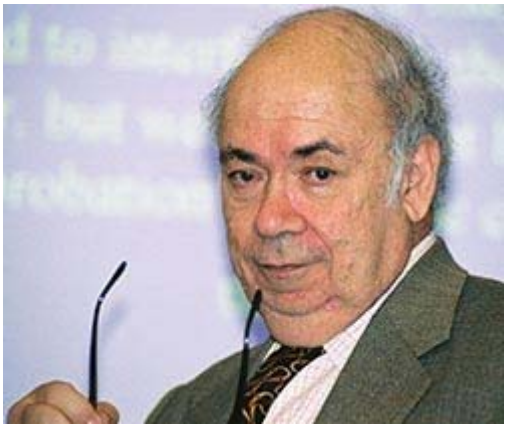
At AAAS Conference, Judges Explore the Impact of Neuroscience on Justice

RENO, Nev.—It was the sort of case that makes news headlines: A man was arrested for soliciting child sex online, and the case was slated for trial. But in the pre-trial investigation, a scan of the suspect's brain using positron emission tomography revealed serious damage to the frontal lobe of his brain, apparently the result of a stroke.



Dr. Monte S. Buchsbaum

The discovery raised a host of difficult questions: In a judicial system based on the assumption that individuals function by free will, how could responsibility be assigned for the crime? Could a man properly be considered guilty if his free will was undermined by a malfunctioning brain? And did the scan suggest a predilection for future criminal behavior?

"You could argue that the brain injury was an extenuating circumstance and that the person should receive some kind of treatment," Dr. Monte S. Buchsbaum, a brain-imaging pioneer, said at a recent AAAS seminar. "Or you could argue that this was an aggravating circumstance [that requires a heavier sentence]. This is a decision for society."

Advances in neuroscience—and the profound implications for the justice system—were the focus of presentations and dialogues at a two-day conference that brought top researchers to Reno from 14-15 November to meet with 19 judges from throughout the Western United States. The Judicial Seminar on Emerging Issues in Neuroscience was sponsored by the Dana Foundation, the National Judicial College, and AAAS.

For the judges, the case cited by Buchsbaum—and the questions it raised—struck a resonant chord. "I work daily with people who suffer from impaired cognitive functioning, as well as with the frustrated families of those individuals," said Judge Linda G. Morrissey, chief judge of the Probate and Guardianship Division in the Tulsa County District Court in Oklahoma. "The genesis of

impairment may stem from an organic condition, brain injury, substance abuse or a myriad of other causes. Many of these people appear normal in all observable ways but engage in inexplicable conduct that poses a risk of harm to themselves and others."

Almost routinely now, brain scanning and other advances in neuroscience are giving courts and juries new insights into those and other behaviors: How addiction and injury compromise functions of the frontal lobes. How lies can be more reliably detected. How faulty our memories are, and how easily they can be manipulated. How it is increasingly possible to discern the subtle but significant differences in patients who are in a minimally conscious state or a permanent vegetative state.

"It is amazing what has happened just over the past few years, or in the past decade" in neuroscience research, said seminar organizer Mark S. Frankel, director of the AAAS Scientific Freedom, Responsibility and Law Program. " Enough progress has been made to believe that the courts will have to deal with these issues sooner than anyone would have anticipated just a few years ago, and in some cases the scientific findings and their meaning will not be clear."

The insights arising from the young but flourishing fields of neuroscience are creating new questions and new quandaries across the U.S. legal system, from local juvenile and criminal courts to the highest courts in the land. Certainly courts have considered subtle issues of behavior, motivation and sanity for decades. What's changing rapidly, however, is that advances in brain imaging—magnetic resonance imaging (MRI), positron emission topography (PET), magnetoencephalography (MEG), and electroencephalography (EEG)—are offering increasingly clear and reliable views of the brain as its neurons fire, and misfire.

The average adult brain weighs just three pounds, and yet routinely does computations that are beyond all but the most powerful computers. It features 100 billion neurons, or 50,000 neurons per square centimeter; a typical brain cell receives input from 1,000 other cells. Given such power and complexity, whole realms of human brain function and human behavior remain a mystery.

Much research in the past two decades has focused on the frontal lobes and their relationship to the amygdala and hippocampus. The prefrontal cortex is a center of impulse control, social cooperation and moral understanding. But it is vulnerable to damage by tumors and strokes and in falls, car collisions, or other traumatic incidents; damage to the frontal lobes has been linked to compromised decision-making and to anti-social behaviors ranging from dishonesty to violence and sexual predation. In children under two years old, such damage can impede moral development or block it altogether.

For this reason, experts said at the seminar, the frontal lobes are a center of interest in the justice system.

