions, in general criminal proceedings for serious crimes include at least two phases: (1) the guilt phase, where guilt or innocence is established, and (2) the sentencing phase, where the penalty is imposed (Baum, 2013). Brief summaries of all the cases are provided in Table 1, and a description of cases involving the introduction of MAOA-L evidence at the guilt, sentencing, and appellate phases follows.

### 3.1. Guilt phase

The guilt phase primarily involves determining whether the accused committed the criminal act charged (*'actus reus'*), while having the requisite, culpable mental state (*'mens rea'*). The relevant mental state is established for each crime and varies (in decreasing degrees of criminal responsibility) from intent to knowledge, recklessness, and negligence, with the goal of ensuring proportionality in punishment (Edersheim, Weintraub-Brendel, & Price, 2012). To negate criminal responsibility, legal decision-makers must be convinced that the accused was unable to form the necessary mental state (e.g., intent) required for the commission of the particular offence (e.g., first-degree murder), or that there was a justification or another legally defensible excuse for the act (Rushing, 2014). Negating all mental state elements of an offence renders the accused not guilty (e.g., as with a finding of “not guilty by reason of insanity”); negating some mental state elements means the accused can be found guilty of a lesser offence (e.g., manslaughter instead of first-degree murder) (Baum, 2013). In the guilt phase, MAOA-L genotype evidence was ruled admissible in one of **two** cases, and may have contributed to a lesser sentence.

The only case in which evidence of the accused's MAOA-L genotype was found to be admissible in the guilt phase and may have contributed to a lesser sentence was *State v. Waldroup* (2011). The accused was charged with murdering his estranged wife's friend and attempting to murder his estranged wife. The trial court admitted evidence from a forensic psychiatrist that the accused had experienced severe childhood maltreatment and that genetic testing showed he carried the MAOA-L genotype. During the trial, defense counsel argued that the accused's genetic vulnerability to impulsive aggression was a causative factor in the crimes (Baum, 2013). Subsequently, the jury found the accused guilty of the lesser-included offences of voluntary manslaughter and attempted second-degree murder, the least serious criminal charges available to them. Given this reduction, the jury must have concluded that, based on the evidence, the accused did not premeditate his crimes (first-degree murder) or knowingly kill (assault where death is a possibility; second-degree murder); instead the crime was “an intentional or knowing killing of another in a state of passion produced by adequate provocation sufficient to lead a reasonable person to act in an irrational manner” (Wilson, 2015, p. 118). The provocation, the facts of which remain largely undisclosed, must have constituted a legally defensible external reason (Rushing, 2014). The accused was sentenced to the maximum custodial term permitted by the lower punishment range (32 years). The role played by the MAOA-L genotype evidence is unclear.

More recently in the *State v. Yeppez* (2015), the accused was charged with assaulting and strangling to death his girlfriend's step-grandfather following an argument (Wilson, 2015), and then burning the body. At a pre-trial evidentiary hearing, testimony from psychiatric experts from both sides on the conclusions that could be drawn from behavioral genetic data led the judge to conclude “there has been no evidence that demonstrates that the gene with environment interaction between a low functioning MAOA and a history of child abuse resulting in a predisposition or inclination toward antisocial or aggressive behavior, including violent acts, qualifies as a mental disease or disorder” (Stiny, 2015, para. 6). Additionally, the judge found that the behavior of persons carrying the MAOA-L genotype was not necessarily affected to the point where any violent acts they committed were

exclusively caused by uncontrollable impulses. She also found that the proposed testimony failed to meet standards of admissibility for scientific evidence (Stiny, 2015). Hence, an order denying admissibility of the expert testimony on the effect of the MAOA-L genotype was issued, and it was reaffirmed after defense counsel filed for reconsideration of the decision (*State v. Yopez*, 2015). The accused was subsequently found guilty of second-degree murder. Similar judicial resistance to the admissibility of evidence on genetic predispositions to aggression and violence has been seen in other cases involving gene variants purportedly linked to criminal behavior (see *State v. Idellfonso-Diaz*, 2006).

### 3.2. Sentencing phase

The sentencing phase, which follows a finding of guilt, is where the criminal penalty is determined. The issues to be decided vary in different legal systems, but may include: (1) whether the accused's unique circumstances contributed to their criminal behavior in such a way as to mitigate their moral responsibility for a crime, and (2) the accused's propensity for committing crimes in the future (Glenn & Raine, 2014; Gonzalez-Tapia & Obsuth, 2015). Criminal courts consider statutory and non-statutory mitigating factors (e.g., family history of abuse, absence of prior convictions, mental health issues, expressions of remorse) and aggravating factors (e.g., prior convictions, future dangerousness, lack of remorse) at sentencing (Denno, 2015). Mitigation evidence does not serve as a justification or excuse, nor does it lessen the degree of the crime. The evidence seeks to persuade the judge (or in the U.S. in capital cases, the jury) to impose a punishment towards the lower end of the sentencing range by demonstrating characteristics of the accused or features of the crime that could be considered extenuating or as reducing moral culpability (Morse, 2011). In the sentencing phase, genotype evidence was found admissible in four of five cases, once serving as the basis for a lesser sentence.

