

Neuroethics & Neurotechnology Series
An Ode to the NFL: On Chronic Traumatic Encephalopathy
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Chronic traumatic encephalopathy (CTE) (previously known as “punch drunk syndrome” and “dementia pugilistica”) is a neurodegenerative disorder caused by repeated head injuries over time.¹ Histopathologically, CTE resembles Alzheimer’s disease (tau proteins accumulate in the brain and disarm existing neural pathways) and can only be definitively diagnosed post-mortem on autopsy. CTE made [national headlines](#) when a [JAMA study](#) found clinicopathological evidence of CTE in 110 of 111 (99%) of former National Football League players.² It has been presumed that the risk of CTE doubles after only three years of playing American football.³

Evidence of CTE [has been found](#) in athletes as young as 18 years old; this suggests that the pathophysiology of CTE can be triggered during childhood or adolescence, leading to permanent neurological deficits later in life. Other vulnerable populations to the disease include combat veterans, survivors of domestic abuse, and individuals with epilepsy.⁴

CTE is characterized by an insidious onset and a collection of neuropsychiatric symptoms, including cognitive impairment, personality changes, depression, and suicidality. Although it cannot be diagnosed through neuroimaging alone,⁵ non-specific CT/MRI findings of CTE include generalized cortical atrophy, hippocampal atrophy, cavum septum pellucidum, and features of diffuse axonal injury (i.e., micro-hemorrhages). To date, there is no cure.

The Rise and Fall of Aaron Hernandez

Aaron Josef Hernandez began playing American football at eight years old. In high school, Hernandez played for the Bristol Rams, starting as a wide receiver before eventually becoming a tight end. He was awarded Connecticut’s Gatorade Football Player of the Year 2007 and was a U.S. Army All-American Player. In college, Hernandez played for the Florida Gators, sky rocking the team to win the 2010 Sugar Bowl and in turn landing himself a pick in the 2010 NFL Draft. He was drafted to play for the New England Patriots, in time becoming “the NFL’s best tight end.”⁶

In 2013, Hernandez was charged with the first-degree murder of Odin Lloyd, whose body was found with gunshot wounds to the back and chest a mile from Hernandez’s house; a year later, he was indicted on murder charges for a double drive-by homicide of Daniel de Abreu and Safiro Furtado in Boston. In 2017, after being convicted of the former charge by a grand jury, Hernandez was found hanging by his bedsheets in his prison cell⁶; his death was ruled a suicide.

An autopsy found that Aaron Hernandez suffered from the most severe case of CTE ever recorded in a person his age.⁷ He was 27 years old.

In retrospect, Hernandez had many of the clinical features of CTE, and it is known that there is a correlation between CTE and criminal behavior. According to the 2017 JAMA² study:

- o 86% of CTE patients have memory difficulties
- o 82% of CTE patients are impulsive
- o 51% of CTE patients have “explosive” outbursts
- o 51% of CTE patients show global apathy
- o 34% of CTE patients show physical violence

The post-mortem findings in Hernandez’ brain coupled with the known clinical features of CTE tell an eerie story and bring to light a bigger question: *would we still have considered Hernandez guilty knowing the extent of his brain damage?*

A Hypothetical Legal Defense

There are three major criminal sanctions that may apply to this case: voluntary behavior, *mens rea* (i.e., knowledge of wrongdoing at the time of the crime), and the insanity defense.^{14,15}

Under each of these categories, a defendant can argue that, in part to his neurologic diagnosis, he cannot bear the same nature of legal accountability for his actions as another, healthy human being. *Commonwealth v. Pirela*⁸ and *State v. Reid* established the precedent for this defense in criminal court; more specifically, there is precedent for considering neurological disease as an extenuating factor for violent behavior (as with behavioral-variant frontotemporal dementia, bvFTD).^{9,10}

Aaron Hernandez was unaware that he had CTE, a condition known to cause erratic, impulsive, and explosive behavior, during his lifetime. His lawyers and doctors did not take steps to determine if his brain capacity was “normal.” Most likely, a basic CT/MRI of Hernandez’ brain would have raised alarms about his mental status and prompted researchers to conduct further psychological testing—alarms that would call into action the aforementioned defenses.

Yes, Hernandez may have committed these crimes. But, *because he did have CTE*, was his punishment fair in the eyes of the law?

The NFL: A Deeper Look

As we established earlier, 34% of CTE patients show physical violence. According to a [2021 article](#), “... **intimate partner violence** accounts for 15% of all violent crimes in the United States... [but] for NFL players, domestic violence is the highest criminal charge at 55% of total arrests made.” Is it possible that this statistical discrepancy is in part to underlying, undiagnosed, developing CTE? Are there dozens of cases *like* Aaron’s that are going unnoticed?

