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REVIEW PAPER

# The Limited Relevance of Neuroimaging in Insanity Evaluations

**Michael J. Vitacco · Emily Gottfried · Scott O. Lilienfeld · Ashley Batastini**

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**Abstract** Forensic evaluations of insanity have recently borne witness to an influx of neuroimaging methods, especially structural and functional magnetic resonance imaging and positron emission tomography, to assist in the development of explanations that help to excuse legal responsibility for criminal behavior. The results of these scanning methods have been increasingly introduced in legal settings to offer or support a clinical diagnosis that in turn suggests that an individual was incapable of knowing right from wrong, or to pinpoint brain dysfunction suggestive of an inability to control behavior. This paper examines how neuroimaging has been employed in insanity evaluations. After addressing the contentious use of neuroimaging scans in insanity evaluations and synthesizing relevant research, we conclude that such scans presently hold limited applicability for forensic determinations of insanity. Furthermore, they can in some cases distract the trier of fact, potentially leading to erroneous conclusions.

M. J. Vitacco (✉)
Department of Psychiatry and Health Behavior, Augusta University, Augusta, GA 30912, USA
e-mail: Mvitacco@augusta.edu

E. Gottfried
Medical University of South Carolina, Charleston, SC 29425, USA

S. O. Lilienfeld
Emory University, Atlanta, GA 30322, USA

A. Batastini
University of Southern Mississippi, Hattiesburg, MS 39406, USA

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The verdict of not guilty by reason of insanity (NGRI) is one of the most controversial issues in mental health law [1]. The notion that an individual can commit a criminal offense yet be found not guilty and not responsible for it because of severe mental illness often elicits strong negative feelings from the public and legal community [2, 3]. Moreover, the public at large harbors significant misconceptions regarding the insanity defense and the people who are ultimately found NGRI [4, 5]. The myths surrounding this defense focus largely on the perception that it is massively overused as a legal loophole that is exploited by unscrupulous mental health experts willing to sell their opinions to the highest bidder [6]. The need for objectivity and transparency with insanity evaluations is clearly required if the public and policy makers are expected to have confidence in the findings of insanity evaluations.

Objectivity in insanity evaluations has been seriously questioned within the scientific community. Dror and colleagues have produced significant scholarship on the cognitive biases associated with forensic evaluations [7, 8]. As they and others observe, insanity evaluations are susceptible to several errors in clinical judgment, including adversarial bias, whereby a clinician is more likely to opine in a manner favoring the side that retained them [9]. Such factors may be key to understanding disagreements in insanity opinions. For example, Gowensmith, Murrie, and Boccaccini (2013) evaluated 483 insanity

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reports authored on 165 defendants; each defendant received up to three independent evaluations [10]. The authors found unanimous agreement only 55% of the time across all evaluators on their insanity opinions. Such a result suggests there may not be widespread agreement on who should be found insane and that traditional approaches, including clinical interviews, are also encumbered by limitations.

In this regard, the notion that brain imaging data, which tend to carry the imprimatur of objectivity and scientific respectability [11, 12], improve decision-making in trials in which culpability is at issue is alluring. Because of a widespread logical error termed "neurorealism" [11, 13], which refers to the idea that brain imaging itself validates or invalidates an objective phenomenon, many triers of fact may erroneously believe that a behavioral deficit, such as poor impulse control, is more "genuine" when it is visible on a brain scan. Many laypersons, attorneys, judges, and even some academic scholars may further regard neuroscience data as inherently more "scientific" or "objective" than behavioral or interview-based information [14]. Still, the question of whether neuroscience adds clarity or instead obfuscates decisions regarding an individual's state of mind at the time of the alleged offense requires an in-depth analysis of legal precedents and a careful dissection of the science of neuroimaging and its relationship to insanity.

Over the past decade or so, there have been increased calls to make neuroimaging more accessible to defendants in a variety of criminal and civil contexts [15]. Even though the field of neuroimaging is relatively new [16], its application to psycholegal issues has evolved quickly. The application of neuroscience to legal proceedings has earned the moniker "neurolaw" (see [17]. Even considering its relative recency, the science and practice of neurolaw has increased dramatically, as evidenced by the development of multidisciplinary neurolaw centers in institutions across the United States, Canada, and Europe. The development of biomedical technology and its application to psycholegal constructs has brought new expectations and controversies regarding the use of imaging in a variety of applications, including lie detection, violence risk prediction, and criminal responsibility. In the eyes of many scholars, these imaging applications lack sufficient empirical support to warrant their widespread use [12, 18].

