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LAW AND NEUROSCIENCE

FORDHAM UNIVERSITY
THE SCHOOL OF LAW
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BRAIN STRUCTURE AND FUNCTION RELATED TO AGGRESSION

Reading Materials

1. Biographical information on Ruben C. Gur, Ph.D.

2. A Perspective on the Potential Role of Neuroscience in the Court

3. Prosecution Rests in Kaboni Savage Murder Trial

4. Jury: Accomplice of Savage Should Get Life

Dr. Gur received his B.A. in Psychology and Philosophy from the Hebrew University of Jerusalem, Israel, in 1970 and his M.A. and Ph.D. in Psychology (Clinical) from Michigan State University in 1971 and 1973, respectively. He did Postdoctoral training with E.R. Hilgard at Stanford University and came to Penn as Assistant Professor in 1974. His research has been in the study of brain and behavior in healthy people and patients with brain disorders, with a special emphasis on exploiting neuroimaging as experimental probes. As Professor in the Departments of Psychiatry, Radiology & Neurology, and Director of the Brain Behavior Laboratory and the Center for Neuroimaging in Psychiatry, he has developed tools for “deep phenotyping” of brain and behavioral parameters using computerized acquisition tools that can integrate clinical and neurocognitive measures with neuroimaging and genomic data within the framework of large multicenter studies. His work has documented sex differences, aging effects, and abnormalities in regional brain function associated with schizophrenia, affective disorders, stroke, epilepsy, movement disorders and dementia. His work has been supported by grants from the NIMH, NIH, NIA, NINDS, NSF, DOD, NASA, private foundations (Spencer, MacArthur, EJLB, Brain and Behavior Research Foundation) and industry (Pfizer, AstraZeneca, Lilly, Merck).
A PERSPECTIVE ON THE POTENTIAL ROLE
OF NEUROSCIENCE IN THE COURT

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INTRODUCTION

This Article presents some lessons learned while offering expert testimony on neuroscience in courts. As a biomedical investigator participating in cutting-edge research with clinical and mentoring responsibilities, Dr. Ruben Gur, Ph.D., became involved in court proceedings rather late in his career. Based on the success of Dr. Gur and other research investigators of his generation, who developed and validated advanced methods for linking brain structure and function to behavior, neuroscience findings and procedures became relevant to multiple legal issues, especially related to culpability and mitigation. Dr. Gur found himself being asked to opine in cases where he could contribute expertise on neuropsychological testing and structural and functional neuroimaging. Most of his medical-legal consulting experience has been in capital cases because of the elevated legal requirement for thorough mitigation investigations in such cases, and his limited availability due to his busy schedule as a full-time professor and research investigator who runs the Brain and Behavior Lab at the University of Pennsylvania ("Penn"). Courtroom testimony, however, has not been a topic of his research and so he has not published extensively on the issues in peer-reviewed literature.

Dr. Gur’s specific experience has been providing testimony as to the potential behavioral effects of brain damage in certain regions of the brain.

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Although the law has a long history with testimony on this subject, the slow process of creating legislation and establishing precedent leaves the law behind the rapid pace of scientific innovation. The law has yet to fully absorb the kind of rigorously tested brain behavior science that is increasingly available. It is no surprise that there are opponents of introducing neuroscience testimony, either because they feel it is flawed in some way (methodologically or as applied) or because they feel that its probative value is outweighed by the potential to unduly influence the trier of fact. Still, the field is rapidly evolving, and multimodal integration will pave the way for additional, heretofore unimaginable mechanistic insights. Ironically, a potential hurdle for the neuroscientist involved in expert testimony is that, while more precise and reliable, data will become increasingly more difficult to understand and, therefore, explain. It has become hard to find experts who can speak knowledgeably about behavior and the range of neuroimaging parameters relevant to its interpretation.

To provide a framework for appreciating the contribution that neuroscience can make to the courts, this Article begins in Part I with a brief historical overview of the evolution of behavioral neuroscience to the point of becoming relevant in court. Next, Part II presents a brief account of how Dr. Ruben Gur became involved in litigation, primarily offering neuroscience-based expertise as mitigation evidence in capital cases. Part II also briefly describes the typical analytical processes used by Dr. Gur and other neuroscience experts he consults with when responding to requests for expert analysis. Part III then outlines some of the lessons learned from testifying as a neuroscience expert. Finally, Part IV concludes with a discussion of some of the objections raised against the use of neuroscience testimony in the courtroom.

I. LINKING THE BRAIN TO BEHAVIOR AND THE LEGAL RELEVANCE OF NEUROSCIENTIFIC EVIDENCE

The story of the application of neuroscience to legal matters cannot be told without briefly tracing the history of neuroscientific methods. Accordingly, Part I.A traces the history of neuroscience and Part I.B explores the emergence of modern methodologies, technologies, and diagnostic tools employed by neuroscientists. Then, Part I.C briefly discusses neuroscience’s recent transition to a useful court apparatus.

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3. For example, some experts lack the expertise to replicate an opposing expert’s findings and will need to consult with additional experts.

4. Our typical analytical processes are reviewed in greater detail elsewhere, and much of what we describe here can be found in a recent publication by Ruben and Oren Gur. See generally Ruben C. Gur & Oren M. Gur, Linking Brain and Behavioral Measures in the Medical-Legal Context, in THE EVOLUTION OF FORENSIC PSYCHIATRY: HISTORY, CURRENT DEVELOPMENTS, FUTURE DIRECTIONS 295 (Robert L. Sadoff ed., 2015).
That the brain is the sole organ that regulates cognition and behavior is a relatively recent discovery in the history of civilization. The ancient Greeks believed that different organs were responsible for aspects of behavior. For example, they thought that courage arose from the heart, reason from the head, and "base qualities" from the stomach. It took another fourteen centuries before Albertus Magnus concluded that the brain controlled behavior. However, he (and others) thought that the "action" was in the three ventricles: The first ventricle processed the five senses, passing images to the middle ventricle that did the reasoning before transferring the results to the third ventricle for memorization and storage. René Descartes was first to articulate the idea that the seat of the soul was in brain tissue. Descartes had difficulty, however, reconciling his knowledge of brain anatomy and his Christian faith, as the soul is considered unitary—deserving of salvation or punishment—yet the brain is clearly separated into two hemispheres. To reconcile this contradiction, he concluded that the one brain structure that does not have two hemispheres, the pineal gland, must be the seat of the soul.

Subsequent investigators accepted the notion that cognition and behavior are products of brain function, but the relation between brain processes and behavior was an enigma. Phrenology developed as a discipline that further influenced scientific thinking about the brain and behavior. Early efforts were restricted by the tools available to investigate the brain, and, to this day, our ability to link brain function to behavior is limited by technology and methodology. Lacking the tools to investigate the brain itself, phrenologists studied the head and attempted to correlate size and shape of different portions of the skull with human "faculties." For example, large foreheads were said to be associated with intellectual abilities. Phrenology was never accepted by the mainstream of science, and the whole idea of localizing behavioral domains in brain regions became tarnished. The experience with phrenology may have generated negative

6. Id. at 18–19.
9. See generally DESCARTES, TREATISE OF MAN, supra note 8; Descartes, Passions of the Soul, supra note 8.
10. See generally DESCARTES, TREATISE OF MAN, supra note 8; Descartes, Passions of the Soul, supra note 8.
12. See id. at 44, 87.
13. See id. at 61.
attitudes toward efforts to localize cognitive “faculties” in specific brain regions.

This was the backdrop for the work of a nineteenth-century French neuroscientist, Pierre Paul Broca, who reasoned that the criticism against phrenologists may have been too focused on the type of “faculties” they associated with specific brain regions.\textsuperscript{14} He argued that the principle that different brain regions control aspects of behavior might still hold true, even if previous efforts had failed to systematically examine the connection between specific brain regions and important human faculties, such as speech.\textsuperscript{15} Broca maintained that speech was both unique and important and should have a localizable brain structure to support it.\textsuperscript{16} He proposed a methodology for scientifically establishing such links between the brain and behavior.\textsuperscript{17} It involved a careful study of people who suffered damage to their brain, outlining and documenting their behavioral deficits, and then finding out which brain regions were damaged by detailed autopsy.\textsuperscript{18}

Broca’s focus on speech led him to study several patients with severe speech deficits who were not otherwise demented. One of the most influential cases he studied was that of Monsieur Lelong, an elderly gentleman who suffered a sudden onset of speech loss.\textsuperscript{19} He used only seven words: “yes,” “no,” “one,” “two,” “three,” “Lelong,” and “toujour” (the French word for “always”).\textsuperscript{20} Broca demonstrated, however, that Lelong understood speech and applied his limited vocabulary appropriately: he used “one” for the number “one,” “two” for the number “two,” “three” for any number larger than two, “yes” for affirmation, “no” for negation, and “toujour” for all other words.\textsuperscript{21} An autopsy revealed a large lesion in the third frontal convolution of the left hemisphere.\textsuperscript{22} Broca published his findings in 1861, thereby establishing the field of neuropsychology.\textsuperscript{23}

Broca’s paradigm became recognized as the “clinical-pathological correlation” method and has contributed much of what we know today about brain behavior relations. In 1874, Carl Wernicke expanded on Broca’s findings and documented that lesions more posterior to what became known as Broca’s area “were associated with relatively preserved speech output, but diminished capacity to comprehend speech.”\textsuperscript{24} Links between brain abnormalities and emotional behavior were first established in 1914 by Joseph Babinski, who reported on a series of sixteen patients with significant brain damage manifested behaviorally by denial of symptoms (anosognosia), and even unusual jollity about having these

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\textsuperscript{14} See Gur & Gur, supra note 4, at 296.
\textsuperscript{15} See id.
\textsuperscript{16} See id.
\textsuperscript{17} See id.
\textsuperscript{18} See id.
\textsuperscript{19} See id.
\textsuperscript{20} See id.
\textsuperscript{21} See id.
\textsuperscript{22} See id.
\textsuperscript{23} See id.
\textsuperscript{24} See id.
\end{flushleft}
symptoms (anosodiaphoria). Notably, all these patients had major lesions in the right hemisphere. The British neurosurgeon Samuel Alexander Kinnier Wilson described a patient who laughed incessantly, to the point of not being able to eat. Wilson had to overcome the danger of dehydration by sitting at the patient’s bedside and yawning deliberately, which induced the patient to yawn long enough for the nurse to feed him. This patient had bilateral brain damage. Other investigators, such as John Hughlings Jackson in 1932, reported that lesions in the right hemisphere produced deficits in spatial abilities. The literature on mood changes associated with regional brain damage was summarized by Harold Sackeim et al., who concluded that right hemispheric lesions were associated with positive symptoms of jocular affect, while left hemispheric lesions were associated with release of negative affect. It is now indisputable that both cognitive and emotional processing are disrupted in patients with brain lesions, and different behavioral domains are affected depending on the location and nature of brain damage.

The most dramatic demonstrations of specific regional control of behavior by the brain were produced in the middle of the twentieth century by the Canadian neurosurgeon Roger Penfield in his studies of brain stimulation. Penfield performed surgery on patients with temporal lobe epilepsy while they were awake and could therefore observe the effects of stimulating different brain regions on behavior. He found that he could consistently induce patients to lift an arm or a finger by stimulating specific regions in the contralateral hemisphere, and he was able to methodically map the entire motor system in this way. Penfield discovered a virtual

25. See id.
26. See id.
28. See id.
29. See id.
31. See Harold A. Sackeim et al., Hemispheric Asymmetry in the Expression of Positive and Negative Emotions: Neurological Evidence, 39 ARCHIVES NEUROLOGY 210, 210, 215 (1982). It is noteworthy that brain lesions can produce both “negative” symptoms and “positive” symptoms. Negative symptoms are behavioral deficits, such as fluent speech or memory that patients can no longer perform at normative levels. Positive symptoms are new behaviors, such as jocular, aggressive, or depressed mood, which may emerge because of damage to regions that inhibit or regulate such behaviors.
32. See generally Richard J. Davidson et al., Emotion, Plasticity, Context, and Regulation: Perspectives from Affective Neuroscience, 126 PSYCHOL. BULL. 890 (2000).
34. See generally PENFIELD, THE MYSTERY OF THE MIND, supra note 33.
35. See id.
"homunculus" (meaning "a little man" in Latin) along the fissure that separates the frontal lobe from the parietal lobe. The entire human body was represented, and each limb (e.g., individual fingers) could be activated by an electrical pulse administered to specific contralateral locations of the brain. A parallel "receptive" homunculus was demonstrated in the parietal side of the same fissure, where stimulation would lead to sensations from corresponding body parts. Thus, one spot, when stimulated, would make the patient feel like his left index finger was being touched, another spot would cause the sensation that the left thumb was touched, and yet another spot would generate the sensation of being touched on the face. Stimulating other parts of the brain could induce or arrest speech.

In addition to helping map behavior into specific brain regions with a powerful experimental paradigm, Penfield's work has another specific relevance to the medical-legal context. Considering the importance of free will in legal culpability, it is noteworthy that during Penfield's procedures, when patients were asked why they moved their arm or finger, or why they began or ceased talking, they typically reported a subjective feeling that such action was their wish. Therefore, patients invariably perceived actions induced by electrical stimulation, which they were obviously not controlling, as being under their voluntary control.

As evidence was accumulating on links between specific types of brain damage and behavioral deficits, the need arose to gauge the probability of brain damage in cases when it was not clear whether aberrations were caused by such damage or by other factors. Most brain disorders do not produce effects as dramatic as those seen in Lelong, and it is not always clear whether a particular level of performance on a specific behavioral domain reflects deviation from what is normative for that individual or for people like him who do not suffer from brain damage. For instance, someone might be a poor performer in the eyes of a physician, when in fact her performance level is within what can be expected of someone of similar educational and socioeconomic background.

