Neurolaw in Australia: The use of neuroscience in Australian criminal proceedings

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Abstract

Recent research has detailed the use of neuroscience in several jurisdictions, but Australia remains a notable omission. To fill this substantial void we performed a systematic review of neuroscience in Australian criminal cases. The first section of this article reports the results of our review by detailing the purposes for which neuroscience is admitted into Australian criminal courts. We found that neuroscience is being admitted pre-trial (as evidence of fitness to stand trial), at trial (to support the defence of insanity and substantial impairment of the mind), and during sentencing. In the second section, we evaluate these applications. We generally found that courts admit neuroscience cautiously, and to supplement more well-established forms of evidence. Still, we found some instances in which the court seemed to misunderstand the neuroscience. These cases ranged from interpreting neuroscience as "objective" evidence to admitting neuroscience when the same non-neuroscientific psychiatric evidence would be inadmissible for being common sense. Furthermore, in some cases, neuroscientific evidence presents a double-edged sword; it may serve to either aggravate or mitigate a sentence. Thus, the decision about whether or not to tender this evidence is risky.

Keywords: Neurolaw; Australian criminal justice system; neuroscience; criminal law; law and science; law and technology; sentencing

Part I. Introduction

In step with rapid technological developments, neuroscientific evidence is playing an increasingly important role in criminal proceedings in many jurisdictions across the world (see, [1–7]). Despite its widespread use, little research has examined how neuroscientific evidence is being used in Australian Criminal courts.[1] In this article, we seek to fill that void by providing the first systematic review and analysis of the application of neuroscientific evidence in Australian criminal proceedings. This is important because neuroscience in court has been the subject of considerable academic debate, in part due to the potential for misunderstanding and prejudice it presents [8, 9].[2] Moreover, basic neuroscientific research itself has been criticized for its use of low sample sizes and unduly flexible methodologies [10]. Generally, our review finds that Australian courts are appropriately cautious in their use of neuroscience, using it as evidence corroborating more traditional forms of evidence, such as expert witness statements and clinical psychological findings. However, we do note cases in which the use of neuroscience was of little (or no) relevance, and in which the trial judge fundamentally misconstrued the evidence.

In this article, we adopt a broad definition of neuroscience.[3] We will review cases in which the neuroscientific evidence takes the form of both diagnostic (i.e., individuating) evidence and framework evidence [11]. By diagnostic evidence, we mean evidence about the brain and brain functioning of a particular person (usually the accused or offender). This can be gleaned by diagnostic imaging tools (e.g., functional magnetic resonance imaging or fMRI) or classic neuropsychological testing (e.g., where a psychiatrist makes some inference about the patient's brain based on his or her behaviour). For a review of the latter, see [12]. By framework evidence, we mean general knowledge about the relationship between the brain and behaviour. This form of evidence is based primarily on imaging studies. Importantly, diagnostic evidence rests on framework knowledge because the expert must infer that the individual's case is an instance of an established relationship between brain and behaviour. For example, an expert opining that an accused's frontal lobe damage impaired his ability to control his actions is, by necessity, relying on previous research demonstrating a relationship between the frontal lobe and impulse control [13].

[1] We are aware of two recent and well-considered works analysing Australian neurolaw that have adopted a narrow focus. First, for a focus on the fMRI methodology, see [7]. And for a focus on New South Wales sentencing decisions in which the neuroscientific evidence was a mitigating factor, see [49].
[2] See [20] for a review of the current theoretical arguments surrounding neurolaw.
[3] In adopting this scope, we follow other recent works, see, e.g., [4, 5].

In the remainder of this part, we will discuss how we went about researching the Australian criminal neurolaw jurisprudence. Part II then goes on to review the use of neuroscience in criminal decisions. This review spans its use both pre-trial and at trial. Part III then focuses on the role neuroscientific evidence plays in informing sentencing decisions. Then, in Part IV, we draw upon the earlier parts to critically reflect on the use of neurolaw in Australia. In Part V, we conclude.

It is useful to briefly describe the breadth of our search – the scope of cases from which we drew in filling in the picture of Australian neurolaw (for more information about our methodology see the Appendix). First, we reviewed all 695 criminal cases in the Australian Neurolaw database (on file with the authors) — the only public database of Australian Neurolaw cases[4] — and sorted the cases into different categories (e.g., 'fitness to stand trial'). We then performed our own search on AustLII — a public database of Australian cases with extensive coverage[5] — using a variety of keywords (i.e. 'CT scan'). We restricted our search to the three levels of court most likely to hear relevant criminal cases: The Supreme Court, the Court of Criminal Appeal, and the District Court. Further, the search was not restricted to a specific time period or to specific jurisdictions in Australia.[6] As a result of this search on AustLII, we reviewed 779 cases (on file with authors).

The selection of cases and the sample size in this study were based on our intention to explore and illustrate different uses of neuroscience in criminal courts and not to speak to the amount of neuroscientific evidence in Australian criminal courts generally (quantitative analysis). Therefore, this article is unable to indicate whether any particular use is more common than others. For instance, we cannot say that neuroscientific evidence is being proffered more as evidence of vitiated intent or as evidence supporting a defence of mental impairment.[7] Rather, our *qualitative* results reflect the use of neuroscientific evidence in Australian criminal jurisprudence on the basis of commonly used categories following the procedural timeline of a criminal law matter (i.e. pre-trial, trial and sentencing).

Several limitations inherent to our search should be noted. First, many Australian criminal cases are not reported or are otherwise made available. Additionally, our examination of the use of neuroscience in Australian

[4] A large proportion of cases on the Database are not published, and the public do not have access to them. See, https://neurolaw.edu.au.
[5] See, https://www.austlii.edu.au/austlii/guide/user_guide.pdf.
[6] The Australian jurisdictions are as follow: (i) New South Wales, (ii) Victoria, (iii) Queensland, (iv) Western Australia, (v) South Australia, (vi) Tasmania, (vii) Northern Territory and (viii) Australian Capital Territory.
[7] We will describe these criminal law concepts in Part II.

courts is based on the contents of the judgments. As such, we did not have access to the expert reports themselves. This means that there may be other aspects of neuroscientific evidence that are relevant to this study but were excluded from the judgment and have subsequently not been examined. Still, the reported decisions are significant because they represent the precedents available to parties as they determine their positions and submissions.

Part II. Neuroscience pre-trial and at trial

Neuroscience Pre-Trial

In the pre-trial phase courts sometimes consider neuroscientific evidence in the context of applications to declare the accused unfit to stand trial. As a matter of fairness and justice, parties are not tried unless they possess a minimum capacity to understand and participate in proceedings (See [14–16]). In determining whether the accused is fit to stand trial, the trial judge must determine if he or she can understand the nature of the charge and follow the evidence that would be presented should the trial take place (See [14, 17] for a review). One way of establishing that an accused is incapable of comprehending the charge and relevant evidence is to demonstrate that they suffer from an "impaired mental process."

