The Potential Contribution of Neuroscience to the Criminal Justice System of New Zealand†

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I INTRODUCTION

Descriptions of "neurolaw", the legal discipline governing the intersection of law and neuroscience, span a continuum from "contribut[ing] nothing more than new details"[1] to ushering in "the greatest intellectual catastrophe in the history of our species".[2] This controversy is not unwarranted. The "technological wizardry"[3] of modern neuroscience tracks the movement of fluids and electrical currents, revealing both structure and organic functioning, and is the closest humans have come to "mind reading".

While not unwarranted, the controversy's reactionary nature gives the misleading impression that neurolaw is a modern invention. In fact, neurolaw's historical roots are evident in the law's foundational preoccupation with concepts of mens rea and moral desert.[4] Connections between criminal behaviour and brain injury appeared as early as 1848,[5] with biological positivism making formal — and sinister — progress at the end of the 19th century.[6] Current legal applications of neuroscience both continue this story and reflect a wider trend of science gaining popular trust and interest from the courts.[7] Such applications have been proposed

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1 Joshua Greene and Jonathan Cohen "For the law, neuroscience changes nothing and everything" (2004) 359 Phil Trans R Soc Lond B 1775 at 1775. The authors summarise the position taken in Stephen Morse "New neuroscience, old problems" in Brent Garland (ed) *Neuroscience and the Law: Brain, Mind, and the Scales of Justice* (Dana Press, New York, 2004) 157 at 157–198.

2 Stephen Morse "Criminal Responsibility and the Disappearing Person" (2007) 28 Cardozo L Rev 2545 at 2556 ["The Disappearing Person"]. Morse quotes Jerry Fodor *Psychosemantics: The Problem of Meaning in the Philosophy of Mind* (The MIT Press, Cambridge, 1987) at xii.

3 George Annas "Foreword: Imagining a New Era of Neuroimaging, Neuroethics, and Neurolaw" (2007) 33 AJLM 163 at 163.

4 See Amanda Pustilnik "Violence on the Brain: A Critique of Neuroscience in Criminal Law" (2009) 44 Wake Forest L Rev 183 at 212–213.

5 Ibid. Pustilnik describes the case of Phineas Gage, a railway worker whose changed personality (due to a serious brain injury) not only seemed to make him more ill-tempered but may have also encouraged his minor encounters with the law.

6 Ibid, at 183; Brent Garland and Mark Frankel "Considering Convergence: A Policy Dialogue about Behavioral Genetics, Neuroscience, and Law" (2006) 69 LCP 101 at 109–110.

7 "The influence of forensic science in relation to criminal justice has risen sharply in recent years": *Wallace v R* [2010] NZCA 46 at [51] per Hammond J. See also Michael Gazzaniga "The Law and Neuroscience" (2008) 60 Neuron 412 at 413; Jennifer Kulynych "Psychiatric Neuroimaging Evidence: A High-Tech Crystal Ball?" (1997) 49 Stan L Rev 1249 at 1251.

for every stage of the criminal process from law-making, sentencing policy and pre-trial and trial-stage lie detection, to psychiatric testimony and testing for recidivist intent at sentencing and parole. Despite this ambitious potential, there are serious theoretical concerns regarding the nexus between the law and science; practical questions about the scientific validity of the neural technology;[8] and legal and ethical issues concerning the appropriate application of neuroscience in evidentiary procedures, as well as a potential "net-widening", as neurolaw proponents venture into pre-emptive deterrence.[9]

Commentators propose vastly different applications for this technology, based on disparate interpretations of both law and science. The "radical school"[10] advocates an extensive remodelling of the law, especially criminal law, along neuroscientific principles. In contrast, the sceptical "moderate school" criticises these "radical" proposals for misunderstanding both premature science and legal philosophy. Whereas the radical school accepts a hard determinist view of humanity, the moderate school is either libertarian or compatibilist, or considers that determinism is irrelevant to existing legal structures.[11] These philosophical positions revive an ancient determinism/free will conundrum, although it is unclear whether neuroscience influences this debate directly.[12]

This article analyses neuroscience's potential contribution to the law of evidence.[13] First, it describes the theoretical potential of neuroscience within the law. Attention turns secondly to the technology behind neuroscience. Thirdly, the article examines the admissibility of this technology in overseas courts. Finally, it analyses the legal framework for neuroscience's potential evidential contribution in New Zealand, especially the potential admissibility of neuroscientific techniques under the Evidence Act 2006. Overall, the article suggests that, despite some international precedent, the science has not reached an adequate threshold of relevance or reliability so as to be admissible in New Zealand courts.

II THEORETICAL POTENTIAL OF NEUROSCIENCE WITHIN THE LAW

There is a substantial body of scientific literature on the neurological bases

8 Henry Greely "Law and the Revolution in Neuroscience: an Early Look at the Field" (2009) 42 Akron L Rev 687 at 688 ["Law and the Revolution"].

9 Stephen O'Hanlon "Towards a More Reasonable Approach to Free Will in Criminal Law" (2009) 7 Cardozo Pub L Poly & Ethics J 395 at 421–422.

10 "Radical" and "moderate" are the author's terms.

11 "Libertarian" is not to be confused with the political term. Libertarians and hard determinists see free will and determinism as inconsistent. Libertarians believe in free will; hard determinists do not. Compatibilists believe free will and determinism are "perfectly compatible". See Greene and Cohen, above n 1, at 1776.

12 Gazzaniga, above n 7, at 412; Greene and Cohen, above n 1.

13 It may be possible for neuroscience to have broader applications, particularly in medical law and sentencing.

of violence, offering endless possibilities as to how such neuroscience might interact with the law.[14] Familiar legal applications of neuroscience include ascertaining capacity to stand trial, establishing mens rea and supporting an insanity defence.[15] Discussion of these applications has provoked extreme responses, "rang[ing] from apocalyptic to 'business as usual'".[16] This section briefly analyses the reasoning behind these reactions.

"Apocalyptic": the Radical School

The radical school essentially contends that a scientific understanding of neurology necessitates acceptance of external causation, or determinism. Specifically, it seeks to prove that "firings of neurons in the brain" control all human actions.[17] Thus, once the mechanisms behind these firings are understood, it may be possible to predict thought and behaviour and fully understand, or even control, the "human condition".[18] The legal implementation of such suggestions requires shifts in the "standard conceptions" of "free will, personhood, and action".[19] These shifts constitute the revolutionary nature of this group.[20]

Commentators within this school portend the legal implications of such scientific understandings of brain function,[21] forecasting "major changes" in investigation, trial and sentencing procedures:[22] for instance, using lie detection, "mind-reading", evidence of bias, and neural "causes" of criminal behaviour to prove facts,[23] and even acting "directly to change a criminal's brain".[24] Neuroscience may eventually demonstrate that "free will ... is an illusion"[25] and that personal responsibility is therefore an artefact of "obsolete philosophical speculation".[26] Scholars of the radical school envisage "a world of criminal justice in which there is no blame [but] only prior causes",[27] arguing that this undermines existing legal

14 Pustilnik, above n 4, at 205.

15 Neal Feigenson "Brain imaging and courtroom evidence: on the admissibility and persuasiveness of fMRI" (2006) 2 Int JLC 233 at 234–235.

16 Henry Greely "Neuroscience and Criminal Justice: Not Responsibility but Treatment" (2008) 56 U Kan L Rev 1103 at 1103 ["Not Responsibility but Treatment"].

17 Ibid, at 1134.

18 Gazzaniga, above n 7, at 412.

19 Morse "The Disappearing Person", above n 2, at 2545.

20 Ibid.

21 Jessica Gurley and David Marcus "The Effects of Neuroimaging and Brain Injury on Insanity Defenses" (2008) 26 Behav Sci & L 85 at 86; Gazzaniga, above n 7, at 414.

22 Greely "Not Responsibility but Treatment", above n 16, at 1104.

23 Ibid.

24 Ibid, at 1134.

25 Greene and Cohen, above n 1, at 1776. See also Nicole Vincent "On the Relevance of Neuroscience to Criminal Responsibility" (2010) 4 Crim Law and Philos 77 at 77–78.

26 Bruce Arrigo "Punishment, Freedom, and the Culture of Control: The Case of Brain Imaging and the Law" (2007) 33 AJLM 457 at 463. See also Morse "The Disappearing Person", above n 2, at 2545, where Morse contends that "[i]f we do not have free will ... then traditional concepts of responsibility and desert are apparently impossible".

27 Vincent, above n 25, at 77, quoting Robert Sapolsky "The frontal cortex and the criminal justice system" (2004) 359 Phil Trans R Soc Lond B 1787 at 1794.

structures fundamentally, requiring them to be rewritten according to scientific principles.

The radical school's arguments raise interesting questions as to the nexus between law and science. To investigate these arguments, two separate inquiries are required. First, the *focus* of legal culpability — the "criminal person" — must be defined. Secondly, it must be seen whether neurological insights affect this entity, or its definition, in a *legally relevant* way. The different definitions of the "criminal person" provided by law and science present a challenge at the outset. The law sees a person as capable of practical reasoning, with a mind/body division that forms the basis of "free will".[28] On the other hand, science sees a person as only comprised of his or her body, including his or her brain, despite being unclear on the issue of free will.[29] If neuroscience yields a defence of "I did not do it, my brain did", this dilemma must be resolved.[30]

"Business as Usual": the Moderate School

In direct opposition to the claims of the radical school, members of the moderate school claim that neuroscience can have no theoretical or practical effect on the law. However, in doing so, many of its members mischaracterise the radical school's propositions. For instance, many commentators of the moderate school selectively emphasise the outlandish claims made by the radical school,[31] giving much less attention to its other practical, and often unremarkable, recommendations.[32] Some critics go further, with suggestions that are as extreme as those of the zealous pro-neuroscience representatives:[33]

> [I]f commonsense intentional psychology were really to collapse, *that would be, beyond comparison, the greatest intellectual catastrophe in the history of our species*; if we're that wrong about the mind, then that's the wrongest we've ever been about anything ... . We'll be in deep, deep trouble if we have to give it up ... .