B. The Emergence of Modern Methodologies and Technologies in Neuroscience Research

Fortunately, the turn of the twentieth century, which introduced neurological evidence linking behavioral domains to regional brain

38. See generally PENFIELD, THE MYSTERY OF THE MIND, supra note 33.
39. See generally PENFIELD & JASPER, supra note 33.
40. See generally PENFIELD, THE MYSTERY OF THE MIND, supra note 33.
41. See generally id.
42. See generally id.
43. See generally id.
44. See supra notes 19–21 and accompanying text.
function, also saw revolutionary progress in psychometric theory and methodology, which allowed for the development of reliable measurement of behavioral performance. Psychologists have developed tests that measure overall intellectual capacity as well as specific domains of cognition, and psychologists who worked with neurological and neuropsychiatric patients—soon to be called "neuropsychologists"—began to develop measures that could help diagnose brain dysfunction. "For example, to measure verbal output fluency, [neuro]psychologists have developed standardized tests where someone is given a limited amount of time to produce as many words as possible that start with a certain letter." Such tests would not be necessary for detecting severe deficits in patients like Lelong, who could not produce more than a dozen or so words even if given an hour, but they could detect smaller lesions in the same area in which damage obliterated Lelong's speech capacity. Applying such verbal fluency tests—such as asking the patient to say in under one minute as many words as possible starting with a specific letter—to patients proved sensitive to the presence of left frontotemporal lesions. Similarly, tests of memory proved sensitive to temporal-limbic anomalies, and tests of executive functions such as concept formation and set shifting proved sensitive to frontal lobe damage. Leading neuropsychologists, such as Dr. Arthur Benton and Dr. Edith Kaplan, have compiled such tests into assessment tools—neuropsychological batteries—that are incorporated into the diagnostic workups in a range of disorders that are associated with behavioral abnormalities and cognitive deficits. Research and clinical work using this methodology helped solidify the field of neuropsychology, and it is now a recognized subspecialty of the American Board of Professional Psychology (ABPP). Neuropsychology has become the discipline at the intersection of linking behavioral domains to the functioning of brain systems.

Progress in neuropsychology was nevertheless hampered by the need to rely on correlating behavioral measures with brain abnormalities that are putatively responsible for behavioral deficits. Neuropsychologists could

46. See Gur & Gur, supra note 4, at 297.
47. Id.
48. See id. at 296.
52. See ARTHUR L. BENTON ET AL., MULTILINGUAL APHASIA EXAMINATION (3d ed. 1994); Janis M. Peyser et al., Guidelines for Neuropsychological Research in Multiple Sclerosis, 47 Archives Neurology 94, 96 (1990).
collect precise data on verbal fluency and language comprehension and find evidence that such functions were impaired in patients with left hemispheric stroke as inferred from hemiplegia (loss of sensation in one side of the body) or hemiparesis (paralysis of a limb) of the right side of the body.\textsuperscript{54} It became possible to document performance on face memory and find that it is associated with temporal lobe damage in the right hemisphere because it was observed in patients with seizure disorders predominantly involving, or starting with, the left side of the body.\textsuperscript{55} But one could never determine the precise location of the stroke or the seizure focus. Furthermore, it is difficult to learn how a system works by only knowing about what happens when parts of it break.

Progress has therefore accelerated exponentially with the advent of neuroimaging. In the late 1970s and early 1980s, methods became available for safely and reliably measuring brain function and structure in humans.\textsuperscript{56} Electroencephalography (EEG) enabled the measurement of changes in the brain’s activity, but localization was hampered by the attenuation and smearing of the brain’s electrical signal by the skull bone and tissue.\textsuperscript{57} Among the first methods for measuring parameters related to the brain’s metabolic activity was the xenon-133 clearance technique, which measured regional cerebral blood flow (CBF).\textsuperscript{58} Using this method, it was discovered that, among other things, CBF increases during cognitive activity compared to a resting (default mode) state and that it increases more in the left hemisphere for a verbal-reasoning task and in the right hemisphere for a spatial task.\textsuperscript{59} This methodology was augmented by positron emission tomography (PET), which allowed three-dimensional measurement of both CBF and metabolism.\textsuperscript{60} Spatial resolution was initially low (about 1.5 cm\(^3\)) but it reaches 3–4 mm\(^3\) with modern devices.\textsuperscript{61}

The introduction of magnetic resonance imaging (MRI) further enhanced the scope and pace of research linking brain systems to behavior. Advanced MRI methodology can generate multimodal information on the

\textsuperscript{57} See Saeid Sanei & J.A. Chambers, *EEG Signal Processing* 7 (2007) ("The skull attenuates the signals approximately one hundred times more than the soft tissue.").
\textsuperscript{58} See generally Walter D. Obrist et al., *Regional Cerebral Blood Flow Estimated by 133-Xenon Inhalation*, 6 *Stroke* 245 (1975).
\textsuperscript{60} See generally M.E. Phelps et al., *Tomographic Measurement of Local Cerebral Glucose Metabolic Rate in Humans with (F-18)2-Fluoro-2-Deoxy-D-Glucose: Validation of Method*, 6 *Annuals of Neurology* 371 (1979).
brain, with exquisite spatial resolution. MRI can segment the cranial volume into compartments (gray matter, white matter, cerebrospinal fluid) and provide reliable information on regional brain volume. More novel MRI sequences can provide measures of white matter structural integrity through diffusion tensor imaging (DTI). Such measures can tell us about how well different regions are structurally interconnected. Resting state CBF can also be measured with magnetic resonance (MR) using arterial spin-labeling methods, and resting state connectivity and response to neurobehavioral probes can be quantified with blood oxygenation level dependent (BOLD) measures. Application of these methodologies has generated more precise models of brain system involvement in regulating behavior. For example, functional MRI (fMRI) studies have shown activation of the frontal system when participants were deliberating ethical dilemmas.

As methodology improved for assessing both behavior and brain structure and function, neuropsychology has matured into one of the most vibrant fields of science. Data have been converging from clinical studies to experimental neuroimaging studies—as well as from animal studies we have not discussed here—that enable firm associations between behavior and brain structure and function. For example, by examining neuroanatomical and neurophysiological substrates of specific neurocognitive domains, such as social cognition, we can bridge between brain processes and behavior.

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63. See Mark I. Kohn et al., Analysis of Brain and Cerebrospinal Fluid Volumes with MR Imaging (pt. 1), 178 RADIOLOGY 115, 115–16 (1991); see also Lyn M. Gaudet & Gary E. Marchant, Under the Radar: Neuroimaging Evidence in the Criminal Courtroom, 64 Drake L. Rev. 577, 584 (2016) ("It is generally recognized that MRI produces a better image than CAT scans because there is a greater contrast between soft tissues, including gray and white matter, which results in a clearer image of brain structures.").

64. See, e.g., Wim Van Hecke et al., DTI Analysis Methods: Voxel-Based Analysis, in DIFFUSION TENSOR IMAGING: A PRACTICAL HANDBOOK 183, 197 (Wim Van Hecke et al. eds., 2016).


67. See generally Bharat B. Biswal, Joel Van Kylen & James S. Hyde, Simultaneous Assessment of Flow and BOLD Signals in Resting-State Functional Connectivity Maps, 10 NMR BIOMEDICINE 165 (1997); Ruben C. Gur et al., An fMRI Study of Sex Differences in Regional Activation to a Verbal and a Spatial Task, 74 BRAIN & LANGUAGE 157 (2000).


neurology, and psychiatry, has become among the showcases of success in applying scientific methodology to understanding the mind.\(^70\)

C. The Beginnings of the Application of Neuroscience to the Law

The implications of neuropsychological knowledge to law have become more evident as demonstrated by their impact on decisions related to culpability. MRI studies have examined the developmental trajectories of different brain systems and shown, for example, that maturation of frontal lobe regions—which are related to executive function—is incomplete until early in the third decade of life.\(^71\) Such data have relevance to criminal culpability of adolescents and individuals with frontal lobe damage.

Indeed, scholars have marveled at the relatively recent emergence of neuroscience testimony in courts.\(^72\) The proliferation has coincided with the decline of much of forensic science after the 2009 National Academy of the Sciences report castigated critical components of the field such as polygraph testing.\(^73\) Relatively recent U.S. Supreme Court decisions like _Atkins v. Virginia_\(^74\) and _Roper v. Simmons_\(^75\) show the increasing influence new knowledge of brain behavior can have at the highest levels of the law, and emerging technologies have shown the potential of neuroscience to fulfill a truth-seeking function in court.\(^76\)

II. DR. RUBEN GUR’S INITIAL INVOLVEMENT IN MEDICAL-LEGAL CONSULTATION AND TYPICAL ANALYTICAL PROCESSES EMPLOYED BY DR. GUR IN THE LEGAL CONTEXT

Dr. Ruben Gur’s foray into medical-legal consultation has afforded him some insights into the application of neuroscience to the law. In describing

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70. See generally Ruben C. Gur, Prospective Community Studies Linking Cognitive Deficits to Subclinical Symptoms and a Step Toward Precision Medicine, 73 JAMA PSYCHIATRY 109 (2016).


74. 536 U.S. 304 (2002).

75. 543 U.S. 551 (2005).

the methods utilized by Dr. Gur in the medical-legal field, Part II.A first tracks his involvement in medical legal consultation. Part II.B then describes methodological approaches to medical-legal consultation and analysis.

A. Dr. Gur’s Experience in Medical-Legal Consultation

In the late 1970s, Dr. Gur became involved in cutting-edge research aimed at harnessing the evolving neuroimaging technology to understand the neural substrates of behavior. The research required extensive study of healthy people that identified factors that influence measures of brain function and structure and required study of normative sex differences and effects of age. The clinical goal of the research was to understand how various brain disorders affect such measures across the lifespan. In that process, Dr. Gur gained experience working with clinical populations and applying budding neuroimaging methods in diagnosis and treatment planning. In one case, he testified:

The first PET scanner I worked with was called PET three. It was technically the third PET scanner that was ever built. And when MRI came on the scene[,] because of my background and work in imaging in relation to behavior[,] I was involved with that work literally from the outset.

This research was both basic, involving healthy populations, and clinical, with neurological patients (e.g., suffering from stroke, seizure disorders, tumors, head injuries, movement disorders, and dementias) and psychiatric patients (primarily suffering from psychosis, mood disorders, and conduct disorders). The resulting normative PET database—the largest in the country at the time—became known to Dr. Frank Wood, a neuropsychologist who also was involved in neuroimaging. Dr. Wood was involved in a medical-legal case in which a PET scan was performed on the defendant. Dr. Wood called Dr. Gur and asked if he could compare his results to Dr. Gur’s normative PET database. Most regional-to-whole-brain ratios obtained by Dr. Wood on the defendant were well within the normal expected range of the controls. The measured value for the

77. See, e.g., Gur & Reivich, supra note 59.
80. See generally Ruben C. Gur et al., Sex Differences in Regional Cerebral Glucose Metabolism During a Resting State, 267 SCIENCE 528 (1995) [hereinafter Gur et al., Sex Differences]; Ruben C. Gur et al., The Effect of Anxiety on Cortical Cerebral Blood Flow and Metabolism, 7 J. CEREBRAL BLOOD FLOW & METABOLISM 173 (1987) [hereinafter Gur et al., The Effect of Anxiety].
amygdala—a critical region responsible for dealing with threat and the main trigger of fight-or-flight behavior—was, however, several standard deviations below the control group from the normative sample. The next day, Dr. Gur was called to testify in that capital case in Florida state court.

The case was that of Robert "Bobbie" Joe Long (a.k.a. the "classified ad rapist"), a man convicted of serial rape and murder in Florida in the early 1980s who received twenty-eight life sentences in 1986 and was sentenced to death. Prior to his crimes, he had sustained a severe head injury from a motorcycle accident. An opposing expert, Dr. Leon Prockop, chairman of the Department of Neurology at the University of South Florida, testified that "Drs. Raquel and Ruben Gur are leading experts in the country on PET research and interpretation."

For Dr. Ruben Gur, the first time testifying as a neuroscience expert in court was memorable, providing opportunities to clinically observe Long's behavior. During the trial, the defendant was kept in a separate room because he was easily agitated, screaming out of control, and threatening his lawyers and the judge. He could still be heard occasionally screaming from the remote room. Upon examining the defendant during a break in the trial, Dr. Gur noted that Long displayed other signs of frontal lobe damage, including disinhibition and tactlessness. Although subsequently sentenced to death, as a mitigating factor the sentencing judge listed that "Long's ability to conform his conduct to the requirements of law was substantially impaired." After that, Dr. Gur began receiving referrals, mostly from defense lawyers in death penalty cases, but occasionally from prosecutors in criminal cases and attorneys in civil cases when a question of brain damage arose.

A decade later, Dr. Gur was contacted by Marc Bookman from the Homicide Unit of the Defender Association of Philadelphia.

82. See id. at 2; Corrections Offender Network: Inmate Population Information Detail, FLA. DEP’T CORRECTIONS, http://www.dc.state.fl.us/ActiveInmates/detail.asp?Bookmark=3&From=list&SessionID=666993367 (last visited Oct. 16, 2016) [https://perma.cc/447K-W9YA]; see also Long, 689 So. 2d at 1056–57 (detailing the complex procedural history of Long's foray with the Florida criminal justice system after his initial death sentence).
83. Initial Brief of Appellant, supra note 81, at 21.
84. For example, while measuring his cranial circumference, Long gyrated his hips while commenting "anything else you want to measure, Doc?"
85. See Initial Brief of Appellant, supra note 81, at 1. Incidentally, note that Long's death sentences (for several crimes) were appealed multiple times and vacated multiple times on procedural grounds unrelated to his brain trauma. See generally Long, 689 So. 2d 1055.
86. Initial Brief of Appellant, supra note 81, at 22.
87. Empirical research suggests that, between 1994 and 2005, public defenders in Philadelphia were more effective for their clients than private appointed counsel in homicide cases. See JAMES M. ANDERSON & PAUL HEATON, MEASURING THE EFFECT OF DEFENSE COUNSEL ON HOMICIDE CASE OUTCOMES 6 (2012), https://www.ncjrs.gov/pdffiles1/nij/grants/241158.pdf [https://perma.cc/3YFG-YFSZ]. Based on data drawn from a sample of 3,412 "defendants charged with murder ... in municipal court," id. at 6, research showed that compared to private appointed counsel, [Philadelphia] public defenders reduce[d] the murder conviction rate by 19%. They reduce[d] the probability that their
involved in a case where the defendant committed capital crimes as a juvenile, requested an affidavit summarizing the literature on brain development and its implications for legal culpability. As brain development was a major research area for Dr. Gur, he had already summarized much of the literature reviewed in the submitted affidavit in a grant application and for a forthcoming manuscript for a psychiatric journal. The research showed that indices of brain maturation in regions related to impulse control and decision making—the frontal cortex involved in executive functions—did not reach their apex until after age twenty-one, and lawyers felt that this impacted legal culpability. The affidavit eventually became part of an amicus brief to the U.S. Supreme Court in Roper, which held that individuals cannot be sentenced to death for crimes committed before turning eighteen.

As the methodology became more widely known and standardized, more referrals in. Colleagues were recruited to perform part of the analysis for which they already had a standardized procedural workflow. For example, Dr. Andrew Newberg, a nuclear medicine physician who performs and analyzes PET scans routinely, processed the PET scans, while Dr. Christos Davatzikos, a nationally renowned image analysis expert, processed the MRI data. With participation of postdoctoral students and support staff at the University of Pennsylvania, Dr. Ruben Gur established a “Neuroforensics Service” at Penn, using the reimbursements to further research into brain processes pertinent to violent behavior. Since 2007, with the assistance of criminologist Dr. Oren Gur, a systematic process has been developed to respond to requests for assessment of behavior, brain structure, and function.

