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The Admissibility of Brain Scans in Criminal Trials:

The Case of Positron Emission Tomography

Susan E. Rushing

The *People of the State of New York v. Herbert Weinstein* (1992)¹ is one of the earliest and most prominent examples of an attorney offering a Positron Emission Tomography (PET) scan as evidence in a criminal trial. Mr. Weinstein, a 68-year-old, married, Caucasian male worked in advertising. Mr. Weinstein had no past criminal history and no history of violence, but he was accused of strangling his wife and throwing her body from their 12th-story Manhattan apartment to make her death appear to be a suicide. When confronted, Mr. Weinstein admitted his guilt and even readily admitted his attempts to cover up his crime.² Mr. Weinstein's lack of emotion when discussing the crime and apparent lack of remorse for his action caused his legal team to question whether the older gentleman could be suffering from a neurological impairment that caused an uncharacteristic act of aggression.³

Acts of aggression have been hypothesized to arise from dysfunction within the prefrontal cortex and impaired connections between the frontal lobe and associated limbic brain regions. Physicians consulting with Mr. Weinstein's defense attorneys suggested Mr. Weinstein undergo neuropsychological testing and brain scanning that could demonstrate potential structural and/or functional deficits in his brain.⁴

An MRI of Mr. Weinstein's brain revealed a large cyst in the arachnoid mater, a protective lining that covers the brain tissue. The arachnoid cyst was situated within the left sylvian fissure and compressed the left frontal, temporal, and insular regions of Weinstein's brain. A functional scan of Mr. Weinstein's brain demonstrated that the areas of brain tissue that were compressed by the cyst were not metabolizing glucose at the expected rate. Mr. Weinstein's attorneys offered the PET scan in support of a claim of not guilty by reason of insanity (NGRI). Prosecutor Zachery Weiss moved for an order to preclude Weinstein from offering any testimony or other evidence concerning his PET scan. The prosecution argued that PET scans were not accurate or reliable depictions of cerebral

metabolism.⁵ The prosecutor further argued that the idea that hypometabolism in the frontal lobes causes frontal lobe dysfunction was not generally accepted in the psychiatric and neurological community.⁶ Likewise, Weiss argued that it was debatable whether a causal link could be established between the presence of a congenital cyst and a single violent act. A *Frye* hearing followed, and Judge Richard Carruthers considered whether the PET scan was generally accepted as a diagnostic instrument within the psychiatric and neurological community.⁷

A PET scan measures brain function by determining the brain's use of glucose—the main energy source for the brain. Brain cells, called neurons, need glucose to survive and to function properly. In order to assess glucose metabolism, glucose is radioactively labeled with a tracer. The most common radiotracer in use today in PET scanning is ¹⁸F-fluorodeoxyglucose (¹⁸F-FDG).⁸ FDG-PET is the only established technique that allows analysis of brain glucose metabolism in a live person. Before the PET scan, ¹⁸F-FDG is injected into the vein of a patient who has previously been fasting. As the radioactive glucose is metabolized by the brain, a pair of photons is emitted and captured by detectors within the PET scanner through a process called co-incidental detection.⁹ The scanner records the number of times that photons are captured. The resulting counts are used to calculate a metabolic rate. The metabolic rates are displayed in color-coded fashion in which metabolic increases are typically shown in shades from yellow to red and metabolic decreases are shaded from blue to purple. The ¹⁸F-FDG PET (FDG-PET) images are used to determine sites of abnormal glucose metabolism and can be used to characterize and localize brain abnormalities.

Edward Hoffman and Michael Phelps developed the PET scanner in 1973, and techniques for diagnosing diseases in humans soon followed. FDG-PET is an accepted clinical test

Footnotes

1. *People v. Weinstein*, 591 N.Y.S.2d 715 (N.Y. Sup. Ct. 1992). For an excellent discussion of the *Weinstein* case including commentary from attorneys and expert witnesses, see Owen D. Jones, Jeffrey D. Schall & Francis X. Shen, *The Case of the Murdering Brain*, in *LAW AND NEUROSCIENCE* 41–67 (2014).
2. Daniel A. Martell, *Causal Relation Between Brain Damage and Homicide: The Prosecution*, 1 *SEMINARS IN CLINICAL NEUROPSYCHIATRY* 184 (1996).
3. Norman Relkin et al., *Impulsive Homicide Associated with an Arachnoid Cyst and Unilateral Frontotemporal Cerebral Dysfunction*, 1 *SEMINARS IN CLINICAL NEUROPSYCHIATRY* 172 (1996).
4. *Id.*

5. Zachary Weiss, *The Legal Admissibility of Positron Emission Tomography Scans in Criminal Cases: People v. Spyder Cystkopf*, 1 *SEMINARS IN CLINICAL NEUROPSYCHIATRY* 202 (1996).
6. *Id.*
7. *Weinstein*, 591 N.Y.S.2d 715.
8. In this paper, the radiotracer used in PET scanning is ¹⁸F-FDG. The term PET will signify ¹⁸F-FDG PET.
9. For a detailed explanation of how a PET scanner measures glucose metabolism, see Susan E. Rushing & Daniel D. Langleben, *Nuclear Neuro-imaging, PET and SPECT*, in 1 *NEUROIMAGING IN FORENSIC PSYCHIATRY: FROM THE CLINIC TO THE COURTROOM* 3 (J. Simpson ed., 2012).

used to diagnose and monitor cancer,¹⁰ epilepsy,¹¹ and degenerative brain disease.¹² FDG-PET is also used for pre-surgical planning, in post-stroke evaluation,¹³ and for evaluation of moderate to severe traumatic brain injury.¹⁴ PET is used by forensic medicine practitioners to demonstrate diffuse axonal injury, which is characteristic of mild traumatic brain injury.¹⁵

The similar single-photon emission computed tomography (SPECT) is used to characterize neurodegenerative disorders such as dementia, stroke, seizures, inflammation, and trauma.¹⁶ SPECT uses the radioisotope technetium-99m (99mTc), a compound with a much longer half-life than ¹⁸F-FDG. The breakdown of 99mTc results in the emission of a single photon. The imaging data is captured by a gamma camera, which is rotated around the patient. The SPECT radioisotopes are more accessible and less expensive than the PET radioisotopes, which must be produced in a specialized cyclotron and used within hours of its production.

