Neurolaw – Potential applications of fMRI in courts

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Abstract

Functional magnetic resonance imaging (fMRI) is a neuroimaging technique used to study cognitive functions. Despite fMRI having successfully been used to identify many cognitive capabilities, recent research has not found any successful submissions of fMRI evidence in criminal courts in Australia, Canada, England and Wales (Chau 2014:1; Chandler 2015:9; Catley & Claydon 2015:14). Neurolaw is an interdisciplinary area involving neuroscience, law, and philosophy. Publications in Neurolaw and research investigating the applications of fMRI in the legal context are increasing (Jones et al. 2013:731). One probable explanation for the lack of admissions of fMRI in the courts is that this is due to the numerous limitations of fMRI. However, many potential applications of fMRI have been recommended. These include lie detection, testing of guilty knowledge, and mind reading. After evaluating the medical uses of fMRI, analysing court cases involving functional neuroimaging evidence and considering the history of imaging evidence, my thesis identifies several potential areas where fMRI might be applicable within the legal context. My study also suggests a hypothetical case that supports a conceptual claim that fMRI might have potential to be useful in court. Moreover, the hypothetical case supplies a few directions for further study.

Statement of Originality

To the best of my knowledge the material presented in this thesis, except where acknowledged, is my own original work, and has not been submitted for a higher degree to any other university or institution.

Daniel Chau

Chapter 1 – Introduction

Functional magnetic resonance imaging (fMRI) is a non-invasive neuroimaging technique used to discover which parts of the brain are activated when the participant performs a task or perceives some external stimuli. Lawyers in criminal cases may introduce fMRI evidence into court with the assistance of some expert witnesses who have expertise in interpreting such neuroimaging evidence. The fMRI evidence may be used to support claims that the defendant lacks the relevant mental capacity to commit the crime or in some cases as direct evidence of mental states relevant to guilt. So far there are a limited number of submissions of fMRI evidence into courts and successful admissions are rare. However, the fMRI technique has extensively been used in clinical settings and neuroscience research. Therefore, there are numerous research articles suggesting fMRI evidence would be of limited assistance to courts due to various inherent difficulties. Despite the fact that there are many issues in interpreting fMRI evidence, I will argue that there is potential to use fMRI evidence in court.

In order to support my thesis that there is potential to use fMRI evidence in court, I begin with an overview of key aspects of criminal law and discover what sort of evidence is required by criminal courts. Thereafter, I discuss various neuroimaging techniques and show that most neuroimaging techniques have already been used to make claims about mental incapacity to justify lesser criminal responsibility. As fMRI evidence has limited success, I review many research articles and identify the key difficulties involved in submitting fMRI evidence. I also confirm the limited successfulness of fMRI evidence by reviewing relevant Australian and American court cases as well as consulting relevant research articles about applying neuroscientific evidence in court. However, I find some positive prospects of using fMRI evidence in court by looking at how another type of neuroimaging evidence (which is similar in nature to fMRI) is applied in courts and by reviewing the history of imaging evidence. As a result, I propose there are several potential ways to use fMRI evidence in court. Moreover, I suggest a hypothetical case to further support my claim.

Chapter 2 begins the investigation by discussing some key features of criminal law. For example, in a criminal proceeding, the prosecution bears the onus of proving that the defendant is responsible while the defendant may remain silent. Neuroimaging data can be a form of critical evidence that has to be explained by expert witnesses. Chapter 2 will also discuss different types of neuroimaging. In brief, there are several structural neuroimaging techniques for displaying the structure of the brain and several functional neuroimaging methods for demonstrating activities in different brain areas whenever a task is conducted.

Chapter 3 examines different limitations of fMRI neuroimaging evidence, and the difficulties of interpreting such evidence. For example, fMRI research cannot be utilised directly. The courts favour the folk psychological view and prefer behavioural data since behavioural evidence enables immediate inferences (Morse 2013:31). The courts require fMRI evidence to be translated into the folk psychological language. Other issues include the technical nature of fMRI, methodological issues, the issues found in the reverse inference problem, and some legal limitations. These constraints seem to offer explanations for the limited submissions of fMRI evidence in court. This point is confirmed by several surveys of legal cases in Australia, Canada, England and Wales (Chau 2014:1; Chandler 2015:9; Catley & Claydon 2015:14).

However, looking back on the history of imaging evidence (for example, photography or X-rays), the first approval by courts was slow and never without impediments. The defining moment when courts began receiving these types of imaging evidence was the time when a trusted process of creating the images became available (Goldberg 2010:520). Consequently, history appears to suggest that if there is a reliable way of making the fMRI images, fMRI may later be approved by courts. Even though there are numerous limitations of fMRI neuroimaging, I suggest there are prospects for fMRI evidence to be presented in court.

Chapter 4 discusses four potential prospects of using fMRI evidence in the legal context. Moreover, my study offers a hypothetical case when simple mind reading research may be deployed in the legal context to adduce evidence from a victim who is suffering locked-in syndrome and who cannot provide behavioural evidence. The hypothetical situation is crucial although the theoretical situation might once in a little while occur. In the hypothetical scenario, behavioural evidence cannot be obtained yet the fMRI neuroimaging evidence can provide the courts with critical information. The hypothetical situation illustrates how to utilise existing research to deliver solutions to read the victim's mind. Specifically, fMRI technology can be used in this situation to extract evidence from the victim from his answers of "yes" or "no" to relevant facts in issue. Therefore, the hypothetical case underpins a conceptual claim that fMRI may be applied in the legal context. Moreover, the theoretical situation supplies a conceptual framework to illustrate when fMRI might be beneficial to the court and provides a course for further research.

Chapter 2 – Criminal law and neuroimaging

2.1. Nature of the criminal law

The criminal law assumes everyone has a certain minimum level of mental and physical capacity to act freely (Cane 2002:70). The court can impose serious punishment to censure and condemn criminal offenders for the public wrongs that they have committed (Duff 2013). Criminal punishment may incorporate loss of liberty, or in a few nations, capital punishment. For the protection of the innocent, the prosecution has a heavy burden to present sufficient evidence to establish the guilt of the accused. The evidence may be pertinent to determine whether the defendant has in reality committed the offence or whether the defendant has adequate capacity to commit the wrongdoing. Preceding sentencing, the prosecution and defendant can present additional evidence of mitigating or aggravating factors. In general, the court admits relevant evidence. The court permits expert witnesses who possess specialised knowledge to give assessments, taking into account scientific evidence. For example, using neuroimaging evidence, expert witnesses may infer that there is an absence of relevant mental capacity or provide valuable information about some facts in issue. The rest of this chapter discusses these points in more detail.

2.1.1. What is criminal law?

Sellers (2004:146,150) suggests “The purpose of law is to realize justice” and “Justice derives, … from the rules that should govern human society, so that all its members can live worthwhile and fulfilling lives". Moreover, the state has an essential obligation to counteract mischief to its citizens (Ashworth 2013:38). The law is comprised of rules for social control that aim to provide an environment that lets each individual lead a good and safe live. Criminal law prohibits grave wrongs committed against citizens or society as a whole. These wrongs include offences that cause death or injury (Ashworth & Horder 2013:28-31).

2.1.2. Capacity

Hart (cited in Cane 2002:29) suggests that the law presumes that every individual has the minimum level of mental and physical capacity needed to be legally responsible for their criminal acts. If a particular individual has less capacity than is needed by law, the lower level of capacity provide grounds for the individual to bear less responsibility and be given less punishment. Although people who have a higher level of capacity may attract more sanctions, excess capacity above the minimum is not relevant to the determination of guilt (Cane 2002:70). The capacitarianism view suggests a direct relationship between mental capacity and responsibility: reduced mental capacity would reduce responsibility, and increased mental capacity would also increase responsibility (Vincent 2014:305).

However, rationality appears to be the primary level of capacity expected from each person. Rationality is an essential criterion for determining liability in law, and the law assumes only a minimal level of rationality from every individual. Therefore, the majority will meet such criteria (Morse 2003:289; 2007:3). The law assumes a person has the competency to act intentionally and according to reason (Morse 2007:2-3). We can infer whether an individual can reason by looking at his behaviour (Hart cited in Glannon 2010:13). Hart (cited in Vincent 2014:22) contends that a responsible person would have both cognitive and volitional mental capacity to comprehend legal and moral requirements, and to exercise appropriate self-control. As per the Model Penal Code, a responsible person has the mental capacity to know what is prohibited by the law and can act according to the law (Vincent 2014:22). Moreover, the opposite would be valid. A substantial lack of capacity for rationality would lead to lesser responsibility (Morse 2003:300; 2005:4; 2007:4). Therefore, while the law assumes a minimal level of physical and mental capacity, incapacity may reduce responsibility.

2.1.3. Elements of criminal law

Morse (2013:35) believes there are five elements of a crime - the criminal act, the associated mental states, the attendant circumstances, the results and causation. The criminal act is also called the actus reus. For example, killing is a criminal act. Moreover, citing *R v Ryan*[1], Hayes and Eburn (2009:35) contend that only voluntary actions would prompt criminal liability. Likewise, as indicated by the Model Penal Code, the agent would be guilty only if the action or omission involved in the crime was voluntary (Davies 2013:114). The Model Penal Code characterises a voluntary act by exceptions (Davies 2013:114). The Code portrays conduct as involuntary if it is a reflex, a convulsion or does not flow from a determination of the agent

[1] (1967) 121 CLR 205

which is made either consciously or habitually. It is also involuntary if the person is unconscious, sleepwalking or under the influence of hypnosis.

A criminal act of killing would require a particular mental state (referred to as mens rea) to be established (Morse 2013:36). Mens rea includes several culpable mental states such as intention or acting with a purpose, knowingly, recklessly, or negligently. Intention means having a mental state "to bring about an act of a particular kind or a particular result. Such a decision implies a desire or wish to do such an act, or to bring about such a result" (Para 5 in *He Kaw Teh v R*[2]). Recklessness differs from intention. If the accused acted recklessly, the accused did not have the desire or wish for the act or result. However, if the accused was reckless, the accused did or should have foreseen that the outcome might occur and continued to act regardless of the foreseeable consequences (Clough & Mulhern 1999:12). *Pemble v R*[3] (para 24-25) suggests that the test for mens rea is subjective which means that the prosecution will need to establish that when the crime was happening the accused had the mental state to intend the criminal act or continued to commit the criminal act despite foreseeing the risk. Consequently, culpability is highest for crimes with a subjective mental state of intention, culpability is lower for crimes with a mental state of recklessness, and lowest for an objective mental state of negligence (Lippman 2009:113).

[2] [1985] HCA 43; (1985) 157 CLR 523
[3] [1971] HCA 20; (1971) 124 CLR 107

According to Morse (2013:35), the attendant circumstances is the third element of a crime. The attendant circumstances would depend on the particular criminal act. For example, if the act is about the intention to kill a police officer, the offender must be mindful of the fact that the person they assaulted was a police officer. Subsequently, the mens rea is a particular mental state as defined by the relevant criminal charge. For example, in a crime of robbery, the prosecution has to prove that the accused intended to permanently deprive the person in lawful procession of the property (Hodgson 2000:662).

In a murder case, the result element of the criminal act may be death, and the causation element would be to establish the connection that some alleged criminal act had caused the death.

In summary, a serious crime, for example, murder would require establishing the actus reus which must be voluntary, and the mens rea which involves a specific mental state at the time that the crime was committed. The law assumes most people have the capacity to form the mental states involved and are capable of acting voluntarily.

2.1.4. Role of prosecution in the guilt determination phase

At the guilt determination phase of a criminal trial, the prosecution plays a vital part in proving the guilt of the defendant by calling relevant witnesses to give testimonial evidence. The defendant is entitled to remain silent because the law grants immunity against self-incrimination to protect the innocent. However, authorised persons may perform forensic examinations and take samples or photographs of the defendant (s 22 in Crimes (Forensic Procedures) Act 2000 (NSW)). Evidence would be admitted if it was relevant and was not excluded on various grounds such as hearsay, opinion and so forth. Then the jury would consider whether they were satisfied by that evidence to the required standard of proof.

The standard of proof varies among cases with the general standard of proof being “on the balance of probabilities” for civil matters, and a higher standard of proof of “beyond reasonable doubt” applicable to criminal cases. The words “beyond reasonable doubt” should be interpreted according to their ordinary meaning, which requires the prosecution to bear the burden of proof, and gives the accused the benefit of any doubt (Clough & Mulhern 1999: 17). In essence, the prosecution has both the legal burden of proving each element of the criminal charges and the evidential burden of providing sufficient evidence to establish each element beyond reasonable doubt (Finlay & Kirchengast 2015:22).

If the accused raises some affirmative defences that may lead to an acquittal, the accused has the evidential burden of providing sufficient evidence to establish the defences (Finlay & Kirchengast 2015:22). After the accused has done so, the prosecution has the legal burden to prove beyond reasonable doubt that the proposed defences are not acceptable (Finlay & Kirchengast 2015:22).

If the accused raises the mental impairment defence, the accused bears both the evidential and legal burden on the balance of probabilities (Finlay & Kirchengast 2015:22). “On the balance of probabilities” means over a fifty percent likelihood.

Generally speaking, relevant evidence presented by the prosecution or defendant may be admitted. Admission of evidence is governed by the appropriate Evidence Act(s). The judge has discretionary power to reject evidence that is unfairly prejudicial or misleading where these facors substantially outweigh the probative value of the evidence (see *Evidence Act 1995* (NSW) s 55, s 56 and s 135).

Therefore, in criminal cases, the prosecution bears the important role of establishing each element of the charge. The defendant can remain silent and the prosecution cannot compel the defendant to give evidence.

