MAPPING THE BRAIN TO PREDICT ANTISOCIAL BEHAVIOUR: NEW FRONTIERS IN NEUROCRIMINOLOGY, 'NEW' CHALLENGES FOR CRIMINAL JUSTICE

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Abstract: Neuroscientific research on the relationship between neurobiology and antisocial behaviour has grown exponentially over the last two decades. One of the most intriguing challenges that has started occupying the minds of scientists and legal scholars is the potential use of neuroscience-based methodology to predict future antisocial behaviour in forensic and justice contexts. While neuroprediction holds the promise of adding predictive value to existing risk assessment tools, its hypothetical use for forensic and justice purposes touches on some specific ethical and legal issues, in particular the threat it poses to offenders' individual rights and civil liberties under the pretext of enhancing public safety. This article provides some arguments for overcoming these concerns. More importantly, it argues that neuroprediction should be viewed as an instrument to help criminal justice integrate current punitive policies and measures with socio-rehabilitative strategies, which could improve the treatment of offenders at risk without threatening their individual rights.

A. INTRODUCTION

One of the most crucial – albeit difficult and controversial – tasks of criminal justice is making predictions. Apart from assessing the criminal responsibility of offenders, criminal courts are also required to make prognostics, which are required to decide a variety of issues, eg whether an offender meets the conditions that merit parole; whether an offender will successfully complete a probation programme; or whether an offender is to undergo specific treatment. Among the criteria that underpin these decisions, criminal courts must consider how probable it is that the relevant offender will engage in criminal conduct in the future; that is, how at risk they are and how likely it is that they recidivate. Criminal justice thus makes predictions based on criminal behaviour risk assessments,[1] on the basis of what is known about the relevant offender, or based on what can be learned from pre-existing available data on other similar offenders.

Notwithstanding the systematic use of either clinical or actuarial[2] risk assessment tools in forensic and justice settings, the accuracy and reliability of these methodologies in

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[1] Risk assessment is an assessment of the probability of reoffending. It is not meant to provide certainty as to whether or not a relevant offender will (re)engage in criminal conduct in the future.

[2] Clinical assessments rely on the judgement of a psychiatrist or a psychologist about an individual's likelihood of engaging in future antisocial behaviour based on specific personality traits or impairments – eg deficits in impulse control – which appear to be positively correlated with the tendency to engage in antisocial behaviour.

predicting future antisocial behaviour is questioned.[3] Predictions of antisocial behaviour can have significant repercussions on the individual rights and public safety of offenders, so it is essential that prediction methodologies be as accurate and reliable as possible. Thus, the development of more powerful predictive tools is crucial.

Over the past two decades, research in the neurosciences, and particularly neurocriminology, has started to explore neurobiological markers that appear to correlate to an individual's predisposition to engage in antisocial behaviour. Notably, research in neurocriminology has identified specific brain features – both structural and functional – that seem to be consistently associated with antisocial traits featuring specific categories of offenders, such as murderers and child abusers. According to neurocriminologists, the detection of neurobiological traits that are associated with specific antisocial tendencies might well be used to increase the accuracy of calculating an individual's likelihood of both offending and recidivating, and thus of predicting and preventing criminal behaviour. Although neuroscientific methods for assessing future antisocial behaviour risks remain mostly in the research stage and are far from being applied in practice, there is evidence to suggest that neuroscience could become a useful and valid prediction tool in forensic and justice settings.

Predicting dangerousness via neurobiological markers implies some challenges for criminal justice. On the one hand, it might have beneficial effects on forensic and justice workings. If the discovery of neurobiological risk factors of antisocial behaviour offers additional variables to be considered in dangerousness evaluations, this could help improve the accuracy of recidivism assessments. As has been noted, if neurobiological markers can reliably boost the accuracy of criminal behaviour predictions, 'it could be viewed as ethically questionable *not* to use such knowledge'.[4]

By contrast, actuarial or statistical assessments assign an individual to a particular group, based on the characteristics he shares with members of that group, and calculate the risk of (re)offending by the rate of (re)offending in that group. A hybrid version of the clinical and actuarial approaches is the so-called structured clinical assessment, in which a clinician administers structured tests, but he can manipulate the results according to his judgement on the concrete case. For detailed explanations, see Jarrod Brown and Jay Singh, 'Forensic risk assessment: A beginner's guide' (2014) 1(1) Archives of Forensic Psychology 49; Jay Singh and Seena Fazel, 'Forensic risk assessment: A metareview' (2010) 37(9) Criminal Justice and Behavior 965.

[3] See, for example, Scott Vrieze and William Grove, 'Multidimensional assessment of criminal recidivism: Problems, pitfalls, and proposed solutions' (2010) 22(2) Psychological Assessments 382; Seena Fazel et al, 'Use of risk assessment instruments to predict violence and antisocial behaviour in 73 samples involving 24 827 people: systematic review and meta-analysis' (2012) BMJ 345:e4692; Tom Douglas et al, 'Risk assessment tools in criminal justice and forensic psychiatry: The need for better data' (2017) 42 European Psychiatry 134.

[4] Andrew L. Glenn and Adrian Raine, 'Neurocriminology: Implications for the Punishment, Prediction and Prevention of Criminal Behaviour' (2014) 15 Nature Reviews Neuroscience 54.

On the other hand, the possibility of predicting dangerousness via neurobiological markers raises a number of ethical and legal issues concerned with potential violations of specific offenders' individual rights and civil liberties. These issues include the potential discrimination and stigmatization of offenders based on their 'neurobiological profile', procedural and constitutional rights violations (eg violation of the privilege against self-incrimination), and criminal policy matters (eg the dividing line between criminal responsibility and social dangerousness).

In view of these contrasting but equally important interests, several questions arise: How should a criminal justice system respond to the potential use of neurocriminology to predict antisocial behaviour? Assuming a day in which neuroprediction will be reliable enough to be used to assess an offender's likelihood of future dangerous behaviour, should criminal justice adopt or prohibit it? If criminal justice allows for neuroprediction, how could it be used to improve its workings? And how should criminal justice balance the individual rights and public safety of offenders in the face of these scientific advances?

The aim of this article is to explore these questions and to make some suggestions on how criminal justice could make a profitable yet cautious use of neuroscientific techniques to predict antisocial behaviour in forensic and justice settings. Section B overviews briefly some neurocriminological literature on the neurobiological underpinnings of specific antisocial traits. Section C analyses selected neuroprediction studies on future reoffending and treatment programmes. Section D illustrates some of the ethical and legal issues that have been raised against the use of neuroprediction for forensic and justice purposes. Section E provides some arguments for overcoming said ethical and legal issues, and offers an approach by which neuroprediction could become a steady tool to assist criminal justice in evaluating offenders' risk of future criminal behaviour. In particular, it argues that neuroprediction might foster the implementation of alternative individualized sentences tending to offenders' actual social rehabilitation and social reintegration. Notably, neuroprediction could assist criminal justice systems to integrate current punitive policies and measures with socio-rehabilitative strategies, which could ultimately improve crime prevention and public safety without undermining the individual rights of offenders.

B. NEUROBIOLOGY AND ANTISOCIAL BEHAVIOUR:
INSIGHTS FROM NEUROCRIMINOLOGY[5]

The central role of the brain and (neuro)biomarkers of antisocial behaviour has regained momentum in criminological research in recent decades. The quest for the neurobiological underpinnings of antisocial traits forms the subject of investigation of neurocriminology, a specific branch of neuroscience studying the interactions between brain, genes, environment, and individual predispositions to antisocial tendencies. While it is not in doubt that there is no definitive (neuro)biology of criminal behaviour, neurocriminologists suggest that there is neurobiology with respect to specific forms of dysfunction that increase the propensity for offending behaviour.