Only since the early 1990s have courts been confronted with admissibility questions regarding the use of nuclear medicine studies, including PET and SPECT technologies, in criminal trials. The primary issue that judges consider is whether the information provided by the scan will assist the jury in determining an issue regarding the cognitive capacity of the criminal defendant. This information is not given the same level of relevance in every court phase. At sentencing in all death-penalty cases, the jury must consider the defendant's cognitive and neuropsychological limitations. But during the guilt phase of a criminal trial, brain imaging studies are generally offered to substantiate a diagnosis or to offer a causal link between a brain-based abnormality and violent behavior. At no point in a criminal trial can nuclear studies be used to determine whether the defendant committed the act in question. And brain images cannot assist the jury in understanding the emotional mindset of the defendant at the time of the crime. However, nuclear medicine studies can demonstrate brain-based abnormalities, which may suggest that a defendant had a limited capacity for self-control.

In *Weinstein*, the defendant underwent a resting-state PET protocol, and his brain's metabolic rate was compared to a group of controls. The PET scan demonstrated that Mr. Weinstein had abnormally low levels of glucose metabolism in the areas of his brain that were compressed by the cyst and in the brain regions opposite to the cyst. There was no doubt that the presence of the cyst altered Mr. Weinstein's brain structure and function. However, the question before the court was one of causation. Was there sufficient evidence to allow psychiatric and neurological experts to testify that Mr. Weinstein's brain abnormality was related to his violent criminal behavior? Further, could a psychiatrist reasonably opine that Mr. Weinstein's abnormal brain function made him unable to appreciate the wrongfulness of his action and therefore rendered him insane as defined by the State of New York?

Judge Carruthers found that the scientific community generally accepted that PET scans provide a reliable measure of brain glucose metabolism. Judge Carruthers also noted that it is generally accepted in the fields of psychiatry, psychology, and neurology that the frontal lobes of the human brain control executive functions, including the abilities to reason and to plan.¹⁷ The court accepted that damage to the frontal lobes could cause cognitive impairment and that the impairment could specifically be in the areas of judgment, insight, and foresight. The defense planned to call a psychiatrist to testify that, at the moment Weinstein allegedly killed his wife, his cognitive impairment prevented him from understanding that his conduct was wrong and that his impairment was in part due to organic brain damage from the cyst. Judge Carruthers

“[N]uclear medicine studies can demonstrate brain-based abnormalities, which may suggest that a defendant had a limited capacity for self-control.”

10. Jamshed B. Bomanji, Durval C. Costa & Peter J. Ell, *Clinical Role of Positron Emission Tomography in Oncology*, 2(3) LANCET ONCOLOGY 157 (2001); Hatem Necib et al., *Detection and Characterization of Tumor Changes in ¹⁸F-FDG PET Patient Monitoring Using Parametric Imaging*, 52 J. NUCLEAR MED. 354 (2011).
11. Yu K. Kim et al., *¹⁸F-FDG PET in Localization of Frontal Lobe Epilepsy: Comparison of Visual and SPM Analysis*, 43 J. NUCLEAR MED. 1167 (2002); Yu K. Kim et al., *Differential Features of Metabolic Abnormalities Between Medial and Lateral Temporal Lobe Epilepsy: Quantitative Analysis of ¹⁸F-FDG PET Using SPM*, 44 J. NUCLEAR MED. 1006 (2003).
12. Béatrice Desgranges et al., *The Neural Substrates of Episodic Memory Impairment in Alzheimer's Disease as Revealed by FDG-PET: Relationship to Degree of Deterioration*, 125 BRAIN 1116 (2002); Kazunari Ishii et al., *Statistical Brain Mapping of ¹⁸F-FDG PET in Alzheimer's Disease: Validation of Anatomic Standardization for Atrophied Brains*, 42 J. NUCLEAR MED. 548 (2001); Yong Jeong et al., *¹⁸F-FDG PET Findings in Frontotemporal Dementia: An SPM Analysis of 29 Patients*, 46 J. NUCLEAR MED. 233 (2005); Raheong Juh et al., *Different Metabolic Patterns Analysis of Parkinsonism on the ¹⁸F-FDG PET*, 51 EUROPEAN J. RADIOLOGY 223 (2004); Andrew