2.1.5. Scientific evidence

Numerous criminal cases involve demonstrating the mental states of the defendant, showing a lack of capacity to reason, or establishing disease of the mind. In these cases, expert witnesses will present scientific, psychological or psychiatric evidence to support the claims. Expert witnesses include medical doctors, psychiatrists or neuropsychologists. The law grants these expert witnesses special status because they possess specialised knowledge in their disciplines from training and experience (see *Evidence Act 1995* (NSW) s 79). Recently, courts have also allowed neuroscientists to act as expert witnesses (Hardcastle 2014:3).

General witnesses can provide evidence of what they did, saw, heard or said, but not opinions (see Evidence Act 1995 (NSW) s 76). However, expert witnesses can provide views to assist in determining the facts in issue. They may offer opinions based on data obtained from special techniques and argue for a not guilty verdict, diminished responsibility, or lesser punishment. Houston & Vierboom (2012:14) suggest that Australian case law requires expert opinions to be relevant, reliable and trustworthy. Therefore, scientific evidence may meet the criteria of relevance when the evidence can show whether a witness's evidence is true or false.

Each stage of a criminal trial may require different types of evidence. The court firstly needs to determine if the defendant can stand trial by making sure that the defendant understands what he or she is being accused of, and can direct their legal representative. For example, a brain scan has been used to suggest that the accused was demented, therefore the accused lacked the capacity to stand trial (Jones et al. 2009:11). In the guilt determination stage, brain images may be used by an expert witness to suggest that the mens rea element required by a murder charge cannot be established (Jones et al. 2009:11). In the sentencing stage, the court can accept further evidence to adjust the penalty to be imposed. Additional evidence may either mitigate or aggravate the punishment. The criteria for admission of evidence is lower in the sentencing phase than the guilt determination phase (Miller 2009:1). For examples, brain images have been offered at the sentencing phase to reduce the punishment or to suggest that the accused would be incompetent to be executed (Jones et al. 2009:11).

Moreover, after the non-parole period, which is the minimum period of time in prison to which they have been sentenced, is served, the parole office needs to assess if the offender is reformed and not dangerous for release into the community (Nadelhoffer et al. 2012:69).

Neuroscientists can play multiple roles in court (Jones et al. 2013:731). Firstly, neuroscientists can act as fact or lay witnesses, for example, to provide results after examining a plaintiff or a defendant. Secondly, neuroscientists can assist the lawyers to evaluate neuroscientific evidence tendered by the accused. Thirdly, neuroscientists can make a submission that helps the court comprehend pertinent matters before the court. Fourthly, neuroscientists can act as expert witnesses to provide their opinions on neuroscientific evidence.

In the USA, the Frye and Daubert tests are used to determine the admissibility of the evidence offered by expert witnesses (Jones & Shen 2012:358). However, the Daubert test is the present standard (Gazzaniga 2008:415). The test poses four questions. The first question is whether the scientific method can be tested or has been tested. The second issue is whether the scientific method has been peer reviewed. The third question is whether the actual or potential rate of error of the scientific method is known and whether it has a control standard. Finally, in common with the Frye test, the last question is whether the scientific method is accepted in the relevant scientific discipline.

In summary, the law allows expert witnesses to present and interpret scientific data. However, there are various criteria for admission of scientific evidence and the judge has the discretion to disallow evidence that may be prejudicial where this outweighs its probative value.

2.1.6. Defences

If the prosecution can establish all the facts in issue, the defendant will be punished unless there is an acceptable defence that can either be a justification or an excuse. A justification is a reason for doing a permissible act. For example, self-defence is a justification because it is a legitimate response to protect oneself. As a result, the justification can lead to outright acquittal (Morse 2014:36). Most excuses are said to be partial in nature as they render the accused less responsible because the accused lacks the relevant capacity assumed by law (Morse 2014:37)

There are various defences to negate the mens rea and actus reus (Hodgson 2000:662-4). The defence of duress would negate mens rea by suggesting that the act was performed under the influences of a threat of death or a real danger of serious harm. The defence of self-defence also negates mens rea by arguing that the act is necessary to protect the defendant against the threat.

The defence of insanity negates the actus reus and mens rea while the defence of automatism negates the assumption of voluntariness. The defence of insanity originates from the famous *M'Naugten*[4] case. Firstly, it requires establishing that the defendant was suffering "a defect of reason" or "disease of mind" (Davies 2013:114; Hodgson 2000:664). Secondly, it requires that these mental conditions had caused the defendant to not understand the nature of the act, or to not know it was wrong to do so. In *R v Falconer*[5], the High Court suggests disease of the mind is synonymous with mental illness resulted from "an underlying pathological infirmity of the mind". In *R v Temp*[6], Lord Devlin suggests that the mind refers to the ordinary meaning of "the mental faculties of reason, memory and understanding". In *R v Porter*[7], the court said that the nature of the act refers to the nature of the physical act and does not include any sense of morality while "wrong" is seen from the perspective of a reasonable person. In the USA, the legal insanity defence examines the cognitive ability of the accused to see if the accused understood that the criminal action was morally or legally wrong (Jones & Shen 2012:361).

The defence of sane automatism would require denying that the act was both conscious and voluntary, and establishing the act was not caused by unsoundness of the mind (Hodgson 2000:664). In the Canadian case of *R v Parks*[8], Parks drove sixteen miles on an early morning, killed his mother in law and then drove to the police station to report the incidence. Parks

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[4] 8 ER 718, Volume 8
[5] [1990] HCA 49; (1990) 171 CLR 30
[6] [1957] 1 QB 399
[7] [1933] HCA 1; (1933) 55 CLR 182
[8] [1992] 2 S.C.R. 871

was acquitted by successfully claiming automatism due to a sleep disorder. Apparently, automatism can be sane or insane. Parks' defence was based on sane automatism, and it succeeded in giving him an outright acquittal. However, if insanity can be established, the automatism will be insane automatism and will have a similar effect as an insanity defence.

A few more defences can reduce guilt. For examples, the defence of provocation suggests a temporary loss of control and the defence of diminished responsibility suggests a substantial impairment of the mind due to some underlying condition (Hodgson 2000:664).

While successful defences of duress, self-defence, or sane automatism can lead to an outright acquittal, insanity is a partial defence that may lead to indefinite detention in a mental institute (Hodgson 2000:663). Finlay & Kirchengast (2015:412) highlight that after the abolition of capital punishment in Australia, the defence has seldom raised the insanity or mental impairment defence because of the possibility of indefinite detainment in an institution. Alternatively, by proposing the defence of diminished responsibility, the defendant can use the defence of diminished responsibility to reduce a murder charge to manslaughter (Finlay & Kirchengast 2015:412).

In summary, most defences involve investigating mental states and capacity. An acceptable defence may allow acquittal or reduce the punishment. Expert witnesses may give opinions on the mental abilities or mental states of the defendant. Their views may rely on scientific evidence such as neuroimaging that will be further discussed in the next section.

2.1.7. Section summary of criminal law

There are several observations from the above discussion. Firstly, reliable and accurate evidence is critical to providing justice in the criminal law. Criminal law can impose a serious penalty. Therefore inaccurate or unreliable evidence may cause the innocent to be wrongly punished, or a guilty defendant to evade punishment. Also, the burden of proof of beyond reasonable doubt demands evidence to be reliable and accurate. Correspondingly, the rigorous rule of evidence such as the Daubert test likewise requires accurate and reliable evidence. Moreover, the judges have discretionary power to reject evidence that is prejudicial or misleading or has little probative value.

Secondly, any relevant evidence may be accepted. The rule of evidence in the guilt determination stage is much higher to disallow unreliable evidence or evidence with little probative value. However, the rule of evidence in the sentencing phase has a lower standard to allow most relevant evidence to be submitted to mitigate or aggravate the punishment (Miller 2009:1; Hughes 2010:340). Given relevant evidence may be accepted, relevant evidence in many forms like neuroimaging evidence may be submitted. Moreover, expert witnesses are utilised to provide a proper interpretation of the evidence that may not be apparent to the court.

Thirdly, there are two main types of evidence. One type is to establish the facts in issue. Another type is to determine whether a party has the relevant cognitive capacity or not. For example, significant damages in certain brain areas suggest an incapacity of particular cognitive functions. Such evidence would be relevant to defences such as insanity or diminished capacity.

The next sections look at various neuroimaging techniques that might be used to support the opinions offered by the expert witnesses.

2.2. Structural and functional neuroimaging

Research proposes localisation of functions in the brain. For example, the right dorsolateral prefrontal cortex (DLPFC) is attributed to moral judgement (Prehn & Heekeren 2009:145). Similarly, the hippocampi and nearby medial temporal lobes are associated with memory consolidation (Glannon 2010: 25).

Neuroimaging is an objective technique that could show the brain structure and mechanism. There are two types of neuroimaging. Structural neuroimaging aims to demonstrate whether or not the brain structures are normal or are damaged or have tumours. Structural brain imaging reveals the structure of the brain like X-ray images. Structural neuroimaging will disclose organic brain damage to support an inference of a deficiency of mental capacity, or to establish mental illnesses to mitigate guilt. Studies have found brain areas that were entirely distinct handle different functions. For example, inhibition is claimed to be located in ventrolateral prefrontal cortex, empathy in anterior cingulate cortex, regret in orbital prefrontal cortex, ethical decision in ventromedial prefrontal cortex, or reasoning in dorsolateral prefrontal cortex (Mobbs, Lau, Jones, & Frith 2009:245). Consequently, any considerable localised damage within the brain might support an inference of an incapacity of the relevant cognitive functions. Structural neuroscience evidence is important to the issues of whether the defendant can stand trial, can perform the actus reus or form the mens rea. Moreover, the evidence is also used to argue that the wrongdoer should not be executed, or used to justify an insanity defence. In some Australian criminal cases such as *Ross v R*[9] , *R v Tortell, R v Tsegay*[10], *R v Caleb James O'Connor aka John Coble*[11], and *R v Lepore*[12], structural neuroimaging has been used to support a claim of diminished capacity and has resulted in a decrease in sentence (Chau 2014:13-5).

For example, structural neuroscience evidence was presented in two Australian cases with the seeming effect of reducing the murder charge to manslaughter. In *R v Terrence David Kain*[13], Kain was accused of killing his mother in February 2011. The defendant tendered an

[9] [2006] NSWCCA 65
[10] [2007] NSWCCA 313
[11] [2013] NSWDC 272
[12] [2013] SASCFC 13
[13] [2013] NSWSC 638

MRI scan to suggest a long-standing diffuse brain damage. The expert witness suggested the damage was possibly caused by previous binge drinking, and further suggested the damage caused dementia and memory impairment. The Honour accepted that Kain at the relevant time was affected by the brain damage and had a loss of control. Therefore, Kain could not appreciate the consequence of his actions. The Honour accepted "mens rea" for intentional killing cannot be established and consented to Kain's plea for manslaughter. In *Director of Public Prosecutions v AB*[14], AB was sixty-seven years old and was charged with the murder of his wife by firing four shots in July 2010. The accused tendered MRI brain scan in November 2011 which showed "generalised mild enlargement of the spaces in the brain occupied by cerebrospinal fluid". Various expert witnesses suggested AB had "an abnormity of mind", impaired capacity to control, cognitive and social impairments, and dementia. The court accepted the defendant had a substantial impairment by an abnormality of mind and the accused was convicted of manslaughter instead of murder.

In the above murder cases, the expert witnesses tendered MRI images to support their opinion that the structural damage in the brain of the two accused persons implied a lack of mental capacity. With a lack of mental capacity, the court cannot establish the mens rea of intentional killing. In these cases, the court has already determined who had caused death. Expert evidence was not used to infer who killed the victim but to suggest that the defendant did not have the mental capacity required for a murder charge. In another similar case from the USA, a defendant argued for insanity defence by tendering brain images that revealed an

[14] [2013] NSWSC 1739

abnormal cyst covering the outside of the brain membrane (Rosen 2007:1). The defendant in this case received life imprisonment instead of the death penalty (Rosen 2007:1).

Different from structural neuroimaging, functional neuroimaging shows activities in various brain regions when a task is performed, or a stimulus is observed. The brain areas that have activities are highlighted in the functional image with different colours. Based on the activation of different brain areas, experiments have demonstrated the ability to use functional neuroimaging to identify the images being perceived by the test participants. Kay et al. (2008:353) suggest the complex combination of brain activities may be used to establish a selected natural image out of a possible 1,750 natural images observed before the test.

Specifically, functional neuroimaging has been used to show whether a person tells the truth or lies. In a nutshell, this line of argument suggests the brain activations can demonstrate whether or not the testimony given is true or false. In the USA civil case *Wilson v. Corestaff Servs. L.P.*[15], the defendant proposed to use functional neuroimaging to establish the defendant was not lying. However, the proposal was rejected.

Functional neuroimaging is different from structural neuroimaging. Structural neuroimaging can be utilised to demonstrate a lack of specific cognitive capacity to justify an acquittal or mitigate punishment. However, functional neuroimaging may also be relevant to determine facts in issue.

[15] 28 Misc.3d 425 (N.Y. Misc. 2010)

While structural neuroimaging is presented by expert witnesses like medical doctors, functional neuroimaging may be submitted by neuroscientists who have developed the relevant tests and experiments. In a manner similar to the way that clinical psychologists and neuropsychologists have acted as expert witnesses, neuroscientists can also serve as expert witnesses (Hardcastle 2014:3).

The next section discusses varieties of neuroimaging technologies with particular emphasis on the fMRI technology.