Many studies have been undertaken to examine whether the structure and functionality of the brain are correlated with different types of antisocial behaviour. These studies have been made possible with the availability of advanced functional and structural neuroimaging techniques, such as voxel-based morphometry (VBM), positron emission tomography (PET), magnetic resonance imaging (MRI) and functional MRI (fMRI).[6] While there is at present no evidence to prove that criminal behaviour results from brain vulnerabilities, there are good reasons to believe that some neurobiological features (coupled with environmental factors) may predispose an individual to antisocial tendencies. To illustrate, neurocriminologist Adriane Raine[7] suggests that specific structural or functional disruptions in brain regions that are involved in socio-emotional abilities may underlie specific cognitive and emotional impairments considered to be risk factors for antisocial behaviour.[8] On this point, Raine explains that amygdala[9] impairments may underlie poor fear conditioning. Poor fear conditioning can impair 'emotional responses that motivate

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[5] Research conducted in this section is part of this author's doctoral dissertation. See Federica Coppola, *The moral brain and the guilty mind: Towards an emotion-oriented theory of culpability informed by the neuroscience of moral decision-making and antisocial behavior*, Cadmus EUI Research Repository, <http://cadmus.eui.eu//handle/1814/46848> accessed 30 June 2017.

[6] Neuroimaging, or brain imaging, refers to noninvasive techniques that produce images of the structure and functionality of the brain. Although still relatively young, the field of neuroimaging has rapidly advanced to become a powerful tool for both research and medical diagnosis. For an overview, see Silvia Bunge and Itamar Kahn, 'Cognition: An overview of neuroimaging techniques' (2009) 2 Encyclopedia of Neuroscience 1063.

[7] Adriane Raine, 'From genes, to brain, to antisocial behaviour' (2008) 17(5) Current Directions in Psychological Science 323.

[8] ibid, Table I, 325.

[9] The amygdala is an almond-shaped brain region located in the limbic system. By and large, the amygdala is responsible for both emotional evaluation of and emotional responses to of external stimuli, and is a crucial component of the neurocircuitry involved in empathy, emotional learning, and prosocial behaviour. See, eg, Michael Numan, *Neurobiology of prosocial behavior: Towards an understanding of the prosocial and antisocial brain* (Elsevier, 2015) ch 7; Jean Decety, 'The neurodevelopment of empathy in humans' (2010) 32 Developmental Neuroscience 257; John Morris et al, 'Conscious and unconscious emotional learning in the human amygdala' (1998) 393 Nature 46.

individuals to desist from previously punished behaviour',[10] and poor emotional responses can, in turn, predispose certain individuals to antisocial behaviour.

Neurocriminological research has generally focused on the neurobiological correlates of personality disorders featured by stable antisocial conduct, such as psychopathy[11] and Antisocial Personality Disorder (ASPD).[12] These studies have been conducted on both adult and young offenders.[13] Interestingly, a growing body of research shows that many common traits among this particular antisocial population – callousness or lack of inhibition, for instance – share common neurobiological bases. These common bases mainly include abnormalities occurring either singularly or in the interaction between cortical and subcortical areas involved in emotion processing and emotion regulation. In particular, both structural and functional alterations in specific regions of the Prefrontal Cortex (PFC),[14] namely the Orbitofrontal Cortex (OFC)[15] and Ventromedial Prefrontal Cortex (VmPFC),[16] on the one

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[10] Raine (n 7) 324.

[11] Psychopathy is a developmental disorder featured by severe emotional deficits. Because of these deficits, psychopaths tend to engage in persistent antisocial behaviour, and are hyper-aggressive, predatory, and recidivistic. Psychopathy, on the other hand, is not officially recognized as a personality disorder. It is not even included in the DSM-5 (Diagnostic and Statistical Manual of Mental Disorders, fifth edition), nor is there a unanimous opinion among psychiatrists and psychologists as to whether psychopathy should be qualified as a personality disorder at all. Attempts to define psychopathy as an autonomous kind of personality disorder and provide specific items to identify it have been made primarily by Dr. Robert Hare, who authored the Psychopathy Checklist Revised in 1990. As described in the checklist, psychopathy would encompass traits typical to both ASPD (eg lack of impulse control) and NPD (eg grandiose sense of self-worth). See Robert Hare et al, 'The Revised Psychopathy Checklist: Reliability and factor structure' (1990) 2(3) Psychological Assessment: A Journal of Consulting and Clinical Psychology 338.

[12] The Antisocial Personality Disorder is a DSM-5 diagnosis assigned to individuals who exhibit a pervasive pattern of disregard for the rights of other people that often manifests as hostility and/or aggression. Deceit and manipulation are also central features.

[13] The neuroscientific literature on psychopathy and ASPDs is extremely wide. See, *inter alia*, Adriane Raine, *The anatomy of violence. The biological roots of crime* (Pantheon Books 2013); Kent Kiehl and Walter Sinnott-Armstrong (eds), *Handbook on psychopathy and law* (OUP 2013); Kent Kiehl et al, 'Limbic abnormalities in affective processing by criminal psychopaths as revealed by functional magnetic resonance imaging' (2001) 50 Biological Psychiatry 677; James Blair, 'Neurological basis of psychopathy' (2003) 182 The British Journal of Psychiatry 5; James Blair, 'Responding to the emotions of others: Dissociating forms of empathy through the study of typical and psychiatric population' (2005) 14 Consciousness and Cognition 698; Yaling Yang et al, 'Morphological alterations in the prefrontal cortex and the amygdala in unsuccessful psychopaths' (2010) 119(3) Journal of Abnormal Psychology 546; Sarah Gregory et al, 'Punishment and psychopathy: a case-control functional fMRI investigation of reinforcement learning in violent antisocial personality disordered men' (2015) 2(2) The Lancet Psychiatry 153; Moji Aghajani et al, 'Dissociable elations between amygdala subregional networks and psychopathy trait dimensions in conduct-disordered juvenile offenders' (2016) 37 Human Brain Mapping 4017; Robert James R. Blair, 'The neurobiology of psychopathic traits in youths' (2013) 14(11) Nature Review Neuroscience 786; Adriane Raine et al, 'Corpus callosum abnormalities in psychopathic antisocial individuals' (2003) 60(11) Archives of General Psychiatry 1134.

[14] The prefrontal cortex (PFC) is the most anterior region of the brain, specifically located in the frontal lobes along with motor and premotor cortices. It includes three main subregions, ie medial–frontal (MFC), orbital–frontal (OFC), and dorsolateral prefrontal (DLPFC), which have different relevance for decisional, emotional and behavioural tasks. For a good explanation on the structure and functioning of PFC, see Joshua J. Knabb et al, 'Neuroscience, moral reasoning and law' (2009) 27 Behavioral Sciences & the Law 219.

[15] See, *inter alia*, Edmund Rolls, 'The functions of the orbitofrontal cortex' (2004) 55 Brain and Cognition 11.

hand and the limbic structures, in particular the amygdala, on the other, appear to have significant and consistent links to antisocial phenotypes, combined also with genetic and environmental factors.[17]

Impairments in these brain areas would explain why patients affected by these types of personality disorders usually show callousness and lack of empathy, as well as deficits in using emotional information to regulate their behaviour. In fact, a much-supported hypothesis emerging from these studies is that those who lack insight into their moral emotions and emotion-related capacities (eg capacity for empathy)[18] are less inhibited in violating the rights of others. For instance, injury to the VmPFC and the Anterior Cingulate Cortex (ACC), which are critical in emotion processing as well as in behavioural motivation and regulation through cognitive and affective mechanisms, have been linked to the onset of reckless and antisocial behaviour without remorse.[19] Importantly, as one study highlights, '[w]ithout the restraint of intuitive moral emotions and self-other conjoining', patients 'may not be able to deter an impulse to act in an unacceptable manner, even as they know right and wrong and understand the nature of their acts.'[20] This means that even if subjects with these dysfunctions are able to verbally state what they should do in a given moral situation, they choose to act differently as they are often unable to control their antisocial impulses.[21]

Apart from psychopaths and ASPD patients, neurocriminological research also provides useful data about sex offenders. Chen et al, for instance, have investigated brain abnormalities in rapists.[22] Their study indicates that rapists exhibit abnormalities in white matter connectivity in brain regions involved in reward, motivation, and moral judgements. These findings suggest that said abnormalities underlie rapists' predisposition to over-

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[16] See, *inter alia*, Wouter van den Boss and Berna Guloglu, 'The role of the ventral medial prefrontal cortex in social decision-making' (2009) 29(24) Journal of Neuroscience 7631.

