The case for pain neuroimaging in the courtroom: lessons from deception detection

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ABSTRACT

From an observer’s perspective, pain is a fairly nebulous concept—it is not externally visible, its cause is not obvious, and perceptions of its intensity are mainly subjective. If difficulties in understanding the source and degree of pain are troublesome in contexts requiring social empathy, they are especially problematic in the legal setting. Tort law applies to both acute and chronic pain cases, but the lack of objective measures demands high thresholds of proof. However, recent developments in pain neuroimaging may clarify some of these inherent uncertainties, as studies purport detection of pain on an individual level. In analyzing the scientific and legal barriers of utilizing pain neuroimaging in court, it is prudent to discuss neuroimaging for deception, a topic that has garnered significant controversy due to premature attempts at introduction in the courtroom. Through comparing and contrasting the two applications of neuroimaging to the legal setting, this paper argues that the nature of tort law, the distinct features of pain, and the reduced vulnerability to countermeasures distinguish pain neuroimaging in a promising way. This paper further contends that the mistakes and lessons involving deception detection are essential to consider for pain neuroimaging to have a meaningful future in court.

KEYWORDS: fMRI, courtroom, deception, neuroimaging, pain

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INTRODUCTION

Why are bruises so perversely satisfying? Despite the aesthetically unpleasant discoloring of the skin that accompanies them, bruises serve as an externally visible signal that effectively communicates and legitimizes pain. Unfortunately, the majority of pain that people endure does not manifest itself through bruising, and subjective measures are frequently used to rate and quantify levels of discomfort. Consequently, there is often a disconnect between an individual’s perception of pain and an observer’s understanding of its degree or intensity.\(^1\)

Neuroscience research has produced many significant findings over the past decades, including localizing specific functions to certain regions or circuits within the brain. However, there is no unified neural area devoted to pain processing, as it involves a multifaceted ‘matrix’ distributed across many neural regions.\(^2\) While our comprehension of the phenomenon is constantly evolving, within the past two years, functional magnetic resonance imaging (fMRI) studies have greatly accelerated the field\(^3\) through identifying and modeling ‘neural signatures’ of pain.\(^4\) These measures can detect the presence of acute and chronic pain and distinguish them from other sensations, such as reactions to non-painful heat as well as feelings of social rejection.\(^5\) Not only are these findings important in the domain of neuroscience, but they are also pertinent to the realm of tort law.

Current tort doctrine distinguishes between physical, emotional, and invisible harms. Pain, especially of the chronic subtype, is considered an invisible harm, which includes physical or emotional injuries that cannot readily be seen by an observer.\(^6\) Courts impose a high threshold of proof for these harms, in part due to the lack of objective measures available to identify or quantify them.\(^7\) The recent advancements in pain neuroimaging have thus piqued the interest of legal scholars for their possible application to tort law, particularly with regard to their potential for demonstrating the presence of pain in plaintiffs.\(^8\)

The concept of employing neuroimaging as an objective measure in the courtroom is neither novel nor inconceivable. Over the past few years, neuroscientists, legal scholars, ethicists, and even judges have had to deal with the question of using neuroimaging for lie detection in trials.\(^9\) The science is still in its infancy, but this topic has nevertheless garnered significant controversy and debate. Furthermore, despite the overlap in proposed applications, a comparative analysis of fMRI for pain versus deception detection

