Neuro-genetic evidence in the courtroom: A randomized, controlled trial with German judges

Johannes Fuss[1*], Harald Dressing[2], Peer Briken[1]

[1] Institute for Sex Research and Forensic Psychiatry, Center of Psychosocial Medicine, University Medical Center Hamburg-Eppendorf, Germany

[2] Department of Psychiatry and Psychotherapy, Central Institute of Mental Health, University Medicine Mannheim, University of Heidelberg, Mannheim, Germany

*corresponding author:

E-mail: jo.fuss@uke.de

Running title: Neuro-genetic evidence and sentencing

Abstract

Background: Prominent court decisions and recent research suggest that introduction of neuro-genetic evidence, e.g. MAOA alleles, may reduce the sentence of convicted psychopaths. Here, we were aiming to demonstrate that judges' response to neuro-genetic evidence is highly influenced by the legal system in which they operate.

Methods: Participating German judges (n=372) received a hypothetical case vignette of aggravated battery and were randomly assigned to expert testimonies that either involved a neuro-genetic explanation of the offender's psychopathy or only a psychiatric diagnosis of psychopathy. Testimonies were presented either by the prosecution or defense.

Results: Neuro-genetic evidence significantly reduced judges' estimation of legal responsibility of the convict. Nevertheless, the average prison sentence was not affected in the German legal system. Most interestingly, analysis of judges' reasoning revealed that neuro-genetic arguments presented by the prosecution significantly increased the number of judges (23% compared to ~6%) ordering an involuntary commitment in a forensic-psychiatric hospital. Such an involuntary commitment due to diminished or absent legal responsibility may last much longer than a prison sentence in the German legal system.

Conclusion: Our data thus demonstrates the socially contingent nature of legal responses to neuro-genetic evidence in criminal cases.

Key words: Sentencing, free will, neuroscience, MAOA, legal responsibility

Background

In 2009, a jury in Tennessee found Bradley Waldroup guilty of shooting his wife's best friend. During the trial the defense presented genetic evidence regarding monoamine oxidase A (MAOA) gene variants and Waldroup was convicted of manslaughter instead of first-degree murder and was not sentenced to death (1). Two comparable trials occurred in Italy where genetically determined low MAOA activity was a main argument for a “partial mental illness of the defendant” and mitigation of the sentence (2, 3). These three decisions caused a debate about how scientific evidence affects culpability, legal responsibility and free will.

The role of MAOA in antisocial behavior was first demonstrated in a Dutch family (4). A complete deficiency of MAOA activity was associated with impulsive aggression, arson, attempted rape, and exhibitionism in male family members. Later Caspi and colleagues (5) revealed that even common MAOA alleles can affect antisocial behavior. Persons with low activity MAOA alleles who were exposed to childhood maltreatment were significantly more likely to exhibit antisocial behaviors as adults.

Shortly after the paper by Brunner and colleagues, Stephen Mobley was convicted of murdering a 25-year-old pizza store manager in 1991 (6). By analyzing Mobley’s family tree researchers found a comparable amount of antisocial behaviors to the Dutch family studied by Brunner and colleagues (1993). His attorney therefore requested to test Mobley genetically for the same gene mutation. However, the judges denied the request and Mobley was sentenced to death. Subsequently, Mobley filed a petition for a writ of habeas corpus at the Superior Court because genetic information was not considered and Mobley’s death sentence was indeed vacated by the court (7). For a time it appeared as if the genetic information was relevant to Mobley’s sentence. However, the Supreme Court finally reversed the habeas corpus court’s order. They reinstated Mobley’s death sentence and he was executed in 2005.

In the following years, scientific evidence regarding the MAOA gene has been introduced in several capital murder cases in the United States in which they served as mitigating evidence

and may have influenced whether offenders were convicted of second-degree murder or manslaughter instead of first-degree murder (8, 9). The number of criminal cases in which genetic (8, 10) or neuroscientific evidence (11-14) was presented increased in the last years. However, court decisions may not necessarily be improved by such evidence. Understanding of scientific mechanisms always reflected the science of the day (i.e. heritability of intellectual disability in the 1930s or association of XYY karyotype and violent behavior in the 1960s (8)). Indeed, although the MAOA x childhood maltreatment evidence has been replicated several times (15) it is unclear how statistical group differences from large samples can be applied to individual cases (16) (for a review see (17)).

Nevertheless, such evidence already plays a role in criminal cases. Recently, Aspinwall, Brown and Tabery investigated how neuro-genetic evidence (low MAOA activity that leads to improper brain development) affects sentencing by US state trial judges in a mock case (18). Participating judges received a case vignette of aggravated battery and were randomly assigned to expert testimonies that involved either a psychiatric diagnosis of psychopathy with a neuro-genetic explanation of the offender's psychopathy or only a psychiatric diagnosis of psychopathy without such an explanation. Aspinwall and colleagues demonstrated that the additional biomechanism reduced sentences significantly.

In the present study, we were interested if this is a general tendency in the Western World or if the legal system influences how biomechanism affects judges' sentencing. All Western legal systems fall into one or the other of two categories: the Anglo-American common law, and the Romano-Germanic civil law. Decisions in the common law are based on precedents, while the civil law has a systemic code. Along with these profound structural differences, the legal systems also differ concerning sentencing of mentally disordered individuals.