### B. Dr. Gur’s Procedures for Preparing Neuroimaging Expert Testimony and for Reporting Findings from Neuroimaging and Neurological Studies

There are several procedures to employ when a legal team requests neuroscience-based analyses. Part II.B.1 explains the typical procedure for preparing expert testimony that incorporates neuroimaging. Part II.B.2 then

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clients receive a life sentence by 62%. Public defenders reduce[d] overall expected time served in prison by 24%. This suggests that defense counsel makes an enormous difference in the outcome of cases.

Id. at 3.

88. Marc Bookman now directs the Atlantic Center for Capital Representation (ACCR).
90. See generally Gur, supra note 71.
91. See generally Gur, supra note 89.
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describes how findings from neuropsychological and neuroimaging studies are reported.

1. Procedure for Preparing Expert Testimony Involving Neuroimaging

Over the years, a standard procedure has been developed for obtaining and analyzing behavioral (neuropsychological), structural (MRI), and functional (PET) neuroimaging data for both civil and criminal cases where linkage was needed between behavior and brain function. When contacted by a lawyer, the first step is to find out whether there is evidence of brain damage and, if so, whether neuropsychological test results or neuroimaging studies are available that document or indicate brain dysfunction. If the answer is positive (and schedule permitting), Dr. Ruben Gur will discuss the case to determine whether available data are sufficient or more data need to be collected. For example, neuroimaging records should exist electronically, and would typically be stored in the Digital Imaging and Communications in Medicine (DICOM) format. If available, neuroimaging records, such as MRI and PET scans, are requested and reviewed by respective experts to determine whether they are of appropriate quality for a quantitative “comparison analysis.”

When prior neuroimaging is not available, efforts are made as necessary to guide legal teams in how to locate appropriate facilities, consult with referring physicians on which MRI and PET specifications to request, and, once imaging has been conducted, analyze the data.

While neuroscience techniques are the focus of our efforts, they are usually not the only and are rarely the first materials upon which we rely. Often, other records are available for review (e.g., school, medical, military, or criminal) that may help gauge the probability of brain dysfunction in

93. See John H. Blume & Emily C. Paavola, Life, Death, and Neuroimaging: The Advantages and Disadvantages of the Defense’s Use of Neuroimages in Capital Cases—Lessons from the Front, 62 MERCER L. REV. 909, 913–14 (2011) (noting that with regard to comparison analysis, the “traditional mode of neuroimaging analysis has been a visual review of the scan films by a radiologist or a neurologist” and that such a method “creates a number of problems related to subjectivity, bias, and error”). Quantitative analysis, such as that employed by Dr. Gur, allows for the application of validated computer algorithms to analyze data generated during an imaging study. Methods have been developed for quantitatively analyzing these data to obtain precise measures of brain structure and function. Such data are obtained from healthy individuals, and these provide “normative” information that can help identify “abnormal” brains. Overall, “[q]uantitative analysis results in a more precise—and, it is hoped, more accurate—determination of whether the brain is structurally and functionally normal. Furthermore, quantitative analysis [sic] can permit a comparison of an individual client’s brain to a database of brains with known abnormalities (such as schizophrenia).” Blume & Paavola, supra, at 914; see also Gaudet & Marchant, supra note 63, at 591 (“One way to account for this individual variability in the analysis is to employ quantitative methods that compare an individual defendant’s data to large data sets that can help define ‘normal’ for purposes of allowing an expert to determine whether there are statistically significant findings in a defendant’s scan”); cf. David. L. Faigman et al., Group to Individual (G2i) Inference in Scientific Expert Testimony, 81 U. Chi. L. REV. 417, 422 (2014) (noting the distinction between scientific and diagnostic testimony and associated considerations).
specific cases. In most cases, this work is done in the context of an in-depth evaluation by another clinician, neuropsychologist, or neuropsychiatrist, who integrates our analysis with the history and their own clinical interviews to render a diagnosis. When such an expert is not available or retained, however, and a complete diagnostic workup is requested, Dr. Gur will complement analysis of neuropsychological and neuroimaging modalities by conducting personal clinical evaluations and administering a computerized neurocognitive battery (CNB). The CNB is a compilation of tasks used in functional neuroimaging studies to document which brain regions are involved in performing specific tasks.\footnote{See Ruben C. Gur et al., \textit{A Cognitive Neuroscience-Based Computerized Battery for Efficient Measurement of Individual Differences: Standardization and Initial Construct Validation}, 187 J. NEUROSCIENCE METHODS 254, 254 (2010) [hereinafter Gur et al., \textit{Cognitive Neuroscience-Based Computerized Battery}]; Ruben C. Gur et al., \textit{Computerized Neurocognitive Scanning} (pt. 1), 25 \textit{NEUROPSYCHOPHARMACOLOGY} 766, 766 (2001) [hereinafter Gur et al., \textit{Computerized I}]; David R. Roalf et al., \textit{Neurocognitive Performance Stability in a Multiplex Multigenerational Study of Schizophrenia}, 39 \textit{SCHIZOPHRENIA BULL.} 1008, 1010 (2013). “The battery has been translated to multiple languages and administered more than 200,000 times in studies around the world.” Gur & Gur, supra note 4, at 301 n.V.}

The CNB tasks have been adapted in large-scale genomic studies for use as biomarkers (endophenotypes) of behavior related to brain systems—\footnote{See generally Tiffany A. Greenwood et al., \textit{Analysis of 94 Candidate Genes and 12 Endophenotypes for Schizophrenia from the Consortium on the Genetics of Schizophrenia}, 168 AM. J. PSYCHIATRY 930 (2011).} their use in genomic studies is part of the effort to understand brain and behavior down to the molecular level. Use of the CNB permits more rigorous neuroscience-based characterization of brain systems involved in a patient’s specific deficits than that afforded by standard neuropsychological test batteries.\footnote{See generally Ruben C. Gur et al., \textit{Computerized Neurocognitive Scanning} (pt. 2), 25 \textit{NEUROPSYCHOPHARMACOLOGY} 777 (2001) [hereinafter Gur et al., \textit{Computerized II}].}

In cases where a complete diagnostic workup is requested, additional records are reviewed when available, such as social, medical, educational, military, criminal, and other relevant official statistics generated by agencies, including information pertaining to the immediate offense and litigation. Notably, record review can be time intensive and not cost effective when done by neuroimaging experts, and, in our experiences, the record is best perused and summarized by an investigator or mitigation specialist already involved with the case and instructed or trained on what to look for (e.g., head injuries, substance use, alcohol use by mother, inconsistent school performance, or time in public housing with lead paint).\footnote{While not all cases are as apparent as Robert Joe Long’s motorcycle accident, many individuals referred for assessment have quite troubled pasts. For example, in one case, Drs. Ruben and Oren Gur traveled to California to assess an individual who huffed solvents from an early age, was regularly raped by older youths after being placed in foster care, experienced a range of other traumas, and then went on to kidnap and murder as an adult. As a child, another California client was forced by his alcoholic father to get into fistfights with his peers, while the father would take bets on the outcome. These early head traumas may have played a role in his misidentification of innocent victims as rival gang members based on the color of their shirts and his impulsive response that resulted in their deaths.}
2. Reporting of Findings from Neuropsychological and Neuroimaging Studies

Reports can be issued at different phases—as requested by the legal team—and multiple reports are often written for the same case, reflecting the emergent nature of information gleaned from the multifaceted approach to linking brain function and structure to behavior. Usually, the first step is to examine available neuropsychological test results. In many cases, such testing is available from both sides, and opposing neuropsychologists argue about whether they indicate brain dysfunction. Often, these tests include measures of "effort" in which easy tasks are disguised as difficult, and someone who tries malingering a deficit will fail them. If a defendant scores below the level of performance achieved by demented individuals, or at a range of scores generated by research participants asked to fake deficits, the neuropsychologist may claim that the defendant is malingering deficits. In typical cases, opposing neuropsychologists will administer several such tests, and if any of them is "failed" by the defendant, the neuropsychologists will argue on whether this means that the defendant is malingering. When there is no evidence of malingering, opposing neuropsychologists usually argue about whether tests in which the defendant performed poorly coalesce to indicate dysfunction in a brain system relevant to the legal issue at hand.

Penn's Neuroforensics Service evaluates the neuropsychological test data received from other experts carefully because the protocols are complicated and scoring itself often requires expert interpretation. The task of reviewing the scoring is usually done by advanced postdoctoral fellows trained in clinical neuropsychology who are versed with current approaches to test administration and scoring, equipped with the necessary manuals and norms, and supervised by a board-certified neuropsychologist. Because interpretation may vary among neuropsychologists, even when they agree on the scores, an algorithm was developed that in effect "consults" with leading experts who rendered their interpretations quantitatively without any knowledge of the specific case at hand. This algorithm was developed in the late 1980's in collaboration with four prominent neuropsychologists (Professors Arthur Benton, Edith Kaplan, Harvey Levin, and Andrew Saykin). Each expert went over each of the neuropsychological tests available at the time (most of which are still used today) and placed numbers indicating the likelihood that damage in that area would be associated with impaired performance. They repeated the assignment a year later, obtaining high levels of interrater and intrarater reliability—meaning each expert consistently gave the same ratings.

99. See generally id.
100. See generally id.
compared to themselves (i.e., over time), and their ratings were similar to the those of the other experts. Using an algorithm based on these expert ratings, we can enter the defendant’s neuropsychological test results and generate an “image” of the brain in which the color scale indicates brain regions that are dysfunctional according to the experts who contributed the “weights.” With this algorithm, we can consult experts separately or use their virtual average.

The process and validation of this “behavioral imaging” (BI) algorithm have been published in peer-reviewed journals, and the output of the algorithm helps illustrate areas of dysfunction. While an expert neuropsychologist should be able to draw conclusions about brain dysfunction from the test results alone, the neuropsychologist could be biased about specific tests, miss relative deficits that point to the involvement of other regions, or simply fail to integrate the totality of performance measures. The BI can help identify areas that may have been missed by visual inspection of the values or complement interpretation with knowledge from renowned and highly experienced clinical neuropsychologists. An objective algorithm is especially helpful in an adversarial medical-legal situation. People may be biased; the algorithm is not, and it can help in interpreting the results of complex assessments and analyses.

An initial report, based on records and a BI, may suggest that neuroimaging seems appropriate given what the behavioral data indicate about the pattern and extent of deficits. The report can suggest what additional information is needed and how it can be obtained. If the BI suggests brain damage, then structural neuroimaging (MRI) and functional neuroimaging (PET) can be recommended. Because most clients in capital cases are unable to travel to Penn for scanning, this stage may involve communication with a scanning facility adjacent to the prison or as directed by the court. Once the results of MRI and PET become available, a second report would follow, which might also include results of the CNB and clinical assessment. The dates and locations of all

101. See generally id.
102. See, e.g., id.; see also Lee Xenakis Blonder et al., Neuropsychological Functioning in Hemiparkinsonism, 9 BRAIN & COGNITION 244 (1989).
103. For example, a Wired article included a picture and description of a behavioral image. See Greg Miller, Did Brain Scans Just Save a Convicted Murderer from the Death Penalty?, WIRED (Dec. 12, 2013, 6:30 AM), http://www.wired.com/2013/12/murder-law-brain/ [https://perma.cc/HHJ9-V9PH].
104. It is noteworthy that our methodology is quite sensitive to the presence of brain damage, in some cases finding abnormalities even though the clinical reading by neuroradiologists reports no abnormalities. Although such findings can be criticized as “false positives,” there is evidence that clinical readings miss effects of diffuse injuries such as those caused by mild traumatic brain injury. See, e.g., Erin D. Bigler, Neuroimaging Biomarkers in Mild Traumatic Brain Injury (mTBI), 23 NEUROPSYCHOLOGY REV. 169, 183 (2013).
105. Initially, Dr. Gur had to travel to the site to ensure that the correct sequences were executed and the data were properly stored, but today most scanning facilities administer the essential sequences for valid quantitation and can store results in DICOM format.
assessments and names of other experts involved are included in the reports.

Volumetric structural analysis of MRI are presented based on quantitative analysis and examination through delineation of regions of interest (ROI) assisted by a semiautomated, template-warping algorithm applied by the developer of the algorithm, Christos Davatzikos.\textsuperscript{106} Regions showing a reduction in volume of at least 1.5 standard deviations (SDs) below normal, and their corresponding contralateral structures, are displayed. Results may show, for example, that the overall volume of the defendant’s brain is in the normal range, except for reduced volume in the frontal lobe (responsible for “executive functions” such as planning, decision making, and regulation of impulses) and the limbic system (responsible for regulation of emotions) on the left (the cerebral hemisphere responsible for verbal mediation of perception and action). Examining more specific regions within the lobes may show that volumes of the frontal pole and posterior frontal orbital regions are reduced as well as those of the hippocampus or amygdala. These important nodes of the brain system regulate emotional behavior, and reduced volume in these regions could impair one’s ability to modulate threat-related behavior or consider morals or the law in situations of stress.

Results of PET establish the regional distribution of cerebral glucose metabolism using fluorine-18 labeled deoxyglucose (FDG).\textsuperscript{107} The PET provides measures of the rate at which different brain regions consume sugar (glucose). Because neuronal activity requires energy, which is derived from metabolizing sugar, the metabolic rate is an index of activity in these regions. PET FDG studies are typically done at what is known as a “resting state”—where the participant is not actively engaged in any task—to provide a measure of the brain’s default mode state.\textsuperscript{108} Dr. Andrew Newberg offers a clinical reading of the scan in a report, which includes images of the PET scans. The PET study is subjected to a quantitative analysis using a standard ROI approach.\textsuperscript{109} The quantitative analysis of cerebral metabolic rates relative to the whole brain can support Dr. Newberg’s clinical reading and may point to more specific sets of regions that show abnormal glucose uptake. For example, the analysis may indicate relative decreases in regions such as the amygdala and hippocampus and abnormally high metabolism in cortical areas, which could further complicate behavioral regulation of emotions. It has been established that regions that are hypoactive (have reduced metabolism) in the default mode state become activated during a task or challenge, whereas regions that are


\textsuperscript{107}See, e.g., SAHA, supra note 61.


\textsuperscript{109}See generally Gur et al, Sex Differences, supra note 80; Gur et al., The Effect of Anxiety, supra note 80.
hyperactive during the default mode state become deactivated during a challenge.\textsuperscript{110} An individual with low-resting metabolism in the amygdala and high-resting metabolism in cortical regions will be vulnerable to loss of control when challenged because the amygdala, which issues the fight-or-flight signal, will be activated while the cortex, or "thinking brain," becomes hypoactivated. The situation is analogous to a car that begins accelerating while the defective breaks are already engaged.