For example, in *R v Moar*,[8] the accused brought evidence from a clinical psychologist that he was suffering from an impaired mental process. Moar was accused of several sexual assaults that had occurred over 40 years prior to the trial and claimed, at the time of the trial, to be suffering from a variety of psychological and physical ailments.[9] The expert neuropsychologist diagnosed Moar with a cerebrovascular disease (i.e., a disease of the blood vessels supplying oxygen to the brain) resulting in cognitive impairment.[10] This diagnosis helped explain Moar's impaired short memory and difficulty in processing incoming information.[11] Moreover, this evidence was largely consistent with that of a geriatrician and a forensic psychiatrist, who also concluded that Moar was unfit to stand trial.[12] The court accepted the neuroscientific evidence and appeared to give it significant weight, finding that Moar was indeed unfit to stand trial.

[8] [2012] SADC 47.
[9] Id. at 25.
[10] Id. at 42-43.
[11] Id. at 43.
[12] Id. at 39-59. But note that two other experts, a psychiatrist and a forensic neuropsychologist opined that Moar's condition was not severe enough to merit a finding that he was unfit to stand trial.

Similarly, in *Re Ma'a*,[13] the court accepted evidence from MRI, CT and SPECT scans to support other psychological evidence suggesting that the accused was suffering from dementia stemming from damage to his front and/or temporal lobes.[14] Interestingly, the first set of scans were not conclusive and there was a suggestion of malingering,[15] but later scans indicated that the accused's condition was progressing.[16] We note here that neuroscientific evidence, while not determinative of dementia, may be a useful diagnostic tool when malingering is suspected.[17]

Overall, such cases indicate some uses of neuroscience before the trial begins. In the next section, we will discuss different uses of neuroscience at trial.

Neuroscience at Trial

In this section, we will discuss uses of neuroscientific evidence at trial, beginning with the defence of mental impairment/illness (all states except Tasmania and Queensland have removed the word "insanity" from their criminal codes in favour of illness or impairment) [18]. These cases diverge from assessments of fitness to stand trial in an important way: the assessment for fitness to stand trial involves an inquiry into the mental state of the accused at the time of the trial, while applying the defence of mental impairment/illness involves an inquiry into the mental state of the accused at the time the alleged crime was committed. Therefore, because any neuroscientific evidence relevant to the accused will typically be gathered close to the time of trial, neuroscience is *more logically relevant, and can be more confidently applied*, to the fitness to stand trial determinations. When applying neuroscience to the defence of mental impairment, experts are forced to make estimations or guesses as to the mental state of the accused at the time the act in question took place. This inherently leads to less probative value and relevance of neuroscientific evidence. Despite this, neuroscience is still adduced in these situations, likely because it bears directly on the presence or absence of a mental impairment or illness.

[13] [2010] QMHC 6.
[14] Id. at 47-49.
[15] Id. at 24.
[16] Id. at 11-13.
[17] For other instances of the use of neuroscience for determination of accused's fitness to stand trial see, *R v Blackman* [2016] NSWSC 1579; *R v Wilson* [2015] NSWSC 1538; *Robinson, Clifford Mark v R* [2008] NSWCCA 64. See also *R v Littler* [2001] NSWCCA 173 in which evidence of organic brain disease revealed in a CT scan support a decision to permanently stay the charges against the accused.

Mental Illness Defence

Mental illness is a complete defence to a criminal charge. The accused, however, bears the onus of proving this defence on a balance of probabilities. To successfully raise the defence, the accused must prove that, due to a mental disease, he or she did not understand the nature or quality of the act, or the wrongfulness of the act [18, 19].

R v Singh is illustrative of the use of neuroscience in supporting a mental illness defence.[18] In that case, the accused was charged with murder and three psychological experts reported on his mental state.[19] Because Singh had resided in a mental hospital just prior to the killing, a great deal of evidence contemporaneous with the act was available. This included several of the results of neuropsychological testing and an MRI image. Both were consistent with a neurodegenerative disorder (i.e., loss of neuron function or structure)[20] capable of impairing cognitive and emotional control (i.e., executive functions).[21] The trial judge, accepting the psychological evidence, found that Mr. Singh was not guilty on the ground of mental illness.[22]

Another revealing case can be found in *R v Berlingo*,[23] a case in which an accused charged with the murder of his wife argued that he was suffering from fronto-temporal lobe dementia at the time the act was committed. Importantly, there was neuroscientific evidence that was inconsistent with this contention.[24] In particular, an expert's interpretation of the neuroscientific evidence was not consistent with this diagnosis:[25]

> This witness felt that there was simply nothing in the MRI scan pictures that positively supported diagnosis of either frontal lobe or fronto-temporal lobe dementia. Indeed, he went so far as to assert that the MRI scan pictures could well have been those of someone aged 50. He said that he did not even see any age related atrophy and was surprised that "this patient has cognitive problems".

Despite this lack of definitive neuroscientific corroboration, the Court found that the accused was suffering from dementia and did so based on the classic manner of inferring it from the facts of the case and from expert psychiatric testing. In particular, the accused was 72 and the attack seemed completely out of step with his

[18] [2010] NSWSC 638.
[19] Id. at 18.
[20] *Singh* 24, 37-38.
[21] Ibid.
[22] Id. at 44.
[23] [2003] SASC 109.
[24] Id. at 83, 93-128.
[25] Id. at 120.

personality and relationship with his wife.[26] Further, his children testified that he had become increasingly withdrawn and confused in the years leading up to the attack.[27] These observations were consistent with the accused's interview with the police after being arrested.[28] Ultimately, the Court seemed to place the most weight on the evidence of the expert (a neurologist) who "not only reviewed the relevant MRI and PET scans, but also made a detailed clinical examination and assessment of the accused, personally interviewed the children of the accused and had careful regard to the neuropsycholological [sic] reports."[29] As a result, the Court placed less weight on the opinion of the Crown's neurologist, who focused on the inconclusive MRI.[30]

Berlingo demonstrates a sensitive approach to neuroscience. The Court readily acknowledged that a dementia diagnosis would resolve the mental impairment defence issue: "It is common ground that, if it be shown that the accused was, at the relevant time, suffering from a condition of fronto-temporal dementia, then he was plainly suffering from a mental impairment within the meaning of the statute."[31] But, in determining whether fronto-temporal lobe dementia was present, the Court considered a variety of sources, brain imaging being just one.