For example, in the German legal system criminals with a mental disorder can be subjected to involuntary forensic treatment instead of a prison sentence if they have a mental disorder and are *not* or "diminished" legally responsible for their offence because the disorder affected

their rationality (see textbox). Until the late 1970s, only those mental disorders that had or were supposed to have a somatic (organic) origin (for example, psychosis was considered to have a somatic origin) affected legal responsibility in Germany (19, 20). This tradition may still affect judges sentencing today. Presentation of a biomechanism emphasizes a somatic underpinning of mental disorder and we thus hypothesized that a biomechanistic explanation would increase judges' estimation of intensity and degree of the mental disorder, thus affecting the frequency with which judges order involuntary forensic-psychiatric treatment.

-- Insert textbox here --

Textbox: The German legal system

In Germany, mentally disordered convicts can either serve their sentence in a prison or a forensic psychiatric hospital (21). Convicts that have been declared legally responsible despite their disorder are imprisoned. In other words, mental disorder did not affect the capacity to understand the wrongfulness of an act or the ability to control conduct during the offence. Those that are found to be legally irresponsible (§20 of the German penal code) or sentenced with "diminished responsibility" (§21 of the German penal code) due to mental disorder are involuntarily sent to a forensic psychiatric hospital (§63 of the German penal code) if they are considered to pose a threat to society. Specifically, likelihood of recidivism is expected to be high. More than 6000 convicts are treated presently in forensic-psychiatric hospitals in Germany (22). Forensic-psychiatric hospitals are separate from other psychiatric institutions and may have a comparable security structure to prisons. Involuntary commitment lasts as long as the risk for a severe reoffending caused by the psychiatric disorder is high and thus may be indefinite: however, judicial procedures regularly consider whether further commitment is necessary. Only "if it is expected that the confined convict will not commit a punishable act" (§67b2 of the German penal code), does discharge from a forensic-psychiatric hospital become possible.

In order to clarify if a convict is mentally disordered and if this disorder affected the legal responsibility during the case at hand, case reports and opinions from psychiatric experts are requested by the court (or the prosecution at an earlier stage of investigation). These experts are also asked for a legal prognosis (the probability and nature of future offences) to assess the risk. In order to collect all mandatory information it is common that psychiatric experts order or perform further examinations (physical examination, structural brain imaging, neuropsychological testing). These further tests help to clarify the diagnosis and rule out differential diagnoses. Psychiatric experts usually rely on established diagnostic tools. In Germany, a testing for MAOA genotype and functional MRI measurements could also be requested as well as an additional expert testimony from a neurobiologist or a neuroradiologist. So far, we are not aware of a single criminal case that was tested for MAOA for an expert opinion in Germany.

Convicts that are legally responsible but also extremely dangerous because they have a high risk for future offences can be sentenced to preventive detention according to §66 of the German penal code. They are mostly confined in specialized prisons of the federal states after they have served their prison sentence and not in forensic-psychiatric hospitals. Discharge from these prisons is only possible when the risk for a severe re-offence is expected to be low.

Methods

Study design

Judges (n=372) were independently randomized to a German translation of the Psychopathy case vignette of Aspinwall and colleagues (18) that was based on Mobley vs. State (6). In the German version we only performed minor modifications (e.g. German names) and omitted some information that was only appropriate in the United States legal system (e.g. that the offender was found guilty by a jury).

Briefly, Jonathan Donahue entered a restaurant brandishing a loaded pistol and demanded money. The shop owner William Porter did not respond to the demand and thus Donahue forced him on his knees and struck him repeatedly on his head with the gun. Then he ran off without money. Porter suffered a moderate, permanent brain damage from the assault. Donahue was arrested and boasted about his assault on Porter to jail staff.

After presentation of these details, judges were randomly assigned to a 2x2 factorial design with presenting party (prosecution, n=175 or defense, n=197) and biomechanism (absent, n=185 and present, n=187) as factors. All participating judges received an identical expert testimony from a psychiatrist that diagnosed Donahue a psychopath. Judges in the biomechanism-present condition furthermore received a second expert testimony from a neurobiologist. The neurobiologist presented a neuro-genetic explanation of psychopathy (low MAOA activity that leads to improper brain development) and the neurobiologist demonstrated that he had tested Donahue genetically and that he had low MAOA activity. In the prosecution condition, prosecutors argued that the expert testimony was aggravating because Donahue's crime and his behavior thereafter all pointed to his being a continued threat to society due to his psychopathy. In contrast, in the defense condition the evidence was argued to be mitigating because Donahue's crime and his behavior thereafter indicated that it was more difficult for him to control his impulses due to his psychopathy.