The first matter in which issues related to the MAOA-L genotype were argued in a U.S. court was *Mobley v. State* (1995). The accused was convicted of having deliberately shot and killed a store manager during the course of a robbery. The jury found him guilty of first-degree murder and imposed the death penalty. His defense counsel could identify only limited mitigating evidence for the sentencing phase given the accused's privileged background. After reviewing the accused's family tree and finding a range of violent relatives, the defense—which was aware of the Dutch study by Brunner and colleagues (1993)—requested both expert and financial assistance to perform genetic testing analysis to ascertain whether the accused had reduced MAOA activity. The court denied the request on the basis that Mobley lacked significant intellectual impairments, which had characterized the affected male family members in the Dutch kindred. The court held that in the absence of sufficient scientific basis to demonstrate a link between Mobley's behavior and the MAOA-L allele, there was no basis to grant the defense's request. The trial court's ruling was upheld on appeal by the Georgia Supreme Court and Mobley was ultimately put to death.

A more recent case with a similar outcome is *People v. Adams* (2014), in which the defendant was accused of shooting and killing three members of the Los Angeles Crips street gang in an unprovoked attack in 1994. It took nearly 10 years for the case to come to

trial. The court heard evidence that the accused had been described as seriously emotionally disturbed as a child. He had mild learning disabilities and attention deficit hyperactivity disorder, and attended a special needs school. Brain scans indicated mild abnormalities of unknown origin in the frontal region, an area often associated with impulse control. Records showed that the accused's mother was substance dependant, physically abusive and neglected him, and that she was often incarcerated. He grew up in a gang-controlled neighbourhood where he was said to have been threatened and beaten regularly.

Among a range of experts, a forensic psychologist testified that genetic testing of the accused indicated that he had inherited the MAOA-L genotype. The psychologist told the court that recent studies showed "the relationship between having this gene, experiencing maltreatment as a child and displaying adult antisocial behavior was equivalent to the correlation between having high cholesterol and having heart disease" (*People (Respondent) v. Adams (Appellant)*, 2011, para. 78). The expert explained to the court there was not a direct causal relationship between the MAOA-L genotype and aggressive and antisocial behavior, and that the MAOA-L genotype was not a genetic defect but rather a risk factor. This evidence did not result in mitigating the accused's moral culpability and the court imposed the death penalty.

In contrast, *State v. Bourassa* (2012) illustrates a case from the U.S. where evidence of a MAOA-L genotype may have contributed to a sentence reduction. The accused had broken into a church and murdered an elderly female parishioner. During sentencing, mitigating evidence was presented describing the accused as having experienced prolonged sexual abuse from an early age and as having a diagnosis of bipolar disorder (Wilson, 2015). The psychiatric expert witness testified that the accused carried the MAOA-L genotype, and that in interaction with the childhood abuse, this led to a greater risk of engaging in impulsive aggressive and antisocial behavior. The defense team argued that the accused should be spared the death penalty given his genetic vulnerability. The jury sentenced him to life in prison without the possibility of parole.

In *State v. Driskill* (2015), the accused forced entry to a home to sexually assault and murder two elderly occupants, after which he mutilated and burnt their bodies. According to the appellant brief, the accused was diagnosed with bipolar disorder, anxiety disorder, intermittent explosive disorder, mild cognitive impairment, and polysubstance dependence (*State (Respondent) v. Driskill (Appellant)*, 2014). The forensic psychiatrist who was engaged as an expert witness did not interview or examine the accused but instead had the opportunity to review his medical records, statements of people who knew him, and ordered genetic testing.

The expert testified the accused had a history of childhood abuse and that genetic testing showed he was a carrier of the MAOA-L genotype. Court documents indicate that the expert gave evidence about the role of genetics in criminal behavior and reported that a person's mood, behaviors, and tendency towards violence are the product of a combination of genetics and environment. Further, the psychiatrist testified that when a person has both the MAOA-L genotype and a history of child abuse he has more difficulty controlling emotion, processing information and thinking things through. Consequently, the person "is 4.6 more

times more likely to commit violent acts than someone who has no history of abuse or the low activity MAO-A genotype” (*State (Respondent) v. Driskill (Appellant)*, 2014, p. 35). It was argued because of his genetic makeup, it was significantly harder for the accused to conform his behavior to what was expected. Unswayed by the evidence, the jury imposed the death penalty.

*Colbert v. State* (2015) was a case in which the MAOA-L genotype evidence was used at sentencing and as a basis for a post-sentencing appeal. The accused murdered his girlfriend by shooting, choking and repeatedly driving over her. He was diagnosed with intermittent explosive disorder, post-traumatic stress disorder (PTSD), bipolar disorder and depression. Court documents from the post-conviction appeal describe how the accused was advised by his trial counsel to plead guilty to avoid the possibility of the death penalty. Consequently there was no trial to determine guilt.

At sentencing, a clinical molecular geneticist testified the accused carried the MAOA-L genotype and that studies had confirmed that individuals with this allele who suffered severe childhood abuse were at greater risk for aggressive behavior as adults. On cross-examination, the expert confirmed that both the genetic predisposition and maltreatment had to be present to make an individual more disposed to aggressive and antisocial behavior. Although the accused reported that his stepfather used to berate him, neither his medical records nor his mother confirmed his contention that he experienced childhood maltreatment. He had graduated high school and had been described as “happy-go-lucky.” The accused received a life sentence after taking a plea bargain.