Neuroimaging studies have been applied to a variety of clinical conditions that carry potential legal implications. These conditions include but are not limited to substance use disorders [19], pathological gambling [20], psychopathy [21, 22], and various psychotic conditions [23, 24]. By using imaging, researchers have reportedly identified brain-based deficits, some of them potentially specific, in rapists [25], batterers [26], and murderers [27]. Some authors have interpreted such findings to suggest that the presence of identifiable brain associations may diminish culpability for criminal actions [28]. However, even many of those who support the veracity of results from brain scans have raised significant questions about brain imaging's diagnostic utility [29]. In encouraging caution with a neuroimaging approach, Erickson (2010) wrote, "Despite claims by neuroscientists that the mind is accessible, measurable, and predictable there are good reasons for skepticism on all these fronts" (p. 31) [30]. These complexities are in part attributable to the uniqueness of the structure and function of every human brain (see [31]).

The use of arguments centered on identified brain deficits to diminish criminal culpability is not novel. Debates in high-profile cases regarding links between brain abnormalities and behavior have arisen for years. Consider the scholarly dispute concerning the relevance of a tumor pressing on the amygdala of Charles Whitman, who killed 13 people and injured over 30 more at a shooting at the University of Texas at Austin clock-tower in 1966. Some gave the tumor great weight in explaining Whitman's behavior, whereas others viewed it as inconsequential, noting that he engaged in serious behavioral problems that appeared to predate his tumor [32]. Perhaps the most famous such argument occurred during testimony in 1982 regarding the mental state of John W. Hinckley Jr. for the attempted assassination of then-U.S. President Ronald Reagan. Defense and prosecution experts quarreled over the results of Hinckley's Computerized Axial Tomography (CAT) scans. Defense experts referred to findings of the CAT scan as "abnormal" and suggestive of "organic brain disease." In contrast, prosecution experts referred to the scan as "normal" and "no more a sign of a mental illness than premature balding would be" [33; see [34], p. A35). More recently, magnetic resonance imaging (MRI) data took center stage in the insanity trial of James Holmes, who was ultimately convicted for the Aurora, Colorado "Batman" movie shooting that killed 12 and injured 70. The jury rejected the insanity defense

in finding Mr. Holmes guilty, but he was spared the death penalty. It is unlikely that debates concerning the utility of brain scans and imaging in criminal cases will be settled anytime soon [35, 36].

In this paper, we address the complexities of applications of neuroimaging to criminal cases, particularly those involving insanity evaluations. In the first section, we address the legal justifications that some legal scholars have offered to advocate for the increased use of neuroimaging in NGRI determinations. In the second section, we review data related to the influence of neuroimaging on juries and their decision-making. In the third section, we discuss legal domains outside of the insanity defense in which neuroimaging has been applied. At times, the application of neuroimaging in these cases has led to notoriety. Attention to neuroimaging in highly publicized cases may lead to an expectation of such data in trials and increase the perceived value of neuroimaging results in criminal cases. In the fourth section, we provide a review of three court decisions related to the admissibility of imaging studies in criminal responsibility evaluations. In the fifth and final section, we present a non-exhaustive list of challenges that would need to be resolved if the neurolaw and imaging is to become relevant to decisions regarding criminal responsibility, especially, insanity.

## Independent and Defense Experts: Accessibility to Neuroimaging

An Oklahoma case [37], although decided before the invention of modern neuroimaging techniques (e.g., functional magnetic resonance imaging), has been relied on to support the use of imaging in insanity cases, especially when capital punishment is at stake. In 1979, Glen Ake was arrested on two counts of capital murder in Oklahoma. He had an extensive history of mental illness and was initially ruled incompetent to proceed to trial. Once his competency was restored, Mr. Ake's attorney requested funds for the defendant to undergo an evaluation of his mental state at the time of the crime (i.e., insanity). The state of Oklahoma denied his request to receive a state-funded insanity evaluation. In an 8 to 1 decision, the U.S. Supreme Court determined that states must provide funding for "appropriate" psychiatric expertise in capital cases. Notably, the Court indicated that this did not require an independent consultant for the defense [37]. As noted by Entin (1988), the *Ake* decision provided some level of equality for capital defendants in need of mental health expertise [38].