[17] As is well known, the brain is not static but constantly subject to change over time, experiences, traumas, and the like. Its mechanisms are proximal mechanisms and do not imply immutability in the sense that they are likely shaped by an interaction of environmental and biological processes over the course of development. Neuroscientists call this phenomenon 'neuroplasticity'. See Alvaro Pascual-Leone et al, 'The plastic human brain cortex' (2005) 28 Annual Review of Neuroscience 377.

[18] See Robert James R. Blair and Karina Blair, 'Empathy, morality, and social convention: Evidence from the study of psychopathy and other psychiatric disorders', in Decety and Ickes (eds) *The Social Neuroscience of Empathy* (MIT Press 2009) ch11; Richard Davidson et al, 'Dysfunction in the neural circuit of emotion regulation' (2000) 289 Science 591.

[19] See, for example, Michael Koenigs, 'The role of prefrontal cortex in psychopathy' (2012) 23(3) Reviews in the Neurosciences 253; Julian Motzkin et al, 'Ventromedial prefrontal cortex is critical for the regulation of amygdala activity in humans' (2015) 77(3) Biological Psychiatry 276.

[20] Mario Mendez, 'The neurobiology of moral behavior: Review and neuropsychiatric implications' (2009) 14(11) CNS Spectrums 608.

[21] See Richard Redding, 'The brain-disordered defendant: Neuroscience and legal insanity in the twenty-first century' (2006) 56(1) American University Law Review 51, 78.

[22] Chiao-Yun Chen et al., 'Abnormal White Matter Integrity In Rapists As Indicated By Diffusion Tensor Imaging' (2016) 17 Bmc Neuroscience 45.

responsiveness to sexual reward stimuli, as well as poor moral decision-making. Other studies focused on paedophilic sex offenders. By and large, these studies outline that men who have committed sex offences against children exhibit either structural or functional alterations in frontal, temporal, and limbic lobes,[23] all of which involve both affective and cognitive functions, and in turn may entail abnormal sexual arousal patterns.[24]

It is interesting to note that findings so far suggest that a considerable number of antisocial traits among different types of antisocial subjects are associated with dysfunctions in the same socio-emotional circuits that are positively correlated with moral judgements and decision-making.[25] In fact, the line of investigation into the neural correlates of moral decision-making highlights that emotions and emotional faculties play an influential role in moral decision-making, and crucially contribute to moral and prosocial behaviour. This would confirm the view increasingly shared in criminological theory[26] that criminal behaviour is not the result of cold and calculating reasoning, but significantly influenced either by anomalies or by imbalances in the emotional processes responsible for appropriate moral judgements and behaviour.

Furthermore, neurocriminological research embraces the relationship between antisocial behaviour and genetic background. An emblematic example of a single allele that is assumed to have an influence on violent behaviour is the gene encoding the neurotransmitter that metabolizes enzyme monoamine oxidase A (MAOA). Low levels of MAOA (MAOA-L) appear to be associated with the aggressiveness of young boys raised in abusive environments. Interestingly, some studies found that subjects possessing this particular genetic polymorphism also exhibit structural and functional abnormalities in the brain areas and regions known to be involved in emotion processing, emotion regulation and

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[23] See Mario Mendez, 'Paedophilia and temporal lobes disturbances' (2000) 12(1) Journal of Neuropsychiatry and Clinical Neurosciences 71; Giulia Capra et al, 'Current scientific research on paedophilia: A review' (2014) 20 Journal of Psychopathology 17; C. Kargel et al, 'Diminished functional connectivity on the road to child sexual abuse in paedophilia' (2015) 12(3) Journal of Sexual Medicine 783.

[24] See, *inter alia*: Gilian Tenberger et al, 'The neurobiology and psychology of pedophilia: recent advances and challenges' (2015) Frontiers in Human Neuroscience 9, 344; Timm B. Poeppl, 'Connectivity and functional profiling of abnormal brain structures in paedophilia' (2015) 36(6) Human Brain Mapping 2374; Koljia Schitz et al, 'Brain pathology in pedophilic offenders: Evidence of volume reduction in the right amygdala and related diencephalic structures' (2007) 64 Archives of General Psychiatry 737; Alexander Sartorius et al, 'Abnormal amygdala activation profile in pedophilia' (2008) 258(5) European Archives of Psychiatry and Clinical Neuroscience 271; Sebastian Mohnke et al, 'Brain alterations in paedophilia: A critical review' (2014) 122 Progress in Neurobiology 1.

[25] See Adrian Raine and Yaling Yang, 'Neural foundations to moral reasoning and antisocial behavior' (2006) 1(3) Social Cognitive and Affective Neuroscience 203.

[26] See, for example, Michael L. Benson and Tara Livelsberger, 'Emotion, choice, crime', in Cullen and Wilcox (eds), *The Oxford Handbook of Criminological Theories* (OUP 2013) ch 10.

impulse control, such as the OFC and the amygdala.[27] Although this line of research is at a very preliminary stage, evidence from behavioural genetics has been used to reduce sentences in two separate murder cases that occurred in Italy in 2009[28] and 2011.[29]

In summary, neurocriminological research is gradually uncovering the existence of specific brain traits and alterations positively correlated with antisocial behavioural tendencies. Based on this growing body of knowledge, neurocriminology has recently started investigating whether an individual's neurobiological profile can be predictive of future antisocial conduct; that is, whether certain brain structures or activity can provide evidence that an individual has a high tendency to engage in stable criminal conduct. Preliminary studies have so far produced promising results, leading neurocriminologists to envisage the possibility of predicting criminal behaviour through neurobiological markers in the near future. Although research in this field is still in its infancy, it is worthwhile following current studies to see if, and how, these discoveries might be used for forensic and justice purposes.

C. NEW FRONTIERS IN NEUROCRIMINOLOGY: THE NEUROPREDICTION OF ANTISOCIAL BEHAVIOUR

Discoveries on the neurobiological correlates of some types of antisocial behaviour led neuroscientists to take one step further, namely that of investigating whether neurobiological variables can be predictive of an individual's likelihood to (re)engage in antisocial conduct in the future. The hypothesis under investigation is that alterations in particular areas of the brain related to violence, aggression, and impulse control, are indicative of whether an individual is more or less likely to engage in stable and persistent criminal activity. In this section, select neuroprediction studies are used to illustrate how research is currently advancing and its potential for antisocial behaviour predictions.

A study conducted by Aharoni et al in 2013[30] showed that brain activity in the Anterior Cingulate Cortex (ACC) – a brain region crucially involved in impulse control – can

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[27] See, for instance, Nelly Alia-Klein et al, 'Neural mechanisms of anger regulation as a function of genetic risk for violence' (2009) 9(3) Emotion 385; Joshua Buckholtz and Andreas Meyer-Lindenberg, 'MAOA and the neurogenetic architecture of human aggression' (2008) 31(3) Trends in Neuroscience 120.

[28] Court of Appeal of Trieste, 10/18/2009, n. 5. For a comment, see Emiliano Feresin, 'Lighter sentence for murderer with bad genes' (2009) Nature <http://www.nature.com/news/2009/091030/full/news.2009.1050.html> accessed 5 March 2017; Francesca Forzano et al, 'Italian appeal court: a genetic predisposition to commit murder?' (2010) 18(5) European Journal of Human Genetics 519.

[29] See *Gip presso Tribunale di Como* 5/20/2011, n. 536. For a comment, see Barbara Bottalico, 'The Albertani Case in Italy' (2011) Neuroethics & Law Blog, <http://kolber.typepad.com/ethics_law_blog/2011/09/the-albertani-case-in-italy-bottalico.html> accessed 5 March 2017.

[30] Eyal Aharoni et al, 'Neuroprediction of future rearrest' (2013) 110(15) PNAS 6223.

predict which offenders would be rearrested after their release. On this point, some researchers contend that the level of activity within the ACC might provide specific information as to whether a given offender will be rearrested within four years of his release.[31] These results thus suggest that activity in the ACC may be a significant biomarker for persistent antisocial behaviour.

