COMMENTARY

FUNCTIONAL BRAIN SCANS AS EVIDENCE IN CRIMINAL COURT: AN ARGUMENT FOR CAUTION

THE ROLE OF THE BRAIN IN CRIMINAL BEHAVior has long fascinated both scientists and the public. The wild popularity of films such as "The Silence of the Lambs," and television such as "Twin Peaks" and a growing number of crime re-enactment and you-are-there police shows testify to this morbid fascination. With theories that attempt to demystify the origins of violent behavior, scientists have tapped into a source of intense public curiosity and found an eager and receptive audience.

Helen S. Mayberg, MD

Although not surprising, it is deeply disturbing to me that society is so willing to embrace the use of functional brain imaging to explain human violence. I question whether we understand enough about the complexities of mind and behavior to read a brain scan and draw conclusions about the judgement, insight, or motives that compel an individual to commit murder or other brutal acts. Yet, as a front page article in *The Wall Street Journal* recently proclaimed, "Brain scans, [and] other new tests are being used to show defects clearly to juries." *(1)* Our scientific sophistication has yet to reach the level of certainty that would justify the introduction of brain scans as evidence in criminal court, and yet criminal defense lawyers are using brain scans more and more frequently.

I'm a neurologist with a personal interest in the use of positron emission tomography (PET) to study the chemistry and functional anatomy of neural systems affecting motivation, reward, attention, and emotion. Studies of criminal behaviors interest me, but I am cautious of the potential impact that such research could have on the legal system and society. My caution was only heightened after being called to testify in a criminal murder trial in which PET brain scans appeared as evidence. As a scientist and as a physician, I am concerned about the premature use of brain imaging technology in individual criminal cases in which the issue is aberrant behavior and not disease diagnosis.

In the case in which I testified, I concurred with testimony offered by other PET experts in similar cases: functional imaging methods have not reached the level of sophistication required to predict any neurological or psychiatric deficit, much less explain more esoteric behaviors such as lack of judgement or remorse. Aberrant sexual drive, homicidal and sadistic tendencies, and psychopathic and sociopathic personality disorders have no known PET pattern; the presence of these behaviors in an individual with *any* PET scan finding cannot be inferred.

Keeping the Reins Tight

Neuroscience has come a long way in understanding basic mechanisms of central nervous system function. The macro- and micro-organization of neural systems in many species have been mapped in anatomical, biochemical, and molecular detail. Rapid advances in high-resolution anatomical imaging methods such as x-ray computed tomography and magnetic resonance imaging have greatly facilitated human in vivo studies of structure-function relationships. These methods provide for precise measurements of focal brain lesions and allow for direct correlations with specific clinical abnormalities, augmenting classical pathological lesion-deficit studies pioneered in the last century. Despite such advances, our understanding of more complex behaviors, including attention, language, memory, and emotions remains relatively superficial.

Functional brain imaging methods have widened the range of possible questions we can pose and have made studies of normal brain function possible. Investigators are testing the use of SPECT and PET in the diagnosis of many neurological and psychiatric diseases. Through careful studies performed by research groups worldwide, there is an emerging consensus in suggesting specific disease diagnoses where certain functional imaging patterns are present. Studies at different centers have consistently identified PET patterns (and in some cases SPECT patterns) that differentiate brain tumor recurrence from radiation necrosis, Parkinson's disease from related syndromes, and Alzheimer's disease from multi-infarct dementia. The sites of unilateral epileptogenic foci in patients with partial complex seizures can be localized. Specific scan abnormalities have also been demonstrated in patients with specific psychiatric diagnoses, including depression, panic disorder, schizophrenia, anxiety, and obsessive compulsive

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disorder, but the uniqueness of patterns for a specific diseases has not yet been fully clarified.

Efforts are underway to establish consistent guidelines for the appropriate use of these imaging methods in clinical practice. An opinion statement developed by PET experts has already been offered to help identify the neurological diseases for which the use of scans is validated and clinical usefulness is established *(2)*. Despite mounting evidence documenting the utility of these scans in a wide variety of clinical circumstances, physicians are still bound by FDA regulations, package inserts, and even insurance stipulations.

Lawyers Can, Doctors Can't

Given that SPECT and PET technology has yet to gain universal acceptance in medicine for the routine work-up of patients with behavioral disturbances, and that most clinical applications await the approval of medical insurers, it is difficult to overstate the irony in the growing use of these brain scanning technologies in the legal arena. Physicians must accept that the use of imaging modalities such as PET is still limited to a few specific clinical indications. These same techniques, however, have been used in court as evidence of brain dysfunction in people for whom the only basis for inferring brain disease is the socially unacceptable act for which they have been charged. In the courtroom, there is no precedent for assessing sensitivity or specificity of any identified scan abnormality, since in most cases, research studies of subjects with comparable criminal behaviors have not been performed. At its cynical best, the judicial system leaves the interpretation of single scans to jury members who must decide the reliability of complex patterns — without a context of data from controlled experiments.

More ominous is the notion — held by a surprising number of lawyers and journalists — that PET and SPECT studies are sophisticated enough to predict the presence of specific behaviors or deficits in a given subject. Up to now, functional imaging studies have concentrated on pattern recognition in groups of patients with well-characterized and often pathologically confirmed diseases. A growing literature addresses the sensitivity and specificity of patterns seen in single studies to correctly predict the presence of a particular *disease*. This tactic is fundamentally distinct from studies in which the presence of specific *behaviors* is predicted in a given patient from the pattern of altered brain function. The distinction is not trivial; there is no clinical or experimental evidence to justify the prediction of neurological, psychiatric, or behavioral deficits from existing brain imaging techniques.