As many commentators in fact offer moderate views, such extreme responses indicate a pre-emptive retraction of neuroscience's potential. Stephen Morse's "Brain Overclaim Syndrome" is an often cited as an example of moderate-school criticism. Morse contends that this syndrome appears when neuroscience is used to advance claims that science cannot

28 Morse "The Disappearing Person", above n 2, at 2553–2554.

29 Greene and Cohen, above n 1, at 1779.

30 Ibid, 1779–1780.

31 See Vincent, above n 25, for examples.

32 See Pustilnik, above n 4; Greene and Cohen, above n 1; Greely "Law and the Revolution", above n 8; Kulynych, above n 7; Vincent, above n 25.

33 Fodor, above n 2, cited in Morse "The Disappearing Person", above n 2, at 2556 (emphasis added).

sustain, and deductive leaps are made from neuroscientific findings to analyses of behaviours and their desired consequences.[34]

1 Controversial Claims that Neuroscience Cannot Sustain

A deterministic view of free will, as allegedly proven by neuroscience, may render the criminal law's notions of retribution obsolete. However, it is unclear whether neuroscience is actually able to revive the mind/body debate.[35] Some posit that neuroscience contributes little, merely demonstrating correlation between brain states and action, but not causation.[36] For the purposes of this article, it is sufficient to note that neuroscience's conceptual and technical inconsistencies render most claims regarding its behavioural consequences based on neural abnormalities unsustainable.[37]

More importantly for the law, even if neuroscience can support this claim, its legal relevance remains unclear. For example, sometimes actions that are out of the actor's control modify the criminality of an act, indicating that free will, or direct agent-causation, is not always a prerequisite for criminal consequences.[38] An obvious example is criminal liability based on negligence; another is the lesser penalty given for attempted homicide than for homicide, despite the intentions being the same. These examples demonstrate an alternative view that "[r]esponsibility reflects a rule ... that emerges out of one or more agents interacting in a social context. Responsibility is not in the brain; it is in the social contract."[39] Thus, the moderate school claims that "all doctrines of criminal law are fully compatible or consistent with the truth of determinism or causation".[40] This claim might preclude determinism's relevancy because causation is not an applicable legal criterion: the law does not ask, beyond limited exceptions,[41] "what caused this person to commit this act with this mental state?" Questions as to the proximate cause of behaviour are limited to sentencing.

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34 See Stephen Morse "Brain Overclaim Sydrome and Criminal Responsibility: A Diagnostic Note" (2006) 3 Ohio St J Crim L 397 at 397 ["Brain Overclaim Syndrome"].

35 See Eyal Aharoni and others "Can Neurological Evidence Help Courts Assess Criminal Responsibility? Lessons from Law and Neuroscience" (2008) 1124 Ann NY Acad Sci 145 at 148; Gazzaniga, above n 7, at 412; Greene and Cohen, above n 1, at 1781; Jeffrey Rosen "The Brain on the Stand" *New York Times* (New York, 3 November 2007) at 49.

36 Greene and Cohen, above n 1, at 1778, citing Morse "New Neuroscience, old problems", above n 1.

37 Greene and Cohen, above n 1, at 1778.

38 O'Hanlon, above n 9, at 401–402, citing Thomas Nagel *Mortal Questions* (Cambridge University Press, Cambridge, 1979) at 29.

39 Gazzaniga, above n 7, at 413.

40 Morse "The Disappearing Person", above n 2, at 2552–2553.

41 Such as in relation to the defences of insanity, automatism and duress.

2 *"Brains do not Commit Crimes; People Commit Crimes."*[42]

The proposed use of neuroscience in guiding the law is additionally problematic as science fails to address normative concerns, and the law governs political concepts with no independent biological reality.[43] Though the experimental results of neuroscience research may have "social or psychological implications", they "remain far from being dispositive on larger social questions".[44] Thus, the descriptive (science) is used to define the normative (what society should do). In this way, commentators have been accused of making the "fundamental psycholegal error"[45] of treating causation per se as an excuse, and excusing all derivative behaviour of that cause, "because all behavior is caused and thus all behavior would have to be excused".[46] Morse argues that "[n]o normative differences are logically entailed by behavioral differences unless ... the behavioral differences precisely track the normative differences".[47] Though science may tell us that one person is more rational than another, it defines neither the level of rationality required for responsibility, nor the suitable punishment.[48]

"Even if Neuroscience Does Not Tell Us Everything, it Tells Us Something."[49]

This article argues that the true position falls between the radical and moderate schools. While accepting neuroscience's limitations, none of them is so fundamental that it completely negates its applicability to the law.[50] Neuroscience may inform, if not dictate, responsibility criteria,[51] and since "[f]act finding is an Achilles' heel of the legal system ... such research is to be encouraged".[52]

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42 Morse "Brain Overclaim Syndrome", above n 34, at 397.

43 See Pustilnik, above n 4, at 224–225 as to the impossibility of using animal brain activation studies to form conclusions on biological bases of human behaviour, such as terrorism: terrorism being a man-made political construct is beyond the realm of biology.

44 Gazzaniga, above n 7, at 412–413. See also Sonja Brown "Application of addiction neuroscience to moral and legal responsibility: Explanations not exculpations" (2008) 32 Crim LJ 239 at 240.

45 Morse "Brain Overclaim Syndrome", above n 34, at 399–400.

46 Ibid.

47 Ibid, at 400.

48 Vincent, above n 25, at 94.

49 O'Hanlon, above n 9, at 406–407.

50 Morse "Brain Overclaim Syndrome", above n 34, at 411, noting DNA evidence as an analogous field where similar concerns have been resolved.

51 Brown, above n 44, at 240.

52 Andrew Lyons "The neuroscience revolution and the law" (2005) 25(3) Proctor 9 at 10.

III THE TECHNOLOGY BEHIND NEUROSCIENTIFIC EVIDENCE

Before commencing analysis of the admissibility of neuroscientific evidence and its potential contribution to law-making, it is necessary to explain briefly brief some scientific mechanisms. This section discusses Positron Emission Tomography and functional Magnetic Resonance Imaging, as they offer the most immediate applications to criminal law and evidence.

Positron Emission Tomography (PET Scans)

On 7 January 1991, Herbert Weinstein allegedly strangled his wife before throwing her body from their apartment. During the pre-trial evidentiary hearing, defence counsel sought to adduce evidence of an arachnoid cyst, local metabolic imbalance and displacement of the left frontal lobe, as being ostensibly responsible for executive functioning:[53]

> [The evidence was offered as] partial support of Weinstein's psychiatrist's opinion that his cognitive ability was so impaired that ... he lacked substantial capacity to know or appreciate either the nature and consequences of his conduct or that his conduct was wrong.

The jury was shown two scans: one of a "normal" brain, in which bright red and green colours indicated metabolically active frontal lobes and, in disturbing contrast, one depicting Weinstein's brain lesion as "a gaping black hole".[54] The prosecution contended that the scans were not "sufficiently reliable as diagnostic devices ... to warrant [their] admission".[55] However, due to the lowered admission standard for evidential materials relied on by expert witnesses,[56] the New York Supreme Court held that the expert's reliance on the test results was "a fortiori, reasonable" and admitted the evidence of Weinstein's "abnormal" brain.[57] Subsequently, the prosecution accepted a manslaughter plea.[58]

It is not difficult to understand the prosecution's reasons. Despite the Court's careful, yet simplistic,[59] explanation of PET scans, the prosecution

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53 *People v Weinstein* 591 NYS 2d 715 (NY SC 1992) at 720.

54 Kulynych, above n 7, at 1251.

55 *People v Weinstein*, above n 53, at 718.

56 "The permissible scope of the testimony ... is set out in CPL 60.55 (1). ... [T]he statute ... requires the admission of evidence directly relating to the diagnosis of mental disease or defect that might otherwise be properly excluded under the *Frye* [*v United States* 293 F 1013 (DC Cir 1923)] test": ibid, at 720.

57 *People v Weinstein*, above n 53, at 722–723.

58 Kulynych, above n 7, at 1251.

59 For example, not explaining the margin of error of test samples; not citing opposing studies, contrasting evidence, or wider work; and mentioning disagreements over "mathematical formulae" but not why those disagreements were immaterial.

probably believed that a jury would be overwhelmed by the stark visual contrast between the pictures. In addition, despite the Court's insistence that suggestions of a causal link between the cognitive abnormalities and Weinstein's actions were neither proffered nor admissible, the evidence is practically irrelevant without some inference of causation.[60]

The prosecution may have been less concerned if the jury were presented with a series of equations based on metabolic ratios in a diagram summarising processed statistics (with error bars). This explanation would have been an accurate representation, though less psychologically compelling than the images.[61]

As summarised in *People v Weinstein*, PET scans involve a relatively old form of nuclear medicine imaging, where small amounts of radioactive material are injected into the patient's body,[62] binding to substrates that are routinely metabolised by the tissue of interest. The Court explained that the radioactive substance was "metabolized ... in the same way that glucose is metabolized".[63] The Court's explanation, however, was not quite accurate. In fact, the substrates are metabolised and the isotopes undergo a decaying process, the products of which are traced by the scanner, which creates a burst of light that is detected and multiplied. The scans measure cognitive activity indirectly: "when a subject performs a cognitive task during a PET scan, scientists infer that the brain structures with the highest metabolic rates are integral to the underlying cognitive process".[64] Though the Court did not state that cognitive ability was being measured directly, it may be inferred from its explanation of the scientific processes that it was not fully aware of how metabolism was being measured, and the implications of this. Next, radioisotope "count" data are processed to determine the metabolic rates across brain structures, and a map of activity is constructed and plotted. After that, a "list of coincidence events" is grouped into "projection images", which undergo significant mathematical processing, and a reconstruction is finally done, usually by another machine.[65]

Functional Magnetic Resonance Imaging (fMRI)

Functional MRI has been said to provide the "ideal neuroimage",[66] in "combin[ing] the high resolution of the best structural scans with the

60 Without employing the following chain of reasoning, it is difficult to see the relevance of the scan: (1) Weinstein's brain was abnormal when he killed his wife; (2) this brain abnormality impaired his ability to reason; (3) Weinstein was unable to reason when he killed his wife; (4) the inability, in part, led him to kill his wife (causation); (5) people who are unable to reason may avail themselves of the insanity defence.