Another predictor of (violent) antisocial behaviour under investigation is the lack of empathy and other moral emotions (for instance, guilt or remorse), which is a typical characteristic of offenders suffering from socio-affective disorders, such as psychopathy.[32] According to Nadelhoffer et al,[33] research on the neurobiological correlates of psychopathy has the potential to provide more reliable models for predicting violent antisocial conduct. Importantly, as Glenn and Raine et al note, the predictive power of said neural variables go 'over and above past history of antisocial behaviour and other confounds'.[34]

In support of this, Pardini et al's 2014 study[35] showed the correlation between reduced amygdala volume and persistent aggression, psychopathic features and increased risk for committing future violence in both young and adult males. More specifically, men with lower amygdala volume exhibited higher levels of aggressive behaviour and psychopathic features from childhood to early adulthood compared with controls. Based on these findings, researchers claimed that amygdala dysfunctions might prove an important biomarker for persistent violence and aggression.

Neuroprediction may also help identify those individuals at the highest risk for committing serious violent offences. Raine et al,[36] for example, investigated prefrontal glucose metabolism in murderers. Their study found lower than average glucose metabolism in the lateral and medial prefrontal cortex of a group of murderers who volunteered to be tested. Although these findings cannot be generalized, they suggest that deficits in the activity in these brain regions may be predictive of one's propensity to violence. Similarly, Cope et al[37] used neuroimaging and VBM to examine and compare grey matter volumes in the medial

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[31] ibid, noting that 'the odds that an offender with relatively low anterior cingulate activity would be rearrested were approximately double that of an offender with high activity in this region, holding constant other observed risk factors'.
[32] See Section B.
[33] Thomas Nadelhoffer et al, 'Neuroprediction, violence, and the law: Setting the stage' (2012) 5(1) Neuroethics 67.
[34] Glenn and Raine (n 4).
[35] Dustin Pardini et al, 'Lower amygdala volume in men is associated with childhood aggression, early psychopathic traits, and future violence' (2014) 75(1) Biological Psychiatry 73.
[36] Adrian Raine et al, 'Selective reductions in pre-frontal glucose metabolism in murderers' (1994) 36 Biological Psychiatry 365.
[37] Lora Cope et al, 'Abnormal brain structure in youth who commit homicide' (2014) 4 NeuroImage: Clinical

and lateral temporal lobes including the hippocampus and posterior insula (also called 'paralimbic areas') in 20 incarcerated male adolescents who committed homicide, and in 135 incarcerated offenders who did not commit homicide. They found that incarcerated homicidal offenders exhibited reduced grey matter volumes in said areas of interest. Abnormalities in these brain areas appear to correlate with more callous and unemotional traits, and poor behavioural control, which are well known risk factors for persistent antisocial behaviour. Based on these results, this group of researchers suggested that brain structural differences are, *inter alia,* indicative of a high risk for serious violent offences.

Neuroprediction has also been used to identify successful treatments of specific categories of offenders. In an ERP[38] study conducted on adult incarcerated participants with problems of substance dependence, Steele et al[39] showed that electrical brain activity could predict who would successfully complete a 12-week substance abuse treatment programme. These results prove significant as they may well help develop more individualized therapies, and lead to positive, long-term outcomes.

In view of this preliminary evidence, some authors have reasonably pondered how exactly the inclusion of neural variables in the evaluation of future criminal conduct could ameliorate risk assessments. Notably, some authors have wondered 'whether any differences revealed by neuroimaging studies are either better predictors of recidivism than the score on a checklist or, even if they are not, whether they would increase the accuracy of any such prediction if used in conjunction with other behavioural measures'.[40] Neuroscientists are beginning to answer this question by speculating that neuroscientific techniques, namely neuroimaging (both structural and functional), are most likely to lend incremental validity to the assessment of criminal recidivism risk. Put differently, neuroprediction of antisocial behaviour will most likely add predictive value to already existing risk assessment methods.[41]

Thus relative to more traditional prediction methodologies, the added value of neuroprediction is that it possesses the potential of improving risk assessments in both group and single individuals by advancing understanding of neurobiological risk factors of

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[38] Event-Related Potentials are a non-invasive method of measuring brain activity during cognitive processing. It helps capture neural activity related to both sensory and cognitive processes. See Shravani Sur and Vijay K. Sinha, 'Event-related potential: An overview' (2009) 18(1) Industrial Psychiatry Journal 70.

[39] Vaughn R. Steele et al, 'Brain potentials measured during a Go/NoGo task predict completion of substance abuse treatment' (2014) 76(1) Biological psychiatry 75.

[40] The Royal Society, 'Brain waves module 4: Neuroscience and law' (December 2011) <https://royalsociety.org/~/media/Royal_Society_Content/policy/projects/brain-waves/Brain-Waves-4.pdf> accessed 20 February 2017.

[41] See, for instance, Lyn Gaudet et al, 'Can neuroscience help predict future antisocial behavior?' (2016) 48(2) Fordam Law Review 503.

antisocial behaviour. It may also contribute to the development of more targeted treatments to mitigate such risks. In other words, the inclusion of neuroscientific information about offenders' neurobiological profile might add predictive utility to current antisocial behaviour prediction analysis, for neuroscientific data might prove useful for a variety of purposes – from providing more accurate recidivism predictions to treatment programs targeting.

On the whole, preliminary findings in neuroprediction studies suggest that the inclusion of neural variables may prove a useful complement to antisocial behaviour risk assessments. The possibility of detecting neurobiological markers that are predictive of future antisocial conduct might soon become more concrete, and it is not inconceivable that there will come a day when neuroscientific prediction tools of antisocial behaviour are reliable enough to use in forensic and justice contexts. However the potential use of these prediction tools raises a number of ethical and legal concerns. While ignoring the use of increasingly sophisticated antisocial behaviour prediction methodologies would be a lost opportunity, at the same, criminal justice should adopt a cautious approach to allow for future use of these tools in a way that preserves offenders' civil liberties and individual rights, but also enhances public safety. These issues, which are complex and require careful elaboration, will be discussed over the next two sections.

D. WHEN NEUROPREDICTION MEETS CRIMINAL JUSTICE: CHALLENGES AND IMPLICATIONS

The potential use of neuroprediction in forensic and justice contexts has sparked considerable debate among legal scholars, forensic psychiatrists and psychologists, and neuroethicists. Whilst some authors envisage neuroprediction to allow for more accurate assessments of persistent dangerousness and recidivism risk of offenders,[42] others are sceptical that use of this prediction methodology will have positive implications for criminal justice. Notably, some commentators raise a number of ethical and legal concerns, and warn against indiscriminate use of neuroprediction considering the potential negative implications it might have for criminal policies and the rights of offenders.

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[42] See, for instance, Thomas Nadelhoffer and Walter Sinnott-Armstrong, 'Neurolaw and neuroprediction: Potential promises and perils' (2012) 7(9) Philosophy Compass 631 ('If advances in neuroscience could enable us to develop more accurate and reliable tools for predicting future dangerousness [...] legal decision makers would be in a better position to make informed determinations concerning what to do about potentially violent offenders'). See also Steven K. Erickson, 'The limits of neurolaw' (2011) 11 Houston Journal of Health Law & Policy 303, 306 ('Our desire for improved accuracy leads us to look elsewhere for an approach that lacks the indeterminacies of psychological science. Neurosciences promises to fill that void').

The first issue to be addressed is that of ethical considerations. Some authors fear that the use of neuroprediction in forensic and justice settings will inevitably lead to stigmatization of, and discrimination against, offenders.[43] More specifically, the concern is that the use of neurobiology as a marker of criminality risks marking criminals as different from law-abiding individuals.[44] On this point, Gkotzi and Gasser hold that the identification of differential neurobiological traits in given categories of offenders could pose the risk of creating a 'medical stigma of criminal behavior'.[45] The authors warn against the risk of overgeneralizing associations by recalling brain studies that associate either structural abnormalities or altered functioning of specific cortical and subcortical regions, which are consistently involved in emotion processing and impulse control, with an increased tendency to engage in antisocial behaviour.[46] Although lesions in these brain areas are positively correlated with an increased risk of antisocial behaviour, 'this is not true in all cases and for all individuals suffering from these lesions'.[47] To argue otherwise would not only be mistaken, but it also risks stigmatizing offenders that exhibit this kind of neurobiological profile. Therefore, Gkotsi and Gasser claim that 'it is not safe to rely exclusively on brain data as a criterion in order to discern a population of dangerous offenders'.[48]

In a similar vein, Fuchs calls for counterbalancing the potential benefits of predictive imaging in preventing possible harm with 'the possible discriminations caused by being an at-risk subject.'[49] In his view, the use of neuroscience for social purposes could have stigmatizing and discriminating effects on other aspects of individuals' lives. For instance, information about individuals' brains could be exploited for such purposes as 'screening job applicants, assessing insurance risks, detecting a vulnerability to mental illness, or

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[43] The issue of stigmatization and discrimination is a far-reaching ethical concern about the social implications of neuroscience. See Owen Jones et al, 'Law and neuroscience: recommendations submitted to the President's Bioethics Commission' (2014) 1(2) Journal of Law and the Biosciences 224 (addressing the concern expressed by President Barack Obama about potential stigmatization and discrimination based on neurological measures; see Presidential Charge to the Commission for the Study of Bioethical Issues [1 July 2013] < http://bioethics.gov/ sites/default/files/news/Charge from President Obama.pdf > accessed 13 March 2017.