After sentencing, an appeal was filed arguing his trial counsel rendered ineffective assistance by not going to trial and presenting the accused’s MAOA-L genotype in an attempt to negate his criminal intent. The trial counsel testified in the appeal proceedings that given the circumstances of the case, introducing evidence of the accused’s genetic predisposition to violence was not a good trial strategy. Two mental health experts had concluded that he was able to appreciate the nature and wrongfulness of his actions and able to form the requisite mental intent. Additionally, the trial counsel consulted with family members of the accused to investigate his allegations of childhood maltreatment. The appellate court conducting the post-conviction review denied the petition for post-conviction relief and reaffirmed the judgment.

### 3.3. Appellate phase

Five cases used genotype evidence for post-conviction appeals, two of which resulted in sentence reductions. The first case with evidence of the MAOA-L genotype heard in a court in Europe was the Italian matter of *Bayout v. Francesco* (2009) (Forzano et al., 2010). The accused was convicted of stabbing another man to death because he falsely believed the victim had assaulted him in an earlier unprovoked attack. He was reported to have had a history of poor medication compliance for schizophrenia and was subsequently sentenced to nine years in prison. On appeal, new mitigating evidence was presented by a molecular neuroscientist who told the court the accused carried the MAOA-L genotype. There was no mention of childhood abuse in the proceedings, with the defense arguing that a move from

Algeria to Italy when the accused was 24 years old caused him significant alienation and distress. The appeals court granted a one-year reduction of his sentence.

The second Italian case involving evidence of the MAOA-L genotype at an appeal hearing was notable because the prisoner was female (Turone, 2011). The accused (*Albertani*) had murdered her sister and then burnt her body in the backyard. She was subsequently arrested while attempting to murder her mother by setting fire to her after several failed attempts to kill both her parents. She plead guilty in 2009 and was sentenced to a life term (30 years). On appeal two years later, several psychiatric witnesses testified that the accused met criteria for dissociative identity disorder and had experienced symptoms of psychosis. Childhood maltreatment was not reported, at least according to the translation of the appeal (Turone, 2011). Genetic testing showed that she was a carrier of the MAOA-L genotype and brain imaging found some minor abnormalities of unknown clinical significance. Taken together with the psychiatric evaluation, the appellate counsel argued that she was mentally unfit at the time of her crimes. Her sentence was subsequently commuted from 30 years to 20 years in prison.

More recently, *United States v. Duran* (2014) dealt with a military court case in which Private First Class Duran awoke one night hearing voices. In response to the auditory hallucinations, he left his barracks to collect a homemade machete and attacked a duty officer he had never met. He was diagnosed with atypical psychosis, chronic post-traumatic stress disorder (PTSD), major depression and schizoid personality disorder. The court heard evidence that Private Duran had experienced severe childhood maltreatment, growing up in a violent home with an alcoholic parent engaged in prostitution. He was sentenced to a 15-year custodial term.

In petitioning for an appeal, Duran claimed that he was denied effective assistance of trial counsel when they failed in their “duty to investigate potentially mitigating evidence arising from behavioral genetics” (*United States, Appellee v. Alex J. Duran Private First Class (e-2) U.S. Marine Corps, Appellant*, 2014, p. 11). The petition noted that MAOA-L genotype carriers who have experienced childhood maltreatment are “460% more likely to be convicted of a violent offense” (p. 12). It was argued that state and federal courts are increasingly recognising behavioral genetics evidence in criminal trials and that without the genetic evidence, the accused’s case in mitigation was negatively impacted.

The appeals court was not convinced that behavioral genetic testing was part of “reasonable [legal] professional assistance” and that failure to pursue it amounted to ineffective assistance of counsel (*United States v. Duran*, 2014, para. 22). Obtaining testing was not considered the “prevailing professional norm” in cases involving a violent offender (para. 25). The appeals court found that the science on the connection between the MAOA-L gene and aggression was “not settled” (para. 23) and the court denied the petition, reaffirming Private Duran’s 15-year sentence.

Lastly, in *Bathgate v Landry* (2016) the accused received a sentence of 45 years after pleading guilty to fatally stabbing and driving over a man he believed had flirted with his girlfriend. In petitioning for state *habeus corpus* (after the appellate phase is exhausted), the

accused claimed his trial counsel had rendered ineffective assistance by not pursuing a criminal defense based on the MAOA-L genotype. The claim was found to be procedurally defaulted because the accused did not exhaust this claim in the post-conviction appellate action available to him.

#### 4. Discussion

Criminal cases in which results of MAOA-L genotype testing were offered into evidence were examined to explore what may be the most common forensic use of behavioral genetic data. We were able to identify **11** criminal proceedings between 1995 and 2016 in which evidence of the MAOA-L genotype was at issue (Table 1). The majority of cases were from the U.S. (**9** cases) and two were from Italy. The experts were commonly forensic psychiatrists and charges for the accused ranged from attempted murder to triple murder. Because of the particularly heinous nature of the crimes, the death penalty was frequently sought where permitted by the law. Of the **11** cases, test results establishing the accused's MAOA-L genotype were known for eight cases (Table 1).