Consecutively, judges were asked to indicate on a 5 point scale the extent to which the evidence concerning psychopathy affected the punishment of Donahue (from *greatly mitigates*=1 to *no effect*=3 to *greatly aggravates*=5) and to rate his legal and moral responsibility and free will (e.g. from 1=*no moral responsibility at all* to 5=*completely morally responsible*). Moreover, judges were asked to indicate the minimum and maximum sentence in years for aggravated battery in Germany, the estimated average and their personal estimated average sentence for aggravated battery. Finally, judges had to provide a sentence for the present case. Response options ranged from less than 1 year to 40+ years in 1-year

178 increments, and a "do not know" option was provided. Responses of “less than 1 year” were
179 given a value of 0.5 years. After each question, judges were asked to explain their answers in
180 an open-ended textbox.
181
182 *Judges and Recruitment Procedure*
183 We recruited German court judges by e-mail invitation to complete an anonymous online
184 survey concerning "science and sentencing". E-mail invitations were sent to all court
185 presidents in Germany. They were asked to distribute an invitation and a link to the study
186 among their judges. In the invitation we explained that our purpose was to compare the legal
187 systems of the United States and Germany. The survey was anonymous and thus we were not
188 able to track how many court presidents forwarded our message and what percentage of
189 judges replied. On page 1 of the survey, we fully explained the procedure and provided
190 contact information. In order to proceed with the study judges had to give their informed
191 consent by clicking “I agree”. We collected data for 2 months from mid-July to September
192 2014 by a single invite e-mail blast that was performed in July. The study was approved by
193 the local ethics committee. Additional information regarding the judges can be found in Table
194 2.
195
196 *Statistical Analyses*
197 Statistical analyses were carried out using PASW 18.0 (SPSS Inc., Chicago, IL). Data are
198 reported as means±S.E.M.. A two-factorial analysis of variance (ANOVA) followed by
199 Bonferroni’s post-hoc analysis was carried out to study the effect of the absence or presence
200 of biomechanism and the effect of presenting party. Qualitative data were first rated by a
201 coder with pre-determined categories from the study of Aspinwall and colleagues (18) and the
202 coder was instructed to highlight quotes that were not covered by the categories. For these
203 codes we added additional categories (for example “No criminal record”). Subsequently, all

data were coded by two new and independent raters, who were trained by one of the authors (JF). Cohens kappa was calculated to compare the inter-rater reliability and is reported in Table 1. The kappa value can be interpreted according to Altman (1991) and was very good for 18 categories (kappa 0.81 - 1) and good for 9 categories (kappa 0.61 – 0.80). Only the category "mentally ill" had a moderate inter-rater reliability. This category was, however, only rarely applied (in 12 of 336 quotes). Chi-square testing was performed to study the quantification of qualitative data. Significance was evaluated at a probability of 5% or less (<0.05).

Results

The evidence concerning psychopathy was rated as mitigating overall (Mean: 2.49 ±0.05, Fig.1). Presenting party significantly influenced the rating of psychopathy. Presentation of expert testimonies by the defense (Mean: 2.33±0.06) increased judgment of mitigation in contrast to presentation by the prosecution (Mean: 2.68±0.07; $F_{1,368}$=16.238, p<0.001). In line with this, post-hoc comparison revealed significantly higher mitigation when the testimonies were presented by the defense compared to the prosecution in the biomechanism absent (p=0.041) and present condition (p=0.019). Biomechanism had no significant effect on the evaluation of psychopathy as a mitigating factor ($F_{1,368}$=2.818, p=0.094).

After presentation of the case vignette, judges were asked to evaluate the offender's legal and moral responsibility and free will. Neither biomechanism nor presenting party affected the judges evaluation of free will (4.30±0.05) or moral responsibility (3.74±0.07). However, the estimated legal responsibility was significantly reduced by biomechanism (Mean present: 4.14±0.08, and absent biomechanism: 4.41±0.07; $F_{1,351}$=6.721, p=0.010, Fig.2).

The minimum sentence (0.57±0.03 years), the maximum sentence (9.62±0.09 years), the estimated average sentence for aggravated battery in Germany (1.27±0.08 years) and the personal average for aggravated battery (1.33±0.07 years) were not significantly affected by

presenting party or biomechanism. Eighty percent of the judges (n=309) provided a sentence for the defendant. The average sentence was 3.1±0.09 years (Fig.3) and was thus significantly higher than the estimated average ($p<0.0001$) and the personal average ($p<0.0001$) for aggravated battery. The sentence was neither affected by biomechanism ($F_{1,305}=0.770$, $p=0.381$) nor presenting party ($F_{1,305}=0.789$, $p=0.375$).

Qualitative data

In total, 336 judges provided opinions concerning the sentencing or defendant's responsibility in the free text fields that were rated by two independent raters into different coding categories (Table 1). The majority of judges mentioned at least one aggravating factor (86.6%), and presentation of the expert testimonies by the defense significantly increased the percentage of judges that mentioned at least one aggravating factor ($\chi^2(1)=7.249$, $p=0.007$, Fig.4). Mitigating factors were listed less frequently (65.2%) and were neither influenced by biomechanism nor presenting party. For example, about 25% of judges admitted that the defendant was incapable of understanding the emotions of others and feeling sorry (Table 1, Supplemental file: Quotes #13 and #26). One judge argued for example:

"(...) He is incapable of feeling empathy or compassion and due to this defect, he did not consciously decide to act particularly violent. (...)"

