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THE POTENTIAL FOR BIOPREDICTION IN CRIMINAL LAW[†]

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I. INTRODUCTION

For over 160 years, we have known that the brain affects behavior. The famous case of Phineas Gage showed how the passage of an iron rod through a man's brain transformed him from a man "[i]n possession of 'a well-balanced mind'" into a "fitful," "irreverent," and "grossly profane" man.[1] However, we still

1. Malcolm Macmillan, *Phineas Gage – Unravelling the Myth*, 21 LOOKING BACK 828, 829 (2008), http://thepsychologist.bps.org.uk/volume-21/edition-9/phineas-gage-unravelling-myth. *See also* James M. Harlow, Letter to the Editor, *Passage of an Iron Bar Through the Head*, 39 BOSTON MED. & SURGICAL J. 389, 389–93 (1848) (describing the nature of Gage's injury), *reprinted in* 11 J. NEUROPSYCHIATRY & CLINICAL NEUROSCIENCE 281 (1999).

do not know exactly *how* the brain does this. We also know that our genes seem to have some effect on our propensity for certain behaviors. Studies in Sweden and Denmark observed that petty criminals and their biological parents both had increased rates of criminality over the population base rate—but this relationship was absent where the criminals had adoptive parents.[2] It seems clear that our genes have an effect on our behavior, but they are not deterministic of our behavior. Because we do not know exactly how our brains and genes affect behavior, neuroscience and genetics currently cannot add anything new that behavior cannot already tells us.

Some researchers argue that one day, we will discover the biological correlates of human behavior and realize that we are all "merely victims of [our] neuronal circumstances."[3] Other scholars argue that neuroscience developments, unless they undermine the law's premise that human beings are rational actors, will not present problems that current legal doctrine cannot handle.[4] Until science can tell us more than behavior currently does, it does not have a place in determining responsibility.

If it were to be discovered that our brains and genes can explain our behavior, intense moral questions would arise. A vital part of what makes us human is our ability to choose how to behave and be accountable for our choices. And, criminal law is based on the assumption that a person does make these choices on her own and so it is acceptable to either reward or punish that person for her decision.[5] A revelation that our unchosen biology

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2. *See* Debra Niehoff, THE BIOLOGY OF VIOLENCE: HOW UNDERSTANDING THE BRAIN, BEHAVIOR, AND ENVIRONMENT CAN BREAK THE VICIOUS CIRCLE OF AGGRESSION 238 (1999).

3. Joshua Greene & Jonathan Cohen, *For the Law, Neuroscience Changes Nothing and Everything*, 359 PHIL. TRANS. R. SOC. LOND. B 1775, 1781 (2004). *See also* Niehoff, *supra* note 3 (arguing that the relevant questions of behavior in law today "will lose their grip in an age when the mechanical nature of human decision-making is fully appreciated").

4. *See* Stephen J. Morse, *New Neuroscience, Old Problems*, *in* NEUROSCIENCE AND THE LAW: BRAIN, MIND, AND THE SCALES OF JUSTICE 157, 166 (Brent Garland, ed., 2004) ("Advances in neuroscience and related fields have revealed hitherto unimagined biological causes that predispose people to behave as they do, but the science typically supporting claims that conscious will is an illusion . . . either is insufficient empirically to support such a claim or does not have the implications supposed.").

5. *See* James J. Hippard, *Unconstitutionality of Criminal Liability without Fault: An Argument for a Constitutional Doctrine of Mens Rea*, 10 HOUS. L. REV. 1039, 1043 (1972) (observing that Anglo-American criminal law presumes that humans have the capacity for free choice).

rather than our free minds determines our behavior would destroy our belief in free will, thereby calling into question the basis of our criminal laws.[6] Even more troubling to some, what if science could foresee our behavior before we know what we're going to do? That possibility is explored in *Minority Report*, in which technology is used to predict the actions and mental states of citizens and to arrest and detain would-be offenders before they have the chance to carry out their crimes.[7] As science becomes more advanced, some may fear that genetics and neuroscience may be used to predict behavior and arrest citizens before they actually act, like in *Minority Report*. While preventing crimes before they happen would arguably be beneficial for the safety and order of society, doing so would likely challenge our moral belief that a person should not be punished for bad thoughts, only for bad acts. Some people may believe that a prediction, so long as it is accurate, would be good enough to punish a would-be criminal because it would prevent a bad act that would otherwise occur. Others would morally require that a person not be punished until he has committed a crime, even if that means that an innocent individual may be hurt, because of the belief that a person should not be punished until he acts.

Despite the moral debate of whether a person is guilty until she acts, today's law accepts the need for and use of prediction tools to measure the future dangerousness of individuals. Since the late 19th century, the legal system has attempted to distinguish between "the innately criminal and those who acted merely by force of circumstance, whose crimes would not pose a future danger to society."[8] The concept of predicting future dangerousness has a

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6. *See* Antoine Bechara & Kelly Burns, *Decision Making and Free Will: A Neuroscience Perspective*, 25 BEHAV. SCI. & LAW 263, 263 (2007) ("[T]he idea of freedom of will on which our legal system is based is not supported by the neuroscience of decision making."); *see also* Stephen O'Hanlon, *Towards a More Reasonable Approach to Free Will in Criminal Law*, 7 CARDOZO PUB. LAW POL'Y & ETHICS J. 395, 395–96 (2009) (arguing that genetic and neuroscience research calls into question the "strong presumption of free will" underlying theoretical justifications for punishment); Matthew Jones, *Overcoming the Myth of Free Will in Criminal Law: The True Impact of the Genetics Revolution*, 52 DUKE L.J. 1031, 1039 (2003) (recent findings in the field of genetics "call into question the role that free, individual choice plays in the commission of crime").

7. MINORITY REPORT (Twentieth Century Fox 2002).

8. Erica Beecher-Monas & Edgar Garcia-Rill, *Genetic Predictions of Future Dangerousness: Is There a Blueprint for Violence?*, 69 DUKE J. L. & CONTEMPORARY PROBLEMS 301, 301 (2006).

large role in the criminal system today,[9] ranging from use in capital sentencing[10] to involuntary civil commitment for sexual predators.[11] Unlike determinations of responsibility, prediction does not require a theory of why or how a certain behavior correlates with a certain brain area or gene. Prediction is concerned with probabilities, so it is enough for the law's sake if a certain behavior—such as future dangerousness[12]—correlates with a certain biomarker (either a genetic or neural marker).[13] For this reason, I argue that biological sciences will soon be able to add to this area of prediction and increase its accuracy.

There are currently three main tools for making risk predictions in the legal context: (1) clinical predictions, (2) actuarial risk assessments, and (3) structured professional judgments. Risk assessment is defined as "[t]he process of using risk factors to estimate the likelihood (i.e., probability) of an outcome occurring in a population."[14] Clinical predictions, made by experts in psychiatry and psychology based on a subjective combination of variables, are most commonly used in criminal trials and are the most vigorously criticized.[15] Actuarial risk assessments are

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9. *See* Adina L. Roskies & Stephen J. Morse, *Neuroscience and the Law: Looking Forward*, *in* A PRIMER ON CRIMINAL LAW AND NEUROSCIENCE 240, 247 (Stephen J. Morse & Adina L. Roskies eds., 2013) ("The prediction of future behavior, especially recidivism and other dangerous behavior, plays a large role in sentencing and parole decisions, and it is a necessary element of involuntary civil commitment for sexual predators.").

10. *See, e.g.,* Jurek v. Texas, 428 U.S. 262, 269 (1976) (upholding the use of dangerousness as an aggravating factor in capital cases); *Barefoot v. Estelle*, 463 U.S. 880, 899 (1983) (allowing expert testimony from psychiatrists about the future dangerousness of a defendant in a capital case).

11. *See* Kansas v. Hendricks, 521 U.S. 346, 359-60 (1997) (stating that Kansas's Sexually Violent Predator Act requires a finding of future dangerousness and holding that the defendant's testimony about his lack of volitional control coupled with his criminal history confirmed a finding of future dangerousness).

12. *See* JAN VOLAVKA, NEUROBIOLOGY OF VIOLENCE 234 (1995) (defining dangerousness as a word that means "either that someone would commit a violent act or that he or she would be likely to do so under some conditions").

13. *See* Roskies, *supra* note 10, at 248 ("One potential virtue of predictive neuromarkers is that they can be empirically discovered without good conceptual understanding of why they are valid predictors.").

14. *See* John Monahan, *The Inclusion of Biological Risk Factors in Violence Risk Assessments*, *in* BIOPREDICTION, BIOMARKERS, AND BAD BEHAVIOR: SCIENTIFIC, LEGAL, AND ETHICAL CHALLENGES 57, 63 (Ilina Singh, Walter P. Sinnott-Armstrong, & Julian Savulescu, eds., 2014).

15. *See, e.g.*, John Monahan, *A Jurisprudence of Risk Assessment: Forecasting Harm Among Prisoners, Predators, and Patients*, 92 VA. L. REV. 391, 407 (2006) ("[O]f the patients predicted to be violent by the clinicians, one-

empirically based, using known risk factors as well as their interrelationships to generate an individual's risk level.[16] While actuarial risk assessments are generally regarded as the most reliable, they are still considered to be flawed.[17] Structured professional judgments are a combination of the former two tools, using a structured data set while allowing clinicians to consider their own professional experience in making a risk assessment. Structured professional judgments are about as reliable as actuarial risk assessments, but are not used as often as clinical predictions.[18] While some assessments are more reliable than others, all have been criticized as not being reliable enough to be used as the "basis for deprivations of life and liberty."[19] Courts and legislatures are aware of the unreliability of dangerousness predictions but continue to allow them to be used, even where there are stakes as high as the death penalty.[20]

Recent studies in neuroscience and genetics suggest that there are biomarkers that correlate with violent behavior.[21] If these biomarkers are proven to be more accurate in predicting future dangerousness than our current prediction tools, they should be used in the legal system to better determine those offenders who are truly dangerous while avoiding punishment of those who are unlikely to recidivate. Since the legal system has already decided

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in-two later committed a violent act, while of the patients predicted to be safe, one-in-three later committed a violent act.").

16. *See* Beecher-Monas, *supra* note 9, at 318.

17. *See id.* at 320 ("[Structured analyses have] many advantages in light of the difficulty people have in synthesizing differently weighted likelihoods of varying significance such as risk factors for violent behavior; but the actuarial instrument is only as effective as the risk factors used and the weight given them, making accurate prediction elusive in all but the highest of the risk categories.").

18. Michael H. Fogel, *Violence Risk Assessment Evaluation: Practices and Procedures*, *in* HANDBOOK OF VIOLENCE RISK ASSESSMENT AND TREATMENT: NEW APPROACHES FOR MENTAL HEALTH PROFESSIONALS 41, 55–56 (Joel T. Andrade, ed., 2009).

19. Beecher-Monas, *supra* note 9, at 317. *See also infra*, note 62 (various studies reporting 25-51% false positives for all three prediction tools); Roskies, *supra* note 10, at 174 ("Even the best-validated [prediction tools] applied to high-risk categories of offenders are only mildly accurate.").

20. *See* Beecher-Monas, *supra* note 9, at 302 ("Courts and legislatures are well aware of the unscientific nature of these predictions; nonetheless, they continue to demand them. . . . No one method is particularly predictive; but the general consensus is that such instruments are superior to clinical judgment alone.").

21. *See infra* Part III.

that using predictive tools is acceptable, "it is hard to imagine what a rational argument *against* increasing accuracy would be."[22]

This article argues that the use of biodata (biological, genetic, and neuroscientific evidence) will be able to improve our predictions of dangerousness in the near future and may, one day, provide a more accurate alternative to the current prediction scheme. Part I of this article provides an overview of where prediction is used in the law today and how these predictions are made. It then discusses the shortcomings of the current prediction scheme, so that the reader can understand why a new prediction scheme is necessary to ensure fairness in the judicial process. Part II gives a brief summary of the primary neuroimaging and genotyping techniques that could be used in the legal context to provide the reader with a background understanding of the science involved as well as the potential concerns of using such techniques. Part III then discusses the promising research that could be used to enhance, or perhaps even replace, the current prediction scheme. In order for this evidence to be admissible, it must pass the evidentiary requirements currently applied to scientific evidence discussed in Part III. Part IV argues that biodata would be accepted under these standards. Finally, Part V analyzes the costs and benefits associated with the use of biodata to predict future dangerousness, including constitutional concerns, financial costs, and moral questions. A conclusion follows, stating that biodata should soon be incorporated into the prediction scheme as an objective, more accurate risk factor that evidences an individual's likelihood to commit future violent acts.

II. PREDICTION IN THE LAW TODAY

Predictions of future dangerousness are used in a number of legal contexts, including civil commitments, sentencing, capital punishment, bail and parole hearings, and treatment determinations. However, current prediction tools rely on clinical judgments rather than objective measures, making them both "rudimentary and inaccurate."[23] Nonetheless, prediction tools are used often and across various areas in the law.

A. Where Predictions of Future Dangerousness Are Currently Used

1. Sentencing

22. Roskies, *supra* note 10, at 247.

23. *See* Beecher-Monas, *supra* note 9, at 305.

When determining the appropriate sentence, judges often consider a variety of evidence, including the defendant's psychological and neurological condition.[24] These considerations may either be used as mitigating factors or as evidence of dangerousness to extend the defendant's sentence.[25] In non-capital cases, most jurisdictions do not have guidelines for the judges on what types of scientific evidence should be mitigating versus aggravating.[26] In those cases, predictions of dangerousness can either be explicitly admitted or subconsciously considered.

2. Capital Punishment

The use of dangerousness in capital cases is a knife that can cut both ways—it can be used as both a mitigating and an aggravating factor.[27] Some courts have held that a defendant in a capital case is allowed to present any evidence that may be mitigating, even evidence that may otherwise be inadmissible.[28] Some states require consideration of future dangerousness in the capital context.[29] Even where consideration of future dangerousness is not required by statute, courts have encouraged defense attorneys to pursue as many mitigating circumstances as possible, including the question of whether a defendant will be dangerous if released.[30]

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24. Stephen J. Morse & William T. Newsome, *Criminal Responsibility, Criminal Competence, and Prediction of Criminal Behavior*, *in* A PRIMER ON CRIMINAL LAW AND NEUROSCIENCE 150, 157–58 (Stephen J. Morse & Adina L. Roskies eds., 2013).

25. *Id.*

26. *Id.*

27. *See Jurek*, 428 U.S. 262 (upholding the constitutionality of the use of dangerousness as an aggravating factor in capital cases); *cf. Lockett v. Ohio*, 438 U.S. 586, 604-605 (1978) (holding that in the sentencing phase of a capital case, the defendant has a constitutional right to present, as a mitigating factor, "any aspect of a defendant's character or record and any of the circumstances of the offense that the defendant proffers as a basis for a sentence less than death").

28. *See* Rupe v. Wood, 93 F.3d 1434, 1439-41 (9th Cir. 1996) (allowing the defendant to use otherwise inadmissible polygraph evidence).

29. TX. CODE CRIM. PROC. ANN. art. 37.071 (West 1996); VA. CODE ANN. § 19.2-264.2 (2004).

30. *See* Williams v. Taylor, 529 U.S. 362 (2000) (insisting that defense attorneys have a duty to explore the defendant's social, psychological, and cultural background to determine whether any mitigating factors exist).

3. Civil Commitment

Predictions of future dangerousness are used for civil commitment, including commitment under sex offender statutes.[31] Typically, civil commitment based on future dangerousness also requires something additional—such as a diagnosis of mental abnormality, overt acts, or even simple threats.[32] While a responsible person cannot be committed for dangerousness alone, someone who suffers from a mental abnormality and is predicted to be dangerous may be involuntarily committed even if she is deemed not responsible.[33] In practice, there is a low bar for dangerousness predictions in civil commitment proceedings.[34] Although civil commitment can potentially be indefinite and thus the stakes are high for defendants, the Supreme Court has reasoned that dangerousness predictions can be used in this context because "there is nothing inherently unattainable about a prediction of future criminal conduct."[35]

4. Parole and Bail Determinations

Societal and political concerns have led to strict policies regarding the need for pre-release psychological or psychiatric

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31. *See, e.g.*, KAN. STAT. ANN. § 59-29a02(a) (allowing the state to detain persons who are "likely to engage in repeat acts of sexual violence"). Although statutes vary in their definition of a sexual predator, all statutes require a finding of likelihood of future dangerousness before a sexual predator can be civilly committed. *See* Beecher-Monas, *supra* note 9, at 310.

32. *See Hendricks*, 521 U.S. 346 (Kansas statute allowing for mentally abnormal sexually violent predators to be committed if the state can demonstrate a sexual criminal charge or conviction, mental abnormality, and serious difficulty controlling behavior in addition to a prediction of future dangerousness); Lessard v. Schmidt, 349 F. Supp. 1078 (E.D. Wis. 1972) (stating that civil commitment can be justified where dangerousness is based upon a finding of a recent overt act, attempt or threat to do substantial harm to oneself or another).

33. *See* Morse, *supra* note 5, at 175.