CNB testing is used to further establish behavioral manifestations of regional brain dysfunction. The computerized battery was validated through functional neuroimaging\textsuperscript{111} and proved sensitive to the existence of major neuropsychiatric disorders, such as schizophrenia.\textsuperscript{112} It is scored by automated procedures and yields measures of accuracy and speed on several major neuropsychological domains. These include (1) executive: abstraction and mental flexibility (ABF), attention (ATT), and working memory (WME); (2) episodic memory: verbal (VME), spatial (SME), and facial memory (FME); (3) complex reasoning: language (LAN); (4) social cognition: spatial processing (SPA) and emotion processing (EMO); and (5) sensorimotor speed of information processing (SM).\textsuperscript{113}

Results may show that the defendant performed both accurately and with normal speed on several domains but that his performance severely lapsed in the verbal memory and spatial processing tasks and was moderately impaired in abstraction, mental flexibility, and emotion identification. The relevance of such impairments to the case are explained—reports will conclude with a summary of the results of neuropsychological and computerized neurocognitive testing, as well as structural and functional imaging, highlighting convergent areas of brain impairment and their meaning. Ascertaining the etiology of abnormalities can be difficult, requiring clinical evaluation and integration with historical information that was not recorded with the present circumstances in mind. Opinions on neuroimaging findings must meet standards of scientific validity.

III. PRACTICAL LESSONS LEARNED

This part presents some of the practical lessons learned over the years from the perspective of a neuroscientific expert asked to offer opinions in the legal realm. They include (A) testify only to what you know, (B) try to remain current with the field, (C) each case is unique, (D) it is important to utilize mitigation specialists, (E) courts and experts may vary in their knowledge and understanding of neuroscience methodology, and (F) jurors

\textsuperscript{110} See, e.g., Gusnard & Raichle, supra note 108, at 688–89.
\textsuperscript{111} See generally Gur et al., Cognitive Neuroscience-Based Computerized Battery, supra note 94; Gur et al., Computerized I, supra note 94; Ruben C. Gur et al., Neurobehavioral Probes for Physiologic Neuroimaging Studies, 49 ARCHIVES GEN. PSYCHIATRY 409 (1992); Roalf et al., supra note 94.
\textsuperscript{112} See, e.g., Gur et al., Computerized II, supra note 96; Greenwood et al., supra note 95.
\textsuperscript{113} See generally Gur et al., Cognitive Neuroscience-Based Computerized Battery, supra note 94.
across the country are interested in neuroscience. These are intended to help court actors appropriately incorporate neuroscientific evidence and testimony into future litigation.

A. Testify Only to What You Know

Expert witnesses sometimes make statements that are either inaccurate or outright ignorant, which is easy to do in complex areas. Experts must be careful to opine only in areas where they feel knowledgeable and stay away from overreaching or overstating the evidence. Experts also should be mindful of the limitations of the technology and be ready to explain these limitations. Finally, as experts review the reports of opposing experts, they often are tasked with responding to information they are not qualified to comment on; acknowledging as much preserves the integrity of the spirit of having experts offer their opinions to the courts and public.

B. Try to Remain Current with the Field

Quite a few experts are well versed in medical-legal proceedings but are not keeping up with the scientific discipline that should inform their testimony. What experts learned about their field during their training many years ago is most likely outdated. This is especially true in a rapidly evolving field such as neuroscience, where foundational knowledge is undergoing transformation and dogmas are being constantly challenged. The number of scientific papers is increasing exponentially, and it is difficult to keep up with the accumulating knowledge. Laboratories performing high-quality research have proliferated, refining the scientific understanding of the brain and behavior. Concurrently, there are more law schools teaching lawyers-to-be about the relationship between neuroscience and the law, and there are centers specializing in the overlap. These groups would benefit from continuing to incorporate neuroscientific advances into curricula. There also are more advanced tools available for finding and summarizing scientific information, and experts have a duty to avail themselves of these tools. Lawyers may do well to seek experts who are at the forefront of their field and can offer an informed perspective.

C. Each Case Is Unique

An independent analysis can be offered by approaching each consultation with an open mind about the defendant (if not yet convicted) or offender (if participating in postconviction litigation) and utilizing procedures that control for the potential influence of any biases stemming from the nature of the crime or legal situation. For example, neuroimaging findings may help inform why the crime was committed in a particular way (e.g., without planning, without the ability to consider long-term consequences, or without emotion or remorse). Appreciating the uniqueness of each case pertains not only to the background of the offender, details of the instant charges, and the nature of the information provided but also to the type of opinion requested, the knowledge that various court actors have of
neuroscience, the stage of the criminal justice process at which one gets involved, the types of instruments and assessments employed, and the range of interactions that may occur in adversarial legal arenas.

In some cases, information regarding the offender’s medical and criminal backgrounds are not reviewed, and an opinion might be offered based predominantly on the quantitative analysis of neuropsychological and neuroimaging data. In such cases, opinions may not be offered linking such findings to specific behaviors, nor should the expert offer, let alone dispute, a specific diagnosis reached by personal clinical examinations. It is possible, however, to opine about the types of behavioral problems that may manifest themselves in individuals with similar cognitive deficits or regional brain abnormalities if such deficits or abnormalities exist.

D. It Is Important to Utilize Mitigation Specialists

It has been suggested that neuroscience evidence is an influential mitigating factor for some jurors, leading them to sentence offenders to life in prison rather than the death penalty. However, the potential usefulness of such technologically based analyses, particularly in capital cases, often relies in large part on preparation by relatively “old-fashioned” investigative efforts of mitigation specialists. Mitigation specialists can collect information on the defendant’s medical history, including incidents of head injuries and other insults to the brain, as well as familial, social, and educational history. They can help locate available results of existing psychological testing conducted throughout the defendant’s life course and any prior imaging studies or neuropsychiatric evaluations. Just as the role of neuroscience in the courts has continued to evolve, so has the subspecialty of capital mitigation.

E. Courts and Experts May Vary in their Knowledge and Understanding of Neuroscience Methodology

Some courts and court actors are more familiar with neuroscience than others. Capital cases often are inherently complex; the successful incorporation of neuroscience evidence requires that at least one member of the legal team become immersed in the neuroscience aspects of the case. In some cases, for example, we learned months later (i.e., after any appeal could be filed) that attorneys and judges had failed to recognize seemingly

114. See Deborah W. Denno, The Myth of the Double-Edged Sword: An Empirical Study of Neuroscience Evidence in Criminal Cases, 56 B.C. L. REV. 493, 494–99 (2015). Conversely, it has also been suggested that the influence of neuroscience has been overstated, particularly in capital cases. See Gaudet & Marchant, supra note 63, at 590 (“The second point is that a 2011 study that surveyed the impact of neuroimaging evidence on over 1,400 potential jurors found no such prejudicial effects of neuroimages presented in the context of a mock criminal case. This large-scale empirical study undermines these concerns and suggests that jurors would not be unduly influenced by neuroimages.”).

rudimentary issues such as the distinction between functional MRI (fMRI) and the more routinely used structural MRI (sMRI). Indeed, during an fMRI, the person whose brain is being scanned is actively engaged in watching or listening to stimuli projected onto a screen in the scanner and is responding to what they are seeing or hearing by pressing buttons on a fiber-optic response device. In contrast, before a routine sMRI, the person whose brain is scanned is instructed before the scan begins to remain still for the duration of the scan. Moreover, they are not given a task, and whatever they are doing during the scan, short of moving their head, is not going to influence the results of structural analysis of their brain anatomy.

The distinction is important, as (1) our team has never assessed a client with fMRI in the medical-legal context; (2) there have been few successful attempts to admit assessments of defendants utilizing fMRI in capital cases; and (3) there have been cases where a law review article about fMRI—rather than scientific, peer-reviewed articles—was inappropriately used to inform the court about the relevance of an analysis that only involved sMRI.116 These types of errors can have a domino effect in the context of a particular case or for future cases in which the expert, or other experts, testify about the brain and behavior. For example, the inappropriate dismissal of or failure to introduce neuroscience evidence pretrial can have long-term adverse effects on subsequent litigation (e.g., appeals). Failure to appeal a decision to bar testimony based, in part, on the consideration of inappropriate and irrelevant material also can negatively impact litigation.117

F. Jurors Across the Country Are Interested in Neuroscience

Across the country, jurors appear to be interested in learning how the brain regulates behavior. They are willing to endure and can handle complicated testimony, especially when there is an effort to facilitate their understanding through visualizations and appropriate examples from familiar situations. Almost every juror knows someone with mental health problems or brain dysfunction. Some may know, for example, a relative with Parkinson’s disease who became a compulsive gambler or recall

116. See generally 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). The article specifically notes that it does not refer to sMRI: “It is important to reiterate that in narrowing our focus to functional brain images addressed to past mental states, we are not evaluating structural brain images such as those that result from X-ray, CT, or regular MRI scans.” Id. at 1125 n.18 (emphasis added).

117. See Transcript of Record at 91, Massachusetts v. Chism, No. 2014-0109 (Mass. Super. Ct. Dec. 3, 2015) (“Finally, the Court notes the Stanford Law Review article, 62 Stanford Law Review 1119, where Through a Scanner Darkly: Functional Neuroimaging as Evidence of Criminal Defendant’s Past Mental Studies (sic) raises serious concerns about this type of evidence where the prejudice cannot be mitigated through cross-examination.” (alteration in original)).

118. See generally id. (exemplifying how a judge relied on a law review article about fMRI to make a decision pertaining to an sMRI analysis performed by Dr. Ruben Gur).
someone who started behaving impulsively following a head injury. They often are relieved to learn that such behaviors are not manifestations of corrupt character but direct results of damage to the frontal lobe associated with both Parkinsonism and traumatic brain injury. Juror interest is further indicated by the types of clarifying questions they have asked and feedback to members of legal teams about what testimony was impactful and helpful in reaching a decision.

While not exhaustive, keeping these issues in mind may be helpful in building bridges from the legal to the scientific arena. Hopefully, the thoughtful application of neuroscience in the court will improve the quality of justice.

IV. OBJECTIONS TO NEUROSCIENCE EVIDENCE

A common response to neuroscience applications in capital cases, among the public and in some academic and legal circles, is that such testimony offers an excuse for violence by deflecting responsibility from the person to a brain structure. This argument has been articulated by Stephen Morse, a professor of law and psychiatry at the University of Pennsylvania, who noted: "Brains don't kill people. People kill people." As is hopefully evident from the preceding text, the brain controls behavior, and behavior informs culpability. Therefore, Morse's characterization is somewhat of a caricature of the nature of neuroscience's involvement in the court. First, in most cases, neuroscience evidence is presented during sentencing as a mitigating factor. Here, neuroscience is presented as one of myriad possible mitigating circumstances postconviction, which may also include testimonials from school friends, teachers, and family. If someone's kindergarten teacher can offer relevant testimony, how could a neuroscience expert documenting brain dysfunction not be germane?

Second, as argued elsewhere, from the standpoint of neuroscience, Morse's statement is either tautological or dualistic and hence flawed. Because behavior is considered by neuroscientists to be the product of brain processing, and killing is a behavior, the statement "Brains don't kill people. People kill people" makes as much sense as its contrapositive: "People don't kill people. Brains kill people." Neuroscience offers a level of explanation for behavior, which is inherent to the question of culpability and mitigation.

121. See Denno, supra note 114, at 495 ("Courtroom battles over mitigating and aggravating evidence are a common aspect of capital cases, but the unprecedented use of neuroscience evidence in these battles has led to some striking outcomes."); Gaudet & Marchant, supra note 63, at 623 ("A defendant charged with a capital offense has the right to present virtually any evidence in mitigation during the penalty phase, and courts are constitutionally required to consider any relevant mitigating evidence.").
122. See Gur & Gur, supra note 4, at 308–09.
123. Id. at 308.
Another objection raised by both academics and in court, usually by the prosecution, can be phrased as follows: “If this brain damage that you showed is responsible for this horrific crime, aren’t there many other people with this type of damage who aren’t going around killing people?” This question, compelling as it seems, fails to consider the complexity of the brain as it interacts with complicated situational factors. In capital cases, a catastrophic crime has occurred, and neuroscience data may prove to a reasonable degree of professional certainty that brain damage impaired the defendant’s capacity to make his behavior conform to the law. This impairment in the defendant, however, does not mean that an average individual with the same brain damage is likely to commit the same crime. Rather, in considering the totality of the defendant’s circumstances, someone with such brain damage is more vulnerable to failures in controlling behavior.

An analogy from a system that is considerably simpler than the brain can help explain the distinction. Cars, built by humans and hence with clearly designed structure and function (i.e., each and every component is known and its function and design understood), are much simpler than brains. Like the human brain, an issue with one component of a car can have severe ramifications for the rest of the car. For example, in 2014, it was estimated that about thirty million cars potentially had faulty ignition switches,124 which could “move easily out of the ‘Run’ position into ‘Accessory’ or ‘Off,’” disabling “the affected car’s frontal airbags.”125 Fortunately, the number of fatalities caused by this faulty feature has seemingly been low, as a combination of events are required for it to end in a deadly accident (e.g., engine stalling during an accident or high speeds). This has nothing to do with the fact that each and every one of these fatalities was caused by the faulty switch. Problems with the switch could affect the entire car and other cars as well.

Very similar analogies can be drawn to Toyota’s “Potential Accelerator Pedal Entrapment,”126 which caused unexpected acceleration, and the faulty Takata airbag that contained “shrapnel-shooting inflator parts.”127 Again these are two components that are vital to the functioning of the car but only in intense situations will the malfunction show. Absent such intense

circumstances, these cars fulfill their normal roles without a hitch. Overall, someone with brain damage would be more vulnerable to lapses in conforming their behavior to socially accepted norms or considering the legal ramifications of their actions, particularly in stressful situations. Dysfunction in certain regions of a brain, when overstimulated and unable to handle the neural activation associated with particular situations, can supersede the normal functionality of brain regions that control behavioral responses to provocative situations.

CONCLUSION

Notwithstanding the objections, paradoxical or otherwise, it is likely that neuroscience will continue to play a role in jurisprudence and that its inclusion will only increase. The field is becoming more accessible to other experts and the public. Indeed, its ability to shed light on increasingly subtle aspects of human behavior is evolving rapidly.

The technologies described herein can contribute not only to improved sensitivity for detection of brain abnormalities but also can inform the truth-seeking function of the justice system. For example, fMRI methods for lie detection have been described and validated. While the polygraph is not currently accepted in court, there is reason to believe that fMRI vastly outperforms polygraphy. Unlike polygraphy, lie detection with fMRI does not rely on the subject’s autonomic response to lies, which may be attenuated in someone who is not anxious about lying. Instead, it turns on the extra step required by the brain to divert a more veridical response. This methodology is likely to encounter even greater resistance, but eventually it could become useful to the extent that it is reliable and valid.