Some argued that the defendant was however intellectually capable of understanding that battery and robbery are prohibited and that he must be sentenced if he premeditatedly brings himself into a situation (entering a restaurant with a gun) in which he has a hard time controlling his impulses (Supplemental file: Quotes #15 and #29). For example, one stressed:

"Why did he own a weapon? Why did he go to a restaurant to do a robbery? Even a psychopath knows that such behavior is prohibited and will be punished. Nevertheless, he did nothing to avoid it."

Some judges that indicated that the evidence concerning psychopathy aggravates or doesn't affect the sentence argued that psychopathy is not a mental disorder in DSM (26) or ICD (27)

and is thus not mitigating *per se* (Supplemental file: Quote #18+19). However, they argued that psychopathic behavior is associated with a negative legal prognosis and to prevent future crimes a higher sentence (or even preventive detention) has to be considered (Supplemental file: Quote #1-6, #12, #32-34). Most judges, however, did not argue against psychopathy as a disorder in the qualitative data (Supplemental file: Quote #3, #8, #20, #24, #28, #31).

Some of the judges also indicated a theory of sentencing in the textbox. For example, one explained:

"if a criminal has the diagnosis of psychopathy, one has to admit that therapy is unlikely to be successful. In this case the reason for a sentence is less influenced by the thought of rehabilitation and therapy and more influenced by the future benefit for society by detaining dangerous and particularly violent criminals."

Another explained:

"sentencing has to put pressure on the criminal to abide by the rules of society. If criminals are less likely to adhere to the rules due to their constitution (be it genetically or environmentally determined) we need more pressure, i.e. a higher sentence."

Interestingly, combination of expert testimony by the prosecution and present biomechanism significantly increased the percentage of judges that ordered involuntary commitment in a forensic-psychiatric hospital for the defendant (23.2% versus 5–6.9% in the three other conditions, $\chi^2(3)=20.509$, $p=0.0001$, Fig.5).

Discussion and Conclusion

In the present study, we investigated how neuro-genetic evidence of psychopathy affects judges' sentencing in Germany. We found that judges estimated evidence concerning psychopathy as mitigating overall and especially when presented by the defense. Biomechanism reduced legal responsibility; nonetheless, biomechanism did not affect the sentence. Interestingly, four times more judges ordered involuntary commitment in a forensic-psychiatric hospital when the prosecution presented the biomechanism. Thus, biomechanism could increase detention time through involuntary commitment that lasts until there is no

longer a risk for re-offence associated with the disorder. A biomechanism of psychopathy therefore affects judges sentencing significantly different in the German compared to other legal systems.

Mitigating or aggravating? Psychopathy and involuntary commitment

Previous studies suggest that diagnosed psychopathy aggravates sentencing in the US (18, 23, 24). For example, the diagnosis of psychopathy has been used to justify the death penalty instead of a life sentence (25). Therefore, it was suggested to omit the use of the PCL-R to diagnose psychopathy in capital murder trials (23). In accordance with this, Aspinwall and colleagues (2012) demonstrated that US state trial judges rated the evidence concerning psychopathy as aggravating overall (Mean=3.59). In contrast, in the German legal system psychopathy rather seems to mitigate the sentence (Mean=2.49).

The presentation of a mental disorder in German trials can serve to reduce the culpability as well as the sentence of the defendant (see textbox). Therefore, it was not surprising that German judges estimated that psychopathy mitigates the sentence. In case of a mental disorder and a poor legal prognosis of the defendant, judges may order an involuntary commitment to a forensic-psychiatric hospital. Interestingly, in the present study we found that the percentage of judges that ordered involuntary commitment was significantly increased in the biomechanism/prosecution condition. The extra neuro-genetic evidence in combination with emphasizing the negative legal prognosis by the prosecution convinced significantly more judges that the defendant was mentally disordered in a way that he would need to be sent to a forensic-psychiatric hospital. This confirms our initial hypothesis, that highlighting the somatic origin of a mental disorder would aggravate the estimation of the degree of a mental disorder (and thus the need for treatment in a forensic institution) due to the influence of German psychiatry on the development and interpretation of the German penal code (20, 28 and Supplemental files: Quote #24+25).

In support of this, Appelbaum and Scurich (29) recently reported that biological explanation of criminal behavior also increases the perception of dangerousness of convicts in the US. So far, neuro-genetic evidence was however mostly introduced as a mitigating factor by the defense in US capital cases (30). In contrast, the German legal system is more inquisitorial and forensic experts are usually appointed by the prosecution or the court.

In our study, one judge argued:

"The defendant cannot be hold responsible for the particularly grave character of the offence; therefore (…) involuntary commitment for rehabilitation and safety reasons is necessary. The duration is dependent on the treatability of the defendant's disorder. In my opinion at least 2 additional years seem appropriate which means that the defendant will spend much longer in confinement than the 4 years of his sentence."

In fact, the primary aim of involuntary commitment is rehabilitation and enabling the defendant to return to society and is thus not seen as aggravating. For instance, one of the judges emphasized that the evidence concerning psychopathy is mitigating because

"the defendant is limited in his capacity of discernment. Ordering involuntary commitment is of course aggravating for the defendant, however, due to its rehabilitative character it is not seen as an aggravated sentence."