34. *See* Monahan, *supra* note 15, at 59 (discussing an article for training mental health professionals on civil commitments where the standard of "substantial likelihood" was operationalized as "a 'one-in-four' estimated risk of serious harm in the near future is sufficient . . . 'substantial risk' is not meant to mean 'more likely than not (51%)'"). *See, e.g., Matter of Gregorovich*, 411 N.E.2d 981, 984 (Ill. App. Ct. 1980) (allowing civil commitment where a defendant was deemed to be dangerous based on a doctor's testimony that "there is a possibility she could harm someone").

35. *Hendricks*, 521 U.S. at 358 (citing *Schall v. Martin*, 467 U.S. 253, 278 (1984)).

evaluations.[36] Increasingly, mental health professionals are asked to make predictions about whether an offender is safe, to both the public and himself, to be released.[37] For example, as of 2010, the California Static Risk Assessment Instrument is administered for all prisoners convicted of nonviolent offenses in the state.[38] If a prisoner is determined not likely to reoffend, he is eligible to be placed into "non-revocable parole," which is defined as "a non-supervised version of parole where you do not report to a Parole Agent."[39] Under federal law, the government must determine that a prisoner's "release would not jeopardize the public welfare" before granting parole.[40] This necessity, to predict a parolee's effect on public safety, is also reflected in the parole release provisions of the states.[41]

5. Diversion Programs

Prediction is also used to determine whether an offender can be successfully rehabilitated in a diversion or treatment program. Courts of general jurisdiction have recently begun to divert offenders charged with nonviolent crimes to treatment programs in lieu of prison or as a component of the prison sentence.[42] Sentencing alternatives are premised on the idea that

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36. Ralph C. Serin, *Violent Recidivism in Criminal Psychopaths*, 20 L. & HUM. BEHAV. 207, 207 (1996).

37. *Id.*

38. *See* Susan Turner & Jesse Jannetta, *California Static Risk Assessment*, NAT'L INST. OF CORRECTIONS (Apr. 2, 2008), http://nicic.gov/Library/023641.

39. *See* Monahan, *supra* note 15, at 62.

40. *See* 28 C.F.R. § 2.18 (1998). Under the Comprehensive Crime Control Act of 1984, federal parole considerations apply only to persons who committed a federal offense before November 1, 1987. Pub. L. No. 98–473 98 Stat. 1976.

41. *See, e.g.*, ALA. CODE § 15-22-26 (1975) (allowing for release on parole only if "there is *reasonable probability* that, if such prisoner is released, he will live and remain at liberty without violating the law and that his release is not incompatible with the welfare of society") (emphasis added); COLO. CODE REGS. § 1511-6.01 (2013) (requiring a finding that "there is a *strong and reasonable probability* that the person will not thereafter violate the law" before granting parole) (emphasis added); D.C. CODE § 24-404 (2009) (parole may be authorized where "there is a *reasonable probability* that a prisoner will live and remain at liberty without violating the law.") (emphasis added).

42. *See* Morse, *supra* note 5, at 174. Although these programs currently exist for nonviolent crimes (e.g., drug-related offenses), in principle, programs could be created for violent offenders with some type of abnormality who are predicted to be successful in a rehabilitation program. *Id. See, e.g.,* MASS. GEN. LAWS ch. 276A, § 2 (2013) (giving district courts jurisdiction to divert any person who has been charged with a crime and meets certain criteria to a rehabilitative

"interventional behavioral treatments will reduce future illegal behavior in predictable ways and that those who may benefit from these interventions can be determined and selected from the general pool of offenders."[43] Thus, prediction is crucial in determining who will benefit from treatment and rehabilitation.

B. Existing Prediction Tools

There are currently three main categories of risk assessment tools psychiatrists and psychologists use to determine an offender's future dangerousness: (1) clinical predictions, (2) actuarial risk assessments, and (3) structured professional judgments. Although these existing prediction tools are not reliable enough to "meet criteria for valid science," the courts nonetheless use them because dangerousness predictions are necessary in criminal law [44] and there is currently no better way to make such predictions.

Clinical judgment (or unstructured professional judgment) is historically the instrument most commonly used by mental health professionals.[45] This tool is an "unstructured, intuitive decision-making process" that varies between mental health professions because of the vast discretion they have in determining which data to consider and how much weight to assign to that data.[46] Clinical judgment is generally regarded as unreliable,[47] but it is still often used by mental health professionals in the legal context.[48]

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program if the district court believes that person would benefit from participation in the program).

43. Steven K. Erickson, *Blaming the Brain*, 11 MINN. J. L. SCI. & TECH. 27, 70–71 (2010).

44. *See* Beecher-Monas, *supra* note 9, at 317 (stating that the courts and legislature require predictions of future dangerousness in some cases because of the "extraordinary public pressure on courts and legislatures to control crime").

45. Fogel, *supra* note 19, at 55.

46. *Id.*

47. *See* John Monahan, et al., RETHINKING RISK ASSESSMENT: THE MACARTHUR STUDY OF

MENTAL DISORDER AND VIOLENCE 5 (2001) ("[P]sychiatrists and psychologists are accurate in

no more than one out of three predictions of violent behavior over a several-year period among

institutionalized populations that had both committed violence in the past (and thus had high

base rates for it) and who were diagnosed as mentally ill.").

48. *See* Barefoot v. Estelle, 463 U.S. 880, 898-900, 916 (1983) (allowing clinical evidence from a psychiatrist about the future dangerousness of a defendant, over the dissent's argument that "such testimony is wrong two times out of three"). *See also* Patterson v. South Carolina, 471 U.S. 1036, 1042 (1985)

Actuarial risk assessment tools were developed as empirical measures in response to the known weaknesses of clinical judgment. These tools consider a number of risk factors that have been selected based on theory, experience, and a demonstrated association with violent behavior. Those risk factors are then combined according to an algorithm to yield a risk score.[49] Violent behavior is statistically correlated with specific factors in the subject's past behavior (e.g., a history of violence), circumstances (e.g., poverty or childhood abuse), attitudes towards other people (e.g., failure to form relationships), medical and psychiatric history (e.g., age when diagnosed with any problems or any brain injuries), and substance abuse (e.g., drugs or alcohol).[50] There is good evidence that actuarial instruments predict recidivism above chance levels.[51] Research shows that actuarial tools are better than clinical judgment when "an algorithmic formula and predictor variables are known, the algorithmic formula has been validated, and the sole purpose of the assessment is the accuracy of the prediction."[52] Although these methods are not substantially more predictive than clinical judgments, "the general consensus is that such instruments are superior to clinical judgment alone."[53] Criminal justice departments in some jurisdictions have begun using actuarial tools for risk assessment based on empirical research.[54]

(admitting into evidence "expert psychiatric predictions of future dangerousness even where the expert witness was testifying based on hypotheticals without ever having examined the defendant").

49. Fogel, *supra* note 19, at 56.

50. It is important to remember that these are factors associated with violence, not causes of violence. *See* Stephan F. Lanes, ERROR AND UNCERTAINTY IN CAUSAL INFERENCE, *in* CAUSAL INFERENCE 173, 182–85 (Kenneth J. Rothman ed. 1988).

51. *See* Min Yang, Stephen C. Wong & Jeremy Coid, *The Efficacy of Violence Prediction: A Meta-Analytic Comparison of Nine Risk Assessment Tools*, 136 PSYCHOLOGY BULLETIN 740 (2010) (reporting that all risk assessment tools analyzed predicted recidivism at about the same moderate level of efficacy).

52. *Id. See also* Mark. D. Cunningham & Thomas J. Reidy, *Don't Confuse Me With the Facts: Common Errors in Violence Risk Assessment at Capital Sentencing*, 26 CRIM. JUST. & BEHAV. 20, 28 (1999). But, if any of those three conditions are not met, the strengths of actuarial prediction disappear. Fogel, *supra* note 19, at 56.

53. Beecher-Monas, *supra* note 9, at 302.

54. For the Level of Service Inventory Revised: Screening version, *see* Don Andrews & James Bonta, Psychological Assessments and Services, Level of Service Inventory Revised, Multi-Health Systems, Inc., http://www.mhs.com/product.aspx?gr=saf&prod=1si-rs&id=overview (last visited

Structured professional judgment (SPJ) is a hybrid of actuarial and clinical predictions. This assessment tool provides a set of core risk factors to be considered in the overall assessment and directions on how these elements should be gathered. The mental health professional making the assessment may then use his or her clinical judgment to render the final decision about violence risk.[55] This assessment tool is regarded to be about as reliable as actuarial instruments.[56]

The most reliable risk assessment tool is the Hare Psychopathy Checklist (PCL-R).[57] The PCL-R yields ratings on

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Feb. 7, 2015) (available for use nationwide); for the California Static Risk Assessment, *see* Susan Turner & Jesse Jannetta, California Static Risk Assessment, Nat'l Inst. of Corrections (Apr. 2, 2009) http://nicic.gov/Library/023641 (used in California); and for the newer Classification of Violence Risk, *see* John Monahan et al., PAR, Inc., Classification of Violence risk, http://www4.parinc.com/Products/Product.aspx?ProductID=COVR (last visited Mar. 13, 2015) (available for use nationwide). *See also* Richard Berk et al., *Forecasting Murder Within a Population of Probationers and Parolees: A High Stakes Application of Statistical Learning*, 172 J. ROYAL STATISTICAL SOCIETY 191 (2009) (arguing that, based on a study conducted on prisoners in Philadelphia, a strictly actuarial approach would improve the accuracy of predictions of future violence acts).

55. Fogel, *supra* note 19, at 55–56. The most researched SPJ tool is the Historical/ Clinical Risk Management 20-item scale (HCR-20), which is intended for use with adult offender and psychiatric populations. It consists of twenty total risk factors: ten from the subject's history, five clinical factors, and five risk management factors. Erica Beecher-Monas & Edgar Garcia-Rill, *Danger at the Edge of Chaos: Predicting Violent Behavior in a Post-Daubert World*, 24 CARDOZO L. REV. 1845, 1876 (2003).

56. The statistical method of receiver operating characteristic (ROC) analysis asks the question: "if we randomly choose one person from the nonviolent group and one person from the violent group, what is the probability that the prediction method will assign a higher probability of violence to the actually violent person?" An overview of predictions made by actuarial instruments estimate the answer to this question is about 65–80% of the time. The estimate for structured professional judgments is similar, at about 66–78%. Douglas Mossman, *Evaluating Risk Assessments Using Receiver Operating Characteristic Analysis: Rationale, Advantages, Insights, and Limitations*, 31 BEHAV. SCI. L. 23 (2013).

57. *See* David DeMatteo & John F. Edens, *The Role and Relevance of the Psychopathy Checklist-Revised in Court*, 12 PSYCH. PUB. POL'Y & L. 214, 214 (2006) ("The Psychopathy Checklist-Revised . . . is the most empirically validated instrument for measuring psychopathy in correctional and forensic psychiatric populations."); John Monahan, *supra* note 45, at 71 ("[T]he Hare PCL:SV is a strong predictor of violence[...]; in fact, it was the strongest predictor of those tested in the [MacArthur] study.").

twenty scales based on behavioral traits and historical features.[58] A score of thirty or higher (out of forty) is considered to be indicative of psychopathy and is a reliable indicator of risk.[59] Although the factors seem to be subjective, the test's author argues that "the scoring criteria for each item . . . are explicit, and the meaning of an item (e.g., shallow affect) is based on these criteria, not on what the title of the item might mean to an individual clinician or researcher."[60]

C. Critiques of the Current Approach to Prediction

Mental health and legal professionals agree that current methods of prediction are unreliable, but the courts and legislatures continue to require and encourage these predictions in the legal context.[61] There is a lack of confidence in the ability of psychologists and psychiatrists to assess violence risk accurately using their unstructured clinical judgment.[62] Although predictions made using actuarial instruments are more accurate than clinical judgments, these predictions "are still tenuous bases for making important decisions such as sentencing a defendant to death or to indefinite commitment."[63] While actuarial instruments are more accurate than clinical predictions because they rely on objective rather than subjective factors, even the use of these supposedly

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58. *See* Jennifer L. Skeem et al., *Psychopathic Personality: Bridging the Gap Between Scientific Evidence and Public Policy*, 12 PSYCH. SCI. IN THE PUB. INTEREST 95, 100–101 (2011).

59. Robert Hare et al., *The Revised Psychopathy Checklist: Reliability and Factor Structure*, 2 PSYCHOLOGICAL ASSESSMENT: J. OF CONSULTING & CLINICAL PSYCH. 338 (1990). For a more in-depth discussion about the PCL-R, see generally, Stephen D. Hart, Robert D. Hare, & Adelle E. Forth, *Psychopathy as a Risk Marker for Violence: Development and Validation of a Screening Version of the Revised Psychopathy Checklist, in* VIOLENCE AND MENTAL DISORDER: DEVELOPMENTS IN RISK ASSESSMENT 81–100 (John Monahan & Henry J. Steadman eds., 1994).

60. Beecher-Monas, *supra* note 56, at 1874 (citing Robert D. Hare, *The Hare PCL-R: Some Issues Concerning its Use and Misuse*, 3 LEGAL & CRIM. PSYCH. 99, 109 (1998)).

61. *See* Beecher-Monas, *supra* note 9, at 302 (Both courts and legislatures are "well aware of the unscientific nature of these predictions; nonetheless, they continue to demand them.").

62. *See* John Monahan, *A Jurisprudence of Risk Assessment: Forecasting Harm Among Prisoners, Predators, and Patients*, 92 VA. L. REV. 391, 406–07 (2006). *See also id.* at 407 ("[O]f the patients predicted to be violent by the clinicians, one-in-two later committed a violent act, while of the patients predicted to be safe, one-in-three later committed a violent act.").

63. Beecher-Monas, *supra* note 9, at 321.

objective actuarial instruments is debated.[64] Studies of all three prediction tools report high false positive rates.[65] While the law requires prediction of future dangerousness, the tools we currently employ are not sufficiently accurate to be used for deprivations of life or liberty. If biobased evidence can make these predictions more accurate, it is hard to think of a reason not to use it.

III. INTRODUCTION TO BIOBASED EVIDENCE

A. Neuroscience Evidence

The earliest brain imaging technologies include computerized axial tomography (CAT) scans, positron emission tomography (PET) scans and electroencephalography (EEG) tests. The machine that produces CAT scans is a multidimensional, computer-assisted x-ray machine. CAT scans are not as precise as magnetic resonance imaging (MRI) scans, but they are less expensive and commonly used in hospitals to detect bleeding, swelling, and structural abnormalities in the brain. CAT scans have been used in the legal context as evidence of insanity or mental impairments. PET scans are used to look at brain function (rather than structure) by injecting a radioactive substance into the subject and measuring the location of this substance in a scanner to

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64. Some research confirms that experts often disagree on how to score an individual's risk level using actuarial instruments, not only when they are on different sides, but even when they are on the same side. *See* Marcus T. Boccaccini et al., *Do PCL-R Scores from State or Defense Experts Best Predict Future Misconduct Among Civilly Committed Sex Offenders?*, 36 L. HUM. BEHAV. 159 (2012). *But see generally* Peter B. Imrey & A. Philip Dawid, A Commentary on Statistical Assessment of Violence Recidivism Risk (Mar. 12, 2014) (unpublished manuscript) (on file with author), http://arxiv.org/pdf/1503.03666v1.pdf (analyzing critiques of actuarial risk assessment tools and arguing that the complaints should not prevent these tools from being used to predict recidivism).

65. *See* Vivenne de Vogel & Corinne de Ruiter, *Structured Professional Judgment of Violence Risk in Forensic Clinical Practice*, 12 PSYCH., CRIME & L. 321 (2006) (reporting a 36% false positive rate for those predicated to be "high risk" using structured professional judgment); John Monahan et al., *An Actuarial Model of Violence Risk Assessment for Persons with Mental Disorders*, 56 PSYCHIATRIC SERV. 810, 814 (2005) (51% using actuarial tool); Charles Lidz et al., *The Accuracy of Predictions of Violence to Others*, 269 J. AM. MED. ASS. 1007 (1993) (47% using clinical judgment); Jay Apperson et al., *Short-Term Clinical Prediction of Assaultive Behavior: Artifacts of Research Methods*, 150 AM. J. PSYCH. 1374 (1993) (25% using clinical judgment); Deidre Klassen & William O'Connor, *A Prospective Study of Predictors of Violence in Adult Male Mental Patients*, 12 L. & HUM. BEHAV. 143 (1988) (40% using actuarial tool).

determine the activity levels of different areas of the brain.[66] The most notable use of a CAT scan was in the case of John Hinckley's attempted assassination of President Reagan to show that Hinckley suffered tissue shrinkage in his brain.[67]

EEG measures the brain's electrical activity by attaching electrodes to the subject's head and then measuring the electrical currents generated by the brain. EEG is very good at measuring the timing of neural activity but is poor at determining the location of the activity. EEG is particularly useful for detecting certain neural conditions, such as epilepsy. It is also relatively inexpensive and easily portable.[68]

MRI technology was developed in the 1970s and is currently the most widely used neuroimaging technology.[69] MRI is capable of producing detailed images of the brain's structure (i.e., structural MRI) and measuring brain function (i.e., functional MRI or fMRI).