In attempting to clarify the decision rendered in *Ake*, the question of how to implement defense-requested mental health evaluations was reviewed in *McWilliams v. Dunn* (2017) [39]. In this Alabama case, Mr. McWilliams was convicted of the rape and murder of a clerk at a convenience store and sentenced to death. The American Academy of Psychiatry and Law and the American Psychological Association submitted a joint Amicus Brief on behalf of Mr. McWilliams, arguing that the Supreme Court should overturn the decision from the appellate court upholding Alabama's use of a state hospital expert who was available to both the prosecution and the defense. In a 5 to 4 decision, the Court ruled that the defense was not only entitled to an independent forensic examination, but that the *Ake* decision should be interpreted as giving the defense access to a competent mental health practitioner who can assist in "evaluation, preparation, and presentation" of a defense. That is, the decision in *McWilliams* provides for an independent mental health expert to join the defense team to plan and assist with strategy in capital cases.

Several authors have proposed that neuroimaging will soon become a mainstay in many mental health defenses. Survey data already point to a recent substantial increase in the introduction of neuroscience and genetic evidence into criminal cases [40]. Perlin (2017) eloquently stated that "In the case of neuroimaging evidence, an individual may feel that he has been given the opportunity to have a voice if he is able to see evidence that supports what he describes as symptoms of mental illness or explanations for his behavior" (p. 3) [41]. If brain imaging is viewed as supportive to developing appropriate opinions in mental health evaluations, especially when insanity is employed in capital cases, the decisions in *Ake* and *McWilliams* would provide support for their use when defense experts deem them necessary [42].

## Impact of Neuroimaging on Jury Decision-Making

The question of the impact of neuroimaging findings on juries certainly warrants discussion. Few studies have examined the effect of neuroimaging and neurological explanations on jury decision-making; however, those that have done so bear important implications. Three

such studies are especially relevant to insanity determinations.

Marshall, Lilienfeld, Mayberg, and Clark (2017) examined results from mock testimony using two community-based samples of 1161 participants in total. Considering sentencing recommendations for a psychopathic offender, they found that neuroscientific explanations of the disorder did not alter the verdict (i.e., not guilty or guilty) [43]. Yet, in both studies, jurors who were exposed to neuroscientific explanations viewed the offenders as less dangerous and more treatable, and they recommended lesser sentences. Of course, the presence of brain damage may actually suggest more permanent changes that are less amenable to treatment. In contrast to some earlier work with student samples (e.g., [44]), Marshall et al. (2017) found no significant impact of brain images on decisions (also see [45]).

Schweitzer and colleagues (2011) conducted four interrelated experiments consisting of 1476 jury-eligible individuals on how the presence of neuroimaging data influence their verdicts and recommendations for a mens rea defense [46]. The authors' mini-meta-analysis of these four studies yielded several insights. The most important factor for mitigation/diminished responsibility was the presence of an expert advocating for mitigation. Not surprisingly, individuals who had committed a criminal act were deemed less responsible for the act if an expert had made such a proclamation. Although the researchers altered conditions across the four studies, they were unable to detect a significant effect from the presentation of neuroscience data.. Instead, mock jurors relied on jury instructions and expert testimony to render verdicts.

Gurley and Marcus (2008) evaluated the impact of neuroimaging among 396 jury-eligible university students, these researchers used a 2 (psychosis v. psychopathy) × 2 (imaging v. no imaging) design to ascertain how scans could influence an insanity defense verdict [47]. The study yielded several noteworthy findings. First, perhaps not surprisingly, defendants with psychosis were most likely among all defendants to be found insane. Second, mock jurors who were provided with a brain scan showing brain damage were more likely to render a verdict in favor of insanity, regardless of diagnosis. Third, mock jurors exposed both to expert testimony and brain scans plus expert testimony were most likely to recommend a verdict of insanity. The authors concluded that "…the results of this research indicate the potential impact that neuroimaging could have in insanity trials and other criminal trials. The presence of neuroimages increased the likelihood of mock jurors finding a defendant NGRI" (p. 95; see also [48].