- B. Newberg & Abass Alavi, *The Role of PET Imaging in the Management of Patients with Central Nervous System Disorders*, 43 RADIOLOGY CLINICS N. AM. 49 (2005).
13. Beau M. Ances et al., *Early Uncoupling of Cerebral Blood Flow and Metabolism After Bilateral Thalamic Infarction*, 25 AM. J. NEURORADIOLOGY 1685 (2004).
14. Marvin Bergsneider et al., *Dissociation of Cerebral Glucose Metabolism and Level of Consciousness During the Period of Metabolic Depression Following Human Traumatic Brain Injury*, 17 J. NEUROTRAUMA 389 (2000); Ronald M. Ruff et al., *Selected Cases of Poor Outcome Following Minor Brain Trauma: Comparing Neuropsychological and Positron Emission Tomography Assessment*, 8 BRAIN INJURY 297 (1994).
15. Samuel H. Mehr & Stephen L. Gerdes, *Medicolegal Applications of PET Scans*, 16 NEUROREHABILITATION 87 (2001); Noel Rao et al., *¹⁸F Positron Emission Tomography in Closed Head Injury*, 65 ARCHIVES PHYSICAL MED. REHABILITATION 780 (1984).
16. Nadine J. Dougall, Sjoerd Bruggink & Klaus P. Ebmeier, *Systematic Review of the Diagnostic Accuracy of 99mTc-HMPAO-SPECT in Dementia*, 12 AM. J. GERIATRIC PSYCHIATRY 554 (2004).
17. Weinstein, 591 N.Y.S.2d at 724.

“[T]here continues to be debate concerning the admissibility of FDG-PET and the appropriateness of expert witness testimony discussing brain scans in the courtroom.”

placed a limitation on the defense witnesses’ testimony and would not permit them to opine either that the cyst or reduced levels of glucose metabolism in the frontal lobes of the brain directly caused Weinstein’s violence.

Nevertheless, Judge Caruthers noted that such assertions would not be generally accepted as valid in the fields of psychiatry, psychology, and neurology. He specifically noted that the sensitivity and specificity of frontotemporal hypometabolism

for impulsivity and violence is unknown. He noted that there were no published controlled PET studies of either episodic violence or subarachnoid cysts, nor were there imaging studies of cyst patients with and without incidents of violence.

There is no legal record of how Weinstein’s insanity claim fared before a jury because on the eve of trial he agreed to plead guilty to manslaughter. Weinstein was sentenced to 7 to 21 years in prison. A surgeon can drain an arachnoid cyst; however, there is a risk of reaccumulation of the cyst. Mr. Weinstein did not undergo cyst drainage. He was incarcerated for more than 12 years and did not engage in any violent acts while in prison.¹⁸ He was granted a conditional release at age 79 and died 2 years after his release. More than 20 years later, arachnoid cysts remain a common incidental finding in neuro-radiologic studies. Arachnoid cysts can lead to epilepsy, headache, and other neuropsychiatric impairment, but no studies directly link this brain abnormality with violence.

PET IN CRIMINAL TRIALS: CURRENT TRENDS IN ADMISSIBILITY

Despite the acceptance of PET in the *Weinstein* case in 1992, today there continues to be debate concerning the admissibility of FDG-PET and the appropriateness of expert witness testimony discussing brain scans in the courtroom.¹⁹ This section reviews the most prominent concerns about the introduction of these brain scans into evidence and explains how the admissibility calculus differs depending on the phase of the legal proceeding. It will review the introduction of scans at pretrial competency hearings and the guilt and sentencing phases of criminal trials and conclude that courts are most willing to admit brain-scan evidence at the sentencing phase.

Admission of PET at Pretrial Competency Hearings

The standard for assessing competency to stand trial was set out in *Dusky v. United States*²⁰ and has since been adopted by

many state jurisdictions. *Dusky* requires that a defendant possess a reasonable capacity to understand the criminal process and be able to function in that process. Mental illness, brain injury, dementia, and mental retardation can significantly affect these abilities. If a defendant is found incompetent to stand trial, the trial is delayed until the defendant becomes competent to respond to the charge. However, there are some conditions that cannot be remedied, and therefore, neither the passage of time nor treatment is likely to restore competence. In these cases, the prosecutor may choose not to pursue certain charges or may request that a defendant be committed to a mental facility to attempt to restore the defendant’s competence.

The ultimate fate of incompetent defendants was addressed in *Jackson v. Indiana* (1972).²¹ Jackson was a 27-year-old man who suffered from an intellectual disability, deafness, and muteness. He was unable to read, write, or otherwise communicate except through limited sign language. Jackson was charged with theft of five dollars and a purse and its contents, estimated to be worth four dollars. Mr. Jackson was not able to communicate with his attorney, so his legal team sought assistance from a teacher at the school for the deaf. The teacher stated that Jackson did not possess adequate sign-language skills for communication and that he would be unable to comprehend the proceedings or aid counsel due to his intellectual disability. The State of Indiana had no facilities that could provide Jackson with rehabilitation for this form of incompetency, and the Supreme Court found that indefinite commitment would violate the defendant’s right to due process.²² The Supreme Court stated that a defendant committed to a mental facility solely on the basis of incompetency “cannot be held more than the reasonable period of time necessary to determine whether there is a substantial probability that he will attain that capacity in the foreseeable future.”²³

Today forensic psychiatrists are routinely asked to evaluate defendants’ competence to stand trial. If the physician deems a defendant incompetent, the physician will be asked to predict whether the defendant’s competence can be restored and what sort of treatment may be necessary to accomplish restoration. There will be cases in which it will be clear to a reasonable degree of medical certainty that competence to stand trial cannot be restored. In some cases, functional imaging may be part of the medical workup to determine the severity of a brain-based cause for incompetency.

Competency is likely to be a growing concern as the population ages. More than 3 million people living in the United States suffer from dementia, a degenerative brain condition.²⁴ As the population of Americans over age 65 is predicted to double by 2030, the number of people with dementia—a risk factor for violence—is also likely to dramatically increase.²⁵

Dementia, including Alzheimer’s-type dementia, frontotemporal dementia (Pick’s Disease), and Parkinson’s disease, are

18. *Weinstein v. Dennison*, 801 N.Y.S.2d 244 (N.Y. Sup. Ct. 2005).