Substantial Impairment

Substantial impairment is a partial defence to murder, which reduces that charge to manslaughter.[32] The accused must show, on a balance of probabilities, that he or she was substantially impaired by an "abnormality of mind" due to a non-transitory mental or psychological condition at the time the event occurred.[33] As with the full defence of mental impairment, the language in the substantial impairment defence seems to have invited parties to proffer neuroscientific evidence.

The case of *R v Peterson (No. 4)* provides an example.[34] Mr. Peterson was accused of murdering his friend by bludgeoning his head with a table leg during a fight. Peterson was a man of limited intellectual ability[35] and the

[26] Id. at 54.
[27] Id. at 66.
[28] Id. at 57.
[29] Id. at 151.
[30] Id. at 237-238.
[31] Id. at 235.
In this case, there were a number of expert witnesses who made different conclusions about accused's mental condition. For more detailed examination of their reports please refer to the case.
[32] The defense of substantial impairment by abnormality of mind is only recognized in four Australian jurisdictions, see [18]
[33] See [18].
[34] [2014] NSWSC 1056.
[35] Id. at 59.

trial judge accepted that the deceased had started the fight (but rejected the accused's self-defence claim).[36] Four experts – two psychiatrists and two clinical neuropsychologists – gave evidence about Peterson's mental condition.[37] The psychiatrists noted that Peterson suffered from two underlying conditions: intellectual disability and "executive dysfunction caused by frontal lobe damage."[38]

This diagnosis of frontal lobe damage was made on the basis of a behavioural assessment, and not any kind of brain scan.[39] The experts explained that these impairments affected the accused's ability to control his behaviour[40] and understand the consequences of his actions.[41] Justice Campbell accepted the expert evidence[42] and allowed the partial defence.[43]

There are also other cases in which neuroscientific evidence supports the defence of substantial impairment.[44] In *Regina v A S Moffatt* [No 3],[45] for example, the court accepted that the long-term alcohol abuse resulted in the brain impairment, however, it was concluded that the mental condition was not severe enough and rejected the defence of substantial impairment.

Examining Intention

Besides the formal defences described above, neuroscientific evidence may be proffered as evidence pertaining to the accused's intention. The relevance of neuroscience is less clear in these cases than in doctrines that specifically invoke mental impairment and illness [20]. Moreover, gradients of intention are themselves fuzzy and the relationship between areas of the brain and these gradients is even fuzzier (see [21]).

In *R v H, LP*, the accused was charged with murder and attempted murder in relation to a shooting but claimed that he did not have the intent to kill.[46] The accused argued that he could not have formed the requisite

[36] Id. at 45.
[37] Id. at 56.
[38] Id. at 57.
[39] Id.
[40] Id. at 60.
[41] Id. at 62.
[42] Id. at 76.
[43] Id. at 75.; We will also discuss another substantial impairment case, *Director of Public Prosecutions v AB* [2013] NSWSC 1739 in our analysis in Part IV.
[44] For example, see *R v Glanville* [2010] NSWSC 364, in which damage to the accused's frontal lobes from a motorcycle accident supported his substantial impairment defence.
[45] [1999] NSWSC 233
[46] [2013] SASC 183.

intention for murder because he was extremely intoxicated (blood level = .252-.284).[47] To support this defence, the accused tendered the evidence of a psychiatrist who provided a thorough explanation of the effect alcohol has on a person's brain.[48] He noted that alcohol "depresses…brain function" [49] causing the drinker to go in and out of consciousness, akin to an individual in a "comatosed [sic]" state.[50] The trial judge concluded that, "Although his condition was one of gross intoxication and his behaviour was in many ways bizarre, nevertheless I find it proved beyond a reasonable doubt that the accused had the intention [to kill]."[51] As such, while the trial judge admitted the framework evidence[52] that alcohol can impact brain function and behaviour, it appeared that the court did not find such potential impact severe enough to negate his intention.

Besides the intention to commit the charged criminal act, neuroscientific evidence may call into question the accused's intention in other ways. For instance, the Supreme Court of Western Australia admitted medical evidence detailing an accused's frontal lobe injury to assist in assessing admissions he made during a police interview.[53] The evidence of the brain injury was relevant to the voluntariness of the admissions,[54] their reliability,[55] and whether the conduct of the police in interviewing a brain-damaged individual was unfair.[56]

Thus far, we have reviewed different uses of neuroscience at two stages: pre-trial and trial. In the following section, we will discuss how neuroscientific evidence is relevant to sentencing.

Part III. Neuroscience at sentencing

Courts consider many factors when determining a prisoner's sentence. Neuroscientific evidence informs the application of many of these factors. First, neuroscientific evidence may impact upon the moral culpability of the offender. This will be the case when brain impairment affects the offender's judgement, ability to understand the

[47] Id. at 75.
[48] Id. at 65-68.
[49] Id. at 66.
[50] Id. at 65.
[51] Id. at 82.
[52] i.e., the psychiatrist, of course, could not have examined the accused while he was intoxicated, and therefore the expert's report was not about the accused per se, but generally how brains are affected by alcohol.
[53] *The State of Western Australia v Clifton* [2012] WASC 302.
[54] Id. at 43-58.
[55] Id. at 54.
[56] Id. at 59-63. For more cases about memory and admission of evidence see, *CDK v Commissioner of Victims Rights* [2016] NSWCATAD 300; *R v Hawi & ors (No 27)* [2011] NSWSC 1673.

wrongfulness of criminal behaviour, or capacity to control his/her acts and emotions. In other words, if brain impairment is causally connected to the commission of the offence, the offender is less blameworthy.[57]

Another sentencing factor is deterrence. Sentencing with the purpose of deterrence aims to deter the public from committing similar crimes (i.e., general deterrence) or the offender from committing further crimes. (i.e., specific deterrence). Punishing an individual with a brain impairment may reduce the effectiveness of general deterrence because the offender is not representative of the population and is thus not a suitable example to deter the society from committing a crime.[58] An impairment may also militate against specific deterrence, as punishment may not deter an individual with a brain abnormality from further offending. Similarly, if the brain impairment that contributed to the offending is treated, there is less need for specific deterrence.[59] In cases where brain impairment is not treated, if the impairment makes the experience of custody more onerous for the offender than for other prisoners, the court may mitigate the punishment.[60]

Finally, courts consider the protection of society when determining a sentence. Here, an untreatable (or difficult to treat) brain abnormality may increase the risk of re-offending and thus militate towards a *longer* sentence in order to keep the offender away from those who could be harmed.[61] To illustrate this complex interplay between sentencing factors and neuroscientific evidence, we will now discuss several representative cases. We will begin with cases in which neuroscience mitigates the sentence and then contrast them with cases in which the sentence was aggravated.[62]