Evidence of the MAOA-L genotype was presented in the guilt phase as a partial defense to first-degree murder for **two** of the **11** cases reviewed (*Waldroup, 2011; Yopez, 2015*). In one case, the evidence was found inadmissible because it did not address a legally relevant question (*Yopez, 2015*). The court found that carrying a high-risk genotype did not satisfy the legal criteria for diminished criminal responsibility (or culpability), which would allow reduction of the charge of first-degree murder to a lesser degree of homicide. For that purpose, an abnormality of mental functioning generally is required that has arisen from a mental disease or defect and that substantially impairs the ability to understand the events, to judge right from wrong or (in some jurisdictions) to exercise self-control (Baum, 2013). Merely identifying contributing causes of a behavior, including genetic influences, does not constitute a legally effective excuse (Morse, 2011).

The court in this case found that a genetic risk for aggressive and antisocial behavior did not satisfy the first legal hurdle of a "mental disease or defect". Moreover, although identifying a mental disease or defect is a threshold criterion that an accused must meet, it is the expression of mental impairment at the time of the crime that is of importance to determinations of degree of criminal responsibility (e.g., whether the accused had a reduced capacity to understand his or her criminal actions) (Glenn & Raine, 2014). The scientific research on the effects of the MAOA-L allele does not suggest that all persons carrying the genotype manifest a mental disorder or are unable to exercise self-control. Thus, the utility of genetic testing for MAOA status for such purposes is limited.

In only one case was evidence of the MAOA-L genotype ruled admissible by a judge in the guilt phase (*Waldroup, 2011*). Moreover, relying in part on this evidence, the defense was successful in persuading the jury to apportion a lower degree of criminal blame, finding the accused guilty of voluntary manslaughter instead of first-degree murder. Unlike the other guilt-phase case (*Yopez, 2015*), the genetic evidence in *Waldroup* (2011) was used to support an affirmative defense of provocation, with its own set of facts presented by the defense, rather than being used solely to negate the prosecution's case (Wilson, 2015).

Neuroscientific evidence has often been used in the sentencing phase of criminal trials where the rules of evidence are less well-defined, allowing for a wider range of material to be admitted compared with the guilt phase (Treadway & Buckholtz, 2011). Although the threshold required for admissibility in the sentencing phase is lower than during the trial of guilt, mitigation evidence still has to be considered relevant to be admissible (Jones, Wagner, Faigman, & Raichle, 2013). With capital murder cases in the U.S., there are additional constitutional rights to present potentially mitigating evidence in the sentencing phase (Jones et al., 2013). The first criminal matter (*Mobley*, 1995) in which the defense argued that the MAOA-L genotype should be considered as a mitigating factor came at a time when the science related to MAOA's effects on criminal behavior constituted a single study (Brunner et al., 1993). The genetic evidence was considered so novel and the accused so unlikely to show the same condition (i.e., a complete absence of MAOA activity) that the courts refused to pay for genetic testing or to consider its omission as grounds for resentencing.

Nearly ten years later, scientific study of the MAOA-L genotype had advanced enough to shift the legal view of behavioral genetics to it being considered a relevant mitigating factor (*Adams*, 2014; *Bourassa*, 2012; *Colbert*, 2015; *Driskill*, 2015). Despite being admissible, the usefulness of MAOA-L genetic evidence in reducing punishment appeared limited. A jury was convinced to impose a life sentence over a possible death penalty in one case, although the role played in that decision by the genetic evidence *per se* is unclear (*Bourassa*, 2012). The death penalty was imposed for two of the cases in which it was introduced (*Adams*, 2014; *Driskill*, 2015), while in the fourth, the accused accepted a plea bargain for life in prison (*Colbert*, 2015). Evidence of a genetic risk for aggression admitted in mitigation nonetheless may have been considered as an aggravating circumstance insofar as it heightened the risk of future dangerous behavior (Appelbaum & Scurich, 2014; Fuss et al., 2015). Alternatively, the genetic evidence may simply have played no role in the sentencing decisions, as has been suggested in studies of the general population (Appelbaum et al., 2015). This may have been due in part to the expert's inability to make reliable statements about the genetic risk in individual cases (Berryessa, Martinez-Martin, & Allyse, 2013), i.e., the difficulty in translating group data into statements about particular individuals (Faigman, Slobogin, & Monahan, 2016). Even if at the group level the presence of an MAOA-L allele increases the risk of impulsive aggressive and antisocial behavior, it cannot be inferred that there is an increased risk for any given individual (Treadway & Buckholtz, 2011). Accordingly, legal decision-makers may not have considered evidence of the general scientific findings applicable to a particular accused, or their potential impact may have paled in comparison to the aggravating circumstances of the accused's crimes. This may have been especially true when evidence of childhood maltreatment was lacking (*Colbert*, 2015), since data on whether there is a direct effect of the MAOA-L allele are conflicting, or when the accused was non-Caucasian (*Adams*, 2014), since limited data are available about those groups. Additionally, the appellate cases that considered issues related to the introduction of MAOA-L evidence showed the genotype is still considered "non-standard" scientific evidence when used for legal purposes. Unlike as regards other psychological, biological or cultural mitigating circumstances, in three cases trial counsel were not considered professionally remiss for failing to investigate the MAOA-L genotype for defense or mitigation purposes (*Bathgate*, 2016; *Colbert*, 2015; *Duran*, 2014).