Therefore, although a defendant with diminished or absent legal responsibility may obtain a lighter sentence, he/she will be confined to a forensic-psychiatric hospital, possibly for the rest of his/her life (31, 32).

In line with an overall mitigating effect of the evidence concerning psychopathy, the percentage of judges that listed at least one mitigating factor was remarkably higher (65.2%) in the present study compared to the study by Aspinwall and colleagues (38.7%), while the percentage that listed at least one aggravating factor was almost identical (86.6% and 86.7%, respectively).

Another possibility of extending a regular prison sentence in Germany is preventive detention of individuals who have committed a grave offence and are considered a permanent danger to society. Yet in such defendants - if they fulfill the criteria for a mental disorder at all – the

disorder had no influence on their criminal responsibility (33). In the present study preventive detention was rarely ordered.

Punishment and legal responsibility

In general, legal punishment can either be justified by consequentialism or retributivism (34). Consequentialist theory stems from classical utilitarianism (35) and measures the moral worth of punishment by the future benefit for society. For example, containment of dangerous individuals protects society and deters others from crimes (36). Retributivist theory, in contrast, argues that people "who engage in criminal behavior *deserve* to be punished" (36) and that punishment re-establishes the moral imbalance that a crime caused. Given that the legal responsibility of an individual is reduced (e.g. through mental disorder), the moral imbalance is smaller and the individual deserves less punishment. Retributivist theory of legal responsibility thus depends on the notion that individuals have a free will to perform criminal acts and thus have moral responsibility. In the present study, legal responsibility of the defendant was significantly reduced by presentation of a biomechanism; however, reduced legal responsibility did not affect sentencing, which clearly opposes retributivist theory. In contrast, Aspinwall and colleagues (2012) found that presentation of a biomechanism increased the number of judges that listed mitigating factors in their opinions such as reduced culpability and reduced the sentence acknowledging an influence of retributivist theory. Our data therefore suggest that a retributivist influence on judges' sentencing is significantly less pronounced in Germany.

Generally, to achieve diminished legal responsibility an individual must "lack a general capacity of rationality" (37). Only when rationality is so far diminished that it is under a certain threshold (in Germany comparable to an acute psychotic disorder (38)) legal responsibility is reduced (Supplemental file: Quote #18). Since this threshold is quite high, it was argued earlier that the extra evidence through genetic or neuroscientific testimonies is not

enough to achieve reduced legal responsibility (8, 39). In the present study, however, we found that neuro-genetic evidence reduces legal responsibility significantly. Of note, even though there was an effect of biomechanism, the evaluations were still at the "responsible" end of the spectrum (i.e. closer to 5 than to 1, Mean=4.14 with biomechanism). In theory, only when the genetic endowment impairs the ability to appreciate the wrongfulness of conduct or the controllability of behavioral impulses substantially, it may affect legal responsibility - otherwise genetic influences are just another pressure an individual is expected to resist (8). Accordingly, in the textbox a judge argued that

"the defendant's capacity to understand the wrongfulness of his action and to behave accordingly was genetically and developmentally impaired",

while another judge (without neuro-genetic evidence) reasoned that

"there is no evidence for impaired understanding of the unjustness of the behavior or an inability to act accordingly in the case at hand. The defendant understands the rules of society yet he doesn't care for them."

It is the task of forensic psychiatrists to evaluate if an individual met the requirement of general minimal rationality at the time of the criminal act according to our socially-constructed folk psychological standards (40). For the evaluation of rationality, however, a psychiatrist considers how the capacity to understand the wrongfulness of an action and to control behavioral impulses during a criminal act was affected and that does not require knowing which biological cause it was based upon. Biological cause is only indirectly relevant if it affected rationality. As Steven Morse puts it

"(...) syndromes and other causes, including those of brain structure and function, do not have excusing force unless they sufficiently diminish rationality in the context in question. In that case, it is diminished rationality that is the excusing condition, not the presence of any particular type of cause" (41).

Similarly, one of the judges in the present study argued that

"the expert testimonies explain underpinnings of the defendant's behavior but they don't excuse the defendant's behavior. If the expert testimonies would have a mitigating force we would have to mitigate any defendant for any conduct because all behaviors are determined by genetic and environmental factors."

The belief that scientific information about a biological cause of behavior is *per se* a legitimate legal excuse is what Morse calls the *fundamental psycholegal error* (42).

In conclusion, our findings underline the socially contingent nature of legal responses to neuro-genetic evidence. In the German legal system, neuro-genetic evidence emphasizes a somatic origin of a mental disorder and thus the estimated degree of the disorder and presumably the need for (involuntary) treatment. This reduces the legal responsibility while it increases the likelihood for indeterminate involuntary commitment.

Limitations

Judges were anonymous in the present study. Therefore, we were not able to study the percentage of judges that responded to our invitation and to compare participating with non-responding judges. Consequently, our data may be influenced by a selection bias. For example, preferably those judges may have completed the online questions that were particularly interested in scientific experiments or particularly interested in the sentencing of psychopaths. Nevertheless, such a selection bias may have also occurred in the study by Aspinwall and colleagues (2012).