2.3. Neuroimaging technologies

With the advancement of neuroscience, neuroimaging produces brain images non-intrusively to uncover the inner structures of the brain. Structural brain scans can be produced by technologies such as computed axial tomography (CAT) and magnetic resonance imaging (MRI). Computed tomography (CT) or CAT scans use a computer to reconstruct two-dimensional brain or body images based on how much X-ray is absorbed (Haidekker 2013:37). They are suitable for detection of tumours and structural abnormalities. Although a CAT scan is less precise than an MRI, it is inexpensive and quick to produce (Greely & Wagner 2011:763). MRI will be discussed later.

There are three kinds of brain measurement techniques that detect either electromagnetic signals produced by active neurons[16], the metabolic activity of neurons, and blood flow resulting from brain activities (Aguirre 2014:S9). For the electromagnetic technique, Electroencephalography (EEG) measures electrical signals from sensors directly attached to the scalp of the head. Event-related potential (ERP) uses EEG method to measure voltage changes. Likewise, magnetoencephalography (MEG) measures the magnetic field. EEG has low spatial resolution and is not a useful method to identify activity locations. However, it has a high temporal resolution in determining when an action starts and ends (Aguirre 2014:S10).

There are several functional neuroimaging techniques that measure metabolic activity, for example, positron emission tomography (PET), single photon emission computed tomography (SPECT), and functional magnetic resonance imaging (fMRI). PET and SPECT require a prior injection of a radioactive material into the bloodstream for attaching to energy compound, for example, glucose. Radioactive images are taken to show the level and location of neuron activities that require the energy compound. PET reveals the locations where glucose is used. PET is a suitable technique to recognise brain damage from Alzheimer's disease or a stroke (Greely & Wagner 2011:764). Given PET and SPECT show activities of radioactive materials, they are functional neuroimaging rather than structural neuroimaging (Feigenson 2006:236). MRI and fMRI will be discussed below.

[16] Neurons are nerve cells.

2.3.1. MRI

MRI is a standard and non-intrusive technique to produce structural images of the brain. MRI can precisely measure the brain dimensions and display the brain structure in images (Farah & Wolpe 2004:36). The MRI images reveal whether the brain structure is normal or abnormal.

An MRI image is captured by a large scanner that is insulated from electromagnetic interference (Haidekker 2013:67). The scanner requires cooling to maintain superconductivity. MRI measures the orientation of protons[17] in a magnetic field produced by a superconductive magnet inside the MRI scanner. Protons are present in hydrogen that is present throughout the brain structure. As the densities of hydrogen vary in different structures of the brain, MRI can map out the anatomy of the brain by measuring the density of the hydrogen. The same MRI scanner may generate fMRI neuroimaging and will be discussed next.

2.3.2. fMRI

Functional magnetic resonance imaging (fMRI) is a non-invasive means to provide high-resolution images of the brain when a participant performs a task or observes a stimulus (Aguirre 2014:S8). The assumption is that when a brain region requires energy for activity, the

[17] Protons are smaller particles inside brain cells carrying a positive electric charge.

region will require oxygenated blood for the metabolic activity. Oxygenated blood will become de-oxygenated when the task is being performed. Oxygenated and deoxygenated blood have different magnetic properties and this difference can be detected by the fMRI scanner as a proxy for brain activity. In other word, the fMRI scanner can identify the locations where there are changes in magnetic properties and treat these locations as activated by the fMRI task. Therefore, fMRI images highlight the brain regions which receive oxygenated blood and are involved in performing the particular task (Aguirre 2014:S9).

Therefore, fMRI does not measure the activities of the brain cells directly but uses blood flow as a proxy for brain activity. The magnetic properties of blood before and after oxygenation are different and are captured as the blood-oxygen-level-dependent (BOLD) measure (Kulynych 1997:1256). The brain is conceptually divided into many tiny cube-shaped spaces measuring 0.5 to 3 millimetres referred to as voxels. The fMRI scanner captures the BOLD level at all voxels in the brain, and the BOLD level serves as a proxy for the activity level of the relevant brain regions. As fMRI technique can identify activity in very tiny areas of the brain, fMRI has a high spatial resolution in determining the locations where activities occur (Aguirre 2014:S10). However, fMRI has a lower temporal resolution because there is a time gap between the time the brain processes begin in the nerve cells and the detection of fMRI activities predicted by the metabolic changes of oxygenated blood becoming de-oxygenated (Aguirre 2014:S10).

There are a few steps involved in producing fMRI images (Aguirre 2014:S12). The BOLD level of each voxel is tested statistically against a pre-defined threshold. Those voxels with an activity level above the threshold are deemed to be active. After that, the results are then overlaid onto the structural brain image of the same participant captured at the same time. The activity levels in various brain regions are shown with different colours. Hence, fMRI images are colourful in appearance.

Practically, fMRI is widely used in clinical settings for pre-surgical planning to identify critical functional brain areas around the region to be operated on. (Matthews, Honey & Bullmore 2006:733). The critical functions can be relevant for motor control, language or sensory processing as identified in neuroscience research (Matthews, Honey & Bullmore 2006:733).

Moreover, the USA National Institute of Health has spent significantly more than $5 billion on neuroscience research and endorses fMRI as having the following benefits (Insel, Landis, & Collins 2013:687):

> "Improvements in functional magnetic resonance imaging (fMRI) have given us better maps of human brain activity, allowing more precise localization of complex functions such as language, emotion, decision making, and hallucinations. Even the analysis of fMRI signals from individuals who are not performing a task ("resting state" imaging) has been explored as a powerful marker of individual cognitive traits".

Hence, fMRI is heavily used in neuroscience to identify cognitive functions. Moreover, the above quotation also indicates there are variations in fMRI neuroimaging techniques. The resting-state fMRI (RS-fMRI) measures the connectivity between different brain regions to identify different brain networks while the participant does nothing (Aguirre 2014:S16). RS-fMRI can identify patients with Alzheimer's disease or with epilepsy (Lee, Smyser & Shimony 2013:1869). RS-fMRI can also identify chronic pain conditions from changes in the default mode networks (Baliki, Mansour, Baria, & Apkarian 2014:1; Salmanowitz 2015:4). Default mode networks are brain networks that are active at rest but deactivated when tasks are performed (Baliki et al. 2014:1). Also, fMRI with dynamic causal modelling can classify an active brain region as either inhibitory or excitatory (Marreiros, Kiebel & Friston 2008:271). Moreover, functional near-infrared neuroimaging (fNIR) functions the same as fMRI but is portable; it is similar in size to a briefcase (Holley 2009:6). With further innovation, more advanced imaging technologies are foreseeable (Moreno 2011:1258).

2.4. Neurolaw – Current applications of neuroimaging in law

Mind and brain are interrelated. A moral and responsible agent has to possess the right level of mental capacity which relies on a properly-functioning brain mechanism (Vincent 2011b:38). Hence, neuroimaging has been used to support a claim of lack of legal capacity. In another case, a teacher had developed paedophilic tendencies and later a large tumour was discovered in his brain (Burns cited in Sifferd 2013:193; Morse 2010:559). After the tumour was removed, his interest in child pornography disappeared. However, his interest in child pornography re-developed after some time. The doctor found there was some tumour residue left behind and the tumour had re-grown. Once the tumour residue was removed, the teacher's interest in child pornography vanished. This example suggests that the interest in child pornography was caused by the presence of the tumour. Hence, neuroimaging helped to identify the presence or absence of the tumour, and allowed the incapacity for self-control to be explained when the tumour was present, and demonstrated that the capacity for self-control re-appeared when the tumour was removed.

Neuroimaging evidence is common in courts and is presented by expert witnesses (Jones et al. 2013:730). The use of neuroscientific evidence in courts is expanding (Jones et al. 2013:731). The accompanying cases illustrate how neuroimaging has been used in courts (Greely 2011:71): In the case of John Hinckley, who attempted to assassinate President Ronald Reagan, a CT scan was used to prove the defendant was guilty by reason of insanity. In the case of Herbert Weinstein, who killed his wife, a PET scan was used as evidence to demonstrate the presence of an arachnoid cyst in the skull affecting the mind. The murder charge was reduced to manslaughter. In the case of Peter Chiesa, who killed two neighbours, a SPECT image was used to show diminished control and decrease the charge from first-degree to second-degree murder.

As an illustration of the EEG technique, two USA cases[18] utilised EEG to check if the defendants possessed guilty knowledge. EEG detects the presence or absence of a positive brainwave at 300 milliseconds (P300) after stimuli is presented to the defendant (Pallarés-Dominguez & González Esteban 2015:6). A brainwave that happens within 250 milliseconds after presentation of stimulation is assumed to represent pre-conceptual processing. Higher cognitive processing would be revealed by brainwaves occurring after 250 milliseconds. Hence, a P300 response happening after 300 milliseconds implies that higher cognitive processing such as recognition has taken place and the subject possesses the relevant knowledge with respect to the stimuli that is relevant to the crime. The expert witnesses recommend these measures because the tests involve automatic detection of a particular brainwave rather than relying on behavioural responses that can be subjected to countermeasures.

In another case, an expert witness tendered fMRI evidence to suggest that the defendant was psychopathic and should be given a lesser sentence (Miller 2009:1; Hughes 2010:341). Brian Dugan kidnapped and killed a young girl. In the sentencing phase, the prosecution sought capital punishment. However, the defendant submitted fMRI evidence in the penalty phase when the admission criteria is lower. The expert witness for the accused was Kiehl, who had tested over a thousand inmates classified as psychopaths and was considered to be a

[18] In *Harrington v. State*, 659 NW 2d 509 – Iowa, EEG was used to perform a brain fingerprinting test to detect the presence of guilty knowledge. EEG was part of the reason for requesting a re-trial. In *Slaughter v. State*, 105 P. 3d 832 – Okla, the court suggested that brain fingerprinting was "likely inadmissible" because details had not been provided about the nature of the tests, the methods, and results.

specialist on psychopathy. Kiehl testified that Dugan showed lower-than-usual activity in certain brain regions. This brain pattern was like the brain patterns of psychopathic prisoners but was less active than non-psychopathic prisoners or non-prisoners (Hughes 2010:341-2). Hence, Kiehl argued Dugan was psychopathic, and he lacked the capacity to control his behaviour. However, the expert witness for the prosecution Brodie put forward two counterarguments against Kiehl's proposal. Firstly, Dugan was scanned twenty-six years after the murder, and the fMRI showed the present brain responses and not those that at the time of the murder. Secondly, Kiehl was comparing Dugan's brain with the average psychopathic brain obtained from thousands of participants in fMRI tests. Brodie contended not all individuals with comparable brain responses would be psychopathic. As an analogy, Brodie suggested most professional basketball players would be more than six feet tall however not everyone with that height could be a professional basketball player. The jury deliberated for ten hours. Hughes (2010: 342) notes that two jury members had initially ruled non-guilty after Kiehl's testimony was presented but later switched back to a guilty verdict after taking more time to read further reports. Also such a lengthy deliberation would imply that the fMRI evidence had a large impact on the jury (Miller 2009:1).

2.5. Chapter Summary

In brief, different neuroimaging techniques have been used by expert witness in criminal cases. Most of the criminal cases used structural brain scans to argue for the lack of required mental capacity. The expert witness would argue that the defendant was unable to form the requisite mens rea, or had insufficient mental abilities to make a rational decision as required by law, or was unable to understand whether the criminal act was right or wrong. For example, the structural brain images may have shown the brains had extensive damage in the relevant brain areas responsible for rational decisions, e.g. at the pre-frontal cortex (PFC). Significant damage in the PFC suggests the inability to make rational decisions.

MRI is one of the latest forms of non-intrusive neuroimaging technology and has been employed to obtain structural images of the brain. fMRI is different. The Dugan case is one of the rare examples where fMRI was used to attest to a psychopathic mind (Miller 2009:1; Hughes 2010:341). Dugan seemed to have a normal brain structure but showed lower activity level in certain brain areas in common with most psychopaths.

As discussed previously, the law demands accurate and reliable evidence. Moreover, any relevant evidence may potentially be admitted under the rules of evidence. Given that fMRI may provide in-depth knowledge about our cognitive functions, it is a fascinating thing to ask whether fMRI neuroimaging evidence can provide useful evidence to the courts. Alternatively, it is likewise intriguing to ask whether fMRI neuroimaging would not be helpful because there are unavoidable inherent limitations. From recent research discussed above, fMRI neuroimaging evidence has not been presented in most courts. This circumstance gives me an opportunity to evaluate whether fMRI neuroimaging has evidential potential in the courts. Indeed, even if this inquiry can be answered in the positive, in light of ongoing improvement of technologies, I still need to identify the potential areas where fMRI neuroimaging evidence can be applied. Therefore, the next chapter begins this investigation by reviewing the limitations in translating fMRI neuroimaging.

Chapter 3 – Limitations of fMRI and the current status

The previous chapter highlighted that neuroimaging can either be structural or functional. Structural images can show an abnormality of certain brain areas. Such knowledge has been used to infer a lack of legal capacity. Functional neuroimaging faces many limitations and interpretation issues which will be discussed fully in this chapter. Thus, there are limited submissions of fMRI neuroimaging evidence in criminal cases as confirmed in my upcoming review in this chapter of the uses of fMRI evidence in Australia and the USA. However, there are some signs that fMRI neuroimaging evidence may in the future be useful to provide evidence. These signs can be discerned from reviewing the history of imaging evidence and the uses of other functional neuroimaging evidence. The various limitations of fMRI are discussed in the first section of this chapter.

3.1. Limitations

The law assumes that a person possesses certain capacity. A lack of relevant capacity can provide various defences such as insanity or diminished capacity. Since neuroimaging can be used to understand cognitive processes (Bechtel 2002:232), it is a potential source of evidence about the presence, absence or impairment of the relevant capacity. However, numerous researchers have highlighted distinctive interpretation issues in the use of functional neuroimaging to infer that a defendant has a certain capacity, or has particular mental states. The issues are discussed below from the different viewpoints of folk psychological view, technical problems, methodological issues, reverse inference issues, legal limitations, and issues because of brain plasticity.