61 For juries' problems with interpreting neuroimages see generally Kulynych, above n 7, at 1254; Feigenson, above n 15, at 246.

62 Or otherwise introduced.

63 *People v Weinstein*, above n 53, at 717.

64 Kulynych, above n 7, at 1255–1256.

65 Ibid. See also Christian Nordqvist "What Is A PET Scan? How Does A PET Scan Work?" (2009) Medical News Today <www.medicalnewstoday.com>.

66 Kulynych, above n 7, at 1256.

dynamic information about brain activity provided by functional scans".[67] Similarly to PET, fMRI scans are useful for studying the relationship between brain modifications and neural events. Both PET and fMRI scans infer neuronal activity through a proxy: for PET, this is glucose uptake; for fMRI, it is the local blood flow and blood oxygen level. Unlike PET, which indirectly traces the movement of the energy-providing substrate to the energy-requiring tissue,[68] fMRI directly traces this movement by measuring the ratio of oxygenated to deoxygenated blood supplied to the vasculature that accompanies neural activity.[69] As more oxygen is supplied to active brain regions than is consumed,[70] the ratio of oxygenated to deoxygenated blood in the active regions increases. As oxygenated and deoxygenated blood have different magnetic susceptibilities, this ratio "changes [the] magnetic resonance (MR) signal intensity".[71] Thus, "areas of the brain where the neurons have recently 'fired' will see, a few seconds after the firing, an influx of fresh, more highly oxygenated blood" (the Blood Oxygen Level Dependence, or BOLD hypothesis).[72] This signal can then be used to assess which brain regions are active during various mental activities. These changes between the control (rest) and experimental (task) states[73] are measured by the fMRI scanner.[74] Finally, the changes are superimposed upon a three-dimensional, computer-generated, high-resolution brain image.[75]

IV ADMISSIBILITY OF NEUROSCIENCE IN FOREIGN JURISDICTIONS

Perhaps the most well-known case involving neurological evidence is the trial of John Hinckley, who was accused of attempting to assassinate Ronald Reagan. Following an expert's refusal to testify without Computerised Axial Tomography (CAT) scan evidence, the Court admitted scans that showed "enlarged and shrunken areas", which some have said probably influenced the eventual insanity verdict.[76]

The second benchmark case is *Roper v Simmons*,[77] in which the Supreme Court of the United States declared that the death penalty

67 Ibid.

68 Ibid, at 1255–1256.

69 Feigenson, above n 15, at 234.

70 Ibid.

71 Ibid.

72 Greely "Law and the Revolution", above n 8, at 694–696.

73 Feigenson, above n 15, at 234.

74 Kulynych, above n 7, at 1255–1256.

75 Ibid, at 1256. See also Columbia University Medical Center Program for Imaging and Cognitive Sciences "The Future Role of functional MRI in Medical Applications" (2010) Columbia University <www.fmri.org>.

76 Don DeBenedictis "Criminal Minds" (1990) 76(1) ABAJ 30.

77 *Roper v Simmons* 543 US 551 (2005).

was unconstitutional for defendants under the age of 18. Simmons had encouraged his friends to assist him in breaking into the home of a woman, whom they bound with duct tape and electrical wire and threw off a bridge. He was subsequently caught and sentenced to death. He filed a petition for state post-conviction relief, arguing on the basis of, among other things, cognitive and behavioural studies that the execution of juveniles was "cruel and unusual punishment" and thus constitutionally barred. The majority agreed and set aside his sentence, noting that juveniles lacked maturity and a fully developed sense of responsibility, which may lead to reckless behaviour; are susceptible to outside pressure; and have an underdeveloped character with transitory personality traits.[78]

Though *Roper* is often cited as a touchstone case,[79] two facts make it less radical and conclusive than it may appear. First, the Court did not analyse or even refer to neurological evidence. The empirical evidence was found only indirectly in the footnotes. Furthermore, it cited six[80] cases of behavioural science evidence with passing references to developmental biology, but not neuroscience.[81] Secondly, the decision included a lengthy dissent,[82] attacking both the logic and the absence of strong empirical evidence, and specifically, the misuse of empirical behavioural evidence to reach a normative result. In fact, the impetus behind the application of neuroscience came from amicus briefs and editorial pages encouraging the Court to consider the evidence.[83]

Despite this equivocal precedent, there appears to be a trend towards the use of neuroimaging in courtrooms.[84] In some death penalty cases, failure to provide brain scans may be grounds for appeal.[85] In California, for instance, neurological evidence was "very influential in [two] decisions" in which it bolstered an insanity plea on which jurors rejected the death penalty for homicide.[86]

Similar testimony has been admitted in non-death penalty sentencing.[87] It has been argued that the right to psychiatric testimony when a criminal defendant's sanity is contested, is "constitutionally mandated" to include PET or MRI scans. One court "accepted this argument and reversed a homicide conviction where the state failed to provide brain scans".[88]

More contentious examples involve the admissibility of neurological evidence at trial. A Californian public defender has stated that "in every

78 Ibid, per Kennedy, Souter, and Breyer JJ with Stevens and Ginsburg JJ concurring.

79 See Melissa Caulum "Postadolescent Brain Development: A Disconnect Between Neuroscience, Emerging Adults, and the Corrections System" (2007) Wis L Rev 729 at 732 and 737.

80 Five were "high-quality": Morse "Brain Overclaim Syndrome", above n 34, at 410.

81 Ibid.

82 *Roper v Simmons*, above n 77, per O'Connor J.

83 Morse "Brain Overclaim Syndrome", above n 34, at 408–410.

84 Kulynych, above n 7, at 1254, citing *Ake v Oklahoma* 470 US 68 (1985).

85 Ibid.

86 Gurley and Marcus, above n 21, at 86, citing Kulynych, above n 7.

87 Kulynych, above n 7, at 1253.

88 Ibid, at 1254.

case where you have the possibility of serious neurological damage, such tests should be done".[89] PET scans have been performed in criminal cases, including the trials of the mass killers Salcido and McNamara.[90] Further, PET scans showed unusual metabolic activity in the frontal lobes of a man convicted of murdering 16 young men.[91] In at least two cases, the defence used the potential introduction of neuroscientific evidence as leverage in plea bargaining. The first was a 1995 case concerning diminished capacity. The defendant was charged with embezzling hundreds of thousands of dollars in charity funds to support a "lavish lifestyle".[92] At trial, MRI evidence indicated that the defendant suffered from a "shrinking" brain over the past 10 years, precluding any requisite criminal intent. If successful, this evidence would lead to a complete acquittal. A plea bargain was subsequently struck.[93] The second case was *People v Weinstein*,[94] in which the prosecution accepted a plea bargain following the imminent introduction of PET and MRI evidence to bolster an insanity defence.

Perhaps the most controversial case is an Indian homicide case concerning the admission of "brain fingerprinting" as evidence.[95] Aditi Sharma and Udit Bharati were in a relationship "on the threshold of marriage", when Sharma left Bharati secretly to marry Pravin, a man with whom she conspired to kill Bharati.[96] Sharma met Bharati in a hotel and offered him arsenic-laced prasad, which he consumed.[97] Bharati was later violently sick and was taken to hospital, where he died.[98] Post-mortem investigations confirmed that he had consumed fatal quantities of arsenic, which was found in the prasad in Sharma's purse.[99]

During the course of the investigation, "[t]he assistance of scientific techniques [was] availed of to elicit the truth".[100] Sharma and Pravin underwent polygraph tests, which were positive, though both denied guilt. Sharma also consented to a Brain Electrical Oscillation Signature Profiling test (BEOS) to reveal her "experiential knowledge of the commission of the offence".[101] This test involved covering her head with a cap with 32 electrodes, 2 of which were attached to the ear lobes and 30 to parts of the scalp. Sharma sat silently, with her eyes closed, and listened to various sentences ("probes") being read out while her brain activation patterns

89 DeBenedictis, above n 76.

90 Kulynych, above n 7, at 1252. *People v McNamara* No CV-88-5343-ER (CD Cal 1990), affirmed 923 F 2d 862 (9th Cir 1990); *People v Salcido* 183 P 3d 437 (Cal 2008).

91 DeBenedictis, above n 76.

92 Kulynych, above n 7, at 1253.

93 Ibid.

94 *People v Weinstein*, above n 53.

95 *State of Maharashtra v Sharma* Court of Sessions, Pune District, Maharastra, Case No 508/07, 12 June 2008.