19. Paul S. Appelbaum, *Through a Glass Darkly*, 60 PSYCHIATRIC SERVICES 21 (2009).

20. *Dusky v. United States*, 362 U.S. 402 (1960).

21. *Jackson v. Indiana*, 406 U.S. 715 (1972).

22. *Id.* at 725.

23. *Id.* at 738.

24. Brenda L. Plassman et al., *Prevalence of Dementia in the United States: The Aging, Demographics, and Memory Study*, 29 NEUROEPIDEMIOLOGY 125 (2007).

25. Gregory J. Paveza et al., *Severe Family Violence and Alzheimer’s Disease: Prevalence and Risk Factors*, 32(4) GERONTOLOGIST 493 (1992).

currently irreversible and incurable. While medications may slow the progression of these diseases, people with cognitive deficits caused by these illnesses are not expected to regain lost cognition. In cases of severe cognitive impairment that prevents defendants from working with their defense attorneys, findings of incompetence to stand trial are possible. FDG-PET can be used to diagnose dementia.²⁶ And depending on the severity of the crimes, the prosecuting attorneys may require more evidence to support the alleged irreversible diagnoses.

The following case provides an example of a PET scan that showed organic brain dysfunction but failed to persuade a court that a defendant was not competent to stand trial.

In *United States v. Vincent Gigante*, the mafia boss known as “the Chin” claimed he was incompetent to stand trial for conspiracy and racketeering.²⁷ Mr. Gigante was court ordered to undergo a competence examination after his legal team claimed he suffered from Alzheimer’s-type dementia. A PET study was offered in support of this finding. The court admitted the PET evidence but declined to rely upon it. The court noted that the scan was of “excellent technical quality but [offered] a number of difficulties in interpretation.” Specifically the court was concerned that the controls in the study were not treated with the same psychotropic drugs as Mr. Gigante.

Defense witness Dr. Monte Buchsbaum of Mount Sinai School of Medicine interpreted the PET scans and concluded that Mr. Gigante was suffering from organic brain dysfunction, possibly due to Alzheimer’s disease or multi-infarct dementia. He believed Mr. Gigante was incapable of being tried. Neuropsychological testing by Dr. Wilfred Van Gorp of New York Hospital’s Cornell Medical Center also supported a diagnosis of severe cognitive impairment. However, the prosecution’s expert, Dr. Jonathan Brodie, a psychiatrist at New York University Medical School, testified that the results of both the neuropsychological tests and the PET scan could have been corrupted by medications that Mr. Gigante was taking.

Dr. Brodie criticized defense experts for not analyzing the defendant’s blood to determine the amount of medication in his system at the time the tests were administered. Mr. Gigante had been taking potent psychotropic medications for a long period prior to the PET scan and did not stop these medications prior to the scan. The medications could have altered blood flow to the brain or crossed the blood-brain barrier and potentially altered metabolism.²⁸ The members of the control group were not medicated at the time of their scans and were not close in age to Mr. Gigante. As a result, the court did not find the results of the PET persuasive. Ultimately, Mr. Gigante was found competent for sentencing and was sentenced to 12 years in federal prison in 1997.

But PET scans have been admitted to support a pretrial

motion of incompetence to stand trial. For example, Miguel Carrizalez was charged with two counts of murder, six counts of attempted murder, and gang-related charges in California.²⁹ Mr. Carrizalez had sustained a gunshot wound to the head and had a bullet lodged in his brain. He claimed incompetence to stand trial due to this severe traumatic brain injury and offered a PET scan in support. The prosecution

objected to the admission of the PET scan, and the court held a *Kelly-Frye* hearing.³⁰ During the competence hearing, the judge stated that PET studies are “generally accepted in the scientific community and . . . are certainly accepted as tools used in clinical settings. And in forensic settings it seems . . . there could be testimony as to the areas of the brain that are relevant to the issue of [trial competency].”³¹ The court admitted the PET study into evidence. Despite evidence of severe traumatic brain injury, Mr. Carrizalez was found competent to stand trial, and the PET scan was presented again during the sentencing phase of the trial. The jury convicted Mr. Carrizalez of all charges but did not return a unanimous vote in favor of the death penalty, a requirement to impose a death sentence in California. The district attorney did not retry the penalty phase, and Mr. Carrizalez was sentenced to life without the possibility of parole. The defense teams’ multiple reminders to the jury of the severity of Mr. Carrizalez’s brain injury both in the form of expert testimony and by pictorial demonstration may have led at least one juror to vote for life in prison rather than death in this double-homicide trial.

“In a capital case, neuroimaging can be used in two ways: first, during the guilt-or-innocence phase. . . , and second, in the penalty phase. . . .”

Admission of PET During the Guilt Phase of Criminal Trials

In a capital case, neuroimaging can be used in two ways: first, during the guilt-or-innocence phase in which the State must prove a defendant committed an alleged crime beyond a reasonable doubt, and second, in the penalty phase, where the jury decides whether a guilty defendant will receive a capital sentence. Admissibility challenges are far more likely to arise when PET images are submitted for consideration in the guilt phase of a criminal trial. During the guilt phase, PET may be introduced to support a defendant’s claim that he has a brain-based abnormality that affects his or her ability to form the requisite *mens rea* for the charged crime. When a defense attorney chooses to display a brain image in the guilt phase of a criminal trial, the image will almost certainly be presented by an

26. See Ishii et al., *supra* note 12; Jeong et al., *supra* note 12; Juh et al., *supra* note 12.

27. *United States v. Gigante*, 982 F. Supp. 140 (E.D.N.Y. 1997).

