NEUROSCIENCE AS EXPERT EVIDENCE IN CANADIAN COURTS

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This paper will explore recent developments in neuroscience, introduce legal tests for the admission of expert evidence, and explore the admissibility of neuroscience and brain imaging in Canadian Courts. First, it will introduce exciting contemporary developments in neuroscience and brain imaging. Some propose these development may revolutionize how we measure damages in personal injury litigation, how we assess credibility and how we determine criminal responsibility. Second, this paper will consider fundamental principles of expert evidence and the test set out in R v. Mohan *(1994), particularly as it relates to novel science, and compare it to tests in other jurisdictions. Finally, this paper will apply the rules of expert evidence to neuroscience and brain imaging. Neuroscience can be expected to increase in prominence in coming years in Canadian Courts and illuminate issues related to expert evidence and novel science in high-profile jurisprudential cases.*

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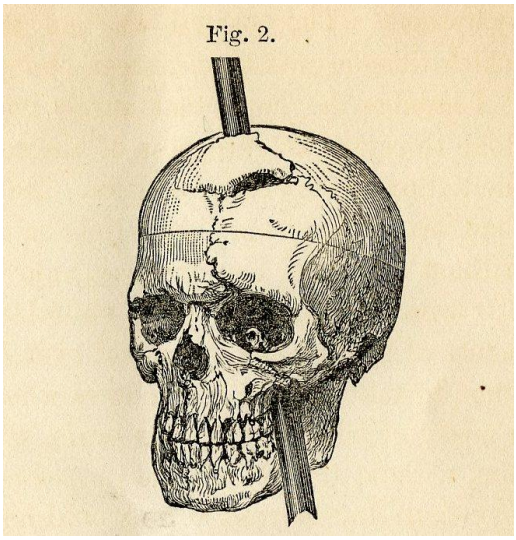

Figure 1

Figure depicting passage of a tampering iron through the skull of Phineas Gage – modelled after skull and tampering iron exhumed in 1867 and currently on display in the Warren Museum at Harvard University's School of Medicine (see generally John Harlow, "Bulletin of the Massachusetts Medical Society" (v. 2 (1868)).

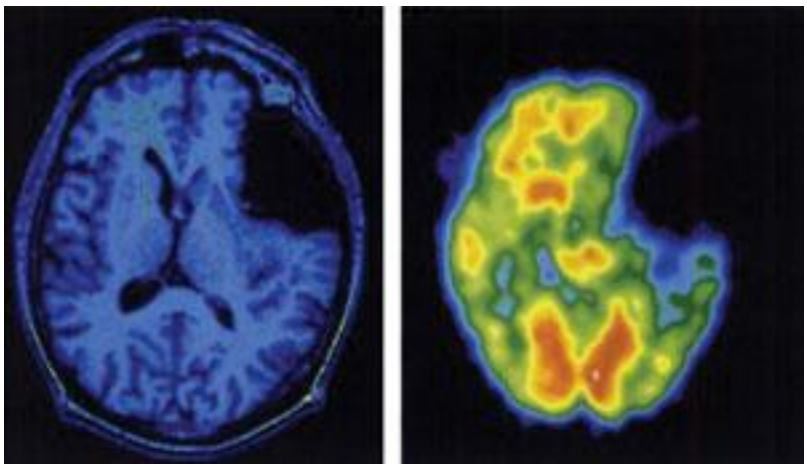

Figure 2

MRI and PET scan of Herbert Weinstein revealing an arachnoid cyst affecting a part of temporal lobe. Herbert Weinstein, a 65-year-old ad executive, was charged with strangling his wife, and throwing her from their 12th floor apartment (Jeffrey Rosen *The Brain on the Stand* New York Times, March 11, 2007).

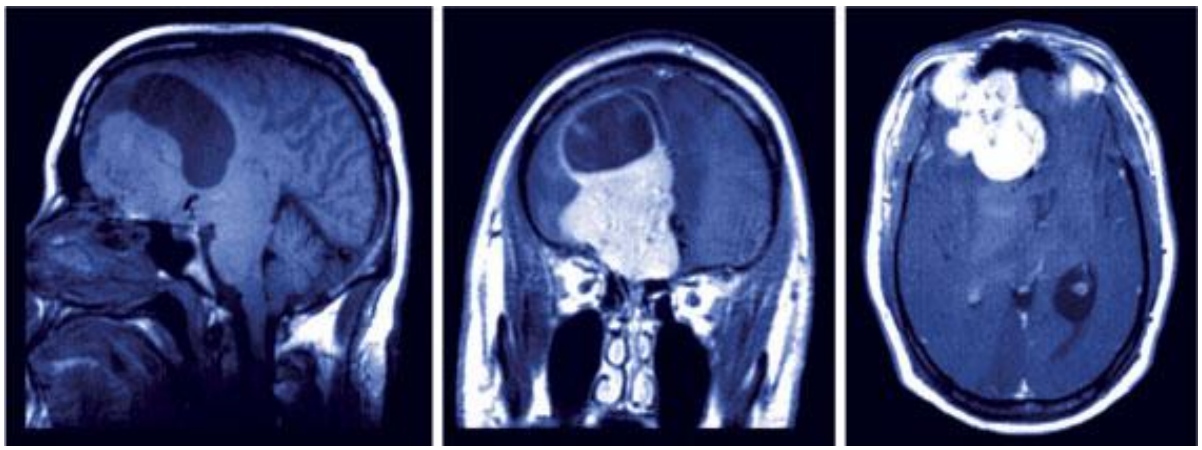

Figure 3

The case of the 40-year-old school teacher: Magnetic Resonance Imaging (MRI) showing an enhancing anterior fossa skull base mass that displaced the right orbitofrontal lobe. (Jeffrey Burns; Russell Swerdlow, "Right Orbitofrontal Tumor With Pedophilia Symptom and Constructional Apraxia Sign", ch Neurol. 2003;60:437-440.)

INTRODUCTION: THE CURIOUS CASE OF PHINEAS GAGE

> We sit on the threshold of important new advances in neuroscience… how the brain behaves in health and disease may well be the most important question in our lifetime." - Richard Broadwell[2]

Phineas Gage was foreman for a crew of rail-road construction workers. On September 13, 1848 a freak explosion propelled a tamping iron at high speed directly through his skull. It entered under the left cheek bone and exited through the top of his head landing over 30 feet away (See "Figure 1" above).

Miraculously, Gage survived. However, the accident destroyed a significant portion of his frontal lobe. Gage "radically changed."[3] He became "fitful, irreverent, [and] indulging at times in the grossest profanity."[4] His friends even lamented he was "no longer Gage."'[5] Phineas Gage is an "index case" for frontal lobe damage and personality change.[6] 160 years later, inquiry into the link between brain processes and human behaviour persists.

We are witness to an age of unprecedented scientific and technological advancement in the mind sciences. Developments in neuroscience and advancements in brain imaging allow for new insight into the vast universe of the human brain and illuminate the link between the brain and behaviour. In the legal context, expert evidence is the conduit through which these scientific advancements will enter the court room and find practical application in our legal system.

The rules of expert evidence and the academic debate about neuroscience and brain imaging are often introduced in the criminal setting. However, they are universal rules of evidence of equal application in both the criminal and the civil contexts. This paper aims to examine neuroscience as a field in which expert evidence will increasingly be tendered in Canadian courts. Some propose future developments may revolutionize how we measure damages in personal injury litigation, how we assess credibility and how we establish criminal responsibility. The principles of expert evidence discussed here highlight avenues of

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[2] *Neuroscience, Memory, and Language: Papers Presented at a Symposium Series Cosponsored by the National Institute of Mental Health and the Library of Congress*, (Washington: Library of Congress, 1995) at xxiv.

[3] John Harlow, "Bulletin of the Massachusetts Medical Society" *Medical Society* (v. 2 (1868): 327-347. Note that the exact nature of his character change is a subject to much debate, and there are those who suggest that the nature of his personality changes is overstated: M. Macmillan, "Phineas Gage—Unravelling the myth". *The Psychologist* 21(9):828–831.

[4] Harlow, *Bulletin supra* note 3 at 346.

[5] *Ibid* at 346.

[6] F.G. Barker, "Phineas Among the Phrenologists: the American Crowbar Case and Nineteenth-Century Theories of Cerebral Localization" J Neurosurg 82 pp. 672–682.

inquiry that bear universal application to any lawyer seeking to introduce neuroscience expert evidence in the litigation context.

In many areas of practice, keeping in stride with these developments, and having a reasonable level of understanding about neuroscience and its overarching theories, benefits, and limitations is essential to effective representation. It is an extension of the lawyer's professional duty to "adapt to changing… standards, techniques and practices."[7]

This paper will proceed in four parts: (I) first, it will summarize contemporary developments in neuroscience and brain imaging; (II) second, it will present the test for expert evidence and novel science in Canadian courts, compared with some other jurisdictions; (III) third, it will review the admissibility of expert neuroscience evidence in Canadian law; and (IV) fourth it willemphasize the important implications of neuroimaging in criminal and civil litigation, and explain why lawyers will observe this evidence in increasing frequency in the coming years. In the future courts will likely be asked to admit neuroscience and brain imaging with increased frequency, on a case-by-case, contextual, and principled basis in a manner that is reactive to promising technological advancements in neuroscience.

(I) CONTEMPORARY DEVELOPMENTS IN NEUROSCIENCE AND BRAIN IMAGING

> A primary task for neuroscience is to explain… how a two and a half pound hunk of organic matter… produces consciousness intentionality, responsiveness, mental causation, and all the other mental apparatus that is so central to our lives…" –Stephen Morse[8]

In an age of exciting scientific and technological advancement in the mind sciences, developments in brain imaging technology (particularly fMRI) stand to have profound implications for our legal traditions. This short section will serve as a brief introduction to developments in contemporary neuroscience.[9] It will (1) define "neuroscience," (2) introduce contemporary methods of brain imaging, particularly fMRI, and (3) explore the promise and limitations of neuroscience.

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[7] See Federation of Law Societies Model Code of Conduct Online amended December 12, 2012 Online: <http://www.flsc.ca/ s. 3.1>

[8] Stephen Morse, "Lost in Translation?: An Essay on Law and Neuroscience" in Michael Freeman, ed., *Law and Neuroscience*, (2011) Current Legal Issues, Vol. 13, p. 529 at 533.

[9] This section gives only a very brief overview of neuroscience and brain imaging. A vast treatise on the intricacies of neuroscience is not necessary for the purposes of this paper. For a detailed explanation of the technical matters of neuroscience the author would refer the reader to the authorities contained in this section. For a useful survey of the landscape see Francis Shen, "Law and Neuroscience Bibliography: Navigating the Emerging Field", (2010) *International Journal of Legal Information* 38, 352-399.