[44] See Adina Roskies, 'Neuroethics' in E. Zalta (ed), *Stanford Encyclopaedia of Philosophy* (Spring 2016) <https://plato.stanford.edu/entries/neuroethics/#CognLibe> accessed 28 February 2017. She observes that, '[w]hen neuroimages are said to "predict" future activity, it means they provide *some* statistical information regarding likelihood. Prediction in this sense does not imply that the predicted behavior necessarily will come to pass; it does not mean a person's future is fated or determined'.

[45] Georgia Martha Gkotsi and Jacques Gasser, 'Neuroscience in forensic psychiatry: From responsibility to dangerousness. Ethical and legal implications for using neuroscience for dangerousness assessments' (2016) 36 International Journal of Law and Psychiatry 58, 64.

[46] See Sections II and III.

[47] Gkotsi and Gasser (n 45) 64.

[48] ibid.

[49] See for instance Thomas Fuchs, 'Ethical issues in neuroscience' (2006) 19 Current Opinion in Psychiatry 600, 601.

determining who qualifies for disability benefits'.[50] Paraphrasing Fuch's thought and adapting it to neuroprediction of antisocial behaviour, the risk could be that of labelling offenders as individuals naturally-predisposed to criminal behaviour on the basis of their neurobiological profile, and discriminating against them in their everyday life after release.[51]

Another ethical issue concerns the mental privacy[52] of offenders. Although it is still unclear how the brain enables the mind, or its exact link to behaviour, brain processes are part of individual identity. Thus, the revelation of the neural correlates of individual thoughts and feelings – both conscious and unconscious – may well be viewed as an intrusion into private aspects of our minds.[53] Some authors consider this a violation of cognitive liberty, being every person's fundamental right to autonomy over his or her own brain states.[54] Cognitive liberty violations would be even more glaring in hypothetical uses of neuroprediction for sentencing or punitive purposes, as offenders might be forced to undergo brain scans without consent.

From a *crimino-political* standpoint, legal acceptance of neuroprediction tools is seen as lending incremental support to the growing tendency in Western legislatures to move from retributivist to utilitarian punitive approaches and policies. Gkotsi and Gasser,[55] for example, argue that the use of neuroscience to predict dangerousness and recidivism risk is just a

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[50] ibid, 632.

[51] See also Hannah Bedard, 'The potential for bioprediction in criminal law' (2017) 18 The Columbia Science and Technology Law Review 268, 320 (likewise observing that '[t]he 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').

[52] See Roskies (n 44), stating that 'even if neuroimaging is not at the stage where mindreading is possible, it can nonetheless threaten aspects of privacy in ways that should give us pause. Even now, neuroimaging provides some insights into attributes of people that they may not want known or disclosed. In some cases, subjects may not even know that these attributes are being probed, thinking they are being scanned for other purposes. A willing subject may not want certain things to be monitored'.

[53] Fuchs (n 49) 601-02. See also Nita Farahany, 'Incriminating thoughts' (2012) 64 Stanford Law Review 351; Roger Highfield, 'Mind reading by MRI scan raises "mental privacy" issue' (9 June 2008) The Telegraph <http://www.telegraph.co.uk/news/science/science-news/3343929/Mind-reading-by-MRI-scan-raises-mental-privacy-issue.html> accessed 1 March 2017.

[54] See Richard Glen Boire, 'On cognitive liberty (Pt I-III)', Center of Cognitive Liberty & Ethics website <http://www.cognitiveliberty.org/curriculum/oncoglib_123.htm> accessed 14 March 2017; Jan Christoph Bublitz, 'My mind is mine!? Cognitive liberty as a legal concept' in Hildt & Franke (eds), *Cognitive Enhancement: An Interdisciplinary Perspective* (Springer, 2013) ch 19; Wrye Sententia, 'Freedom by design: Transhumanist values and cognitive liberty' in M. More and N. Vita-More (eds), *The Transhumanist Reader: Classical and Contemporary Essays on the Science, Technology and Philosophy of the Human Future* (John Wiley & Sons, 2013) ch 34; Jan Christophe Bublitz and Reinhard Merkel, 'Crime against minds: On mental manipulations, harms and a human right to mental self-determination' (2014) 8 Criminal Law and Philosophy 61; Henry Greely, 'The social effects of advances in neuroscience: legal problems, legal perspectives' in Illes (ed), *Neuroethics: defining the issues in theory, practice and policy* (OUP 2006) 253 (outlining that the brain represents 'a last inviolate area of self' that brain scans may compromise).

[55] See Gkotsi and Gasser (n 45).

shortcut to shift the paradigm of punishment from retribution for past wrongs to pure prevention of future harm. Given the growing tendency in both European and Anglo-American systems to promote public safety by enforcing 'zero tolerance of risk'[56] policies, courts are increasingly inclined to determine punishment not only based on an offender's actual guilt for the crime committed, but also on the offender's probability of reoffending in the future – that is, his or her future dangerousness.

In this scenario, 'the use of neuroscience to predict dangerousness and recidivism risk assessment might imply an instrumentalization of neuroscience as a tool to increase in the interest of public safety, which can run against the proper exercise of justice and civil liberties of the offenders'.[57] In other words, the authors fear that courts might be tempted to use neuroscience to ground responsibility assessments and sentencing decisions in antisocial behaviour (neuro)predictions, as the assessment of criminal responsibility would also factor the offender's perceived risk of recidivism. This might lead to the rendering of sentences more severe than necessary to preserve public safety, undermining the principle of proportionality that lies at the core of criminal sentencing.

This crimino-political concern is exacerbated by the fact that neuroscientific evidence can be easily misconceived. Several studies have shown that juries and judges tend to overestimate the accuracy of neuroscientific data, believing it to be more accurate and reliable than it actually is.[58] Neuroscience is perceived as 'hard' science, and thus sounds more compelling for fact finders to ground their determinations on neuroscientific data. However, as has been observed, 'the potential overreliance on neuroprediction could crowd out other traditional goals of the criminal justice system such as giving offenders what they deserve'.[59] For instance, there is the concern that judges might rely too heavily on neuroprediction and opt for perpetuating post-sentence measures in the assessment of post-sentence treatment, ie the treatment issued for offenders that have served their sentence for crimes committed, as would be the case in continental European systems.[60] Alternatively,

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[56] ibid, 63.
[57] ibid, 59.
[58] See, for instance, Deena Weisberg et al, 'The seductive allure of neuroscience explanations' (2008) 20(3) Journal of Cognitive Neuroscience 470.
[59] Nadelhoffer and Sinnott-Armstrong (n 42) 636.
[60] In Italy, for instance, when offenders are assessed socially dangerous, they are submitted to security measures, eg psychiatric hospitalization or parole, for an indefinite amount of time, regardless of the length of the sentence.

judges might order involuntary civil commitment (as would be the case in the US)[61] on the basis that the offender exhibits a neurobiological profile that allegedly proves their inclination to be socially dangerous, and thus at a high risk of recidivism. The potential overreliance on neuroprediction could crowd out other traditional goals of the criminal justice system, such as imposing fair sentences.