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\(^1\) See Tor D. Wager et al., An FMRI-Based Neurologic Signature of Physical Pain, 368 NEW ENG. J. MED. 1388, 1389 (2013).
\(^2\) Michael C. Lee & I. Tracey, Imaging Pain: A Potent Means for Investigating Pain Mechanisms in Patients, 111 BRIT. J. ANAETH. 64, 65 (2013).
\(^3\) Eg Adam J. Kolber, Will There Be a Neurolaw Revolution?, 89 IND. L.J. 807, 831–833 (2014).
\(^4\) Maria J. Rosa & Ben Seymour, Decoding the Matrix: Benefits and Limitations of Applying Machine Learning Algorithms to Pain Neuroimaging, 155 PAIN 864, 865–866 (2014).
\(^5\) Wager et al., supra note 1, at 1395.
\(^6\) Shaun Cassin, Eggshell Minds and Invisible Injuries: Can Neuroscience Challenge Longstanding Treatment of Tort Injuries?, 50 HOUS. L. REV. 929, 933–937 (2013).
\(^7\) Id. at 937, 938.
\(^8\) Eg Jean M. Eggen & Eric J. Laury, Toward a Neuroscience Model of Tort Law: How Functional Neuroimaging Will Transform Tort Doctrine, 13 COLUM. SCI. TECH. L. REV. 235, 298 (2012).
\(^9\) Eg Martha J. Farah et al., Functional MRI-Based Lie Detection: Scientific and Societal Challenges, 15 NATURE REV. NEUROSCI. 123, 127–128 (2014).
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is largely absent from the current literature. This article will therefore briefly summarize recent studies in both pain and deception neuroimaging, explore commonalities between the two techniques and their respective applications to the legal system, and conclude with an analysis of several key differentiating factors. Contrasting fMRI for pain versus deception detection is necessary to determine whether pain neuroimaging will find a place in the current tort system or fade into oblivion in spite of its potential promise.

THE NEUROSCIENCE BEHIND PAIN NEUROIMAGING

Recent advancements in pain neuroimaging have employed fMRI technology, which provides an indirect measure of brain activity during various tasks. The basic premise of this technique is that more engaged areas of the brain will require higher levels of oxygen, which is transported via the hemoglobin found in red blood cells. fMRI technology detects changes in the blood oxygen level-dependent (BOLD) signal, and researchers can subsequently display this information by superimposing a ‘map’ of active areas over a structural image of the brain. The highlighted regions reflect the difference in activity during a task versus that during resting state. In analyzing imaging results, researchers can use computer algorithms created with preliminary sets of data to predict activation patterns in subsequent datasets (‘Machine Learning’).

fMRI experiments have been conducted to elucidate both acute and chronic pain processes. While a multitude of studies have made important contributions to the field, this paper will focus on recent findings that purport to show a pain signature, which allows for detection on an individual level. In 2011, Brown and colleagues applied thermal stimuli to the forearm of healthy participants in two different conditions: hot but not painful, and painful (to an intense but not unbearable level). Via Machine Learning techniques, the researchers utilized fMRI data from a subset of subjects to create algorithms for these two conditions. When used to analyze activity patterns from the remaining subjects, the algorithm correctly differentiated between painful and non-painful stimuli with 81% accuracy. Moreover, the authors found increased activity during the painful conditions in areas commonly associated with the pain matrix, such as the primary and secondary somatosensory cortices as well as the insular cortex. Using a similar paradigm, Wager and associates reported a pain signature with 93% accuracy. In two subsequent follow-up tasks, the researchers distinguished acute pain from social feelings of rejection, and demonstrated the reduction of prediction accuracy upon giving participants analgesic medications. Furthermore, as a testament to the field’s increasingly complex understanding of pain, Favilla and colleagues employed Machine Learning to analyze neural activation in patients receiving injections of ascorbic acid while gathering their self-reports of pain intensity. Interestingly, the researchers

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10 Eg Daniel D. Langleben & Jane C. Moriarty, Using Brain Imaging for Lie Detection: Where Science, Law and Research Policy Collide, 19 PSYCHOL., PUB. POL’Y L. 222, 223 (2013).
11 Id. at 223.
12 Rosa & Seymour, supra note 4, at 864, 866.
13 Justin E. Brown et al., Towards a Physiology-Based Measure of Pain: Patterns of Human Brain Activity Distinguish Painful from Non-painful Thermal Stimulation, 6 PLoS ONE e24124, 2–7 (2011).
14 Wager et al., supra note 1, at 1389, 1396.
15 Stefania Favilla et al., Ranking Brain Areas Encoding the Perceived Level of Pain from FMRI Data, 90 NEUROIMAGE 153, 159–160 (2014).
ranked brain areas according to their time course in contributing to the perception of pain, specifying regions most associated with perceived pain intensity. For example, whereas the mid-cingulate and posterior insula were active throughout the pain experience, the parietal operculum’s role seemed isolated to the beginning stages. Additionally, abnormalities in these regions might inform future research on patients exhibiting excess amounts of pain. Although the significance of these three experiments should not be overlooked, it is nevertheless important to note that they all involved temporary manifestations of acute pain in healthy patients.