28. Mr. Gigante was reportedly taking Thorazine (chlorpromazine), Restoril (temazepam), Lanoxin (digoxin), Tenormin (atenolol), Pamelor (nortriptyline), and Dalmane (flurazepam) at the time of his scan.

29. Transcript of *Kelly-Frye* Hearing at 1-267, California vs. Miguel Carrizalez, (2011) (No. VCF 169926C).

30. A *Kelly-Frye* hearing is California’s evidentiary hearing for scientific evidence as detailed in *People v. Kelly*, 549 P.2d 1240 (Cal. 1976).

31. *Id.* at 261–62.

“Legal and medical scholars alike have feared the effect that [neuro] images could have on a jury determining a defendant’s guilt.”

expert, who will testify as to whether the defendant was capable of forming the *mens rea* needed to accomplish the crime. To negate *mens rea*, the expert must believe that a neurological defect caused the defendant to be unable to form the intent required to constitute a crime. In cases in which the expert plans to testify that a neurological deficit precludes *mens rea*, an evidentiary challenge is likely. But when the claim is diminished capacity due to a neurological deficit, an

evidentiary challenge is less likely to arise. Evidentiary challenges are rarely raised when neuroimaging is presented in the sentencing phase of trial.

Legal and medical scholars alike have feared the effect that images could have on a jury determining a defendant’s guilt.³² Critics fear a “Christmas tree effect,” whereby jurors may be unduly influenced by the visual display of a colorful brain scan and accept the scan as authoritative evidence without considering the merits of the expert’s accompanying testimony.³³ Critics have also feared that the expert testimony interpreting scans will prejudice or mislead the jury. Further, there is concern that a jury will find a misshapen or malfunctioning brain more persuasive than traditional forms of lay or expert testimony.³⁴ A study by Gurley and Marcus (2008) weighed the effects of structural neuroimaging with MRI used in support of an insanity defense in a simulated murder trial.³⁵ In this study, involving a sample of 400 mock jurors, jurors were more likely to find a defendant not guilty by reason of insanity (NGRI) if an MRI showing a brain lesion was presented than if no image was presented. Mock jurors were even more likely to choose NGRI when both expert testimony and neuroimaging was presented than when either type of evidence alone was presented. This study suggested that the combination of expert testimony and imaging can lead jurors to find that a defendant lacked the *mens rea* needed to commit murder.

However, in a mock study by Schweitzer, there were no increases in successful *mens-rea*-specific defenses when brain images were presented to the “jury.”³⁶ In the research study, brain images had no consistent impact on the verdicts or sentences rendered by the mock jurors.³⁷ Further, showing the mock jurors neuroimages also had no impact on jurors’ perceptions of the defendant’s criminal responsibility.³⁸

Admissibility challenges are less likely to prevail if the

defense offers the incomplete defense of diminished capacity or a variant thereof. When a defendant raises a diminished-capacity defense, the defendant suggests that he or she was deprived of a normal level of mental wherewithal at the time of the crime. Not every state employs this partial defense. In states that do, a successful plea of diminished capacity in a murder trial would likely result in a charge of first- or second-degree murder being reduced to manslaughter.

When introduced in the guilt phase of the trial, PET should aid the physician in making a diagnosis. In some cases, the court has required that PET demonstrate information that is not otherwise available to the clinician. In *People v. Goldstein*, the defendant, Andrew Goldstein, pushed Kendra Webdale in front of an oncoming subway train, killing her.³⁹ Both prosecution and defense experts agreed that defendant Goldstein had schizophrenia. At issue in the trial was whether he was insane at the time he pushed Kendra in front of the oncoming train. PET was offered by a defense expert witness to show that Goldstein’s brain imaging was consistent with schizophrenia. Specifically, the defense witness planned to testify that Mr. Goldstein had a massive reduction in metabolism in the frontal lobe and the basal ganglia.⁴⁰ A special master appointed by the court stated that PET cannot conclusively prove schizophrenia. He continued that regardless of any brain abnormality that PET could show, PET would not be probative of the key issue of the insanity defense, namely, whether Mr. Goldstein comprehended either the nature and consequences of his actions or that his actions were wrong. As PET was not offered to further probe into the impact of schizophrenia on the defendant’s cognition and behavior, it was excluded from evidence.⁴¹

In addition, an expert’s attempt to introduce PET to demonstrate that a particular process or substance altered brain metabolism can be risky if PET is not routinely used for such a diagnosis. Michael Jackson (not the pop star), a man with a history of phencyclidine (PCP) dependence, shot and killed West Covina Police Officer Kenneth Wrede in 1983 when Jackson was intoxicated on PCP.⁴² Mr. Jackson admitted to shooting Officer Wrede but maintained that he had no recollection of the encounter whatsoever. Defense put forth a defense of actual innocence under the theory that Mr. Jackson could not form the requisite *mens rea* required to commit the crime of first-degree murder. The defense expert offered a PET scan to demonstrate brain damage secondary to chronic PCP abuse. The prosecution expert testified that the use of PET scans to diagnose chronic PCP abuse is not generally accepted by the scientific community, and the defense expert did not dispute this fact. No evidence was introduced to suggest that a PET scan could prove that Jackson was unable to premeditate or

32. Teneille Brown & Emily Murphy, *Through a Scanner Darkly: Functional Neuroimaging as Evidence of a Criminal Defendant’s Past Mental States*, 62 STAN. L. REV. 1119 (2010).

33. *Id.* at 1190–91.