Future research that studies the effect of neurobiological and genetic research on judges' sentencing should also consider other psychiatric disorders with relevance for the legal system like pedophilic disorder or schizophrenia. Moreover, we think that it is important to study additionally how neurobiological and genetic research may affect the expert testimonies of forensic psychiatrists.

Declaration of interest

We have no competing interests

Acknowledgements

We are extremely thankful to James Tabery for his fruitful comments to an earlier version of the present paper and his help for the present study. We thank Lisa G. Aspinwall and Teneille R. Brown for their help regarding methodological questions and data analyses. We are grateful to Ute Lamparzer for her help regarding the qualitative data analysis, Rudolf Fuss and Christiane Lindner-Fuss for coding qualitative data, Philipp Vermehren for his helpful comments and all judges for their participation in the present study.

Authors' contribution

JF designed and coordinated the study, collected the data and drafted the manuscript. HD participated in the design of the study. PB participated in the design of the study and revised the manuscript. All authors gave final approval for publication.

Funding statement

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors

References

1. State v. Davis Bradley Waldroup. Tenn. Crim. App., at Knoxville; 2011.
2. Nature News. Lighter sentence for murderer with 'bad genes'. Nature. 2009; http://www.nature.com/news/2009/091030/full/news.2009.1050.html.
3. Nature News Blog: Italian court reduces murder sentence based on neuroimaging data. http://blogsnaturecom/news/2011/09/italian_court_reduces_murder_shtml2011.

4. Brunner HG, Nelen M, Breakefield XO, Ropers HH, van Oost BA. Abnormal behavior associated with a point mutation in the structural gene for monoamine oxidase A. Science. 1993; 262(5133): 578-80.

5. Caspi A, McClay J, Moffitt TE, Mill J, Martin J, Craig IW, Taylor A, Poulton R. Role of genotype in the cycle of violence in maltreated children. Science. 2002; 297(5582): 851-4.

6. Mobley v. State. Supreme Court of Georgia; 1995.

7. Mobley v. Head. United States District Court for the Northern District of Georgia; 2001.

8. Appelbaum PS. The double helix takes the witness stand: behavioral and neuropsychiatric genetics in court. Neuron. 2014; 82(5): 946-9.

9. Bernet W, Vnencak-Jones CL, Farahany N, Montgomery SA. Bad nature, bad nurture, and testimony regarding MAOA and SLC6A4 genotyping at murder trials. J Forensic Sci. 2007; 52(6): 1362-71.

10. Denno DW. Courts' Increasing Consideration of Behavioral Genetics Evidence in Criminal Cases: Results of a Longitudinal Study. Michigan State Law Review. 2011: 967-1047.

11. Roper v. Simmons. 2005.

12. Graham v. Florida. 2010.

13. Miller v. Alabama. 2012.

14. Steinberg L. The influence of neuroscience on US Supreme Court decisions about adolescents' criminal culpability. Nat Rev Neurosci. 2013; 14(7): 513-8.

15. Baum ML. The Monoamine Oxidase A (MAOA) Genetic Predisposition to Impulsive Violence: Is It Relevant to Criminal Trials? Neuroethics. 2013; 6(2): 287-306.

16. Buckholtz J, Meyer-Lindenberg, A. MAOA and the bioprediction of antisocial behavior: science fact and science fiction. In: Bioprediction, Biomarkers, and Bad Behavior: Scientific, Lergal, and Ethical Challenges (ed I Singh, Sinnott-Armstrong, W. P., Savulescu, J.): 131-52. Oxford University Press, 2013.

17. Faigman DL, Monahan, J., Slobogin, C. Group to Individual (G2i) Inference in Scientific Expert Testimony. University of Chicago Law Review. 2014; 81(2): 417-80.

18. Aspinwall LG, Brown TR, Tabery J. The double-edged sword: does biomechanism increase or decrease judges' sentencing of psychopaths? Science. 2012; 337(6096): 846-9.

19. Lackner K. Insanity and Prevention: On Linking Culpability and Prevention in the Concept of Insanity. Brigham Young University Law Review. 1986: 769-92.

20. Schneider K. Klinische Psychopathologie. Thieme, 1950.

21. Müller-Isberner R, Freese, R., Jöckel, D., Gonzalez Cabeza, S. Forensic Psychiatric Assessment and Treatment in Germany. International Journal of Law and Psychiatry. 2000; 23: 467–80.

22. Konrad N, Lau, S. Dealing with the mentally ill in the criminal justice system in Germany. International Journal of Law and Psychiatry. 2010; 33: 236–40.

23. Edens JF, Colwell L. H., Desforges, D. M., Fernandez, K. The impact of mental health evidence on support for capital punishment: are defendants labeled psychopathic considered more deserving of death? Behavioral Science & Law. 2005; 23(5): 603-25.

24. Lee C. The Judicial Response to Psychopathic Criminals: Utilitarianism over Retribution. Law and Psychology Review. 2007; 31: 125-36.

25. Edens JF, Petrila, J., Buffington-Vollum, J. K. Psychopathy and the dealth penalty: Can the psychopathy checklist-revised identify offenders who represent "a continuing threat to society?" Journal of Psychiatry & Law. 2001; 29(4): 433-81.