Structural MRI scans produce detailed images of the brain by detecting the density of hydrogen atoms in the brain. These brain scans can be used to study variations in the size and shape of brain features in subjects, as well as to detect brain abnormalities.[70] Before MRI existed, this type of information was only gathered after death in autopsies or through extensive neurosurgery.

Neuroimaging technology advanced even further in the late 1990s with the development of fMRI, allowing researchers to measure more than just brain structure.[71] Today, fMRI is arguably the most promising neuroimaging technique for understanding brain function.[72] fMRI does not directly measure brain activity;

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66. Henry T. Greely & Anthony D. Wagner, *Reference Guide on Neuroscience, in* REFERENCE MANUAL ON SCI. EVIDENCE 747, 763-66 (3d ed. 2011).

67. *Id.* at 762–73.

68. *Id.* at 772–73.

69. *Id.* at 766.

70. *Magnetic Resonance Imaging (MRI) of the Spine and Brain*, Johns Hopkins Medicine Health Library, http://www.hopkinsmedicine.org/healthlibrary/test_procedures/orthopaedic/magnetic_resonance_imaging_mri_of_the_spine_and_brain_92,P07651/ (last accessed Feb. 17, 2017) (explaining that MRI can be used to examine the anatomy of the brain and diagnose abnormal conditions such as tumors, aneurisms, and degenerative diseases like multiple sclerosis).

71. Brett Walker, *When the Facts and the Law Are Against You, Argue the Genes?: A Pragmatic Analysis of Genotyping Mitigation Defenses for Psychopathic Defendants in Death Penalty Cases*, 90 WASH. U. L. REV. 1779, 1792 (2013).

72. For an excellent discussion about functional neuroimaging and its limits, *see* Geoffrey K. Aguirre, *Functional Neuroimaging: Technical, Logical,*

rather, it uses the blood oxygen level dependent (BOLD) response to measure how blood flow changes in response to brain activity.[73] To make this measurement, the fMRI machine uses a magnet to detect the magnetic release from concentrations of oxygenated and deoxygenated blood in brain tissue.[74] The BOLD measurement allows the researcher to infer patterns of brain activity by measuring what regions of the brain are more or less active in response to particular stimuli or performance of a particular task.[75] The researchers then randomly assign colors to indicate the result of the test.[76] Generally, the brighter the color is, the greater the statistical significance of the differences in brain activity between two conditions. Critically though, there is "no inherent meaning to the color on an fMRI brain image."[77]

While researchers are able to infer brain activity from these blood flow measurements, it is important to understand that blood flow and oxygenation are not the same as brain activity. Currently, it is unknown whether blood flow correlates exactly with neural activity.[78] However, the medical community has deemed it acceptable to use blood flow and oxygenation as a proxy for brain activity even though the nature of the cause-and-effect relationship

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and Social Perspective, Special Report: Interpreting Neuroimages: An Introduction to the Technology and its Limits, 45 HASTINGS CTR. REPORT 2 (2014). For more discussion of structural and functional MRI, *see* Greely, *supra* note 64, at 766–72. *See also generally* Erin D. Bigler, Mark Allen and Gary K. Stimac, *MRI and Functional MRI, in* NEUROIMAGING IN FORENSIC PSYCHIATRY: FROM THE CLINIC TO THE COURTROOM 27-40 (Joseph R. Simpson, ed. 2012).

73. It is critical to understand that fMRI does not produce actual images of the brain. The presentation of fMRI images, showing colorful markers indicating brain activity, could be, but should not be, interpreted as actual pictures of the brain. Rather than revealing an innate state of the brain, these images actually show activity in the brain under a particular set of experimental circumstances. *See* Aguirre, *supra* note 73, at 12; *see also id.* at 5–6 (discussing the multiple steps that are required to translate the initial brain activity recorded in an fMRI scan into "the final, polished result").

74. *See* Walker, *supra* note 72, at 1792–93.

75. Greely, *supra* note 67, at 770.

76. Where fMRI images are used as evidence, a court must emphasize that the color-coding is arbitrary. While some critics argue that this makes the colored images inherently deceptive, others accept that color-coding is necessary and legitimate in biological sciences. *See* Martha J. Farah, *Brain Images, Babies, and Bathwater: Critiquing Critiques of Functional Neuroimaging*, *Special Report: Interpreting Neuroimages: An Introduction to the Technology and its Limits*, 45 HASTINGS CTR. REPORT S19, S21 (2014).

77. *See* Owen D. Jones et al., *Brain Imaging for Legal Thinkers: A Guide for the Perplexed*, 2009 STAN. TECH. L. REV. 5, at ¶ 34.

78. *See* Farah, *supra* note 77, at S20.

is not yet clear.[79] Although there are reasonable critiques of functional neuroimaging, it is subject to "the self-correcting process of science" and is currently the best measurement of brain activity available in both science and law.[80]

B. Genetics Evidence

In addition to neuroimaging, genotyping is another type of biobased evidence that seeks to explain human behavior by discovering associations between genes and behavior. Genotyping is the process of determining "all or part of the genetic constitution of an individual or group."[81] It is generally agreed that genes influence behavior, despite the fact that the mechanism behind this influence is currently unknown.[82] Genotyping research has focused on isolating specific genes related to an individual's predisposition to certain conduct, such as violence.[83] Behavioral genetics research seeks to discover associations between behavioral tendencies and genetic differences.[84] The studies that are currently most relevant to predictions of future dangerousness are those of gene-by-environment interactions (G x E).[85] These studies seek to explain

79. *See id.*

80. *See id.* at S28 ("None of the criticisms . . . constitute reasons to reject or even drastically curtail the use of neuroimaging."); *see also* Jones, *supra* note 74, at ¶¶ 29–42 (reviewing the "key concepts about brain imaging that legal thinkers should know").

81. Merriam-Webster, *Genotype*, http://www.merriam-webster.com/dictionary/genotype.

82. *See* Richard P. Ebstein et al., *Behavioral Genetics, Genomics, and Personality*, *in* BEHAVIORAL GENETICS IN THE POSTGENOMIC ERA 365, 380 (Robert Plomin, John C. Defries, Ian W. Craig, & Peter McGuffin eds., 2003) ("[T]he importance of genetic factors in determining human temperament has been recognized for two decades."); Patrick Bateson, *The Corpse of a Wearisome Debate*, 297 SCIENCE 2212, 2212 (2002) (reviewing STEPHEN PINKER, THE BLANK SLATE: THE MODERN DENIAL OF HUMAN NATURE (2002)) ("[T]he center of th[e] academic debate is not about whether genes influence behavior but rather how they do so.").

83. *See* D.H. Kaye, *Behavioral Genetics Research and Criminal DNA Databases*, 69 L. & CONTEMP. PROBS. 259, 264–68 (2006) (discussing genetic studies of gene isolation and the influence those genes have on behavior).

84. See Jonathan Kaplan, *Misinformation, Misrepresentation, and Misuse of Human Behavioral Genetics Research*, *in* THE IMPACT OF BEHAVIORAL SCIENCES ON CRIMINAL LAW 45, 46 (Nita A. Farahany ed., 2009).

85. Laramie E. Duncan et al., *A Critical Review of the First 10 Years of Candidate Gene-by-Environment Interaction Research in Psychiatry*, 168 AM. J. PSYCHIATRY 1041 (2011) ("Gene-by-environment interactions (G x Es) occur when the effect of the environment depends on a person's genotype or,

the relationship between a person's genotype and a specific measured environment.[86] Although these interactions were ignored and assumed to be trivial in the past, current research suggests that G x E interactions are common and should be researched more extensively to gain a better understanding of how our genes interact with our environment and vice versa.[87]

G x E studies are relatively new to the biological field and have garnered some criticism for their early results.[88] Genotyping, like neuroimaging, is currently unable to confirm that a certain genetic predisposition causes a certain behavior. Both types of evidence are only able to show a correlation between a biomarker and behavior.[89] However, genotyping evidence is more advantageous than neuroscience in one important respect—genetics can explain permanent conditions, whereas neuroscience is only able to explain brain structure or activity at the time of testing.[90] Because genotypic evidence and neuroscience evidence provide different types of information, an attorney may decide to employ both to strengthen his or her case.[91]

C. Cases Where Biobased Evidence Has Already Been Used

There are already a number of cases where biobased evidence has been used as a mitigating factor. *People v. Weinstein*, a New York state case, involved a sixty-four-year-old accounting

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equivalently, when the effect of a person's genotype depends on the environment.").

86. *See* Terrie E. Moffitt, Avshalom Caspi & Michael Rutter, *Measured Gene-Environment Interactions in Psychopathology: Concepts, Research Strategies, and Implications for Research, Intervention, and Public Understanding of Genetics*, 1 PERSPECTIVES ON PSYCH. SCI., no. 1, 2006, at 5, 6.

87. *See id.* at 7 ("It is reasonable to suggest that wherever there is variation among humans' psychological reactions to the major environment pathogens for mental disorders, G x E must be expected to operate to some degree.").

88. One research group analyzed the results from all 103 published studies in the first decade of G x E studies (2000–2009) and concluded that because of publication bias, replication studies should be regarded more highly than novel G x E studies. *See* Duncan, *supra* note 86, at 1047 ("Almost all novel results are positive, compared with less than one-third of replication attempts.").

89. Walker, *supra* note 72, at 1798–99.

90. *Id.*

91. Some researchers are pushing to join the fields of genetics and neuroscience because the fields are complimentary and because replication attempts in G x E studies have often failed and progress has been slow. *See generally* Avshalom Caspi & Terrie E. Moffitt, *Gene-Environment Interactions in Psychiatry: Joining Forces with Neuroscience*, 7 NATURE REVS.: NEUROSCIENCE 583 (2006).

executive with no prior history of violence or criminal acts.[92] One day, during a marital argument, the defendant snapped and strangled his wife, then threw her out of their twelfth-story window to make the incident look like a suicide.[93] The defendant pleaded insanity, using neuroimaging evidence that he had a subarachnoid cyst and claiming that it impaired his brain functioning. His attorney argued that because of the cyst, the defendant "lacked substantial capacity to appreciate the criminality of his actions."[94] Although the case was ultimately resolved before trial, the judge ruled that the neuroimaging evidence was admissible.[95] In *Weinstein*, it was not clear (and probably unlikely given his otherwise normal behavior) whether the cyst directly *caused* the defendant's violent behavior; we only know that the cyst existed at the time of the violent behavior. Despite this lack of a causal connection, the judge was still willing to consider this evidence at trial.

It is a rare case where a biological deficiency can be said to have *caused* a specific behavior. The case of Mr. Oft is one such case.[96] In his forties, Mr. Oft suddenly and uncharacteristically developed pedophilic desires. He was convicted of child molestation and, the evening before his prison sentencing, he went to the hospital with complaints of a headache. An MRI showed that Mr. Oft had a large tumor in his orbitofrontal cortex, an area of the brain associated with impulse control problems and antisocial behavior. Once the tumor was removed, so were Mr. Oft's pedophilic urges. Mr. Oft then successfully completed the outpatient treatment program ordered by the judge and he went back to living a normal life—until a year later, when both the tumor and his urges came back. Again, the tumor was removed and the desires went away. This strong correlation between Mr. Oft's sexually violent behavior and his brain disorder "might elicit sympathy" and "suggest[] that a medical rather than punitive response might be cost-benefit justified."[97] It appears that the judge was sympathetic to Mr. Oft's brain abnormality because the judge

92. People v. Weinstein, 591 N.Y.S.2d 715 (Sup. Ct. 1992).

93. *Id.* at 717.

94. Stephen Morse, *Brain and Blame*, 84 GEO. L.J. 527, 539 (1996).

95. *Weinstein*, 591 N.Y.S.2d at 724, 726.

96. This case was first reported in Jeffrey M. Burns & Russell H. Swerdlow, *Right Orbitofrontal Tumor with Pedophilia Symptom and Constructional Apraxia Sign*, 60 ARCH. NEUROL. 437 (2003).

97. Stephen J. Morse, *Lost in Translation? An Essay on Law and Neuroscience*, *in* L. & NEUROSCIENCE, 13 CURRENT LEGAL ISSUES 529, 559–62 (Michael Freeman ed., 2010).

sentenced him to treatment instead of prison time. It is therefore likely that the neuroimaging evidence would have been admitted had there been a trial.

Other cases have used neuroimaging evidence as convergent evidence to behavioral tests. In 2009, for instance, Brian Dugan pleaded guilty to the rape and murder of a ten-year-old girl in Illinois.[98] The defense used evidence, both behavioral and neuroimaging, in an attempt to show that Dugan is a "psychopath and could not control his killer impulses."[99] He scored a 38.5 out of 40 on the PCL-R compared to a score of four or five by the average male.[100] The court also allowed the defense to present its expert witness, neuroscientist and psychopathy expert Kent A. Kiehl, to testify about the defendant's fMRI scans and his interpretation of the scans, even though the scans themselves were inadmissible.[101] Although the jury ultimately sentenced Dugan to death, Kiehl's testimony turned the case "from a slam dunk for the prosecution into a much tougher case."[102]

Other courts have allowed for the introduction of G x E interactions in capital cases in recent years.[103] In *Tennessee v. Waldroup*,[104] the defendant was charged with the brutal murder of his estranged wife's friend. The defense presented evidence of the defendant's propensity for violence because of a genetic defect and childhood abuse.[105] Specifically, the defendant was diagnosed with

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98. Barbara Bradley Hagerty, *Inside a Psychopath's Brain: The Sentencing Debate*, NPR (June 30, 2010), http://www.npr.org/templates/story/story.php?storyId=128116806.

99. Virginia Hughes, *Head Case*, 464 NATURE 340, 340 (2010).

100. *See* Hagerty, *supra* note 99. For more information on the PCL-R, *see infra*, notes 55–57 and accompanying text.

101. Hughes, *supra* note 100, at 341.

102. *See id.* at 342. *See also* Hagerty, *supra* note 99 ("The jury seemed to zero in on the science, asking to reread all the testimony about the neuroscience during 10 hours of deliberation. But in the end, they sentenced Dugan to death.").

103. The admission of G x E evidence was a recent development, dependent upon the scientific acceptance of the research. The Georgia Supreme Court in 1995 denied one defendant's request to get tested for low Monoamine Oxidase A (MAOA) activity because the testing had not yet reached the level of scientific certainty required to be admissible at trial. Mobley v. State, 455 S.E.2d 61, 65–66 (Ga. 1995).

104. This case was highly publicized but unreported. *See* Walker, *supra* note 72, at 1800–801; Barbara Bradley Hagerty, *Can Your Genes Make You Murder?,* NPR (July 1, 2010), http://www.npr.org/templates/story/story.php?storyId=128043329.

105. *See* Hagerty, *supra* note 99.

the low Monoamine Oxidase A (MAOA) activity genotype.[106] The jury apparently placed considerable weight on this genetic evidence, ultimately convicting the defendant of voluntary manslaughter instead of murder.[107] One juror said that "the science helped persuade her that Waldroup was not entirely in control of his actions," reasoning that "[a] diagnosis is a diagnosis, . . . [a] bad gene is a bad gene."[108]

In another case of genotyping evidence, a defendant charged with first-degree murder introduced evidence of his low serotonin levels[109] to establish a diminished capacity defense.[110] The jury ultimately found him guilty of second-degree murder instead of first-degree murder, and it is possible that the jury relied on this evidence to mitigate the defendant's charge. This case further suggests that the introduction of genotyping defense evidence has the ability to assist defendants in capital cases.[111]

Taken together, these cases suggest that courts are becoming more open to the idea of admitting biological evidence where it could have some bearing on an element of the case against the defendant.[112] In cases involving the death penalty, such

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106. *See infra* Part III.B.1 for a discussion of this G x E interaction.

107. *See* Walker, *supra* note 72, at 1800-801.

108. *See* Hagerty, *supra* note 99.

109. Serotonin is a neurotransmitter associated with mood and aggression in humans. There is a gene, SLC6A4, discussed *infra*, part III.B.2, that is believed to be part of a G x E interaction that is linked to a higher incidence of violence.

110. *See* Tennessee v. Godsey, No. E2000-01944-CCA-R3-CD, 2001 WL 1543474, at *3 (Tenn. Crim. App. Dec. 4, 2001); *see also* Walker, *supra* note 72, at 1801–802.

111. *Id.* Although *Godsey* only introduced evidence of low serotonin levels and not evidence of a G x E interaction, this case suggests that the introduction of SLC6A4 evidence may be helpful for defendants in criminal cases.