1. Neuroscience Defined

Broadly speaking, neuroscience is concerned with the structure or function of the nervous system.[10] The term "neuroscience" is not ontologically unique. It encompasses a variety of disciplines that have different applications in the forensic and legal context. In the contemporary criminal law setting, neuroscience is best conceived of as a form of science that uses technological advances in brain imaging to "illuminate the links between mind and brain, [and] to reveal the brain bases of human behavior and cognition."[11]

2. Brain Imaging Studies and Neuropsychological Testing

Functional Magnetic Resonance Imaging (fMRI) provides a non-invasive, real-time window into the human brain. As Stephen Morse explains, advancements such as fMRI present "hitherto, unimaginable possibilities… for understanding the link between brain and behaviour."[12] While fMRI is only one of a number of techniques used to analyze brain function, it is "the most prevalent, promising, and persuasive."[13] It grants scientists time-variable information about neural activity based on cerebral blood-flow and neuronal activation in various brain regions. This allows scientists to correlate neuronal activity with the behaviour of test subjects.

(a) Novel Brain Imaging Studies

There has been an explosion of fMRI studies reported in the literature. For example, in one study scientists were able to tell in advance when test subjects had solved certain problems, by fMRI signalling and "aha!" moment.[14] In another study, scientists claimed to successfully predict whether not certain consumers would make a purchase before the subjects made their purchasing decisions based on event relevant fMRI activation of distinct neural circuits.[15] In line with these trends, some marketing consultants offer pricey neuroimaging studies to evaluate the effect of product advertising on focus groups.[16]

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[10] "Neuroscience, n.". OED Online. September 2013. Oxford University Press.

[11] Stephen J. Morse and Adina L. Roskies eds. *A Primer on Criminal Law and Neuroscience*: *A Contribution of the Law and Neuroscience Project, Supported by the MacArthur Foundation* (Oxford: Oxford University Press, 2013) at 1.

[12] Morse and Roskies, *Primer supra* note 11 at xv.

[13] Annabelle M. Belcher & Adina L. Roskies, "Brain Imaging Techniques," in Morse and Roskies, *Primer supra* note 11 at 38.

[14] John Kounios and Mark Beeman "The "Aha! Moment: The Cognitive Neuroscience of Insight", Current Directions in Psychological Science, 18, 210-216 cited in Morse and Roskies *Primer* supra note 11 at xv.

[15] Brian Knutson et al, "Neural Predictors of Purchases" Neuron. 2007 January 4; 53(1): 147–156.

[16] Uma R. Karmarkar (2011). "Note on Neuromarketing". Harvard Business School Background Note 512-031, September 2011.

Scientists have also performed novel studies with related goals: to study the effect of the meditation on brain function in Tibetan monks;[17] to compare the difference the neuro-workings of introverted and extroverted persons;[18] to detect early signs of Alzheimer's disease;[19] to investigate the brain processes related to lack of empathy in psychopaths;[20] and to identify neurocognitive biomarkers related to persistent antisocial behaviour.[21] Neuroimaging tests have also confirmed that physical pain and the pain associated with social isolation by solitary confinement in incarceration result in identical brain imaging test results.[22] The latter fascinating study provides a foundation for arguing that there is no distinction between solitary confinement and torture from a moral perspective.

More recent studies purport to provide objective neurological evidence of depression, anxiety, fibromyalgia and chronic pain.[23] For personal injury lawyers, such studies about pain and traumatic brain injuries have significant implications for civil litigation and the assessment of damages.

(b) Novel Imaging to Detect Chronic Pain and Assess Traumatic Brain Injuries

One of the most seminal contemporary fMRI studies in the area of chronic pain was performed by Dr. Robert England. England's study, and similar studies, have important implications for persons practicing personal injury law, particularly in the areas of chronic pain and traumatic brain injuries (TBI). England used Radiofrequency (RF) emissions, alongside fMRI to observe a multiplicity of persons who are free of chronic pain and subjected them to a given pain stimuli. England demonstrates that such testing will permit the detection of brain patterns consistent with chronic pain without any conscious input from the

[17] A. Lutz, J.D. Dunne, & R.J. Davidson, "Meditation and the Neuroscience of Consciousness" In P.D. Zelazo, M. Moscovitch, & E. Thompson (Eds.), *The Cambridge Handbook of Consciousness*, (Cambridge: Cambridge University Press, 2005).

[18] T. Canli, et al, (2001). "An fMRI Study of Personality Influences on Brain Reactivity to Emotional Stimuli" in *Behavioral Neuroscience*, 115, 33-42.

[19] L.K. Laatsch, et al (2004). "Investigating the Neurobiological Basis of Cognitive Rehabilitation Therapy with fMRI." Brain Injury, 18, 957-974. C.L. Leveroni, et al "Neural Systems Underlying the Recognition of Familiar and Newly Learned Faces." (2000) The Journal of Neuroscience, 20, 878-886.

[20] Q. Deeley, et al, "Facial Emotion Processing in Criminal Psychopathy: Preliminary Functional Magnetic Resonance Imaging Study" (2006) British Journal of Psychiatry, 189, 533-539.

[21] S.W. Anderson et al. "Impairment of Social and Moral Behavior Related to Early Damage in Human Prefrontal Cortex." (1999) Nat Neuroscience 2:1032–1037.

[22] "The Archipelago of Pain", David Brooks, New York Times, March 6, (2014).

[23] H.S. Mayberg, et al (1999): "Reciprocal Limbic-Cortical Function and Negative Mood: Converging PET Findings in Depression and Normal Sadness" Am J Psychiatry 156:675–682. See also especially Robert England, "Objective Determination of Chronic Pain in Patients", (2011) Camporesi & Bottalico (explored in greater depth below).

patient. The method can be used in personal injury litigation or in the context of other compensation claims to objectively assess claims of chronic pain.[24]

Related to the above, recent development in imaging technologies in the context of neuropsychology have proved to be a potent tools used to assess traumatic brain injuries. Generally speaking, scientists and physicians use fMRI to facilitate pre-surgical activation mapping, characterize differences between clinical populations, correlate changes in Blood Oxygen Level Dependent ("BOLD") signal with behavioral data, and to give baseline information related to perfusion and blood oxygenation and resting state activity. That said, many scientists, and physicians, particularly neuropsychologists, use other innovative techniques to correlate fMRI data, and to provide a more fine-grained analysis of brain function. These tools contribute significantly to our understanding and explanation of damages for traumatic brain injury, including closed head injury, neuroblast trauma, and other series of trauma.

For example, (a) Positron Emission Tomography (PET), (b) single Positron Emission Tomography (SPECT), (c) Proton Magnetic Resonance Spectroscopy (PMRS), and Defuse Tensor Imaging (DTI) have all been employed to study effects traumatic brain injury:

(a) PET is the “Gold Standard” for examining baseline neurometabolism and quantifying cerebral metabolic rate of oxygen ($CMRO^2$) and Cerebral metabolic rate of glucose (CMRgLc). PET Whole-Brain Glucose metabolism is correlated with cognitive performance.

(b) SPECT is a nuclear medicine tomographic imaging technique. It uses gamma rays to provide high resolution, true 3D information, generally displayed in cross-sectional slices. This allows correlation of structural data with cognitive function (or dysfunction).

(c) PMRS is a non-invasive technique that is used to examine baseline alterations in neurometabolism. It is used to evaluate individuals after acute traumatic brain injury. Studies using this method have shown that changes in certain brain metabolites are associated with poor neurological outcomes. PMRS is used to evaluate early excitotoxic injury, and show changes associated with both neuronal injury and membrane disruption secondary to diffuse axonal injury.

(d) DTI is also used to evaluate axonal damage proximal to torsion flexion whiplash in motor vehicle accident (MVA). DTI is particularly effective for detecting mild traumatic brain injuries. Mild traumatic brain injuries often present challenges for both diagnosis and prognosis. DTI shows

[24] See generally England *Ibid*

> promise in providing objective evidence that white matter pathology often correlates with mild traumatic injury. DTI's major limitation is its lack of 1:1 correspondence with Brain Atlas Maps of Neural Pathways. Given this, and other limitations, it has been suggested the technology may not yet satisfy judicial tests for admissibility as expert evidence.[25]

As an entry point, neuropsychologists often use neuropsychological screening tests to generate computer profiles. These profiles highlight which brain areas should be further assessed through a more comprehensive Neuropsychological Test Battery. Employing the aforementioned techniques, neuropsychology can provide objective test results to support claims of traumatic brain injury. Physicians are able to correlate these findings with certain functional impairments in a various areas, including: (a) working memory (b) spatial learning, (c) attention, (d) behavioral (Limbic System), (e) processing speech, (f) verbal comprehension and (g) language (aphasias).

(c) fMRI and Lie Detection

As mentioned above, fMRI has recently been used for lie detection in a novel technology colloquially referred to as "no-lie fMRI". Academic papers on testing of the Blood Oxygen Level Dependent ("BOLD") effect through fMRI technology, first published in 2001, outlined the pioneering efforts of applying fMRI technology for pre-surgical mapping for epilepsy and brain tumour surgery. In the years that followed, lab testing addressed the promise of fMRI to lie detection.

Early development saw volunteers, monitored for cerebral blood-flow undertake various tasks in a study setting, and different patterns of blood-flow during different exercises were identified and then averaged to a "standard brain template." It was noted that activation of certain pre-frontal and anterior regions of the brain could be identified in testing subjects who were consciously communicating a lie. fMRI readings were successfully able to identify neuronal activity in two areas of the brain, specifically associated with the following:

(a) response suppression, that is, in many cases, the impulse to tell the truth, and;

(b) executive pre-frontal systems, linked to the creation of "new information", possibly the false utterance.[26]

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[25] Wortzel HS, Kraus MF, Filley CM, Anderson CA, Arciniegas DB. "Diffusion tensor imaging in mild traumatic brain injury litigation", J Am Acad Psychiatry Law. 2011;39(4):511-23.

[26] See G. Ganis et al. Neural Correlates of Different Types of Deception: An fMRI Investigation" (2003) Cerebral Cortex, 13, 830-836. See also J.R. Simpson, "Functional MRI Lie Detection: Too Good to be True?" J Am Acad Psychiatry Law. 2008; 36(4):491-8.

With this early success, commercial enterprises, including Cephos and No-Lie MRI, have promoted this technology for use in a forensic setting. However, fMRI lie detection is a very young technology. It is subject to a number of limitations and the legal issues surrounding this technology are addressed specifically, and in greater depth below.[27]

3. The Promise and Limitations of Neuroscience

Research into the promise and limitations of neuroscience and functional imaging continue in the scientific, legal and academic community.[28] Proponents suggest that as science progresses, the use of fMRI data in concert with advanced computer technology and "systems neuroscience" will allow us to unlock the secrets of the human brain. They believe future advancements will allow scientists to dissect the physical neural workings of a human "mechanism" in the same manner one would analyze a complex circuit system or advanced computer code.[29] This prognosis is premised on the assumption that brain states and "consciousness" are reducible to physical neural processes that are determined subject to universal physical laws. Such proponents are optimistic that in the near future neuroscience will live up to its promise of "turning the black box of the mind into a transparent bottleneck" allowing us omniscient clarity into the expanses of the human mind.[30] Many others are more cautious in their predictions.