Although explaining neuroscience methods can become increasingly challenging—as it frequently involves the explication of complex analytical techniques—the increased prevalence of tools that illustrate a data set’s relevant features likely will aid in mitigating such challenges. And contrary to assertions that such illustrations are designed to mislead or confuse the jury, they are typically the products of standardized rigorous data processing techniques published in scientific, peer-reviewed journals. Indeed, because the illustrations are necessarily complicated and sometimes

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130. See generally Langleben et al., supra note 76.

tedious, their link to specific brain systems needs to be elucidated by a knowledgeable expert. Those interested in the intersection of neuroscience and the law can look forward to interesting times and debates ahead.
Prosecution rests in Kaboni Savage murder trial

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Body

After more than 10 weeks of trial, federal prosecutors on Wednesday rested their case against Kaboni Savage, the drug trafficker accused of ordering a 2004 North Philadelphia firebombing that killed the mother, son and four relatives of a witness against him.

FBI agent Kevin Lewis, who spent more than a dozen years investigating Savage, was the first government witness when the trial opened and became its last on Wednesday. Lewis took the stand to verify secret prison recordings that prosecutors contend show Savage's deadly and relentless determination to retaliate against cooperators.

"Their kids gonna pay, their mother gonna pay," Savage told a fellow inmate in December 2004, about two months after the deadly arson, according to one recording. "That's the kind of conviction I got for this."

Later, he told his girlfriend in a phone call: "That's all I dream about - killing rats."

After Assistant U.S. Attorney David Troyer declared the government concluded its case, U.S. District Judge R. Barclay Surrick dismissed the jury for the rest of the week.

Lawyers for Savage and his three codefendants are scheduled to begin their case on Monday. None have revealed if the defendants will take the stand, but the defense case is projected to last a week.

Savage, 38, is accused of committing or directing 12 murders while running a sprawling drug network. He is already serving a 30-year term on trafficking charges but faces the death penalty if convicted of racketeering and murder.

His alleged victims include the mother, cousin, 15-month old son and three other children related to Eugene Coleman, a onetime friend and associate who was preparing to testify against him.
Prosecution rests in Kaboni Savage murder trial

Each died when two men hauling red gas cans bombed their North 6th Street home in a predawn attack in October 2004.

To put an exclamation point on their case, prosecutors played for jurors a tape secretly recorded days after the bombing, when Savage had learned that prison authorities would escort Coleman to the funerals for his relatives.

Savage joked that the guards ought to stop first and get Coleman some barbecue sauce, "so he can pour it on those burnt (expletive)."

His court-appointed lawyers have denied his role in the attacks and asked the jury - a panel whose names are sealed - not to be swayed by rambling jailhouse bravado.

Also facing death are two codefendants, Steven Northington and Robert Meritt Jr. Prosecutors say Merritt was one of the two men who carried out the firebombing and that Northington was an enforcer who murdered a rival for Savage.

Savage's sister, Kidada Savage, faces life in prison on charges that she helped plot the attack.

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Defense at Savage trial casts hit man as a liar


Hitman: Drug lord ordered bombing that killed 4 children, 2 others

http://www.philly.com/philly/news/20130402_Hitman__Drug_lord_ordered_bombing_that_killed_4_children__2_others.html

Load-Date: April 18, 2013
The jury that ordered death for drug kingpin Kaboni Savage unanimously recommended life in prison Thursday for an accomplice, prosecutors said.

The panel of nine women and three men announced its decision Thursday after a two-week penalty hearing in U.S. District Court for Steven Northington, 41.

As they did with Savage, prosecutors sought the death penalty for Northington, an enforcer in the drug ring who was convicted in the murders of two rival dealers, Tybias Flowers and Barry Parker, in 2003 and 2004. Flowers was killed as he was preparing to testify against Savage in another murder case.

Defense lawyers Thomas Egan, William Bowe, and Michael Wiseman called Northington's mother and medical experts to bolster their claim that he suffered from limited mental capacity, a situation compounded by his upbringing in a poor, drug- and crime-ridden swath of the city.

Savage, 38, is awaiting execution for 12 murders, including the deaths of Parker and Flowers. He also ordered the 2004 firebombing of a North Philadelphia home that killed two women and four children related to another witness.

Two other defendants, including his sister Kidada, face life in prison when they are sentenced this year by U.S. District Judge R. Barclay Surrick.

A senior Justice Department official said officials hope the verdicts bring some measure of justice to the victims in the case.

"For more than a decade, Kaboni Savage and members of his organization used murder and violence to intimidate and retaliate against anyone who threatened their drug trade," said acting Assistant Attorney
Jury: Accomplice of Savage should get life

General Mythili Raman, "and along the way mercilessly killed a cooperating witness's family members, including innocent children."

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Load-Date: June 14, 2013
DR. RUBEN GUR, was duly sworn.

[ESTABLISHED QUALIFICATIONS]

1 DIRECT EXAMINATION

2 BY MR. WISEMAN:
Q. Good morning again, Dr. Gur.

A. Good morning.

Q. What were you asked to do in this case with regard to Mr. Northington?

A. I was asked to review the neuropsychological testing performed by Dr. Shea, and then analyze the results of the PET scan and the MRI scan that were performed on Mr. Northington. All these results were transferred to me, and based on these results I wrote the report.

Q. [COULD YOU EXPLAIN THE BEHAVIORAL IMAGING ALGORITHM?]

A. An algorithm is a mathematical procedure that every time when you put in the same data, it will give you the same results.

Q. So explain what the behavioral image algorithm is with that definition in mind.

A. The behavioral imaging algorithm was developed…to come up with a standard way of interpreting neuropsychological test results.

[EXPLAINING HOW THE TEST WAS CREATED]

Now, using this algorithm, we can now input a set of results of neuropsychological testing and the algorithm produces an image that indicates which brain regions seem most affected by the pattern of neuropsychological performance.

The algorithm simulates what every good neuropsychologist should be doing when they look at the test results. That's what distinguishes a neuropsychologist from a clinical psychologist. A neuropsychologist based on the test results should be able to tell what parts of the brain are likely dysfunctional in that particular individual. That is exactly what the algorithm is doing.

Q. Could you…walk us through that science?

A. So I think in order to understand this whole issue of behavioral imaging, magnetic resonance imaging and positron emission tomography, which are the three that I have used here, I will have to make a brief introduction to at least make sure that everybody is on the same page in terms of some basic brain science concepts. If you understand those, you should be able to understand the technology and how we use it and the findings.

First, importantly, we need to understand how the building blocks of the brain work and the building blocks of the brain are brain cells. They are called neurons.

So what distinguishes a neuron from other cells in the body is first that the cell itself is covered by multiple protrusions that are called dendrites. Those dendrites are literally swimming in a sea of chemicals that are called neurotransmitters. All these protrusions include receptors that can receive those transmitters.

Now, these transmitters would have a different electrical charge than what is inside the cell. And when that builds up to above a certain threshold, you get a short where the electrical charge goes from outside to inside the cell. That produces a pulse, an electrical pulse that travels along the membrane or the skin of the cell and shoots down a fiber that is called an axon. That electrical
charge goes down that axon and comes to the axon terminals.

When it reaches the axon terminals, it releases neurotransmitters, and they travel to the next cell. If the next cell is another neuron, then that will propagate the electrical charge, and this is how brain cells communicate with each other.

If, on the other hand, at the end of the axon terminal you have the muscle, the muscle will contract. This is literally how the brain controls behavior. The axon can be very short, barely visible or even not visible, or it can be very long, as long as several feet.

There are axons that connect our brain to our toes. Because those fibers are very long, the electrical pulse that travels along them will dissipate, and in the same way that the electrical company puts rubber around electrical wires, the brain needs to insulate these axons.

The brain doesn't have rubber. It uses fat for that purpose. It's called myelin.

During the first year of life, the parts that control movement become covered with this myelin, and that process is called myelination. That's the main thing that happens during brain development.

By around the age of three, you have all the brain you will ever have. The only thing that happens between age three and adulthood is that more and more fibers get myelinated. That's why you get more and more control over different aspects of your behavior.

Another process that begins around adolescence is actually brain cells begin to die, and that process is called pruning. Any parts of the brain that you haven't used by age 12, the brain figures it's not needed and it will shrivel off and die.

It's important to know that every time a neuron fires, it adds to its viability, and when a neuron doesn't fire for a while, it will disintegrate. This is essentially the way the brain communicates among regions and the way the brain communicates and controls behavior.

The way the brain processes information, it depends on the source of information. Visual information is obtained through the eyes, and from the eyes it goes pretty straight to the occipital lobe.

In the occipital lobe, visual information is processed quite primitively. It starts with detecting lines, detecting light. Motion can be detected there, but it's a very primitive perception. The first job of the occipital lobe is to really invert the image because the way our eye lenses are arranged we see the world upside down, and the occipital lobe reverses it.

The occipital lobe will note if there's lines, if there's orientation of lines, darkness, motion, and that information flows forward in two streams. One is called the dorsal stream, which is going on top of the brain, and one is the orbital stream that goes at the bottom of the brain.

It is forwarded to the parietal lobe. Now, auditory information comes through the temporal lobe, which is right behind our ears, and similarly the first processing is very primitive. Is this loud or not loud, what is the pitch, what is the frequency of the tone. And then further down is this human noise, or is that coming from something non-human. It's a very important determination that happens.

Then eventually it goes to the parietal lobe where it's visual with the information, and in the parietal lobe it acquires meaning. So if you see motion going from left to right and it looks squarish, and it
has a sound of an engine, then in the parietal lobe the concept of a car passing by will be formed.

That information is relayed forward to the frontal lobe. The frontal lobe gets all the sensory information coming from all the sense organs and puts them together and that role is to serve as the chief executive of the brain. The frontal lobe decides what to do with all of that information.

The hippocampus keeps asking for everything that you experience. It asks, is this new, or have I experienced this before? If it's new, then further decisions have to be made. But in order to answer that simple question, the hippocampus has to have access to all your memory. That's a little complicated.

But we learned a lot about the function of the hippocampus from patients who have undergone temporo-limbictomy. The hippocampus is part of the temporal lobe. In general, if you remove the hippocampus from the left hemisphere, people will have deficits in remembering verbal materials; whereas, if you remove it from the right hemisphere, they'll have deficits remembering spatial information.

If you remove both of them, you get the famous case of HM, who had the hippocampus removed, what happened to him, he remembered everything that happened to him up to the day of surgery, and nothing that happened to him after the surgery.

So 20 years after the surgery, every day if his wife would show up to visit him, he would look in shock at how much she has aged. He always remembered her at the age that she was before the surgery. If you got to know him after the surgery, you had to introduce yourself to him every time.

The…amygdala asks another question, which is am I in danger? Is there a threat? If the amygdala perceives threat, it issues an alarm or a demand for action.

These structures connect very tightly with the frontal lobe, especially the orbital part of the frontal lobe, which is at the bottom of the frontal lobe, right above the orbital bones. These are where your eyes are, sitting right on top of your eyes.

The orbital frontal deals with modulating or controlling pulses coming from these limbic regions, like amygdala. It roughly would go as follows: For example, you may be at a cocktail party and somebody gives you a nasty remark, your amygdala will feel it is being threatened and will issue a demand, kill the bastard. I mean, amygdala thinks like a crocodile because that's where it comes from.

The orbital frontal part lobe is the part of the executive brain, and it will say, wait a minute, there are people around. This is inappropriate. It's illegal. That's not what somebody like you should be doing, and will move you to perhaps give a nasty comment back.

Two other important structures to note, one of them is the corpus callosum.

That's a huge body of nerve fibers. It has no cells. It has only axons, and they connect the two sides of the brain to each other. They are important to achieve integrated perception of the world.

Now, our own experience of having a unified mind comes from the fact that the corpus callosum constantly connects and sends information back and forth between the two hemispheres. The two hemispheres have a different approach to the world.
The left hemisphere looks at the world analytically, sequentially, using language. The right hemisphere has very primitive language, but it looks at the world more intuitively, spatially, in an integrated way.

These are two different modes of looking at the world, and through the corpus callosum we can integrate our behavior to take into account both aspects of our experience.

Another important set of structures are the basal ganglia and hypothalamus. The basal ganglia and hypothalamus are known as this striatal brain, and they are responsible for motivation and reward.

They also are important in controlling purposeful movement. These are the regions that are damaged with Parkinson's disease. These regions also produce dopamine, which is the main neurotransmitter that activates the frontal lobe. So that's why patients with Parkinson's disease first show movement abnormalities, but then later on they develop deficits in frontal lobe function.

They become disinhibited, and they start taking risks. Some of them would go and gamble the family fortune away. The reason is because of the basal ganglia that are part of the reward system is damaged, but also the frontal lobe is damaged, and so they lose executive control over their impulses. So if they have a gambling impulse, they can't control it.

So one more concept to understand, because that is essential to the way that we use and interpret the data, is the concept of standard deviation.

In general, if -- we take measurements of almost anything, we will get -- for example, initially to establish that they took a tree and measured the length of the leaves on that tree, they found that it will have this U-shaped distribution in that if you calculate the average, say, for example, the length of all the leaves of a tree, you then calculate the average difference from the average.

So if we measured the height of all the people here, let's say it will be 5-7, that doesn't tell us the distribution or how widespread those values are. We have to take each measurement, subtract it from the average.

Now, if we sum all of those differences, it will come to zero. That's why we square them. Then we sum the squares, and we take the square root of that sum and that tells us what is the average difference from the average. That is called standard deviation.

For almost anything that you can measure, it turns out that 68 percent of observations will be within one standard deviation from the average.

If you go to two standard deviations from the average, you're covering 95 percent of the population, and every additional standard deviation you go out, you will be accounting for more and more of the population. But notably the further out you go, the smaller the population will become.

So, for example, the average IQ is 100, and the standard deviation is 15. So two standard deviations below that average gives you an IQ of 70. So anybody who has IQ below 70 will be labeled mentally retarded. Everyone who has an IQ above 130 will be called gifted.

So essentially, in all those measures, the question is, how does an individual stack up relative to a normative data set.

Q. Did you find as a result of the algorithm any areas of abnormality with regards to Mr. Northington's brain
based on Dr. Shea's data?

A. Yes.

Q. What areas in particular did you find to have been abnormal in Mr. Northington's brain based on that data?

A. So the behavioral image shows the areas of relative impairment. You can see that he's overall impaired. On the right-hand side you see the color scale, and it goes from yellow, which is the best area, the region that is least impaired, to blue, deep dark blue, which is most impaired.