3.1.1. Folk psychological view

Folk psychology explains human behaviour mainly with mental states such as beliefs, desires, and intentions (Morse 2014:31). Moreover, folk psychology proposes that humans use reasons to decide and explain actions (Morse 2014:31). Mental states are invisible. We infer them through mind-reading and reasoning of other's actions and responses. Morse (2014:31) suggests that the law embraces a folk psychological view that relies heavily on behavioural evidence and uses the language of folk psychology to explain and make inferences about human behaviour. fMRI evidence claims to bypass the need for these kinds of inferences and to reveal mental states via direct examination of brain states.

Morse (2011:838) proposes that neuroscience will have only a moderate impact on the law in the foreseeable future. He suggests that neuroscience may be relevant in assisting legal policy making or providing additional evidence in some legal cases.

It has been proposed that neuroscience evidence can be used to determine whether there is an excusing condition (Morse 2011:839). To establish an excuse, neuroscience evidence needs to demonstrate that there was a lack of capacity to reason or control at the time when the wrongdoing happened. However, there is a temporal gap when using neuroimaging to retrospectively investigate the mental states of the defendant back at the time of the criminal event (Morse 2011:849). Consequently, in cases where there is a conflict between neuroscience and behavioural evidence, Morse (2011:852) suggests that behavioural evidence will prevail. Moreover, neuroscience evidence is about the brain and, expert witnesses will be required to translate fMRI neuroimaging into the folk psychological language of the court. For example, the court would be interested to learn from the expert witnesses whether certain fMRI activities mean that the defendant had a certain intention or knowledge about the crime, or some fact in issues in layman's terms.

Morse (2011:853-4) concludes that neuroscience evidence is mainly supportive of other evidence, but may assume a critical role if there is a lack of behavioural evidence or the behavioural evidence is ambiguous.

3.1.2. Technical issues of translating fMRI

There are inherent technical difficulties in acquiring fMRI images. Firstly, good fMRI results require cooperative participants (Aguirre 2014:S13). The measurement result may be affected by slight movements of the head (Greely & Wagner 2011:783). Moreover, countermeasures like prior drinking of coffee or consumption of medicine may significantly change the physiological responses to an input stimulus and cause a different measurement result (Aguirre 2014:S13; Feigenson 2006:241; Greely & Wagner 2011:783-4). Results also depend on the level of attention of the participants or their expertise in the fMRI tasks (Feigenson 2006:241).

Secondly, fMRI neuroimaging shows the average activity of an area of the brain, not the activity of the actual brain cells. The scanner distinguishes blood flow activity from many tiny cube-shaped brain spaces referred to as voxels that are between 0.5 to 3 millimetres in length (Aguirre 2014:S10). Given that there are millions of neurons in the cortex, there can be thousands of neurons or nerve cells in a voxel (Aguirre 2014:S10). Neurons are working units in the brain and can have distinctive functions. Moreover, voxel activity does not show the types of neurons or reflect the excitatory or inhibitory natures of the individual neuron (Aguirre 2014). Despite the fact that the spatial determination of fMRI is brilliant for the human eye, the resolution is still not sufficiently fine to demonstrate the activity of each neuron.

Thirdly, the threshold for classifying a voxel as activated may be arbitrary (Greely & Wegner 2011:782). Therefore, the relevant activity level in some brain regions might be too small when compared against the thresholds to be visible (Aguirre 2014:S11; Klein 2010:187).

Fourthly, the fMRI measurement is sensitive to the task design. The participant has to perform a control task and a relevant task. The control task may be watching a neutral face while a relevant task involves watching a sad face. The fMRI image is the result of a subtractive design based on the two tasks. The analysis method is called multivoxel pattern analysis (MVPA) which analyses a vast number of voxels in the brain to see if the activity of each voxel exceeds a threshold. Hence, the fMRI result reflects the difference of neural activation between the control task and the relevant task. In the above illustration, the fMRI image is intended to show the relevant brain regions that are activated when the participant reacts to the sad face. Therefore, fMRI results depend on the selection of the control task and also depend on the threshold that is set arbitrarily to show areas with activity above the threshold.

In summary, fMRI images depend on several factors including cooperative participants, an arbitrary threshold for classifying a voxel as active or inactive, a sophisticated statistical analysis, as well as the task design. It assumes a series of relationships (Feigenson 2006:239; Glannon, as cited in Vincent 2011b:39): firstly it assumes that an fMRI task will cause a relevant cognitive function to be active; then it assumes that the cognitive function will trigger neuronal activities; next that the neuronal activities will demand oxygenated blood; then it assumes that oxygenated blood becomes deoxygenated while the defendant performs the fMRI task. The changes in oxygenation constitute the fMRI measurement. Finally, the fMRI data is calculated and an image is produced. This long chain of relationships is not clearly understood (Wolpe, Foster, and Langleben as cited in Feigenson 2006:8). Therefore, the fMRI method is not particularly reliable for producing images for supporting the relevant claims.

3.1.3. Methodological issues

It is suggested that "most fMRI studies are small, unreplicated, and compare differences in the average brain activity of groups, rather than individuals, making it difficult to interpret for single cases" (Jones, Schall & Shen 2014:6).

As fMRI scans are expensive and time-consuming, research involving fMRI tends to use a small number of subjects (Greely & Wagner 2011:779). Hence, the sample size may not be adequate to support generalised inferences (Mackintosh 2011:7). Moreover, due to variations in experimental design, the number of exact replications is too small to confirm the results (Greely & Wagner 2011:777).

There are also practical issues which make it difficult to directly use group results from experiments to assess an individual brain (Greely & Wagner 2011:780; Mackintosh 2011:7). There are individual differences in brain shapes and it is difficult to resolve the structural differences. Therefore, the combined result may not be an accurate model for an individual (Aguirre 2014:S13).

In addition to the issues concerning sample size, replication, and applying group average results to an individual, the experimental tasks may not reflect real-life scenarios (Greely & Wagner 2011:778; Harenski, Hare, & Kiehl 2010:145). For example, it is unethical to simulate the mind of a killer in the laboratory. Therefore, experimental scenarios which measure reactions to stimuli or tasks might not provide situations that are sufficiently similar to those in criminal cases.

3.1.4. Reverse Inference

Forward inference data is often used for reverse inference. For example, if one attempts to lie, some brain regions XYZ would display some fMRI activity. The information allows the forward inference that trying to lie will trigger activities in XYZ. However, people also use these forward inference results for reverse inference (i.e. reasoning backwards). For example, when brain regions XYZ are activated, the result might be used to support the reverse inference that the participant has attempted to lie. If XYZ is only activated by lying, the reverse inference would be acceptable. However, if region XYZ can become active under a wide range of conditions, then the reverse inference would be problematic as the activity from region XYZ would not reveal which particular condition triggered the activity in XYZ.

There are several causes for reverse inference errors, for example, the relationship between brain regions and cognitive functions appears to be many-to-many (Feigenson 2006:243), and some brain regions may respond to multiple tasks (Aguirre 2014:S14). Hence, the inference from brain activity to cognitive functions would not be unique. For instance, both the actual playing of tennis and the state of imagining that you are playing tennis can trigger activity in the motor cortex (Cyranoski 2012:3; Mizuguchi 2015:5). Remembering the past and imagining the future activate common brain regions such as left hippocampus (Addis, Wong & Schacter 2007:1). Moreover, the amygdala can be activated by fear as well as sadness (Wang 2005:20). Therefore, activation of the amygdala cannot be used to infer uniquely whether the person is being threatened or is feeling grief. In brief, when the same brain region can handle different functions, reverse inference result will not be unique (Klein 2010:192). Further information about the stimulus or situation may be required to support a specific inference.

Moreover, scientific studies suggest that these experiments will be subjected to the possibility of false positives and false negatives. False positives happened when the particular regions for lying were accidentally activated, but the participants did not indeed lie (Fine 2010:280). False negatives happen when the tests could not identify the participants were indeed lying because the regions for lying did not activate as expected.

3.1.5. Legal issues of fMRI neuroimaging evidence

Within the current legal framework in most nations, fMRI pictures may not be obtainable from the defendant, or there may be numerous hurdles for admitting such evidence.

The prosecution bears the burden of proof in criminal cases and also the defendant is protected against self-incrimination. Consequently, the defendant does not need to offer evidence as a witness (Greely & Wagner 2011:790-2). fMRI images are not classified as physical evidence although physical evidence like pictures or blood samples can be taken from the defendant. On the other hand, the defendant can voluntarily submit to fMRI neuroimaging to provide evidence in support for a claim of insanity or diminished capacity.

Judges would disallow evidence that is unfairly prejudicial, misleading, confusing, or leads to a waste of time (see Evidence Act 1995 (NSW) s135). As fMRI images are similar to photographs, the images have caused a couple of misconceptions as discussed below (Feigenson 2006:247-8). Firstly, fMRI images could lead the jury to believe they can objectively view the precise internal mechanisms of the brain. Secondly, the pictures carry with them a status of scientific truth and objectivity. Thirdly, the pictures also ground the mental competence to the brain rather than the person. Even if another person may have their brain regions activated in a similar way, he or she may not have reacted in the same way due to various strategies employed in different situations. For instance, if a fearful stimulus activates the amygdala, the possible responses could be different among different persons. Fourthly, small differences can be magnified by displaying a region slightly above threshold with colour but using no colour for an area with activation somewhat below the threshold. Thus, the activated brain regions in an fMRI image can depend on an arbitrary threshold, for example, if the expert witnesses chooses to use a marginally lower threshold, this would mean that more areas are labelled as activated.

Furthermore, neuroimaging cannot be utilised to investigate the mental state retrospectively at the time the offence occurred (Glannon 2014:157). Thus, recent neuroimaging can only establish the current status of mental capacity, character or temperament of the defendant.

The inference is simply correlational and cannot show legal causation (Glannon 2014:155). Glannon (2014:156) indicates that more information is needed. The legal test for causation is the "but-for" test which requires that the effect would not have happened without the behaviour of the accused. If the "but-for" test is employed in conjunction with an fMRI picture, it would mean the criminal act would happen when some specific brain areas are activated. Moreover, it also means the criminal act would not occur if the particular brain regions are not activated. The paedophilia case discussed before offers an example where causation could only be inferred with added information. A tumour alone does not suggest that a person would have paedophiliac tendencies unless there is additional behavioural information about their sexual urges to indicate whether the tumour has or has not caused a particular effect.

3.1.6. Issues with brain plasticity

It is problematic to infer from a lack of brain activity that there is a lack of capacity (Pardo & Patterson 2011:186). The inference may be faulty because the function can be performed in other brain areas due to neural plasticity (Vincent 2011b:40; Glannon 2014:155). Research suggests that the structure of the brain changes with learning and experience. For example, expert taxi drivers appear to have a larger hippocampal region (Zatorre, Fields & Johansen-Berg 2012:530). As an illustration, language function typically resides in the Broca’s area in the left brain hemisphere. However, a patient suffering brain damage to the left Broca’s area may re-learn the language function by making use of the right Broca’s area (Thulborn, Carpenter, & Just 1999:749). In theory, if such patient is tested for language function in the standard left Broca's area, there would be no fMRI activation. However, this inactivation does not mean the language function is absent. With brain plasticity, the language function is now in the right Broca's area of that patient.

Moreover, activation can be extended to more brain regions in some individuals. When performing cognitive tasks at capacity limits, a research study found that low-performing participants show more fMRI activation due to the recruitment of more brain regions to perform the tasks (Jaeggi et al. 2007:87).

3.2. Status of using fMRI neuroimaging in courts

Though neuroscientific evidence has appeared in some Australia criminal cases, none of them involves fMRI (Chau 2014:1). Similarly, a recent Canadian research study has found 279 cases involving neuroscientific evidence. Moreover, another recent analysis of criminal cases between 2005-2012 has found 204 cases involving neuroscientific evidence in England and Wales (Catley & Claydon 2015:9). However, none of the criminal cases have involved fMRI (Chandler 2015:9; Catley & Claydon 2015:14). In the research study in England and Wales, the majority of the neuroscience evidence used in the cases was in the form of MRI, CAT, or CT scans (Catley & Claydon 2015:14). That research study indicated that in one civil case there was a suggestion that fMRI could be used to assess a person in a vegetative state. Nevertheless, there are a few USA criminal cases that have involved some uses of fMRI in some superficial ways. The use of fMRI in Australian and American criminal cases is analysed below.

3.2.1. Status of using neuroimaging in Australia criminal courts

A recent search of Australian legal databases has confirmed that no fMRI evidence has been used in criminal cases[19]. However, there were two superficial mentions of fMRI in Australian Administrative Appeals Tribunal cases. *Krauss v Comcare*[20] involved a claim for permanent impairment and non-economic loss due to the pain suffered by the applicant. The Tribunal at paragraph 103 quoted a journal article which stated: "Neuroimaging methods have the capacity to fulfil this need [for objective identification] as they provide a non-invasive, systems-level understanding of the central mechanisms involved in pain processing". In the second case *Fowler v Repatriation Commission*[21], the applicant attempted to claim a higher pension because of post-traumatic stress disorder (PTSD) and alcohol dependence. A psychiatrist in the case had performed an fMRI scan but did not find any abnormality.