96 Ibid, at [1].

97 Ibid, at [4]. "Prasad" is an edible gift.

98 Ibid, at [9].

99 Ibid, at [10].

100 Ibid, at [11].

101 Ibid.

were measured. The computer system analysed the electrical activation for relevant probes in comparison to neutral probes and generated a report analysing the cognitive processes.[102] The evidence gained from the polygraph and BEOS tests was admitted at trial, where the Indian Court of Sessions accepted the analyst's conclusion that Sharma demonstrated "experiential knowledge" of conspiring to kill Bharati, collecting prasad, mixing it with purchased arsenic, giving the mixture to Bharati and subsequently experiencing relief and fear.[103] The Court concluded that "[t]hese findings clearly indicate [Sharma's] involvement in the murder of [Bharati]".[104]

The expert witness's experience in the field led to a dismissal of the defence's challenges to the reliability of the science.[105] The Court indicated that "the results of these [t]ests are not to be treated as conclusive ... [t]hey are just one of the link[s] in the chain of circumstantial evidence".[106] Despite this caveat, this use of BEOS technology has been alternately described as "fascinating", "ridiculous", "chilling", and "unconscionable".[107]

Finally, *Entertainment Software Association v Blagojevich* (*Entertainment Software*)[108] highlights the potential of neuroscience in public interest litigation. In *Entertainment Software*, it was argued that minors who play violent video games are more likely to experience a reduction in the frontal lobe activity that controls behaviour. To buttress this claim, the State of Illinois offered expert testimonies of several witnesses, including a clinical psychologist who relied on fMRI data to show that adolescent brains that were exposed to substantial media violence exhibited lower activity in particular regions, resembling those diagnosed as aggressive or violent. The plaintiffs (members of the video game industry) called another cognitive psychologist who criticised both the experimental design (as the young people could not play the games in the scanner, they were shown videos) and the inferences drawn.[109] The District Court for the Northern District of Illinois was convinced by these and other criticisms of the research, and "enjoined enforcement of the anti-violent video game laws".[110]

These cases demonstrate the nascent trend of introducing neuroscientific evidence in overseas jurisdictions in pre-trial negotiation, trial and sentencing. The final two cases, *State of Maharashtra v Sharma*

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102 Ibid, at [101].

103 Ibid, at [103].

104 Ibid.

105 Ibid, at [107]–[108]. Questions as to the science were dealt with in relation to the polygraph test.

106 Ibid, at [118].

107 Anand Giridharadas "India's Novel Use of Brain Scans in Courts is Debated" *New York Times* (New York, 15 September 2008).

108 *Entertainment Software Association et al v Blagojevich* 404 F Supp 2d 1051 (ND Ill 2005).

109 Feigenson, above n 15, at 244–245. The psychologist explained that a one-to-one relationship between frontal lobes and function does not exist, and that reduced activity may simply indicate greater expertise in task-relevant functions. He also indicated the gap between the psychological constructs measured by fMRI and those on which legal judgements depend.

110 Feigenson, above n 15, at 245.

and *Entertainment Software*, provide extreme examples of the outer limits of this trend. Ms Sharma's experience, which offends the legal sensibilities of many commentators, suggests that her case demonstrates the undesirable applications of this technology. Similarly, *Entertainment Software*, though unsuccessful, provides an ethically fraught glimpse into neuroscientific insights that may shape law and policy.

V POTENTIAL RELEVANCE OF NEUROSCIENCE WITHIN NEW ZEALAND'S LEGAL STRUCTURES

Examination of neuroscience's potential in New Zealand requires a two-fold inquiry: within which legal structures may neuroscientific evidence be prima facie relevant, and under which evidentiary laws might it be admissible?

Essentially, any legal structure relating to the operation and capacity of an accused's mind at the time of the offence will be relevant. Briefly, lie detection may ascertain the knowledge of the accused about the nature and consequences of his or her actions, while PET or fMRI scans may examine the accused's capacity to understand and control his or her conduct or appreciate the moral consequences of his or her actions. This evidence may help to show whether the accused was suffering a relevant brain injury or merely acting under, for example, an irresistible impulse. Though the following examination is limited to the criminal law, it may also be relevant to any tort that requires some element of proof of mental state or knowledge.

Negating Mens Rea and Intoxication

Mental disorders that do not constitute insanity but prevent the formation of intent may undermine mens rea.[111] Where submitted, this must usually be supported by the expert opinion of doctors or psychiatrists.[112] A specific example is where children between 10 and 14 years who commit an offence may not be convicted unless they knew that their behaviour was wrong or illegal.[113] Similarly, while intoxication is not itself a defence,[114] it may evidence a lack of mens rea by negating the intent, knowledge, or recklessness for the crime in question,[115] if there is no intention to commit

111 See *R v Clarke* [1972] 1 All ER 219 (CA); *R v G* (1984) 1 CRNZ 275 (HC); *R v Arnold* [1985] 1 NZLR 193 (CA).

112 See *R v Gordon* (1993) 10 CRNZ 430 (CA); *R v McKeown* [1984] 1 NZLR 630 (CA).

113 Crimes Act 1961, s 22(1).

114 *R v Kamipeli* [1975] 2 NZLR 610 (CA) at 616; *R v Munro* (1986) 2 CRNZ 249 (CA) at 250; *Attorney-General for Northern Ireland v Gallagher* [1963] AC 349 (HL).

115 *R v Kamipeli*, above n 114, at 616.

the criminal act.[116] Where intoxication is used in this way, detailed jury direction is required.[117]

Automatism and Insanity

Automatism[118] denotes a state in which actions amounting to a criminal actus reus are performed "without conscious volition".[119] Though the required degree of unconsciousness is unclear,[120] the courts essentially consider whether the accused had the basic mental capacity to form the mens rea for the particular crime charged.[121] There is a clear overlap with insanity, which holds that no person shall be convicted of an offence committed whilst "labouring under natural imbecility or disease of the mind" rendering him or her incapable of understanding the nature and quality of his or her behaviour, or knowing that his or her conduct was morally wrong.[122] In cases where the facts lend themselves to either a plea of automatism or insanity, insanity is preferred.[123] If something other than a disease of the mind caused automatism, the defence is (sane) automatism, but if a disease of the mind caused it, the defendant must plead insanity, or "insane automatism".[124] The evidential burden is particularly high for automatism, and medical or scientific evidence is required because knowledge of this form of functioning of the mind is beyond the ordinary expertise of the judge and jury.[125]

VI POTENTIAL CONTRIBUTION OF NEUROSCIENCE TO THE EXISTING LEGAL LANDSCAPE

Evidence Act and Case Law

Once the legal areas in which neuroscientific evidence is prima facie applicable have been adduced, the second step is to identify the mechanisms for evidential admissibility. Two approaches to this step have been identified: one looks at precedent, while the other considers the conceptual

116 Ibid, at 616 and 617–619. See also *R v Hart* [1986] 2 NZLR 408 (CA) at 414; *R v Clarke* [1992] 1 NZLR 147 (CA) at 148.

117 See *R v Tukaki* CA360/05, 14 June 2006; *R v Hagen* CA162/02, 4 December 2002.

118 Automatism as an applicable defence is preserved by virtue of the Crimes Act 1961, s 20.

119 *Bratty v Attorney-General for Northern Ireland* [1963] AC 386 (HL) at 392 [*Bratty*]; *R v Cottle* [1958] NZLR 999 (CA) at 1007–1020.

120 *Police v Bannin* [1991] 2 NZLR 237 (HC) at 249.

121 Ibid, at 243.

122 Crimes Act 1961, s 23.

123 Automatism results in an unqualified acquittal. There may be serious consequences of allowing an insane person to escape both prison and the mental health system.

124 *Bratty*, above n 119; *R v Cottle*, above n 119; *Burnskey v Police* (1992) 8 CRNZ 582 (HC) at 583.

125 *Bratty*, above n 119, at 413; *R v Falconer* (1990) 171 CLR 30 (HCA).

and methodological underpinnings of the technology.[126] This article merges these considerations as neurological evidence has yet to be considered by a New Zealand court, so an understanding of the underpinnings of neurological evidence is essential to drawing viable analogies with existing precedent.

Evidence Act 2006

Under the Evidence Act, the starting point is that "[a]ll relevant evidence is admissible",[127] subject to it being inadmissible or otherwise excluded,[128] or unfairly prejudicial.[129] "Relevant evidence" is evidence that "has a tendency to prove or disprove anything that is of consequence to the determination of the proceeding".[130] Evidence is "unfairly prejudicial" if its "probative value is outweighed by the risk that the evidence will" either "have an unfairly prejudicial effect on the proceeding",[131] or "needlessly prolong the proceeding".[132] The prejudicial value of evidence is ascertained in part by considering "the right of the defendant to offer an effective defence".[133] Further constraints are imposed on neuroscientific evidence under the Evidence Act. As testimony based on neuroscience is scientific evidence, admissibility is determined by specific rules on expert opinion evidence,[134] the admission of published documents and novel scientific evidence.

Expert Opinion

If neuroscientific evidence is found to be relevant and admissible, it will be introduced as a form of expert opinion evidence, delivered by a qualified expert.[135] Unlike general opinion,[136] expert opinion is admissible if "the fact-finder is likely to obtain substantial help from the opinion in understanding other evidence in the proceeding or in ascertaining any fact that is of consequence to the determination of the proceeding".[137] This is unavoidably the case regarding neuroscientific evidence, regardless of how the findings are presented. The fact-finder cannot interpret the evidence without technical instruction.