If you look at this image, it seems that the greatest impairment is on the right in the back of the head. That impairment extends to the frontal lobe on the right. To some extent it's bilateral, so it looks like someone who may have been hit on the right side on the back of the head. That part was damaged, but also the part that is in the orbital frontal area we see some damage.

Q. What structures in particular were damaged or show as being impaired on the BI?

A. Notably areas of the visual cortex, the visual brain, as well as frontal areas, orbital frontal, midfrontal areas.

Q. What types of brain functions are impacted by such damage?

A. Well, in the case of behavioral image, this looks like he has some deficits in visual processing and in the ability to control and modulate behavior and make it fit into the social context.

Q. Did you then subsequent to the publication of your report process into the BI algorithm Dr. Denney's testing data?

A. Yes. We received Dr. Denney's report and asked and obtained raw data and processed it through the same algorithm.

Q. And, again, what areas of the brain show relative impairment?

A. Well, it shows literally the same areas. The main damage is in the back of the head, in the visual cortex, but it extends forward to the orbital frontal area.

Q. Did your review of these two algorithm results show in your view consistency or inconsistency in the two sets of data?

A. They are highly consistent. What you focus on when you interpret the behavioral image is the area of greatest abnormality, and then the extent to which it moves to additional regions. When you interpret the behavioral image is the

Definitely the area of greatest abnormalities is the same, exactly the same from both testing.

Also the extension of the abnormality to the frontal area is the same. He performed overall somewhat better for Dr. Denney, but this is a fairly negligible difference.

Q. When you were describing the areas of abnormality with regard to Dr. Shea's data, you have indicated that it looked like it was a right side impact. You are not diagnosing that, are you? You are not saying that’s the cause of the dysfunction?
A. No, I'm just saying that this kind of abnormality is seen in people who had that sort of an event happen to them.

Q. What did the algorithm with respect to the MRI show you? Did it show you regions of dysfunction?

A. It shows that Mr. Northington has average to larger than average brain size overall, that you see on the left. But relative to that, there is a reduced volume in the frontal and parietal area. On the right, you see all the regions that show clinically significant reduction involvement.

There's bilateral damage -- reduction of volume in the superior frontal area, whereas in the middle and medial frontal, as well as lateral orbital frontal, the damage is more one-sided. In the middle, frontal and medial frontal is more on the left side. The lateral orbital frontal is more on the right.

Then the rest of the damage is on the right side, but in the back of the brain. Superior parietal cuneus, which is part of the visual cortex and lingual gyrus, which is also part of the visual cortex, in all these areas the damage is on the right side.

Q. The area of greatest abnormality, which is three standard deviations beneath the mean, what area is that?

A. That's the subthalamic nucleus. That's a midline structure. It's in the middle of the brain, and it deals extensively with motivation, arousal. It’s part of the reward system.

Q. What is the next area of greatest abnormality?

A. That will be lingual area, which is part of the visual cortex, but it's a part that is quite advanced, that is responsible for more nuance interpretations of the visual world.

Q. Now, you're familiar with the concept of malingering in the field of neuropsychology?

A. Yes.

Q. Is there any way that a subject can affect the outcome of an MRI?

A. Nothing that they can do will influence this particular type of MRI, which is a structural MRI. It looks at the anatomy.

Q. Now, you also subjected the PET scan imaging to the third algorithm that you had discussed. Could you tell us what areas, if any, showed up as abnormal in the PET scan?

[WHAT YOU’RE TRYING TO MEASURE IS THE RATE AT WHICH THE INJECTED SUGAR IS METABOLIZED?]

A. Exactly. If you remember our neurons, every time a neuron fires, it gets exhausted, it can't fire again for a while because it needs to refresh its energy.

It gets energy from the blood essentially from burning sugar using oxygen, so the blood brings the oxygen and the sugar to the brain. The brain extracts the oxygen and the blood, and uses the oxygen to bring sugar, and from that it gets its energy to fire again.
So brain regions that have a high rate of firing will take more sugar than brain regions that have lower rate of activity. So by mixing the synthetic sugar with positron emitter, we get that synthetic sugar into different brain regions in proportion to the amount of sugar that these regions need for their regular activity.

These measurements are taken at rest. So there is -- it's called a default state. That default state PET scan indicates which regions are active or inactive when there is no task.

Q. Are you looking for high levels of metabolism of a sugar, low levels, or both?

A. Unlike MRI, where the larger the volume, it's always the better, with PET -- with glucose metabolism, too high metabolism is bad and too low metabolism is bad at any state.

In the resting default state study, those regions that are hypometabolic are those regions that will become hypometabolic when the subject is given any task to do, and conversely those regions that are hypometabolic at the default resting state will become hyperactive for any task that you will give that subject.

Now, depending on the specific task, there could be some regions where there will be greater change than in others.

Q. What areas of the brain in this analysis show impairment?

A. The entire cortex almost is hypometabolic at this default resting state. The regions are ranged from frontal to the back and then subcortical and basal ganglia regions. So the areas of hypometabolism are superior frontal gyrus, dorsal lateral prefrontal gyrus, dorsal medial prefrontal gyrus, midfrontal, inferior frontal, and then from the parietal lobe the sensory motor area is high.

The superior parietal is high, abnormally high; angular gyrus is high; the supramarginal gyrus is high; the precuneus is especially high. The precuneus is seven standard deviations higher than normal. So these are the regions that are most distinctly hypermetabolic.

Q. Now, is the left portion of the chart showing the left, the right, or the whole brain?

A. The whole brain.

Q. The one on the right side of the chart is showing --

A. Shows the difference between left and right. You can see on the left the most dramatic effect is for the hippocampus and amygdala, which are 7 and 4 standard deviations hypometabolic relative to normal, and then other hypometabolic regions all relate to mostly the basal ganglia. But also the posterior corpus callosum is also hypometabolic, as well as mid brain and other basal ganglia regions, thalamus, hypothalamus.

Q. The results of the algorithm of the PET, how do they line up with the results of the MRI analysis?

A. Well, again, they indicate abnormal frontal lobe function, but they also indicate that the hippocampus and amygdala are highly dysfunctional, in that they are hypometabolic.

The laterality slide indicates that for most regions you can see that the right hemisphere is especially
in the superior parietal area; you can see the right hemisphere is hypometabolic. So when you have brain damage, you get two phenomenon. One is that when there is anatomic tissue loss, the remaining tissue increases its activity. The same way if you come to work one day and half the staff hasn't shown up because of the flu, whoever did show up has to work harder.

But when that continues, there is some point where you quit. You can't work ten times harder. So following brain damage, you have two phenomenon. One, that some brain regions become more active than normal, and other brain regions become less active than normal.

Q. [ARE THESE ALGORITHMS ANALYZED BLINDLY?]
A. [YES, WHOEVER PROCESSES THEM DOESN'T KNOW THE PATIENT'S DISORDER (SEIZURE, ALZHEIMER’S, ETC)]

Q. Now, I know you said earlier that the neuropsychological testing can't test some of the structures tests for abnormalities of some of the structures, but to the extent that the neuropsychological data that you looked at and analyzed can provide such information, is there a congruence between that data and what you see on the PET?
A. Yes. That's what we do for a living is look across those sources of data. What I explained before is that you would want to look mostly for congruence of the behavioral imaging results with the anatomic data. With PET you have this phenomenon that some regions are hypometabolic following brain damage, so it's hard to make a direct link. You can conclude from the PET data that his cortical area is abnormal, almost the entire cortex. You can also conclude that subcortical metabolism is abnormal, grossly abnormal in the hippocampus and amygdala, and these are not regions that are measured with neuropsychological testing.

Any damage that is subcortical, you can't correlate with the behavioral image because the behavioral image is sensitive to damage in the cortex.

Q. [DO YOU WORK WITH REAL LIFE PATIENTS?]
A. [YES.]

Q. Final question, all of your opinions today were to a reasonable degree of neuropsychological certainty?
A. Yes.

MR. WISEMAN: No other questions. Thank you, Doctor.

1 CROSS-EXAMINATION

BY MR. MELLIN:

Q. Doctor, I'd like to start with your CV. You list, I believe, 355 articles that you have written, correct?
A. Yes.
Q. There’s not one in the 355 that deals with mental retardation, is there?

A. No.

Q. Now, you talked about your behavioral imaging algorithm, which I’d like to call the BI [algorithm]. All right?

A. Okay.

Q. Fair enough? The BI [algorithm] dealt with and was used to diagnose Parkinson’s, correct? Yet you were applying that BI [algorithm] to the defendant’s information?

A. Yes.

Q. He does not have Parkinson’s, correct?

A. I applied it to anybody. I don’t know what he has.

Q. As you sit here today, you don’t know what caused the brain damage to the defendant, correct?

A. Correct.

Q. If someone receives a concussion, that causes brain damage, agreed?

A. Yes.

Q. And you would agree with me that if someone receives a concussion, there’s going to be damage – likely damage throughout the brain, correct?

A. No, I have to qualify that. Almost regardless of where the concussion happens, you get damage in the frontal lobe and you get some – if the hit was not – has some laterality to it, like if it was from the side and it causes the brain to twist, then, as you know, the strongest force of a torque is right in the middle. That’s why we have a handle to open the door and we don’t try to open it at the pivot.

When the brain twists, that’s the reverse that happens and there’s a huge force right in the middle of the torque of the twist. That’s where all the amygdalic basal ganglia are all there. What happens when the brain twists, the neurons stretch and then fall back to position.

If you take a rubber band and you stretch it, it will go back, but not exactly right. So for neurons, if they go back, well

then everything is fine. But if they don’t go exactly right, they will die. That’s why you tend -- almost with any head injury you tend to get some damage along the midline, exactly the midline structures of the brain.

The reason you also get frontal lobe damage is because the back of your head is nice and smooth, but the front has those nasty bones right over your eyes, the orbital bones. If the brain hits it, it rubs against it and you tend to get damage in that area.

The olfactory nerve is also right at the bottom of the brain and that tends to also get damage. So a lot of people following head injuries may lose the ability to smell.
Q. Now, if the hit is centered, say on the front or the back, excuse me, the back or the front, would you have corresponding damage on both the front and the back portions of the brain?

A. Well, there is some evidence that if you are hit in the front, you will get damage in the front and not that much in the back, but sometimes even more in the front because of the bony structures that the brain sits on in the front.

Q. Okay, let's go with the MRI. Where is the greatest area of impairment?

A. It's on the -- the greatest is the subthalamic nucleus on the right. That's the greatest impairment followed by the lingual gyrus on the right.

Q. Where is that located specifically in the brain?

A. The subthalamic nucleus is a midline structure. The lingual gyrus is part of the visual cortex and it's roughly here toward the back of your head.

Q. So the subthalamic nucleus is part of the midline?

A. Yes.

Q. I believe you just testified that when we were talking about types of concussions, the midline would be affected either if you get hit in the front or the back or the side, correct?

A. Usually, if it's a little -- if your brain is twisted, that's the main factor.

Q. So if Mr. Northington is hit on the side and his brain twists, that would account for this abnormality in the subthalamic nucleus?

A. Yes.

Q. Now, the subthalamic nucleus, that shows up in the MRI but does not show up in your PET scan; is that right?

A. Yes. It's not unfortunately one of the reasons we look at with PET. It's too small for the PET resolution. The MRI has a resolution of one-by-one-by-one millimeter. The PET resolution is much less, it's about five-by-five-by-five millimeters.

Q. You also said when looking at the MRI the lingual area was also a large abnormality. I believe you said it’s clinically significant.

A. In the MRI, it's highly significant. It's two standard deviations below normal.

Q. But it's not as far outside the normal range in the PET scan as it is in the MRI?

A. Correct

Q. Would you agree with me that the scores that you have accounted for Mr. Northington, the majority of them, if not the supermajority show up in the normal range?
A. That is correct, yes. Most of the laterality is normal.

Q. I believe you already covered this, but I wanted to make sure I made this point. You do not have a baseline PET scan for the defendant, correct?

A. Correct. By baseline, you mean --

Q. I was just going to break it down for you, but there's not an age specific -- you don't have a PET scan before the PET scan that you're dealing with in this case, correct?

A. Correct.

Q. You don't have a PET scan just before he received the concussions that he's received?

A. No.

BY MR. MELLIN:

Q. If you analyze someone else's brain, if you believe them to be normal, would they all show up in the normal range on the chart?

A. Yes, most brains are normal.

Q. For every area that you test?

A. No. I mean, you can get some occasionally, some abnormality that we are not sure about where it comes from, but most brains that we evaluate – I mean, for example, in every study we include a group of healthy people and these are people who are screened neurologically and psychiatrically. They come and most of them have normal brains, but occasionally you find someone with an abnormal brain. We just recently scanned 1,500 children from the Philadelphia area, the Delaware Valley and about one hundred of them -- there were fewer than one hundred. I have the exact number, but about that had some anomaly in the brain. In a small number of those there were -- they were lucky that they came to the study because it was dangerous and they went straight from our study to a clinical referral. But most, a vast majority of healthy people have healthy brains with no abnormalities at all.

Q. Is there deviation in the various areas of the brain? Whereas, if it's a normal, healthy person, their brain has no deviations outside of your normal range?

A. They will be within the normal range. It's normal to have within one standard deviation from your own average.

Q. [QUESTIONING ABOUT SOURCES OF ORIGINAL DATA. DR. GUR WENT INTO DETAIL ABOUT THE THREE SOURCES OF HIS DATA AND THE LEVEL OF SUPERVISION/CHECKING HE DID FOR EACH SOURCE]

1 REDIRECT EXAMINATION

2 BY MR. WISEMAN:
Q. You were questioned at some length about your checking the work of people who contributed to the analyses you discussed today. Do you recall that?

A. Yes.

Q. Was the process used in putting together this analysis different in any respect than the process used for the analysis of clinical patients at your hospital?

A. No. It was the same.

Q. [IS THERE A REASON YOU MIGHT FIND ABNORMALITIES ON THE MRI THAT ARE NOT ON THE PET AND VICE VERSA?]

A. Well, in general it's unusual to find a region that has abnormality in the MRI and will not have an abnormality on the PET. But very often you find abnormalities on the PET that you look at the MRI and the MRI looks fine.

And the reason is that the MRI looks at structure and the PET looks at function. If the structure is damaged, then obviously there would be some function level abnormality, but sometimes you get function abnormalities in areas where the structural damage either doesn't exist and the abnormal activity is because of damage in other areas that inhibit -- that normally inhibit activity in that area, or it could also be that the damage is there, but the MRI is not sensitive enough to pick it up.

Q. You were asked a number of questions about the etiology of the abnormalities you identified in Mr. Northington. I think they mostly had to do with blows to the head. I wanted to ask you about a couple of other potential etiologies. Is there any consistency between the abnormalities you identified with a history of lack of a school achievement as a youngster?