From a *substantive legal* perspective, some commentators outline that the use of neuroprediction poses the risk of violating individual rights of offenders. Notably, some authors emphasize that neuroscience-based risk assessments might challenge the privilege against self-incrimination,[62] the presumption of innocence, as well as the right to refuse medical treatment. The privilege against self-incrimination (also known as *nemo tenetur* principle), which is a subset of the more general right to remain silent, applies at both the pre-trial and trial stages. It enshrines the right of a person not to provide information that is likely to be self-incriminatory. Importantly, the privilege applies to *verbal* information provided by suspects or offenders, but it does not apply to physical evidence, which can usually be compelled.[63]

It is still unclear whether evidence produced by brain scans is to be considered testimonial (or communicative), or physical. Commentators are split over this issue.[64] According to one view, data emerging from neuroscientific data should be characterized as testimonial, or communicative, evidence. Pursuant to this account, neuroscience-based methods 'involve asking the subject questions to which he or she gives answers, either orally, by pressing buttons, or by some other form of communication'.[65] Another view contends that neuroscience-based evidence belongs by nature to the category of non-testimonial evidence, and hence does not fall within the scope of the privilege against self-incrimination. For this branch of thought, 'an fMRI scan is nothing more than a computer record of radio waves emitted by molecules in the brain. It does not seem like testimony'.[66] As brain-based

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[61] For instance, post-sentence measures, notably involuntary civil commitment, are provided for sexual predators in some US jurisdictions; see Wanda Kendall and Monit Cheung, 'Sexually violent predators and civil commitment laws' (2004) 13(2) Journal of Child Sexual Abuse 41.

[62] See Nadelhoffer et al (n 33).

[63] For instance, in *Schmerber v California*, the US Supreme Court expressly stated that the provision under the Fifth Amendment of the US Constitution is to be interpreted in the sense that no person shall be compelled to prove a charge 'from his own mouth', but 'compulsion which makes a suspect or accused the source of 'real or physical evidence does not violate it'. See *Schmerber v California* (1996) 384 U.S. 757 <https://supreme.justia.com/cases/federal/us/384/757/case.html> accessed 13 March 2017.

[64] This issue has been raised with regard to neuroscience-based lie detection. However, the same considerations may well equally apply to neuroprediction.

[65] Henry Greely and Anthony Wagner, 'Reference Guide to Neuroscience' in National Research Council (ed), *Reference Manual on Scientific Evidence* (3rd edn, The National Academies Press 2011) 747, 791.

[66] ibid.

evidence is no different from evidence produced with a blood sample, it can also be compelled.

Importantly, the privilege against self-incrimination applies by definition to the communication of information related to the alleged crime committed in the relevant case, not to the relevant offender's future dangerousness. On the contrary, neuroprediction relates to offenders' future behaviour, not past crimes. However, as Merkel notes, the privilege against self-incrimination 'does not [...] preclude any effort to obtain as many clues as possible concerning [offenders'] future dangerousness'.[67] This might increase the risk that courts 'confound grounds for punishing past deeds with grounds for predicting future dangerousness'.[68] Thus, sustaining that neuroprediction potentially violates the privilege against self-incrimination depicts an even worse scenario, for it implicitly accepts that incrimination and punishment could also be based upon an individual's future behaviour, not just past actions. This is both legally questionable and legally undesirable.

Another legal concern emerging from the potential use of neuroprediction is the possible violation of the right to be considered innocent until proven guilty, ie the presumption of innocence. In this respect, the use of neuroprediction would be particularly alarming in cases of pre-emptive detention.[69] The risk here is that a person would be deprived of their liberty on the basis that their brain displayed specific dysfunctions that made them appear potentially deviant, even without having been convicted of an offence. For instance, consider the hypothetical scenario of an individual – named John – *suspected* of child abuse. In the process of gathering evidence about his likely involvement in the crime, John is forced to submit to an fMRI assessment. The fMRI shows that John exhibits dysfunctions in the brain areas that are consistently associated with pedophilic traits. Although it does not prove whether or not John committed child abuse, the court decides to issue an order of pre-emptive detention based on this evidence. At trial, John is found to be innocent. The court here failed to consider that although John displayed a neurobiological profile with pedophilic traits, and perhaps also the fact that he experienced pedophilic urges, did not necessarily imply that he also acted upon them. In fact, there can be cases in which individuals who experience pedophilic urges are still able to resist them.

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[67] Reinhard Merkel, 'Neuroimaging and criminal law' in Clausen and Levy (eds), *Handbook of Neuroethics* (Springer 2015) ch 84, 1357.
[68] ibid (n 41).
[69] The controversial relationship between presumption of innocence and pre-emptive detention is widely debated in literature. See, *inter alia*, Andrew Ashworth, 'Four threats to the presumption of innocence' (2006) 10 International Journal of Evidence & Proof 241; Kimberly Ferzan, 'Preventive justice and presumption of innocence' (2014) 8(2) Criminal Law and Philosophy 505.

This hypothetical scenario shows how a bad use of neuroprediction might enhance the law's inability to comply with the presumption of innocence in pre-emptive detention. That is, an excessive overreliance on neuroscientific evidence could open the door to a more aggressive use of pre-emptive detention in the name of public safety, especially as a solution for categories of criminals that inspire special fears in the society – like sexual predators and terrorists. This attitude might lead to considerable mistakes, and ultimately turn the right to be presumed innocent into an inadmissible presumption of guilt.

Furthermore, neuroprediction potentially challenges the right to refuse medical treatment*,* the denial of which may result in inhumane and degrading treatment that is prohibited both by national constitutions[70] and international instruments.[71] The issue here is whether courts might use neuroprediction to force alleged high-risk offenders to undergo therapy, or to institutionalize them before they commit an offence.[72] Consider a post-sentence scenario in which an offender, Tim, is serving a sentence for burglary. Tim is forced to undergo a brain scan to assess whether or not he exhibits 'dangerous' traits to possibly keep him detained. The brain scan shows that Tim exhibits a neurobiological profile that is 'typical' of sex offenders. Based on this brain scan, and despite never having committed a sex offence, the court orders Tim to undergo a specific treatment or therapy provided for sex offenders. The court's order to submit Tim to a brain scan, as well as to make him undergo a specific treatment or therapy for sex offenders based only on Tim's perceived danger to engage in sexual offences, may be seen as an act against his will and conscience,[73] and therefore degrading and humiliating treatment of his person and dignity.[74] To remedy this risk, informed and written consent to neuroprediction tests and treatment should be a mandatory requirement.[75]

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[70] See, for eg, Eighth Amendment of the US Constitution.

[71] See Convention for the Protection of Human Rights and Fundamental Freedoms (European Convention on Human Rights, as amended) (ECHR) Article 3; Universal Declaration of Human Rights (adopted 10 December 1948) Article 5; International Covenant on Civil and Political Rights (adopted December 16, 1966) Article 7; United Nations Convention Against Torture and Other Cruel, Inhumane or Degrading Treatment or Punishment (adopted 26 June 1987).

[72] This hypothetical scenario is largely inspired by the (in)famous *Toomey* case. See *Toomey v United Kingdom*, n. 37231/97, ECtHR, Decision Final (1999) <http://freecases.eu/Doc/CourtAct/4550782#> accessed 17 June 2017.

[73] The protection of will and conscience, the violation of which may give rise to degrading treatment, has been stated by the ECtHR in *Denmark, Norway, Sweden and the Netherlands v Greece* (1969) 12 YB 1 186.

[74] The imposition of medical treatment without consent may constitute a form of degrading treatment. For an argument on this topic, see Elizabeth Wicks, 'The right to refuse medical treatment under the European Convention of Human Rights' (2011) 9 Medical Law Review 11.

[75] For an argument on informed consent and neurotechnologies, see Henry T. Greely, 'Neuroscience and criminal justice: Not responsibility, but treatment' (2007) 56 Kansas Law Review 1103.

The illustration of ethical and legal concerns emerging from a hypothetical entrance of neuroprediction in forensic and justice contexts shows how misuse of neuroprediction could seriously compromise offenders' rights and civil liberties. While the accuracy of neuroprediction tools could improve crime prevention and guarantee public safety, neuroprediction raises significant legal and ethical issues that make its use for forensic and justice purposes questionable. How, then, can criminal justice best utilize neuroprediction without threatening offenders' individual rights and civil liberties? At which procedural stage should neuroprediction be allowed, and under what conditions?