Application of Scans, Dangerous Predictions

To see the danger in overestimating the predictive power of focal scan abnormalities observed in a single patient, consider the stroke patient who presents with an acute hemiparesis or aphasia and a well-demarcated lesion on MRI and PET and who, one-year post-infarct, has no demonstrable clinical deficits and reveals no change in the size of the lesion seen on either scan. Or consider the multiple sclerosis patient who presents with a first episode of transient monocular blindness and whose MRI scan shows diffuse, multi-focal white matter lesions. Or the neurologically and psychiatrically normal subject (perhaps a colleague, friend, or patient's relative selected as a control subject in a research study) whose PET or SPECT scan shows a pattern consistent with Alzheimer's disease.

What do we make of these results? In the case of the stroke patient, we have no hesitancy in attributing recovery of function to neuronal and functional plasticity, despite the permanence of the lesion itself. In cases of multiple sclerosis, we are accustomed to seeing many lesions in brain regions without associated clinical findings, although we do not yet understand the mechanism. The most awkward situation arises when scan abnormalities are detected in subjects with no identifiable diseases or even symptoms. Do we warn the 30-year-old volunteer that he might develop Alzheimer's disease? Do we initiate an exhaustive clinical work-up?

How can we be any more certain when criminal defendants with sociopathic or violent behaviors are scanned and demonstrate evidence of "focal hypometabolism"? While many neurologists, psychiatrists, and neuroscientists might concur that violent behavior probably involves dysfunction of specific systems in the brain, and some indirect evidence exists to support this claim, specific, conclusive experiments have yet to be conducted *(3)*. Are we comfortable then, with courts concluding that brain scan abnormalities *may* explain a defendant's competency, judgement, motivation, insight, or lack thereof in circumstances absent the necessary controlled studies? Perhaps more disquieting is the possibility that acceptance of scans in court could presage a time when authorities conduct screenings of incarcerated populations in search of a tell-all brain scan defect, or worse, when educators and employers adopt the use of scanning to prospectively identify "questionable" tendencies.

The Scientific Responsibility for Legal Use

In the end, the outcome of the case in which I testified had little to do with the PET scan evidence, which the jury considered more confusing than helpful. Nevertheless, I remain troubled by the fact that PET brain scans were admitted as evidence in the first place. Although the criteria for admissibility of evidence during the sentencing phase of a trial are generally less strict than during determination of guilt or innocence, the criteria for acceptability of expert testimony rest on a 1923 Supreme Court decision *(4)*. In affirming a law defining acceptable evidence, the Court concurred with the decision of a district court judge who wrote that "Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define.

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lease in New York City and the responsiveness of the staff. I predicted that the latter issue would resolve with the recruitment of a new executive director, and that clearly has been the case. The number of complaints from membership about the support from the New York Office has dropped precipitously under the leadership of our new executive director. There is likewise greater satisfaction with the efforts of our staff in new York.

The discussion yet to occur regarding relocation will focus on two areas: dissatisfaction with the present location and costs in New York; and the need to be closer to where regulations are formulated and implemented. The opinions of the majority of the past six presidents are that most of their activity has focused in Washington as a result of government interaction with our specialty. The Society and College need to establish for legislators a resource base, which they can call upon for information prior to the drafting of new regulations and legislation. We recognize that our Joint Office of Government Relations has been our most effective means of responding to government regulation. Its very success underlines the need to further enhance that effort with supplemental resources beyond the levels that are being matched by the ACNP.

Thus, the recommendation of the Executive Committee that will be brought to the Trustees perceives that the best relocation site for the Society's national office is the Greater Washington area, which, though not the least expensive site, represents the best value to the Society in terms of protecting the interest of the nuclear medicine community. No matter what changes occur in the health care system in the future, it is safe to assume that the focus of activity will be Washington. I expect that a lively discussion will surround that recommendation. The future role of the Society in protecting and fostering the interests of nuclear medicine may be profoundly affected by the outcome of that discourse.

In closing, I would like to report to you that the issues that you asked me to address during the year of my tenure have been and are being addresseed. At no time in our history has Nuclear Medicine been so integral a part of healthcare. The procedures we perform on a daily basis are as much a part of the clinical practice of medicine as are those of any other specialty. These techniques were conceived in nuclear medicine departments and are now being actively pursued by other specialities who wish to take them for their own. What better accolade could there be for the accomplishments of our specialty than their appropriate clinical application and the desire of other specialists to assume them for their own?

Our strategic plan reconfirms our primary commitment to education and research. Our Journal subscriptions are at a peak level. Attendance at our national scientific meetings continues to increase to record highs. New techniques in nuclear medicine are being developed. Some of the most exicting applications of nuclear medicine are on the horizon.

Superbly qualifiifed individuals are applying for our residency programs and research and development in both radiopharmaceuticals and imaging equipment promises that the future applications of nuclear medicine will further enhance the quality of patient care. I am gratified that you asked me to lead our Society over the last year and I appreciate your confidence in me. It is with continued optimism that I greet with you our new president, Paul H. Murphy, PhD.

Brain Imaging

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Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the field in which it belongs."

As we become more competent, creative, and motivated to tackle many of the most esoteric brain behavior questions with new research tools, it remains our scientific and social obligation to address these issues in an experimentally responsible and unbiased manner. Controlled and reproducible imaging studies designed specifically to examine these complex issues are needed. Of paramount importance is evaluation of the sensitivity and specificity of patterns to predict the presence of specific behaviors. Unambiguous results are needed before any introduction of these methods into the courts could be considered scientifically acceptable. We need to be both circumspect and methodical about our short-term and long-term scientific objectives. Our decisions today will strongly influence our questions and society's actions in the future.

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