A. Definitely the reduced metabolism in the basal ganglia and the low volume in the striatal brain.

They can explain lack of motivation because these are the structures that are related to reward and motivation and drive. Lack of motivation and drive would impact school performance. So it could be that the damage in the visual associations area, like the cuneus, may produce difficulties in reading or in comprehending spatial layouts, and that can be also an obstacle to achieving in school.

BY MR. WISEMAN:

Q. The same question with regard to the presence of in utero exposure to toxic substances, like drugs or alcohol.

A. Yes, they would explain, for example --

That may explain abnormalities in white matter, for example, the low metabolism in the posterior corpus callosum.

BY MR. WISEMAN:

Q. Which could result from such toxic exposure?

A. Yes.

Q. You talked about this concept of pruning, and I guess paraphrasing it you said something about if as a
child portions of the brain aren't utilized, the brain sort of ignores them and eventually they get pruned out of existence?

A. Yes. It's quite well-known. That explain why I still don't have a West Philly accent, even though I spent most of my life in West Philadelphia.

Q. Would that type of pruning result from a childhood that's intellectually impoverished?

A. There's evidence that impoverished environment hampers brain development and, of course, it will result in more aggressive pruning because fewer brain regions are utilized. That was shown in animals and in humans.

Q. Just a couple other questions I want to ask you. You were questioned with regard to whether it matters that your BI algorithm was developed on the older version of the WAIS. Did I understand your response was that the algorithm measures functions regardless of what test is inputted?

A. Yes, I can explain that. Each test is measuring a structure concept, what we call in the jargon a construct. So each construct that's measured by that test was rated by the experts. We did that deliberately. We knew that future versions of those tests will come and we agreed that, therefore, we will focus on what that test construct is and rate that rather than any specific version.

Q. Can you apply the algorithm to any person regardless of their condition or lack of condition?

A. Absolutely. A brain is a brain and brains function the same way in all human beings. So that's sort of -- an algorithm is really neutral as to which condition you're applying it to.

Q. So the bottom line, so to speak, on the algorithm is that it will show with input data whether there is or is not an abnormality and if there is one, where it's located?

A. Exactly. it's one piece of information in the total picture.

MR. WISEMAN: Thank you. No other questions. Thank you.

1 The United States would call Dr. Robert Denney.

2 DR. ROBERT L. DENNEY, was duly sworn.

3 [ESTABLISHING QUALIFICATIONS]

DIRECT EXAMINATION

1 BY MR. TROYER:

Q. Dr. Denney, also, have you rendered opinions previously as to whether somebody is or is not mentally retarded?

A. Yes.

Q. Okay. Okay. When you're retained or appointed to conduct examinations, specifically examinations to determine whether somebody is mentally retarded or not, how do you go about doing that, sir?

A. Well, it somewhat depends on the nature of the case. I mean, if there are potential neurocognitive issues
that go beyond the possibility of -- and usually there are, basically it boils down to, you have a clinical interview with the individual. You perform a set of tests that attempt to measure intellectual functioning across a broad spectrum.

I typically throw in other cognitive-related tests that would get attention, concentration, learning and memory, executive function, other things like that, that would help tease out if there are some other conditions there. There would also be a series of tests designed to identify poor effort, potential exaggeration or even malingering mixed into the battery.

Then I would obtain corroborative information or collateral information, as it were, from other sources. In the question of intellectual disability, specifically that information would be directed toward adaptive function skills in the community.

Q. Okay. Part of that adaptive function process, testing process, would that also involve, say, interviews of other people, such as people who know the defendant or knew the defendant during the appropriate time?

A. Yes, exactly.

Q. You mentioned receiving materials from other sources. Typically, do you receive materials from other sources prior to undertaking this testing?

A. Yes. I mean, historically I would be involved in a case and we would then request records from everybody, you know. I want to try to get all of the records that I possibly can, childhood records, medical records, childhood medical records, adult records, prior evaluations, everything we could potentially find, military records, what have you.

Q. Okay. Let's explore some of those items, Dr. Denney. Did you receive some letters that were written—some by Mr. Northington and a few to Mr. Northington in this case?

A. Yes, I did.

Q. Okay. Did you review those letters as well in anticipation of performing testing on Mr. Northington?

A. I reviewed the letters I received. My understanding is that there's a lot of letters. I just recall reviewing a small number of them.

Q. Okay. What did you find when reviewing Mr. Northington's letters that you reviewed?

A. Well, first of all, I found handwriting that was very nice and neat writing, almost an artistic flair to it, very well lined, very well maintained on the line.

Q. All right. Based on the contents of the letter, without reading the entire letter, what else did you find?

A. Well, he described his interactions with an attorney and interaction with his family and telling his family to watch after business, watch after things back at home, and also to stay on top of the attorney, make sure he's doing his job.

I think that this letter also mentioned making sure that they pay him his first half of his fee that he's
supposed to have so the person can continue working. Then there was just general relationship issues, you know, hold down the fort and keep things working back there in the neighborhood until I get back.

Q. Okay. What does that tell you as a psychologist?

A. Well, that would suggest to me that he's got some organization ability, some executive skill as far as following up on things that need to be done and making sure that his family is doing things that he believes are important to be done in his absence.

Q. Okay. All right. Now, while perhaps not perfectly written, how did you find that basically the letter itself was, in terms of how far it was written? Did it have appropriate sentence structure, et cetera?

A. Yes, it did. It communicated well. I mean, there were clearly signs that the person -- again, it was signed by Mr. Northington -- that suggests some grammatical issues and some slang terms thrown in and such, but the overall sentence structure and the links of sentences were very good.

Q. All right. Then we go to Government Exhibit 12, which is Dr. Ryan's report of March 22, 2006.

A. Yes.

Q. Okay. It entered into your analysis in formulating the opinions that you would eventually reach in this case; is that correct?

A. Yes, it contributes to that opinion.

Q. Okay. Did Dr. Ryan, according to this report, perform any malingering tests?

A. He did, actually.

Q. Okay. Was one of those malingering tests the so-called TOMM test, T-O-M-M?

A. Yes. The test of memory malingering.

Q. Okay. Is it noted in the report, then, what the results were of this test performed by Dr. Ryan?

A. Yes. He indicated that Mr. Northington performed at very low percentages on this particular test. I was able then to calculate exactly what those rough scores have been given this particular percentage correct.

He indicated Mr. Northington achieved 24 percent correct on the first recognition trial, 20 percent correct on the second recognition trial, and 20 percent correct in an optional retention trial.

It's an extremely easy test. If someone were truly guessing or had absolutely no ability whatsoever, their score would fall around 50%, just like flipping a coin multiple times.

Q. Is it unusual for people to get 100 percent right?

A. No, no, that's not unusual. It's very common, because again it's a very, very easy test. It's designed so that people with significant brain damage can still easily pass it over 90 percent levels.
Q. Okay. Does a score below 90 percent essentially indicate a suboptimal effort?

A. It is suggestive of suboptimal effort.

Q. I'm jumping ahead a little bit, but you're also familiar with Dr. Shea's administration of the TOMM test to Mr. Northington in this instance, right?

A. Yes.

Q. When Dr. Shea in 2011 administered the TOMM test to Mr. Northington, he got what percentage right?

A. 100 percent. Dr. Shea only administered the first two trials. He didn't administer the third trial, but on the first two trials Mr. Northington obtained 100 percent each time.

Q. Okay. Back in 2006, when Dr. Ryan administered this test to Mr. Northington. What were the percentages that Mr. Northington got correct on those three times administering this simple TOMM test?

A. The first time he obtained 24 percent, and then he obtained 20 percent on the second and 20 percent again on the third.

Q. What did that indicate to Dr. Ryan?

A. That Mr. Northington was performing significantly lower than he should have and was likely malingering memory deficit.

Q. Okay. Essentially what are the odds of a person who would take this test would get 24 percent randomly, would get 24 or 20 percent right?

A. let's…hypothetically say, what if the person taking the test had absolutely no ability whatsoever and they were truly blindfolded and guessing? What are the odds that they would produce that low of a score? In other words, that's only going to occur by chance alone less than one time out of a million administrations of this test. It's that rare.

Q. Okay. Now, did you also obtain a transcript and later on an actual recording of a state court proceeding that occurred in the Court of Common Pleas in Philadelphia with regard to Mr. Northington?

A. Yes, I did.

Q. What did you note from this transcript and this recording of Mr. Northington back on April 27th 2007?

A. Well, it really was striking to me because Mr. Northington demonstrated in a real-life setting that he was able to respond quickly. He demonstrated a fast speed of mental processing.

He started off, first of all, by raising his hand and interjecting into the courtroom his concern about what was going on and the fact that he had just gone through a bench trial, but he initially voiced his concern that he was being represented by attorneys who really didn't want to represent him.

He talks about them Googling and all this stuff to try to get him to go with a bench trial rather than a jury trial. Judge Sarmina, of course, was responding to this. So there was an interaction between the two of them that was very striking to me. I mean, Mr. Northington, first of all, he used the letter as an...
appropriate support for his argument. And the letter was talking about the issue and I think it was a reasonable thing to use his support for it. It was reasonable. Mr. Northington demonstrated quick thinking, fast pace in his thoughts. That's a direct real life indication of speed of mental processing. He also demonstrated tenacity, a willingness to stand up for his opinions and the fortitude to stand up to a judge and disagree with her and voice his complaint.

his demeanor, his mental processing as it was demonstrated in this audio recording and transcript in my professional opinion is not consistent with somebody who has mild mental retardation.

Q. When you met Steven Northington for the first time, what observations did you make when you interviewed him for the first time? In other words, how did Mr. Northington present himself?

A. He was jovial. He was pleasant, friendly, even. He had no difficulty interacting with me. He could understand my questions. I could understand his questions. We could verbally communicate well. He demonstrated good eye contact with me. We were able to establish a rapport readily, easily.

Q. Okay. So, he cooperative with you then?

A. Cooperative in the sense that he was willing to talk with me, interact with me and do the things that I asked him to do, yes.

He started talking about -- explaining to me that he spent ten years in prison, and he did this time and he got out, and he had -- he also had a probation or type of supervised release or something like that, that he also had to do. It was supposed to run concurrent over those ten years, and that then he got out for just a couple -- small number of months, but then got re-picked up. They said it was because of that probation violation, which he said was wrongful imprisonment.

He described all this, and then he started pulling out his paper. He said, look --he described having -- the first time he was arrested was under one alias. He told me the name of the alias and the birthdate of the alias and the fingerprint number. Then he'd pull out documents that then supported that.

Then he described having aliases made for him or what he would call a hookup where he would order a new driver's license, and it would be under a different name with a different birthdate.

So he then listed different names and different birth dates, and he described these different aliases of when he had them at different times. Then he pulled out different documents showing legal proceedings with these different names, and it all supported what he was saying. Then he described that when he was in Kaboni's basement, when the police came in and—basically he was describing events that I since understand to be part of the conspiracy investigation.

Then he raised the issue of, you know, that his -- he had just requested a new ID under the name of Kevin Lewis, but that ID hadn't quite come yet. So once the police came in and they asked him who he is, he gives them the Kevin Lewis name. He said it was just a coincidence that he did that because he knew he had this ID coming.

Anyway, he described this whole process. Again, I don't know all of the accuracy about that, but what he was demonstrating to me was insightful, speed of mental processing.

Q. Was he able to recall dates, times, places?

A. Exactly. His speed of mental processing was quick. He was able to remember dates and times and even addresses. He said, "I had a probation officer I was supposed to see, but they had moved," and he
described to me where the new office was and when that was. He described the different names of these aliases with the different birth dates and fingerprint numbers. He was able to come up with the fingerprint numbers out of his own recollection, and then pull out the document that demonstrated that same name and number. The documents he had were in different envelopes in his bag, and he had it all organized and knew where to find things.

Or he would start to say something and maybe not remember exactly what it is it was, and he would pull another document out of a different envelope and say "right here." He would immediately show me what the document was, and there's the answer of what he was trying to tell me.

Q. So he was able to locate and provide to you supporting documentation for these factual arguments that he was making to you?

A. Yes. And when I gave him time to explain himself to me, his argument made sense to me. You know, yes, it was built upon a coincidence, but then he later described his perception that basically he was being really -- what's the word – prosecuted harder because of not cooperating in the investigation. And if he had just cooperated with the investigation, then it wouldn't be this way at all.

Q. All right. Now, how does that contrast with earlier testimony in these hearings that the defendant was merely perseverating and obsessing and saying the same things over and over again?

A. Perseveration, no. Saying the same things over and over again, sometimes he would when he's emphatically trying to get a point across. I have to say, he certainly got intense in his emotion about this. He said, because it's very personal to him "because they are trying to kill me." And it was very reasonable, his emotional intensity, but I was able to say, now, wait, Mr. Northington, I have a question. Wait.

And he'd stop. I'd say, "I want to understand this." So he would pull out another document or something, and he would then clarify for me so I would understand what his point was. So it wasn't that he was just wildly going on uncontrollably. He had a lot of energy and passion in what he was saying, yes, but I was able to say, "time out, time out, I don't understand something. What about this." He would then backtrack with me and help me understand it.

Q. Okay. So based on that, especially that conversation of October 2nd, would you say that that conversation that you had and how the defendant was acting on that date, would you say that was consistent or inconsistent with a person who was actually mentally retarded?

A. In my professional opinion, it was simply inconsistent. It's not consistent with mental retardation at all.

Q. All right. Now, you also mentioned a short time ago that he had talked to you about the use of aliases and ordering various forms of identification in other names. The use of aliases, again, is that something that you would typically find in your professional opinion in a person who is mentally retarded, the ability to obtain that type of information and use that information to their benefit?

A. It's very common for low functioning individuals, particularly if they are involved in a criminal society, other individuals who are involved in criminal activity and such to go by a nickname or -- and you could use it by alias. In that sense it's a nickname, certainly. That's not uncommon at all. That's standard, really. But it's not what I see when I evaluated and worked with low-functioning individuals, that they had an organized way of changing their identity in a systematic, with a new
driver's license, new number, new fingerprint, and then to use that ID, that new alias, to then buy motor vehicles, which is what he said he did.

Q. Let me pose to you a brief, very brief abbreviated hypothesis, too. If a person were to visit someone in a correctional facility and that person could not get into the correctional facility under their own name because they were a convicted felon, but used a different name to get into that correctional facility to see that person, again, would that be consistent, would you say, or inconsistent, generally speaking, with somebody who is mentally retarded, to have that ability?

A. To have that ability, no, it's not consistent with mental retardation. That's problem solving, planning, organizing and carrying through with something that is—it’s nonsense to think that it would be.