126 Feigenson, above n 15, at 233.
127 Evidence Act 2006, s 7(1).
128 Ibid.
129 Ibid, s 8.
130 Ibid, s 7(3).
131 Ibid, s 8(1)(a).
132 Ibid, s 8(1)(b).
133 Ibid, s 8(2).
134 Feigenson, above n 15, at 235.
135 Ibid; see also *R v Calder* HC Christchurch T 154/94, 12 April 1995 at 3–6.
136 Evidence Act 2006, s 23.
137 Ibid, s 25(1).

1 Substantial Helpfulness

Expert testimony is used to clarify or provide information additional to the parties' theories of the case and to the facts ascertainable by the jury themselves, rather than to direct the jury:[138]

> [T]he Court, independently ... [must] reach its own conclusion as to whether or not an accused person was insane within the meaning of s 23 of the Crimes Act 1961 ... . It is important that the Court not be seen to be a mere "rubber stamp" for the views expressed by professionals ... .

An opinion that relates to the ultimate issue or a matter of common knowledge is not immediately excluded,[139] but may be of limited helpfulness. This may be especially true where insanity is at issue: while "unanimous expert evidence is not to be rejected without good reason",[140] the jury ultimately decides whether the accused is insane.[141]

2 Factual Foundation

An expert opinion must be based on facts that are admissible. With neuroscience, this would include either facts that are specific to the proceeding itself, for instance tests done on the patient (personal knowledge); the testimony of other witnesses (an expert opinion on another expert's testimony); or out-of-court information that is outside the "general body of knowledge" of the expert's specialty.[142] Brain scans or similar evidence will need to be proved, as they are likely to qualify as idiosyncratic facts falling outside the general body of expertise.[143]

Novel Scientific Evidence

The current test for admitting novel scientific evidence is derived from *Daubert v Merrell Dow Pharmaceuticals*.[144] The *Daubert* test considers the testability of the underlying theory, its error rate, whether it has been published and peer reviewed, and its acceptance among the scientific community.[145] This test was referred to and heavily relied on in New Zealand in *R v Calder* with regards to the admissibility of expert evidence,

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138 *R v Brown-Howarth* HC Whangarei CRI-2006-088-2445, 10 December 2007 at [19], cited in *R v Lewis* HC Whangarei CRI-2007-027-2932, 28 October 2009 at [23].

139 Evidence Act 2006, s 25(2).

140 *Taylor v R* (1978) 22 ALR 599 (FCA) at 610–611 and 618.

141 *R v Rivett* (1950) 34 Cr App R 87 (CA).

142 Evidence Act 2006, s 25(3).

143 *R v Abadom* [1983] 1 WLR 126 (CA) at 130. The documentary basis "was not only permissible in principle, but ... was an essential part of his function as an expert witness".

144 *Daubert v Merrell Dow Pharmaceuticals* 509 US 579 (1993) [*Daubert*].

145 Garland and Frankel, above n 6, at 106.

though *Calder* used slightly different language and tailored the test to New Zealand's evidential framework and legal system.[146]

1 Daubert v Merrell Dow Pharmaceuticals

Jason Daubert, Eric Schuller and their parents sued Merrell Dow Pharmaceuticals Inc, claiming that the company's drug caused birth defects in Daubert and Schuller. Though no published studies supported this claim, expert evidence submitted on their behalf suggested a link between the drug and the defects. This evidence was based on methodologies that had not gained general scientific acceptance, including animal studies, thus constituting "novel scientific evidence". The Supreme Court of the United States considered the then-applicable *Frye* approach,[147] pursuant to which evidence was admissible if it had general acceptance in the relevant field. However, the new Federal Rules of Evidence allowed the Court to modify the approach to the following: all scientific evidence must be (1) relevant and reliable; and (2) scientifically valid and applicable to the facts in issue.[148] Considerations under the second limb include the testability of the theory, whether it has been published and peer reviewed, its known potential rate or error, its acceptance within the relevant scientific community and other rules applicable under United States law. Though "general acceptance" is a relevant factor, it is no longer the ultimate test. Without believing this new test would significantly lower evidential quality, the Court did consider that "vigorous cross-examination, presentation of contrary evidence and careful instruction on the burden of proof are traditional and appropriate methods of attacking shaky but admissible evidence".[149]

2 R v Calder

The Crown charged Victoria Calder with attempted murder by acrylamide poisoning, which it sought to prove using a novel scientific technique. The novelty lay in its use of hair, rather than blood samples.[150] Tipping J summarised both the *Daubert* test[151] and the stricter Australian approach,[152] in which "caution must be exercised [regarding] whether challenged scientific evidence should be admitted because its appearance of validity may be overwhelming to a jury".[153] Noting New Zealand authorities that

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146 *R v Calder*, above n 135, cited with approval in *R v Carter* (2005) 22 CRNZ 476 (CA) at [64]. See also Karen Belt "Novel Scientific Evidence and Judicial Gatekeeping: *R v Calder* and *Daubert v Merrell Dow Pharmaceuticals* Compared" (1998) 28 VUWLR 399.

147 See *Frye v United States*, above n 56.

148 *Daubert*, above n 144; Belt, above n 146, at 403–404.

149 See *R v Calder*, above n 135, at 4.

150 Ibid, at 6.

151 Ibid, at 4.

152 Ibid, at 5.

153 Ibid. See also *R v Lucas* [1992] 2 VR 109 (SC); *R v Gilmore* [1977] 2 NSWLR 935 (CCA).

had dealt with evidence in sex abuse cases,[154] and the unsettled criteria for admissibility of novel scientific evidence in Australasia, Britain and Canada, Tipping J observed: "[t]he issue of how to deal with areas that have not yet fully emerged from their developmental stages remains unresolved".[155]

Tipping J considered that judges should err on the side of exclusion if in doubt,[156] and concluded that the requirements in New Zealand are as follows:[157]

> Before expert evidence ... can be put before the jury by a suitably qualified person it must be shown to be both relevant and helpful. To be relevant the evidence must logically tend to show that a fact in issue is more or less likely. To be helpful the evidence must pass ... the minimum threshold of reliability. This means the proponent of the evidence must show that it has a sufficient claim to reliability to be admitted. If this threshold is crossed the weight of the evidence and its probative force can be tested by cross-examination and counter evidence and is ultimately a matter for the jury. If the minimum threshold of reliability is not crossed, the evidence is deemed unhelpful and is excluded ... as more prejudicial than probative.

The evidence was admitted, with the Judge stating that the application of the same techniques to hair rather than blood samples is a "logical and rational development resting on perfectly intelligible scientific reasoning",[158] and that there was no "illegitimate prejudice".[159]

Endorsed in recent cases,[160] this approach confirms the "gatekeeper" role of the courts,[161] and that "measures for admissibility"[162] include relevance[163] and whether juries are likely to obtain substantial aid from the expert opinion.[164]

3 Other Case Law

In *McIntyre v Christchurch City Council*,[165] a case concerning conflicting

154 *R v Calder*, above n 135, at 5–6.

155 Ibid, at 3, citing Ian Freckelton and Hugh Selby (eds) *Expert Evidence* (Looseleaf ed, Law Book Company, North Ryde Australia) at [9.10].

156 *R v Calder*, above n 135, at 7–8.

157 Ibid, at 7.

158 Ibid, at 9.

159 Ibid, at 13.

160 Eg *R v Thompson (No 2)* HC Auckland CRI-2007-090-5246, 30 May 2008.

161 Ibid, at [31].

162 Ibid, at [37].

163 Evidence Act 2006, s 7.

164 Ibid, s 25. See also *R v Thompson (No 2)*, above n 160, at [34]–[38]; *RA v R* [2010] NZCA 57, (2010) 25 CRNZ 138 at [28]–[29].

165 *McIntyre v Christchurch City Council* [1996] NZRMA 289 (PT).

expert opinion on resource consent,[166] it was noted that "[t]he Tribunal does not conduct a scientific inquiry to discover absolute truth",[167] but rather functions "to make findings on the evidence before [it] on the balance of probabilities".[168] Citing *Daubert*, the Planning Tribunal considered that the concern that liberalising evidentiary standards would lead to a "free-for-all in which befuddled juries are confounded by absurd and irrational pseudoscientific assertions" was "overly pessimistic about the capabilities of the jury, and of the adversary system generally".[169]

After *Calder*, *R v Carter* continued this trend towards acceptance. The accused in *Carter* was found guilty of attempting to manufacture a Class A drug and possessing equipment and precursor substances. He appealed both his conviction and sentence on the grounds that, among other things, the expert evidence of the fingerprint analysis (his only direct link to the address) was inadmissible because the witness could give no reasoned basis for his opinion.[170]

The Court of Appeal noted that "expert evidence must be based on reason as opposed to conclusions incapable of being tested in any meaningful manner"[171] and the expert must explain the methodology, steps in the logical reasoning and inferences drawn.[172] The Court referred to the Court of Appeal in *R v Buisson*:[173]

> [B]y insisting on maintaining a standard of virtual certainty, ... police agencies may be depriving the prosecution of useful information ... . Taken in conjunction with other evidence tending to implicate the accused, it may still help to establish his or her guilt beyond reasonable doubt. The Courts frequently receive evidence of probability ... as part of the overall circumstances relied on to establish an offender's identity. ... [But] it would be desirable for the Judge to warn the jury ... .

Finally, *Wallace v R* considered whether a "substantial miscarriage of justice" occurred where a jury was allegedly misled as to the strength of DNA and fingerprint evidence at trial.[174] The evidence was based on DNA amplified by a Low Copy Number technique and analysed using a technique

166 The Resource Management Act 1991 does not have a rigorous reliability threshold (*Shirley Primary School v Telecom Mobile Communications Ltd* [1999] NZRMA 66 (EC) at [141]); however, it does address highly technical issues.