Neuroimaging and fMRI is *not* "mind-reading." Contemporary neuroscience is a relatively young science subject to many limitations. Morse believes that until we know "vastly more" neuroscience will not add much to our understanding of moral or criminal responsibility.[31] Others note that when it comes to the workings of the human brain "there are many things, even quite basic things, that we do not know."[32] The limitations of neuroscience are considered in greater depth below, where the legal rules of expert evidence and novel science are applied to neuroscience and brain imaging.[33]

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[27] See (III) below.
[28] See for example, a funding initiative by the John D. and Catherine T. McArthur Foundation for Law aimed at researching neuroscience as a tool to further criminal justice (see <www.lawneuro.org>).
[29] J. Green and J. Cohen, "For the law Neuroscience Changes nothing and everything," in Law and the Brain, ed. S. Zeki and O. Goodenough (Oxford, U.K.: Oxford University Press, 2006) 217-218.
[30] Green and Cohen, *supra* note 29 at 217-18.
[31] Stephen Morse, "Brain Overclaim Syndrome and Criminal Responsibility: A Diagnostic Note", (2006) State Journal of Criminal Law, Vol. 3, p. 397.
[32] Belcher and Roskies, *supra* note 13 at 35.
[33] See (III) "Neuroscience as Expert Evidence" infra.

(II) LEGAL TEST FOR ADMISSIBILITY OF EXPERT EVIDENCE IN CANADIAN COURTS

> A pitiable specimen is that poor man of science, pilloried up in the witness box, and pelted by the flippant ignorance of his examiner. – Tal Golan[34]

It is nearly 20 years since the Supreme Court of Canada delivered its seminal judgment on expert evidence in *R v. Mohan*.[35] A cursory scan of the literature shows an explosion of interest in the area, precipitating hundreds of articles, new treatises, and many conferences for academics, judges and practitioners. This section (1) introduces the criteria for the admissibility of expert evidence both in Canada and in other jurisdictions, (2) explores the test for "novel" science, and (3) makes general comments about the flexible, principled, and case-by-case nature of the test for expert evidence.

1. R v. Mohan and Expert Evidence in Canadian Courts[36]

In *Mohan*, the Supreme Court introduced the current legal test for admissibility of expert evidence.[37] The trial judge is the gatekeeper. Under the test, the party tendering evidence has the burden[38] to satisfy the court of four criteria:

1. necessity in assisting the trier of fact;
2. the absence of any exclusionary rule;
3. a properly qualified expert.[39]
4. relevance;[40]

While *Mohan* is a criminal case, the test and underlying principles apply equally in civil proceedings, although depending on the particular context, different considerations will apply. This is clear based on the fact that in *Mohan* Justice Sopinka cites both criminal and civil cases in support of the test.[41] It has also been confirmed in recent cases Supreme Court cases that Mohan applies with equal force in both civil and criminal cases.[42]

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[34] *Laws of Men and Laws of Nature: The History of Scientific Expert Testimony in England and America* (Cambridge: Harvard University Press, 2004) quoting "Science in the Witness-Box" London Chemical News, (Griffin, Bohn and Company, 1864) at 318.
[35] [1994] 2 S.C.R. 9 [*Mohan*].
[36] Note this paper focuses on expert evidence in Canadian Courts. But Canadian and the US jurisprudence are generally seen as a "movement in parallel" (see Generally Glen B. Anderson, Expert Evidence, 2nd ed. (Toronto: LexisNexis, 2009) at 59-80).
[37] *Mohan*, *supra* note 35.
[38] The burden is on the party calling the evidence: *R v. J.(J.-L.)* [2000] SCR 600 [*J.L.*] at paras 28-29.
[39] See generally *Mohan*, *supra* note 35.
[40] *Ibid*
[41] See *Mohan*, *supra* note 35.
[42] See generally *Masterpiece Inc. v. Alavida Lifestyles Inc.*, 2011 SCC 27 [*Masterpiece*] applying the rules of expert evidence in a trademark case.

(a) Necessity

Expert testimony is necessary if, due to its technical nature, certain information, it is "likely to be outside of the experience or knowledge of the jury."[43] Expert evidence is not admissible in relation to matters of common-sense that the trier of fact can determine independently. Thus, while an expert is necessary to explain the psychological intricacies of "battered woman syndrome,"[44] an expert is not necessary to explain the frailties of eye-witness testimony,[45] or to assess whether a casual consumer would observe resemblance between trade-marks or trade-names.[46] In circumstances where fMRI lie detection evidence might be proposed with the objective of enhancing, or refuting, a witness' credibility with respect to specific testimony, and a court may consider whether that determination can be made by the trier of fact without it.

(b) Exclusionary Rules

The second stage of the test merely confirms that expert evidence is subject to ordinary rules of evidence. For example the "character evidence rule" precludes an expert from presenting evidence of general propensity,[47] the "opinion evidence" rule prevents an expert from giving a personal opinion on matters outside his or her expertise,[48] the "hearsay" rule limits the ability of experts to tender out-of-court statements for their truth,[49] and the rule against "oath-helping" prevents an expert from presenting evidence to bolster the credibility of sworn testimony.[50] The latter of these rules, the rule against oath helping, has been cited as an obstacle to the admission of polygraph evidence, and could apply equally to the admission of fMRI evidence in the context of lie detection.

(c) Properly Qualified Expert

In Canada, the requirement of a "properly qualified expert" is not a strict requirement. Expertise is a "modest status"[51] attained through a "special or peculiar knowledge" based on study or experience that goes beyond the understanding of the trier of fact.[52] Lack of credentials alone will not generally bar

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[43] *Mohan, supra* note 35 at 23-24. See also *R. v. Burns*, [1994] 1 SCR 656.
[44] *R. v. Lavallee*, [1990] 1 S.C.R. 852.
[45] *R. v. McIntosh*, (1997) 35 OR (3d) 97 (ONCA) at para 20.
[46] *Masterpiece supra* note 41.
[47] See *Mohan, supra* note 35. See also *R. v. Morin*, [1988] 2 SCR 345.
[48] See *Mohan, supra* note 35.
[49] *R. v. Khelawon*, 2006 SCC 57.
[50] For example, an expert might be limited from presenting fMRI or lie detector evidence to show an accused is telling the truth, or testifying to the "truthfulness" of the accused's testimony.
[51] David M. Paciocco, Lee Stuesser, *The Law of Evidence* 5th ed. at 203 (Toronto: Irwin Law, 2008) at 161.
[52] See *R. v. Marquard*, [1993] 4 S.C.R. 223, at p. 243.

admissibility but can affect the weight which the evidence receives.[53] That said, newly credentialed "fMRI experts" may well face challenges here. *Dulong v. Merril Lynch Canada Inc.*[54] provides a list of factors that judges regularly consider in determining if an expert is properly qualified. The following factors are those found to be relevant to determining an expert witness' threshold reliability:

1. the proposed expert's professional qualifications;
2. actual experience;
3. participation or membership in professional associations;
4. the nature and extent of his or her publications;
5. involvement in teaching;
6. involvement in courses or conferences in the field and his or her efforts to keep current with the literature;
7. whether the expert has previously been qualified as an expert in the area.[55]

(d) Relevance

The relevance inquiry is a central feature of the *Mohan* analysis. There are two stages to the application of the principle: (i) logical relevance and (ii) the "cost-benefit" analysis. (i) Logical relevance does not require that evidence firmly establish facts. The test is broad. Evidence need only "increase or diminish the probability of… a fact in issue..."[56] (ii) The "cost-benefit" analysis, a crucial factor, weighs the probative value of the evidence against its potential prejudicial effect.[57]

Probative value, that is the benefit of evidence, is assessed on the particular facts of the case in light of what the evidence purports to prove. Expert evidence is relevant and probative when it is founded on proven facts, supports the inferences drawn from those facts, and tends to prove an important issue in the proceedings.[58] The question is whether the evidence "in some degree advances the inquiry."[59] In criminal

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[53] *R v. Fisher*, 2003 SKCA 90 at para 19.
[54] *Dulong v. Merril Lynch Canada Inc.* (2006), 80 OR (3d) 378 (S.C.), at para. 21
[55] *Ibid*
[56] See generally *R. v. Arp*, [1998] 3 SCR 339, citing Sir Richard Eggleston, *Evidence, Proof and Probability* (2nd ed. 1978), at p. 83.
[57] Note, this is also a general rule of evidence that might properly be further applied under (c) "Exclusionary Rules" as a trial judge always has discretion to exclude evidence if it's probative value outweighs its prejudice (*R. v. Seaboyer; R. v. Gayme*, [1991] 2 SCR 577 at 390-391 [*Seaboyer*]). This provides an ongoing discretion to exclude expert evidence, or portions thereof, later in proceedings even after expert evidence has already been admitted.
[58] *R v. K.A.*, 176 DLR (4th) 665 (ON CA) per Charron J.A.
[59] *R. v. Rose*, [1998] 3 S.C.R. 262 at para. 97.

proceedings, the aversion against excluding probative defence evidence represents a critical corollary of a defendant's constitutional right to make a full answer in defence.[60]

In civil proceedings, particularly in personal injury cases, and quite apart from lie detection, neuroscience and neuroimaging may be relevant to quantum of damage. In this context evidence is probative when it speaks to objective deficits, and may allow for the detection of malingerers. Evidence will be probative where it assists a trial judge in determining appropriate compensation for complex questions about loss and injury.

Prejudicial effect concerns whether the evidence occasions undue time, delay, and particularly in civil proceedings, expense. Evidence is also prejudicial when it confuses or "distorts the fact-finding process".[61] There is concern that under "[t]he prestige of science or expert credentials" the jury will give the evidence an "exaggerated importance… act on emotion or prejudice" or may be "divert[ed] from real issues in the case".[62] As Justice Sopinka cautions in *Mohan*:

> Dressed up in scientific language which the jury does not easily understand and submitted through a witness of impressive antecedents…cloaked under the mystique of science…this evidence is apt to be accepted by the jury as being virtually infallible and as having more weight than it deserves….[63]

Even if expert evidence is admitted, a judge retains an ongoing residual discretion to limit the scope of such evidence where it becomes prejudicial. For example, as in the U.S. case *People v. Weinstein*,[64] a judge may allow testimony about brain abnormality or tumour, but still preclude the admission of potentially inflammatory fMRI images showing a malignant brain tumour, if a judge feels such an image may unduly prejudice the jury (see "Figure 2" above). Prejudice, particularly among jurors, is a critical consideration for neuroscience and brain imaging and is specifically considered below.