26. American Psychiatric Association. Diagnostic and statistical manual of mental disorders (4th ed., text rev.) 2000.

27. World Health Organization. The ICD-10 classification of mental and behavioral disorders 1993.

28. Wetzell RF. Inventing the Criminal: A History of German Criminology, 1880-1945 (Studies in Legal History). The University of North Carolina Press, 2000.

505 29. Appelbaum PS, Scurich, N. Impact of Behavioral Genetic Evidence on the
506 Adjudication of Criminal Behavior. J Am Acad Psychiatry Law. 2014; 42: 91-100.
507 30. Denno DW. What Real-World Criminal Cases Tell Us About Genetics Evidence.
508 Hastings Law Journal. 2013; 64: 1591-618.
509 31. Kroeber HL, Lau, S. Bad or Mad? Personality Disorders and Legal Responsibility—
510 The German Situation. Behavioral Sciences and the Law. 2000; 18: 679-90.
511 32. Leygraf N. Wirksamkeit des psychiatrischen Massregelvollzugs. In: Sexualstraftaten
512 und Gewaltdelinquenz (ed HL Kröber, Dahle K. P.): 175-84. Kriminalistik 1998.
513 33. Felthous AR, Sass, H. Introduction to this Issue: International Perspectives on
514 Preventive Detention. Behavioral Sciences and the Law. 2013; 31: 307-11.
515 34. Lacey N. State punishment: political principles and community values. Routledge &
516 Kegan Paul, 1988.
517 35. Bentham J. An Introduction to the Principles of Morals and Legislation. Methuen &
518 Co Ltd, 1988.
519 36. Greene J, Cohen, J. For the law, neuroscience changes nothing and everything.
520 Philosophical Transactions of the Royal Society B. 2004; 29(359): 1775-85.
521 37. Goldstein AM, Morse, SJ, Shapiro, DL . Evaluation of criminal responsibility. In:
522 Handbook of psychology: Vol II Forensic Psychology (ed IB Weiner, Goldstein, A.M.): 381-
523 406. Wiley, 2003.
524 38. Sass H. Ein psychopathologisches Referenzsystem für die Beurteilung der
525 Schuldfähigkeit. Forensia. 1985; 6: 33-43.
526 39. Morse SJ. Genetics and criminal responsibility. Trends in Cognitive Sciences. 2011;
527 15(9): 378-80.
528 40. Morse SJ. The ethics of forensic practice: reclaiming the wasteland. Journal of the
529 American Academy of Psychiatry and the Law. 2008; 36(2): 206-17.

41. Morse SJ. New Neuroscience, Old Problems: Legal Implications of Brain Science. Cerebrum online. 2004.

42. Morse SJ. Mental Disorder and Criminal Law. The journal of criminal law & criminology. 2013; 885: 885-968.

43. Altman DG. Practical statistics for medical research. London: Chapman and Hall. 1991.

Figure legends:

Fig. 1: The effect of the evidence concerning psychopathy on punishment was evaluated from greatly mitigates (1) to no effect (3) to greatly aggravates (5). In all groups the diagnosis of psychopathy had a mitigating effect on the sentence, which was significantly higher when the expert testimonies were presented by the defense. Error bars represent Mean + SEM.

Fig. 2: The legal responsibility was rated from *not at all legally responsible* (1) to *completely legally responsible* (5). Biomechanism significantly reduced the legal responsibility.

Fig. 3: Sentencing in years was neither affected by biomechanism nor presenting party.

Fig. 4: Percentage of judges listing at least one aggravating or mitigating factor in their opinions in the free text fields. Presentation of expert testimonies by the prosecution significantly reduced the percentage of judges that mentioned at least one aggravating factor.

Fig. 5: Involuntary commitment (German: *Maßregelvollzug* according to §63 of the German penal code) in a forensic-psychiatric hospital was significantly increased when expert testimonies were presented by the prosecution in the biomechanism present condition.

Preventive detention (German: *Sicherungsverwahrung* according to §66 of the German penal code) was ordered only seldom by the judges.

Tables

Table 1: Analysis of the qualitative data of the judges' responses in the open text boxes. The values represent number of judges citing any aggravating or mitigating factor to any of the textbox questions. Numbers in parentheses are the proportions.