167 *Darroch v Whangarei District Council* PT Decision A18/93, cited in *McIntyre v Christchurch City Council*, above n 165, at 296.

168 *Canterbury Regional Council v Canterbury Frozen Meat Co Ltd* PT Decision A14/94, 3 NZPTD 368, cited in *McIntyre v Christchurch City Council*, above n 165, at 296.

169 *McIntyre v Christchurch City Council*, above n 165, at 302.

170 *R v Carter*, above n 146, at [1]–[4] and [15].

171 Ibid, at [47].

172 Ibid, at [77].

173 *R v Buisson* [1990] 2 NZLR 542 (CA) at 548.

174 *Wallace v R*, above n 7.

novel to New Zealand courts.[175] The prejudicial effect of unchallenged expert evidence and the importance of advising jurors to analyse critically the evidence was acknowledged. However, the Court felt that the trial Judge had issued proper warnings,[176] with the following direction:[177]

> [T]hese people have all given evidence about their opinions on various matters ... But it is important for you to understand that ... your task is to ... decide for yourselves whether you accept or reject what they have told you. This is a trial by jury, not a trial by experts. So, although you must have regard to their qualifications and experience, you do not accept their evidence uncritically simply because they are experts. And whether you accept it in whole, in part, or not at all, is a matter for you as jurors.

4 Attitude of New Zealand Courts to Novel Scientific Evidence

Overall, the general trend in New Zealand courts is to view novel scientific evidence as helpful and to take a reasonably lenient approach to its admissibility. Accordingly, the courts require experts to explain their logic and reasoning, and trust juries' ability to use this explanation to assist, rather than dictate, their final decision.

Combining the applicable statutory provisions with *Calder* and subsequent cases, a summary of the relevant law is as follows. Expert opinion evidence is admissible if the fact-finder can derive substantial help in understanding or ascertaining a relevant fact. The opinion's documentary basis is admissible (and required) if it goes to an idiosyncratic aspect of the case. For novel scientific evidence to be admitted under *Calder*, it must be shown to be relevant, helpful and more probative than prejudicial. When the principles are summarised in this way, substantial overlap can be seen between the considerations required by the statutory rules and the case law. In fact, as demonstrated by *Calder* and subsequent cases, each issue may be addressed within the framework of the factors indicating relevance, as it is within this inquiry that questions of substantial helpfulness and unfair prejudice arise.

Thus, combining these requirements for general admissibility, the admissibility of expert opinion, and novel scientific evidence, neuroscientific evidence is admissible where the proponent of the evidence is an "expert" in the relevant field, the evidence is relevant and helpful, and its prejudicial effect does not unfairly outweigh its probativeness. Each branch requires analysis of the weight and reliability of the evidence.

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175 Ibid, at [26]–[34].

176 Ibid, at [44]–[45].

177 Ibid, at [72].

Application of Evidential Principles to Neuroscientific Evidence

Each of the above requirements will be addressed in turn. This structure is intended to address the substantive requirements of each inquiry, rather than to follow the framework of the Evidence Act or case law.

1 Who Is an Expert?

According to Evidence Act, expert evidence is "evidence of an expert based on the specialised knowledge or skill of that expert", and an expert is "a person who has specialised knowledge or skill based on training, study, or experience".[178] No further guidance is given, and judicial statements usually reiterate this section. The consequences of this definition for an "expert" giving evidence of facts beyond his or her expertise are significant, as the evidence would become an inadmissible "opinion".[179] In the case of neuroscience, the qualifications required of an "expert" may be unclear:[180]

> [P]sychiatric credentials do not ensure competence to testify regarding neuroimaging evidence. ... [W]hen brain images are admitted as psychiatric evidence, the primary courtroom issue — diagnostic interference — remains the province of a psychiatrist who may have limited knowledge of the technical parameters affecting the visual appearance and interpretation of a PET or MRI scan.

While evidence is usually presented by a single member of a team, neuroscientific evidence is particularly problematic as its legal legitimacy raises highly technical issues that often relate to novel methods. A medical team member may be unable to explain sufficiently technical issues, while a technical member may be unable to explain the medical or diagnostic inferences drawn from the scan.[181] In the context of admissibility, Jennifer Kulynych distinguishes between the "hard" science techniques (the brain image) and "soft" science (interpretations of the mental state).[182] It is possible that more than one expert may be required.

The case law is somewhat scattered. In *Platt v R*,[183] the Court of Appeal excluded the opinion of an expert with extensive experience in the field of sexual assault forensic examinations, but not the specific condition at issue, namely Foetal Alcohol Syndrome (FAS). The expert could support her opinion with her critical research of the medical literature, but this was insufficient:[184]

178 Evidence Act 2006, s 4.
179 Ibid, s 23.
180 Kulynych, above n 7, at 1259–1260.
181 Ibid.
182 Ibid, at 1264.
183 *Platt v R* [2010] NZCA 43 at [27]–[47].
184 Ibid, at [44].

> The fundamental principle is that an expert can only give evidence on matters on which he or she is an expert. On her own resume [the witness] is not an expert on FAS. She has resorted to medical literature by persons who are experts and endeavoured to apply it to this case ... . We seriously doubt that [the witness] was an "expert" for [this] purpose ... .

A less direct analogy can be drawn to *R v Howe*,[185] in which the Court of Appeal allowed an individual who had watched an unclear videotape numerous times to give his "expert opinion" as to its contents. For neuroscientific evidence, it may be said that psychiatrists working alongside technicians would have seen the types of scans and the conclusions drawn many times. However, this may be too wide an interpretation of "study" or "experience".

Given the necessity of both the medical doctor and technician's involvement in brain scans, this issue will certainly arise, and a principled conclusion will have to be drawn. This requires thorough investigation of the witness's credentials regarding both technical aspects and medical implications. Each side may have a firm grasp of the literature of the other side, without the relevant training and expertise, and legal consequences will likely vary between cases.

2 Is this Evidence Relevant and Helpful?

To be "relevant", evidence must show logically that a fact in issue is more or less likely.[186] To be "helpful", it must pass the "minimum threshold of reliability", having a "sufficient claim to reliability".[187] Though evidence that has passed this test will rarely be excluded,[188] it must further be shown that its probative value is not outweighed by its unfairly prejudicial effect on the proceedings.[189] If this standard is met, the weight of the evidence is tested before the jury by cross-examination and counter-evidence. If it is not met — for example where the evidence is irrelevant, unhelpful or more unfairly prejudicial than probative — it is excluded.

3 Is this Evidence Relevant to Proving or Disproving a Material Fact?

The relevance inquiry consists of two parts: one part requires a logical nexus between the evidence and what it purports to prove; the other is linked to validity, as testimony based on unsound theory or unreliable methodology is inherently irrelevant.[190]

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185 *R v Howe* [1982] 1 NZLR 618 (CA) at 626–628.

186 Evidence Act 2006, s 7(3).

187 *R v Calder*, above n 135, at 7.

188 Ibid.

189 Evidence Act 2006, s 8.

190 Kulynych, above n 7, at 1261–1262.

(a) Logical Nexus

For neuroscience, the two parts of the relevance inquiry overlap. The principal criticisms of neuroscience's application to crime relate to its unsound methodology or theory, and/or its focus on correlation, not causation, which limits its relevance in proving a fact. It has been said that the "best argument against the tests" is that they are not probative, because demonstrating an abnormal portion of the brain does not directly lead to obvious legal consequences,[191] as the logical nexus is unclear.[192] For example, suppose that doctors have found damage to the prefrontal cortex, a part of the brain that has been linked to judgement,[193] in a defendant charged with homicide, and the defence wishes to prove a logical nexus between the brain damage and the criminal actions to undermine mens rea. The logical chain of inferences linking this evidence to the homicide would be: (1) the defendant has a damaged prefrontal cortex; (2) the defendant's prefrontal cortex was damaged during the commission of the crime; (3) the prefrontal cortex is linked to the ability to make sound judgements; (4) a defendant with impaired judgement is likely to make bad decisions; (5) a defendant who is likely to make bad decisions may be violent; (6) a defendant who is likely to be violent may commit homicide; and (7) the defendant committed homicide due to this lack of judgement.

Links one to four are scientifically weak. The issues that arise between links two to four are discussed in detail below. Regarding links one to two, it is true that much evidence used in court is gathered after the crime, such as psychiatric testimony, scientific reconstruction, forensic evidence and eyewitness testimonies. There is no bar to obtaining such evidence, unless the manner undermines its legal reliability. For neuroscience, the lack of contemporaneousness is legally problematic as it inaccurately assumes that brain dysfunctions remain largely unaltered over time.[194]

Links three to six are particularly contestable. A vague likelihood or tendency towards poor judgement or violence could be channelled or manifested in many different ways, or not at all. Thus, the logic linking neuroscience to an element of a crime for admission in court is, at best, nebulous. Consequently, neuroscience is likely to be deemed irrelevant at the outset in failing to prove what it purports to prove. However, even if it is not excluded at this point, other possible evidentiary challenges to its reliability exist and are analysed in the following sections.

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191 DeBenedictis, above n 76; Morse "Brain Overclaim Syndrome", above n 34, at 400.

192 Pustilnik, above n 4, at 225–226 concludes that there is no reliable scientific link. See also at 206–207: "Although brain injuries can be catastrophic, there is no reliable relationship between pfc damage and violent or impulsive behavior."

193 See ibid, at 189: "The prefrontal cortex comprises the 'associational' part of the frontal lobes of the brain ... involved in 'distinctly human activities [including] planning, memory, problem-solving, [and] social conduct'." See also at 198: "The current view is that violence emerges from disorders of the prefrontal cortex, which is said to regulate executive function and judgment."