112. In addition to those cases discussed, there are a number of other cases where the defense has offered brain images as evidence. *See, e.g.,* People v. Goldstein, 786 N.Y.S.2d 428, 432 (Sup. Ct. 2004), *overruled on other grounds*, 6 N.Y.3d 119 (2005) (defendant sought to introduce evidence of a brain abnormality in support of an insanity defense after he pushed a woman in front of a subway train.); Coe v. State, 17 S.W.3d 193, 200–201 (Tenn. 2000) (allowing psychiatrist expert to introduce brain images to show that convicted murderer was not competent to be executed). Other cases have sought to argue that defense counsel's failure to procure neuroimaging evidence should be considered ineffective assistance of counsel. *See* People v. Morgan, 719 N.E.2d 681, 710 (Ill. 1999) (concluding that defendant received ineffective assistance because the evidence regarding his severe organic brain damage may have provided the court with information which would have influenced the sentence imposed); *cf.* Ferrell v. State, 918 So.2d 163 (Fla. 2005) (denying defendant's

as the case of Brian Dugan, the defense "may present just about anything as a mitigating factor, from accounts of the defendant being abused as a child to evidence of extreme emotional disturbance."[113] In addition, by allowing the defense to present this type of evidence as a mitigating factor, future courts may allow the prosecution to present evidence showing a natural propensity for violence as an aggravating factor.[114]

IV. POTENTIAL FOR BIOBASED EVIDENCE IN PREDICTION

Using biobased evidence to predict future dangerousness would work by establishing correlations between a certain brain activity or structure, or a gene, and a certain behavior.[115] This section discusses brain regions and genes that could potentially be used in dangerousness predictions in the near future, and provides suggestions for future research on other potential biomarkers.

A. Promising Neuroimaging Evidence for Bioprediction

1. Amygdala Damage or Abnormal Activity

The amygdala is part of the limbic system and is associated with emotional regulation. People with damage to the amygdala show disengagement and a lack of empathy.[116] Because of this

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claim of ineffective assistance of counsel because brain scans were not necessary to corroborate the existing diagnosis provided by his neuropsychologist expert).

113. Hughes, *supra* note 100, at 340.

114. *See infra* notes 236–42 and accompanying text. It is important to note that the same data that suggest that a defendant suffered from a rationality problem at the time of the criminal offense may also suggest that the defendant is likely to behave dangerously in the future. "Thus, neurodata is a knife that may cut both ways." Roskies, *supra* note 7, at 173.

115. *See* Kasper Lippert-Rasmussen, *Neuroprediction, Truth-Sensitivity, and the Law*, 18 J. ETHICS 123, 129 (2014) ("At a very abstract level, neuroprediction of dangerousness works by establishing correlations between how the brain works or is structured, on the one hand, and certain kinds of dangerous criminal behavior or disorders such as psychopathy which in turn is strongly correlated with such behavior . . . on the other.").

116. *See* Niehoff, *supra* note 3, at 238. *See also* Andrea L. Glenn & Adrian Raine, *Neurocriminology: Implications For the Punishment, Prediction and Prevention of Criminal Behavior,* 15 NATURE REVIEWS NEUROSCIENCE 54, 56 (2014) (noting that patients with amygdala damage "have a reduced sense of danger, are less fearful and have deficits in the recognition of fearful facial expressions (a process involved in experiencing empathy")); Yaling Yang et al., *Localization of Deformations Within the Amygdala in Individuals with Psychopathy,* 66 ARCH. GEN. PSYCHIATRY 986, 990 (2009) (reporting that

effect, the authors of a recent study hypothesized that amygdala volume may be a useful biomarker for identifying individuals at risk for exhibiting early and persistent aggression.[117] Study participants were selected from a longitudinal study of about five hundred male subjects who were initially recruited in the first grade.[118] Ultimately, a subsample of fifty-six men was recruited for this neuroimaging study at age twenty-six.[119] The researchers used structural MRI scans to analyze amygdala volume in these subjects, first at age twenty-six, and again at age twenty-nine.[120] Lower amygdala volume was significantly associated with measures of aggression and psychopathic features collected in childhood and adolescence.[121] This is the first longitudinal study to show that adult men with lower amygdala volume were at increased risk for future aggression, violence, and psychopathic personality traits – even after controlling for earlier recorded levels of these features and potential confounds (e.g., race, IQ, total intracranial volume).[122] Since this is the first study to show that amygdala volume might be a significant risk factor for future violent behavior, future research must examine its shortcomings before it is used for prediction in law. As with all scientific research, there must be successful replication studies with larger sample sizes. Additionally, because various socio-contextual factors influence the development of antisocial behavior, further studies should investigate the relative influence that amygdala abnormalities play in the emergence of criminal behavior.[123]

2. Anterior Cingulate Cortex (ACC) Damage or Low Activity

The ACC is a region of the brain associated with error processing, conflict monitoring, response selection, and avoidance

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subjects with psychopathy showed significant bilateral volume reductions in the amygdala compared with controls (left, 17.1%; right, 18.9%)).

117. Dustin A. Pardini et al., *Lower Amygdala Volume in Men is Associated with Childhood Aggression, Early Psychopathic Traits, and Future Violence*, 75 BIOLOGICAL PSYCHIATRY 73 (2014).

118. *Id.* at 74.

119. *Id.* This subset included twenty men with a history of chronic serious violence, sixteen men with a history of transient serious violence, and twenty men with no history of violence.

120. *Id.* at 77.

121. *Id.*

122. *Id.* at 75, 78.

123. *Id.* at 79.

learning.[124] Damage to this area in humans has been observed to produce changes in disinhibition, apathy, and aggressiveness.[125] Scientists consider patients with ACC damage to have an "acquired psychopathic personality."[126] One recent study tested the hypothesis that ACC activity would correlate with future antisocial behavior (i.e., rearrest) in a study of released criminal offenders.[127] This fMRI study demonstrated that decreased activity in the ACC during a go/no-go test[128] correlated with a higher probability of rearrest.[129] Offenders with low ACC activity were about twice as likely to be rearrested as compared to offenders with high ACC activity.[130] The ACC region showed incremental predictive validity independent of other known risk factors and the go/no-go commission error rate, suggesting that ACC activity may have a predictive advantage over some behavioral and personality risk factors.[131] Not only does this study have implications for predictions made at trial and commitment, but it could also be used for treatment intervention.[132] The authors of the study hypothesize that treatments that modulate ACC activity may help enhance cognitive control systems and thus reduce future recidivism.[133] While this study is promising for the potential of biological evidence in predictions, the authors acknowledge that their results must first survive particular sensitivity and specificity

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124. Eyal Aharoni, et al., *Neuroprediction of Future Rearrest*, 110 PNAS 6223, 6223 (2013); Glenn & Raine, *supra* note 117, at 56; Kent A. Kiehl, Peter F. Liddle & Joseph B. Hopfinger, *Error Processing and the Rostral Anterior Cingulate: An Event-Related fMRI Study*, 37 PSYCHOPHYSIOLOGY 216, 220 (2000) (reporting that the rostral anterior cingulate is involved in the brain's error checking system).

125. *See* Aharoni, *supra* note 125, at 6223.

126. *Id.*

127. *Id.*

128. The go/no-go task is commonly used to measure behavioral impulsivity. This task presents participants with a frequently occurring target (e.g., the letter "X") interleaved with a less-frequent distractor (e.g., the letter "K") on a computer screen. Participants are told to press a button whenever they see the target ("go" stimulus) and not when they see the distractor ("no-go" stimulus). Because the target is shown more frequently than the distractor, participants develop a dominant response towards the target. When a distractor is shown, participants are required to inhibit their response. This task requires the ability to monitor conflicts and to selectively inhibit the prepotent go response on cue. *Id.* at 6225.

129. This study predicted subsequent rearrest within four years. *Id.* at 6223.

130. *Id.*

131. *Id.* at 6224.

132. *Id.*

133. *Id.*

thresholds with the use of large random samples.[134] Until this study is successfully replicated, it represents only a step towards the use of biomarkers in prediction.

3. Frontal Lobe Damage or Abnormal Activity

Abnormal brain function in the frontal lobe of the brain is "to date the best-replicated brain imaging correlate of antisocial and violent behavior."[135] The prefrontal cortex is thought to be responsible for executive control—to process brain activity when "behavior must be guided by internal states or intentions."[136] Various neurological studies strongly suggest that there is a relationship between brain injury to the prefrontal cortex and abnormal behavior. Studies of war veterans provide a helpful example. A study that analyzed aggression in war veterans found higher levels of aggression in veterans who experienced injuries localized to the ventral prefrontal cortex as compared to those who had not.[137] Further, patients who have suffered an injury to the ventral prefrontal cortex demonstrate poor decision-making, reduced autonomic reactivity to socially meaningful stimuli, and psychopathic-like behavior.[138] Yet another study predicted whether a person had antisocial personality disorder by analyzing the prefrontal gray matter volume in subjects.[139] A meta-analysis of

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134. *Id.* One critic of this neuroprediction study agrees that the Aharoni study must be further analyzed and replicated. Russ Poldrak used the data from Aharoni and examined its ability to predict rearrest on out-of-sample data using cross validation. His analysis showed that there is a slight benefit to using ACC activation to predict future rearrest in the out-of-sample population. However, the effect was "exceedingly small," and it is unknown whether there are other unmeasured demographic or behavioral measures that might provide similar predictive power. *See* Russ Poldrack, *How Well Can We Predict Future Criminal Acts from fMRI Data?*, RUSSPOLDRACK.ORG (April 6, 2013), http://www.russpoldrack.org/2013/04/how-well-can-we-predict-future-criminal.html.

135. Glenn & Raine, *supra* note 117, at 56.

136. Earl K. Miller & Jonathan D. Cohen, *An Integrative Theory of Prefrontal Cortex Function*, 24 ANN. REV. NEUROSCIENCE 167, 168 (2001).

137. *See* Jordan Grafman et al., *Frontal Lobe Injuries, Violence, and Aggression: A Report of the Vietnam Head Injury Study*, 46 NEUROLOGY 1231 (1996) (reporting study results that confirm the hypothesis that ventromedial frontal lobe lesions increase the risk of aggressive and violent behavior).

138. Glenn & Raine, *supra* note 117, at 56 (citing ANTONIO R. DAMASIO, DESCARTES' ERROR: EMOTION, REASON, AND THE HUMAN BRAIN (1994).

139. *See* Adrian Raine, et al., *Reduced Prefrontal Gray Matter Volume and Reduced Autonomic Activity in Antisocial Personality Disorder*, 57 ARCH. GEN. PSYCHIATRY 119, 123 (2000) (concluding that subjects with antisocial personality

forty-three independent studies all evaluating the relationship between prefrontal impairment and antisocial behavior demonstrated that this behavior is significantly associated with reduced prefrontal structure and function.[140] Other studies propose that the prefrontal cortex is critical to behaviors that are implicated in aggression, such as self-control,[141] behavioral flexibility,[142] and decision-making.[143] Future research should further explore this area of the brain to determine whether there is a predictive quality of the already known relationship between the prefrontal cortex and antisocial behavior.

B. Promising Genotyping Evidence for Bioprediction

1. Monoamine Oxidase A (MAOA) Gene

The interplay between genetic predispositions and environmental factors employs an interdisciplinary model for explaining, and even predicting, antisocial and violent behavior. In 2002, a research team in New Zealand published a study proposing a mechanism through which a person's genes and childhood experience might combine through a G x E interaction to increase an individual's risk of becoming violent or expressing

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disorder showed, on average, an eleven percent reduction in prefrontal gray matter).

140. Yaling Yang & Adrian Raine, *Prefrontal Structural and Functional Brain Imaging Findings in Antisocial, Violent, and Psychopathic Individuals: A Meta-Analysis*, 174 PSYCHIATRY RESEARCH 81, 86 (2009).

141. *See* Todd A. Hare et al., *Self-Control in Decision-Making Involves Modulation of the vmPFC Valuation System*, 324 SCIENCE 646 (2009) (suggesting that the ventromedial prefrontal cortex plays a critical role in the deployment of self-control); Jessica R. Cohen & Matthew D. Lieberman, *The Common Neural Basis of Exerting Self-Control in Multiple Domains*, in SELF CONTROL IN SOCIETY, MIND, AND BRAIN 141 (Ran Hassin, Kevin Ochsner, & Yaacov Trope eds., 2010) (reporting that the right ventrolateral prefrontal cortex is commonly activated in fMRI studies when people are exerting various forms of self-control).

142. *See generally* Michael E. Ragozzino, *The Contribution of the Medial Prefrontal Cortex, Orbitofrontal Cortex, and Dorsomedial Striatum to Behavioral Flexibility*, 1121 ANN. N.Y. ACAD. SCI. 355 (2007) (finding that the prefrontal cortex is implicated in behavioral flexibility, which refers to the ability to shift strategies or response patterns with a change in the environment).

143. *See* Antoine Bechara, *The Role of Emotion in Decision-Making: Evidence from Neurological Patients with Orbitofrontal Damage*, 55 BRAIN & COGNITION 30, 39 (2004) (reporting that damage to the orbitofrontal cortex creates deficits in mechanisms of decision-making and impulse control).

antisocial personality traits as an adult.[144] The authors hypothesized that an individual's genetic makeup might affect his or her vulnerability to maltreatment as a child.[145] The MAOA gene was selected for analysis because an earlier study had identified a mutation of the MAOA gene in a Dutch family that had a history of violence in the male members.[146] The MAOA gene regulates many of the brain's key neurotransmitters, such as serotonin and dopamine,[147] and the mutation in the Dutch family was linked to antisocial behavior in the family's males.[148] The authors concluded that individuals with a particular allele of the MAOA gene and a history of serious childhood maltreatment were more likely than males without the G x E interaction to exhibit violent and antisocial behavior as adults.[149] The study reported that males with a history of childhood violence and the low-MAOA activity genotype were more likely than non-maltreated males with the same genotype to be convicted of a violent crime by a significant odds ratio.[150]

Caspi's findings have been replicated,[151] with at least one replication conducted on actual violent offenders.[152] This

144. Avshalom Caspi, et al., *Role of Genotype in the Cycle of Violence in Maltreated Children*, 297 SCIENCE 851 (2002).

145. *Id.* at 852.

146. *Id.* at 851. *See also* Kaye, *supra* note 84, at 265 (summarizing the findings about the Dutch family).

147. Walker, *supra* note 72, at 1795.

148. *See* Kaye, *supra* note 84, at 265 (describing the criminal acts committed by the Dutch family, including assault and arson).

149. Caspi, *supra* note 145, at 853. However, it is not novel to believe that childhood maltreatment would have negative effects in adulthood. Thus, this G x E discovery provides convergent evidence to what is already known behaviorally. *See* Cathy Spatz Widom, *Child Abuse, Neglect and Violent Criminal Behavior*, in CURRENT APPROACHES TO THE PREDICTION OF VIOLENCE, 123–143 (David A. Brizer & Marther Crowner eds., 1989) (reviewing research exploring the link between childhood abuse and violent criminal behavior as an adult).

150. Caspi, *supra* note 145, at 853. *See also* Matthew Baum & Julian Savulescu, *Behavioral Biomarkers: What Are They Good For?*, in BIOPREDICTION, BIOMARKERS, AND BAD BEHAVIOR: SCIENTIFIC, LEGAL, AND ETHICAL CHALLENGES 12, 18 (Ilina Singh, Walter P. Sinnott-Armstrong, & Julian Savulescu eds., 2014) ("While only 12 percent of the boys possessed the MAOA-L genotype AND were maltreated . . ., this small group was responsible for 44 percent of convictions for violent crime.").

151. For successful replications of the Caspi study, *see* Debra L. Foley et al., *Childhood Adversity, Monoamine Oxidase A Genotype, and Risk for Conduct Disorder*, 61 ARCH. GEN. PSYCHIATRY 738 (2004); Yung-yu Huang et al., *An Association Between a Functional Polymorphism in the Monoamine Oxidase A Gene Promoter, Impulsive Traits and Early Abuse Experiences*, 29

replication examined low MAOA activity in violent offenders facing murder charges in Tennessee and confirmed that some of the offenders matched the G x E interaction studied in Caspi.[153] Many now accept that there is a G x E interaction between the MAOA gene and childhood maltreatment, consistent with Caspi's research from 2002.[154]

2. Serotonin Transporter (SLC6A4) Gene

The SLC6A4 gene[155] has also been linked with a predisposition to aggressive behavior.[156] This gene is active in the serotonin recycling process, and researchers have found problems with this process in individuals with the short allele of the SLC6A4 gene.[157] Serotonin is associated with both mood and aggression in humans.[158] A disrupted serotonin recycling process decreases the amount of serotonin in the body, thus affecting both mood and aggression.[159] Studies have linked the low activity of the transport

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NEUROPSYCHOPHARMACOLOGY 1498 (2004); Sara R. Jaffee et al., *Nature x Nurture: Genetic Vulnerabilities Interact with Physical Maltreatment to Promote Conduct Problems*, 17 DEV. AND PSYCHOPATHOLOGY 67 (2005); Kent W. Nilsson et al., *Role of Monoamine Oxidase A Genotype and Psychosocial Factors in Male Adolescent Criminal Activity*, 59 BIOLOGICAL PSYCHIATRY 121 (2006).