These studies paint a mixed picture with respect to the impact of brain imaging data on juror decisions. On the one hand, jurors and would-be jurors sometimes appear to be influenced by brain imaging and to find brain-based explanations of causation somewhat compelling. On the other hand, jurors also listen closely to experts. Of course, experts are needed to provide appropriate interpretation of scientific-based results, such as those generated by neuroimaging. Experts are also invaluable when discussing the reliability, validity, and limitations of neuroimaging data [49, 50]. Finally, explanations that rely on imaging data may not lead jurors to completely excuse behavior, but may be useful in mitigation to decrease the overall sentence (e.g., jury recommending life and not the death penalty).

## Use of Neuroimaging in Non-Insanity Cases

As noted throughout this paper, it is becoming increasing common for courts to issue rulings on the relevance of neuroimaging to specific psycholegal questions. The admissibility and pertinence of neuroscience to criminal contexts will be reviewed in three disparate cases. The first will examine aspects related to mitigation in a murder case. The second will consider how mental illness can interfere with rational thinking related to competency to be executed. The third will consider the use of neuroimaging in sentencing decisions.

A good example of how imaging works is evident in the noteworthy case of Herbert Weinstein [51]. Featured in the book *The Brain Defense* [52], Weinstein, then 65 years of age, strangled his wife and threw her body out of a 12th story window in Manhattan, ostensibly to make it appear as though her death were a suicide. A neurologist who found an arachnoid cyst on an MRI scan opined that this condition rendered Mr. Weinstein less culpable for his criminal behavior. As a result, Weinstein pled guilty to lesser charge of manslaughter. This case gained national interest, as it was the first to use case-specific neuroscience findings to support a reduction in a criminal charge. Yet, after the fact, several questions arose considering other aspects of Weinstein's history that were incongruent with the reduction in sentence, including his significant gambling debts. In addition, Mr. Weinstein was never again reported to

have behaved violently toward another individual or himself despite the continued presence of this cyst. The use of imaging in the Weinstein case has been roundly criticized by both supporters and skeptics of neurolaw [53].

The cases reviewed in this section focus on imaging application in sentencing. Denno (2005) provided the most comprehensive analysis of neuroimaging data in criminal cases [16]. She found that neuroimaging is most frequently introduced for mitigation during the sentencing phase of trials. Presenting specifics from two cases (John McCluskey and Grady Nelson), she argued that brain scans were instrumental in allowing defendants to avoid the death penalty. The data in the *McCluskey* case was particularly contentious. McCluskey escaped from prison, and while on the run, killed an elderly couple vacationing in Oklahoma. Neuroimaging data showed multiple areas of hyper- and hypoactivity, seemingly related to deficits in impulse control, emotional processing, and planning. Although the prosecution argued that McCluskey evidenced the capacity to plan in many domains of his life, including overseeing an illegal drug operation, the jury opted for life without parole, not death. Likewise, Grady Nelson was convicted of murder after stabbing his wife 60 times and then killing his stepchildren. The jurors viewed functional brain images that were reportedly consistent with deficits in impulse control. After the trial, jurors reported that the neuroimaging presentation was influential in their decision to choose a sentence of life in prison over the death penalty (see also [54]. It appears that the jurors believed the imaging of the identified brain issues excused him from the death penalty. Notably, as discussed by Denno (2005), invoking imaging in this manner for mitigation is its most common use in the law [16].

The final use of neuroimaging in non-insanity legal circumstances is in post-conviction relief. In his discussion of the neuroimaging findings relied upon in the *Panetti* decision (see [55]), Perlin (2010) noted that using such technology can improve sentencing decisions by making them "rational and more humane" or in other terms, more "objective" [56]. Such consideration was given weight in the Panetti case. Scott Panetti was found guilty and sentenced to death for the murder of his wife's parents. Both sides agreed that Panetti suffered from mental illness; however, the prosecution argued that the mental illness did not interfere with his ability to understand the factual basis for his pending execution. The district court and Fifth Circuit Court of Appeals upheld Panetti's death sentence. However, in a 5 to 4 decision, with direct relevance to Panetti, the U.S. Supreme Court ruled that the government is not allowed to execute individuals whose mental illness interferes with their ability to understand the impending punishment. The *Panetti* case illustrates how brain scans may be considered by triers of fact when mental health problems interfere with competency to be executed, a significant legal issue with implications for capital decisions [56].