On the other hand, it is common for expert witnesses to refer to MRI. For example, there are eighteen cases in the Court of Criminal Appeal of New South Wales captured by the keyword "MRI scan"[22]. In the case of *EG v R*[23], the expert witness used the MRI scan to suggest a

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[19] A search was conducted on 10 July 2015 in the criminal practice area in the LexisNexis legal database.
[20] [2010] AATA 722
[21] [2013] AATA 499
[22] As per a search on www.austlii.edu or the Austlii Legal Information web site on 10 July 2015.
[23] [2015] NSWCCA 21

diagnosis of significant depressive illness. As discussed before, two Australian murder cases of *R v Terrence David Kain*[24] and *Director of Public Prosecutions v AB*[25] involved the use of MRI scans. The defendants evaded the murder charge in both cases.

3.2.2. Status of using fMRI neuroimaging in American courts

Jones et al. (2013:730) suggest that neuroscientists have attempted to present fMRI evidence. Similarly, Jones & Shen (2012:349) suggest fMRI lie-detection evidence has been tried first in the case *US v. Semrau*[26]. As discussed before, Miller (2009:1) reports fMRI evidence was first introduced in the sentencing phase of a murder case involving Brian Dugan and appeared to have affected jury decision making. The report suggests that the jury had a lengthy deliberation when the fMRI evidence was proposed.

My examination of fMRI cases in the USA suggests that fMRI evidence has been attempted to be presented or has been referred to in four types of cases: cases involving lie detection, cases arguing that violence in video games reduces self-control, cases arguing for a lack of capacity to receive the death penalty, and cases confirming a disease in insurance benefit claims.

[24] [2013] NSWSC 638
[25] [2013] NSWSC 1739
[26] 693 F.3d 510 (6th Cir. 2012)

In a civil case *Wilson v. Corestaff Servs. L.P.*[27], the plaintiff attempted to use an fMRI test to show that a witness was not lying in his testimony. However, the attempt failed. In *United States v. Semrau*[28], Semrau provided psychiatric care and was charged with fraud claims in relation to Medicare reimbursements. He proposed to subject himself to fMRI scanning to support the assertion that he did not lie in his claims. Moreover, the case notes in this case suggest that there have been attempts to use fMRI evidence in several cases. Specifically, various American courts have examined “the admissibility of fMRI lie detection technology in a civil case”, “[used] fMRI tests to demonstrate impaired brain functionality”, “[reviewed] fMRI research on juvenile brain development”, and “[reviewed] fMRI research on media violence exposure and brain activation".

The court in *United States v. Semrau*[29] identified several reasons for excluding the fMRI evidence and suggested that the method has not been tested in the real world, that the specific test used by the expert witness was not consistent with other studies, that the test was done without prior awareness of the prosecution, and that the test did not show the truthfulness of Dr Semrau on each test item.

In *Entertainment Software Ass'n. v. Blagojevich*[30], Blagojevich was the defendant and the State attorney attempted to introduce results of fMRI studies to support the claim that video games would reduce self-control by showing reduced brain activity in the frontal region.

[27] 28 Misc.3d 425 (N.Y. Misc. 2010)
[28] 693 F.3d 510 (6th Cir. 2012)
[29] 693 F.3d 510 (6th Cir. 2012)
[30] 404 F. Supp.2d 1051 (N.D. Ill. 2005)

However, the expert witness, who was a cognitive psychologist for the plaintiff, provided more credible testimony on the following basis. Firstly, the expert witness for the defendant assumed a one-to-one mapping between brain regions and behaviours but instead there is a many-to-many relationship. Secondly, there could be alternate explanations for reduced activity in particular brain regions. There were results supporting brain plasticity such that other brain regions may evolve to perform functions previously performed by some defective brain regions. Thirdly, the fMRI studies provided results from composites of brain images instead of individual brain images.

In *Turner v. Epps*[31], Turner attempted to subject himself to fMRI examination to argue that he should not be executed. The court did not comment on the fMRI test but granted a delay of execution pending Turner's medical examination results. In *Turner v. Epps No. 12*[32], the State appealed against the delay of execution. In *Hooks v. Thomas Case No. 2*[33], fMRI was proffered by the defendant to show frontal lobe dysfunction that would render his execution unconstitutional. However, from the court's perspective, fMRI was not an "accepted scientific method".

In *Van Valen v. Employee Welfare Ben. Com. Northrop Grumman*[34], the court referred to scientific articles that said that "tests can objectively show decreased cognitive performance

[31] 842 F.Supp.2d 1023 (S.D. Miss. 2012)
[32] 70003 (5th Cir. Feb 08, 2012)
[33] 10-CV-268-WKW. (M.D. Ala. Oct 17, 2011)
[34] 741 F. Supp.2d 756 (W.D. Va. 2010)

in patients with CFS [Chronic Fatigue Syndrome]”. In *Smith v. Astrue Civil Action No. 08*[35], the expert witness for the plaintiff proposed to use fMRI to demonstrate the plaintiff would be “psychiatrically disabled” for insurance claims. However, the court referred the case back to the administrative tribunal so that the tribunal may try to interpret the submission from the expert witness.

Hence, there are a limited number of references to fMRI in cases in the USA. The Brian Dugan case in the USA appears to be the only case when fMRI evidence has been presented in a criminal court. Furthermore, it was presented in the sentencing phase when evidence can be admitted to a lower standard.

3.3. History from similar types of evidence

The following considers two similar types of evidence to see if they provide any hints about the future application of fMRI: evidence in the form of other functional images created from PET and SPECT, and photographic images.

[35] 347. (W.D. Pa. Nov 06, 2008)

3.3.1. History of other functional neuroimaging evidence

Given PET and SPECT are also forms of functional neuroimaging, Feigenson (2006:237) has tried to analyse previous American court cases involving PET and SPECT to infer whether fMRI will be admissible. It appears that the admissibility of PET and SPECT was case specific and context dependent. For example, in the case of *People v. Protsman*[36], the American court rejected the use of PET to evaluate head trauma because PET was typically used to diagnose stroke, Alzheimer's disease and epilepsy (Feigenson 2006:237).

My review of Australian court cases on the uses of PET and SPECT suggests that these forms of functional images have been presented to identify brain damage or disease. For example, the evidence in *R v Berlingo No*[37] suggests that a PET scan can ascertain whether the subject has brain disease. Again in *R v Ian David Kennedy*[38], a PET scan was used to confirm organic brain damage to support an inference of a lack of impulse control due to brain abnormalities. Similarly in *R v Jason Robert NAA*[39], a PET scan was used to show abnormality in the temporal lobe.

[36] 105 Cal. Rptr. 2d 819, 88 Cal. App. 4th 509 (Ct. App. 2001)
[37] SCCRM-01-296 [2003] SASC 109
[38] [2008] NSWSC 703
[39] [2009] NSWSC 1077

Similarly, it was suggested in *R v Dunne*[40] that a SPECT scan confirmed frontal and temporal hypoperfusion[41], and in *R v LEPORE*[42] a SPECT scan was used to diagnose dementia. Moreover, in *R v Clay*, *Lonsdale and Jm*[43], a SPECT scan was used to link abnormal perfusion[44] with a psychotic episode.

As discussed above, it has been proposed in a couple of civil cases that fMRI can be used to reveal abnormality of the brain or to examine pain. A common use of PET, SPECT and fMRI is to identify abnormalities of the brain.

3.3.2. History of other image evidence

A review of the history of graphical evidence such as maps or diagrams suggests that these types of evidence were not given any special evidential status until the appearance of photography in the nineteenth century (Goldberg 2010:508). When photographs were initially presented in court, they were seen as the products of artificial and mechanical processes, liable to human manipulation and easily falsified (Goldberg 2010:509). Hence, the epistemic value of photographs was low, similar to the status of fMRI neuroimaging today. Goldberg (2010:510) emphasises that there are two views of objectivity. Truth-to-nature objectivity only aims to present a model or prototype of the object rather than actual

[40] [2001] WASC 263
[41] Hypoperfusion refers to a condition of "decreased blood flow through an organ" (see http://www.merriam-webster.com/medical/hypoperfusion)
[42] [2013] SASCFC 13
[43] [2006] NSWSC 1220
[44] Perfusion refers to "blood flow" (see http://medical-dictionary.thefreedictionary.com/perfusion)

correspondence, and the results are seen from the eye of the artist. An example of this is a hand drawn atlas. However, mechanical objectivity aims to remove human subjectivity by using scientific accuracy. Wigmore (cited in Goldberg 2010:512) suggests that a photograph is not evidence by itself but has to be presented by a credible witness. When X-ray images were tendered in the late nineteen century, the party presenting the X-ray faced the problem that the witness could not show that the images represented the true state of the inner body. However, an attorney in the case of *Smith v Grant* had argued that X-ray images were the products of a reliable and accurate scientific method and hence should be admitted; and earlier history suggested that scientific evidence was admitted from scientists who were considered trustworthy (Goldberg 2010:514-5). In the USA, the requirements for accuracy and reliability were later spelt out in relevant evidence rules such as the Daubert and Frye tests (Goldberg 2010:521-2).

The above discussion by Goldberg (2010:512) provides an avenue for the possible acceptance of fMRI evidence if expert witnesses present it on the basis that the images are produced by a reliable and accurate scientific method. Some scholars have suggested that the method of producing fMRI images is not reliable, and that they can be manipulated by humans in various ways which can affect their accuracy (Aguirre 2014:S13). However, other scholars have expressed confidence in the view that neuroimaging will be accepted by the medical and scientific communities when the images are produced by a reliable and accurate method (Goldberg 2010:505). Moreover, the initial issues for photographs and X-rays were later overcome with improved technologies and the support of expert evidence. This history seems to suggest that fMRI may one day become acceptable by courts when fMRI neuroimaging can be produced reliably and accurately.

An essential feature of fMRI images is that they are not a photograph of the brain but instead show activity in various brain regions when certain cognitive tasks are performed (Roskies 2007:860). Photographs are graphical representations of some real objects while X-ray, CT scans and MRI images are also graphical representations of the inner structure of the brain or body. The graphical representations suggest some one-to-one correspondence or mapping between the objects represented in the photographs or images and the real objects in the world or the internal body structure. With a photograph, we can verify the correspondence by making a trip to visit the object or the location in the external world. With X-ray or MRI images, we can theoretically perform an operation to confirm a tumour, lesion or fracture shown by the images. Hence, there is a visible verification procedure available in case we want to verify the truthfulness of photograph, X-ray or MRI images. fMRI images are different from these other images in that we cannot physically verify the task mechanism represented by the fMRI images. Hence, this aspect poses another challenge for interpreting fMRI images. Nonetheless, despite the above challenges, there are some positive prospects for using fMRI neuroimaging evidence, to be discussed below.

3.4. From criminal law to prospects for fMRI

In the previous chapter, I have discussed the requirements of the criminal law and suggested that the law requires accurate and reliable evidence. Evidence may be related to establishing a lack of relevant mental capacity or proving facts in issue. Expert witnesses have presented neuroimaging evidence in criminal cases. This chapter explores various limitations and translation issues for interpreting a particular type of neuroimaging evidence employing the fMRI technique in criminal cases. In fact, no fMRI neuroimages have been presented in criminal courts in Australia, Canada, England and Wales (Chau 2014:1; Chandler 2015:9; Catley & Claydon 2015:14). There are a few cases in the USA that have involved fMRI. The case of Brian Dugan appears to be the first case involving the submission of fMRI evidence in the sentencing phase when the admission criteria is lower (Miller 2009:1). In the case notes of *United States v. Semrau*[45], the court confirmed and listed a limited number of cases that have referred to fMRI. In the majority of the cases, the defendant or the prosecution referred to fMRI studies rather than actual fMRI neuroimaging images or raised a suggestion that fMRI could be used to establish an excuse.

However, other types of functional neuroimaging such as SPECT and PET have been used in criminal cases. My research of their uses in Australian courts also suggests that SPECT and PET have been used to diagnose diseases. Given fMRI is widely used in clinical settings for pre-surgical planning to identify critical functional brain areas around the region to be operated

[45] 693 F.3d 510 (6th Cir. 2012)

on (Matthews, Honey & Bullmore 2006:732) and numerous uses of fMRI such as in identifying chronic pain conditions (Baliki, Mansour, Baria, & Apkarian 2014:1; Salmanowitz 2015:4), there are no ambiguities in interpreting fMRI images in the medical setting and hence I suggest that fMRI might potentially be used to diagnose diseases and provide relevant evidence to courts in this regard when the relevant circumstances arise.

Moreover, the literature review of the history of photographic evidence suggests that the admission of X-ray was based on a reliable method for producing photographs. Hence, by analogy, fMRI evidence may be accepted if fMRI can be produced by a reliable method. Notably, huge sums of money have been spent in neuroscience research to discover cognitive functions in the brain and fMRI has been successfully used to identify many cognitive functions (Insel, Landis, & Collins 2013:687). Despite many limitations and interpretation difficulties for fMRI neuroimaging evidence, there are no interpretation issues arising in these neuroscience explorations of the cognitive functions. Therefore, a more mature and reliable fMRI technique may lead to some prospects to provide neuroimaging evidence in courts.

Hence, despite many limitations of interpreting fMRI neuroimaging evidence, I argue there are some prospects that fMRI neuroimaging evidence may have the potential to be useful to courts. In the next chapter, I explore a few potential ways that fMRI neuroimaging may be applied in courts. I also propose a hypothetical case when some existing neuroscience research can be used to translate fMRI neuroimaging data into acceptable court evidence to support a conceptual claim that fMRI may be useful in criminal cases.

Chapter 4 - Discussion

4.1. Potential of applying fMRI evidence in court

Despite the limitations noted in the previous chapter, fMRI is extensively involved in research and medical uses. Based on the successful interpretations of fMRI neuroimaging in research and medical applications and other supporting arguments to be discussed, the first proposed prospect of employing fMRI neuroimaging evidence would be to provide a diagnosis of diseases and disorders.