152. *See* William Bernet et al., *Bad Nature, Bad Nurture, and Testimony Regarding MAOA and SLC6A4 Genotyping at Murder Trials*, 52 J. FORENSIC SCI. 1362, 1363 (2007).

153. However, the majority of these offenders did not possess the low activity MAOA gene in combination with childhood maltreatment. *Id.* at 1363–65. Therefore, this specific G x E interaction is not a necessary factor for violent behavior, although it may be a sufficient factor.

154. *See e.g.*, *id.* at 1365 ("[W]hen male subjects had a low activity of the MAOA enzyme and also were maltreated as children, there was a much greater likelihood the person would manifest violent antisocial behavior in the future.").

155. This gene is also known as the 5-HTTLPR or 5-HTT gene.

156. Caspi, *supra* note 145, at 851 (discussing the behavioral effects of having a short form allele of the SLC6A4 gene); Bernet, *supra* note 153 at 1367 (discussing the link between the short allele of the SLC6A4 gene and aggressive antisocial behavior).

157. Bernet, *supra* note 153 at 1366 ("The transporter is the cell membrane structure that recycles synaptic serotonin for repackaging and subsequent release. . . . The SLC6A4 gene . . . can have either a 'long allele' or 'short allele.' The short allele . . . causes low activity of the transporter system, which means there will be more serotonin in the synapse and less serotonin available for reuse.").

158. See *id.*; Volavka, *supra* note 13, at 49 ("Serotonin (5-HT) exhibits inhibitory control over aggression.").

159. Bernet, *supra* note 153 at 1366.

system created by the gene to a significantly higher incidence of depression and suicide.[160] Like the MAOA gene, the likelihood of a person with the SLC6A4 gene exhibiting these behaviors is dependent on the individual's environment.[161] More recent research has supported this possible G x E interaction.[162] One replication study concluded that youth with certain variations of the SLC6A4 gene from low socioeconomic environments are more likely to manifest psychopathic tendencies.[163]

It is worth noting that the finding that both the MAOA and SLC6A4 genes are implicated in aggression is seemingly contradictory. The short allele of the SLC6A4 gene, which has been linked to aggression, is associated with a low level of serotonin in the body. Meanwhile, because MAOA is an enzyme that breaks down serotonin, lower levels of MAOA (like those studied by Caspi) would seem to result in higher levels of serotonin. This conundrum demands that future studies simultaneously examine multiple biomarkers to discover how they interact.

C. Relationship Between Neural Markers and Genetic Markers

Although we currently do not know how our brains and genes interact to motivate human behavior, it is clear that there is a relationship between the two. For example, there may exist a relationship between the participants in the Caspi study and those in the Pardini study. Males with a specific MAOA genotype also reportedly have an eight percent reduction in amygdala volume as compared to males without that genotype.[164] This suggests that

160. *Id.*

161. *Id.*

162. For successful replications of the Bernet study finding a link between the short allele of the SLC6A4 gene and aggression, see Naomi Sadeh et al., *Serotonin Transporter Gene Associations with Psychopathic Traits in Youth Vary as a Function of Socioeconomic Resources*, 119 J. OF ABNORMAL PSYCH. 604, 606–07 (2010); Joseph H. Beitchman et al., *Serotonin Transporter Polymorphisms and Persistent, Pervasive Childhood Aggression*, 163 AM. J. OF PSYCHIATRY 1103 (2006); Brett C. Haberstick, Andrew Smolen & John K. Hewitt, *Family-Based Association Test of the 5HTTLPR and Aggressive Behavior in a General Population Sample of Children*, 59 BIOLOGICAL PSYCHIATRY 836 (2006); Xingqun Ni et al., *Association Between Serotonin Transporter Gene and Borderline Personality Disorder*, 40 J. PSYCHIATRIC RESEARCH 448 (2006).

163. Sadeh, *supra* note 163, at 606–07.

164. Andreas Meyer-Lindenberg et al., *Neural Mechanisms of Genetic Risk for Impulsivity and Violence in Humans*, 103 PNAS 6269, 6271 (2006).

there is a causal pathway from genes to neurotransmitters to behavior. Future research should concurrently study both neural and genetic markers to understand the relationship between them.

V. PASSAGE OF EVIDENTIARY STANDARDS BY BIOPREDICTION

In practice, biobased evidence would virtually never be introduced without expert interpretation.[165] Thus, the value of this evidence will likely be established through interpretive expert testimony.[166] The following section offers a summary of the relevant evidentiary standards and a discussion of how biobased evidence would be analyzed under these standards.

A. Summary of Evidentiary Standards

The admissibility of biobased evidence depends on whether the evidence passes the standards set forth in *Daubert* and the rules of evidence. Before *Daubert*, *Frye v. United States*[167] established the "general acceptance" test for scientific evidence. The defendant in *Frye*, on trial for murder, moved to prove his innocence using expert lie detector testimony.[168] The appellate court affirmed the district court's exclusion of this evidence. In addition to the traditional criteria for expert testimony – logical relevance, helpfulness to the fact finder, and witness qualifications – the appellate court added an additional requirement that the testimony be based on scientific principles that were "sufficiently established to have gained general acceptance in the field in which it belongs."[169] *Frye*'s general acceptance test was the dominant test for expert testimony until 1993, when the Supreme Court decided *Daubert v. Merrell Dow Pharmaceuticals, Inc.*[170]

In *Daubert*, the trial court used *Frye*'s general acceptance test to exclude expert testimony that was not peer-reviewed, published, or generally accepted, and the Ninth Circuit affirmed.[171] The Supreme Court vacated, holding that *Frye*'s general acceptance standard was too rigid and "incompatible with" the Federal Rules

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165. *See* Teneille Brown & Emily Murphy, *Through a Scanner Darkly: Functional Neuroimaging and Evidence of a Criminal Defendant's Past Mental States*, 62 STAN. L. REV. 1119, 1158 (2010).

166. *Id.* at 1175.

167. Frye v. United States, 293 F. 1013 (D.C. Cir. 1923).

168. *Frye*, 293 F. at 1013.

169. *Id.* at 1014.

170. Daubert v. Merrell Dow Pharms., Inc., 509 U.S. 579 (1993).

171. Daubert v. Merrell Dow Pharms., Inc., 727 F. Supp. 570, 572 (S.D. Cal. 1989), *aff'd* 951 F.2d 1128, 1129 (9th Cir. 1991).

of Evidence.[172] The Court changed the evidentiary standard for scientific evidence in federal courts to allow only science that is "not only relevant but reliable" so that the standard would be compatible with Federal Rule of Evidence 702.[173]

After *Daubert*, judges must first inquire whether the reasoning or methodology underlying the testimony is scientifically valid and whether that reasoning or methodology can be applied to the facts at issue.[174] Judges can consider four factors during the scientific validity inquiry: (1) testability, (2) peer review and publication, (3) the existence of methodological standards (including known or potential error rate), and (4) general acceptance.[175] Two subsequent cases clarified the standard set forth in *Daubert*. First, *General Electric Co. v. Joiner*[176] reiterated the trial judge's mandate to review scientific testimony for scientific validity and fit. Later, *Kumho Tire Co. v. Carmichael* extended the scope of the *Daubert* inquiry to technical evidence.[177] In combination, this trio of cases requires that judges only allow expert testimony that passes scientific muster.[178] The Federal Rules of Evidence were amended in 2000 to reflect this change in light of *Daubert* and *Kuhmo Tire*.[179]

If evidence is determined to be admissible under *Daubert* and Rule 702, it can nonetheless be excluded from evidence. Federal Rule of Evidence 403 allows a court to exclude relevant evidence if its value is substantially outweighed by such costs as "unfair

172. *Daubert*, 509 U.S. at 589.

173. *Id.* at 589.

174. *Id.* at 592-93.

175. *Id.* at 593-94.

176. 522 U.S. 136 (1997).

177. 526 U.S. 137 (1999).

178. *See also* United States v. Barnette, 211 F.3d 803, 815-16 (4th Cir. 2000) ("The *Daubert* test's gatekeeping requirement is to ensure that the expert witness in question in the courtroom employs the same level of intellectual vigor that characterizes the practice of an expert in the relevant field.").

179. Amended Rule 702 now provides:

A witness who is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion or otherwise if:

(a) the expert's scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact in issue;

(b) the testimony is based on sufficient facts or data;

(c) the testimony is the product of reliable principles and methods; and

(d) the expert has reliably applied the principles and methods to the facts of the case.

FED. R. EVID. 702 (2011).

prejudice, confusing the issues, misleading the jury, undue delay, wasting time, or needlessly presenting cumulative evidence."[180]

B. Application of Evidentiary Standards to Biobased Evidence

In most jurisdictions, the admissibility of expert testimony is subjected to a three-pronged inquiry: (1) the evidence must be relevant to a fact in dispute;[181] (2) the witness must be qualified to offer testimony on the subject;[182] and (3) the evidence underlying the expert's opinion must be scientifically valid.[183]

The introduction of biobased evidence would likely pass the first two prongs of the admissibility inquiry. The evidence would be considered relevant under the Federal Rules because it would make the question of dangerousness either "more probable or less probable" than it would be without the evide3nce, provided that the biobased evidence adds more certainty to the inquiry than the current prediction tools. Biobased evidence also adds something more than just "logical relevance:" it provides information "beyond what [the jurors'] own experience or common sense can provide."[184] The second prong of the inquiry would also be satisfied so long as the expert is qualified in his or her respective field. For biological evidence, the expert would need to be qualified to speak both to the validity of the science and its

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180. FED. R. EVID. 403 (2011). This is the process through which evidence is analyzed at the federal level. While many states have adopted the *Daubert* standard, other states continue to apply the general acceptance test from *Frye*. Twenty-four jurisdictions have adopted the *Daubert* standard. Victor E. Schwartz & Cary Silverman, *The Draining of Daubert and the Recidivism of Junk Science in Federal and State Courts*, 35 HOFSTRA L. REV. 217, 267 n.300 (2006). Those states that still use the *Frye* standard are Arizona, California, Florida, Illinois, Kansas, Maryland, Minnesota, New York, North Dakota, Pennsylvania, and Washington. *Id.* at 267 n.301.

181. Relevance is defined as evidence "having any tendency to make the existence of any fact that is of consequence to the determination if the action more probable or less probable than it would be without the evidence." FED. R. EVID. 401 (2011).

182. Rule 702 requires that the expert be qualified by "knowledge, skill, experience, training, or education." FED. R. EVID. 702 (2011). Since Daubert, there seems to be a trend toward greater scrutiny of expert qualifications. *See* David L. Faigman, *Admissibility of Neuroscientific Expert Testimony, in* A PRIMER ON CRIM. L. & NEUROSCIENCE 89, 95 (Stephen J. Morse & Adina L. Roskies eds., 2013).

183. Scientific validity is assessed under either the *Daubert* or *Frye* standard. *See supra* note 181 for a discussion of which states use *Daubert* versus *Frye*.

184. *See* Faigman, *supra* note 183, at 92–93.

relevance to the case at hand.[185] For neuroimaging, the ideal expert would have a medical degree and experience in both neurology and psychiatry. For genotyping, the expert should have a medical degree and experience in biology and psychiatry. Experts that testify about bioprediction may have more or fewer qualifications depending on the client's budget and the particular case. Ultimately, the decision about an expert's qualifications is left to the discretion of the trial court.[186]

The third prong of the inquiry is a more rigorous analysis of admissibility under *Daubert* and Rule 702. The *Daubert* court suggested four factors to be considered by the courts: (1) testability (or falsifiability), (2) error rate, (3) peer review and publication, and (4) general acceptance.[187] Although these four factors are only a guideline and courts are free to consider other factors, this article only considers these four factors in order to predict how courts would likely treat biobased evidence under *Daubert*.[188]

The first consideration, testability (or falsifiability), asks whether a theory or technique "can be (and has been) tested."[189] Thus, the scientific knowledge must be capable of being empirically tested rather than simply hypothesized about. It is also essential that a theory be tested more than once and replicated successfully.[190] Because most biological experiments are conducted under laboratory conditions on a limited number of subjects (often undergraduate college students), it is unclear how the results would translate to the real world.[191] One benefit of the most promising

185. *Id.* at 95 ("The depth of the expert's credentials would have to be sufficient to sustain the content of his or her testimony.").

186. *Id.* at 96.

187. Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 580 (1993).

188. Most courts generally consider at least the four factors laid out in *Daubert*. Any other factors that are considered are usually used on a case-by-case basis.

189. *Daubert*, 509 U.S. at 593.

190. *See* Henry T. Greely, *Mind Reading, Neuroscience, and the Law, in* A PRIMER ON CRIM. L. & NEUROSCIENCE 120, 137 (Stephen J. Morse & Adina L. Roskies eds., 2013) ("Scientists rarely put much confidence in any result until it has been replicated by a second (or third, or fourth) laboratory. . . . A result achieved by only one laboratory should be viewed with great caution, and even if several groups reach the same result, if they do so by different methods, any one method must still be considered suspect.").

191. *See* Brown, *supra* note 166, at 1143 ("[T]he behavior being solicited in response to the task is usually so isolated that the results are difficult to generalize to other real-world functions."). *See also* Faigman, *supra* note 183, at 104 ("[M]uch of the legal concern surrounding the 'testability' criterion . . . will involve the fit between how the testimony was done and what it is being used to prove.").

biological studies for prediction, discussed in Part III, is that they were longitudinal studies conducted on subjects with a propensity for violent behavior.[192] Where the subjects of a study are representative of the population to which the results are being applied, the testability consideration should be satisfied.[193]

In addition to the uncertainty about whether the study conditions can map onto the real world, there is also a concern about group to individual (G2i) inference.[194] While scientific studies are often concerned about generalizing results to a group of people (e.g., people with low amygdala volume are more likely to be violent),[195] courts must individualize the result to the defendant (e.g., this specific individual is violent).[196] Thus, the question for evidence based on group studies is whether it can be reliably used to testify about a particular individual.[197] One area where G2i inferences are required is in making diagnoses of medical and psychological conditions.[198] Medicine and psychology are based on general knowledge, and professionals in these fields are required to make and treat individuals based on a diagnosis that was defined based on groups. In general, "courts have, without a second thought, allowed these experts to provide the same service

192. *See* Caspi, *supra* note 145; Aharoni, *supra* note 125; Pardini, *supra* note 118.

193. Even where this is not the case, that does not automatically mean that the evidence is not testable. For a discussion of testability that is broader than its application to prediction, *see* Faigman, *supra* note 183, at 103–04.

194. *See* David Faigman, *Evidentiary Incommensurability: A Preliminary Exploration of the Problem of Reasoning From General Scientific Data to Individualized Legal Decision-Making*, 75 BROOK. L. REV. 1115 (2010) (stressing that predicting an individual's behavior from group data linking patterns of neurological dysfunction to behavioral tendencies is dangerously subject to inaccuracies).

195. *See* Pardini, *supra* note 118.

196. *See* Owen Jones & Francis Shen, *Law and Neuroscience in the United States, in* INT'L NEUROLAW: A COMPARATIVE ANALYSIS 349, 356 (T.M. Sprangner ed., 2012) ("Making individualized inferences, as law is typically required to do, from group-averaged neuroscientific data presents a particularly difficult problem for courts to overcome.").

197. *Id.* ("Just because a particular pattern of neural activity is associated, on average at the group level, with impaired decision making, it does not necessarily follow that a defendant before the court whose brain scans produce the same neural patterns necessarily has such a cognitive deficit.").

198. David L. Faigman, John Monahan & Christopher Slobogin, *Group to Individual (G2i) Inference in Scientific Expert Testimony*, 81 U. CHI. L. REV. 417, 434 (2014) ("[T]he professions of medicine (including psychiatry) and clinical psychology have long practiced particularization in ordinary practice.").

in the courtroom."[199] The currently admissible predictions of dangerousness made using clinical judgment are thus based upon individual inferences made using group data. Similarly, actuarial and structured professional judgment tools make dangerousness predictions based on risk assessments created by analyzing groups. While these predictions may not be accurate in every case, by continuing to make individual inferences, society has confirmed that there is net benefit to their use. [200] Therefore, the general problems associated with G2i inference should not prohibit the use of biobased evidence for dangerousness predictions.[201]

The second criterion for scientific evidence is a measurement of the error rate. Error rate is especially important in the legal system because the "cost of making a mistake, whether of the false positive or the false negative variety, is an integral component of the policy implications of any admissibility determination."[202] However, since *Daubert*, courts do not seem to delve deeply into this question; rather, it is common for courts to simply report the error rate.[203] Biobased evidence may be more likely to be admitted into evidence for prediction because the error rate of the existing prediction tools is relatively high.[204] If, after further research, it is confirmed that the error rate for bioprediction is less than, or equal to, that for current prediction instruments, it should be acceptable under this prong of the inquiry.

Another concern related to error rate is the base rate problem. The base rate is the underlying prevalence of the specific functional deficit.[205] For example, if one person in a population of one hundred is a lawyer, then the base rate of lawyers is 1%. Often,

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199. *Id.*

200. *See* Imrey, *supra* note 65, at § 2.3 ("[E]xperience in many fields, such as medical diagnosis and prognosis has shown that prediction need not be highly accurate at the individual level for major collective benefit to accrue.").