Neuroimaging might be used to inform diagnoses of psychotic disorders, the conditions most pertinent to findings of non-responsibility [57]. Neuroimaging findings have been associated with a variety of psychotic symptoms relevant to criminal responsibility. For example, several findings have pointed to brain abnormalities in individuals with delusional ideations [58, 59], although the differences may be subtle and difficult to differentiate using structural brain imaging [59]. Yet, even though imaging may be helpful to support a diagnosis, there are key limitations to consider. First, despite high hopes expressed over the past two decades that psychiatric classification would be informed by neuroscience findings, the Diagnostic and Statistical Manual-Fifth Edition (DSM-5) [60] does not contain a single neuroimaging indicator among any of its 300-plus diagnostic criterion sets [61]. This fact strongly suggests that, at least as of 2013 (the year of DSM-5's release), the multiple DSM-5 work groups remained unconvinced that any neuroimaging findings were sufficiently informative to assist in the diagnosis of any psychiatric condition. There is little reason to believe that the state of evidence has changed in the intervening years [62]. Second, there is no replicated research evidence that neuroimaging possesses incremental validity above and beyond simpler and less expensive traditional methods. At best, neuroimaging results could in principle be broadly consistent with and perhaps help to corroborate a given diagnosis. Although this situation could well change in the coming years, neuroimaging for diagnostic purposes in court-related matters is not presently well supported. Third, extrapolating from these two points, specific brain deficits from imaging have not been shown to be directly related to any psycho-legal finding, even as some scholars advocate for increased use of imaging to assist with forensic questions [42].

## The Courts and Imaging in Insanity Cases

Several cases have focused on the admissibility of brain imaging in criminal responsibility evaluations. We will present several cases that underscore the caution courts have exercised when admitting neuroimaging evidence in insanity evaluations and the delicate balancing act between expert and lay testimony that can arise in mental health trials. In insanity cases, the court must consider a range of evidentiary issues when confronted with neuroscience evidence.

The high-profile case of Lisa Montgomery [63] highlights some of the complex issues associated with neuroimaging and insanity. Montgomery was convicted of a kidnapping that resulted in the death of the victim. Her defense centered around a diagnosis of pseudocyesis—a condition also termed "phantom pregnancy," in which a woman falsely believes she is expecting a baby. Pseudocyesis, a somatoform disorder in the DSM-5 [60], can include all physical characteristics associated with pregnancy except for the presence of a fetus. The defense-retained expert presented brain imaging evidence supposedly consistent with the diagnosis of pseudocyesis (although there are no data supporting sensitive or specific brain imaging markers of this condition). A positron emission tomography (PET) scan requested by the defense was excluded on the basis of its "minimal probative value" and on the fact that the results "could ultimately confuse the jury and distract from relevant and significant issues." On appeal, the Fifth Circuit Court of Appeals upheld the decision to not admit the PET scan findings on the matter of questionable relevance to the insanity defense. They also agreed with the district court that the imaging should be excluded because the methodology used to conduct the scan was determined to be unreliable.

The Illinois case of *People v. Glenn* (1992) dealt with additional problems related to imaging and insanity [64]. Glenn's defense argued that he was legally insane with respect to charges of murder and rape stemming from exposure to carbon monoxide, which caused irreversible brain damage to such a substantial degree that he was unable to control his behavior. To advance this hypothesis, the defense relied on a radiologist, neurologist, psychologist, and psychiatrist, all of whom testified to the presence of brain damage due to carbon monoxide exposure. The prosecution countered with a neurologist and brain wave specialist, both of whom testified that Glenn's brain imaging findings were inconsistent with the defense explanation. The prosecution further presented lay testimony, which supported the hypothesis that Glenn did not behave in a manner consistent with carbon monoxide exposure. Ultimately, the jury found Glenn guilty. On appeal, the defense argued their expert evidence was "overwhelming" and that lay testimony had no place in verdicts on insanity. The Illinois appellate court disagreed and upheld the conviction. In doing so, the court wrote, "When a defendant's sanity is in issue, great latitude is allowed in admitting evidence relating to mental condition because, rather than an isolated cross-section of a single series of acts, one must examine the person, his history, his relationship with the victim, prior mental illnesses, and other intervening factors of causation" [quoted from 65–67]. In other words, brain imaging data inconsistent with behavioral data may be less persuasive to the trier of fact [68].