A limitation of this study was our restricted access to court documents; we were reliant on published opinions and briefs available through standard legal electronic databases. This may have led us to underestimate the frequency with which the MAOA-L genotype has been offered in evidence in criminal proceedings. Court documents for two U.S. cases were limited as neither accused had lodged post-conviction appeals (*Bourassa*, 2012; *Yépez*, 2015). Moreover, our review of court documents was limited to English-speaking countries and documents available in English, so untranslated proceedings from non-English-speaking jurisdictions may have been missed.

Since Caspi and colleagues' (2002) findings gained notice in the scientific literature, concerns have been raised about the potential use of behavioral genetic data by the law (Nuffield Council on Bioethics, 2002). Our review of relevant cases showed that there appears to have been a modest shift in acceptance by the law of testimony regarding an accused's MAOA-L status, coinciding with a growing body of scientific data examining genetic influences on aggressive and antisocial behavior. Evidence of the presence of a MAOA-L genotype appears not to support a legal defense that would excuse an accused from criminal responsibility, but it has repeatedly been found admissible to mitigate moral culpability in serious criminal proceedings. Although the use of behavioral genetic evidence for defense purposes has been growing (Denno, 2011), the results of the current study—supported by experimental data (Appelbaum & Scurich, 2014; Appelbaum et al., 2015)—suggest that evidence regarding the MAOA-L genetic risk for aggressive and antisocial behavior is likely to have only a limited effect on the punishment imposed.

## References

- Appelbaum PS, Scurich N. Impact of behavioral genetic evidence on the adjudication of criminal behavior. *Journal of the American Academy of Psychiatry and the Law*. 2014; 42(1):91–100. [PubMed: 24618524]
- Appelbaum PS, Scurich N, Raad R. Effects of behavioral genetic evidence on perceptions of criminal responsibility and appropriate punishment. *Psychology, Public Policy, and Law*. 2015; 21(2):134.
- Armstrong TA, Boutwell BB, Flores S, Symonds M, Keller S, Gangitano DA. Monoamine oxidase A genotype, childhood adversity, and criminal behavior in an incarcerated sample. *Psychiatric Genetics*. 2014; 24(4):164–171. [PubMed: 24983833]
- Åslund C, Nordquist N, Comasco E, Leppert J, Orelund L, Nilsson KW. Maltreatment, MAOA, and delinquency: sex differences in gene–environment interaction in a large population-based cohort of adolescents. *Behavior Genetics*. 2011; 41(2):262–272. [PubMed: 20734127]
- Aspinwall LG, Brown TR, Tabery J. The double-edged sword: Does biomechanism increase or decrease judges' sentencing of psychopaths? *Science*. 2012; 337(6096):846–849. [PubMed: 22904010]
- Bathgate v. Landry*, No. 2–15cv221 (Maine Dist. Ct. Feb. 9, 2016)
- Baum ML. The monoamine oxidase A (MAOA) genetic predisposition to impulsive violence: Is it relevant to criminal trials? *Neuroethics*. 2013; 6(2):287–306.
- Bayout v. Francesco* (2009) RGAssise App. 6/2008 RGNR 1685/2007, RG. Sent 5, dd 18 settembre 2009.
- Beach SR, Brody GH, Gunter TD, Packer H, Wernett P, Philibert RA. Child maltreatment moderates the association of MAOA with symptoms of depression and antisocial personality disorder. *Journal of Family Psychology*. 2010; 24(1):12. [PubMed: 20175604]
- Beaver KM, Barnes JC, Boutwell BB. The 2-repeat allele of the MAOA gene confers an increased risk for shooting and stabbing behaviors. *Psychiatric Quarterly*. 2014; 85(3):257–265. [PubMed: 24326626]