In contrast, studies examining chronic pain have compared healthy populations to chronic pain patients in deriving their neurological signatures. In a Machine Learning experiment exploring chronic back pain, Callan and associates administered painful electrical stimulations to the lower back of both chronic pain patients and healthy controls. Their algorithm correctly differentiated between pain perceptions in the two subject groups with 92.3% accuracy. The authors speculated that the difference in pain processing observed in chronic pain patients was a result of functional reorganization in brain regions such as the primary somatosensory cortex and the inferior parietal cortex. Bagarinao and colleagues conducted a similar study in patients with chronic pelvic pain, but reported much lower accuracy rates (73%). While not Machine Learning-based, a study by Kucyi and researchers used fMRI technology to demonstrate that chronic pain patients with temporomandibular disorder show atypical resting state functional activity in the default mode network, a group of brain regions believed to impact pain ruminations.

Although tremendous progress has been made over the last few years in pain neuroimaging, the field is still too nascent to be applied to real-world contexts. Future research should focus on improving accuracy rates and expanding studies to include greater varieties of pain intensities and locations. Additionally, since a standardized method of data interpretation would optimize consistency for settings such as the courtroom, researchers will need to determine which Machine Learning techniques work best. While current neuroimaging protocols might be sufficient for chronic pain patients (given their differential neural activation patterns compared to healthy controls), researchers must explore acute pain detection among subjects exhibiting pre-existing pain. Theoretically, if an individual suffering from acute pain in his left arm were to receive a non-painful stimulus to both arms, the resulting activation patterns from the stimulation of each arm should be predictably different, assuming that the pain threshold would be lower for the already sensitive left side. Yet, studies would need to test this hypothesis. Overall, despite the shortcomings, the current pace of progress in this field suggests that pain neuroimaging holds substantial promise.

16 See Id. at 161.
17 Daniel Callan et al., A Tool for Classifying Individuals with Chronic Back Pain: Using Multivariate Pattern Analysis with Functional Magnetic Resonance Imaging Data, 9 PLOS ONE e98007, 2–4 (2014).
18 Epifanio Bagarinao et al., Preliminary Structural MRI Based Brain Classification of Chronic Pelvic Pain: A MAPP Network Study, 155 PAIN 2502, 2505–2508 (2014).
19 Aaron Kucyi, Enhanced Medial Prefrontal-Default Mode Network Functional Connectivity in Chronic Pain and Its Association with Pain Rumination, 34 J. NEUROSCI. 3969, 3970–3974 (2014).
THE NEUROSCIENCE OF DECEPTION DETECTION

Whereas studies involving neuroimaging of pain generally incorporate common protocols from one experiment to the next, those examining the use of fMRI for lie detection are more heterogeneous. Part of this diversity can be explained by variations in study design for mock crime scenarios, as minor discrepancies among methodologies can lead to significant differences in accuracy rates. Even so, researchers have highlighted a relatively consistent set of neural regions (particularly the dorsolateral and ventrolateral prefrontal cortices) that become more active during conditions of deceit than honesty.