The final case reviewed here involves an appellate case from New Jersey alleging ineffective assistance of counsel for failing to present an insanity defense in light of imaging data. In *State v. Thach* (2016), imaging data were available along with expert testimony regarding Mr. Thach's competency to proceed to trial on charges of murder [69]. The defendant pled guilty to reduced charges. The New Jersey Court of Appeals overturned the verdict, citing the lower court's failure to hear testimony from experts who conducted and interpreted the brain imaging as a violation of the defendant's rights in relation to his criminal charges. Notably, the appellate court did not rule on any of substantive concerns related to the neuroimaging. It noted only that because the state did not challenge the admissibility of the evidence, it should have been considered part of Mr. Thach's mental health defense, especially as the data and testimony proffered by the defense went unchallenged by the prosecution. Procedurally, this case bears direct implications for challenging neuroimaging findings if they disagree with the underlying findings.

## Five Issues Regarding Neuroimaging in Insanity Cases

Much has been written about the current state and expectations for the continued use of neuroscience in the courtroom to mitigate criminal responsibility. As noted by Kolla and Brodie (2012), the use of imaging in criminal responsibility evaluations is fraught with uncertainty [70]. They observed that it is nearly impossible

to infer functional legal ability based on brain scans alone, and even more difficult when the scans are taken months or even years after the alleged act. In contrast, Palermo (2012) argued that neuroscientific data, including imaging, should be considered when making determinations of criminal culpability [71]. He also posited that neuroimaging results that point to brain involvement in conditions such as psychopathic personality (psychopathy) may warrant mitigation. Much of this debate revolves around the degree of criminal responsibility. In the case of an insanity finding, persons are deemed so incapacitated that they are viewed as non-responsible for their alleged criminal behavior. In contrast, neuroimaging may suggest decreased culpability [16, 36]. This is a critical distinction, both clinically and legally.

In examining the intersection of legal decisions and scholarship, we provide five specific domains in which the promise of the science has not met legal expectations in the context of neuroimaging's application to insanity evaluations. The law and fields of forensic psychology/psychiatry maintain an uneasy alliance and are often joined for a time-limited purpose of answering a specific psycholegal question. The alliance remains tenuous partly because of their often sharply different approaches to human behavior. Psychology and psychiatry, through their use of large data sets and (ideally) reliance on scientific methods, traditionally adopt a nomothetic approach to legal problem-solving. By applying inferences generated from research methods, psychology and psychiatry attempt to make generalized predictions that apply to many individuals' behavior. Virtually all brain scans rely on group data to determine the presence or absence of irregularities [72]. The law, in contrast, typically relies on an idiographic approach, whereby each case is decided on its unique merits and facts. To that point, much theoretical discussion has emerged regarding insanity and neuroimaging, but large-scale normative imaging data on individuals found insane have yet to be collected. This does not mean that brain imaging data are irrelevant to real-world behaviors, but that data are not sufficiently advanced to bear direct relevance to insanity determinations. Indeed, no brain imaging study has demonstrated concrete links between imaging data and the inability to understand right from wrong, although some have suggested that deficits in frontal and temporal cortex are associated with deficits in moral reasoning [73, 74]. Even if more evidence were to show that this conclusion was legitimate, this finding would alone would not be sufficient to qualify one for an insanity defense.