The second prospect is to use fMRI neuroimaging to provide evidence to confirm that some cognitive functions are intact. This second prospect is supported by the fact that fMRI is extensively used in research to identify cognitive functions and widely used in clinical settings for pre-surgical planning to identify critical functional brain areas around the region to be operated on (Matthews, Honey & Bullmore 2006:733).

Based on associations between brain patterns and some psychological attributes, fMRI could offer a better model than behavioural assessment to predict future dangerousness (Nadelhoffer et al. 2012:85). As discussed previously, a prediction of dangerousness is an important parole function to provide protection of the society. With further research, fMRI may one day be able to identify some brain activity patterns or signatures that accurately determine dangerousness (Nadelhoffer 2012:80) and provide another prospect to assist the court in the better performance of the parole function. This prospect may be extended to provide evidence that is based on a strong correlation between fMRI activation and cognitive functions.

Moreover, fMRI may provide information about certain mental states as the fourth prospect to submit evidence about the facts in issue. For examples, research has tried to interpret fMRI activity as having specific mental states, suggesting that one is telling the truth or lying, or indicating knowledge of certain facts from some biomarkers or memory traces (Carver & Robin 2011:198-200). A hypothetical case is used to support a fourth prospect to use fMRI neuroimaging to interpret brain patterns to provide simple “yes” or “no” replies as answers to some facts in issue. The following sections explore these four prospects in more details.

4.1.1. Providing medical diagnosis

I suggest that fMRI has the potential to offer evidence relevant to the diagnosis of diseases and disorders. The main arguments in favour of fMRI are that:

(i) fMRI has been used to identify cognitive functions,

(ii) fMRI is capable of diagnosing some diseases or disorders,

(iii) the interpretation of fMRI seems clear for the scientific and medical communities,

(iv) the technology will further improve as there are more funds being invested into fMRI research,

(v) other forms of functional neuroimaging techniques have been accepted by the court for the diagnossis of diseases and disorders, and

(vi) there are ongoing attempts to submit fMRI evidence and continuing improvments of the fMRI technique, therefore these attempts may one day become successful.

These points are discussed below. I also illustrate the idea with a theoretical example in the criminal context to show that evidence of pain might potentially be admitted. Thereafter, I discuss what I have assumed in the proposal of this prospect.

4.1.1.1. Arguments for the potential to provide medical diagnosis

As discussed before, fMRI is heavily used in neuroscience to identify cognitive functions (Insel, Landis, & Collins 2013:687). For examples, research has found that the right dorsolateral prefrontal cortex (DLPFC) is relevant to moral judgement (Prehn & Heekeren 2009:145), the hippocampi and nearby medial temporal lobes are associated with memory consolidation (Glannon 2010:25). Hence, research suggests that cognitive functions are localised in different brain areas.

Furthermore, fMRI has been employed to diagnose various diseases such as Alzheimer's disease and epilepsy (Lee, Smyser & Shimony 2013), to identify chronic pain conditions (Baliki, Mansour, Baria, & Apkarian 2014:1; Salmanowitz 2015:4), to detect post-traumatic stress disorder (PTSD) (Christova et al. 2015:2695), and to establish the existence of functional disorders, such as conversion syndrome, or chronic neurological diseases such as Huntington's Disease, and schizophrenia (Matthews, Baby & Bullmore 2006:741). Bullmore (2012:1269) suggests that fMRI identifies specific biomarkers that can prove that there is abnormal brain function. The above analysis provides empirical support for the proposition that fMRI can be used to diagnose specific diseases.

Despite the limitations noted in the previous chapter about interpreting fMRI neuroimaging evidence, neuroscientists and medical researchers are not bothered by these interpretation issues. fMRI images provide clear information about where various cognitive functions are located in the brain and correctly identify some diseases and disorders. Evidence of diseases or disorders can be relevant to the court in the determination of guilt. Hence, I argue that fMRI has the potential to provide evidence to the court in this regard.

The future of this possibility is brighter with further ongoing support from the government to fund fMRI-related research (Insel, Landis, & Collins 2013:687). With more research that uses the fMRI technique, there will be further improvement in the fMRI technology. Research may one day create a reliable process to produce fMRI images. The history suggests that X-rays became acceptable to the court after the development of a reliable process for creating X-ray images (Goldberg 2010:505). By analogy, fMRI neuroimaging may become acceptable to the court when a reliable process is available. Therefore, with ongoing and further research using the fMRI technique, it is likely that this research will lead to the development of a reliable process which can provide fMRI evidence that is acceptable to the court.

My review of the Australian court cases involving SPECT and PET neuroimaging evidence suggests that these neuroimaging techniques have been used to diagnose diseases or disorders. My findings confirm a previous research study done by Feigenson (2006:237) that deals with the use of SPECT and PET neuroimaging evidence in American courts. Given that fMRI neuroimaging evidence has also been used to diagnose specific diseases or disorders, when the right situation arises, fMRI evidence may potentially be used in a similar way to the way that SPECT and PET scans are used to offer evidence to courts. Therefore, for some particular diseases or disorders, fMRI can be a useful and reliable diagnosis tool.

Furthermore, the review of functional neuroimaging evidence suggests that, in order to be acceptable to the court, the functional technique proposed must be highly relevant to the relevant disease or disorder. An American court case indicates that the recommended medical diagnosis must have been frequently used with the relevant technique (Feigenson 2006:237). Hence, if the fMRI tool has not been commonly used to diagnose a specific disease or disorder, an expert witness would have a less convincing reason to propose the evidence. In this regard, fMRI evidence might have the potential to provide evidence associated with Alzheimer's disease, epilepsy, or PTSD because fMRI neuroimaging has already been used in diagnosing these conditions.

Lawyers and expert witnesses have been attempting to submit fMRI-related evidence to court. In the case of *Krauss v Comcare*[46], the fMRI neuroimaging technique was viewed as an objective method to detect pain. However, the tribunal was not ready to recognise this objective scientific method for the examination of pain. Similarly, in another AATA[47] case of *Fowler v Repatriation Commission*[48], the fMRI neuroimaging technique was suggested to diagnose post-traumatic stress disorder (PTSD) by identifying some irregularities. No irregularity was discovered from the fMRI examination. Moreover, a couple of American civil cases have mentioned fMRI. In the case of *Van Valen v. Employee Welfare Ben. Com. Northrop Grumman*[49], fMRI evidence was proposed to show decreased cognitive function in patients with CFS [Chronic Fatigue Syndrome]. In the American case of *Smith v. Astrue Civil Action No. 08*[50], the fMRI technique was suggested to diagnose a disability. In summary, most attempts have failed. However it is possible that lawyers and expert witnesses will continue to try using fMRI evidence and they may be successful when the technology has improved significantly.

As discussed above, there have been numerous attempts to bring fMRI evidence before the courts to diagnose a few disorders or diseases. fMRI is already a tool that is used to diagnose some specific diseases or disorders. More relevant research will improve the reliability of such uses, and the level of confidence the court can have in relation to such uses. Hence, I suggest that when fMRI technology (and its applications) becomes much more mature, fMRI will be used to provide admissible evidence to the court to diagnose particular diseases or disorders.

[46] [2010] AATA 722
[47] Administrative Appeals Tribunal of Australia
[48] [2013] AATA 499
[49] 741 F. Supp.2d 756 (W.D. Va. 2010)
[50] 347. (W.D. Pa. Nov 06, 2008)

4.1.1.2. A theoretical example when evidence of pain might be admitted

Neuroimaging evidence of pain may be helpful in both criminal and civil cases. Pain is difficult to measure (Salmanowitz 2015:1). RS-fMRI (Resting-State fMRI, see 2.3.2 for details) can identify chronic pain conditions from changes in the default mode networks (Baliki, Mansour, Baria, & Apkarian 2014:1; Salmanowitz 2015:4). Consider a hypothetical situation, where an offender claims that a prohibited act, such as the acquisition and use of prohibited drugs, or alternatively a violent action, was done because of uncontrollable chronic pain. RS-fMRI could be a tool to identify if the offender has serious pain or not. Such evidence may influence the degree to which the court accepts the defendant's state. In case such evidence is accepted to support a claim that a chronic pain condition is relevant to the criminal act, it might constitute an excuse for the criminal act. The law should be open to such evidence if it sheds light on the real cause of a prohibited act. Chronic pain was proposed to be a mitigating factor in at least one murder case[51] and possibly may be useful to confirm or rebut a relevant fact in issue as in the above hypothetical situation.

4.1.1.3. Assumptions

My argument here assumes that the relevant limitations will be overcome when fMRI technology is more mature and reliable. For instance, the fMRI data currently has to be gathered from a co-operative and willing person because a stable head position must be

[51] *R v Hiroki* [2015] NSWSC 496

maintained. My argument assumes that necessary measures to overcome different technical restrictions can be followed to ensure a trustworthy result. Notably, the defendants may wish to utilise fMRI evidence to claim a lack of relevant capacity (for example, that the defendant's inability to control their movements was due to a chronic pain condition) to minimise the punishment or to seek to provide an excuse. The expert witnesses can explain the basis of the evidence and can translate the fMRI neuroimaging evidence into folk psychological terms. To illustrate, fMRI neuroimaging may support a claim that the defendant has a chronic pain condition that caused an uncontrollable action leading to the criminal act and this may support a relevant defence. To minimise the temporal gap between using current fMRI evidence to infer a past condition, the fMRI test should be done soon after the criminal event. Furthermore, for the fMRI technique to be accepted by the court, the diagnosis technique should be tested, be peer reviewed, have a recognised and manageable error rate, and become approved in the relevant scientific discipline and recognised as meeting a rigorous standard of evidence like the Daubert test. The sample sizes in the related research must be sufficiently significant, and the experimental results must be replicated to be able to support the necessary generalisations. Given that research using fMRI is increasing, it is probable that this may happen.

4.1.2. Assessment of cognitive functions

The second prospect for the use of fMRI evidence in court is the prospect of using fMRI neuroimaging to confirm that a specific cognitive function is intact. This is based on the fact that the neuroscience and medical communities use fMRI in this way without any difficulty in interpreting the fMRI image. Moreover, this usage only involves forward inference. Hence the reverse inference problem is not relevant. Moreover, I illustrate with a theoretical example involving a defendant with blindsight to demonstrate that fMRI evidence can provide evidence concerning a fact in issue. These arguments are discussed next.

4.1.2.1. Arguments to use fMRI neuroimaging to confirm cognitive functions

The second prospect for the use of fMRI evidence in court (which is discussed above) is supported by the fact that the fMRI technique is widely used in scientific research to identify cognitive functions and in pre-surgical planning to identify critical functional brain areas around the region to be operated on (Matthews, Honey & Bullmore 2006:733). Scientific research uses the fMRI technique to identify where different cognitive functions are located in the brain (Insel, Landis, & Collins 2013:687). Similarly, in clinical situations, fMRI neuroimaging is used before neurosurgery to locate the brain areas responsible for various cognitive functions (Bullmore 2012:1270). The information obtained during such pre-surgical planning is used to prepare the strategy to perform the brain operation to avoid any major damage to the brain areas responsible for various essential motor, sensory and language functions (Bullmore 2012:1270). Moreover, after a patient has a stroke, fMRI neuroimaging may be used to review the brain activity before and after treatment to identify the brain locations where the motor functions have been restored (Matthews, Honey & Bullmore 2006:740). Therefore, fMRI has frequently been used to identify cognitive functions like motor, sensory and language functions. Scientists and neurosurgeons can use such information without much difficulty in interpretation. Therefore, I suggest that fMRI is a useful tool to confirm that a specific cognitive function is intact.

4.1.2.2. The second prospect involves forward inference only

In general, fMRI has been used in research to identify which brain regions are activated when a participant performs a specific task or observes a particular stimulus. For example, the fusiform face area (FFA) has been identified as a brain region that is activated when faces are perceived (Kanwisher & Yovel 2006:2109). If the court wants to confirm whether a person can perceive faces, pictures of different faces can be presented to that person to see if there is fMRI activity in the FFA brain region. Detection of fMRI activity in the FFA region when a face stimulus is presented would suggest that the cognitive function of perceiving faces is intact.

Notably, the above example only involves a forward inference and not a reverse inference. The process only tries to test if a face stimulus can activate the FFA area. It is different from a reverse inference process of trying to identify which task or stimulus has activated the FFA area. Therefore, the reverse inference problem is not relevant in the second prospect for the use of fMRI evidence in court.

In a criminal context, there are possibly some situations that may require the court to verify whether a cognitive function is intact. For example, a defendant or a witness may need to show that he or she has the appropriate capability demanded by the court process. I illustrate this below with a theoretical example showing that fMRI can provide evidence concerning a fact in issue.

4.1.2.3. Theoretical example involving a person with blindsight

The following theoretical example involves a person with blindsight. In the example, I try to show that the fMRI technique can be used to obtain evidence when behavioural evidence is not available to achieve the same purpose. People with blindsight do not have normal vision but may make a response to an object despite extensive damage to the primary visual cortex (Eysenck & Keane 2010:62; Schmid et al. 2010:373). Schmid et al. (2010:373) suggest that fMRI activity in the thalamic lateral geniculate nucleus (LGN) would indicate that the person can still sense an object despite the fact that he or she is not consciously aware of that object.

For example, a defendant with blindsight may want to claim the defence of diminished capacity. In other words, the defendant may wish to argue that he lacked the capacity to perceive the victim and therefore he did not intend to throw a heavy object to kill the victim. The defendant might try to convince the court by submitting the results of a few behavioural tests to suggest that he did not have the relevant capacity. However, behavioural tests may be falsified with countermeasures and the defendant may deny perceiving any visual stimuli.