2. Alternative Expert Evidence Admissibility Tests

Before considering the Canadian test for novel science, it is useful to consider and compare some alternate tests for the admissibility of expert evidence. Before the Supreme Court issued its seminal decision in *Mohan* in 1994, the entry of expert evidence into Canadian courts was governed by the more

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[60] *Canadian Charter of Rights and Freedoms*, s. 11(d) [*Charter*].
[61] *J.L., supra* at para. 29.
[62] Paciocco, and Stuesser, supra note 51 at 203.
[63] *Mohan*, *supra* note 35 at 411.
[64] 591 N.Y.S.2d 715, 717 (N.Y. Sup. Ct. 1992)). See also, generally, *Seaboyer supra*.

simply stated threshold in *R v. Abbey*[65] which directed courts to apply a subjectively determined "helpfulness" standard to the issue. The *Abbey* decision was later criticized for imposing too low of a standard for determining the admissibility of proposed expert evidence, leaving concerns to be addressed exclusively a matter of weight to be attributed to the opinion, even if based entirely on second-hand evidence. Decisions that followed *Abbey*, including *Mohan*, adopted a more principled approach in response.

Perhaps not surprisingly, the first efforts amongst common law jurisdictions to accommodate the introduction of fMRI technology appear to have been initiated in the United States, and accordingly different legal tests have been brought to the consideration of admissibility. Courts in Canada may review the reasoning in these decisions when assessing the admissibility of neuroscience. Thus a review of these alternative standards may be useful.

In most US jurisdictions, the use of expert scientific or technical evidence is governed by the decision of the United States Supreme Court in *Daubert v Merrell Dow Pharmaceuticals*.[66] In *Daubert*, the Court directed that the Federal Rule of Evidence 702 requires trial judges to determine whether expert testimony is both reliable – supported by scientifically valid reasoning or methodology – and relevant – applicable to the specific issue the court must resolve. Judges making these determinations are subsequently to consider the following criteria as relevant to deliberation:

(1) whether the scientific technique is testable and whether it has been tested;
(2) whether the technique has been subject to peer review and publication;
(3) the technique's known or potential error rate;
(4) whether there are standards governing the technique's application; and
(5) whether the scientific community accepts the technique.[67]

The admissibility of scientific evidence in New York State remains governed by an alternative preceding threshold, that is the test set out in *Frye v United States [T-Rue]*,[68] which has been replaced by *Daubert* in most American jurisdictions. The *Frye* test was recently applied as the standard by which the admission of fMRI evidence would be considered in *Wilson v. Corestaff Services*.[69] *Frye* permits expert testimony based on "scientific principles, procedures or theory only after [they] have gained general acceptance in

[65] *R v. Abbey* [1982] 2 SCR 24, 138 DLR (3d) 202, 68 CCC (2d) 394.
[66] (1993) 516 US 869.
[67] Rebecca Dresser, "Brain Imaging and Courtroom Deception" (2010) *Hastings Centre Report – At Law*, Nov-Dec 2010, pp. 7-8.
[68] (DC 1923) 293 F. 1013.
[69] (2010) WL 1949095 (NY Sup. Ct.).

the relevant scientific field." Such testimony must also bear "on a topic beyond the ken of the average juror."[70]

Questions of reliability and probative value were paramount in the analyses in two recent US cases. The decisions of *Wilson and Semrau*, reviewed below, consider the admission of fMRI evidence either under the *Frye* or *Daubert* tests. These considerations would appear to have a significant place in a *Mohan* analysis as well. The specific considerations of reliability in *Daubert* could be adopted by courts in considering whether an expert is "properly qualified" under a *Mohan* analysis, though Canadian courts have adopted their own approach to "novel science."

3. Novel and "Junk" Science in Canadian Courts

Since *Mohan*, the Supreme Court of Canada has considered the reliability and the validity of what is identified as "novel science" with heightened scrutiny. Before admitting novel science, Canadian courts require novel science or theories to have a “reliable foundation”.[71]

Science is novel if:

(a) the court does not have an "established practice" of admitting it; or
(b) an expert is using an established theory or technique for a new purpose.[72]

Novel science must have a "reliable foundation." Central considerations are whether the theory or technique:

1. can be and has been tested;
2. has been subject to peer review and publication;
3. has a determined or potential rate of error; and
4. has been generally accepted.[73]

These requirements advance the reasoning in Mohan and require heightened scrutiny for novel forms of science.[74] In contemporary jurisprudence, reliability is becoming a central theme in evaluating novel science.[75]

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[70] Dresser, *supra* note 67 at 8.
[71] See generally *J.L.*, *supra* note 38.
[72] Paciocco, and Stuesser, supra note 51 at at 205.
[73] *R. v. Trochym*, 2007 SCC 6 [Trochym] adopting a similar test and reasoning to *Daubert v. Merrell Dow Pharmaceuticals Inc*., (1993) 509 U.S. 579.

Note that "general acceptance" is just one factor to be considered. Canadian courts have rejected the more strict U.S. test of "general acceptance". Under Canadian law, a lack of general acceptance alone is not necessarily fatal so long as the science has a "reliable foundation".[76] The rules of expert evidence are "flexible and non-exclusive".[77] The test for novel science is at the heart of the debate surrounding the admissibility of neuroscience and brain imaging, and is considered in greater depth below.[78]

4. Contextual, Principled and Reactive Approach to Expert Evidence

Before considering the admissibility of neuroscience it is useful to make general comments about the nature of the test for expert evidence. The test for expert evidence and novel science is (a) contextual, (b) principled, and (c) reactive to developments in science.

The test for expert evidence is *contextual*. Admissibility is necessarily informed by the nature of the proceedings, particularly: (i) whether the proceedings are criminal or civil; (ii) whether the evidence is tendered to assess liability, determine breach of contract, assess damages in tort or negligence, evaluate fitness for trial, identify mental disorder, speak to matters of sentencing, or to prove an essential element of an offence such as *mens rea*;[79] (iii) whether the trial is before judge or jury; (iv) the availability of safeguards to limit potential prejudice such as adversarial experts, discovery, notice, effective cross-examination, and juror instruction; and (v) whether the evidence is tendered by the crown, an accused, a plaintiff or a defendant. The context also informs fundamental principles that animate the endeavour.

The test for expert evidence is *principled*. Fundamental principles direct the endeavour in both the criminal and the civil setting. In the criminal law context, the rights of an accused are weighed against the interest of the state in punishing criminal activity. In this context, a guiding principle is the "golden thread" of our criminal system, namely the presumption of innocence.[80] The test is also informed by heightened concern in contemporary society about the devastating injustice of wrongful conviction, and a

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[74] *Trochym*, *supra* note 73 at para 33.
[75] *Trochym*, *supra* not 73 at paras 29-30, see also Gary Edmond and Kent Roach "A Contextual Approach to the admissibility of the State's Forensic Science and Medical Evidence", (2011) 61 UTLJ at 385-389.
[76] In J.L., *supra* note 38 at 593-594 in which the Supreme Court of Canada states "Mohan kept the door open to novel science, rejecting the "general acceptance" test formulated in the United States in *Frye v. United States*, 293 F. 1013 (D.C. Cir. 1923).
[77] *Trochym* supra note 73 at para 139.
[78] See (III) "Neuroscience as Expert Evidence" infra.
[79] Specifically relevant are dangerous offender proceedings (*Criminal Code*, S.C, 1985, c. C-46 Part XXIV [*Criminal Code*]) where expert evidence is a legal requirement to determine indicia of dangerousness and potential for recidivism.
[80] *Woolmington v DPP*, [1935] UKHL 1.

general revulsion against punishing the "morally innocent."[81] In line with these principles, a court will allow greater leniency in assessing evidence provided by the accused to facilitate the constitutional right to full answer and defence, only excluding defence evidence where its prejudice substantially outweighs its probative value.[82] Conversely, prosecution evidence is scrutinized with increased rigor, particularly where such evidence speaks to a central or "ultimate" issue. This is of heightened importance in light of a growing awareness of the reality of wrongful conviction. For example, one study indicates that of 311 post-DNA exonerations, invalidated or improper forensic science played a role in over 50% of them.[83]

In civil settings, contrasting principles apply. Civil litigation generally focuses on balancing the rights of opposing litigants, and can involve providing adequate compensation to persons injured due to the negligence of others. In the context of the rules of civil procedure, practical considerations take center stage. In this context, guiding principles such as equity, restitution and efficacy animate the endeavour, all in the context of a heightened awareness that, as the Supreme Court of Canada has recently noted, "litigation is costly."[84] Increased concerns about proportionality in civil litigation in Canada will play a role in how neuroscientific evidence is received in the future.

Finally the test for expert evidence is *reactive to developments in science*. It is a general principle of evidence that all probative evidence should be admissible, absent a clear basis in law or policy to exclude it.[85] Like the law, science continues to evolve and develop its base of knowledge. The rules governing the admissibility of scientific evidence are not "cast in stone… enacted in a vacuum",[86] or "frozen in time."[87] As Binnie, J. states:

> A case-by-case evaluation of novel science is necessary in light of the changing nature of our scientific knowledge: it was once accepted by the highest authorities of the western world that the earth was flat."[88]

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[81] *R. v. Ruzic*, 2001 SCC 24.

[82] See for example the suggestion in *Seaboyer*, *supra* note 57) that the exclusion of defence evidence requires probative value to "substantially" outweigh its probative value. See also generally *R v. B.M.*, (1998) 42 OR (3d) 1 (ON CA).

[83] See "Innocence Project", Online: <http://www.innocenceproject.org/Content/DNA_Exonerations> Select "Fact Sheet".

[84] See *Masterpiece*, *supra* note 41 at para 76.

[85] *Corbett v. R.*, [1975] 2 SCR 275 at para 100 per La Forest J.

[86] *R v. Levogiannis*, [1993] 4 SCR 475 at para 22.

[87] *Trochym*, *supra* note 38 at para 31.

[88] *J.L., supra* at para 25. See also J. Sopinka, S.N. Lederman & A.W. Bryant, *The Law of Evidence in Canada*, 2nd ed. (Toronto: Butterworths, 1999) at 6-7. Note that while Justice Binne introduces this example for metaphorical purposes, whether or not the "flat earth" myth was in fact widely accepted among western authorities is suspect. In fact, Eratosthenes, Greek Geographer, mathematician and astronomer measured the circumference of Earth 2200 years ago at 252 thousand "stadia" which it has been suggested was, impressively,

Therefore scholars propose "a flexible, principled case by case approach in which competing policy interests at stake are weighed in the context of the circumstances of a particular case",[89] in the context of what is observed as a "discernible trend" towards the increased admissibility of expert evidence.[90]

To summarize, expert evidence is evaluated in a contextual and principled manner that is reactive to developments in science. This has significant implications for the approach which Canadian courts may take to the reception of neuroscience and brain imaging in both criminal and civil proceedings.