Neuroscience as a mitigating factor

Neuroscientific evidence may mitigate sentencing by supporting an explanation for why the offender behaved the way he or she did (i.e. the degree of offender's culpability). That is the case in the first two sentencing decisions we discuss, *DPP v Cook*[63] and *R v Terence Martin*.[64] Neuroscientific evidence may be also unrelated to the commission of the crime itself but still relevant during sentencing. For instance, it may provide information about

[57] *R v Israil* [2002] NSWCCA 255; *R v Hemsley* [2004] NSWCCA 228 (at 33 –36).
[58] *Engert* (1995) 84 A Crim R 67 at 71 per Gleeson CJ; *R v Hemsley* [2004] NSWCCA 228.
[59] *Director of Public Prosecutions (Cth) v De La Rosa* [2010] NSWCCA 194; also see, *R v Henry (1999)* 46 NSWLR 346, (Wood CJ at CL, Adam and Kirby JJ) at 46.
[60] See, *R v Hemsley* [2004] NSWCCA 228.
[61] *Benitez v R* (2006) 160 A Crim R 166; *Director of Public Prosecutions (Cth) v De La Rosa* [2010] NSWCCA 194
[62] For more discussion of mental condition and sentencing see [18, 50].
[63] [2015] VCC 116.
[64] [2011]. Unreported judgment. For a summary of this case see, https://neurolaw.edu.au/cases/10703.

how the offender would react to a jail sentence. This jail-experience factor played a part in the third case in this section, *DPP v Buckley*.[65]

In *DPP v Cook*, the offender pled guilty to a charge of armed robbery of a supermarket. At the time of the robbery, the offender apologised to the staff and said that he had a drug issue. A month later he claimed that he could not remember the robbery.[66] Several expert psychological reports were tendered to the court. The first report by a general practitioner concluded that the offender's seizures caused a brain condition at the time of the offence. A hospital neurology report on the offender noted that because of an organic brain disorder, the offender had significant cognitive impairment including problems with daily living and planning.[67] Finally, a report by a psychiatrist stated that there was a compounding interaction between the offender's drug addiction, his pre-existing cerebral deficits and dysfunctional background.[68]

The sentencing judge concluded that there was a causal relationship between these mental issues and his criminal behaviour and noted that without the pre-existing mental illness, the offender would not have committed that offence.[69] The judge found that the offender's brain damage reduced his moral culpability and made general deterrence less of a factor.[70]

In *Cook*, the neuroscientific evidence focused on an impairment in brain structure, an effectively permanent feature of the offender's anatomy. By contrast, some conditions are more transient, such as those caused by a chemical imbalance in the brain. This was the situation in *R v Terence Martin*,[71] in which the offender was found guilty of sexual intercourse with a minor and production of child exploitation material. The offender, who was a member of Tasmanian Legislative Assembly, had no prior convictions. His sexual desire was triggered after taking Parkinson's medication. Before taking this medication, he was allegedly celibate. The medication did not initially improve Martin's condition and the dosage of the medication was doubled on two different occasions. Following the increase in dosage, the offender formed hyperactive sexual tendencies. He spent approximately $150,000 on engaging with sex workers on 506 occasions. He also looked at internet pornography including child pornography.

[65] [2013] VCC 471.
[66] Id. at 1; 3; 4.
[67] Id. at 12.
[68] Id. at 13.
[69] Id. at 14.
[70] Id. at 11; 14.
[71] See, https://neurolaw.edu.au/cases/10703.

Changing the medication did not help to prevent further hypersexuality, however terminating all treatment was successful in stopping his abnormal sexual behaviours.

A report from a neurologist indicated that the offender's behaviour was a severe case of hypersexuality induced by the medication that also resulted in a change of sexual preference. Even though the offender understood the relationship between the drug and his sexual activities, he was not able to control his behaviour. A forensic psychiatrist similarly opined that the medication caused the offender's behaviour. The sentencing judge agreed that the medication caused mental issues. Consequently, the offender's capacity for "choice, moral reasoning and judgment" was reduced. As in *Cook*, this determination mitigated the offender's moral culpability and reduced the significance of general deterrence.

Unlike *Cook* and *Martin,* in some cases there is no connection between neuroscience and criminality, but neuroscience is still relevant to sentencing. In *DPP v Buckley*,[72] for instance, the offender suffered a stroke and a CT scan indicated an acquired brain injury. While it appeared that the brain impairment was not causally related to criminal behaviour and consequently did not influence the offender's moral culpability, the judge concluded that psychological issues derived from the brain impairment would make the prison sentence more onerous for him.[73] As such, the brain impairment reduced the sentence due to custodial hardship.[74]

Neuroscience as an aggravating factor

While the offenders in the above cases appeared to benefit from adducing neuroscientific evidence at sentencing, such evidence does not always represent such a clear advantage to the offender. This is the case when the neuroscientific evidence suggests that the accused poses a particular risk of reoffending. In *R v McCann*,[75] the jury found the offender guilty of manslaughter for strangling the deceased.[76] Five experts opined regarding the offender's mental condition. A clinical psychologist found evidence of cognitive impairment consistent with frontal

[72] [2013] VCC 47.
[73] Id. at 12; 13.
[74] Other than custodial hardship there are other sentencing factors that do not require a link between neurological impairment and criminal behaviour. For example, because an offender with brain impairment may not be a proper tool to deter the society from offending, the court may give lower consideration to general deterrence even if the brain impairment is not causally connected to offending or it occurs after the crime, see, *R v Caleb James O'Connor aka John Coble* [2013] NSWDC 272.
[75] [2012] NSWSC 1462.
[76] Id. at 2-13; 28.

lobe damage, resulting in issues such as poor planning and evaluation of behavioural responses.[77] A neuropsychologist reported that CT and MRI indicated brain abnormalities.[78] The neuropsychological assessment also revealed problems with working memory and impairment in creating novel ideas.[79]

Although the sentencing judge acknowledged that the offender's mental condition meant that lower weight should be attached to moral culpability and general deterrence, his honour also added that, "However, … the irreversible condition of the frontal lobes and the brain generally, raises the question of his dangerousness in the future."[80] As such, the offender's brain condition was both a mitigating and aggravating factor.[81]