Framework and Limitations for Neuroimaging in Civil and Criminal Courts

Neuroimaging is beginning to rear its head in American courtrooms, as an increasing number of cases involve the presentation of brain scans as evidence. As this trend continues, the necessity rises for governmental and regional policies that take into account the strengths and weaknesses of the use of neurotechnology.

With respect to this case, the most notable considerations include:

a) **Understanding neuroimaging, its limitations, and its meaning:** Judges, juries, and attorneys must be trained in the value, meaning, and limitations of these scans. The limits to the accuracy of the scans should be delineated and discussed among members of the court and jury as a part of training prior to case review.¹¹ With Hernandez' case, any CT/MRI findings (e.g., hippocampal atrophy, cavum septum pellucidum, etc.) would be a *trigger* for further psychological and neurological evaluation—not a final diagnosis or an assumption of innocence.

b) **Recognizing the slippery slope of inferring a state of mind:** Abnormal CT/MRI findings in this case would **not** have automatically implied that Hernandez was thinking/behaving a particular way at the time of the murders; a single anomaly in Hernandez' brain would not elucidate the entirety of his actions after 2007. **That is, behavior can be explained by brain evidence, but brain evidence cannot directly explain behavior.** Case studies should be referenced to link how abnormalities in particular regions could impact behavior.

c) **Protecting the privacy of the defendant**¹²: A wide range of personal information can be disclosed within a brain scan; thus, **any irrelevant information** should not be revealed *particularly because* it may confer a bias for or against the defendant. Furthermore, any data gleaned from neuroimaging should be protected as classified medical data under the Health Insurance Portability and Accountability Act (HIPAA).

d) **Recognizing the reliability and accuracy of results:** Neuroimaging requires interpretation; interpretation introduces human error. Thus, multiple tests should be conducted, and multiple medical professionals should be consulted to corroborate the relevant findings; inconsistencies should *not* be admissible in court and any disagreements as to the validity of the data should be shared with the jury.

e) **Implementing neuroimaging only when necessary:** Consistent implementation of neuroimaging in courtrooms can be dangerous; will criminals begin to rely on these technologies to “bail” them out? Thus, clear guidelines as to when the use of neuroimaging is permitted must be set out. Neuroimaging should not be allowed to be used in every case, and a justification must be made for its application.¹³ This could have been done with the Hernandez case, citing the wide literature of evidence linking American football to CTE and linking CTE to violent behavior.

f) **Avoiding neuroimaging as the “be-all and end-all”:** Neuroimaging should only be one piece of a larger body of evidence presented in a trial. Any brain changes found on brain imaging of Hernandez should not decide innocence or guilt; rather, it should be a mitigating factor of decisions made throughout the course of the trial.

It should go without saying that Hernandez' death may also have been prevented had he received proper psychiatric testing and counseling before, during, and after the two criminal trials. Ten percent of the individuals enrolled in the JAMA CTE study died by suicide, and it is a known manifestation of the disease. Throughout the progression of this case, safeguards could have been put into place that may have changed the outcome in its entirety.

Overview:

The ethical dilemma: While serving time for three murders, NFL tight-end Aaron Hernandez committed suicide in prison. An autopsy found that he suffered from the most severe case of CTE ever recorded in a person his age; he was 27 years old. He was unaware of this diagnosis, a condition known to cause erratic, impulsive, and explosive behavior. His lawyers and doctors did not take steps to determine if his brain capacity was “normal.” Most likely, a basic CT/MRI of Hernandez’ brain would have raised alarms about his mental status and prompted researchers to conduct further psychological testing—alarms that would call into action several legal defenses. Yes, Hernandez may have committed these crimes. But, *because he did have CTE*, was his punishment fair in the eyes of the law?

Takeaways/lessons: Within the legal sphere, a defendant can show that thanks to his disorder, his behavior was not voluntary, that he lacked the mental state essential to enact the crime, or that he is lawfully insane.^{14,15} This, with the help of neuroimaging, could have changed the outcome of the Hernandez trial. However, the linear causality between a neurologic diagnosis and an individual’s subsequent mental state and/or conduct remains unclear.¹⁶ Thus, the legal system must carefully follow developments from research on neuroimaging and establish useful guidelines for the permissibility of neuroimaging in courts. Perhaps more importantly, *developers of technologies* must be wary of how they can be used and preemptively assign limitations to them.

Concepts considered: justice, social-notions, responsibility, long-term implications

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About the Author:

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Sunidhi's writing has been featured in numerous peer-reviewed journals. Her work on neuropsychiatry and neurolaw, in particular, has won her numerous recognitions at international conferences. Her research spans neurology, ophthalmology, and sociology; she is particularly focused on the intersections of science, disparity, social justice, and ethics.