(III) NEUROSCIENCE AS EXPERT EVIDENCE IN CANADIAN COURTS

> An expert is one who knows more and more about less and less until he knows absolutely everything about nothing - Nicholas Murray Butler[91]

So far in this paper we have introduced recent developments in neuroscience that stand to have significant implications for our legal traditions. We have also introduced the law of expert evidence, and novel science in Canadian courts. In this section we will apply the rules of expert evidence to neuroscience.

In this section we will: (1) introduce two examples of where neuroscience might be tendered; (2) apply the *Mohan* test to neuroscience; and then (3) apply the test for novel science to neuroscience. To expand on these factors we will then (4) highlight the central practical and theoretic problems with neuroscience; (5) consider the specific case of fMRI lie detection; and (6) conclude with a short note on the importance of juror instructions, and juror education in the context of neuroscience.

1. Illustrations

Here we introduce two illustrations of cases in which neuroscience might be introduced as expert evidence in Canadian Courts in both the criminal and civil setting.

One of the most widely cited and fascinating cases in the academic literature is the case of the 40-year old Virginia schoolteacher. The teacher had a master's degree, a clean record, and enjoyed a stable marriage. Suddenly, and inexplicably he began exhibiting paedophilic tendencies.[92] An ensuing MRI revealed a tumour the size of a chicken egg in his right orbitofrontal lobe (See "Figure 3" above). The tumour was excised and the paedophilic tendencies subsided. The teacher completed a treatment course and

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within 2% of the actual circumference: see Bishop, Louise M. "The Myth of the Flat Earth", in eds. Harris, Stephen J.; Grigsby, Bryon Lee, Misconceptions about the Middle Ages, (New York: Routledge, 2008)

[89] *Ibid* at 6-7.

[90] Paciocco and Stuesser, *The Law of Evidence in Canada*, at 7.

[91] *The Meaning of Education and Other Essays and Addresses* (New York: The Macmillan Company, 1898) at 45.

[92] His symptoms also included headaches, loss of bladder control, and problems with balance and walking.

reconciled with his family. A year later, the paedophilic tendencies re-emerged. A subsequent MRI showed that the tumour had re-grown. This case is extensively cited in the law and neuroscience literature because it is a rare and unique case. The significance attributed to the case is that it provides a recognition of neuroscientific evidence that goes beyond mere correlation and provides stronger evidence of a causal relationship between brain dysfunction and behavior.

Brain imaging evidence in this case was tendered and admitted as a factor in sentencing. In considering the same factual circumstances in a Canadian criminal court situation, this scenario might very likely satisfy the *Mohan* indicia of being necessary in assisting the trier of fact, without a prohibiting exclusionary rule, advanced by a properly qualified expert, and relevant to the issue of degree of sentencing, if not a criminal responsibility for the acts.

In the civil setting, neuroscience might be tendered for contrasting purposes. Consider the following hypothetical scenario. A Plaintiff is injured in a motor-vehicle accident. He brings a claim against a Defendant. The Plaintiff claims to have suffered traumatic brain injury, and to suffer from chronic pain. The Plaintiff will testify that the traffic light facing him, as he approached the intersection where a motor vehicle accident occurred, was at all material times showing green. In preparation for trial, the Plaintiff will undergo fMRI lie detection in a controlled environment, and hopes to present fMRI evidence confirming that his testimony in this respect is credible, and that he is not consciously lying when he says so. The Plaintiff also intends to present neuropsychological testing, fMRI evidence, and Radiofrequency emissions to provide objective evidence of chronic pain, and traumatic brain imaging. There is a good chance Canadian courts would admit imaging and neuroscientific evidence speaking to brain injury and chronic pain. However expert evidence related to lie-detection, at least for the near future, be determined to be subject to more significant obstacles to admissibility.

The reader ought to bear these illustrations in mind as the test for expert evidence is applied to proposed neuroscientific evidence. It should be clear that while the same *Mohan* four-point test is applicable in both of these illustration, quite different intuitions are likely with respect to the evidence in question.

2. Mohan Applied to Neuroscience

How will the *Mohan* test, and the analysis of novel science, apply to neuroscience? Expert evidence is the conduit through which neuroscience will enter Canadian courts. As set out above, the Mohan test considers (a) necessity; (b) exclusionary rules; (c) qualifications; and (d) relevance. While all of these criteria bear scrutiny in this context, courts will likely focus their attention on the issue of relevance, and accordingly the discussion below expands on that in more detail.

(a) Necessity

Is expert evidence introducing neuroscience and brain imaging *necessary*? This will always depend on the circumstances of the particular case. In relation to many forms of neuroscience, the necessity requirement is generally satisfied. The intricacies of neural processes and their purported impact on criminal responsibility and personal injury claims are generally outside of the experience or knowledge of the jury.

(b) Exclusionary Rules

In the context of neuroscience, two exclusionary rules are significant. First, the character evidence rule will limit the *purpose* for which a neuroscientist presents evidence. It would preclude a neuroscientist or neuropsychologist from presenting theories or introducing brain imaging to as evidence of general propensity. In other words, a neuroscientist would not be able to introduce evidence to show that a particular accused is the *type* of person, or a person of a certain character such that he or she would not act in a certain manner. This would, presumably, be considered circumstantial evidence tendered to speak to the *actus rea*, and whether the accused committed the prohibited act. Such evidence would fall under the ambit of the character evidence rule and would likely be subject to exclusion.

Similarly, the rule against "oath-helping" will, at least for the foreseeable future, preclude neuroscientific evidence that is tendered to show that a litigant is being honest. Thus, an expert might attempt to introduce fMRI, or other imaging to show that an accused is being truthful. The rule against "oath helping" is premised on the belief that there is no need to bolster the credibility of a litigant who has already taken the stand and sworn under oath to tell the truth. As part of our legal traditions, it has always been the trier of fact, be it a judge or jury, who bears the duty to assess the credibility of an accused. Thus, expert neuroscientific evidence tendered to prove an accused is truthful, such as polygraph evidence, has been strictly excluded. Such a rule would arguably support the exclusion of fMRI lie detection evidence, at least for the foreseeable future. However, future developments may change this. The specific instance of fMRI lie detection is considered in greater depth below.

(c) Properly Qualified Expert

Finally, from a practical point of view, in the context of neuroscience, qualifications will not generally be in issue. An expert with, modest credentials, introducing brain imaging and speaking to the link between brain abnormality and criminal responsibility will generally have "special or peculiar knowledge" going beyond that of the trier of fact. However, the consideration of the qualification of an expert tendering fMRI evidence would likely be considered in the context of fMRI as novel science, introduced above, and applied below.

(d) Relevance

Relevance will generally be the central factor a court considers in assessing neuroscience as expert evidence. This involves weighing the probative value of neuroscience and brain imaging against its potential prejudice.

i. Relevance – Probative Value

Whether or not neuroscience evidence is *probative* is determined on a "case-by-case" basis. As set out above, relevance is a principled inquiry.[93]

In the criminal context probity is animated by fundamental organizing principles of our criminal law such as the presumption of innocence,[94] the right to full answer and defence and the devastating impact of wrongful conviction. In the case the 40-year-old school teacher neuroscience and brain imaging speaking to the effects of a pre-frontal tumour are *extremely* probative as they stand to impact the existence of a "guilty mind", "the capacity to choose" and "the ability to reason right from wrong".[95] Of critical importance in the case of the school teacher, is objective behavioural evidence supporting the link between brain and behaviour.[96] Neuroscience and brain imaging will becomes more probative, as a litigant is able to present more objective behavioural evidence to support any theory, or imaging. In the case of the school teacher, neuroscience, taken alongside corresponding behavioural evidence, may ultimately be extremely relevant to questions of capacity, culpability and whether imposing criminal sanction will involve punishment of the morally innocent.

In the civil context, brain imaging and neuroscience is extremely probative as a powerful tool to prove or disprove claims of chronic pain, and assess the full scope and extent of traumatic brain injury. In many cases, the inability to provide objective verification of such injuries has amplified problems of appropriate compensation, and heightened concerns about malingering. The probative value of fMRI lie detection, however, is subject to different considerations as courts generally view the assessment of credibility as a task within the ambit and competence of the trier of fact. The case of lie detection is specifically considered below.

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[93] See (II)(3) *supra*.

[94] See *Woolmington supra* note 80.

[95] *R. v. Ruzic*, 2001 SCC 24, at para 4.

[96] See Walter Glannon "What Neuroscience Can (and Cannot) tell us about Criminal Responsibility" in Walter Glannon, *Brain, Body, and Mind: Neuroethics with a Human Face*, (Oxford: Oxford University Press, 2011). See also Rebecca Dresser, "Neuroscience's Uncertain Threat to Criminal Law," Hastings Center Report 38, no. 6 (2008): 9 at 10.

ii. Relevance – Prejudice

In the context of neuroscience, the potential for *prejudice* will be a central concern in determining whether or not such evidence is admissible.

In both the criminal and the civil setting, there are legitimate concerns that neuroscience and brain imaging may cause prejudice. Scholars caution that neuroscience has an irresistible, seductive, and persuasive force and an "incredible ability to make the complex simple".[97] Morse cautions that neuroscience has a "rationally unhinging effect".[98] There is a risk that technical theories about brain function, particularly when accompanied by colourful brain images, may demand inappropriate weight, command disproportionate influence in jurors, and be accepted uncritically. This concern is heighted by controlled studies that suggest brain imaging results in juror bias.[99]

That said, more recent studies suggest concerns about brain imaging prejudicing jurors are overstated, and that that jurors are capable of acting critically and forming reasonable conclusions.[100] Based on these tests some scholars suggest that "neuroimagery's seductive powers may have faded".[101] Along these lines, perhaps it is time to bestow greater confidence in the trier of fact, specifically jurors. This is explored in greater detail below.[102] In the criminal setting, concerns about prejudice, particularly juror prejudice, will take center stage. Admissibility may well vary depending on whether a trial is before a judge or a jury.

In the civil setting, concerns about the reliability and accuracy of relevant imaging technologies, and concerns about *cost* will take center stage. Advanced brain imaging and fMRI expert evidence will often result in a substantially greater cost in comparison to traditional psychiatric assessment.[103] While advancements will almost certainly make this technology more affordable in the future, the cost must

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[97] Barbara Bottalico "Neuroscience and Law in a Nutshell", (2011) domenica 1 maggio 2011. Online: <http://www.diritticomparati.it/2011/05/neuroscience-and-law-in-a-nutshell.html>.