In this example, fMRI may be used to discover whether the defendant has the ability to respond to a stimulus. This is achieved by observing fMRI activity at the LGN when an object is presented to the defendant. The defendant cannot use any countermeasures because he or she lacks normal vision and does not have any perception or awareness of the object. However, the presence of fMRI activity in the LGN suggests that the defendant can still sense and respond to a visual stimulus. It is impossible to use behavioural evidence to prove that a defendant with blindsight cannot respond to visual stimuli. However, fMRI evidence could have the advantage of being able to confirm this possibility.

The defendant is protected by the privilege against self-incrimination and can remain silent. However, if the defendant raises an affirmative defence that may lead to an acquittal, the defendant has the evidential burden to provide sufficient evidence to establish the defence (Finlay & Kirchengast 2015:22; see 2.1.4. for details). The prosecution may persuade the court that the behavioural test used by the defendant is inadequate to prove that the defendant lacked the capacity to respond to a visual stimulus unless the relevant fMRI test is used. I have assumed that the fMRI method is a proven and established procedure for discovering whether a specific cognitive function, namely the ability to respond to visual stimuli, is intact.

4.1.2.4. Summary

The second prospect for the use of fMRI evidence in court is possible but may require further research. Using fMRI to identify cognitive functions is common in neuroscience (Insel, Landis, & Collins 2013:687). Rosen & Savoy (2012:1318) suggest that the use of fMRI in pre-surgical planning (to identify cognitive functions in various brain regions) is growing but has not yet been widely adopted and may not be widely adopted until there are well-controlled studies. However, the example involving a defendant with blindsight suggests that fMRI evidence would be in demand when behavioural evidence is lacking. Hence, Neurolaw research may further investigate the situations where behavioural evidence is lacking and fMRI evidence is possible.

4.1.3. Predictions based on strong correlations

If there is a strong correlation between a particular behaviour and a neuro signature that is identified by fMRI activity in some specific brain areas, fMRI neuroimaging can play a role in the criminal system by predicting the particular behaviour. For example, fMRI neuroimaging could potentially be used to predict future dangerousness. Such use of correlational evidence is further supported by a theoretical argument that new brain-based criteria may replace the existing and popular behavioural criteria. Even though correlational evidence may be subject to error, it can be useful. For example, other types of correlational evidence like DNA[52] and fingerprinting are offered as evidence despite the fact that they are subject to error. In this section, I suggest that the priming technique can be used in further research to reduce countermeasures and hence improve the reliability and accuracy of correlational evidence. I also highlight some other potential uses for correlational evidence.

[52] Deoxyribonucleic acid (see http://ghr.nlm.nih.gov/handbook/basics/dna)

4.1.3.1. Predicting future dangerousness

When a convicted accused has served the non-parole period of their prison sentence, which is the minimum period of time in prison to which they have been sentenced, the parole office has to assess the future dangerousness of the prisoner before releasing him or her back to the community. In the Crimes (Administration of Sentences) Act 1999 (NSW) s 135A concerns the topic "Preparation of reports by Probation and Parole Service", and sub-section (b) requires an assessment of "the risk of the offender re-offending while on release on parole, and the measures to be taken to reduce that risk". If there is a significant chance of future dangerousness and the prisoner is released without adequate monitoring and safeguards in place, the community will be at significant risk. Hence, good tools for assessing the future dangerousness of the prisoner is essential and fMRI neuroimaging may have potential to satisfy this need.

Nadelhoffer et al. (2012:80) are confident that research on psychopathy can provide a good framework for predicting future violence. They suggest that the test using criteria from the Psychopathy Checklist-Revised has been proven to provide a good prediction of violence but it has the disadvantage of being time-consuming. They have identified from the psychopathy research that there are neural correlates of psychopathy at various brain regions such as the amygdala, and ventromedial prefrontal cortex. They further explain that the technique of multi-voxel pattern analysis (MVPA) has been successfully used in mind-reading. MVPA uses the complicated patterns of fMRI activity at many brain locations to infer some meaningful information about the mind. Hence, they suggest that MVPA may provide a more promising avenue for predicting future dangerousness than current human assessments.

Some research investigates the relationship between neuro correlates and violence. For example, research on psychopathy may in the future provide a good method for predicting violence (Nadelhoffer et al. 2012:85). Glannon (2014:154) also suggests that neuroimaging research might identify biomarkers which can be used to predict criminal behaviour. Moreover, another research study suggests that the fMRI tool can be used with an impulse control test to predict the likelihood of rearrest after release from prison (Aharoni et al. 2014:332). The research suggests that higher fMRI activity in the brain region called the anterior cingulate cortex (ACC) has been found to be a good predictor of rearrest (Aharoni et al. 2013:6224).

<u>4.1.3.2. A theoretical argument that new criteria may be better</u>

In theory, brain states, which are not visually observable, can provide the criteria to define a cognitive process instead of the observable behavioural criteria (Nadelhoffer 2011:209; Levy 2014:173). A criterion provides the definition or meaning of a concept while a symptom provides the evidence to support a criterion (Nadelhoffer 2011:209). For example, water has been described by some old criteria such as freezing at zero degrees and boiling at one hundred degrees. However, with scientific advances, water is now better described with a new criteria or the chemical formula H_2O (Nadelhoffer 2011:209; Levy 2014:177). By analogy, fMRI may one day be able to identify some neuro correlates or signatures that accurately describe and determine dangerousness (Nadelhoffer 2012:80).

4.1.3.3. Non-perfect evidence may still be acceptable

In general, a prediction based on correlation only requires the two related variables to covary in a reliable and significant way. If there is a proven correlation between a specific brain state and a personal feature, the appropriate brain state can be used to indicate that the related personal feature is present (Craver & Robins 2011:197-8). Craver & Robins (2011:198) suggest that DNA[53], eyewitness accounts and fingerprinting are suitable sources of evidence despite the fact that they can be wrong.

The reliability of DNA evidence depends upon the number of distinct loci or sites available in a DNA sample. Hence, DNA matching may have low accuracy if the matching only uses a few loci. For example, from a database of 65,493 persons, 122 and 20 potential suspects can respectively be found when 9 or 10 loci are used (Ungvarsky 2007:12). From this example, when just 9 loci are used for the DNA matching, there could be 122 suspects within the database who can fit a specific DNA test. However, with more loci, there will be a lesser number of potential suspects. DNA may use up to 13 loci and hence the chance of error in matching would be reduced if more loci are available for matching.

[53] DNA tests are based on some unique DNA patterns or loci (Griffith & Roth 2006:8). As cited in Griffith & Roth (2006:2), a submission suggests "UNSWCCL, n 1, p 37. Of DNA evidence, it was explained - 'First, it is not 100 per cent accurate. Second, it is susceptible to various interpretations by experts. Third, it is only one piece of evidence that goes to establishing the guilt of an accused'." DNA evidence is based on the degree of matching of 13 loci or sites between the DNA of a suspect and that obtained at the crime scene (Ungvarsky 2007:11).

In the above discussion, the chance of a false positive can be high when the number of loci used in DNA matching is small. In such a situation, the DNA matching cannot conclude that the DNA sample must have come from a particular defendant because there are many potential suspects. In other words, an issue similar to reverse inference can occur as a unique suspect cannot be identified from the DNA sample. To prevent the reverse inference problem, the number of loci used must be sufficiently large.

To reduce the chance of a false positive and mistaken reverse inferences when fMRI neuroimaging is involved, there should be a high correlation between the fMRI activity and a particular behaviour. Although correlation does not give any explanation about why the specifics covary, a strong correlation suggests a higher chance that one factor links to the second factor. Moreover, a strong correlation can inspire research to explain the phenomenon. Furthermore, correlation does not describe cause and effect. When correlation evidence is pertinent and admitted, it would have to be weighed with other evidence, for example, DNA, eyewitness accounts, fingerprinting, and so forth.

4.1.3.4. A suggestion to reduce countermeasures

Countermeasures can be reduced through the use of test strategies that may elicit brain activity without the awareness of the test participants (Pallarés-Dominguez & González Esteban 2015:6,8). In other words, if a task or stimulus can automatically trigger some fMRI activity in specific brain regions, the correlation between the task or stimulus with the fMRI activity is not affected by personal strategies employed by the participants. In neuroscience research that uses the fMRI technique, priming can produce automatic responses. In priming experiments, certain stimuli could be presented fleetingly. Very brief stimuli are not detectable by the test participants but could influence their decision making (Dehaene et al. 1998:597). The existence of automated responses is backed by research that finds people might lack conscious awareness and control of implicit attitudes (Stanley, Phelps & Banaji 2008:164). For example, there was a research study which found that if a black face was presented rapidly without the conscious awareness of a test participant, the test participant appeared to answer faster in relation to bad words, showing some implicit biases against black people (Lane et al. 2007:72). In brief, a test for dangerousness may be more reliable if test stimuli can elicit automatic and unconscious responses to avoid any possibility of the test participants employing countermeasures to defeat the test.

4.1.3.5. Other possible uses that rely on strong correlation

Another place where functional neuroimaging may be useful is in malingering and lie detection. This involves determining neural correlates as biomarkers for lying. Many brain regions have been recognised to be relevant including the prefrontal-parietal region, left inferior frontal cortex, and the limbic system (Langleben 2008:4). Accuracy and reliability are improving for fMRI lie detection tests, and there is high demand for this type of test. Therefore, it is possible that research may produce special fMRI lie detection tests in the foreseeable future that can achieve the level of reliability and accuracy required by the court (Langleben 2008:5). In many cases, experimental conditions and real life situations are not compatible and hence methods used in the laboratory may not be applicable to the real life environment. To overcome this issue, data collected from real-life situations have been used as test inputs. For example, the test participant could bear a camera to record events in a day, and the recordings are later used as inputs for the detection test (Meixner 2015:513).

In brief, prediction of future dangerousness with the fMRI technique is a potential prospect that may improve the parole aspect of the criminal law system. This prospect is based on the potential availability of a strong correlation between a neural signature and violence. In a similar context, evidence based on strong correlation may in the future help the court to determine facts in issue such as whether a person is lying or not.

4.1.4. Providing evidence based on simple mind reading

Some research suggests that simple mind reading capability may be relevant to provide evidence about a fact in issue. The following discusses several research studies that try to identify from fMRI activity at some specific brain locations whether the participant is giving a "yes" or "no response. The next section will discuss a hypothetical case to apply such research findings in the criminal context.

It is important to realise that a person in a vegetative state may show activity in different brain areas when asked to perform some tasks by imagining. Owen et al. (2006:1402) conducted a research study involving participants in a vegetative state and trained each participant to imagine playing tennis and walking through his or her home. The researchers identified that the former imagination task triggered fMRI activity in the motor cortex and the latter task caused fMRI activity in other brain regions.

Moreover, in a research study to see if patients can alter their mental states to indicate either a “yes” or “no” answer, participants were asked to imagine swinging an arm to hit a tennis ball to give a “yes” response and walking between rooms in their own houses to give a “no” answer. Five out of fifty-four patients who experienced traumatic brain injury, and all healthy control participants could alter their mental states as instructed (Monti et al. 2010:583).

Furthermore, Naci et al. (2013:9386) trained each participant to count a target word that could either be “yes” or “no”. In the test stage, a question was asked which would require a “yes” or a “no” response. The question was then followed by a sequence of forty words including approximately ten “yes” words and other number words. The same question was then repeated, but the subsequent sequence of forty words would only include the “no” words and other number words. If the participant wanted to respond with a “yes”, the participant needed to count the number of “yes” words in the first block, otherwise, the participant would have to count the number of “no” words in the second block. When the participant was counting, he or she needed to use focused attention to look for the relevant words and such action would activate specific areas of the brain that were previously identified to be relevant to mental arithmetic calculations (Naci et al. 2013:9390).

Notably these approachs to identify “yes” and “no” responses agree with the mechanistic model of the mind and are not affected by brain plasticity. In the research discussed above, the research assumes that different tasks can trigger fMRI activity in different brain areas. For example, playing tennis would activate the motor cortex. The mechanistic model of the mind supports the idea that a function or activity can be identified with some brain processes, and each brain process is localised within one or more brain regions (Bechtel 2002:232). There are really no concerns for the mechanistic model that the function is done in multiple brain areas or new places resulting from brain plasticity because the mechanistic model simply requires a function to be performed in specific brain regions.

In case there is a need to obtain evidence in the form of “yes” and “no”, methods using the fMRI technique are readily available. A hypothetical case is used below to demonstrate this possibility.

4.2. A hypothetical case

I propose a hypothetical case to adduce evidence using the research findings discussed above. In this hypothetical situation, I imagine that a man with locked-in syndrome has been attacked, or alternatively, that a man becomes locked-in after a serious assault. A person with locked-in syndrome still has an intact brain but generally cannot provide behavioural responses, however, some of them may provide answers by blinking their eyes (Pardo &

Patterson 2011:184-5). I further imagine that the victim cannot provide any behavioural responses such as eye blinking. In this situation, the research findings discussed above can be used to elicit evidence from the victim by asking questions that only require either a “yes” or “no” answer to each fact in issue. Therefore, fMRI neuroimaging would be most useful to obtain evidence from a victim with locked-in syndrome who is also unable to provide any behavioural response.