There are several reasons why evidence of the offender's brain condition will not always be an aggravating factor, as it was in *McCann*. As noted above, the neuroscientific evidence may indicate a condition that is temporary, such as with the effects of the Parkinson's medication in *Martin*. Alternatively, the brain impairment may reduce – rather than increase – the risk of future offending. This was the case in *R v Goodridge (no 2)*.[82] In *Goodrich*, the offender was found guilty of murder.[83] Much earlier – at the age of three – the offender was run over by a car and experienced a head injury. As a result, he could not remember his childhood.[84] In 2010, he suffered another head injury following an assault in gaol.[85] Four experts, three psychiatrists and a psychologist, submitted reports. The psychologist reported that the offender had marked cognitive deficits that were associated with his history of cerebral insult and a lengthy history of substance and alcohol abuse.[86] The psychiatrists reported brain damage resulting from excessive alcohol use and head injuries,[87] baseline low IQ, poor judgment, cognitive impairment,[88] and the result of an MRI scan that indicated brain abnormality[89] consistent with vascular disease.[90]

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[77] Id. at 17.
[78] Focal abnormalities in the frontal lobes and significant cerebral atrophy Id. at 21.
[79] Id. at 21.
[80] Id. at 36; Although two psychiatrists believed that the risk of re-offending was fairly low, the judge accepted the third psychiatrist's opinion that the offender posed a risk of violence to community once he is released (Id. at 37-40).
[81] Proof of brain impairment may also have another negative outcome for the defendant. For instance, according to the *Crimes (High Risk Offenders) Act 2006* (NSW), in order to prevent further offending by 'high-risk sex and violent offenders', the court may impose post-sentence preventive detention order or an extended supervision order at the end of the custodial sentence. See, *Dangerous Prisoners (Sexual Offenders) Act 2003* (Qld); *Dangerous Sexual Offenders Act 2006* (WA); *Serious Sex Offenders Act 2013* (NT); also see [51]. There are many concerns with regard to these Acts such as proportionality of the sentence, double punishment and procedural fairness. See [51-53].
[82] [2012] NSWSC 1180.
[83] Id. at 5-10.
[84] Id. at 41.
[85] Id. at 30.
[86] Id. at 32, 41-43.
[87] Id. at 33.
[88] Id. at 34-36.
[89] 'cerebral atrophy and lesions in the white matter' Id. at 35.

The MRI scan, a cognitive test, and the offender's memory issues contributed to a diagnosis of dementia. [91] It was concluded that if the cognitive decline continued, the offender's lifespan would not be more than 6 to 7 years.[92]

The sentencing judge concluded that "[h]is long-standing history of alcohol abuse and the concomitant brain damage meant that he was prone to binge-drinking which tended to make him behave erratically and aggressively"[93] with impaired judgment. Consequently, his moral culpability was reduced.[94] His mental condition also significantly reduced the consideration of general and specific deterrence.[95] Importantly, the sentencing judge found that the offender's severely compromised mental condition (i.e. his dementia and short lifespan) eliminated his danger to the society.[96]

McCann and *Goodrich* also demonstrate the particular relevance of neuroscientific assessments in sentencing decisions (as opposed to trial decisions). The inquiry at sentencing is broadened from not just the state of the accused's (or offender's) brain when the crime was committed, but its condition post-conviction and beyond. In cases like these, neuroscientific evidence (and psychological evidence generally) is more likely to be relevant because the state of the offender's brain post-conviction is the fact-in-issue.[97]

The double-edged sword effect of neuroscience

As we discussed earlier in relation to *R v McCann*,[98] while a brain abnormality may support a more lenient sentence (for example, due to lessening the effect of general deterrence and reducing moral culpability), it may also require the risk of re-offending to be given greater consideration. Since the neuroscientific evidence can both support a more severe sentence or a more lenient sentence, it is often labelled a double-edged sword [1]. Many scholars have discussed this dual effect of neuroscience on sentencing (see, [44-46]). For instance, Owen Jones and

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[90] Id. at 31.
[91] Id. at 35.
[92] Id. at 34; 36.
[93] Id. at 37.
[94] Id. at 18; 37.
[95] Id. at 44; 45.
[96] Id. at 46.
[97] For further cases about contribution of neuroscience to sentencing in Australia see, *R v Lepore* [2013] SASCFC 13 (where fresh neuroscientific evidence in the appellate court required mitigation of the sentence); *The Queen v Hildebrandt* [2014] VSC 321 (where the offender's frontal-lobe damage was a mitigating factor in sentencing); *The Queen v Giles* [2014] VSC 210 (where neuroscientific evidence indicated further consideration of future offending and protection of the society); *The Queen v Furlan* [2014] VSC 361 (where the offender's acquired brain injury was a mitigating factor in sentencing); *Ross v R* [2006] NSWCCA 65 (where the sentence was found to be excessive for the defendant who suffered from frontal-lobe impairment); *Regina v Michael James ELSWORTH* [2000] NSWSC 582 (where neuroscience explained the criminal behaviour); *R v Tortell, R v Tsegay* [2007] NSWCCA 313 (where neuroscientific evidence indicated frontal-lobe damage); *R v Millard* [2014] ACTSC 267 (where neuroscience reduced the consideration of moral culpability).
[98] [2012] NSWSC 1462

Francis Shen explain that, "a brain *too* broken may be simply too dangerous to have at large, even *if* it is somehow less culpable" ([25] p. 362 quoted in [5]).

Beyond *McCann*, this double-edged feature of neuroscientific evidence has been recognised in Australia since at least 1979. In two highly cited judgments of the High Court of Australia (HCA), *Veen v R*[99] and *Veen v R (No 2),*[100] the accused's brain damage contributed to the successful defence of substantial impairment. However, while his brain impairment was considered a mitigating factor, it also resulted in arguments regarding the danger the offender would present to society.[101] Accordingly, defence lawyers may find a decision about whether or not to use neuroscientific evidence risky. However, that does not seem to be the case in Australia. In most sentencing cases that we analysed in this study, neuroscience only leads to mitigation and is rarely used as evidence for the offender's risk of recidivism.[102]

Neuroscience and the Juvenile's Brain

A subset of sentencing cases focuses on juveniles. These cases rely on studies of developmental neuroscience that have increased our understanding of the neural bases of psychosocial development during adolescence and adulthood. Such studies explain the relationship between neurological development and behavioural tendencies such as risk-taking or impulsivity in adolescents [26]. For instance, the prefrontal cortex – the area of the brain that is associated with advanced thinking abilities such as planning and measuring risk and reward, as well as self-regulation and impulse control – is immature during adolescence. As such, juveniles are more inclined to take risks and tend to act more impulsively than older individuals [27].