201. For an excellent discussion of the G2i inference in the legal context, *see generally* Faigman, *supra* note 199; *see also* Monahan, *supra* note 12, at 65 ("[G]roup data theoretically can be . . . highly informative when making decisions about individual cases. . . . In the insurance industry, 'until an individual is treated as a member of a group, it is impossible to know his expected loss, because for practical purposes that concept is a statistical one based on group probabilities.'").

202. Faigman, *supra* note 183, at 105.

203. *Id.* at 106 ("It is not unusual . . . for courts to simply list the error rate factor and offer little more than a conclusory statement that it was met . . . or not met . . . without explaining why.").

204. *See supra* note 66 (reporting false positive rates of between 25–51% for all risk assessment tools).

205. *See* Brown, *supra* note 166, at 1180.

base rates for these biomarker studies will either be low or unknown. Consider a case where an offender's brain scan shows an abnormality. There is currently not enough data about these biomarkers to know how many people with the same abnormality do not behave as that individual did.[206] To overcome this issue, experts should be candid about this limitation so that judges and juries understand how this can affect predictions.

As a third consideration, peer review and publication may be used as a helpful indication of scientific validity, but should not be considered the *sine qua non* of validity.[207] Some reputable journals publish bogus studies, and some less reputable ones publish valid studies. In addition to publication in a peer-reviewed journal, another critical factor to consider is whether replication studies have been published.[208] Where there is only a single study supporting a result, courts should be skeptical of publication bias (i.e., the tendency to only publish positive results).[209] Often, if there is only one published study, it means that attempted replications were unsuccessful and so the reported result may not be dependable.

Finally, the criterion of "general acceptance" depends on the field from which the findings come and is only as good as those doing the accepting or rejecting of the results.[210] Some fields have arguably replaced critical assessment with consensus.[211] However, professionals in the fields of neuroscience and genetics do not seem to suffer from this mentality because they are mature scientific fields that are based on competition.[212] Although biological scientists often collaborate, the general culture is to

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206. *See id.* ("Without knowing the prevalence of any functional brain abnormality in the population, we can say very little about the positive predictive value of an fMRI that seeks to establish this abnormality."). *See id.* for a detailed hypothetical showing how a low base rate can result in a high number of false positives.

207. *Daubert*, 509 U.S. at 593.

208. *See* Faigman, *supra* note 183, at 107 ("The single most effective checking tool in science is replication.").

209. *See* Duncan, *supra* note 86, at 1044–47 (warning readers about the publication bias and false discovery rates present in G x E studies).

210. *See* Faigman, *supra* note 183, at 108.

211. For example, in some forensic specialties such as bite-mark and handwriting identification, law enforcement is the main community involved, and dissent is strongly disfavored. So, general acceptance may reflect agreement with the majority rather than genuine agreement. See *id.* at 108.

212. *Id.* ("At this point in time, expert evidence based on neuroscience does not appear to suffer from the guild mentality").

review the work of others in a rigorous and independent fashion.[213] Thus, general acceptance of these scientific techniques serves to mark these studies as unbiased and legitimate. Additionally, neuroimaging and genetic evidence have already been admitted in several cases, although the courts have not explicitly commented on general acceptance.[214]

Since neuroimaging and genetics data have been admitted in other types of cases, it is likely that biobased evidence will pass under Rule 702. Admission of expert testimony regarding biobased data for predictions could thus turn on a weighing of the probative value of the evidence and any unfair prejudice it may cause.[215] The probative value of biobased evidence will likely be quite high. Current research studies suggest that biobased dangerousness predictions have the potential to be more accurate, objective measures than the existing prediction tools.[216] With future research replicating promising studies and new studies identifying additional biomarkers, biobased evidence will attain scientific validity and reliability. Neuroimaging and genetic testing will also become progressively less expensive and more convenient if they follow the path of almost all technologies.[217]

Even if the probative value of this evidence is high, it is necessary to consider its prejudicial effect. There is a valid concern that a jury, upon being presented with biobased evidence, could assign too much weight to the evidence. The appearance of fMRI images may suggest that they are more scientific and reliable than they actually are.[218] If experts do use neuroimages,[219] it is crucial

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213. *Id.*

214. *See infra* Part II.C.

215. FED. R. EVID. 403 (2011).

216. *See* Aharoni, *supra* note 125, at 6224 (Biomarkers "could potentially improve overall risk estimates.").

217. *See* Barry Ritholtz, *Why Technology Price Drops Are Not Proof of Deflation*, THE BIG PICTURE (Apr. 28, 2011, 8:30 AM), http://www.ritholtz.com/blog/2011/04/why-technology-price-decreases-are-not-proof-of-deflation/ (opining that owning a big-screen TV was a luxury in 2000 because it cost about $10,000, but is now commonplace as they are sold "for less than $600 at Best Buy"). *But see infra* notes 266–68 and accompanying text for a discussion of the current costs of biological evidence.

218. *See supra* notes 73–77 and accompanying text for a discussion of the process that fMRI images go through. *See also* Brown, *supra* note 166, at 1163 ("Although brain images may *appear* more scientific and less capable of distortion, . . . it is this *appearance*, and not the validity of the science, that parties expect to do the persuading."); State v. Pappas, 776 A.2d 1091, 1113 (Conn. 2001) ("The concern is that jurors will overvalue DNA evidence and ignore other types of evidence.").

that they do not fall victim to the reductionism that is rampant in the literature.[220] Calling a brain scan a "picture of the brain" is extremely misleading and can lead to jurors placing too much weight on this evidence.[221] fMRI images may convey a degree of scientific fact to the fact finder unworthy of the evidence, and so jury instructions must be careful to warn jurors that scientific evidence is not necessarily more reliable than the expert testimony itself. It is a legitimate concern whether jury members will be able to sufficiently appreciate the complexity inherent to making any inference regarding individual behavior from group-averaged data. Thus, scholars have rightly contended that "courts must ask whether jurors are capable of assessing, presumably with the aid of cross-examination and opposing expert witnesses, the inferential chain for themselves."[222]

Additionally, there is a valid concern that the use of biobased evidence could encourage the fundamental "psycholegal error." Professor Stephen Morse coined this term to describe the tendency to think that an actor is not responsible for behavior that is caused by his brain or genes.[223] While this error is surely of greater concern for the use of biobased evidence for determinations of responsibility, it could still affect the use of biobased evidence for prediction. Where an offender has been convicted of a crime and prediction is being used in sentencing, the psycholegal error could affect the decision to sentence an offender more leniently or avoid the death penalty because "it's not really his fault." However, the knife could cut the opposite way and the jury could reason that, because an offender is "wired that way," his release would be dangerous to the community because his brain and/or genes is the

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219. This argument is equally applicable to genetic evidence.

220. An example of this reductionism is a statement such as: "[n]ew functional magnetic resonance imaging (fMRI) technology can take pictures of a person's brain at the very moment the person is engaged in a task." Leo Kittay, *Admissibility of fMRI Lie Detection: The Cultural Bias Against "Mind Reading" Devices*, 72 BROOK. L. REV. 1351, 1351 (2007).

221. The same issue occurs where an expert testifies on genetics and calls something a "gene for [a behavior]" (e.g., MAOA is a gene for violence). This too must be avoided if this evidence is to be used in the courtroom. *See, e.g.*, WILLIAM LANDAY, DEFENDING JACOB: A NOVEL (2012) (a fictional but realistic example of how using the term "murder gene" in a criminal trial can detrimentally impact the defendant's case).

222. Jones, *supra* note 197, at 357.

223. Morse argues that "[d]iscovering a cause for behavior, whether it is biological, psychological or sociological, does not mean that the agent is not responsible for the behavior." Stephen J. Morse, *Criminal Responsibility and the Disappearing Person*, 28 CARDOZO L. REV. 2545, 2569 (2007).

reason for his violence.[224] The case of Brian Dugan demonstrates an example of the jury being faced with compelling biobased evidence but still sentencing the offender to death, suggesting that jurors are able to overcome this psycholegal error in the face of biobased evidence.[225] Although the psycholegal error could certainly creep into the courtroom, we should not exclude the use of biobased evidence if it could make the current prediction scheme more accurate.[226]

Despite the fact that neuroimaging and genetics evidence are relatively new and untested technologies, it is likely that courts would allow this evidence for dangerousness predictions because the inquiry has a relaxed evidentiary standard.[227] The current prediction scheme itself likely does not meet the standards for scientific evidence, yet judges and legislatures continue to employ predictions in the law.[228] Arguably then, so long as biobased

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224. For an example of how this could play out in the courtroom, *see* Stephen J. Morse, *Gene-Environment Interactions, Criminal Responsibility, and Sentencing*, *in* GENE-ENV'T INTERACTIONS IN DEV. PSYCHOPATHOLOGY 207, 231 (Kenneth A. Dodge & Michael Rutter eds., 2011) ("[A] trial judge may decide to use the fact that the defendant has the MAOA gene as a mitigating factor to reduce the defendant's sentence because he has already suffered a hard life. On the other hand, another judge may use the very same evidence to support a longer sentence or denial of parole, reasoning that this defendant, because of the MAOA gene, is more likely to commit another crime in the future."). *See also* Jones, *supra* note 197, at 360 ("Where neuroimaging evidence is presented to show a convicted individual's lessened responsibility or culpability during sentencing, the sentencing authority may actually treat the fMRI evidence offered as a mitigating factor as an aggravating circumstance, believing 'a brain too broken may be simply too dangerous to have at large, even if it is somehow less culpable.'").

225. *See supra* notes 99–103 and accompanying text.

226. Safeguards to protect against the psycholegal error should include carefully crafted jury instructions and strict rules for experts.

227. *See* Beecher-Monas, *supra* note 9, at 311 ("No such trustworthiness inquiry is compelled regarding expert testimony about the defendant's future dangerousness, whether that testimony is presented in a capital sentencing hearing or in sexual offender commitment proceedings."). *See, e.g.*, Barefoot v. Estelle, 463 U.S. 880 (1983) (upholding the admissibility of expert testimony about future dangerousness, even where the testimony was based on hypothetical questions about the defendant); *Hendricks*, 521 U.S. 346 (1997) (upholding the use of expert testimony to predict future dangerousness of a sexually violent predator for civil commitment).

228. *See* Beecher-Monas, *supra* note 9, at 307 ("[J]udges continue to admit predictions that no one seriously argues can meet these standards. If the test by which an evidentiary practice should be judged is whether it increases the likelihood that the truth, defined as correspondence to the real world, will be attained, expert future dangerousness testimony fails to make the grade.").

evidence is at least as good at prediction as clinical judgment, the least reliable yet most often used prediction tool, it should be accepted in the courtroom.[229] Although the research has not reached this point yet,[230] once studies—like those of Aharoni,[231] Caspi,[232] and Pardini[233]—have been successfully replicated to gain general acceptance, evidence of these biomarkers should be admitted in court. When this evidence is admitted for predictions of future dangerousness, it is important that the jury understand that the evidence is being used solely in a predictive manner in this context, and not as an excuse for wrongful conduct.[234] Even if the biobased evidence itself is deemed to be inadmissible, the expert testimony regarding the evidence is admissible under the Federal Rules of Evidence[235] and the evidentiary rules of 30 states,[236] provided that the evidence is "of a type reasonably relied upon by experts in the particular field."[237]

VI. BIOBASED EVIDENCE CAN MAKE PREDICTIONS MORE ACCURATE

A. How Biobased Evidence Should Be Used

When deciding whether to use biobased evidence for predictions, the analysis should balance the value of the prediction against its costs, including the costs of neurological or genetic

229. Some reports suggest that clinical prediction is wrong two times out of three, yet it is still admissible in court. *Barefoot*, 463 U.S. at 916 (Blackmun, J., dissenting). Thus, if biobased evidence is shown to be accurate more than 34% of the time, it should be admissible.

230. *See* Morse, *supra* note 25, at 176 ("At present, there is no general, valid neuromarker to increase the accuracy of dangerousness predictions, and using neurodata risks introducing prejudice and confusion.").

231. *See supra* note 125.

232. *See supra* note 145.

233. *See supra* note 118.

234. *See* Stephen J. Morse, *Avoiding Irrational NeuroLaw Exuberance: A Plea for Neuromodesty*, 62 MERCER L. REV. 837, 848 (2011) ("Causal information may be of prophylactic or rehabilitative use for people affected, but no excuse or mitigation is applicable just because these variables make antisocial behavior far more predictable."); *but cf.* Morse, *supra* note 25, at 156 ("If the variables that enhance prediction also produce a genuine excusing or mitigating condition, then excuse or mitigation is justified for the latter reason and independently of the prediction.").

235. FED. R. EVID. 703.

236. Under state counterparts to Federal Rule of Evidence 703, an expert may be allowed to disclose the facts on which his or her opinion is based. *See* 89 A.L.R.4th 456, §§ 2, 3 (West 2009).

237. FED. R. EVID. 703 advisory committee's note.

testing and ethical concerns.[238] Given the potential for biobased predictions to be more accurate and objective than the current prediction scheme, bioprediction should be incorporated into the law as soon as the biomarkers are confirmed in replication studies. The value added by bioprediction would be a more accurate prediction scheme with fewer false positives and false negatives. A scheme based on biomarkers would also remove some of the subjectivity inherent in clinical judgments. However, because this research is in its infancy, it is not known whether there is one single biomarker indicative of violent behavior. Considering the current research of Aharoni, Caspi, and Pardini, it is likely that there is more than one biomarker for dangerousness. For prediction making, it will be crucial to take into account the fact that not all offenders will have each and every one of these biomarkers.[239]

In a hypothetical legal system that only uses biomarkers to predict for future dangerousness, the scheme might resemble the following. Any offender charged with a crime would be given both a structural and a functional MRI scan, and he or she would also provide a DNA sample. An expert would then analyze the neuroimages for any neural markers and the DNA for any genetic markers. Depending on which biomarkers the expert finds, the court would then determine the likelihood that the offender would commit a future criminal act and sentence accordingly (where the sentencing might include diversion to a treatment facility, civil commitment, or the death penalty).

Until every biomarker—both neurologic and genetic—whas been identified and verified, this futuristic scheme is unrealistic. Today, biomarkers should be incorporated into the current prediction scheme to increase accuracy, while still allowing for

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238. Morse, *supra* note 25, at 152 ("[A]n overarching practical question for all use of neuroscience in criminal law adjudication is whether it is cost-benefit justified.").

239. Bernet concluded that not all violent offenders possess the G x E interaction of MAOA gene and childhood maltreatment. *See* Bernet, *supra* note 153, at 1363 (noting that the majority of violent offenders tested did not possess the low activity MAOA gene in combination with childhood maltreatment). Some researchers in the field believe that there is no one biomarker that will be sufficient on its own to predict future dangerousness. *See* Glenn, *supra* note 117, at 57 ("A predisposition to criminal behavior is unlikely to be reduced to one or even two simple brain circuits but probably involves multiple brain dysfunctions and multiple circuits that each give rise to different risk factors for violence."); *see also* Aharoni, *supra* note 125, at 6224 ("We are skeptical that emerging neurobiological markers could ever independently outperform these existing tools in sensitivity and specificity, but they could potentially improve overall risk estimates in combination with known psychosocial risk factors.").

consideration of other risk factors. Biomarkers could be integrated with actuarial assessments, structured clinical judgments, and clinical judgments. For biomarkers that are confirmed to relate to increased risk by a certain amount, clinicians could use this knowledge in making their assessment by considering the biomarker as one of the patient's signs of mental abnormality. The more patients whom the mental health professional diagnoses with a particular biomarker, the more accurate their diagnoses of those types of patients will become. Additionally, the identification of biomarkers could help the fields of psychology and psychiatry to better define mental abnormalities by adding another sign by which to compare patients. Biomarkers could also be incorporated into actuarial risk assessment tools. The instruments could use statistics from studies about biomarkers and information progressively gathered about individuals with the biomarkers to assign a probability to each biomarker as a risk factor. This prediction scheme that incorporates biomarkers rather than replacing current tools with biomarkers should be implemented as soon as the studies that purport to have identified biomarkers are replicated and verified.

B. Benefits of Using Biobased Evidence

Predictions of future dangerousness are most often used, and sometimes required, in capital punishment and civil commitment proceedings. Courts currently struggle with and disagree over how much weight, if any, predictions of dangerousness should be given.[240]

In capital sentencing hearings, biobased evidence could be introduced as evidence for future dangerousness in several ways. For one, it may be used as an aggravating circumstance, either statutory[241] or non-statutory.[242] The prosecution may introduce the

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240. Compare the majority in *Barefoot*, 463 U.S. at 899 (holding that predictions of future dangerousness are admissible, reasoning that the adversary process can sort out the reliable from the unreliable evidence) with Justice Blackmun's dissent, *id.* at 916 ("The Court holds that psychiatric testimony about a defendant's future dangerousness is admissible, despite the fact that such testimony is wrong two times out of three."); *see also Hendricks*, 521 U.S. at 373–96 (Breyer J., dissenting) (arguing that a person should only be committed in response to a crime committed, disagreeing with the majority's approval of the Kansas Sexually Violent Predator Act, which allowed civil commitment based on a charge, even without a conviction).