194 Vincent, above n 25, at 95.

(b) Level of Scientific Acceptance

Although courts do not require evidence to meet the standard of scientific certainty, and it is unclear whether *Calder* retained this requirement, the level of acceptance within the scientific community is a helpful gauge for a technique's reliability:[195]

> The assertion by a few well-known psychiatrists that a "general consensus" exists for the use of neuroimaging in psychiatric diagnosis has swayed more than one trial court judge to admit such evidence.

Such swaying of juries may have been relatively easy, given the public's alleged understanding of science as dealing with certainties, rather than probabilities.[196] In reality, due to the field's relative immaturity, its knowledge consists of a very small pool of correlational data that lacks standardised technical parameters, and presents "technical and interpretative problems".[197]

(c) Reliability of fMRI

Functional MRI analysis and interpretation "can be understood as based on a chain of inferences running from the data to the psychological function or construction of interest", with each step raising "questions about [its] reliability ... applicability or relevance".[198] First, the data processing methods, set by the researcher, have yet to achieve scientific consensus. Secondly, the relationship between local blood flow and neural activity is not precisely understood.[199] Thirdly, issues arise concerning the "design of fMRI studies and the associations drawn between fMRI data and the cognitive or emotional function of interest".[200] Feigenson lists the following reliability questions arising at the stage of comparing the control (rest) and experimental (task) brain states, using fMRI:[201] the difference between brain states is a relative, not absolute, measure of activity in constantly active areas; and these differences in brain activity may be very small, and mostly ignored.

From a mathematical perspective, the threshold significance for these data is not set at a widely accepted level.[202] Thus, some research may appear to show differential brain activity patterns while others,

195 Kulynych, above n 7, at 1259.
196 Gazzaniga, above n 7, at 414.
197 Kulynych, above n 7, at 1249–1250 and 1259.
198 Feigenson, above n 15, at 239.
199 Ibid.
200 Ibid, at 239–240.
201 Ibid, at 240.
202 Ibid. Often, but not always, $p < 0.05$.

using a different level of significance, would not.[203] Moreover, individual anatomical variability undermines claims that behaviour can be localised to a small universal brain region, with variations able to be mapped onto a standardised "brain map". Finally, the results are not comparable or cannot be generalised due to the variability of experimental designs between laboratories such as in different magnetic resonance signals between scanners.[204] Feigenson concludes:[205]

> Authors of peer-reviewed fMRI studies can satisfy their professional obligations ... by reporting their methodological and interpretive choices, trusting that their readers will understand the theoretical and practical contexts for those choices and appreciate the limitations on what may be validly inferred [from] their findings. Judges applying rules of evidence to proffers of fMRI data, in contrast, ought not to be as sanguine ... .

Feigenson also identifies concerns regarding the assumptions implicit in the use of blood oxygen signals to infer neuronal activity. Though it is generally agreed that local blood flow is related to neuronal activity, the intricacies of the relationship are not understood.[206] Most studies assume a one-to-one relationship between brain activation in a region and an operation. Yet the physical distribution of neural correlates is subject to debate, and significant evidence suggests that it is impossible to localise a particular function to a specific region. If so, a scan showing a "lack of activity" in a given region cannot explain or predict behavioural correlates, as it is unclear whether this is the sole region of this function, or whether other regions may take over this function in the event of inactivity.[207] Unsurprisingly, complex functions such as intent or knowledge, which are often the subject of legal scrutiny, are widely distributed due to the numerous discrete processes.[208] Adding to this complexity is the lack of accepted scientific or psychological definitions of such complex processes,[209] which means that even if some relevant activity — or lack of activity — is shown, researchers have few standards for definition. If researchers cannot define it by psychological standards that are designed to incorporate such data, a legal standard may be impossible.[210]

(d) Localisation

Concepts such as "violence" and "fear" are often attributed to the

203 Ibid.
204 Ibid.
205 Ibid, at 242.
206 Ibid.
207 Ibid, at 243.
208 Ibid.
209 Ibid.
210 Ibid, at 244.

prefrontal cortex. However, a review of studies establishing this link reveal "widely disparate conclusions about [their] functions ... implicating them in diverse mental processes".[211] The list includes "intelligence, problem solving, executive control, attention, decision-making, semantic memory, perceptual analysis, self-awareness, relational representations, [and] free won't", with regions of interest potentially "related to some, all, or none of the functions".[212] Local activation may signify the region's position in a distributed network of mechanisms that together perform the task, rather than the locus of the function.[213] Even though some psychopaths have unusual prefrontal cortex patterns, many people with damaged prefrontal cortexes never commit a crime.[214]

Similarly, the amygdala helps interpret social information, and may assist visual memory.[215] In fact, "[a]ny unexpected image can produce activation".[216] The amygdala's empirical connection to violence is based on limbic modification of monkeys and bulls, which resulted in passivity and tameness.[217] Researchers subsequently discovered that the modification had impaired their visual memory and ability to recognise what they were looking at, ultimately pacifying their "aggressive" reactions.[218] Given this information, it is unsurprising that a gap is observable between objectively measured brain activation patterns and a person's subjective assessment of her emotional state.[219]

Further examples of the complexity and current opacity of neural linkages may be derived from sense processing.[220] For example, audio processing, which creates the experience of "hearing", activates several brain regions with 24 distinct areas when a noise surprises a subject. These areas are associated with sound processing, surprise, identification and memory. The mere fact of activation does not render each area necessary, and no specific region(s) may be identified as "sufficient" for normal hearing ability.[221] Thus, lesion experiments and data from brain accidents indicate the areas of activity and help to elucidate the relationship between them, but are inconclusive as to sufficiency of each area.[222] Even further complexity exists in the visual system, which is comprised of non-hierarchical series of modules that create "seeing".[223] This is linked to the issue of individual

211 Pustilnik, above n 4, at 219.

212 Ibid, at 219–220. "Free won't" is a reference to one interpretation of a famous experiment conducted by Benjamin Libet and Hans Helmut Kornhuber that appeared to demonstrate that free will is an illusion. See for example Rosen, above n 35.

213 Feigenson, above n 15, at 243.

214 Pustilnik, above n 4, at 225–226.

215 Ibid, at 221.

216 Ibid.

217 Ibid, at 200–202.

218 Ibid, at 223.

219 Ibid, at 222.

220 Ibid, at 217.

221 Ibid.

222 Ibid, at 219.

223 Ibid, at 217–218.

differences.[224] For example, an individual's developmental history determines which neurons in the motor system control simple movements. Even identical twins demonstrate different neural activation patterns, which makes sense, because "if our brains were not individual, we could not be individuals".[225] If this level of distribution and individuality exists in very simple neural pathways, complex mental phenomena will be difficult, if not impossible, to understand via brain imaging alone.[226]

(e) Animal Studies

Added to these issues, much research is based on non-human animal studies.[227] Greely argues that these provide little, if any, insight into human neurology, because animals' different lifestyles shape their brain structures.[228] First, although mammalian brains share essential components, brain anatomy functions differently between the genuses.[229] Humans have significantly larger frontal and prefrontal cortexes, and experimental animals sometimes have no equivalent brain structures.[230] Humans' larger brain structures affect the interaction and experimental interpretation of the structures: "The human amygdala is acting and reacting in conjunction with the huge human cortex; the rat amygdala is not."[231] Secondly, most experiments are conducted on rodents with different brain structure, behaviour and motivations to humans,[232] making it difficult to extrapolate insights into human neurology. In other words, though animals may commit "criminal" acts (for example, murder, infanticide, rape or theft) they lack a comparable "interplay between motives and social norms" that differentially shape the causal neural links driving their actions.[233]

(f) Technical Error

Our knowledge of brain structure and function is in the early stages of development, speculative, and subject to interpretative error.[234] *Technical* error is another consequence, compounding interpretative errors and confounding our understanding. As mentioned, the chosen parameters of experimental design and image construction may vary between researchers and studies. Additionally, mechanical differences between scanners and computer software may produce varying results between

224 Ibid, at 218.
225 Ibid.
226 Kulynych, above n 7, at 1258.
227 Pustilnik, above n 4, at 209.
228 Greely "Not Responsibility but Treatment", above n 16, at 1121–1122.
229 Ibid, at 1122.
230 Ibid.
231 Ibid, at 1122.
232 Assuming that the human concept of "motivation" applies to rodents.
233 Greely "Not Responsibility but Treatment", above n 16, at 1121–1122.
234 Vincent, above n 25, at 93.

different laboratories,[235] mathematical error rates may cause variations in data reconstruction,[236] and "substantial overlap" between experimental and control groups often results from findings being based on mean differences.[237] Difficulties in post-scan analysis also arise as there are no known "normal" brain standards.[238] Further, the expense of these scans entails both financial and scientific limits: "imaging ... requires carefully chosen and cooperative subjects. Consequently, the number of experimental subjects and controls in any study tends to be small and precise replications are infrequent."[239]

4 Substantial Helpfulness

Briefly, expert opinion may be admissible if it will substantially help the fact-finder understand the evidence or to ascertain a relevant fact. As alluded to above, it is no longer inadmissible simply because it is about the ultimate issue to be determined or a matter of common knowledge,[240] though this may affect its "helpfulness".[241]

(a) Capacity Responsibility and Virtue Responsibility

It is important to distinguish a tendency to behave or think in a particular way (virtue responsibility, which is probably legally irrelevant), and an inability to control one's actions (capacity responsibility, which is usually legally relevant).[242] A clear example is fMRI studies showing reduced activation of the hypothalamus and prefrontal cortex in people who identify as paedophiles compared to "normal" adults. Although such studies demonstrate the parts of the brain involved in arousal, it does not uncover the causes of paedophilia and, more importantly, it does not predict which individuals will abuse children.[243]

Such evidence of virtue responsibility is often misconstrued as being relevant to legal liability. Another example is a neurological predisposition to anger. This predisposition does not necessarily translate into a decreased *capacity* for control; it may simply denote an unattractive personality trait.[244]

In New Zealand, Clayton Weatherston has recently provided an

235 Kulynych, above n 7, at 1254–1255.

236 Ibid.

237 "[M]eaning that some individual experimental brains look like individual control brains and vice versa": Morse "Brain Overclaim Syndrome", above n 34, at 403–404.