[98] Stephen Morse, "Brain Overclaim Syndrome and Criminal Responsibility: A Diagnostic Note", (2006) State Journal of Criminal Law, Vol. 3, p. 397.

[99] S.E. Compton, "Not Guilty By Reason of Neuroimaging: The Need for Cautionary Jury Instructions for Neuroscience Evidence in Criminal Trials", (2013) Vanderbilt Journal of Entertainment and Technology Law 12(1) 333–354).

[100] R.B. Michael, et. al. "On The (Non) Persuasive Power of a Brain Image"(2013) Psychonomic Bulletin &Review, 1-6. Note, juror studies must be approached cautiously, their efficacy is suspect as they naturally involve a controlled environment that varies in many respects from a traditional jury setting.

[101] *Ibid* at 6.

[102] See III(5) infra.

[103] See generally American Association of Physicists in Medicine, NMR Task Group #8…Practical aspects of functional MRI, (2002) Online < http://www.aapm.org/pubs/reports/rpt_77.pdf>.

always be weighed against the verifiable benefits that the technology will provide in offering objective proof of the reliability of witness evidence notoriously resistant to empirical verification.

When assessing neuroscience as expert evidence, probative value and prejudice are necessarily informed by an assessment of whether the science upon which the proposed theory is based has a "reliable foundation" and necessarily involves an assessment of novel science. The relevance criteria, and concerns about probative value and prejudice are heightened when an expert relies on novel science. Thus, at the heart of the relevance inquiry and central to the admissibility of neuroscience will be concerns about novel science, and concerns about junk science. The test for novel science is now considered in depth.

3. Neuroscience as Novel Science

As set out above, *novel science* must have a "reliable foundation" based on (a) testability, (b) peer review and publication, (c) rate of error and (d) acceptance in the scientific community. Again these factors as "flexible and non-exclusive."[104] Having a standard that is too high would result in the exclusion of far too much probative and relevant evidence.[105] As a whole, the test evaluates whether a novel theory conforms to established scientific principles. Specifically a novel theory should encompass a connected body of demonstrated truths or observed facts systematically classified and more or less connected by a common hypothesis operating under general laws.[106]

In most cases, neuroscience based on fMRI evidence generally represents a form of "novel" science. The legal test for novel science requires a careful examination not only of the theory itself but of any "underlying assumption" upon which said theory is based.[107] Neuroscience involves not only discrete theories, but underlying and unifying theoretical assumptions about the link between brain and behaviour. Brain imaging is not new to Canadian courts. Neither are theories about brain dysfunction and criminal behaviour, or disability. However, insofar as neuroscience uses brain imaging to support novel theories about the link between neurological dysfunction and criminal responsibility or disability, it involves a novel application of accepted theories or techniques and likely falls under the purview of "novel" science.[108]

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[104] *Trochym supra* note 73 at para 139.
[105] *Ibid* at para 140.
[106] *R. v. McIntosh*, (2007) 35 O.R. (3d) 97 (C.A.) at p. 103, per Finlayson J.A.
[107] *Trochym supra* note 73 at para 32.
[108] Paciacco and Stuesser, *supra* note 51 at 205.

(a) Testability

To have a reliable foundation, a scientific theory must be testable. To be testable a theory must be "falsifiable."[109] This presents problems for neuroscience, which is an "archetypical" science, resistive to effective testing and with "limited value to individual cases".[110] However, discrete theories can and have been tested. For example, the links between frontal lobe damage and anti-social behaviour have been thoroughly surveyed in the literature, have been tested, and are theoretically falsifiable,[111] as is the case in studies about the neurological basis of injuries involving chronic pain.[112]

(b) Peer Review and Publication

Neuroscience is subject to extensive peer review and is a rich and growing area for publication and academic debate. The general hypothesis of neuroscience, that it is possible to reach conclusions about criminal responsibility and complex questions about pain and disability based on observation of empirical brain states, is subject to extensive debate in the scientific, legal, and philosophical community.[113] Discrete theories about the relationship between particular brain states and behaviour based on fMRI imaging are also subject to rigorous testing and are reviewed in thousands of articles presented in leading medical journals.[114]

(c) Rate of Error

In science, particularly neuroscience, "error" is a "complex multidimensional concept."[115] Determining a potential rate of error requires an appropriate amount of testing. Sometimes the lack of effective testing will foreclose reasonable conclusions about rate of error, as may well be the case with fMRI lie detection.[116] In the criminal law setting, any allowance for "error" must be weighed against the risk of wrongful conviction. Thus little allowance for error is appropriate where the prosecution presents science

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[109] Karl Popper, *The Logic of Scientific Discovery*, (Toronto: Routlage, 2002) at 19.
[110] David L. Flaigman, "Admissibility of Neuroscientific Expert Testimony" in *Primer supra* note 11 at 104.
[111] For studies on in the area see J.L. Saver and A.R. Damasio, "Preserved Access and Processing of Social Knowledge in a Patient with Acquired Sociopathy Due to Ventromedial Frontal Damage", (1991) *Neuro-psychologia*, 1991;29:1241-1249; R.J. Blair, L. Cipolotti "Impaired Social Response Reversal. A Case of Acquired Sociopathy" (2000), Brain. 2000 Jun;123 (Pt 6):1122-41; Antoine Bechara, Hanna Damasio and R. Antonio. "Damasio, Emotion, Decision Making and the Orbitofrontal Cortex", *Cereb Cortex* (2000) 10 (3): 295-307 (cited in Burns and Russell, *Orbitofrontal Tumor*).
[112] See for example England *supra* note 23.
[113] For a survey of the landscape see Francis Shen, "Law and Neuroscience Bibliography: Navigating the Emerging Field", (2010) *International Journal of Legal Information* 38, 352-399.
[114] See for example *supra* notes 14 to 23 and studies cited therein.
[115] Flaigman, *supra* note 110 at 106.
[116] Flaigman, *supra* note 110 at 106. See also Glannon *Criminal Responsibility supra* note 96 at 18.

that speaks to ultimate or dispositive issues.[117] One would anticipate greater leniency in the civil setting, although novel theories about the link between neurological function and the subjective experience of pain or disability would certainly warrant heightened scrutiny.

(d) Acceptance in the Scientific Community

In Canada acceptance in the scientific community is only one factor to admissibility. The Supreme Court of Canada has expressly rejected the "general acceptance" test, and Canadian law does *not* require total consensus.[118] That said there is anything but consensus in the literature. The discourse is rife with polarizing debate about the general ability of neuroscience to support normative conclusions about compensation, disability and criminal responsibility. However, as above, discrete theories such as the theory about frontal lobe damage and its relation anti-social behaviour, do enjoy some measure of acceptance in the scientific community. Along the same lines, many studies claiming to identify disability, specifically anxiety, depression, and chronic pain, have gained relative acceptance in the medical community. Expanding on these factors, it is useful to explore central theoretical, practical, and ethical considerations related to neuroscience.

4. Neuroscience – General Theoretical, Practical, and Ethical Concerns

It is useful to highlight some of the central theoretical, practical, and ethical concerns related to neuroscience. When it comes to neuroscience, the scientific and academic community are sharply divided. It is useful to (a) list the 10 central concerns with neuroscience discussed in the literature, (b) highlight underlying theoretical problems of translation, and then (c) suggest that moving forward many concerns can be appeased through procedural safeguards, public education, and by equipping jurors with the tools necessary to evaluate neuroscience evidence critically.

(a) 10 Problems with Neuroscience and Brain Imaging

A survey of the literature identifies 10 central concerns about the limits of neuroscience and brain imaging in assessing criminal responsibility and damages. Many Canadian lawyers will inevitably encounter neuroscience evidence in increased frequency over the decades to come. Bearing these 10 concerns in mind will allow the lawyer to better prepare an expert, and also represent fruitful grounds for challenging such evidence, and cross examining opposing experts on their reports.

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[117] For example, where expert evidence speaks to dispositive core issues and stands to produce a wrongful conviction, the cost of error is *much* higher. On the other hand, where defence evidence speaks to capacity, intentionality, or mitigating factors in sentencing, errors, while costly, are not as devastating.

[118] *Trochym*, *supra* note 73 at para 144.

1. *Correlation is not causation* – a correlation between brain states and behaviour does *not* entail causation. It is seldom a simple matter to prove that a particular defendant "can't help himself" or that every person with condition "X" performs behaviour "Y,"[119] or similarly, that certain neurological phenomenon always result in chronic pain.

2. *Functional integration* - Brain activity is not limited to particular areas of the brain. Particular localized areas of the brain are often associated with certain behaviours, but they are not *exclusive* to those areas. The brain consists of a series of "complex interacting neural networks."[120]

3. *The problem of contemporaneity* – this is particularly problematic in the criminal context. We will almost never have brain imaging contemporaneous with the brain state of an accused at the time of a crime.[121] The brain is continually changing. It will always be difficult to draw conclusions about the state of mind of an accused at the time he committed the crime based of *ex post facto* brain imaging.[122] Along the same lines there are problems in civil cases. Brain injury has a complex evolution, stemming from an initial traumatic event and evolving over time.

4. *Neuroplastcity* – the brain is malleable. It is not a static organ. Moreover, "today's brain is not yesterday's brain." Neural process change as a result of environment, behaviour, and in reaction to brain injury. For example, when one portion of the brain is damaged, neural function may be rerouted to other brain regions.[123]

5. *Assessment over time* – it is widely accepted that effective assessment, particularly of any purported link between brain dysfunction and criminal responsibility, requires observation of behaviour over time.[124] This is a luxury often unavailable during expert assessment in the context of criminal proceedings, and may result in exorbitant expense in civil proceedings.

6. *Conflicting interpretations* – neuroimaging can also be subject to various interpretations that support conflicting conclusions. This amplifies concerns about the dangerous effect of self-

[119] See generally Henry T. Greely, "Neuroscience and Criminal Responsibility: Proving "Can't Help Himself" as a Narrow Bar to Criminal Liability", in *Law and Neuroscience*, in Michael Freeman, ed., *Law and Neuroscience*, (2011) Current Legal Issues, Vol. 13, p. 529 at 533.
[120] Glannon *Criminal Responsibility supra* note 96 at 18.
[121] *Ibid* at 18.
[122] Belcher and Roskies, *supra* note 13 at 70.
[123] Glannon *Criminal Responsibility supra* note 96 at 19.
[124] Glannon *Criminal Responsibility supra* note 96 at 19.

interested adversarial experts employing misleading rhetoric and oratory and the prospect of acrimonious "trial by doctor" as opposed to trial by jury.[125]

7. *The problem of "abnormality"* – no two brains are exactly alike. Normality and abnormality are complicated concepts.[126] Given a range of individual variability in functional architecture it can be difficult to distinguish what is "normal" and what is "abnormal". Among other things, this presents problems for drawing solid or consistent conclusions about general populations from specific cases.[127]

8. *"Situational" factors* – brain imaging alone cannot currently tell the whole story. Effective assessment often requires consideration of elusive and often concealed situational variables that often preclude conclusive assessment.[128]

9. *Experimental problems* – Neuroscience and brain imaging suffer from experimental problems. Alongside concerns about individual variability, it is often difficult to find a large enough sample size to attain reliable data or draw conclusions about general populations.