Q. Okay. I'd like to begin now talking about some of the tests that you administered. Referring back to Government Exhibit 2(a), Page 2, do you outline then or rather specifically list the various tests that you worked with on Mr. Northington?

A. Yes.

Q. Of course, the first one is the Wechsler Adult Intelligence Scale Fourth Edition known as the WAIS-IV, right?

A. Yes.

Q. And that is, of course, essentially the IQ test; is that right?

A. Yes, it is.

Q. And is that the main test given to people to ascertain whether or not they are mentally retarded?

A. Yes, it is a primary test used for that purpose. I mean, it's an intellectual test battery, so it's not just a test. It's a cumulative set of tests that's used to mention an adult's intellectual functioning.

Q. Okay. Of course, in determining whether someone is mentally retarded you don't just rely on the one test alone, do you?

A. No. You can't rely only on test scores even. You can't become what some people call test-bound. You have to look at the entire information, the whole clinical picture. But certainly test results are important.

Q. All right. Well, right now, and we'll get to the rest of the picture in a little while, but right now let's focus on some of these tests. Now, of the 19 tests that are listed here, are some of these tests tests that you performed in order to determine whether Mr. Northington was malingering or not?

A. Well, tests to help me understand, I'll use that term, like we talked about earlier, negative response bias. Malingering is a clinical judgment based upon test findings and overall clinical recollection. It's just easier to say malingering tests when in effect they are really not malingering tests. They are what I would term performance validity tests. They tell you whether the person's performance is a valid reflection of their real abilities or not.

Q. So having stood corrected here, how many performance validity tests are there among these 19 tests that are listed? How many of these are performance validity tests?
A. Three independent freestanding tests, and then one symptom validity test. It's like a performance validity test, but it's a report and that's embedded within the MMPI.

Q. Let's look at the ones then that we're talking about. Is number two Advanced Clinical Solutions Word Choice test? What is that?

A. Yes, that is a performance validity test.

Q. Without getting into the entire creation of the test and every single question in it, obviously, but could you summarize for us or basically explain to us what that test is, the number two, the Advanced Clinical Solutions Word Choice test?

A. It's a very simple task that was actually developed and formed along with the Wechsler Intelligence Scale. It's connected into those same norms. It's simply a little task where you have a little booklet. There's a word on each page. There's 50 different words, and they are simple words.

So I flip the page and I ask the person to read the word and tell me whether this is a natural or man-made thing. It could be like, for example, like something like "bed" or "tree" or "lake" or "car" or "skyscraper," some simple thing like that. It's not a reading test. If the person has any trouble reading, I read the word out loud for them. So that's not the issue.

They go through all of those words, and then at the end of those words I ask him a question saying, which one of these words is one of those words you remember from that list? Was it this word or that word? You'll recognize that it's a two alternative, forced choice task.

So it actually measures something that is very, very easy. It's a quick recognition task, something that you just seen before, and it's very, very simple. That's how it works to explain --

Q. Okay. When you administered that test, how many of these choices or essentially questions are then posed to the subject?

A. There are 50.

Q. All right. What is the false positive rate for this test?

A. Well, Mr. Northington obtained -- the false positive of a test varies depending on the cutoff score one uses. Mr. Northington obtained 32 correct out of these 50. When I looked on the norms for the test -- so I look at the actual standardization sample upon which the test was created. It's insightful because it's the entire standardization sample for the entire intellectual battery. As a result, it includes people with different types of conditions because I needed to know how people perform in the normative sample with the IQ test.

Q. Does it even include mentally retarded subjects?

A. It does. So when you take the overall normative group and take out those individuals with IQs that fall in the range of mild intellectual disability, of that group less than 10 percent of that subject pool performed that poorly on this test, which tells me that it's very unlikely for somebody even with significant impairment to perform this poorly on it because it's a very easy test.

Then that gives me the false positive rate; in other words, this low score suggests poor effort or invalid results. To a level of probability I can say that is less than – it was less than 10 percent of that particular mild intellectual disability that performed that poorly, so that would be a false positive rate
of greater than .90.

Q. All right. Now, let's be a little bit more concrete about this, then. For somebody to score what, 31, 32, did you say --

A. Thirty-two, I believe.

Q. -- 32 out of 50 on this test, if somebody were so impaired to the extent that they would not even be able to help themselves in their everyday affairs, that they would need constant help and supervision, is that the type of score that you would expect to find from that person or would even that person do better, perhaps?

A. They would do better. The norms tell us that they would do better. Over 90 percent of those people with significant intellectual disability performed better.

Q. All right. So when you mentioned the term like “significant intellectual disability,” you're talking about somebody who is basically in an institutionalized setting where they have to have help with dressing and feeding and day-to-day activities?

A. No. I mean, no, not necessarily. I don't know that. We're talking about just the standardization sample for the WAIS-IV, which would not be institutionalized people in this instance. But these are those individuals from that standardization sample who had intellectual disability, mild intellectual disability. So these are people who had mental retardation. We know that over 90 percent of them performed better than he did on this test.

So the statistics of that tell me that it's got a low false positive rate, and it is suggestive of somebody who is not putting forth the appropriate positive effort.

Q. Okay. All right. Let me go to the next test, then, this Test of Variables of Attention 8. Is that sometimes called TOVA?

A. TOVA. I didn't mention TOVA when I just described the potential validity test. It's a computerized test of attention. It's got inside it an embedded index to identify when somebody appears to be exaggerating their problem.

Q. What does that mean, "embedded index"?

A. Well, the purpose of the test has a clinical purpose, like in this instance the TOVA is commonly used for assessment of attention deficit, hence, the term of Test of Variables Of Attention. It gets out somebody's ability to focus attention and respond appropriately to stimuli and not respond inappropriately to incorrect stimuli. So it's a sustained focus attention task.

Inside this computer process it measures the timing and the correct hits and the false hits and all of these different variables inside it, and then it has a list of findings that when these findings are positive, are consistent with suggesting that it's been exaggerated, that the impairments on this test has been exaggerated.

Q. Okay.

A. With Mr. Northington, he hit positive on three of these four indices. The tests' printout then said "Caution, these results are not valid. The findings on this index symptom exaggeration index suggested this person was attempting to exaggerate."
Q. Okay.
A. Making the results invalid.

Q. Now, then the next test that we would deal with is performance validity. We would go down to 16 and 17, the Green's Word Memory Test?
A. Yes.

Q. And the Green's Medical Symptom Test?
A. Yes.

Q. Okay. Those are -- Green's Word Memory test is now marked as Government Exhibits 20 and 21, I believe, 20 being a chart that shows what is referred to as a Z score, and 21A being the Green's Word Memory Test chart showing the percent correct; is that right?

You'll find that in the very back of your book. Unfortunately, everybody else is going to see there's not a Government exhibit number on it, but I've just described it, so hopefully they'll be able to find it.

A. Yes, there's four pages here, and two of them have on the top of them "Green's Word Memory Test." That's what we're talking about.

Q. Okay. Is that a test that you administered then to Mr. Northington?
A. Yes, it is. This is a printout graph from that test.

Q. Okay. Before we go to specifically to the printouts, let's talk about the test. What is that test?
A. The Word Memory Test is a very well researched performance validity test. It's a computer-administered test, although it can be administered orally, and oftentimes is administered with the computer and orally, if there's any question about reading concerns.

The way it works is on the computer screen is shown a list of 40 -- I'm sorry, 20 word pairs on the screen, and this is the way it presents. On the screen the first word will come up, and then the second word will come up.

Now, the instructions first come up on the screen, and I always have the individual taking the test read the instructions out loud to me. That verifies that I know they have a reading level that is consistent with this particular test, and the reading level of the test is at the fourth grade reading level.

Mr. Northington read the instructions to me out loud. He didn't have any significant difficulty reading those instructions. He stumbled over it a tiny bit, but overall did fine with that. But I sat with him, too, so when those words came up on the screen, I could help him if he wasn’t able to read the word.

The instructions of this task are, there are going to be words coming up on this screen, and I want you to pay attention and remember these words.
Then the words come up and the word pairs, as I mentioned. So the first one would come up something like, you know, "cup, saucer." I'm just making those up because I don't want to disclose the items of the test. But there are simple words like that that have a somewhat of a semantic connectiveness to it.

The first one comes up, the second word comes up, and both are on the screen for a little bit and they go away, and the next word and the next pair goes up with it. It does that 20 times for a total of 40 words. The person is watching the screen, and, then in Mr. Northington's case, reading it out loud.

So it does that through the whole list, and then the instructions come up on the screen again saying, okay, pay attention, we're going to read the same list again. Go through the same list again. Pay attention and remember the words. So then it goes through the other words again in that same exact process, same words, same order, same everything.

And then it changes. The next thing that the test has is a recognition task where it shows on the screen one word that was on that list and another word, a foil, a different word that had never been seen on the list.

Mr. Northington or whoever is taking the test then has to choose which word was on the list. So it's a Two alternative forced choice task again, and it goes through all 40 words that way with different foils.

Then there is a half-an-hour delay, during which time you do other psychological testing that does not involve verbal learning or list learning or anything like that. Then you come back together and you turn on the computer and it has another recognition task. It says the same thing again. Here's a word and here's a brand-new foil that the person has never seen before, and they have to choose which word they remember from the list half an hour ago from the original list that they saw twice on the computer. So that’s delayed recognition trial.

Immediately after that, then the test has a multiple choice trial where it gives the first word of a pair and it gives a list of five different options and they have to choose which one went with that word.

Then the next trial is a paired associated trial where I turn the computer around, and I say the first word to him and ask for him to tell me what word went with it.

So it's like a -- it's almost free recall, but with a prompt. So I give him the first word, and he has to give me the second word and I type that into the computer, or mark it on the list.

Then the last trial is a complete free recall where I say, okay, now, tell me all the words that you remember from that original list.

Q. Okay. Well, Dr. Denney, it sounds to me like some of these parts of these tests are really easy, and some are really hard.

A. That's exactly the way the test is designed. It's elegant in that regard. Some aspects of the test are extremely easy, and yet some other aspects of the test are honest-to-goodness true memory tests that are somewhat hard.

Q. How did Mr. Northington do on that test then?

A. Well, he failed, to put it bluntly. His performance fell below standard cutoffs on the easy portion of the test. On the immediate recognition and on the delayed recognition, he performed at the 55 percent
and 60 percent level respectively. That is well below cutoffs for suggesting a failure in this test.

But because of the elegance of the test, you have to differentiate between a fail due to genuine cognitive impairment. Somebody really does have so serious a cognitive impairment that they can't pass the test, and there are those individuals versus somebody who failed a test because of not poor ability, but because they were not putting forth appropriate effort on the test. That's where you look at the overall pattern of scores; you look at the harder scale scores, as well in relationship to the easy scores.

Q. When it came to the harder parts of the test, how did Mr. Northington do?

A. Actually, when you go to the hardest part of the test, the free recall score, he put that in the normal range, I should say, in the non-impaired range. Yet he put the easiest part of the test in the severely impaired range, significantly impaired.

We have different lines here. Mr. Northington is the bold blue line with a larger circle dot. You can see that his performance on here -- and there's a little key at the bottom, it says the patient, Northington, Steven.

Now, it has the dark dot up here for IR. It's at 55 percent. You'll see DR, Delayed Recognition, is at 60 percent. And then Consistency is at 70 percent. As I mentioned, all three of those are below the criteria, which is up here. So that would be classified as a fail.

But sometimes people who have genuine serious cognitive problems fail this test as well, but they always do better on the easy part, and then their more difficult scales fall off even worse, as you can see demonstrated by this gray line, because that's established on people who have real impairment. You see it falls off, and that's what you would expect.

Q. So it's contrasted with the standard for impairment where it falls off dramatically as the questions get harder. How did Mr. Northington do?

A. Well, not necessarily that the questions get harder, but the scales are harder, yes, the tasks are harder. So what Mr. Northington did, he was at very poor. He did do less well on the others, but not by very much. He then came back with a multiple choice of 50 percent, which is down in the impaired range. Multiple choice is one of these sort of hybrid scales where it's half clinically relevant but half also performance validity scale because it is so easy most everybody does well on multiple choice. If it falls below about 70 percent, it raises some concern as well.

But then on the paired associate and free recall, the two most difficult scales, Mr. Northington produced performances at 45 percent and then 42.5 percent.

Q. So what does that tell you?

A. So what that tells me is that you need to look at it in context with other groups. Well, first of all, obviously, given the nature of this particular proceeding we are concerned about, well, how does somebody with mental retardation perform on this test? Well, we have that data. You'll see groups of mentally retarded adults who passed or failed this performed...in the normal range.

Now, we also have some other groups. At the very top is this -- what is that kind of purple color, is the moderate and severe brain injury people. You see their performance mirrors that pattern, but they do better on the easy, and they do hard -- they don't do as well on the harder things.
The red line, the next one down, these are moderate to severe brain injury who failed the WMT, Word Memory Test. They failed the WMT because their consistency is low, but if you notice their pattern they fall off rapidly, suggesting they failed because they have genuine serious brain damage problems.

Then the next group down is green. We'll look at the green one. Now, these are sophisticated volunteer simulators. These are normal people who are faking. You can see their performance is down there at 70 and about 68, and then they fall down on CNS to about 62.

Then their pattern falls down as well, sort of follows along Mr. Northington's path as well, about the same.

Then the last group is this beige color or golden color, and those are individuals who have advanced dementia, and they are in hospital settings. These are people who cannot take care of themselves because they are so cognitively impaired.

They do poorly on the IR & DR as well, so they would be a fail. But then when you look at the overall pattern, you see that the hard part of the test is tanked. It drops way down here because they really do have terrible memory problems.

So you can see Mr. Northington's performance compared to these other reference groups, and that I think is very insightful. What we look at is the ratio between the easy subtest and the hard subtest. There should be a standardized difference between those two groups and scores that the demented people show and people with severe brain injury that have tremendous cognitive problems show, but the simulators, the malingering, and people not putting forth perfect effort don't show that difference.

Q. Okay. A person who has taken that test and putting forth an honest full effort in this test, would it even be possible for somebody to do so poorly on those easy questions and then do so well on the other ones, unless it was just hit or miss or random?

A. Well, again, if they are actually applying their brainpower to the task, with the intent of choosing the right answer, every time that they can answer correctly, we see here by other relative groups that even people with significant nursing home dementia level cognitive problems do poorly on it, but they do better than Mr. Northington.

So this could only be a valid reflection of his true ability if Mr. Northington -- and, again, not looking at the pattern because that makes no sense, but just looking at the easy part of it, if this were genuine, Mr. Northington would have to have the cognitive difficulties that would require bedpans. In fact, he would be in a hospital setting and have to be fed because these are severely demented individuals.