- Beaver KM, DeLisi M, Vaughn MG, Barnes JC. Monoamine oxidase A genotype is associated with gang membership and weapon use. *Comprehensive Psychiatry*. 2010; 51(2):130–134. [PubMed: 20152292]
- Bernet W, Vnencak-Jones CL, Farahany N, Montgomery SA. Bad Nature, Bad Nurture, and Testimony Regarding MAOA and SLC6A4 Genotyping at Murder Trials. *Journal of Forensic Sciences*. 2007; 52(6):1362–1371. [PubMed: 17944904]
- Berryessa CM, Martinez-Martin NA, Allyse MA. Ethical, legal and social issues surrounding research on genetic contributions to anti-social behavior. *Aggression and Violent Behavior*. 2013; 18(6): 605–610.
- Brunner HG, Nelen MR, Van Zandvoort P, Abeling NG, Van Gennip AH, Wolters EC, Van Oost BA. X-linked borderline mental retardation with prominent behavioral disturbance: phenotype, genetic localization, and evidence for disturbed monoamine metabolism. *American Journal of Human Genetics*. 1993; 52(6):1032. [PubMed: 8503438]
- Byrd AL, Manuck SB. MAOA, childhood maltreatment, and antisocial behavior: Meta-analysis of a gene-environment interaction. *Biological Psychiatry*. 2014; 75(1):9–17. [PubMed: 23786983]
- Caspi A, McClay J, Moffitt TE, Mill J, Martin J, Craig IW, ... Poulton R. Role of genotype in the cycle of violence in maltreated children. *Science*. 2002; 297(5582):851–854. [PubMed: 12161658]
- Catley P, Claydon L. The use of neuroscientific evidence in the courtroom by those accused of criminal offenses in England and Wales. *Journal of Law and the Biosciences*. 2015; 2(3):510–549. [PubMed: 27774211]
- Chandler JA. The use of neuroscientific evidence in Canadian criminal proceedings. *Journal of Law and the Biosciences*. 2015; 2(3):550–579. [PubMed: 27774212]
- Choe DE, Shaw DS, Hyde LW, Forbes EE. Interactions between monoamine oxidase A and punitive discipline in African American and Caucasian men's antisocial behavior. *Clinical Psychological Science*. 2014; 2(5):591–601. [PubMed: 27014508]
- Cicchetti D, Rogosch FA, Thibodeau EL. The effects of child maltreatment on early signs of antisocial behavior: Genetic moderation by tryptophan hydroxylase, serotonin transporter, and monoamine oxidase A genes. *Development and Psychopathology*. 2012; 24(3):907–928. [PubMed: 22781862]
- Colbert v. State*, No. W2013-02768-CCA-R3-PC (Tenn. Crim. App. Feb. 3, 2015).
- de Kogel CH, Westgeest EJMC. Neuroscientific and behavioral genetic information in criminal cases in the Netherlands. *Journal of Law and the Biosciences*. 2015; 2(3):580–605. [PubMed: 27774213]
- Denno DW. Courts' increasing consideration of behavioral genetics evidence in criminal cases: results of a longitudinal study. *Michigan State Law Review*. 2011; 2011:967–1047.
- Denno DW. Myth of the double-edged sword: an empirical study of neuroscience evidence in criminal cases. *Boston College Law Review*. 2015; 56:493.
- Derringer J, Krueger RF, Irons DE, Iacono WG. Harsh discipline, childhood sexual assault, and MAOA genotype: an investigation of main and interactive effects on diverse clinical externalizing outcomes. *Behavior Genetics*. 2010; 40(5):639–648. [PubMed: 20364435]
- Dorfman, HM., Meyer-Lindenberg, A., Buckholtz, JW. Neurobiological mechanisms for impulsive-aggression: The role of MAOA. In: Miczek, KA., Meyer-Lindenberg, A., editors. *Neuroscience of Aggression*. Springer; Berlin Heidelberg; 2014. p. 297-313.
- Edersheim, JG., Weintraub Brendel, R., Price, BH. Neuroimaging, Diminished Capacity and Mitigation. In: Simpson, JR., editor. *Neuroimaging in Forensic Psychiatry: From the Clinic to the Courtroom*. John Wiley & Sons, Ltd; Chichester, UK; 2012. p. 163-193.
- Edwards AC, Dodge KA, Latendresse SJ, Lansford JE, Bates JE, Pettit GS, ... Dick DM. MAOA-uVNTR and early physical discipline interact to influence delinquent behavior. *Journal of Child Psychology and Psychiatry*. 2010; 51(6):679–687. [PubMed: 19951362]
- Eme R. MAOA and male antisocial behavior: a review. *Aggression and Violent Behavior*. 2013; 18(3): 395–398.
- Enoch MA, Steer CD, Newman TK, Gibson N, Goldman D. Early life stress, MAOA, and gene-environment interactions predict behavioral disinhibition in children. *Genes, Brain and Behavior*. 2010; 9(1):65–74.