1. A principal objection to applying neuroimaging to insanity cases relies on a lack of incremental validity (added psychometric value; see [75]) above and beyond extant information. Brain imaging findings have been linked to a multitude of diagnoses that bear forensic relevance, including psychotic disorders [24, 76]. However, structured interviews have been the most stringent and best validated methodology for diagnosing psychotic disorders in research and clinical settings. Structured interviews, such as the Schedule of Affective Disorders and Schizophrenia – Change Version (SADS-C; see [77]), are consistently effective in identifying psychotic symptoms in the context of insanity evaluations [78]. Such interviews have gained significant traction in both psychiatry and psychology [79]. Packer (2009) argued that interviews with the defendant and witnesses, a review of relevant history, and careful reading of official police documentation, are needed to form valid opinions of criminal responsibility at the time of the offense [80]. To date, no published studies have provided evidence that imaging provides incremental validity above and beyond the tried-and- true, as well as time- and cost-effective, clinical techniques of evaluating insanity [12]. Unless and until such data can be adduced, imaging data's direct relevance to insanity cases remains speculative.
2. A practical objection to neuroimaging in insanity cases is rooted in the dynamic nature of the brain and neurologic functioning. Neuroscientists have promulgated several promises related to imaging findings. In addition, some have presented their data in court with high levels of confidence that the deficit evident on the scan bears directly implications for criminal responsibility (see [63]). Given the dynamic nature of brain functioning, many inferences related to brain functioning in insanity cases are necessarily tentative. In particular, when it comes to criminal responsibility evaluations, time is a critical but often overlooked variable. Evaluations of criminal responsibility frequently occur weeks, months, or even years after the alleged offense. Of course, the moment that matters most for determining responsibility is the precise moment the offense(s) occurred. The application of

neuroimaging to insanity evaluations might be on somewhat firmer ground if brain structure and functioning were static or if the imaging were conducted at the time of the alleged offense. Erickson (2010) aptly noted that "While it was once assumed that adult brain structure was static and mostly unaltered by the environment and behavior itself, it has been firmly established that this is not the case. It is now known that the brain is constantly in flux, with its structure and function ceaselessly molded by environment influences" ([30] p. 53; see also [53]). Such change is an important challenge to the use of imaging data in insanity evaluations. In neuroscience language, decrement in brain functioning over time is termed comparative decay. As such, brain imaging may suggest dysfunction that was not present at the time of the offense. Of course, one must also consider the possibility that decrements in a defendant's brain structure or functioning at the time of the alleged offense have since dissipated or disappeared. Comparative regeneration is rarely discussed in the neuroscience legal literature, but it could lead to false inferences regarding brain dysfunction at the time of the crime.

3. During trials, neuroimaging experts often posit direct connections between brain data and criminal actions, arguing that such connections form the foundation for an insanity defense [42]. However, the brain and rest of the central nervous system (CNS) ultimately govern all human behavior at some level of analysis, as even reflexive and automatic behaviors are governed by the CNS. To that end, Morse (2016) coined the term "fundamental psycholegal error" to refer to the mistake of concluding that a person should be excused for his or her criminal behavior by claiming this behavior can be traced to brain activity [81]. Indeed, the mere association between brain and behavior does not qualify one for an insanity defense. Armed with vivid and at times colorful pictures of the brain, some neuroscientists purport to be able to identify the activity of specific brain structures and relate activation or under-activation to functional abilities and even psychiatric diagnoses. However, as Baskin, Edersheim, and Price (2007) observed, "With respect to understanding the brain and certain behaviors, the state of scientific knowledge is nascent, but promising. The more complex and specific the behavior examined, the more speculative the connection" (p. 239 [82]). In this regard, behaviors leading to a NGRI verdict are usually exceedingly complex and multi-determined. Scarpazza and colleagues' (2018) guidelines provide a pathway for managing some of the inherent complexities involved in using imaging in insanity evaluations [68].
4. Many scientists and legal professionals have debated the relevance and admissibility of neuroimaging data to the insanity defense [83, 84]. The evidence here is governed by a trilogy of interrelated Supreme Court cases [85–87]. This trilogy focuses on the fact that admissibility is governed by appropriate scientific techniques and includes the following: (1) Are the methods used testable? (2) What is the known error rate associated with the method? (3) Has the method been subjected to peer review? And, (4) Is the method generally accepted within the profession? The key lynchpin for considering the admissibility of brain imaging for any issue centers on relevance. For insanity, this is a difficult proposition. Consider *Montgomery*, in which the MRI scan was ruled inadmissible because it was deemed irrelevant to the issue at hand [63]. Addressing *Daubert* and its progeny further, no published studies have differentiated the brain functioning of individuals adjudicated NGRI from those who pled NGRI but have been adjudicated criminally responsible. Furthermore, to there are no published studies on the error rates associated with neuroimaging and its associated use for diagnostic purposes in insanity cases. However, in MRI interpretive findings on spinal cord damage across 10 distinct sites, Herzog, Elgort, Flanders, Moley, and colleagues (2007) found large error rates and little consistency across the centers [88]. Because reliability and validity are the lynchpins of admissibility under the Federal Rules of Evidence (2017) and until such studies are conducted, the utility of imaging in NGRI evaluations remains highly circumscribed. Neuroimaging would be even more difficult to admit into court based on the Frye standard, still in use in several U.S. states, which mandates acceptance in the general scientific community as a criterion for admissibility [89]. That is the case because brain imaging data have not gained sufficient scientific acceptance for the purpose of rendering individuals not responsible for their criminal behavior [53]. One caveat to note is that this