The court may accept testimony evidence from a victim with locked-in syndrome if the process is commonly accepted as a means of communicating with people with locked-in syndrome. Moreover, such communication would also be ideal for interacting with family members or hospital staff to indicate treatment preferences or decisions about life. The practice may become proven and reliable within the foreseeable future following further research and sufficient replication of experimental results. In the hypothetical case, the victim is assumed to be a person who is willing to cooperate to perform the fMRI tasks in order to give evidence. Therefore, the legal limitation to compel the defendant to undergo an fMRI test is not relevant here as the hypothetical case only concerns getting evidence from a victim witness. To make sure that the victim is indeed willing to provide evidence, we can ask him whether he is willing to do so and use the same method to obtain a “yes” or a “no” answer. Given that the hypothesised victim cannot give any behavioural responses, fMRI evidence specifically takes over the function of behavioural evidence. It is a case when neural evidence is most relevant and behavioural evidence is completely inadequate. Neuroimaging may provide useful information when the required behavioural evidence does not exist or cannot provide sufficient details to answer a fact in issue (Morse 2011:853). Moreover, the technique to communicate with the victim can be easily translated into folk psychological terms. For instance, the fMRI activity in the motor cortex can be interpreted as "yes", otherwise, the fMRI activity in the other brain areas would suggest a "no" response.

The simplicity of the hypothetical scenario creates a greater likelihood that the prosecution will overcome the legitimate concerns that neuroimaging evidence may introduce prejudicial bias. Researchers suggest that neuroimaging evidence is seen as an objective way to reveal the mechanisms of the brain and such a conception may bias the jury towards placing more weight on the neuroimaging evidence than necessary (Feigenson 2006:248; Kulich, Maciewicz & Scrivani 2009:373). Given that behavioural evidence is not available in the hypothetical case and the fMRI activity in the relevant brain regions can reliably and easily be interpreted as "yes" or "no" to answer facts in issue, the court may recognise that such tests are ideal in this hypothetical situation. The colouring system of the fMRI images may not present difficulties to the court. For instance, the activity in the motor cortex is viewed as a "yes" response. Moreover, the jury assess the victim's responses to various relevant and control questions to make a logical decision about whether the evidence is accurate, reliable, and consistent.

The hypothetical case is not affected by the methodological limitations of fMRI and other issues relating to fMRI. A person with locked-in syndrome rarely moves, the victim could be physically secured in the fMRI tests and the issue caused by head movements is totally irrelevant. As all the fMRI measurements would be extracted from the same person, this approach avoids the problem of using group or average results to make conclusions about an individual.

Though it may be possible that there are other tasks which can trigger fMRI activity in the target regions, this reverse inference issue can be minimised by reviewing the task design to prevent accidental triggering by these unwanted tasks. The reverse inference problem is one of the major limitations of fMRI and suggests that fMRI is unlikely to identify a unique cognitive process causing the fMRI activity in some brain areas. However, there are some relevant research findings which may overcome this problem or improve the accuracy of making reverse inferences. Notably, the accuracy of a reverse inference may be higher if the relevant brain regions are only selectively activated by few particular processes (Poldrack 2006:2). Conversely, if there are many cognitive processes that can activate certain brain regions, the inference that a particular cognitive process has activated those regions would be subject to the reverse inference issue and this would result in a lack of certainty that that particular process has activated the regions. The precision of a reverse inference would be higher in relation to smaller brain regions because smaller regions would only be activated by a lesser number of cognitive processes (Poldrack 2006:2). This notion suggests that a reverse inference can be improved with a finer spatial resolution of fMRI neuroimaging. Moreover, a statistical calculation can be used to estimate the accuracy of a reverse inference using a database[54] that records associations between particular brain regions and cognitive processes (Poldrack 2006:2). Hence, with further research and discoveries, the reverse inference issue may be overcome or controlled. In all cases, researchers can boost the court's confidence in the translation of the fMRI results by using a more stringent process and design such as by asking more control questions and setting up the questions clearly.

[54] BrainMap (http://www.brainmap.org) may be one of such databases (Poldrack 2006:2)

The responses required in the hypothetical case are simple “yes” and “no” answers to concrete questions. There are significantly fewer difficulties in interpreting the data for the hypothetical case than in other instances. In contrast, there are more interpreting difficulties in other instances such as the task of screening for psychopathy which might contain tasks to detect the level of activity in the paralimbic network (Hughes 2010:341). The methods for screening psychopathy can be much more abstract and complex in nature and also the level of activity can overlap between psychopaths and non-psychopaths. Therefore, the level of fMRI activity can be very difficult to understand and interpret when compared to identifying fMRI activtiy at different locations of the brain. Moreover, these methods for screening psychopaths may also need many coherent trials to determine the correlations between brain regions and psychopathy and also face the problem of comparing the group average to an individual (Greely & Wagner 2011:780; Mackintosh 2011:7). In contrast, the hypothetical case only needs fMRI activity in two distinct brain areas for classifying the reactions into either “yes” and “no”. Compared to other uses of the fMRI technique such as screening psychopaths, the hypothetical case should have a better opportunity to overcome a smaller number of limitations and be accepted by the court.

4.2.1. Importance of the hypothetical case

The law serves everyone. Some studies provide methods to obtain “yes” and “no” responses with the fMRI technique. Such research findings can offer an opportunity to be used in court to obtain “yes” or “no” responses from people suffering locked-in syndrome who are unable to respond behaviourally. In the unusual circumstance of a victim with locked-in syndrome who cannot provide verbal testimony, fMRI could serve to let the victim present evidence about facts in issue. Though the possibility that there is a victim who also suffers locked-in syndrome may be minimal, the chance might not be zero.

The successfulness of fMRI research to provide evidence is limited. Scholars are arguing whether fMRI will be useful or not. The hypothetical scenario offers support for a conceptual claim that fMRI can be helpful in a criminal context.

The scenario may rarely arise in the criminal context. However, the potential to apply fMRI in the manner described in the hypothetical case might be higher in other areas of law. For example, fMRI may be beneficial to help individuals in a vegetative state to consent to treatments or to express their testamentary wishes. The effective method of obtaining two alternate responses of "yes" or "no" can lead to further research to investigate methods for obtaining answers to questions having more than two possibilities. For instance, decoding fMRI activity distributed across multiple brain areas may allow us to interpret various mental states (Haynes & Rees 2006:524). If such future research is successful, a person in a vegetative state may indicate his or her wish to see a particular person if images of various persons can be incorporated into the task design.

Therefore, the hypothetical case is important because it suggests a particular application of fMRI in unusual circumstances to obtain evidence from a person with locked-in syndrome. The case also provides assistance to researchers wanting to understand different psychological states with fMRI. Future research may look into applying the same technique to other persons with communication deficits. Moreover, in the broader field of Neurolaw, the hypothetical case and other prospects discussed above provide a few examples to support the stance that fMRI could be applied in the criminal context in the debate of whether fMRI would have potential to be useful in court.

Moreover, I can identify from the hypothetical case a set of criteria for further research to find methods that could be useful to the court. These criteria are discussed below.

4.2.2. Implications from the hypothetical case

Based on the hypothetical case, a method using the fMRI technique can be useful to the court if the method used to obtain evidence has some unique features that I will describe below.

Firstly, all the evidence is obtained from a single person. This process avoids the problem of utilising group information obtained via various tests to match against a single person.

Secondly, the hypothetical case only requires consistent and distinct brain activity for each answer. Various persons have different brain structures. For example, behaviours can lead to changes in brain volume (Zatorre, Fields & Johansen-Berg 2012:530). Therefore, there are no concerns that the function is performed in multiple brain areas or new places as a result of brain plasticity.

Thirdly, the individual can learn the procedure quickly and reliably. Pre-training is not needed and significantly less than five minutes is required to identify where the fMRI activity is located for each question requiring an answer of “yes” or “no” (Naci et al. 2013:9385). A brief learning period suggests that the task is simple and can be done by everyone. The law assumes only minimal capacity of each person, and hence, a straightforward task ensures that most individuals have sufficient capacity to meet the legal assumption. Furthermore, an easy task means that the interpretation of the fMRI results is likely to be straightforward, and the jury can easily understand the method.

Moreover, control questions can be used to test and ensure the consistency of the answers. The law requires evidence to be accurate and reliable for pertinent facts in issue. Control questions serve to enhance the reliability of the answers, improve the court’s confidence in the responses, and provide an estimate of the accuracy of the responses.

Therefore, future research may identify applications that meet these four unique features to ensure the methods can overcome many limitations.

4.3. Chapter Summary

Although fMRI is currently rarely admitted in court (because of the numerous limitations discussed above), I have proposed four prospects for employing fMRI in the legal context. The first prospect would be to provide evidence to diagnose diseases or disorders in a similar way to the way that other forms of functional neuroimaging techniques such as PET and SPECT are used.

Secondly, fMRI has also been involved in rehabilitation and pre-surgical planning to find out whether cognitive functions are intact. Hence, fMRI could be utilised in the criminal context to confirm that relevant cognitive functions are intact. For example, this method may be used in specific situations to rebut deceptive claims submitted by offenders wanting to avoid taking responsibility for their actions.

Thirdly, fMRI may be used to demonstrate a substantial correlation between fMRI activity and facts in issue. A significant amount of research indicates that there is potential to use fMRI activity to predict future dangerousness, and potentially to determine if someone is lying or not.

Fourthly, the hypothetical case provides a possible situation in the criminal context when simple mind-reading research might be deployed to elicit evidence from a victim who is suffering locked-in syndrome and who cannot offer behavioural evidence. Although there is a low probability that the hypothetical case would occur in reality, the case is vital since it offers a particular application in an unusual but possible scenario when evidence can be obtained from a victim with locked-in syndrome. The case supports research which shows that various mental states can be recognised using the fMRI technique. Furthermore, the hypothetical case provides a positive conceptual claim to support the proposition that fMRI can be useful in the criminal context.

In addition, the hypothetical case offers a set of criteria setting out when fMRI might be useful to courts and would be used to identify further research areas. Four criteria have been identified. Most of the evidence is obtained from a single person and it only requires a consistent and distinctive brain pattern for each answer. Moreover, the individual can learn the task quickly and reliably. Finally, control questions can be used to check and confirm the accuracy and reliability of the answers.

Chapter 5 - Conclusion

I began by asking why fMRI evidence has not been presented in Australian criminal courts despite the fact that fMRI has been extensively used in research to investigate and discover cognitive functions. This lead to my research question which asked whether fMRI neuroimaging has any potential to be useful to the court.

I have confirmed that there is a lack of admissions of fMRI evidence by researching the literature and court cases in Australia and the USA. Research suggests that fMRI functional neuroimaging evidence has not been presented in Australia, Canada, England and Wales (Chau 2014:1; Chandler 2015:9; Catley & Claydon 2015:14). Moreover, my research into American court cases suggest that there has been limited submissions of fMRI evidence, and mostly the court cases only refer to fMRI studies instead of actual fMRI neuroimaging data. In some cases a request is made to the court to have the defendants examined using the fMRI technique to confirm a lack of relevant capacity and, therefore, demonstrate that the defendant is incompetent to be executed.

Hence, one possible answer to my question is that there are too many limitations to allow any significant admissions of fMRI neuroimaging evidence in court. In Chapter 3, I researched the literature and summarised the limitations of fMRI. In brief, the folk psychological view suggests that fMRI evidence requires translation by expert evidence. Accurate and reliable translations may be problematic because of the reverse inference and brain plasticity problems. Head movement can affect the accuracy and reliability of fMRI measurements. In addition, fMRI research has not reached the level of full scale testing and has not ben validated by sufficient replication. Moreover, the prosecution cannot compel the defendant to undergo fMRI tests and this restriction will therefore limit the use of fMRI evidence in court.

However, there are several main findings and arguments which suggest that fMRI neuroimaging evidence will become accepted by the courts and that it has potential to be useful to the court. Firstly, there is an increasing amount of scientific and medical research which uses the fMRi technique to discover and investigate cognitive functions. The fMRI neuroimaging technique may be improved in the future to offer the reliability and accuracy demanded by the court. Secondly, the history of imaging evidence suggests that tools like X-rays became acceptable to the court as evidence when there was a reliable way to produce those X-ray images (Goldberg 2010:520). By analogy, this historical trend suggests that when fMRI neuroimaging develops to the point where reliable fMRI neuroimaging outputs can be produced, fMRI neuroimaging will become acceptable to the court. Thirdly, as per my research, other forms of functional neuroimaging techniques like PET and SPECT have already been accepted to diagnose disease and disorders both in the USA (Feigenson 2006:237) and in Australia. Given that fMRI is extensively used in medical areas to confirm that cognitive functions are intact and diagnose a number of specific diseases and disorders, it appears that when the right situation arises, fMRI neuroimaging evidence can be used to offer the court evidence of a diagnosis of a particular disease and disorder.

Based on these arguments, I have concluded that there are a few significant prospects for fMRI neuroimaging evidence to be useful to the courts. Moreover, I have proposed the hypothetical case to make a conceptual claim that it is possible to have a clear interpretation of fMRI neuroimaging evidence with the help of a couple of existing mind-reading research techniques. In that situation, fMRI evidence can provide answers to facts in issue when behavioural evidence is not available. This finding is significant as it demonstrates the unique usefulness of fMRI evidence in a rare but possible imagined scenario. Additionally, my arguments also provide positive support to the proposition that fMRI neuroimaging can be useful to the court, which is the subject of ongoing debate. Hence, I have provided justification for my theory that there is potential for using fMRI neuroimaging evidence in court.

Moreover, I have discussed a few directions for further research. In the discussion about using fMRI evidence to test whether a defendant with blindsight can claim that he or she did not notice the victim, I suggested that research should look for situations when fMRI evidence can provide relevant evidence while behavioural evidence cannot do so. This approach is supported by the hypothetical case where I have highlighted that there are already a couple of empirical methods used in research that can be applied in court to obtain evidence from fMRI activity in the brain of a victim who cannot provide behavioural responses. In addition, I suggested that the priming technique can be used in further research to obtain a more reliable and accurate correlation between stimuli and fMRI activity because participants are not aware of fleetingly presented stimuli and therefore they cannot use countermeasures.

In conclusion, my research findings support my thesis that there is potential to apply fMRI evidence in court.

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