Early studies of detection deception relied on group level findings by averaging results across multiple participants. Given the focus of this article on new developments as well as the importance of detection in individuals for legal applications, only studies which analyze deception on the individual level will be discussed. One such study was conducted by Davatzikos and colleagues, who used Machine Learning techniques to predict deception. Subjects were told to lie about having one of two possible playing cards, and the experimenters were not aware of which card the subjects chose. During the scanning portion of the test, participants clicked buttons to indicate whether they did or did not have the card presented on the screen. Only a small proportion of the trials thus included the lying condition since hundreds of images were displayed. The authors were able to predict deceptive responses with an accuracy rate of 88%. However, critics have noted the potentially confounding nature of the motor demands in this study, as the number of times the button was pressed for truthful conditions far surpassed that of the lying ones.

Kozel and associates employed a different paradigm to examine deception on an individual participant level. Using a mock crime scenario intricately designed to approximate the pressures and stress inherent in the real world, participants in the crime condition were tasked with stealthily destroying evidence of previous infractions. Meanwhile, participants in the no-crime group were instructed to lie about an alibi during the time these evidence-tampering crimes were committed, but did not actually commit the crimes themselves. All participants then answered both neutral and crime-related questions while in the fMRI scanner. In a subsequent task, each participant was told to steal a ring or a watch and to lie about taking either when asked during scanning. The researchers analyzed activation patterns in the ring-watch scenario in order to identify participants for whom they could accurately detect deception during this simple task. When the researchers then tried to predict which of the individuals in this subgroup

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20 Farah et al., supra note 9, at 124.
21 Giorgio Ganis, Deception Detection Using Neuroimaging, in DETECTING DECEPTION: CURRENT CHALLENGES AND COGNITIVE APPROACHES 105, 105–118 (Par A. Granhag, Aldert Vrij & Bruno Verschuere eds., John Wiley & Sons, Ltd., 2014).
22 Farah et al., supra note 9, at 124.
23 Langleben & Moriarty, supra note 10, at 229.
24 Christos Davatzikos et al., Classifying Spatial Patterns of Brain Activity with Machine Learning Methods: Application to Lie Detection, 28 NEUROIMAGE 663, 664–668 (2005).
25 Farah et al., supra note 9, at 126.
26 Frank A. Kozel et al., Functional MRI Detection of Deception After Committing a Mock Sabotage Crime, 54 J. FORENSIC SCI. 220, 221–231 (2009).
were in the mock crime condition, they correctly identified all members of the crime group, while incorrectly identifying 66% of participants in the no-crime condition.

Whereas this study exemplified issues of specificity without countermeasures, Ganis and colleagues\(^{27}\) demonstrated the effects of using deliberate methods to beat the system. Accuracy rates during the normal paradigm were 100%, but when participants were instructed to make unnoticeable movements in certain fingers or toes, the rates declined to 33%. The authors noted that cognitive countermeasures would be similarly effective—for example, participants could think of specific memories in order to make answers to neutral questions seem more personally relevant.

Although neuroimaging for lie detection has improved considerably over the past decade, there are a number of frequently cited concerns with the current state of the field. In addition to vulnerabilities to countermeasures, critics question whether deception is what is actually being tested, as opposed to memory or attention.\(^{28}\) Moreover, deception in the real world often entails highly emotional and complex situations, which might never be replicable in the lab.\(^{29}\) Lastly, as evidenced by Kozel and colleagues’ study, even if neuroimaging can accurately identify those who are telling lies, the risk of making false predictions remains precariously high.\(^{30}\)

**NEUROIMAGING FOR PAIN AND DECEPTION: WHY THE COMPARISON IS IMPORTANT**

Before contrasting respective applications of pain and deception neuroimaging to the courtroom setting, it is necessary to explicate the importance of making this comparison in the first place. The legal system is a conservative domain, relying on laws and jurisprudence that have evolved over centuries. Proposed sources of evidence must achieve acceptance not only among the scientific community but also among judges, who are responsible for determining relevancy and admissibility.\(^{31}\)

Despite the fact that using fMRI for deception detection could one day be a valuable resource for the courts, its current state of reliability is remarkably far from what it would need to be. Nevertheless, in three recent trials, defendants and witnesses have tried to use the technology to confirm their credibility; in each case, the judge ruled the evidence to be inadmissible.\(^{32}\) Attempts to introduce the technology well before it was established and reliable have significantly set back the prospect of applying deception neuroimaging to the courtroom, as many scholars, judges, and members of the public are now skeptical of the idea.\(^{33}\)

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\(^{27}\) Giorgio Ganis et al., *Lying in the Scanner: Covert Countermeasures Disrupt Deception Detection By Functional Magnetic Resonance Imaging*, 55 Neuroimage 312, 313–318 (2011).