psycholegal analysis is most clearly applicable to cases in the United States, and different countries may treat admissibility of imaging in insanity cases differently [68].

5. As best as we can ascertain, there are no published studies demonstrating the validity of brain imaging for identifying the functional deficits required for a successful NGRI verdict (e.g., inability to differentiate right from wrong). Even proponents of imaging have noted the limitations of imaging in determining if specific functional impairments exist. For example, Scarpazza et al. (2018) argued that imaging "should support behavioral findings to reduce controversies in court" (p. 6 [68]). In following these published guidelines, neuroscientists must link problematic behaviors evidenced at the time of the offense with brain deficits, and that task remains exceedingly difficult [90]. Likewise, the mere presence of associations between findings on imaging related to brain structure and function are not dispositive of the presence of a diagnosis, and certainly not dispositive of an insanity finding. This is a needed area of research to begin to use the findings of neuroimaging to fully support an insanity defense, and not just the presence of a mental illness.

## Conclusions

We have addressed significant limitations associated with applying neuroimaging to the evaluation of criminal responsibility. Attempting to use brain scans to retrospectively determine the state of culpability of an individual is beyond the capacity of any current methodology, especially when months or years separate the evaluation from the alleged crime. The inferential limitations of neuroimaging in insanity evaluations go far beyond issues with the retrospective application of brain scans. As observed by Morse (2016), most data gleaned from brain imaging are irrelevant to criminal cases [81] (see also [30]). He questioned the pertinence of neuroscience research to legal contexts, arguing that "Even if there is clear evidence of brain damage or a neurological disorder, it does not mean the defendant lacked *mens rea*, was less culpable, is incompetent, or will be dangerous in the future. All the criteria depend on direct assessment of the defendant's behavior" (p. 339). We concur, and would note that such assessment still hinges on tried-and-true methods of psychiatric and psychological assessment, including rigorous clinical interviews and history-taking. Admittedly, as we have discussed, there are significant weaknesses in relying only on traditional methods of clinical interviewing, and traditional data gathering methodologies in criminal responsibility evaluations. Although the validity of these techniques is well-established scientifically, they are far from panaceas. When relying on these methodologies only, triers of fact may benefit from an awareness that experts frequently disagree on the ultimate issue of insanity [10].

Regarding criminal responsibility, brain imaging cannot allow valid inferences concerning motive, or moral or legal knowledge of the distinction between right and wrong at the time of the offense. Brain imaging cannot determine planning, evasiveness, or whether individuals were so impaired they were unable to conform their behavior to the law. These judgments must be established through a direct and careful review of the defendant's behavior, including consideration of collateral sources and extensive clinical interviews. Given the increasing use of neurolaw in criminal cases, evaluators must view neuroimaging as at best merely one fallible data source among many others. Evaluators are encouraged to be especially cautious when brain imaging data are inconsistent with other commonly relied-upon data sources (e.g., academic records). We do not go as far as Felthous and Sass (2008), who argued that there is no role for neuroimaging in insanity evaluations [83]. Instead, we call for caution in use of neuroimaging data in insanity cases and recommend strict adherence to published guidelines when applying such data to insanity determinations [68].

We acknowledge brain imaging's utility in establishing certain legally-relevant criteria. For example, imaging may provide information related to the long-term presence of brain damage useful in establishing the presence of a possible threshold condition. As an illustrative example, pedophilic behavior has been associated with orbitofrontal tumors in the right hemisphere even though the ability to understand the wrongfulness of this behavior remains intact [91, 92]. This final finding underscores the importance of appropriately evaluating data in light of relevant legal criteria, and a reminder of the crucial caveat that experts must explain how they used and weighed data from brain images in forming their opinion.

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