These issues will be examined in the next section, along with a proposed approach to making neuroprediction a useful tool for criminal justice. Drawing upon the views shared by some commentators, the following analysis will attempt to overcome any previously-mentioned ethical and legal concerns, and offer some insights into how criminal justice could make an appropriate and balanced use of neuroprediction techniques – ones which might improve public safety while also preserving offenders' individual rights

E. BALANCING PUBLIC SAFETY AND INDIVIDUAL RIGHTS: NEUROPREDICTION AS A TOOL TO MOVE TOWARDS A SOCIO-REHABILITATIVE MODEL OF CRIMINAL JUSTICE

As illustrated in the previous section, the potential benefits of neuroprediction for forensic and justice purposes are counterbalanced by several ethical and legal concerns. The core issue is that indiscriminate use of neuroprediction in the name of public safety might result in abuses of power on the part of legislative and judicial authorities, with detrimental effects on the individual rights and civil liberties of offenders. While these concerns are fair, they are not insurmountable. Certainly misuse and abuse of neuroprediction can be detrimental to the rights of offenders, however this does not mean that criminal justice must dismiss neuroprediction in its entirety. Rather, criminal justice should exploit the potential benefits that neuroprediction could bring to forensic and justice domains in a way that enhances offenders' individual rights while also guaranteeing public safety.

Before considering how criminal justice could profitably and appropriately include neuroprediction in its settings, three preliminary clarifications are in order. First, neuroprediction does not pose any more alarming threat to individual liberties and rights than those posed by more traditional prediction methodologies. On this point, the writings of

Stephen Morse in 'Neuroprediction: New Technology, Old Problems'[76] provide a compelling argument. Morse asserts that the ethical and legal issues raised by neuroprediction are not unique, but rather similar to those raised in relation to other, pre-existing prediction methodologies. Neuroprediction is neither more nor less intrusive than predictions *per se*, as predictions are 'normatively justified'.[77] Thus, the possibility of using new tools that can possibly increase the accuracy of risk assessments should not sound so worrisome.[78] As long as the law relies upon predictions of future dangerousness, these predictions should be as accurate and reliable as possible.[79] Hence, Morse asks, 'if neural variables increase the accuracy of such predictions [...] what possible argument could there be for not using neural variables?'[80]

The second clarification is that, contrary to popular understanding, brain scans *alone* are not sufficient to make predictions about future antisocial behaviour. Rather, brain scans would be used in addition to behavioural assessment tools to provide incremental knowledge and accuracy in measuring offenders' actual tendencies to engage in antisocial conduct.[81] Neurocriminology will not revolutionize current ways of predicting antisocial behaviour. Rather, as has been argued above, neurocriminology can fill gaps in existing prediction tools by adding further variables to consider when assessing an individual's dangerousness.

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[76] Stephen J. Morse, 'Neuroprediction: New technology, old problems' (2015) 8(4) Bioethica Forum 128.

[77] ibid, 129.

[78] See also Nadelhoffer and Sinnott-Armstrong (n 42) 636 (while discussing the ethical and legal issues about neuroprediction raised by some legal scholars, the two authors observe that 'these issues are not unique to neuroprediction. After all, the same problems would arise if non-neural actuarial models became markedly more accurate and reliable. The real issue here is and elsewhere is the potential increased power of prediction, not the fact that neural information is being used to make predictions'). See also Valtteri Arstila and Franklin Scott, 'Brain reading and mental privacy' (2011) 15(2) Trames Journal of the Humanities and Social Sciences 204 (making similar considerations as regards the fear that brain imaging can uniquely breach our mental privacy. More specifically, the two authors claim that 'brain reading does not violate privacy in any way different from the already established psychological methods to determine mental phenomena').

[79] See also Merkel (n 67) 1356 (likewise observing that 'it seems cogent that the state is obliged to utilize and exhaust all available, scientifically acceptable methods to ascertain the prognosis of the future dangerousness of a delinquent, given that such a prognosis is indispensable once the question of dangerousness has seriously arisen in a case.')

[80] Morse (n 76) 129. In addition, it is worth mentioning a very recent case held before the Wisconsin Supreme Court (USA), where the relevant offender, Mr Eric Loomy, was sentenced to six years' imprisonment based on a report generated by a secret algorithm of a software programme called *Compas*. Mr Loomy complained that his right to due process has been violated, since the court based its evaluation upon an algorithm that he was not allowed to access or inspect. See Adam Liptak, 'Sent to prison by a software program's secret algorithms' (1 May 2017) *The New York Times* <https://www.nytimes.com/2017/05/01/us/politics/sent-to-prison-by-a-software-programs-secret-algorithms.html> accessed 20 June 2017. This case emblematically shows that already existing risk assessments tools are pretty questionable from an individual rights perspective.

[81] For an argument on the better epistemological accuracy of behaviourally driven neuroscience, see John Krakauer et al, 'Neuroscience needs behavior: Correcting a reductionist bias' (2017) 93 Neuron 480 (calling for a more pluralistic notion of neuroscience when it comes to the brain-behaviour relationship, for which neural investigation must follow up independent detailed studies of the behaviour itself).

In this respect, some authors endorse an integrated and interdisciplinary model of risk assessment. For instance, Bufkin and Luttrel suggest that risk assessments should be based upon a biopsychosocial model of criminal behaviour,[82] which entails the consideration and the evaluation of sociological, psychological, and (neuro)biological risk factors. In order for the criminal justice system to intervene properly on antisocial individuals, 'it is imperative that the field embraces the interdisciplinary model'.[83] Thus, it would be a mistake to believe that an offender's inclination to engage in violent or antisocial behaviour could be assessed by only looking at their brain or biology.

Of course, the issue of excessive overreliance on neuroscience remains, and a critical understanding of brain-based data on the part of courts is necessary. The 'perils' of overconfidence in neuroscience may only be overcome through a fruitful interdisciplinary dialogue between legal practitioners and neuroscientists, one which helps the former to appropriately interpret the type of information neuroscience offers in matters of neurobiological markers of antisocial behaviour. Such an interdisciplinary dialogue will be crucial to avoid the risk of making epistemological and evaluative mistakes about the predictive power of neuroscientific evidence.

The third clarification concerns the fear expressed by some scholars that neuroprediction is likely to undermine the basic traditional principles underlying criminal responsibility and punishment. As outlined in Section D, some scholars contend that neuroprediction threatens retributivist principles of just desert and proportionality. Rather, neuroprediction supports a utilitarian justice approach by virtue of which criminal responsibility and punishment are to be grounded in forward-looking criteria such as offenders' future social dangerousness and recidivism risk. As has been claimed:

> Instead of looking back at an agent's wrongful conduct as the meter of his deserved punishment, cognitive neuroscience looks exclusively forward at an agent's risk of future dangerousness. [...] By advancing a criminal law regime animated by the consequentialist aim of avoiding social harms [...], neuroscience promotes a return to a therapeutical approach [sic] to crime. [84]

This statement is misleading as it makes the common inferential mistake of attributing normative value to, and deriving normative conclusions from, neuroscientific information.[85]

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[82] See Jana Bufkin and Vickie Luttrel, 'Neuroimaging studies of aggressive and violent behavior: Current findings and implications for criminology and criminal justice' (2005) 6(2) Trauma, Violence, and Abuse 176.
[83] ibid, 188.
[84] Gkotsi and Gasser (n 45) 63.
[85] See, for example, Selim Beker, 'The normative insignificance of neuroscience' (2009) 37(4) Philosophy and

The fact that neuroscience provides new insights into human behaviour does not imply any direct consequence for the law, as long as the law does not want to use these insights for normative purposes. Claiming that neuroscience fails to consider an agent's past wrongful conduct is inaccurate. Why should neuroscience look back at an agent's wrongful conduct as a metre of his deserved punishment? Neuroscience is not concerned with responsibility and punishment; these are matters to be determined by law.