\(^{28}\) Farah et al., *supra* note 9, at 123, 128.

\(^{29}\) Matthias Gamer, *Mind Reading Using Neuroimaging: Is This the Future of Deception Detection?*, 19 Eur. Psychol. 172, 177–179 (2014).

\(^{30}\) Kozel et al., *supra* note 26, at 226.

\(^{31}\) Amanda C. Pustilnik, *Painful Disparities, Painful Realities: How Chronic Pain Neuroimaging Should Change the Law* 57 (University of Maryland Legal Studies Research Paper No. 2014–18, 57-59, 2014), http://ssrn.com/abstract=2407265 (accessed Dec. 20, 2014).

\(^{32}\) See United States v. Semrau, 693 F.3d 510, 516 (2012); See Wilson v. Corestaff Servs. L.P., 28 Misc.3d 425, 426 (2010); See Farah et al., *supra* note 9, at 128 [discusses attempts at using fMRI evidence in the pretrial hearing of Smith v. State of Maryland (2008)].

\(^{33}\) Sally Satel & Scott O. Lilienfeld, *Brainwashed: The Seductive Appeal of Mindless Neuroscience* 73, 96 (Basic Books 2013).
While pain neuroimaging has distinct benefits and weaknesses, its inexorable association with fMRI for lie detection cannot be denied. However, by learning from the mistakes with deception detection and analyzing the ways in which the two techniques overlap and diverge, we can form a better idea of the extent to which pain neuroimaging may be accepted in the courtroom as well as anticipate potential roadblocks that might arise.

**NEUROIMAGING FOR PAIN AND DECEPTION: THE SHARED PROBLEMS**

The most practical connection between neuroimaging for pain versus deception is that both applications seek to provide objective measures for issues that are notoriously difficult to detect with the naked eye. While researchers have elucidated common activation patterns for the respective processes, some studies report activation in areas not found in other experiments. The lack of exclusively confined networks might therefore elicit concerns with reliability for both phenomena. An additional problem involves contrived laboratory settings that might not reflect real-world complexities. For example, the type of deception that would be implicated in criminal trials would typically entail very high stakes and a slew of concurrent emotions. Moreover, people undergoing an fMRI-based lie detection test would never be instructed to lie, which is a prominent feature of current deception studies. Similarly, the acute pain produced in the lab lasts for a matter of seconds. It is unclear whether acute pain from a persistent injury would present the same activation patterns observed with temporarily induced pain.

Another common issue revolves around the limitations of fMRI technology. Although it has better spatial and temporal resolution than other brain imaging techniques, fMRI still cannot account for factors such as the actual speed at which neurons fire. Furthermore, since the technique relies on blood flow, it is an indirect measure of brain activity and does not tell us exactly what is occurring at the neuronal level. Other concerns involve vulnerabilities to misinterpretation of findings and spurious results due to multiple statistical comparisons. However, some scholars believe that these criticisms might be overemphasized.

In addition to issues with the protocols and techniques themselves, both uses of neuroimaging raise questions specific to the legal setting. To start, how accurate does the technology need to be in order to be admitted in court? Deciding what threshold is acceptable for admissibility will most likely contain some degree of arbitrariness. Moreover, measurements of accuracy will need to consider levels of sensitivity (correctly identifying those who are lying or in pain) and specificity (correctly identifying those who are not lying or are not in pain).