34. Deena S. Weisberg et al., *The Seductive Allure of Neuroscience Explanations*, 20 J. COGNITIVE NEUROSCIENCE 470 (2008).

35. Jessica R. Gurley & David K. Marcus, *The Effects of Neuroimaging and Brain Injury on Insanity Defenses*, 26 BEHAV. SCI. & L. 85 (2008).

36. Nicholas J. Schweitzer et al., *Neuroimages as Evidence in a Mens*

Rea Defense: No Impact, 17 PSYCHOL., PUB. POL’Y & L. 357 (2011).

37. *Id.*

38. For a summary of the above-mentioned study, see also Adina L. Roskies et al., *Neuroimages in Court: Less Biasing Than Feared*, 17 TRENDS COGNITIVE SCI. 99 (2013).

39. *People v. Goldstein*, 843 N.E.2d 727 (N.Y. App. Div. 2005).

40. *People v. Goldstein*, 786 N.Y.S.2d 428, 432 (N.Y. Sup. Ct. 2004).

41. *Goldstein*, 843 N.E.2d 727.

42. *Jackson v. Calderon*, 211 F.3d 1148 (9th Cir. 2000).

form specific intent to kill at the time of the shooting. The PET scan could not explain what effect PCP-induced brain damage would have on Jackson's capacity for higher thought. The appeals court found that the trial court did not err in excluding the PET scan and found that Jackson failed to make the required showing of probable innocence.⁴³

PET was also excluded from evidence in the case of *U.S. v. Montgomery*.⁴⁴ Lisa Montgomery had an online friendship with her pregnant victim Bobbie Jo Stinnett. The two had engaged in email exchanges about their respective "pregnancies." Montgomery arranged to meet Stinnett and buy a puppy from her. Montgomery strangled the expectant mother, performed a cesarean section, and kidnapped Stinnett's premature baby. Stinnett died, but her premature daughter survived. Montgomery crossed state lines with the baby, making her crime a federal offense. A PET scan was offered to support Montgomery's defense of pseudocyesis, or false pregnancy, a mental disorder that could have led to a diminished-capacity finding. The court found that a PET scan was not ever used as a diagnostic aid for pseudocyesis. Further, the abnormalities revealed on PET did not predict behavior, nor did the abnormality cause Montgomery to commit the crime. Accordingly, PET was excluded from evidence in the guilt phase of the trial. In this case PET was also excluded from evidence during the sentencing phase, but such exclusion at sentencing is exceedingly rare in death-penalty cases.

PET scans are also only admissible if unlikely to mislead the jury. In *United States v. Mezvinsky*,⁴⁵ Edward Mezvinsky, a former congressman, was charged with 69 violations of federal law arising from fraudulent schemes and related financial crimes. The crimes occurred over a 12-year period. In his defense, Mr. Mezvinsky offered a PET scan to demonstrate that he was incapable of deception, an element necessary to prove fraud. Dr. Ruben Gur, the Government's witness, and Dr. Jonathan Brodie, Mr. Mezvinsky's witness, agreed that no study exists that links the diminished capacities in various parts of Mezvinsky's brain to any specific disorder. Both agreed that a PET scan is only a snapshot of a patient's brain at one particular time and that one cannot make retrospective appraisals of that brain from such snapshots. Thus, neither expert could make any inference about the state of Mezvinsky's brain at any point during the 12 years in question. Neither expert could identify anything in the scan that would elucidate Mezvinsky's capacity to deceive.⁴⁶ Accordingly, the court found that the relevance of the evidence was outweighed by its capacity to mislead the jury, and PET was excluded from evidence in Mezvinsky's trial. Such a result is unlikely in the sentencing phase, however.

PET Admissions Rarely Challenged at Sentencing Phase

The penalty phase arises after the jury has found the defendant guilty of the capital crime. To help the jury determine whether a defendant should be sentenced to death, the State presents evidence of aggravating factors about the defendant and the crime, and the defense presents evidence of mitigating factors. The penalty phase presents the jury with "the moral and normative choice" of whether a capital defendant deserves execution.⁴⁷

PET scans are often admitted because criminal defendants facing the death penalty have a constitutional right to present any evidence at sentencing that could lead to a sentence less than death. In *Lockett v. Ohio* (1978), the Supreme Court determined that a capital defendant is entitled to present any aspect of character or record and any circumstance of the offense that might serve as a basis for a sentence less than death, regardless of whether the evidence supports a statutorily authorized mitigating factor.⁴⁸ And in *Tennard v. Dretke* (2004), the Supreme Court stated that any cognitive or neuropsychological impairment may be considered a mitigating factor even if the impairment bears no direct link with the homicidal behavior.⁴⁹ Evidence of a structural or metabolic brain abnormality could be included as evidence of a severe mental disturbance, a prong that most states and the federal government include as a mitigating factor in the death-penalty statute.⁵⁰ Further, most states allow a defendant to present any "other factor" in the defendant's background, record, or character or any other circumstance of the offense that mitigate against imposition of a death sentence.⁵¹ Evidence of brain damage or brain dysfunction can be offered under the "other factor" prong as well. Functional images of the brain are commonly admitted in death-penalty litigation to demonstrate brain abnormalities that a jury could find mitigating.⁵²

The admission of PET to demonstrate brain abnormalities has become routine during the penalty phase of capital trials in several states. The right to present a PET scan in the state of Florida was determined in *Hoskins v. State*.⁵³ Mr. Hoskins was charged with multiple felonies, including first-degree murder, and the State sought the death penalty.⁵⁴ Mr. Hoskins's examining physicians noted that he had an IQ of 71 and recom-

"The admission of PET to demonstrate brain abnormalities has become routine during the penalty phase of capital trials in several states."