Neuroscience provides clues about how the brain works, how the brain supports mental functions, and ultimately what brain mechanisms are involved in different behaviours. This kind of information is purely empirical. As such, it does not have any direct relevance at the normative level. Whether or not neuroscientific knowledge can also have normative relevance is a normative issue, and one that the law may want to consider. For instance, the law may decide to exploit new scientific information to revise assumptions about human behaviour that underlie out-dated theories and practices that prove to be significantly flawed in light of scientific advances, and change those theories and practices accordingly. Yet, once again, this is a purely normative issue. Therefore, whether punishment should be based on offenders' future dangerousness rather than on past wrongdoing does not depend on neuroscience. The rationale of punishment is a crimino-political choice, which shares very little with neuroscientific discoveries about the neural correlates of antisocial behaviour.

This observation leads to the real potential of neuroprediction in the forensic and justice contexts. Sharing the views of some authors, this author envisages neuroprediction to most positively contribute to the sentencing stage. Notably, neuroprediction would be a useful instrument to assist courts in identifying correctional measures and treatment programmes more tailored to the actual features and needs of single offenders.

In times when traditional punitive measures have basically failed – considering the negative effects that correctional practices (notably incarceration) have on offenders' rights and their lives,[86] as well as on society as a whole[87] – the possibility of providing a more accurate picture of offenders' personal traits by also considering neurobiological variables might well lead to the identification and implementation of more individualized correctional

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Public Affairs 293.

[86] See, *inter alia*, Bruce Arrigo, 'The psychological effects of solitary confinement on prisoners in supermax units: Reviewing What we know and recommending what should change' (2002) 52(6) International Journal of Offender Therapy and Comparative Criminology 622; Craig Haney, 'The wages of prison overcrowding: Harmful psychological consequences and dysfunctional correctional reactions' (2006) 22 Journal of Law & Policy 264; Allison Lieblin, *Suicide in Prison* (Routledge 1992).

[87] See Seena Fazel and Achim Wolf, 'A systematic review of criminal recidivism rates worldwide: Current difficulties and recommendations for best practice' (2015) PLoS 10(6): e0130390.

measures that deal more efficiently with different classes of offenders. As has been rightly observed:

> Recidivism rates worldwide reflect a criminal justice system that is ineffective at remediating criminogenic factors that contribute to the revolving door problem of incarceration. The lack of effective, evidence-based treatments, coupled with personality differences that affect why and how individuals engage in a criminal behavior, perpetuates the lack of rehabilitation and therefore leads to an extremely high likelihood of returning to prison.[88]

If neuroscience improves our understanding of the brain and neurological correlates of antisocial behaviours, criminal justice systems can implement more effective rehabilitative strategies, and provide sentencing alternatives to ineffective imprisonment.[89]

Put this way, neuroprediction might be a useful tool, among others, to help criminal justice systems shift from a punitive to a more socio-rehabilitative approach to criminality. As explained in Section B, growing evidence emanating from behavioural and neuroscientific disciplines shows that the brain and mental dynamics that underpin antisocial decision-making are often featured by alterations in emotion processing, moral reasoning, moral judgement, and self-control – alterations that affect an individual's ability to make socially appropriate decisions and engage in socially acceptable conduct.[90] With this emotion-oriented understanding of antisocial decision-making, it is hypothesized that socially scarce environments – like prisons – produce negative effects on the activity of specific socio-emotional regions of the brain (notably, the amygdala)[91] that are key to social behaviour.[92]

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[88] Gaudet et al (n 41) 530.

[89] ibid (arguing that, '[e]ven among the highest risk individuals, identifying the neural mechanisms at work can help isolate targets for specific therapeutic interventions and, thus, afford an opportunity to remediate the risks through tailored sentences alternative to incarceration'). An example of how neuroscience proves helpful in rehabilitative sentencing comes from Canada, where neurofeedback treatment programmes have been tested on juvenile offenders. Neurofeedback is direct training of brain function by which the brain learns to function more efficiently. Neurofeedback treatment is particularly used to train self-regulation. The results of neurofeedback programmes demonstrated reduction in subjects' recidivism, improvement in cognitive performance, improvement in regulation of emotional reactions and behaviour, and inhibition of inappropriate responses. See George Martin and Cynthia Johnson, 'The Boys Totem Town Neurofeedback Project: A pilot study of EEG biofeedback with incarcerated juvenile felons' (2006) 9(3) Journal of Neurotherapy 71.

[90] See Bufkin and Luttrell (n 82).

[91] See Alexis M. Stranahan, 'Social isolation delays the positive effects of running on adult neurogenesis' (2006) 9(4) Nature Neuroscience 526; Thomas Adams and J Amiel Rosenkranz, 'Social isolation during postweaning development causes hypoactivity of neurons in the medial nucleus of the male rat amygdala' (2016) 41(7) Neuropsychopharmacology 1929; Claudia Lieberwirth et al, 'Social isolation impairs adult neurogenesis in the limbic system and alters behaviors in female prairie voles' (2012) 62(4) Hormonal Behavior 357; Louise C. Hawkley et al, 'Perceived social isolation: Social threat vigilance and its implications for health' in Decety and Cacioppo (eds), *The Oxford Handbook of Social Neuroscience* (OUP 2011) 765.

[92] See Daniel Reisel's TED talk: 'The Neuroscience of Restorative Justice' <https://www.youtube.com/watch?v=tzJYY2p0QIc> accessed 8 February 2017.

Importantly, social isolation is likely to have particular detrimental effects on individuals exhibiting severe emotional impairments, like psychopaths or subjects with socio-affective disorders featured by antisocial tendencies.

Based on these assumptions, it is hypothesized that empathy training programmes that promote pro-social and morally appropriate behaviour could be an asset to treat offenders with socio-affective deficits.[93] Strikingly, it is suggested that these programmes take place outside of prison, in morally and socially stimulating environments.[94] Perhaps relationally-based situations could actually prove the most suitable way to create new opportunities for neural growth in emotion brain circuits, increasing the likelihood of developing empathy, and enabling these offenders' emotional transformation towards pro-social attitudes.

These insights could lead to an increased adoption of individualized, inclusionary socio-rehabilitative measures, which act as positive incentives for high risk offenders' emotional healing and social functioning, thereby reducing risks of recidivism facing offenders upon their return to the community. Admittedly, very little is known in this respect. Further research in both scientific and legal domains is thus needed to explore these complex and important issues.

To conclude, the legal discussion on neuroprediction has mainly focused on its perceived detriment to criminal justice. This paper has taken a more optimistic approach. A cautious and critical use of neuroprediction tools might aid criminal justice in identifying and implementing new correctional practices to treat individual offenders more efficaciously. This could set the stage for a range of changes to current criminal justice policies in terms of integrating, or even replacing, traditional punitive measures with greater socio-rehabilitative strategies to help offenders strengthen pro-social attitudes in view of their actual social functioning. An intensified implementation of socio-rehabilitative strategies could ultimately prove more humane, safer, and more efficient[95] in terms of recidivism reduction and offenders' actual re-socialization. Put this way, neuroprediction in forensic and justice contexts could be a crucial tool that could be used to increase public safety, especially in the long-term, as well as to foster offenders' individual rights in terms of social rehabilitation and reintegration.

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[93] ibid.
[94] ibid.
[95] See Greely (n 75).

F. CONCLUSION

Research in neurocriminology is painting an increasingly accurate picture of the neural correlates of antisocial behaviours. The possibility of using neurocriminological knowledge for prediction purposes in forensic and justice settings might soon become more concrete. While misuse of neuroprediction could risk undermining offenders' individual rights, ignoring neurobiological influences on antisocial behaviour to make more accurate risk assessments may be a lost opportunity. This paper has attempted to overcome some of the ethical and legal concerns around the forensic use of neuroprediction, and provided an argument as to how criminal justice can use neuroprediction to ameliorate current policies and practices. Notably, it suggests that neuroprediction be used to identify and implement alternative sentences, and perhaps more efficient sentences aimed at offenders' social rehabilitation, tailored to the actual features and needs of offenders. By adopting this perspective, the use of neuroprediction in forensic and justice contexts no longer appears as a threat to offenders' individual rights under the pretext of public safety. On the contrary, neuroprediction may well be viewed as an instrument to help criminal justice integrate current punitive policies and measures with socio-rehabilitative strategies, which could improve the treatment of offenders at risk without threatening, but rather enhancing, their individual rights in terms of actual social rehabilitation and successful social reintegration.