241. Future dangerousness is a statutory aggravating factor in six states: Idaho, Oklahoma, Oregon, Texas, Virginia, and Wyoming. *See* IDAHO CODE ANN. § 19-2515(h) (West 2006); OKLA. STAT. ANN. tit. 21, § 701.12 (West 2011);

evidence through expert testimony, cross-examination of the defense, or through the prosecutor's argument itself.[243] Some states have allowed the consideration of future dangerousness as a mitigating factor in capital sentencing statutes.[244] In those states, the defense may introduce evidence of future dangerousness through expert testimony, character witnesses, or argument.[245] A few states, including California, have common law prohibitions against the prosecution introducing expert testimony on the issue of future dangerousness.[246] But, even where future dangerousness is not a statutory aggravating factor, it can often sneak into evidence when the defense introduces related evidence.[247] Introduction of biobased evidence in capital sentencing proceedings would ensure that the court makes the most accurate prediction possible before depriving a person of life and liberty.

OR. REV. STAT. § 163.150(b) (1999); TEX. CODE CRIM. PROC. ANN. art. 37.071, § 2(b) (West 2001); VA. CODE ANN. § 19.2-264.2 (West 2016); WYO. STAT. ANN. § 6-2-102(e) (West 2001).

242. *See, e.g.*, People v. Evans, 708 N.E.2d 1158, 1167 (Ill. 1999) (stating that the judge was allowed to consider the combination of the defendant's troubled life and his criminal record as evidence of future dangerousness); State v. Hughes, 521 S.E.2d 500, 503-04 (S.C. 1999) ("The State may establish as an aggravating factor that the defendant would in the future pose a danger to others if not executed.").

243. *See, e.g.*, *Barefoot*, 463 U.S. at 898–99 ("[J]urors should not be barred from hearing the views of the State's psychiatrists [about future dangerousness] along with the opposing views of the defendant's doctors."); Nethery v. State, 692 S.W.2d 686, 708 (Tex. Crim. App. 1985) (upholding admissibility of expert testimony regarding defendant's future dangerousness).

244. *See, e.g.*, COLO. REV. STAT. § 16-11-103(4)(k) (2000); IND. CODE ANN. § 35-38-1-7.1(c)(8) (LEXIS Supp. 2001); MD. ANN. CODE art. 27 § 413(g) (Supp. 2000).

245. *See, e.g.*, Vialpando v. People, 727 P.2d 1090, 1094-95 (Colo. 1986) (en banc) (concluding that the defense should have been allowed to introduce evidence regarding conditions designed to reduce the defendant's dangerousness).

246. *See, e.g.*, People v. Malone, 762 P.2d 1249, 1266 (Cal. 1988) (en banc) ("[E]vidence of future dangerousness is inadmissible in the prosecution's case-in-chief").

247. *See id.* ("[S]uch evidence many be introduced [by the prosecution] in rebuttal where . . . the defense has raised the issue.") *See also* Ruiz v. Norris, 868 F. Supp. 1471, 1532 (E.D. Ark. 1994) (allowing testimony from the prosecution's expert on future dangerousness because the defendant's expert "open[ed] the door" to such testimony, even though future dangerousness is not an aggravating factor under Arkansas Law); Hunt v. State, 583 A.2d 218 (Md. 1990) (allowing the prosecution to rebut the potential mitigating factor of lack of future dangerousness by introducing the defendant's prison escape plan).

As discussed above, all sexually violent predator statutes require a prediction of future dangerousness in order to civilly commit an offender.[248] In civil commitment proceedings for sexually violent predators, biomarkers could be especially useful in predicting recidivism if it were determined that having sexual desires of sufficient intensity were predictive of recidivism and biological testing could confirm whether an offender possesses those desires.[249] Biomarkers indicating these desires could also help divert offenders into treatment programs.

Identifying biomarkers may provide the basis for the development of treatment programs to help offenders avoid recidivating. The ability to accurately predict future violence could allow the courts to determine whether an individual would be a good candidate for treatment based on a test for biomarkers.[250] In addition to deciding generally between treatment and commitment, courts in the future could also divert offenders to treatment programs designed specifically for certain biological risk factors.[251] Neuroscience and genetic technologies have the potential to help states understand disorders with biological underpinnings – such as addiction and post-traumatic stress

248. *See supra*, note 32.

249. *See* Morse, *supra* note 25, at 176.

250. *See* Glenn, *supra* note 117, at 57–58 ("[N]eurobiological characteristics could ultimately help to determine which offenders are best suited to specific rehabilitation programmes and are more likely to re-integrate into society safely."). The successful treatment of individuals in the criminal justice system reduces the likelihood that those persons will be dangerous to themselves or to others, justifying the costs of such treatments. *See* Jeffrey W. Swanson et al., *Involuntary Out-Patient Commitment and Reduction of Violent Behaviour in Persons with Severe Mental Illness*, 176 BRIT. J. PSYCHIATRY 324, 330 (2000) (concluding that a period of six months or more in involuntary out-patient commitment may significantly reduce the risk of violent behavior in persons with severe mental illness).

251. *See* Andrea L. Glenn, Yaling Yang, & Adriane Raine, *Neuroimaging in Psychopathy and Antisocial Personality Disorder: Functional Significance and a Neurodevelopmental Hypothesis in Neuroimaging, in* FORENSIC PSYCHIATRY: FROM THE CLINIC TO THE COURTROOM 81, 93 (Joseph R. Simpson ed., 2012) ("In the future, it may be possible to develop individualized treatments that target specific neurobiological risk factors."). *See, e.g.*, Antonia S. New et al., *Fluoxetine Increases Relative Metabolic Rate in Prefrontal Cortex in Impulsive Aggression*, 176 PSYCHOPHARMACOLOGY 451 (2004) (reporting that, in adults with impulsive aggression, treatment with selective serotonin reuptake inhibitors increases glucose metabolism in the orbitofrontal cortex, thereby decreasing aggressive behavior).

disorder – and design treatment programs specifically for offenders with those disorders.[252]

One group of offenders for which biomarkers would be extremely useful is those diagnosed with psychopathy. There is evidence suggesting that there is a "common neurological basis for psychopathic traits."[253] Psychopaths are overrepresented in the criminal system[254] and have one of the highest rates of recidivism of any group.[255] If biomarkers for psychopathy were discovered, it would be possible to distinguish psychopathic from non-psychopathic offenders and make sentencing and parole decisions based upon this identification. A biomarker for psychopathy could have implications for treatment as well.[256] Identifying and using biomarkers that predict future dangerousness would benefit those areas of the law that require these predictions and help the legal system deal with the group of offenders who are most likely to recidivate.

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252. *See* Owen D. Jones et al., *Law and Neuroscience: Recommendations Submitted to the President's Bioethics Commission*, J. L. & BIOSCIENCES 224, 232 (2014).

253. Psychopathy is believed to affect 15–25% of the male and female prison population. Kent A. Kiehl, *A Cognitive Neuroscience Perspective on Psychopathy: Evidence for Paralimbic System Dysfunction*, 142 PSYCHIATRY RES. 107 (2006).

254. *Id.*

255. *Cf.* John Monahan, *supra* note 48, at 134, 166 (2001) (reporting that in the MacArthur study, a patient with a diagnosis of antisocial personality disorder was over three times more likely than a patient without such a diagnosis to commit a violent act within several months after discharge from the hospital).

256. There is evidence that juveniles with psychopathic traits who are treated at a young age can be rehabilitated. The Mendota Juvenile Treatment Center is a behavioral program for psychopathologic youths, which has been quite successful in rehabilitating youths who show traits of psychopathy. *See Program Profile: Mendota Juvenile Treatment Center*, NAT'L INST. OF JUST. (Mar 7, 2017, 10:16), http://webcache.googleusercontent.com/search?q=cache:81M3FW2u8PAJ:https://www.crimesolutions.gov/ProgramDetails.aspx%3FID%3D274&num=1&hl=en&gl=us&strip=1&vwsrc=0. A 2005 study reviewed offenses committed by patients in the 2 year follow up period from release from the center. This study reported that 37 percent of the comparison group was charged with a violent felony, while only 18 percent of the treatment group was charged with a violent felony. *See* Michael F. Caldwell & Gregory J. Van Rybroek, *Reducing Violence in Serious Juvenile Offenders Using Intensive Treatment*, 28 INT'L. J. L. PSYCHIATRY 622 (2005).

C. Issues Presented by Biobased Evidence

While biobased evidence will likely have a high probative value for predictions of future dangerousness, the use of this type of evidence could pose some legal issues. Some critics may claim that the use of biobased evidence is generally inconsistent with the principles of criminal law.[257] Others will likely make more specific arguments against the use of this evidence. These arguments are discussed below, including concerns about potential constitutional violations, privacy violations, high costs, discriminatory effects, and moral and ethical implications.

1. Possible Constitutional Issues

Several constitutional issues may be raised in opposition to the use of biobased evidence. If biobased evidence becomes a mandate in criminal trials, opponents may raise an argument against such evidence on Fifth Amendment grounds. It could be argued that defendants have a right not to self-incriminate under the Fifth Amendment, and thus they should not be compelled to produce biodata, such as an MRI scan or DNA sample, for a criminal case. This argument will probably not be successful where the biodata is being used only for predictive purposes. Because the biodata would be used to predict future behavior and not to determine actual responsibility for the crime charged, the right to not self-incriminate should not be implicated.[258] Additionally, even if the Fifth Amendment extended to production of biodata for predictions of future crimes, the court would likely still be able to compel this evidence because biodata would be considered non-testimonial evidence. Testimonial evidence, such as statements directly from the person charged, cannot be compelled.[259]

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257. *See* Daniel S. Goodman, *Demographic Evidence in Capital Sentencing*, 39 STANFORD L. REV. 499, 521–27 (1987) (A "procedure that allows judgments about an individual's blameworthiness to be based on statistical correlations to anonymous prior malefactors is deeply inconsistent with the general principles undergirding our system of law."); *see also* Barbara D. Underwood, *Law and the Crystal Ball: Predicting Behavior with Statistical Inference and Individual Judgment*, 88 YALE L.J. 1408, 1436 (1979).

258. *See* Miranda v. Arizona, 384 U.S. 436, 444 (1966) (holding that an individual being questioned about a crime has the right to remain silent so as to not implicate himself in the crime at issue).

259. Schmerber v. California, 384 U.S. 757, 764 (1966) ("The distinction which has emerged, often expressed in different ways, is that the privilege is a bar against compelling 'communications' or 'testimony,' but that compulsion

However, non-testimonial evidence, such as fingerprints or DNA, can be compelled.[260] Brain images or genetic samples would likely fall into the non-testimonial category because they are physical evidence that is not being used to determine guilt or innocence. Defining biobased evidence as either testimonial or non-testimonial will be especially important if this type of evidence is to be used in *mens rea* determinations.[261]

If biobased evidence is to be compelled, the Fourth Amendment may also be implicated. Individuals have a right not to be subject to unreasonable searches and seizures under the Fourth Amendment. This right extends past just physical property to the rights of individuals as people to be free from unreasonable searches.[262] A brain scan or genetics test may be viewed as unreasonably seizing the private thoughts of a person. "One can easily imagine the introduction of neuroimaging evidence about psychopathy to aid in the prediction of future dangerousness. Will the police request a warrant to search your brain?"[263] While this proposal sounds unrealistic today, it will surely be a real question in the minds of some critics as a legitimate future concern. The argument for compelling this type of evidence would be that because it is only being used for prediction, the information being gathered is strictly physical, as opposed to gathering substantive thoughts to determine responsibility. Where the procedure is not invasive (such as an MRI or cheek swab for DNA), and the probative value of the information obtained is high (such as determining the likelihood that an offender will recidivate), the request for an MRI or genetic test will likely not be considered an unreasonable search or seizure under the Fourth Amendment.[264]

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which makes a suspect or accused the source of 'real or physical evidence' does not violate it.").

260. *Id.* at 771 (holding that compelling a blood sample from an apparently intoxicated person does not violate the Fifth Amendment because blood is non-testimonial).

261. *See* Jones & Shen, *supra* note 193, at 360 ("A particular issue which scholars have shed light on is whether fMRI evidence is testimonial or physical, since this problem is as of yet unresolved and self-incrimination protections apply to testimonial but not physical evidence.").

262. *See* Katz v. United States, 389 U.S. 347, 351 (1967) (holding that what an individual "seeks to preserve as private, even in an area accessible to the public, may be constitutionally protected").

263. Elizabeth Ford & Neil Aggarwal, *Neuroethics of Functional Neuroimaging in the Courtroom*, *in* NEUROIMAGING IN FORENSIC PSYCHIATRY: FROM THE CLINIC TO THE COURTROOM 325, 334 (Joseph Simpson ed., 2012).

264. Under the Supreme Court's precedent, the courts use a balancing test to determine whether there has been a violation of the Fourth Amendment.

2. Financial Costs of Using Biobased Evidence

The cost of the testing itself, whether borne by the court or by the defense, would be quite high. The use of an MRI machine is expensive and requires additional costs to interpret the results of the MRI, totaling over $1,000.[265] Genetic testing is also expensive, though not as costly as an MRI. Fees for MAOA gene and SLC6A4 gene testing would cost about $300 each.[266] In addition to the biological testing itself, the defense (or prosecution) will have to retain, prepare, depose, and ultimately examine at trial (and perhaps also at a *Daubert* hearing) an expert witness to testify about the evidence. The total cost of presenting biological evidence could range anywhere from $5,000 to $50,000.[267]

This high cost could create discriminatory effects against defendants who cannot afford the testing. As a practical matter, where there is a claim involving a mental abnormality, such as propensity towards violence, it is virtually impossible for the defense to succeed without using an expert witness.[268] If biobased evidence becomes the norm, courts, public defenders' offices, and Legal Aid offices could be confronted with difficult decisions about whether or not to use this costly type of evidence.[269] This could become especially problematic where the prosecution introduces biobased evidence as an aggravating factor, and the defense is forced to hire an expert who is qualified to rebut that evidence and possibly collect its own biobased evidence.

But this situation is not without a solution. In *Ake v. Oklahoma*,[270] the Supreme Court acknowledged the unfairness

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Riley v. California, 134 S. Ct. 2473, 2484 (2014) (citing Wyoming v. Houghton, 526 U.S. 295, 300 (1999)). That test considers whether the degree to which the search intrudes upon privacy is less than the degree to which the search is needed for a legitimate government interest, such as public safety. *Id.*

265. *See Brain MRI (with and without contrast)*, HEALTHCARE BLUEBOOK (Mar. 26, 2017, 2:10 PM), https://healthcarebluebook.com/page_ProcedureDetails.aspx?id=136&dataset=MD (estimating total fair price of MRI procedure to be $1,156).

266. Walker, *supra* note 72, at 1803.

267. *Id.* at 1804 (referencing email correspondence between the author and expert of neuroscience and psychopathy, Kent A. Kiehl).

268. *See* Stephen J. Morse, *Preventive Detention: Mental Disorder and Criminal Law*, 101 J. CRIM. L. & CRIMINOLOGY 885, 905 (2013) ("Although either the defense or prosecution can succeed with or defeat a claim involving mental disorder without using expert witnesses, as a practical matter it is extremely difficult and perhaps impossible for the defense.").

269. *See* GREELY, *supra* note 191, 142.

270. Ake v. Oklahoma, 470 U.S. 68 (1985).

that can result when indigent offenders are faced with the prospect of rebutting expert mental health evidence.[271] For that reason, the Court held that convicted parties are entitled to a psychiatric expert when the prosecution introduces psychiatric evidence of dangerousness,[272] and held more generally that a defendant is entitled to a psychiatrist's assistance if his sanity at the time of the offense is likely to be a significant factor and the defendant cannot afford an expert.[273] This case implies that before biobased evidence of future dangerousness can be admitted for consideration at trial, courts must be prepared to offer financial support to indigent defendants who need to hire an expert to address the question of future dangerousness.[274]

3. Privacy Violations

People have a tendency to think of their brains and their genes as defining features of themselves: a unique part of them that makes them different from every other person. The use of a person's brain or genes in the courtroom may raise objections about the use of personal information, akin to exposing personal thoughts and secrets. Gathering data from a person's brain and genes could be deemed an interference with personhood. Using that data to predict not only a person's likelihood to recidivate, but also to predict whether treatment would be effective would raise issues that states have not yet tackled.[275] Thus, in addition to needing to assure the validity of biomarkers, states must also consider the use of biodata as a policy matter. It is likely that the different states will treat this issue differently, depending on the

271. *Id.* at 76.

272. *Id.* at 86–87.

273. *Id.* at 74. Entitlement to an expert only applies in criminal trials, so offenders subject to civil commitment proceedings would not necessarily have access to this assistance, although courts could theoretically extend the rule.