- Faigman DL, Slobogin C, Monahan J. Gatekeeping Science: Using the Structure of Scientific Research to Distinguish Between Admissibility and Weight in Expert Testimony. *Northwestern University Law Review*. 2016 in press.
- Fergusson DM, Boden JM, Horwood LJ, Miller A, Kennedy MA. Moderating role of the MAOA genotype in antisocial behavior. *British Journal of Psychiatry*. 2012; 200(2):116–123. [PubMed: 22297589]
- Ficks CA, Waldman ID. Candidate genes for aggression and antisocial behavior: a meta-analysis of association studies of the 5HTTLPR and MAOA- uVNTR. *Behavior Genetics*. 2014; 44(5):427–444. [PubMed: 24902785]
- Foley DL, Eaves LJ, Wormley B, Silberg JL, Maes HH, Kuhn J, Riley B. Childhood adversity, monoamine oxidase A genotype, and risk for conduct disorder. *Archives of General Psychiatry*. 2004; 61(7):738–744. [PubMed: 15237086]
- Forzano F, Borry P, Cambon-Thomsen A, Hodgson SV, Tibben A, de Vries P, ... Cornel M. Italian appeal court: a genetic predisposition to commit murder? *European Journal of Human Genetics*. 2010; 18(5):519–521. [PubMed: 20216573]
- Frazzetto G, Di Lorenzo G, Carola V, Proietti L, Sokolowska E, Siracusano A, ... Troisi A. Early trauma and increased risk for physical aggression during adulthood: the moderating role of MAOA genotype. *PLoS One*. 2007; 2(5):e486. [PubMed: 17534436]
- Fuss J, Dressing H, Briken P. Neurogenetic evidence in the courtroom: A randomised controlled trial with German judges. *Journal of Medical Genetics*. 2015; 52(11):730–737. [PubMed: 26307568]
- Glenn AL, Raine A. Neurocriminology: Implications for the punishment, prediction and prevention of criminal behavior. *Nature Reviews Neuroscience*. 2014; 15(1):54–63. [PubMed: 24326688]
- González-Tapia MI, Obsuth I. “Bad genes” & criminal responsibility. *International Journal of Law and Psychiatry*. 2015; 39:60–71. [PubMed: 25708001]
- Gorodetsky E, Bevilacqua L, Carli V, Sarchiapone M, Roy A, Goldman D, Enoch MA. The interactive effect of MAOA-LPR genotype and childhood physical neglect on aggressive behaviors in Italian male prisoners. *Genes, Brain and Behavior*. 2014; 13(6):543–549.
- Haberstick BC, Lessem JM, Hewitt JK, Smolen A, Hopfer CJ, Halpern CT, ... Harris KM. MAOA genotype, childhood maltreatment, and their interaction in the etiology of adult antisocial behaviors. *Biological Psychiatry*. 2014; 75(1):25–30. [PubMed: 23726513]
- Huang YY, Cate SP, Battistuzzi C, Oquendo MA, Brent D, Mann JJ. An association between a functional polymorphism in the monoamine oxidase A gene promoter, impulsive traits and early abuse experiences. *Neuropsychopharmacology*. 2004; 29(8):1498–1505. [PubMed: 15150530]
- Jones OD, Wagner AD, Faigman DL, Raichle ME. Neuroscientists in court. *Nature Reviews Neuroscience*. 2013; 14(10):730–736.
- Kieling C, Hutz MH, Genro JP, Polanczyk GV, Anselmi L, Casey S, ... Rohde LA. Gene–environment interaction in externalizing problems among adolescents: Evidence from the Pelotas 1993 Birth Cohort Study. *Journal of Child Psychology and Psychiatry*. 2013; 54(3):298–304. [PubMed: 23215821]
- Kim-Cohen J, Caspi A, Taylor A, Williams B, Newcombe R, Craig IW, Moffitt TE. MAOA, maltreatment, and gene–environment interaction predicting children’s mental health: new evidence and a meta-analysis. *Molecular Psychiatry*. 2006; 11(10):903–913. [PubMed: 16801953]
- Kolla NJ, Attard S, Craig G, Blackwood N, Hodgins S. Monoamine oxidase A alleles in violent offenders with antisocial personality disorder: High activity associated with proactive aggression. *Criminal Behavior and Mental Health*. 2014; 24(5):368–372.
- Kiive E, Laas K, Akkermann K, Comasco E, Oreland L, Veidebaum T, Harro J. Mitigating aggressiveness through education? The monoamine oxidase A genotype and mental health in general population. *Acta Neuropsychiatrica*. 2014; 26(01):19–28. [PubMed: 25142096]
- McGrath LM, Mustanski B, Metzger A, Pine DS, Kistner-Griffin E, Cook E, Wakschlag LS. A latent modeling approach to genotype–phenotype relationships: maternal problem behavior clusters, prenatal smoking, and MAOA genotype. *Archives of Women’s Mental Health*. 2012; 15(4):269–282.
- Mobley v. State*. 265 Ga. 292, 455 S.E.2d 61 (Ga. Sup. Ct. Mar. 17, 1995)