43. *Id.* at 1165.

44. *United States v. Montgomery*, 635 F.3d 1074 (8th Cir. 2011).

45. *United States v. Mezvinsky*, 206 F. Supp. 2d 661 (E.D. Pa. 2002).

46. *Id.* at 674.

47. John H. Blume & Emily C. Paavola, *Life, Death, and Neuroimaging: The Advantages and Disadvantages of the Defense's Use of Neuroimaging in Capital Cases—Lessons from the Front*, 62 MERCER L. REV. 909, 914 (2011).

48. *Lockett v. Ohio*, 438 U.S. 586 (1978).

49. *Tennard v. Dretke*, 542 U.S. 274 (2004).

50. 18 U.S.C. § 3592. Mitigating and aggravating factors are to be con-

sidered in determining whether a sentence of death is justified.

51. *Id.*

52. O. Carter Snead, *Neuroimaging and the Courts: Standards and Illustrative Case Index, Emerging Issues in Neuroscience Conference for State and Federal Judges* (June 29, 2006), available at <http://www.ncsc.org/Conferences-and-Events/STC-seminar/~media/Files/PDF/Conferences%20and%20Events/AAA%20Neuroimaging%20and%20the%20Courts%20Standards%20and%20Illustrative%20Case%20Index.ashx>.

53. *Hoskins v. State*, 702 So. 2d 202, 209 (Fla. 1997).

54. *Id.*

“[T]he use of PET scans is growing, [and] some courts are now dealing with the question whether an attorney should be required to proffer a brain scan. . . .”

mended that PET be obtained as part of the workup for brain damage. The trial court refused to grant the defendant's motion seeking to transport Hoskins to a hospital for PET scanning. Mr. Hoskins was convicted of first-degree murder and sentenced to death. The appellate court remanded the case, ordering that a brain scan be obtained and a new penalty phase considered, in effect overturning Hoskins's death sentence.⁵⁵ The court's denial had limited the physician's ability to evaluate the

degree of Hoskins's mental impairment, which is a statutory mitigating factor under Florida law.⁵⁶

In most capital cases, the image of the defendant's brain is but one piece of evidence demonstrating the disadvantages confronted by the defendant. A complete mitigation workup will review the developmental, genetic, social, family, home environment, educational, and vocational history of the defendant. When evidence of brain damage or brain dysfunction has not been explored during the original sentencing phase of a capital trial, this oversight may be grounds for appeal.

INEFFECTIVE-ASSISTANCE-OF-COUNSEL CLAIMS FOR FAILURE TO EXPLORE BRAIN-BASED ABNORMALITIES

As explained in the previous section, it appears that the use of PET scans is growing, most rapidly in the sentencing phase of criminal trials. Accordingly, some courts are now dealing with the question whether an attorney should be required to proffer a brain scan in some contexts. This section reviews this emerging area of caselaw. While most of the time the use of a brain scan is not warranted, the illustrative cases raise the possibilities that in some circumstances, an attorney's failure to gather brain data would be ineffective assistance of counsel.

The U.S. Supreme Court established a two-part test for ineffective assistance of counsel in *Strickland v. Washington* (1984).⁵⁷ A case may be remanded if a criminal defendant can show that counsel's performance fell below an objective standard of reasonableness and that counsel's performance gave rise to a reasonable probability that, if counsel had performed adequately, the result of the trial or sentencing would have been different.⁵⁸

If an attorney fails to present mitigating evidence, including evidence of mental illness or extreme emotional distress, the case can be remanded for ineffective assistance of counsel. For example, California defendant Fernando Caro's death sentence was vacated and remanded for re-trial because his attorney

failed to investigate and present evidence of the impact that exposure to neurotoxicants and child abuse had on his brain.⁵⁹ The court stated that attorneys must cast a wide net for all relevant mitigating evidence at capital-sentencing hearings because “the Constitution prohibits imposition of the death penalty without adequate consideration of factors which might evoke mercy.”⁶⁰ The court did not state that neuroimaging was required in Caro's case. Rather, it gave an extensive list of circumstances that were likely to lead to brain damage. Caro spent his childhood working and playing in pesticide-soaked fields, and he bathed in and was fed food cooked in water contaminated with pesticides. The court noted that Caro worked as a “flagger” for a crop-dusting company and at a company that made toxic pesticides. He was regularly exposed to organophosphates, solvents, organochlorines, and carbamates, and he was poisoned by a number of toxic chemicals at the plant. In addition, Caro suffered serious physical abuse and head injuries as a result of horrific child abuse. Caro also sustained several head injuries as a child: he was born with a three-inch lump on his head due to the use of forceps during his difficult delivery, a water cooler fell on his head at the age of three, and he was hit by a car later that year.⁶¹

It is possible that testimony regarding these unfortunate circumstances would be adequate to allow a jury to sentence Caro to life rather than death. However, if a psychiatrist were to claim that these multiple neurologic insults caused brain damage, evidence of damage would need to be submitted to the court. The *Caro* court suggested that it is adequate for counsel to obtain a corroborated injury history listing factors that led to demonstrated cognitive impairment. But evidence could also be presented through neuropsychological testing, structural brain scans (MRI), and/or functional brain scans (SPECT or PET).