238 Turhan Canli and Zenab Amin "Neuroimaging of emotion and personality: Scientific evidence and ethical considerations" (2002) 50 Brain Cogn 414 at 424.

239 Morse "Brain Overclaim Syndrome", above n 34, at 403.

240 Evidence Act 2006, s 25(2).

241 See *RA v R*, above n 164, at [30].

242 Vincent, above n 25, at 94.

243 Pustilnik, above n 4, at 210–211.

244 Vincent, above n 25, at 90–91.

example of the distinction between an unattractive personality trait and one that is "so pathological that it has a bearing on criminal responsibility". Weatherston was accused of murdering his previous girlfriend by stabbing her to death. Testifying in his own defence, he pleaded guilty to manslaughter, arguing that he was provoked. Two psychiatrists testified to his "narcissistic personality disorder". Believing that the killing was deliberate and controlled — in other words distinguishing virtue responsibility (narcissism) from capacity responsibility (self-control) — the jury returned a guilty verdict.[245] While not drawing a clear "conceptual distinction", this case indicates that the law has dealt with such issues, and that similar logic may provide a basis for this distinction in neuroscientific evidence.

5 *Unfair Prejudice*

Tipping J in *Calder* considered it possible, but unlikely, for evidence that passes the threshold of being helpful and relevant nevertheless to be more prejudicial than probative. Evidence will be excluded where this unfair prejudicial effect is apparent.[246] Evidence is prejudicial "if its probative value is outweighed by the risk that the evidence will have an unfairly prejudicial effect on the proceeding",[247] which is ascertained in part by considering "the right of the defendant to offer an effective defence".[248] "Prejudice" in this context has a very specific meaning. To some extent, all evidence is prejudicial as it provides a logical step in the case against an accused. For exclusion, prejudice must be "illegitimate":[249]

> [T]he impugned evidence has little probative force but may lead the jury into an erroneous process of reasoning or ... to conclude that the Accused is guilty on an insecure or improper basis.

(a) Commentary

A striking contrast appears when one surveys the commentary on neurological evidence. As mentioned, commentators tend to cite extreme statements of neuroscience's potential, allegedly proposed on a limited scientific or legal understanding, which they criticise and dismiss in favour of a moderate approach. Similarly, potential reactions to the science are often characterised in general, unsubstantiated, and rather patronising terms: where "juxtaposed images 'just look different'", they are thought "to be different in psychologically and legally relevant ways";[250]

245 See *R v Weatherston* HC Christchurch CRI-2008-012-137, 15 September 2009.

246 *R v Calder*, above n 135, at 7.

247 Evidence Act 2006, s 8(1)(a).

248 Ibid, s 8(2).

249 *R v Calder*, above n 135, at 13.

250 Feigenson, above n 15, at 248.

"[p]rosecutors fear the colourful pictures ... may dazzle jurors ... [who] 'would be staring at these pretty pictures ... and just equate all the red colours with crazy colours'";[251] warning is given of "the 'Christmas tree phenomenon' — [where] jurors will be dazzled by the 'pretty lights' in the fMRI image and will not pay sufficient attention to the expert's interpretation".[252] This is based on three concerns: the perceived cultural "over acceptance" of science,[253] an over-estimation of experts' capabilities,[254] and the use of these images in popular culture, where people expect brain images to look like fMRI scans.[255]

(b) Judicial Statements

Examples of this fear can be seen in *People v Weinstein* and *People v McNamara*.[256] In *People v Weinstein*, the potential admissibility of PET scans "led the prosecution to accept a manslaughter plea",[257] and in *People v McNamara*, jurors acknowledged giving "significant credence" to brain image evidence in rejecting the death penalty.[258] Though New Zealand judges appear not to share this scepticism, they have warned against the overwhelming effect of experts.[259]

(c) Studies of Expert Evidence

Few published empirical studies have concentrated on neurological evidence.[260] However, some studies have demonstrated that "hard" scientific evidence, like that provided by neuroscience, is particularly compelling. For example, lay subjects are more likely to believe logically flawed explanations when they are accompanied by a brain scan or neuroscientific information.[261] Perhaps in a pre-emptive response, proponents of the evidence usually seek to present the evidence before a judge alone, where the evidence is admitted at a significantly higher rate than in proceedings before juries.[262]

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251 DeBenedictis, above n 76.

252 Feigenson, above n 15, at 246.

253 Gazzaniga, above n 7, at 413.

254 Kulynych, above n 7, at 1263.

255 Feigenson, above n 15, at 247. See also Eric Racine, Ofek Bar-Ilan and Judy Illes "fMRI in the public eye" (2005) 6 Nat Rev Neurosci 159.

256 *People v Weinstein*, above n 53; *People McNamara*, above n 90.

257 Kulynych, above n 7, at 1251.

258 Ibid, at 1252–1253.

259 *RA v R*, above n 164, at [25].

260 Though some have been conducted on the general ability of juries to understand expert evidence: Gurley and Marcus, above n 21, at 87; Belt, above n 146, at 411. There have been two experiments conducted in the United States, which indicated that jurors considered irrelevant factors; and generally found the interpretation and application of the evidence difficult. However, these experiments have been criticised: Belt, above n 146, at 411. See also Brown, above n 44, at 243.

261 Brown, above n 44, at 243.

262 Feigenson, above n 15, at 237.

(d) Studies of the Effect of Neurological Evidence on an Insanity Verdict

Research has found that subjects may be more likely to find defendants diagnosed with psychosis insane than those diagnosed with psychopathy. When researchers introduced neurological images of brain damage or testimonial evidence linking the defendant's disorder to brain injury, the likelihood of an insanity verdict increased. There was an additive effect of the images and testimony, with jurors becoming more likely to find defendants with both types of evidence insane, than those who presented one type.[263] Importantly, however, the brain damage portrayed in the scan was so extensive that the defendant would have been unfit to stand trial. Evidence is required as to the effect of a lesser injury, and the effect of scans on a defence that would effectively absolve the defendant of responsibility.[264]

When the conditions were altered so that the "defendant" in the study had schizophrenia and an abnormal MRI, half the jurors still found the defendant guilty.[265] However, it is important to note that participants in this study were mainly female university students involved in an introductory psychology class,[266] and the jury instructions were based on an American Law Institute standard, which includes a volitional limb not included in the *M'Naghten* standard.[267]

Based on these preliminary results, researchers have concluded that there is "no strong empirical support for the often expressed judicial fear that juries will be overwhelmed by 'shaky' scientific evidence and will give it more credibility than it deserves".[268] In fact, other surveys have found that jurors are capable of considering complex scientific issues and give primacy to evidence obtained through personal understanding.[269] Within this trend, jurors and mock jurors gave more weight to concrete experimental testimony based on clinical opinion, rather than abstract opinions based on actuarial instruments.[270]

VIII CONCLUSION

This article commenced with a brief description of the divide between the "radical" and "moderate" schools of neurolaw. It did not attempt to reconcile their differences, preferring to address neuroscience's immediate

263 Gurley and Marcus, above n 21, at 93.
264 Ibid, at 94.
265 Ibid, at 94–95.
266 Ibid, at 88.
267 Ibid, at 90. See *Daniel M'Naghten's Case* (1843) 10 Cl & Fin 200, 8 ER 718 (HL).
268 Belt, above n 146, at 411–412.
269 Ibid, at 411.
270 Gurley and Marcus, above n 21, at 87.

capabilities, particularly given its current applications overseas and its potential to affect New Zealand law. The technical mechanisms behind neuroscience were described so as better to identify the potential issues that would arise if the technology were introduced in a court context. This article also provided examples of how neuroscience has been used in foreign jurisdictions. It has also examined the attitude of the New Zealand courts in admitting novel scientific evidence. Within current legal structures, defence counsel may seek to admit neuroscientific evidence to demonstrate that a brain injury, congenital defect, or mental illness "caused" the defendant's actions (that is, made the defendant unable to process those actions). The defence may argue that this evidence undermines the mens rea for the crime, proves intoxication or automatism, and/or assists in establishing an insanity defence.

However, given theoretical and technical concerns about neuroscience, and despite the New Zealand courts' latitude towards admitting novel evidence, it is likely that the strict statutory standards for admissibility would bar neuroscience, either because it is irrelevant, unhelpful or unfairly prejudicial. It is possible that the detailed questioning required of the witness or the calling of multiple witnesses would prolong proceedings needlessly. If this is not the case, a judge is likely to find the evidence to be insufficiently relevant, given the weak links in the chain of inferences connecting a brain dysfunction to an action. Even if it does not fail at this point, the evidence may be found irrelevant or unhelpful given its scientific issues, particularly the inability to localise behaviour to a particular brain area, uncertainty surrounding the ability to discern generalised trends in the data, and the lack of consensus surrounding data collection, collation and interpretation. Aside from any prima facie relevance of the evidence, these factors would weaken its relevance such that unfair prejudice could easily outweigh its probative value.