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34 C.f. Eggen & Laury, supra note 8, at 277 (discussing the relationship between uncertainty and skepticism).
35 Gamer, supra note 29, at 178.
36 Id. at 178.
37 Wager et al., supra note 1, at 1396.
38 Martha J. Farah, Brain Images, Babies, and Bathwater: Critiquing Critiques of Functional Neuroimaging, HASTINGS CENT. REP. S19, S20 (2014).
39 SateL & Lilenfeld, supra note 33, at 17, 18.
40 Id. at 19, 21.
41 Eg Farah, supra note 38, at S28.
42 Farah et al., supra note 9, at 126; Brown et al., supra note 13, at 6.
As with many emerging technologies, factors of cost and distributive justice will also be present.\textsuperscript{43} If fMRI evidence was considered admissible, whether for pain or deception, it would be inequitable for only those who could afford the technology to use it. Even though the current cost of fMRI usage might drop if the demand increased, defendants represented by public defenders would still not have the resources to pay for the technology. Issues of access also elicit concerns with the ‘CSI effect’, in which jurors might come to expect neuroscientific evidence and make negative assumptions in its absence.\textsuperscript{44} Inherent in this theory is the notion of ‘seductive allure’, whereby jurors put more stock in brain images than is merited.\textsuperscript{45} While there is doubt regarding the existence of these effects,\textsuperscript{46} the mere fact that many are worried about them foreshadows the difficulty of introducing new technologies into the courtroom.

**NEUROIMAGING FOR PAIN AND DECEPTION: THE CRUCIAL DIFFERENCES**

Despite the shared problems faced by these two applications of fMRI, pain neuroimaging might diverge in enough meaningful ways to yield more favorable chances of acceptance. Although both fields are still in their infancy, pain neuroimaging seems to offer more robust results, especially in regard to the detection signature. As critics have noted, neural regions believed to be involved in deception overlap with other cognitive functions such as memory and attention.\textsuperscript{47} Pain perception appears to avoid at least some of these issues. A recent study by Liang and colleagues\textsuperscript{48} demonstrated that painful stimuli produce activation patterns in the primary sensory cortex that are differentiable from those of other sensory processes. This suggests that certain neurons within areas of the pain matrix are responsive specifically to pain even if the general regions are activated by other sensory modalities.

With respect to questions of accuracy, sensitivity, and specificity, it is difficult to make a direct comparison since not all studies lend themselves to analysis of such factors. However, at least in regard to overall accuracy, neuroimaging for deception detection faces clear challenges from countermeasures.\textsuperscript{49} While pain neuroimaging studies have not explicitly tested measures to beat the system, the nature of pain itself might render it less vulnerable. With deception, cognitive strategies can successfully be employed to trick the technology in a manner imperceptible to outside observers.\textsuperscript{50} In contrast, simply imagining pain elicits noticeably reduced activation patterns in the pain matrix.\textsuperscript{51} Thus, successful attempts at countermeasures during pain neuroimaging would most likely involve self-infliction of pain. Hypothetically, an individual could

\begin{itemize}
\item \textsuperscript{43} Eggen & Laury, supra note 8, at 302.
\item \textsuperscript{44} Cassin, supra note 6, at 958, 959.
\item \textsuperscript{45} Martha J. Farah & Cayce J. Hook, The Seductive Allure of ‘Seductive Allure’, 8 Persp. Psychol. Sci. 88, 88 (2013).
\item \textsuperscript{46} Id. at 89.
\item \textsuperscript{47} Farah et al., supra note 9, at 125.
\item \textsuperscript{48} Meng Liang et al., Primary Sensory Cortices Contain Distinguishable Spatial Patterns of Activity for Each Sense, 4 Nature Comm. 1, 7–8 (2013).
\item \textsuperscript{49} Ganis et al., supra note 27, at 317.
\item \textsuperscript{50} Id. at 317.
\item \textsuperscript{51} Stuart W.G. Derbyshire et al., Cerebral Activation during Hypnotically Induced and Imagined Pain, 23 NeuroImage 392, 395 (2004).
\end{itemize}
bite his or her tongue to induce pain, but simple safeguards like requiring the person to use a mouth guard during scanning could circumvent such issues.