- Morse, S. Gene-environment interactions, criminal responsibility, and sentencing. In: Dodge, KA., Rutter, M., editors. *Gene-Environment Interactions in Developmental Psychology*. Guilford Press; 2011. p. 11-26.
- Nilsson KW, Sjöberg RL, Damberg M, Leppert J, Öhrvik J, Alm PO, ... Orelund L. Role of monoamine oxidase A genotype and psychosocial factors in male adolescent criminal activity. *Biological Psychiatry*. 2006; 59(2):121–127. [PubMed: 16125147]
- Nuffield Council on Bioethics. *Genetics and Human Behaviour: The Ethical Context*. Nuffield Council on Bioethics; London, U.K: 2002.
- People (Respondent) v. Adams (Appellant)*. 2011 WL 2835701 (Sup. Cal. Appellate Brief, Jun. 22, 2011).
- People v. Adams*. 336 P.3d 1223, 60 Cal. 4th 541, 179 Cal. Rptr. 3d 644 (2014).
- Presidential Commission for the Study of Bioethical Issues. *Grey Matters: Topics at the Intersection of Neuroscience, Ethics, and Society*. Washington: U.S. Government Printing Office; 2015.
- Prom-Wormley EC, Eaves LJ, Foley DL, Gardner CO, Archer KJ, Wormley BK, ... Silberg JL. Monoamine oxidase A and childhood adversity as risk factors for conduct disorder in females. *Psychological Medicine*. 2009; 39(4):579–590. [PubMed: 18752729]
- Reti IM, Xu JZ, Yanofski J, McKibben J, Uhart M, Cheng YJ, ... Nestadt G. MAOA regulates antisocial personality in Caucasians with no history of physical abuse. *Comprehensive Psychiatry*. 2011; 52(2):188. [PubMed: 21295226]
- Rushing SE. Admissibility of brain scans in criminal trials: the case of positron emission tomography. *Court Review*. 2014; 50:62–69.
- Sjöberg RL, Nilsson KW, Wargelius HL, Leppert J, Lindström L, Orelund L. Adolescent girls and criminal activity: Role of MAOA-LPR genotype and psychosocial factors. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*. 2007; 144(2):159–164.
- State (Respondent) v. Driskill (Appellant)*. 2014 WL 4277584 (Sup. Mo. Appellate Brief, Jun. 12, 2014).
- [Last accessed March 1, 2016] *State v. Bourassa*, No. 19CR-10-258 (Ark. Cir. Apr. 17, 2012). Retrieved from Arkansas CourtConnect at <http://www.caseinfo.aoc.arkansas.gov>
- State v. Driskill*, 459 S.W.3d 412 (Mo. 2015).
- State v. Idellfonso-Diaz*, No. M2006-00203-CCA-R9-CD (Tenn. Crim. App. Aug. 8, 2006).
- State v. Waldroup*, No. E2010-01906-CCA-R3-CD, 2011 WL 5051677 (Tenn. Crim. App. Mar. 29, 2011).
- [Last accessed March 1, 2016] *State v. Yépez*. No. D-101-CR-201200758 (New Mex. Ct., Santa Fe Div., Jan. 30, 2015; Mar. 4, 2015). Retrieved from *New Mexico Courts Case Lookup*, <http://www.caselookup.nmcourts.gov>
- Stetler DA, Davis C, Leavitt K, Schriger I, Benson K, Bhakta S, ... Bortolato M. Association of low-activity MAOA allelic variants with violent crime in incarcerated offenders. *Journal of Psychiatric Research*. 2014; 58:69–75. [PubMed: 25082653]
- Stiny, A. [Last accessed March 1, 2016] No ‘warrior gene’ testimony allowed in Santa Fe murder trial. *Albuquerque Journal*. 2015 Mar 12. Retrieved from <http://www.abqjournal.com>
- Taylor A, Kim-Cohen J. Meta-analysis of gene–environment interactions in developmental psychopathology. *Development and Psychopathology*. 2007; 19(4):1029–1037. [PubMed: 17931432]
- Treadway MT, Buckholtz JW. On the use and misuse of genomic and neuroimaging science in forensic psychiatry: Current roles and future directions. *Child and Adolescent Psychiatric Clinics of North America*. 2011; 20(3):533–546. [PubMed: 21683918]
- Turone F. Medical tests help reduce sentence of woman accused of murder. *BMJ*. 2011; 343:d5761.
- United States, Appellee v. Alex J. Duran Private First Class (e-2) U.S. Marine Corps, Appellant*. 2014 WL 1608281 (U.S. Armed Forces Appellant Brief Suppl, Apr. 17, 2014)
- United States v. Duran*. 2014 WL 341587 (N.M. Ct. Crim. App. Jan. 31, 2014).
- Vassos E, Collier DA, Fazel S. Systematic meta-analyses and field synopsis of genetic association studies of violence and aggression. *Molecular Psychiatry*. 2014; 19(4):471–477. [PubMed: 23546171]

- Verhoeven FE, Booij L, Kruijt AW, Cerit H, Antypa N, Does W. The effects of MAOA genotype, childhood trauma, and sex on trait and state-dependent aggression. *Brain and Behavior*. 2012; 2(6): 806–813. [PubMed: 23170243]
- Whelan YM, Kretschmer T, Barker ED. MAOA, Early Experiences of Harsh Parenting, Irritable Opposition, and Bullying–Victimization: A Moderated Indirect- Effects Analysis. *Merrill-Palmer Quarterly*. 2014; 60(2):217–237.
- Widom CS, Brzustowicz LM. MAOA and the “cycle of violence:” childhood abuse and neglect, MAOA genotype, and risk for violent and antisocial behavior. *Biological Psychiatry*. 2006; 60(7): 684–689. [PubMed: 16814261]
- Wilson, D. *Genetics, Crime and Justice*. Elgar Publishing; U.K: 2015.
- Young SE, Smolen A, Hewitt JK, Haberstick BC, Stallings MC, Corley RP, Crowley TJ. Interaction between MAO-A genotype and maltreatment in the risk for conduct disorder: failure to confirm in adolescent patients. *American Journal of Psychiatry*. 2006; 163(6):1019–1025. [PubMed: 16741202]

**Table 1**

Legal Proceedings with Evidence of MAOA-L Genotype from 1995 to March 1, 2016

Case (Year) Court	MAOA-L	Reason for Test	Court Proceedings	Outcome
Mobley (1995) U.S.	N/A	Murder	S	No sentencing reduction; death penalty
Bayout (2009) Italy	+	Murder	A	Appeal upheld; 9 years reduced to 8 years
Waldroup (2011) U.S.	+	Murder Attempted Murder	G	Charge reduction; first-degree murder reduced to voluntary manslaughter
Albertani (2011) Italy	+	Murder Attempted Murder (2)	A	Appeal upheld; life reduced to 20 years
Bourassa (2012) U.S.	+	Murder	S	Sentenced to life; spared death penalty
Adams (2014) U.S.	+	Murder (3) Attempted Murder	S	No sentencing reduction; death penalty
Duran (2014) U.S.	N/A	Attempted Murder	A	Appeal dismissed; 15 years
Driskill (2015) U.S.	+	Murder (2)	S	No sentencing reduction; death penalty
Colbert (2015) U.S.	+	Murder	S/A	No sentencing reduction; life sentence
Yepez (2015) U.S.	+	Murder	G	Evidence inadmissible; second-degree murder
Bathgate (2016) U.S.	N/A	Murder	A	Habeas corpus dismissed; evidence procedurally defaulted

Note. + = MAOA-L genotype carrier; A = Appellate phase; G = Guilt phase; N/A = No test undertaken; S = Sentencing phase.