In the U.S., scholars have discussed the influence of this research on reduced sentences for juveniles in the criminal justice system [28]. In some recent U.S. cases, courts ordered comparatively lower sentences for juveniles who committed serious crimes than for their adult counterparts [29]. For instance, in one decision, the death penalty

[99] [1979] HCA 7; (1979) 143 CLR 458
[100] *Veen v R (No 2)* [1988] HCA 14; (1988) 164 CLR 465 (29 March 1988).
[101] Also, in *R v Morton* [2010] NTSC 26, EEG and MRI scans confirmed brain damage and temporal lobe epilepsy resulting in mental impairment, that led to a reduced weight given to moral culpability, and general and specific deterrence, but resulted in a greater consideration of the need to protect society from the risk of recidivism.
[102] Similar to this study, an empirical study in the U.S. by Deborah Denno titled "The Myth of the Double-Edged Sword: An Empirical Study of Neuroscience Evidence in Criminal Cases" indicates that only in a few cases neuroscience is an indicative of the offender's risk of recidivism. [5]

for juveniles who committed their crimes before the age of 18 was set aside.[103] In another case, life without parole was prohibited for non-homicides with juveniles who were under 18 when the crime was committed [28, 29]. [104]

While brain development and biological maturity are historically considered to have been achieved by the age of eighteen or during early adulthood, some relatively recent studies have found that the connection between a person's prefrontal cortex and the areas of the brain associated with rewarding giving and responding to social and emotional stimuli is not complete until their mid-twenties [27, 30]. The bond that develops between these two areas of the brain in later years enables the prefrontal cortex to control the emotionally aroused actions and lead to socially accepted behaviour [31].

In Australian criminal proceedings, neuroscience has also contributed to the way in which courts sentence juveniles and young adults. In *Webster (a Pseudonym) v R*[105], the Victorian Court of Appeal[106] stated that sentencing young offenders requires a different application of the various purposes of punishment in comparison to sentencing adults.[107] Three reasons were given for this: the immaturity of a young offender reduces their moral culpability, "custody can be particularly criminogenic for a young person, whose brain is still developing", and the process of maturation and development that they are experiencing provides a unique opportunity for rehabilitating a young offender.[108]

To support the relationship between the immaturity of young offenders and their criminality, the court, quoting from a study ([32] p. 434), mentioned that '[w]hile the cognitive capacities of 16-year-olds may approximate those of adults, psychosocial maturation proceeds more slowly than cognitive development, leading to social and emotional differences between adolescents and adults that continue well beyond mid-adolescence and have profound effects on decision making'.[109] In relation to the importance of rehabilitating juvenile offenders, the court referred to research [26] that has shown that immature juvenile brains respond to punishment in a way that increases the risk of re-offending rather than reducing it.[110]

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[103] *Roper v. Simmons*, 543 U.S. 551 (2005).
[104] *Graham v. Florida*, 560 U.S. 48 (2010).
[105] [2016] VSCA 66.
[106] Majority decision.
[107] Id. at 7.
[108] Id. at 8.
[109] Id. at 26.
[110] Id. at 27.

In another case, with regard to the influence of alcohol and drugs on young male offenders when compared to more mature adults, the court explained that '[r]esearch shows that the executive functions of the brain of eighteen and twenty-five years old males are still developing…Consequently, alcohol, drugs and passion impair the judgment of young men to a greater degree than the same ingredients are likely to do with more mature males.'[111] The court also noted that sentencing considerations related to the age of the offender should not alter based on the seriousness of the offence.[112]

A different aspect of the mental development of a juvenile offender and their future dangerousness was discussed in *R v Wong.*[113] In that case, the psychiatrists explained that the brain and personality of an eighteen-year-old offender are still developing. As such, '[i]t would [be] expected that [the offender's] brain and personality will mature during the years he spends in custody accompanied by improved judgment and impulse control.' [114]

Part IV. Critical Analysis of Australian Criminal Courts' Use of Neuroscientific Evidence

Now that we have reviewed the many uses of neuroscience in Australian criminal courts, it is possible to critically reflect on those uses. As many commentators have noted, the amount of basic and applied research in neuroscience has greatly increased over the past several decades (For a review, see [33]). In other words, it is a discipline that is still very much in its formative stages. While the scientific literature underlying neuroscience can self-correct over the years, there are fewer opportunities for self-correction in law (e.g., limited rights of appeal) . As a result, both scientists and legal actors must establish an "ethic of caution" when relying on neuroscientific evidence [34]. In other words, should not go beyond their data and make claims that cannot be defended (see, [34] p. 38-42).

The importance of caution when relying on neuroscientific evidence is underscored by recent findings demonstrating uncertainties in its scientific foundations. For instance, it is well known that neural imaging studies are expensive to perform and thus have historically included fewer participants than non-imaging behavioural studies. Denes Szuchs and John Ioannidis recently performed a study finding that this lack of sample size is so

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For a similar case see, *R v Hawkins [2015]* ACTSC 333 at 64, "[the offender's] age is also relevant in itself. He is still a relatively young man and neuroscience shows that the male brain is not fully mature and developed until mid twenties."
[111] *R v Khosravi, Alborz* [2008] NSWDC 298 at 1.
[112] Id. at 71.
[113] [2010] NSWSC 171.
[114] Id. at 27.

problematic that it is likely that over half the published studies in cognitive neuroscience contain spurious findings [10]. Similarly, neuroscience researchers have a great deal of discretion in how they analyse imaging data. Many have likely strategically selected measurement points (i.e., voxels) in brain images when comparing them to the behaviour of interest ([35]; see also [36]). This practice produces artificially inflated findings (i.e., "voodoo correlations") that misrepresent the robustness of the specific claim.

More generally, there have been two broad academic responses (schools of thought) to the use of neuroscience evidence in the courtroom (see [20] for a review). The first is sceptical and cautious. These researchers say that brain states are rarely relevant to criminal law criteria, which are largely behavioural [34]. And moreover, the use of brain images in court may be highly prejudicial with lay factfinders ascribing them more weight than they deserve ([8]; see also [9]). As a result, neuroscience may be high in persuasiveness but possess little-to-no legal relevance (i.e., Morse refers to such evidence as merely 'rhetorically relevant')[9, 34]. The second school of thought embraces a more expansive role for neuroscience in the criminal justice system [37].

As we will discuss below, we did not observe many of the first school of thought's concerns about neuroscience in court in our review of the Australian jurisprudence. This is demonstrated by the fact that the neuroscience is generally treated as a contributory tool among other tools in assessing a mental state or merely a suggestive evidence rather than dispositive proof of a mental state (i.e. smoking gun). For example, recall that in *Berlingo*, other traditional forms of psychiatric assessment overcame imaging suggesting there was no mental impairment.[115] Still, the picture in Australia was not unilaterally so rosy. We did find some indication of neuroscience's prejudice and merely rhetorical relevance. We will describe these in the following section.

Prejudicial Neuroscience and Rhetorical Relevance in Australian Neurolaw

One of the most serious dangers presented by the rapid increase in neuroscience in court is that the tribunal of fact may place undue weight on this evidence. In evidence law, this danger is meant to be countered by the trial judge's discretion to exclude evidence when the danger of prejudice it presents outweighs its probative value [38].