10. *Dysfunction and impairment come in degrees* – dysfunction is not an "all or nothing" proposition. It is a matter of degree. An assessment of what *degree* of impairment is sufficient to satisfy legal standards invariably requires subject assessment measured against normative legal standards.[129]

In the context of these limitations, this latter consideration highlights theoretical problems about *translation* that bear further consideration.

(b) Lost in Translation[130] – Central Theoretic Problems with Neuroscience

Perhaps the greatest challenge neuroscience faces is one of translation. This highlights the long-standing surrounding and disinterested, dysfunctional yet ironically interdependent relationship between law and science. As Sir Louis Blom-Cooper explains:

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[125] H. Rollin "Nineteenth Century Doctors in the Dock" (1981) 283 B Med J 1176.
[126] Belcher and Roskies, *supra* note 13 at 69.
[127] Roskies and Armstrong *supra* note 13 at 33-34.
[128] See *Ibid* at 34. See also Glannon *Criminal Responsibility supra* note 96 at 18.
[129] Adina Roskies and Walter Sinnott-Armstrong "Brain Images As Evidence in Criminal Law" in Michael Freeman, ed., *Law and Neuroscience*, (2011) Current Legal Issues, Vol. 13, p. 529 at 533.
[130] See generally Morse, "Lost in Translation?" *supra* note 8.

> Law and science are distinct disciplines that meet one another in everyday life, not infrequently in the courtroom. Law is prescriptive. Science, on the other hand, aims to describe, interpret, and even predict the social and natural world.[131]

Science is empirical. It describes how things *are*. It attempts to draw empirical conclusions about the neuronal basis of brain states and their impact on human behaviour. The law is normative and prescriptive. It prescribes normative legal standards that govern how people ought to act, and use legal descriptors to define the contours of phenomena such as criminal culpability, moral responsibility, pain and disability.

As Morse states, "[b]rains are not held responsible. Acting people are."[132] We do not put brains on trial. We do not compensate brains for injuries. As explained above, brain function, dysfunction, and abnormality give rise to complex questions. Dysfunction and impairment come in degrees. How much dysfunction is enough to satisfy an excusing condition or to confirm that an accused acted intentionally with sufficient capacity? What degree of impairment, anxiety, pain, or depression is sufficient to represent disability and prevent a person from working? What measure of damages are required to compensate or "make a person whole"? No brain scan will provide objective definitive empirical answers to these subjective, normative legal questions.

For example, experts will present scientific evidence and theories. An expert may explain that the school teacher referred to earlier had suffered from a right orbitofrontal tumour and research suggests dysfunction in this area is associated with symptoms of pedophilia and constructional apraxia. Assuming a court accepted the explanation, it would need to draw a legal conclusion. It would need to translate this empirical data into so-called "folk" psychological concepts. Did the accused appreciate the nature and quality of the act? Did he know it was morally wrong? Were his actions voluntary? Did he act with intention, knowledge, or recklessness?

In a civil context, an expert might testify that fMRI evidence shows that our Plaintiff, introduced above, had more neuronal activation in the somatosensory cortices than controls, which an expert argues results in reduced pain inhibition and subsequent lower back pain. The law then must assign a value to this pain, and make a normative determination of whether the neurological phenomenon represents a disability for the purposes of the law. Moreover, restitution necessarily involves subjective assessment of consequent neurological distress, chronic pain, and traumatic brain inujury and what is legally required to make a person whole.

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[131] Sir Louis Blom-Cooper, QC (ed.), *Experts in Civil Courts* (Oxford, Oxford University Press, 2006) at 183.
[132] Morse, *Brain Overclaim Sydrome* at 405.

Asymmetry between empirical scientific data and normative legal standards presents a significant explanatory gap.[133] When preparing an expert, the lawyer should ensure the expert is able to bridge the gap and translate empirical findings into legal terms that are accessible to the trier of fact, and support sound legal conclusions.

5. The Specific Case of fMRI Lie Detection as Novel Science

Having identified some of the concerns around neuroscience, it is now useful to consider the specific case of fMRI lie detection. fMRI lie detection shows great promise. However, there is much debate in the literature about its reliability as a means of credibility assessment.

Detractors point out that fMRI lie detection is subject to limitations, has not yet received adequate testing, and does not yet enjoy widespread acceptance in the scientific community. Such academics conclude that fMRI lie detection techniques require much more testing before they are ready for courtroom use.[134] That said, many proponents suggest concerns about the reliability of fMRI lie detection are overstated. They argue that fMRI lie detection must be assessed in relation to legal standards and our legal practices, particularly regarding the reliability of our traditional methods of assessing credibility.[135]

Though not uncontested, the technology will continue to develop and be tested. In the future, such evidence may meet standards allowing for it to be received in courts, particularly given the aforementioned obvious shortcomings inherent in our current methods of assessing credibility.

The limitations on early laboratory testing of fMRI as a device for the consistent identification of "induced untruths" are numerous at present. Most studies to date have involved generally younger volunteers, unaffected by mental conditions, promised a small payment for telling a relatively inconsequential untruth about a card in their possession, or instructed theft of a small item. U.S. courts have to date been unwilling to admit fMRI evidence by extending it to alleged "untruths" in an older accused, denying allegedly fraudulent conduct six years prior, noting that lab detection of an instructed lie at the moment may be very different than evidence of much older deception, with more significant

[133] Glannon *Criminal Responsibility supra* note 96 at 14. Moreover, assessment of criminal responsibility in many cases involves subjective assessment of the *effect* of empirical data. For instance, one could conceive of the inability of a psychopath to feel empathy as both a mitigating, and an aggravating consideration in sentencing: *Ibid* at 18-20.

[134] See generally Rebecca Dresser, "Brain Imaging and Courtroom Deception", (2010) Hastings Center Report, Vol. 40, No. 6 p. 7, 2010).

[135] F. Schauer, "Neuroscience, Lie-Detection, and the Law: Contrary to the Prevailing View, the Suitability of Brain-Based Lie-Detection for Courtroom or Forensic Use Should be Determined According to Legal and Not Scientific Standards", Trends Cogn Sci 2010 Mar;14(3):101-3.

consequences. In *United States v. Semrau*[136] the admission of fMRI evidence on behalf of the accused, commissioned from Cephos, was denied when the researchers conceded that "different types of lies may produce different brain patterns."[137]

In *Semrau*, the court also expressed concerns about the unilateral nature of the testing, without the prosecutor's participation, conflicting results from repeated testing justified because the accused was fatigued, and the expert's admission that the defendant's overall credibility, rather than the truth or falsity of specific responses, was a better conclusion from testing.[138] Others have observed that fMRI test interpretations are still at the earliest stages of development, and there is at present a limited understanding of the extent to which long held practiced lies may override the response suppression and executive prefrontal system activity, the identification of which fMRIs rely on to identify a conscious untruth.

It is likely that cases like *Semrau*, and the observations made by the court in such cases, will be replicated in future similar expert witness evidence admission applications. As fMRI lie detection testing develops, it may be that its success rate and reliability will be broadened to more circumstances than closed laboratory experiments and improved, and that some of the concerns expressed by the court in *Semrau* will be addressed.

For centuries, legal systems have relied upon the ability of judges and lay jurors to evaluate the veracity of witnesses by "demeanor," distinguishing truth from lies. The ultimate effectiveness of triers of fact to assess witness credibility has always been a concern, and has been performed at a success rate that many academics, and researchers, have concluded rarely goes above random. Since the 1920s, law enforcement officials, lawyers, and from time to time the courts have turned to science, and what has been hoped as more objective means of lie detection. Courts have considered for admission lie detection by polygraphs as a way to address this problem.[139]

Polygraph results have found little favour with courts generally, and the scepticism has been justified by high error rates and false positives, which are common when sweating, fear, nervousness, and other traits can interfere with the physical changes being measured to isolate a witness concealing an honest answer.

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[136] 2010 U.S. Dist. (W.D. Tenn., May 31, 2010) [*Semrau*].
[137] *Ibid.*
[138] Comments on *Semrau* in Rebecca Dresser, "Brain Imaging and Courtroom Deception", Hastings Centre Report, Nov.-Dec., 2010, pp.7-8.
[139] Frederick Schauer, "Neuroscience Lie-Detection, and the Law" (2009) Cell Press, *Trends in Cognitive Sciences*, Vol 14, No 3, pp 101-103.

In the United States, outside of government agencies and companies involved in the provision of security, the routine use of polygraph examination evidence is generally barred by the *Federal Employee Polygraph Protection Act of 1988*.[140] It remains unclear as to whether fMRI lie detection is covered under *FEPPA* or not. In *FEPPA*, in the section prohibiting their use, the term "lie detector" is defined to:

> …include a polygraph, deceptograph, voice stress analyzer, psychological stress evaluator, or any other similar device (whether mechanical or electrical), that is used, or the results of which are used, for the purpose of rendering a diagnostic opinion regarding the honesty or dishonesty of an individual…The term "polygraph" means an instrument that – (A) records continuously, visually, permanently and simultaneously changes in cardiovascular, respiratory, and electrodermal patterns as minimum instrumentation standards; and (B) is used, or the results of which are used, for the purposes of rendering a diagnostic opinion regarding the honesty or dishonesty of an individual.[141]

Similarly, in Canada, the use of polygraph evidence has been considered and restricted in the common law for traditional exclusionary rules of evidence, including restrictions against oath-helping, reputation bolstering, and subsequent consistent statements.[142] In this context, the Supreme Court of Canada has noted its concern about the trier of fact and their "human fallibility in accessing the proper weight to be given to evidence cloaked under the mystique of science."[143] However, what remains to be determined in Canada is whether, if fMRI test results become demonstrably more verifiable in lie detection than polygraph evidence, courts will take a more open approach to fMRI evidence in recognition of its superior probative value in some circumstances.