Apart from countermeasures, scholars and judges will still need to determine what levels of accuracy, sensitivity, and specificity are sufficient to constitute acceptance in the courtroom. It is important to remember that this discussion analyzes pain neuroimaging as applied to tort law only, whereas deception detection, due to its broader nature, is considered in both civil and criminal settings. As a result, the thresholds for pain versus deception neuroimaging might not need to be equivalent, given the different stakes involved in tort law compared to criminal law. The burden of proof, for instance, is much weaker in torts, where juror decisions are based on the preponderance of evidence as opposed to the beyond a reasonable doubt standard. While any objective measure would need to be reliable in order to serve its purpose, judges, juries, and the public might be more willing to accept a 90% accuracy rate in the tort context than the criminal one.

The nuances between various legal doctrines are also important in assessing the degree to which each application of neuroimaging challenges fundamental traditions. Even though the science is not yet there, much of the hype regarding neuroimaging in court imagines using fMRI to prove or discredit an individual’s claims. This could take the form of demonstrating the defendant is lying about his innocence or intent, or showing that the plaintiff is clearly in pain. Our knowledge of the neuroscience behind these processes will likely never be definitive enough to conclusively meet such objectives, but for the sake of argument let us temporarily indulge this widely held concern and consider the relative impacts on legal traditions. In the case of criminal law, if actus reus and mens rea can both be determined by neuroimaging, the role of the jury becomes fairly negligible. In contrast, if the presence of pain is shown to be undeniable, juries in tort law would still be tasked with assessing causation as well as awarding damages. The point here is that deception detection is much more central to the role of the jury in criminal law. As legal scholar Adam Kolber articulates:

> according to [Justice Clarence] Thomas, ‘[a] fundamental premise of our criminal trial system is that “the jury is the lie detector.”’ His remarks admit the possibility that even perfectly accurate lie-detection evidence could be excluded from the courtroom on the ground that it would infringe the province of the jury.

Neuroimaging for pain appears to be significantly less controversial due to the lower stakes of tort cases, the different standard used for the burden of proof, and the dual role that tort juries play in both determining responsibility and deciding the subsequent consequences.

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52 For examples of alternative applications of pain neuroimaging to the legal system, see Pustilnik, supra note 31, at 25–36.
53 Judicial Education Center, University of New Mexico, Overview of Torts, http://jec.unm.edu/education/online-training/torts-tutorial (accessed Nov. 25, 2014).
54 See Adam J. Kolber, The Experiential Future of the Law, 60 EMORY L.J. 585, 602–605 (2011).
55 Eg Cassin, supra note 6, at 943.
56 Pustilnik, supra note 31, at 65.
57 Kolber, supra note 3, at 836.
CONCLUSION

Pain and deception neuroimaging are emerging areas of study. Much research still needs to be conducted to improve accuracy rates, test the techniques across various population groups, establish the efficacy in real-world settings, and determine safeguards against countermeasures. Despite the current state of the field, the pace of progress is so rapid that conversations regarding fMRI’s potential implications, especially when applied to the courtroom setting, are necessary well in advance of the technology reaching its prime. At least one purpose of the legal system is to ascertain the truth, and the search for more objective measures is vital to achieving that goal. Neuroimaging has been proposed for ameliorating subjective issues in assessing pain and deception, and the two applications face common obstacles in entering the legal realm. However, when the nature of tort law, the lower susceptibility for countermeasures, and the fine distinction between pain and other sensory modalities are taken into account, the prospect of using neuroimaging in the courtroom to support claims of pain seems significantly more promising. Nevertheless, many judges and members of the public are skeptical of using neuroimaging as an objective measure due to premature excitement with fMRI for lie detection. As a result, emphasizing the key differences between pain and deception, as well as learning from hasty mistakes with fMRI for lie detection, will be essential for moving pain neuroimaging beyond academic and clinical settings and into actual legal practice.