274. The need to provide this type of assistance would undoubtedly add costs to the legal system. However, if biodata can vastly improve the prediction scheme, such that fewer innocent people are deemed to be dangerous and more dangerous people are correctly identified, those costs would be justified by the increase in fairness of the predictive system.

275. *See* Roskies, *supra* note 10, at 248 ("[T]reatment for many offenders is likely to affect things as deeply ingrained as one's personality, temperament, beliefs, and values. This may raise deep issues about the State's interference in a citizen's personhood and identity, which are issues that the legal system in general and the criminal law in particular have seldom had to face thus far.").

current treatment of predictions of future dangerousness[276] and judicial and legislative goals of treatment programs.[277]

In the future, biodata could potentially become so advanced that it could be used to identify people who are dangerous before they commit any crime and place them in preventative treatment.[278] This use of biodata would probably raise the question of whether the state has the power to do this to ensure public health despite the invasiveness. The dangers to privacy and liberty would be immense if the state were able to do this. Courts have already held that it is unconstitutional to punish an individual based on status alone (here, that status would be dangerousness).[279] The Court has emphasized that more than dangerousness must be proven before a person is committed.[280] The use of biodata in this way would be equivalent to punishing for dangerousness alone, provided that the treatment for the identified biomarkers is considered punishment. But what if the treatment is not considered punitive? Dangerous and responsible individuals who have not yet committed an offense "fall into a gap between desert and disease," and society is constantly trying to fill in this gap by expanding both desert jurisprudence (e.g.,

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276. For example, Kansas and Texas courts prefer the use of predictions of future dangerousness, even where the reliability of those predictions is questionable. *See* Kansas v. Hendricks, 521 U.S. 346, 358 (1997) (upholding the statute's requirement of a finding of future dangerousness for civil commitment of sexually violent predators); Jurek v. Texas, 428 U.S. 262, 276 (1976) (upholding the constitutionality of the use of dangerousness as an aggravating factor in capital cases). *See also* TEX. CRIM. PROC. CODE ANN. art. 37.071 (West) (requiring consideration of future dangerousness in capital sentencing).

277. Some courts have stated that if a person is to be committed for dangerousness, that person should be entitled to treatment aimed at rehabilitation. For those states that have emphasized the importance of treatment, the use of biodata for treatment interventions would probably only be allowed where there is a high likelihood of treatment success.

278. However, some researchers argue that biomarkers will never, on their own, be able to predict future dangerousness. *See* Ilina Singh & Nikolas Rose, *Biomarkers in Psychiatry*, 460 NATURE 202, 205 (2009) ("[I]nformation about a biomarker can help to build a risk profile for a particular condition of set of behaviours. But biomarkers alone, taken out of context of environmental influences, are unlikely ever to provide complete explanations for children's behavior or a forecast of how children's lives will unfold. Biology is not destiny: biology provides information about potentials.").

279. *See* Robinson v. California, 370 U.S. 660, 667 (1962) (holding unconstitutional a statute that made the status of being an addict a criminal offense).

280. *See* Foucha v. Louisiana, 504 U.S. 71, 84 (1992) (holding a person cannot be committed for dangerousness alone).

enhancing sentences for recidivists) and disease jurisprudence (e.g., involuntary commitment of mentally abnormal sexually violent predators).[281] The Court has historically been accepting of states' attempts to close this gap.[282] Thus, it is not unfeasible that the Court may one day be receptive to a treatment program for dangerous persons who have not yet committed a violent crime but who are likely to do so. In upholding this type of program, the Court may also reason that the police power of the state to ensure public health is broad.[283] If neuroscience progresses sufficiently to permit successful screening and rehabilitation in treatment, the courts will need to weigh the value of individual liberty against societal safety, considering, among other things, moral considerations.

One situation where this "screen and intervene" approach may not be as disputed is the use of genetic testing for the MAOA and SLC6A4 gene (and any other genes that are identified as being part of a G x E interaction where the environment is childhood maltreatment). Society has already determined that childhood maltreatment is always immoral and often illegal.[284] If some genetic markers are confirmed to predispose children in abusive environments to violence, child protection services should consider prioritizing the removal of these children from abusive environments. If analysis of the cost-benefit ratio determines that the cost of prioritizing some children over others is overcome by

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281. *See* Roskies, *supra* note 10, at 254.

282. *See* Ewing v. California, 538 U.S. 11 (2003) (upholding California's "three strikes law," which requires that a defendant who is convicted of a felony and has previously been convicted of two or more serious or violent felonies receive an indeterminate life imprisonment term). *See generally Hendricks*, 521 U.S. 346 (upholding Kansas' statute permitting involuntarily commitment for mentally abnormal sexual predators).

283. A program for the treatment of dangerousness could be analogized to the measures used to contain and treat seriously dangerous and contagious diseases. Consider the treatment protocol for persons traveling from Africa into the United States during the Ebola crisis of 2014. *See* Josh Voorhees, *Are Quarantines Really Legal?: The Rules and Regulations on Confining People Who've Been Exposed to Ebola*, SLATE (March 23, 2017, 2:45 PM), http://www.slate.com/articles/health_and_science/politics/2014/10/ebola_quarantines_can_the_government_really_quarantine_sick_people_without.html (discussing the forced quarantine of citizens who were potentially in contact with Ebola as an exercise of the state's power to protect public health).

284. *See* Baum & Savulescu, *supra* note 151, at 20 ("The UN Convention on Rights of the Child specifies that no child should experience maltreatment. Following this belief, many societies have established structures and social services to minimize the occurrence of maltreatment.").

the benefit of decreasing future violence in society, then this scheme may be approved and used.[285]

4. Discriminatory Effects

Biobased evidence could be used for discriminatory purposes. It is critical to be sure that each biomarker is not being used as a proxy for race. One study explicitly acknowledged that "more African-Americans carry the long allele [of the SLC6A4 gene] than European-Americans."[286] Further research will have to be conducted to ensure that the use of this gene is not simply a proxy for race. The identification of these biomarkers could also open the door for discrimination outside of the legal context. It is possible that employers, insurers, and the like could begin to use this evidence to discriminate against applicants. A person with the MAOA gene may be considered to be higher risk, and thus be denied for certain jobs or forced to pay higher car and health insurance. In reality, insurers and employers already use some biobased evidence (e.g., life insurance companies often require blood samples for disease testing before issuing a policy). If biobased evidence is considered non-testimonial,[287] insurers and employers may easily be able to obtain and utilize this type of information, as it would be considered just another physical risk factor to consider in policy assessment.

5. Moral Implications

Whether biodata is ultimately used to predict dangerousness of a person who has not previously committed a crime or to increase a person's insurance premium as high-risk, we must query whether, as a society, we can accept the use of factors that are out of our control to discriminate among us. Even though our current tools are less than chance at predicting future dangerousness, it is true that those tools can allow for us to speak for ourselves – to answer "no" when a judge asks if we are going to commit the same crime again. The use of biodata could potentially make our chosen

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285. For more discussion of this potential approach, *see id.* at 20–21.

286. Sadeh, *supra* note 163, at 5 (citing J. Gelernter, Henry Kranzler & Joseph F. Cubells, *Serotonin Transporter Protein (SLC6A4) Allele and Haplotype Frequencies and Linkage Disequilibria in African and European American and Japanese populations and in alcohol dependent subjects*, 101 HUM. GENETICS 243 (1997)).

287. *See supra* Part V.C.1.

expressions irrelevant, and allow our biological makeup to speak for us, threatening to eliminate the value of free will.

Our criminal system today is premised on the idea of free will—the understanding that we as humans have choices in our actions, and thus, we can be held accountable for those choices.[288] Traditional moral philosophers argue that an actor is only responsible for bringing about an event if, with respect to a given act, she could have acted otherwise, that is, she chose to act based on her free will.[289] The possibility that modern science could debunk the assumption that an individual's behavior is her own choice is threatening to this reliance on free will.[290] For instance, the moral reasoning behind retribution, i.e. an eye for an eye, may seem less fair if we believe that the person did not choose to commit a crime, but rather, he had no choice because of the way he was born.[291] A judge or a juror may feel less comfortable imposing a harsh sentence on a person if they think that the person simply drew the short stick in the gene pool as opposed to voluntarily choosing to commit the crime.

This question of whether it is morally acceptable to punish a person who has "bad genes" will surely spark debate among scholars. Some scholars argue that even if science could tell us that our biology causes our behavior, that should not affect the rule that those who commit criminal acts deserve to be punished. Morse argues that the tendency to take biological determination as meaning that no one deserves punishment stems from the error of thinking that "causation of behavior is per se an excusing

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288. Hippard, *supra* note 6, at 1043. *See also* Bechara & Burns, *supra* note 7, at 263.

289. Richard C. Boldt, *Construction of Responsibility in the Criminal Law*, 140 U. PA. L. REV. 2245, 2254 (1992); s*ee also id.* at 2304 ("The legal model . . . assumes that human actors possess the capacity to choose to engage in or refrain from untoward conduct.").

290. David Eagleman, *The Brain on Trial*, THE ATLANTIC (March 26, 2017, 3:00 PM), http://www.theatlantic.com/magazine/archive/2011/07/the-brain-on-trial/8520 (explaining how our newfound understanding of science disturbs our historical understanding of criminal behavior and assignment of blame).

291. *See* Greene & Cohen, *supra* note 4, at 1776, 1784 ("Freewill as we ordinarily understand it is an illusion generated by our cognitive architecture. Retributivist notions of criminal responsibility ultimately depend on this illusion, and, if we are lucky, they will give way to consequentialist ones, thus radically transforming our approach to criminal justice."). *See also* Luis E. Chiesa, *Punishing without Free Will*, 2011 UTAH L. REV. 1403, 1409 ("[B]laming other people for their sins and crimes loses meaning in a world without freewill");

condition."[292] In other words, the fact that an individual's criminal behavior is rooted in his biology does not mean that he is any less immoral or that it would be unfair to punish him for his evil acts. Other scholars believe that the notions of free will and determinism are compatible, allowing for the possibility of freely willed action even if all our actions are fully determined by natural laws and remote events in the past.[293] Some have even made a distinction between "free will" and "freedom of action," arguing that the reason why a person desires to do something is distinct from that person's choice to act on his desire.[294] Thus, while the introduction of biobased evidence could suggest that a person's biology and not his free will is the cause for his actions, it can still be compatible with our morals to punish or reward that person for the behavior he chooses.

VII. CONCLUSION

Biobased evidence is not yet ready to be used in the legal context for dangerousness predictions, but it is only a matter of time before it will be, and should be, admitted.[295] The Aharoni,

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292. Stephen J. Morse, *Determinism and the Death of Folk Psychology: Two Challenges to Responsibility from Neuroscience*, 9 MINN. J.L. SCI. & TECH. 1, 18 (2008).

293. *See, e.g.*, Anders Kaye, *The Secret Politics of the Compatibilist Criminal Law*, 55 KAN. L. REV. 365, 374–79 (2007) (describing compatibilist accounts of freewill); Harry Frankfurt, *Freedom of the Will and the Concept of a Person*, 68 J. PHIL. 5 (1971) (Frankfurt's "hierarchical mesh theory of free will" argues that a person acts freely so long as acts on the basis of a desire that suitably "meshes" with other elements of her psychology. For example, an addict acts freely when she chooses to take drugs based on a pathological impulse to take drugs.).

294. Nita A. Farahany, *A Neurological Foundation for Freedom*, 2011 STAN. TECH. L. REV. 11, at ¶ 29 (explaining the difference between 'free will' and 'freedom of action,' using a food-related example: "One may have little to no control over whether they crave chocolate cake. But that craving (freedom over preferences, desires and dispositions) is distinct from the action choices to purchase chocolate cake, to delve their fork into that cake, and to eat their chocolate cake (freedom of action). If a person acts in the manner he desires and moves with a will that is his own at a time, then he acts freely and at least in some sense has freedom, irrespective of whether he also acts with freedom of will." (citing Eleonore Stump, *Intellect, Will, and the Principle of Alternate Possibilities*, *in* PERSPECTIVES ON MORAL RESPONSIBILITY 244–25 (John Martin Fischer & Mark Ravizza eds., 1993)). *See also* Nita A. Farahany & James E. Coleman Jr., *Genetics and Responsibility: To Know the Criminal from the Crime*, 69 L. & CONTEMP. PROBS. 115, 135–38 (2006).

295. Because predictions only require the showing of a correlation between a marker and a behavior, and not a theory behind this correlation, the use of

Pardini, and Caspi studies are promising in that they show a possibility for using neural and genetic markers to predict future dangerousness. These studies should be replicated in order to better determine their validity and legal implications. Additionally, as more possible biomarkers are identified, they should be tested in a similar way to determine their usefulness in dangerousness predictions. In addition to replicating these studies, sensitivity (i.e., the true positive rate, measuring the proportion of actual positives which are correctly identified as such) must also be addressed. The studies of currently identified biomarkers do not satisfy the sensitivity required for use in the law.[296] However, if society decides that it would prefer to treat an innocent person than to let a dangerous person go free, then sensitivity may not be as prominent of a concern as some critics suggest. Even if we decide we are not concerned with sensitivity, the reliability of biomarkers must be established before they can be used as evidence.

As soon as biobased evidence is shown to be reliable,[297] it should be considered in dangerousness predictions as an additional risk factor in the current prediction scheme and assigned the appropriate weight as determined by studies for each biomarker. Biomarkers could easily be incorporated into any of the three existing prediction tools—clinical judgments, actuarial risk assessments, or structured professional judgments. Either the prosecution or the defense, depending on state law, could use biobased evidence to show a likelihood of future dangerousness. Where the prosecution introduces biobased evidence, states must be prepared to provide indigent defendants with an expert.

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biobased evidence for prediction is more likely to happen before the use of this evidence for responsibility determinations. The use of biobased evidence for responsibility determinations would require a theory behind the correlation, e.g., this region of the brain (or this gene) causes this behavior. Our current knowledge suggests that we are not as close to finding these types of associations as we are to finding the correlations required for prediction.

296. *See* Lippert-Rasmussen, *supra* note 116, at 135 (the common shape of biobased predictions is that "the presence of a certain neural correlate increases the risk-often from a low base rate-that the offender will engage in the relevant kind of criminal activities in the future relative to its absence, but that many people who do not have the relevant neural correlate engage repeatedly in the relevant kind of crime and where many people who do have the relevant kind of neural correlate never engage in the relevant kind of crime.").

297. *See* Brent Garland, *Monitoring and Imaging the Brain*, *in* NEUROSCIENCE AND THE LAW: BRAIN, MIND, AND THE SCALES OF JUSTICE 7, 13 (Brent Garland, ed., 2004) ("While 'sound science' is the optimal criterion, it is not essential for predictive technologies to be 100% accurate (a level of accuracy unlikely ever to be achieved) to be declared of use to the court system.").

Evidentiary concerns will be higher, for example, for capital punishment than for diversion programs.[298] Because of these evidentiary concerns and financial costs, states may have to look to policy considerations when determining when and how to use this type of evidence.

When biomarkers are admissible under *Daubert* and Rule 702, it is still imperative to assure that the probative value of the evidence is not substantially outweighed by any prejudice it could cause. Critics understandably fear that jurors will place too much weight on biobased evidence because of its scientific appearance. Courts can overcome this possible prejudice by either ensuring through jury instructions that jurors are discouraged from this behavior, or alternatively, allowing experts to testify only based on the evidence without introducing the biobased evidence itself. In addition to warning the court and jury about the potential biases, experts themselves should be careful not to assign more weight than is deserved to biobased evidence.[299] The gatekeeper concern is that experts will overpredict an offender's dangerousness so as to avoid being responsible for letting a dangerous person back into the community. However, this concern exists in the current state of the law, and introducing biobased evidence would likely not exacerbate it so long as experts are careful to not assign extra weight to scientific evidence.

Morals inform the widespread belief that punishing a person for their biological make-up alone would be akin to punishing a person for desiring to do something criminal, but not acting on it. Just as we do not punish people for guilty minds, we should not punish people for a genetic make-up or brain activity. In either case, it is not until the person acts on those inner desires that he or she deserves to be punished. For that reason, biobased evidence should be used only in situations where a person has already committed a crime to determine things such as that person's rehabilitative potential or sentence.

Today, biobased evidence serves as additional proof of what is already known behaviorally. One day, biobased evidence might

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298. *See* Morse, *supra* note 269, at 944 ("Despite the Supreme Court's willingness to accept admittedly inaccurate predictions in Barefoot, one would hope that an extremely high level of accuracy would be required before increasing a sentence or putting a capital offender to death on the basis of a dangerousness prediction.").

299. *See* Stephen J. Morse, *Preventative Confinement of Dangerous Offenders*, 32 J.L. MED. & ETHICS 56, 59 (2004) ("The incentive structure predisposes the gatekeepers in cases involving danger to over-predict.").

become "as *de rigueur* a form of forensic evidence as DNA evidence is today."[300] Given the progress of scientific evidence over the past decades, the question thus seems to be *when* biobased evidence can be used, rather than *if* it can be.

300. Roskies, *supra* note 10, at 243.