	Kappa	Biomechanism				Total (n = 336)
		Absent		Present		
		Prosecution (n = 72)	Defense (n = 101)	Prosecution (n = 82)	Defense (n = 81)	
Aggravating factors						
Any aggravating factor		57 (0.792)	91(0.901)	68 (0.829)	75(0.926)	291 (0.866)
Aggravates (increases sentence)	0,700	6 (0.083)	2 (0.020)	8 (0.098)	2 (0.025)	18 (0.054)
Future dangerousness and incapacitation	0.913	8 (0.111)	8 (0.079)	13 (0.159)	0	29 (0.086)
Won't change (recidivism)	1,000	6 (0.083)	3 (0.03)	2 (0.024)	0	11 (0.033)
Seriousness of the crime and nature of the harm to victim	0.872	48 (0.667)	63 (0.624)	50 (0.610)	50 (0.617)	211 (0.628)
Lack of remorse/guilt	0.884	12 (0.167)	19 (0.188)	12 (0.146)	13 (0.160)	56 (0.167)
Lack of empathy (cold-blooded)	0.776	2 (0.028)	3 (0.030)	2 (0.025)	2 (0.024)	9 (0.027)
Had control	0.738	29 (0.403)	52 (0.515)	37 (0.451)	44 (0.543)	162 (0.482)
Culpable (deserves punishment)	0.737	19 (0.264)	21 (0.208)	13 (0.159)	19 (0.235)	72 (0.214)
Guilty mind (appreciates wrongfulness of action)	0.770	19 (0.264)	36 (0.356)	25 (0.305)	29 (0.358)	109 (0.324)
Not mentally ill	0.836	5 (0.069)	13 (0.129)	9 (0.110)	8 (0.099)	35 (0.104)
Mitigating factors						
Any mitigating factor		49 (0.681)	67 (0.663)	54 (0.659)	49 (0.605)	219 (0.652)
Mitigates (reduces sentence)	0.789	10 (0.139)	20 (0.198)	15 (0.183)	10 (0.123)	55 (0.164)
Lacks control	0.824	8 (0.111)	24 (0.238)	12 (0.146)	12 (0.148)	56 (0.167)
Mentally ill	0.497	1 (0.014)	2 (0.020)	5 (0.061)	4 (0.049)	12 (0.036)
Not culpable	0.865	13 (0.181)	25 (0.248	24 (0.293)	16 (0.198)	78 (0.232)
Feel sorry (for defendant)	1.000	0	0	0	0	0
Lacks empathy (defendant is incapable of feeling sorry)	0.725	22 (0.306)	24 (0.238)	17 (0.207)	13 (0.160)	76 (0.226)
No criminal record	0.975	12 (0.167)	12 (0.119)	10 (0.122)	10 (0.123)	44 (0.131)
Inculpable mind (is incapable of understanding wrongfulness of action)	0.725	10 (0.139)	18 (0.178)	20 (0.244)	17 (0.210)	65 (0.193
Confess the crime	1.000	3 (0.042)	2 (0.020)	2 (0.024)	2 (0.025)	9 (0.027)
Double-edged sword						
Balance/weigh	0.911	11 (0.153)	6 (0.059)	4 (0.049)	7 (0.086)	28 (0.083)
No effect reasons						
Questioning/Dismissing the Science	0.886	2 (0.028)	10 (0.099)	4 (0.049)	5 (0.062)	21 (0.063)
What, not Why	0.914	3 (0.042)	6 (0.059)	1 (0.012)	1 (0.012)	11 (0.033)
Legal System Restricts Judges' Assessments	1.000	1 (0.014)	0	0	0	1 (0.003)
Facts of Crime Already Inherently Aggravate	0.799	0	2 (0.020)	0	0	2 (0.006)
Judges Don't Do This	0.899	12 (0.167)	15 (0.149)	12 (0.146)	8 (0.099)	47 (0.140)
Study is Bogus	1.000	0	0	0	0	0
Further containment						
Involuntary commitment (German: Maßregelvollzug §63 StGB)	0.908	5 (0.069)	5 (0.050)	19 (0.232)	5 (0.062)	34 (0.101)
Preventive detention (German: Sicherungsverwahrung §66 StGB)	1.000	3 (0.042)	1 (0.010)	4 (0.049)	0	8 (0.024)

560 Table 2: Sociodemographic variables of the participating judges

Participating Judges [n]	375
Included	372 (99.2%)
Excluded (no correct answer to the multiple-choice question)	3 (0.8%)
Judicial experience [Mean in years ± SEM]	14.2 ± 1.1
No criminal docket	28 (7.5%)
Sex [n]	
Male	214 (57.5%)
Female	138 (37.1%)
No answer	20 (5.4%)
Region [n]	
Baden-Württemberg	65 (17.5%)
Bavaria	65 (17.5%)
Berlin	30 (8.1%)
Brandenburg	11 (3%)
Bremen	4 (1.1%)
Hesse	24 (6.5%)
Lower Saxony	34 (9.1%)
Mecklenburg-Vorpommern	12 (3.2%)
North Rhine-Westphalia	23 (6.2%)
Rhineland-Palatinate	23 (6.2%)
Saarland	10 (2.7%)
Saxony	13 (3.5%)
Saxony-Anhalt	7 (1.9%)
Schleswig-Holstein	10 (2.7%)
Thuringia	15 (4%)
No answer	26 (7%)
Prior knowledge about psychopathy [n]	
Nothing at all [1]	107 (28.8%)
Very little [2]	74 (19.9%)
Some familiarity [3]	121 (32.5%)
Quite a lot [4]	45 (12.1%)
Extensive [5]	3 (0.8%)
No answer	22 (5.9%)
[Mean ± SEM]	2.32 ± 0.055
Highest level of biological science training [n]	
College course	41 (11%)
Biology exam at end of highschool	127 (34.1%)
Biology lessons in highschool	113 (30.4%)
Biology for 10 years in school	71 (19.1%)
No answer	22 (5.9%)

561