[115] Beyond the cases reviewed above, see also *R v Santos* [2001] NSWSC 923 where the offender's substantial impairment defence (manslaughter) was based on three contributory factors. First, the offender suffered personality change (i.e. irritable and predisposed to losing temper) as the result of a head injury. Neuropsychological testing also showed cognitive impairment as another result of head injury. The third factor was depression that according to expert report "added to his difficulties in understanding [victim's] actions and resolving the issues which arose from them." (at 20) While none of these factors seems to be sufficient to substantially impair the offender's abilities, the combination of these factors met that threshold.

And, in *Uniform Evidence Act* jurisdictions, there is a mandatory exclusion of such evidence in criminal matters when it is adduced by the prosecution [38].[116] For instance, trial judges often exclude images from grisly crime scenes under the theory that they add little to the understanding of the crime, but may deeply prejudice the jury against the accused [39]. In the context of neurolaw, one of the first objections to the use of neuroscientific images in court was that they were overly prejudicial and added little to the expert's testimony [8]. In particular, Joseph Dumit was concerned that fact-finders would overemphasise testimony buttressed by brain images because they seemed more objective: "…I argue there is an undue risk in courtrooms that brain images will not be seen as prejudiced, stylized representations of correlation, but rather as straightforward, objective photographs of, for example, madness" [8].[117]

Scans are not objective (see [8, 34]), in that their meaning relies on interpretation by expert neuroscientists (and others). In other words, brain scans are, by themselves, almost never dispositive of any legally meaningful mental condition [8, 34, 40, 41]. To illustrate the latter point, Emma Sprooten and colleagues performed a meta-analysis of 537 fMRI studies spanning 21,427 total participants [42]. They examined whether those scans could reliably differentiate between patients suffering from five major mental illnesses (schizophrenia, bipolar disorder, major depressive disorder, anxiety disorders, and obsessive compulsive disorder). They found that fMRI was largely not up to the task – the differences between patients and controls were largely the same across illnesses. In other words, fMRI, currently, has very low diagnostic specificity. Of course, brain scans can certainly assist an expert in coming to an opinion or diagnosis (see [8]). That process, however, depends on the subjective judgment of the expert – the scan should not be mistaken as objective, dispositive evidence.

In reviewing case law, it can be difficult (and sometimes impossible) to determine if a judge or jury is misconstruing neuroscientific evidence as objective. We did, however, find one judgment in which a trial judge's reasons expressly misconceived neuroscientific as objective. In this case, *R v Hussein*,[118] the issue was whether Mr. Hussein was fit to stand trial. The defence proffered a clinical neuropsychologist, Dr. Dowla, who performed a scan

[116] Uniform evidence jurisdictions are New South Wales, Tasmania, Victoria, the Northern Territory, and the Australian Capital Territory.
[117] The neurolaw literature mainly criticises the use of brain imaging evidence and it seems there is less concern about other types of neuroscientific evidence (See [55, 56]). As such, the main focus of this section is on cases that brain imaging evidence is discussed because that seem to present to most possibility for prejudice.
[118] [2011] NSWDC 103.

showing abnormalities in the Hussein's prefrontal cortex.[119] Still, the prosecution's experts maintained that Hussein was fit to stand trial.[120] Ultimately, the trial judge preferred the defence's experts and seemed to misunderstand the nature of the neuroscientific evidence: "To my mind, there is clear *objective* evidence from Dr. Dowla's testing of Mr. Hussein's disability."[121] (emphasis added) He thus found Hussein unfit to stand trial.[122] Brain scans, while a useful diagnostic tool, should not be considered objective evidence. They rely on the subjective interpretation of the analyst.

Despite the experience in *Hussein*, many researchers have found that fact-finders do not have their decision-making overwhelmed by the purported objectivity of neuroscience (see [43, 44]). Recently, Shen and colleagues performed a study, presenting some participants with EEG information that either supported or challenged the accused's credibility [43]. They found that the EEG information indeed influenced the verdict participants chose, but the overall strength of the case was a stronger predictor of the verdict (approximately double the effect size). While there still seems to be no strong consensus in the field [43], it seems safe to say that neuroscientific evidence can affect jurors' (or, more specifically, the jury-eligible subject pool commonly used in studies like Shen's) decision-making, but it does not seem as prejudicial as academics originally thought.

Our review generally accords with findings like those made by Shen and colleagues. We found that Australian judges rarely expressly favoured neuroscience over well-established behavioural psychological evidence. One case that came close to the line was *R v AB*.[123] In that case, the accused argued that he had been substantially impaired when he killed his wife.[124] The trial judge considered the opinions of several psychological experts who opined on the accused's dementia. Some of the cognitive measures were inconclusive. For instance, the accused scored a 24 on the Minimum Mental State Examination (MMSE, a test for cognitive impairment) – a borderline score.[125] The trial judge weighed this score together with an MRI that showed frontal lobe damage: "…'frontal impairment' – in which judgment and planning are adversely affected – are not demonstrated well in an MMSE and behavioural impairments are not tested. It is important, therefore, not to ascribe too much significance to this test in

[119] MRI and EEG scans did not indicate any abnormality. But the third test a Ceretec Brain Perfusion Study, showed some abnormalities. Id. at 20, 24.
[120] Id. at 40-43.
[121] Id. at 40.
[122] Id. at 46, 47.
[123] [2013] NSWSC 1739.
[124] See Part II for a description of substantial impairment.
[125] Id. at 51.

light of the MRI's demonstration of frontal lobe damage."[126] In other words, the trial judge appeared to be aware of the limitations of the various tests that were performed, rather than irrationally preferring the neuroscientific tests.

The experience in *AB* also illustrates the fact that, in Australia, the neuroscience is regularly duplicative of well-established clinical tests and thus may be categorized as merely rhetorically relevant [34]. In *AB*, for instance, the finding of substantial impairment due to dementia was supported (beyond the MMSE) by other classic forms of psychiatric testing and interviewing.[127] The dangers with admitting merely rhetorically relevant evidence are not as serious as misunderstanding evidence, but the practice can consume valuable court resources and encourage parties to retain costly rebuttal witnesses. The practice can also lead to legal outcomes that are plainly irrational. The legal treatment of neuroscientific and non-neuroscientific evidence about intoxication is an excellent example of an irrational legal distinction.