6. A Peripheral Note on Juror Education

Finally, it is useful to provide a brief note on the importance of educating jurors about neuroscience. This is a matter of heightened importance in the criminal law setting.[144] It is argued that we should place greater confidence in the ability of jurors to critically assess neuroscience and brain imaging evidence, and suggested that model jury instructions be introduced to address neuroscience and brain imaging.[145]

It is somewhat perplexing that our law presumes an accused to be a "rational, autonomous and choosing agent,"[146] yet we fail to instil the same confidence in jurors who stands to pass judgement on them. The

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[140] 29 U.S. Code Chapter 22 [FEPPA].
[141] Ref. 58, Section 2001, cited in Joseph R. Simpson M.D. "Functional MRI Lie Detection: Too Good to be True?", *The Journal of the American Academy of Psychiatry and the Law*, Vol. 36, No. 4, 2008, 491-498, at 495.
[142] *R. v. Beland*, [1987] 2 SCR 398. See also *Phillion v. R.*, [1978] 1 SCR 18.
[143] *Phillion*, *Ibid*, at 434.
[144] This would also be relevant in the (rare) instance of a civil trial before a jury.
[145] *Ibid.*
[146] *R. v. Ruzic*, 2001 SCC 24 at para 4.

trial judge is a "gatekeeper,"[147] but the trial judge is also an "educator."[148] In the context of opposing witnesses, effective cross examination, and careful juror instructions, we should put faith in jurors to act rationally, discharge their solemn duty responsibly, and critically assess expert evidence related to neuroscience.

For example, in *R v. Baker*,[149] jurors weighed all of the evidence, and rejected expert evidence suggesting an accused was suffering from methamphetamine-induced psychosis when he murdered his pregnant friend – whom he believed to be bearing "Lucifer's child." In another case a jury rejected expert evidence suggesting diminished mental capacity, which the jury presumably found to be wholly inconsistent with the behaviour of the accused, who had devised an intricate plan that involved triggering a fire-alarm and dressing as a firefighter to gain access to a victim's apartment.[150]

Model jury instructions could be of significant importance in limiting potential prejudice while still allowing for a full answer, adequate defence, and the prevention of the punishment of the morally innocent. As part of her charge to the jury, a trial judge might caution that that brain imaging and neuroscience is not "mind reading," is not dispositive, and that neuroscience must be seen as a piece of the larger picture to be considered critically in the context of all of the other evidence. Specifically, she could caution that neuroscience may, and should, be rejected if it is inconsistent with the testimony and objective behaviour of the accused.

In this section we have considered whether neuroscience and brain imaging are sufficiently relevant, and have the reliable foundation necessary, to gain admissibility in Canadian courts. We have surveyed limitations, but have also encouraged progressive optimism about the benefits of neuroscience, and the prospect that as the science progresses, Canadian courts will admit neuroscience on a case-by-case basis when it probative, is supported by behavioural evidence and accompanied by procedural safeguards such as effective juror instruction.

In the final section of this paper, it is useful to now briefly forecast the future reception of neuroscience and brain imaging in Canadian courts.

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[147] See *Seaboyer*, *supra* note 57.
[148] The Honourable Justice David Watt, *Helping Jurors Understand*, (Toronto: Carswell, 2007).
[149] *R. v. Baker*, 2009 ABCA 252.
[150] See Amenona Hartocollis and Anahad O'Conner, "Fashion Writer Sentenced in Attack on Woman" New York Times, June 18, 2007 Online < http://www.nytimes.com/2007/06/18/nyregion/18cnd-braunstein.html>.

(IV) LOOKING FORWARD – NEUROSCIENCE IN CANADIAN COURTS

As neuroscience and brain imaging develop, judicial receptivity is likely to increase. Roskies and Armstrong note a significant trend towards the admissibility of neuroscience and brain imaging in judicial proceedings.[151] They even cite one case in which a court heard a motion to exclude expert testimony on the grounds it was not accompanied by brain imaging.[152] A trend towards increased admissibility may continue progressively alongside developments in science in (1) civil proceedings, (2) sentencing, and (3) more gradually in substantive criminal proceedings.[153]

1. Civil Proceedings

Canadian courts have already begun to admit neuroscience in civil proceedings, and there is a trend towards increased receptivity. Neuroscience and brain imaging are often admitted as a tool to assess damages,[154] and could prove useful in affirming excusing conditions for negligence and detecting malingerers.[155] As explored above, this movement is fuelled by a flurry of studies purporting to use fMRI to explore the neurological basis of anxiety, depression, PTSD, and chronic pain.[156]

2. Sentencing

Canadian and American courts continue to admit neuroscience and brain imaging in sentencing where many rules of evidence are relaxed.[157] One would anticipate that neuroscience will begin to play a leading

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[151] Roskies and Armstrong *supra* note 13 at at 98 citing *USA v. Naee K. Williams*, 78 Fed. R. Evid. Ser. (Callaghan) 1204 (USDC for Hawaii 2009).

[152] Roskies and Armstrong *supra* note 13 at 98.

[153] This is particularly the case where fMRI gains prominence outside of the legal setting. Aside from it's obvious application in the therapeutic context, fMRI, particularly as a form of lie detection has been introduced in settings such as pre-employment screening.

[154] See for example *McKenzie v. Sidhu*, 2013 BCSC 925 which cites expert evidence declaring "it is hoped that, in future, techniques such as functional MR imaging (fMRI) may help to determine susceptibility to these changes (increased sensitivity to pain) and demonstrate objectively when they are present". See also *Verma v. Kennedy*, 1995 CanLII 1577 (court allowing Psychiatrist to submit report on the link between chronic pain and employability).

[155] Where mental disability precludes the formation of an intention to act there is generally no liability: See *Wilson v. Zeron* [1941] 4 D.L.R. 510 (Ont. H.C.); affirmed in [1942] 2 D.L.R. 580 (Ont. C.A.)). See also Glannon *Criminal Responsibility supra* note 96 at 25-26. Glannon presents an example of a father who leaves a child unattended by a swimming pool. He suggests in such a case neuroscience could demonstrate a genuine dysfunction in the workings of the short-term working of the memory that may be exculpatory.

[156] For example, as explored above, Dr. Robert England employs fMRI to attempt to identify chronic pain in patients: England *supra* note 23. Another study purports to identify biomarkers for anxiety disorders such as Post-Traumatic Stress Disorder: A. Georgopouloset. al. "The Synchronous Neural Interactions Test as a Functional Biomarker for Post-traumatic Stress Disorder: A Robust Classification Method Based on the Bootstrap" (2010) Journal of Neural Engineering, 7; 1-7.

[157] See *Roper v. Simons*, 542 US 551 (2005) (Neuroscience evidence presented in capital punishment proceedings); See also *Sexton v. State*, 775 So. 2d 923 (disturbed state of mind mitigating factor in sentencing).

role in dangerous offender proceedings as a tool to support or refute claims about dangerousness and the potential for recidivism.[158]

3. Substantive Criminal Proceedings

Neuroscience and brain imaging will get a "foot in the door" in civil cases and sentencing. However, one can expect that as the science develops, the public and the judiciary will become more versed in the intricacies of neuroscience and brain imaging. This could eventually culminate in wide-spread acceptance in civil proceedings, and the admissibility of neuroscience and brain imaging and neuroscientific theories to assess criminal responsibility in substantive criminal proceedings in compelling cases. As emphasized above, admissibility will always be contextual, principled, and reactive to developments in science.

CONCLUSION

Contemporary developments in neuroscience, particularly fMRI, provide unprecedented insight into the active workings of the human brain. Canadian courts will admit neuroscience and fMRI, and related technologies in criminal and civil proceedings according to the rules of expert evidence. The central concern is the probative value of the evidence weighed against its potential to prejudice and distort the fact finding process or result in excessive cost. This will relate to questions about whether a particular theory which brain imaging supports has a reliable foundation. A court will determine admissibility on a case-by-case basis attentive to the context of the proceedings and objective behavioural evidence.

It is a well-known maxim of the common-law that "the thought of man is not tryable; the Devil alone knows the thought of man".[159] As Fyodor Dostoyevsky rightly cautions "the causes of human actions are usually immeasurably more complex and varied than our subsequent explanations of them."[160] What does neuroscience stand to add to our understanding of the nuances of injury, disability, or the complexities of criminal and moral responsibility? Can neuroscience provide us with the promised insight into the mysteries of the human mind?

As we have identified in this paper, Neuroscience suffers from many limitations. However, this does not mean that neuroscience has no place in the courtroom. Assessing damages and determining criminal responsibility involves a complex and multifaceted inquiry into a myriad of factors. Neuroscience cannot

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[158] See generally *Criminal Code* part (XXIV). Dangerous offender designations present the prospect of indefinite detention for the purpose of public protection (See generally *R. v. Ipeelee*, 2012 SCC 13 at para 10).
[159] C.J. Brian, Year Books (1477), ch Ed. IV Fi pl.2.
[160] *The Idiot* (Oxford: Oxford World Classics, 1998).

tell us everything we need to know. But taken alongside other evidence, particularly objective behaviour, it can play a crucial role as part of the larger picture in furtherance of critical and foundational principles of law. The rules of expert evidence are reactive to advancements in science. Neuroscience and brain imaging present "a genuine opportunity to enrich the legal understanding of agency and to inform legal responsibility and practices."[161] As such, one can be cautiously optimistic that brain imaging will enjoy increased prominence in Canadian courts in the coming years.

It has been four centuries since Galileo first gazed through his telescope. To this day we remain inspired by the depth and complexity of the universe. Ingenuity and concerted resolve have afforded previously unimagined insight. From space-time points and quantum entanglement, to dark matter and primordial black holes we continue to decipher its vast mysteries.[162] The mind is a universe in itself. When viewing colourful images that show the workings of the human brain, one cannot help, as Galileo did when gazing into the vast cosmos, that we sit on the threshold of exciting discoveries.[163]

Yet while the vast universe has carried on for time immeasurable, largely indifferent to our plight, the human mind bears a mysterious and mystic immediacy. The mysteries of the human mind inspire awe and wonder, and compel us to explore the unknown recesses of our nature. Future research will challenge what we know, or we think we know about the human mind. Perhaps the most significant impact these discoveries will have will be on our legal practices and our legal traditions. Both future and contemporary advancements will have tremendous implications for our legal system. Not only in the distant, but in the near future these developments will animate fascinating legal issues and the rules of expert evidence will take center stage in exciting jurisprudential cases.

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[161] Nicole A. Vincent, *Neuroscience and Legal Responsibility* (Oxford: Oxford University Press, 2013) at 6.

[162] See generally S.W. Hawking, (1977),"The Quantum Mechanics of Black Holes" Scientific American, 236, p. 34-40; Tim Maudlin, "Part and Whole in Quantum Mechanics" in *Interpreting Bodies: Classical and Quantum Objections in Modern Physics*, ed. Castellani (Princeton: Princeton University Press, 1998) at 50; S.W. Hawking, (2005), "Information Loss in Black Holes", Physical Review D 72 (8); and D. Stojkovic; K. Freese and G. D. Starkman (2005). "Holes in the Walls: Primordial Black Holes as a Solution to the Cosmological Domain Wall Problem", Phys. Rev. D 72 (4).

[163] See Floyd E. Bloom, *Introduction to Best of the Brain from Scientific American*, (New York: Dana Press, 2007).