A California court also vacated a death sentence when an attorney failed to consult a neurologist, neuropsychologist, or psychiatrist regarding the defendant. In Francis Hernandez's case, the defense attorney failed to arrange a neurological exam of Hernandez despite the fact that he wrote notes in his legal file suggesting that he planned to do so. On appeal, the attorney stated that “evidence of neurological impairment is the type of evidence I wanted because it would have helped to explain and mitigate Francis's state of mind at the time of the killings.”⁶²

The United States Court of Appeals for the Tenth Circuit also determined that counsel's failure to present this evidence of brain-based abnormalities fell below the constitutional minimum standard for effective representation. Roderick Smith murdered his wife and four step-children. His defense counsel failed to present evidence of brain-based abnormalities including “borderline mental retardation, mental illness, and organic brain impairment” as mitigating evidence at trial.⁶³ The Tenth

55. *Id.*

56. FLA. STAT. § 921.141 (1995).

57. *Strickland v. Washington*, 466 U.S. 668 (1984).

58. *Id.*

59. *Caro v. Calderon*, 165 F.3d 1223, 1228 (9th Cir.), *cert. denied* 527 U.S. 1049 (1999).

60. *Id.* at 1227.

61. *Caro v. Woodford*, 280 F.3d 1247 (9th Cir.), *cert. denied* 536 U.S. 951 (2002).

62. *Hernandez v. Martel*, Acting Warden, California State Prison at San Quentin, CASE NO. CV 90-4638 RSWL (August 16, 2011).

63. *Smith v. Mullin*, 379 F.3d 919, 939 (10th Cir. 2004).

Circuit vacated his sentence, stating: “The sentencing stage is the most critical phase of a death penalty case. Any competent counsel knows the importance of thoroughly investigating and presenting mitigating evidence.”⁶⁴ We are cognizant of “the overwhelming importance of the role mitigation evidence plays in the just imposition of the death penalty.”⁶⁵

A brain scan does not replace a thorough mitigation analysis of a capital defendant, which should include the developmental, genetic, social, family, home environment, educational, and vocational history of the defendant. But evidence of brain deficit may arise from the mitigation analysis. If brain injury or intellectual deficit is suspected, defense counsel must have a qualified medical professional evaluate the defendant, and the professional may request neuropsychological testing. If physical examination or neuropsychological testing reveals brain-based deficits, these deficits may be confirmed or further characterized with brain imaging. The magnitude of the abnormality detected by neuropsychological testing can assist an expert in determining whether neuroimaging is likely to reveal brain-based abnormalities. In some cases, experts may recommend against obtaining costly brain images if they feel the abnormalities that could be pictorially displayed by the images will be minimal. In such cases, the prosecution is likely to draw attention to the lack of abnormality.

CONCLUSION

The inner workings of a defendant’s mind are often a central issue in each phase of criminal jurisprudence. However, different standards apply for admission of scientific evidence during the guilt phase and the penalty phase in criminal trials. In the pretrial phase, attorneys may request the evaluation of a criminal defendant for competence to stand trial. If a defendant is found incompetent to stand trial, the examiner is asked to give a diagnosis as to what caused the mental incapacity as well as a prognosis for when and how competence can be restored. In cases where a physician believes it will not be possible to restore a defendant’s mental wherewithal due to brain damage, a PET scan can help illustrate the brain-based abnormality that the examiner detected.

In the guilt phase of a criminal trial, PET may elucidate damage to areas of the brain that are involved in cognitive functions such as judgment and impulse control. Physicians may use PET to corroborate their clinical impression of a defendant. In some cases, prosecutors’ motions to exclude PET evidence that challenge defense experts’ plans to present a causal link between violence and brain damage have been successful.⁶⁶ But even in the face of evidentiary challenges, PET’s colorful imagery of brain damage can be useful during trial or in plea bargaining discussions, as in *Weinstein*.

At sentencing, brain-based deficits are a mitigating factor for both capital and non-capital defendants. While there is not yet an absolute mandate that brain-based deficits be considered in all criminal cases, the defendant’s cognitive and neuropsychological limitations must be considered in capital

cases, even if the impairment bears no direct link with the homicidal behavior.⁶⁷ Accordingly, when PET is offered as mitigating evidence during the sentencing phase of a capital murder trial, an admissibility challenge is unlikely. Failure to present evidence of brain damage has been a factor in overturning death sentences in ineffective-assistance-of-counsel cases. In addition, evidence of brain damage could assist a jury in understanding the defendant’s limitations, resulting in a lesser sentence.

When a judge has to decide whether to admit brain imaging, the rules of evidence provide clear guidelines regarding when and for what purposes such evidence can be introduced. The judge will consider whether the defense is offering the original scan or a comparison between the defendant’s scan and other scans. In cases where an extrapolation has occurred, the judge is the gatekeeper who must consider the reliability of the methodology used in the interpretation of the brain image. If scan methodology is determined to meet admissibility standards, then the judge will consider the reason why the scan is being offered. Before trial, does the information demonstrated by the scan assist the jury in determining the cognitive capacity of the criminal defendant? At the guilt phase, will the brain image assist the jury in deciding a fact at issue in the guilt-innocence phase of trial? Is there sufficient evidence to allow an expert to testify that a brain abnormality was related to violent or otherwise criminal behavior? During the sentencing phase, does the scan assist the judge or jury in understanding a particular deficit or disadvantage experienced by the defendant? In this final phase, brain images are almost always permitted to supplement the mitigation plea. In fact, in some cases not providing PET scans or other evidence of any brain abnormalities may be ineffective assistance of counsel.



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64. *Id.*

65. *Id.*

66. See Goldstein, 843 N.E.2d 727; Mezvinsky, 206 F. Supp. 2d 661;

Montgomery, 635 F.3d 1074.

67. Tennard, 542 U.S. 274 (2004).