On the topic of intoxication evidence, contrast the admitted testimony of the expert in *H, LP* (reviewed in Part II), who couched his testimony about the effects of alcohol in neuroscientific terms, with a long line of cases excluding opinion evidence about the effects of intoxication (but not couched in neuro-language). These latter cases excluded the evidence because it was either irrelevant or duplicative of common sense. As to common sense, courts noted that intoxication is a phenomenon that juries can adequately form their own judgments about: "where the jury are faced with aberrations of human behaviour caused by the intake of alcohol, that is an area they are perfectly able to form a judgment about without being assisted by the experts…"[128] And regarding relevance, courts have held that the expert evidence is not sufficiently probative of the fact in issue (often intent).

These cases excluding expert evidence about the role of intoxication on intent are difficult to reconcile with *H, LP*. In *H, LP*, the defence's psychiatrist had not examined the accused directly after the event and merely gave framework evidence "of a general nature as to how alcohol affects the processes of thought that go on within a person's brain."[129] This was precisely the type of evidence excluded in the earlier cases, only couched in neuroscientific language. This distinction supports some concerns with neuroscientific evidence. Indeed, several studies support a phenomenon sometimes termed "neuromania" whereby lay people prefer explanations that include

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[126] Ibid.
[127] Id. at 52. It is noteworthy that as discussed above in cases such as *Berlingo* and *Re Ma'a* that malingering is suspected neuroscientific evidence might be helpful and provide additional information on which to base a diagnosis.
[128] *R v Haidley and Alford* [1984] VR 229 at 233, quoting *R v Darrington and McGauley* [1980] VR 353. And for similar reasoning see *R v Morgan* [1986] 2 Qd R 627 at 656; *R v Carn* [1982] 5 A Crim R at 469-470.
[129] *H, LP* at 66.

neuroscientific jargon [45]. For example, in a well-known series of studies titled "The seductive allure of neuroscience explanations", Deena Weisberg and colleagues reported that their participants found descriptions of psychological phenomena more satisfying when they included irrelevant neuroscientific terms [46]. Similarly, scientific studies are more persuasive to lay people when they include irrelevant neuroscience [47]. In our analysis, neuromania indeed appears to be the only way to reconcile *H, LP* and the traditional Australian legal position on intoxication evidence.[130]

Finally, while in some cases it appears that neuroscience is merely duplicate of other traditional forms of evidence, it may still be useful. There are several circumstances where other types of evidence may be inconclusive and unable to meet the legal standard of proof.[131] This is evident in cases where the expert is not confident about the outcome of the assessment, or cases in which different experts have conflicting opinions. In such cases, neuroscience can have a "buttressing" function when it is coupled with other types of evidence, forming a more robust claim [48] and meet the standard of proof.[132]

Part V. Conclusion

Despite recent research finding that parties increasingly rely on neuroscience as evidence in court, very little is known about how such evidence is being used in the Australian legal context. This study has demonstrated, for the first time, that neuroscience is being used in Australian courts in the forms of diagnostic and framework evidence at several stages in the legal process: pre-trial, trial, and sentencing. In general, the admission of neuroscientific evidence throughout the court process leads to the conclusion that Australian courts welcome the submission of neuroscience.

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[130] Although note that *H, LP* was a judge alone trial and thus the trial judge may have been more permissive towards the evidence for that reason. Still, the contrast between the traditional position whereby intoxication evidence is irrelevant and the trial judge in *H, LP* taking the time to specifically report the "neuroscientific" opinion evidence about intoxication is striking. We cannot, however, conclusively rule out other distinctions between *H, LP* and the traditional position towards evidence of the effects of extreme intoxication.

[131] The two main standards of proof are 'beyond reasonable doubt' and 'on the balance of probability'. When the ultimate fact in question is to the detriment of the accused/offender, the standard is the former, and when it is for their benefit, the standard is the latter.

[132] For instance, in *R v McCann* (discussed above) two psychiatrists suggested that the offender posed a low risk of re-offending. However, the court, based on the irreversible condition of the offender's brain and another psychiatrist's report (i.e. referred his 'dementing process'), concluded that the offender was a danger to the community.

Our analysis of how Australian criminal courts use neuroscientific evidence suggests that courts perform balanced reasoning between neuroscientific evidence and other types of evidence, and that neuroscience is generally treated as a contributory tool rather than definitive proof (or, a 'smoking gun'). Further, courts appear to be cautious about the limitations of neuroscience and do not seem to unilaterally favour it over more traditional forms of evidence. (except the alcohol case, *H, LP* which suggested the court prefers evidence couched in neuroscientific language).[133]

Although this research extends our knowledge of the use of neuroscience and qualitatively examines hazards and themes that may flow from the use of this evidence in Australian criminal law, it cannot provide empirical conclusions. As such, we encourage more comprehensive empirical research to build on our findings.

Appendix

Following our review of criminal cases on the Australian Neurolaw database we sorted them into different categories such as 'fitness to stand trial', 'sentencing', 'the juvenile brain', and 'the brain and memory'. As our categories were largely based on a review of cases in the Australian Neurolaw Database, the general search on AustLII aimed to find any other reasons for the use of neuroscience in Australia that were not included in the Australian Neurolaw Database.

We used a variety of keywords including 'neuroscience', 'brain', 'neuropsychology', 'EEG', 'MRI', 'CT scan', 'fMRI' and 'SPECT scan'. As the result of our search thousands of cases were produced; however, as the purpose of this study is to explore different uses of neuroscience in criminal courts, we purposefully reviewed a number of cases to find out whether neuroscience is used in a way that we had not previously considered. Accordingly, revision of cases ended when we could not find any new use of neuroscience.

In order to identify cases where neuroscience was used for specific purposes, we used Boolean operators. For instance, to find cases in which reference is made to both 'memory' and 'the brain', we searched 'brain AND memory'. We also used more complex searches such as '(false/5/memory) AND brain AND eyewitness'. This only produced results in which 'brain', 'eyewitness', 'false' and 'memory' were noted in the case, and where there are not

[133] And this is consistent with empirical research examining the effect of neuroscientific jargon on laypeople. See [46].

more than 5 words between ‘false’ and ‘memory'. This approach (proximity operator) helped to avoid cases where irrelevant combinations (i.e. ‘false accusation’ and ‘childhood memory’) are noted in different parts of the judgement.

We then sorted the cases into different categories (similar to our categories on the Australian Neurolaw Database). A review of the dataset indicated that in some categories all the cases were from a single jurisdiction (i.e. New South Wales). We conducted a further search to balance the distribution of cases from different jurisdictions. As such, our research better represents the use of neuroscience in Australia.

Of the 779 cases that we reviewed, a proportion of the cases were irrelevant to the study and were excluded. For instance, in many cases neuroscientific tests, such as MRI and CT scans, were used to examine other body parts than the brain, or were conducted on the victim rather than the accused/offender. Occasionally the cases were also the same as those listed on the Australian Neurolaw Database.

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