Joe S. Cecil

But the courts have long been cautious in admitting knowledge obtained from new technology, said Joe S. Cecil, who directs the Program on Scientific and Technical Evidence at the Federal Judicial Center and serves as principal editor of the Center's *Reference Manual on Scientific Evidence*. In the late 19th century, he said, courts struggled with how to use photographic evidence. They are similarly struggling now with how to interpret and use brain scans, he said, but with thousands of peer-reviewed papers on such research being published every year, the courts more frequently recognize the tools' credibility.

Cecil and other seminar speakers cited a high-profile Illinois case for a view of how the courts view the new neuroscience: When Illinois approved a new law to ban the sale of violent and sexually explicit video games to children, trade associations representing the video games industry sued. While the court held that the video games are protected under the First Amendment, an extensive passage in its opinion discussed functional magnetic resonance imaging (fMRI) research that assessed whether children become more aggressive after viewing violent video games. The court concluded that the research was not yet conclusive.

But, said Cecil, "the very fact that a judge is talking about the front lobes of the brain is breathtaking...I think this is the kind of case that will be coming before the courts more and more."

Buchsbaum, director of the Neuroscience PET Laboratory at Mt. Sinai Hospital in New York City, said that means that judges and jurors will increasingly need to understand complex medicine and science in order to make solid decisions. For example, he said, if a person loses a hand in an accident, the jury can see that and assess the damage. But if the person suffers permanent damage to the frontal lobes, that's not visible, and proof of the impact on the victim's behavior might be more elusive.

Buchsbaum frequently serves as an expert witness in trials requiring insight on brain function, and he said he's been impressed by the positive impact created when a judge allows attorneys to present a courtroom primer to jurors about the workings of the frontal lobe.

Throughout the two-day seminar, the scientists and judges explored a range of other topics where the law and neuroscience intersect:

Lie-detection

The use of fMRI to help separate truth from lies in suspects, witnesses and others has provoked extensive debate and news media coverage, and the controversy continued to play out during an extended dialogue at the seminar.

Steven J. Laken

Steven J. Laken, a pioneer in new-generation lie detection and founder of Cephos Corp., explained how his company has conducted tests on subjects' brains to catch them in acts of deception. Research has shown that lying activates different areas of the brain—and more areas overall—than telling the truth. Today, Laken says, the technology has advanced far enough to permit "careful and controlled" use in courts.

Laken cited one Cephos experiment in which 30 subjects were asked, individually, to go into a room, open a drawer, and then take either a ring or a watch from the drawer; they were then to keep their choice secret. Each subject was put into an MRI tube and asked 160 questions in 16 minutes, including questions about what they took from the drawer.

Based on which areas of the subjects brains lit up, the test was able to correctly identify the ring- and watch-takers in 28 cases, a 93% percent success rate. The experiment was repeated with a different set of subjects, with results that were almost exactly the same.

Laken acknowledged that not everything is known about the technology, but that doesn't mean that it can't be useful in real legal settings. "I think it's been proven the fMRI can be effective in detecting deception supported by numerous publications by different groups," he said.

Craig Stark

Craig Stark, a neuroscientist at the University of California—Irvine, answered that fMRI currently remains too unreliable to use in court cases where someone's life or freedom are at stake. He offered a broad critique of fMRI and its limitations: The threshold for saying an area of the brain is activated is "arbitrary," he said. Further, he added, while the technology might be relatively reliable with a group of experimental subjects, it would be much less reliable for use on a single criminal suspect who might be trying to game the test.

Stark said such subjects could try various tactics to throw off the results: They could practice lies so that it appeared as true in the tests. They could think of lies during truth trials. They could practice thought patterns that would activate the brain in ways that would cloud the results. Another scholar at the meeting suggested that if a man simply *thought* of murdering his wife, it would activate the same brain areas as if he had done the murder. So if a man had contemplated the crime but never committed it, he said, the test might see him as guilty.

"Nobody has investigated these efforts to beat the test," Stark said. "...I'm not saying it doesn't have a future. I'm not saying its day won't come. I'm just saying that today is not that day."

Laken acknowledged the shortcoming cited by Stark. But, he said, further development and improvement of the technology—including research involving drug abusers, the mentally ill and criminal suspects, for example—could eventually make the tests more accurate and reliable.

"I don't think this technology will ever be 100% accurate," Laken said. "There will be mistakes. We will misclassify people." In any event, he added, fMRI would never be more than one among many pieces of evidence in any criminal proceeding. "You don't put away people based just on this evidence," he said.

"The judicial system puts people away based on ambiguous evidence all the time," he added, citing imperfect forensic evidence such as bite marks and tool marks. "The system is able to deal with ambiguity."

Stark acknowledged that DNA evidence was once regarded as too esoteric and unreliable for use in the courts. But, he said, analyzing genetic evidence is "more do-able" than trying to plumb the workings of a brain, "where 10 billion neurons have 1000 connections apiece."

Addiction

George F. Koob, an influential global authority on addiction, described the case of a rat that was given unlimited access to cocaine for 12 hours. The rat's brain rewarded the drug use by releasing sharply elevated levels of dopamine and serotonin—positive hedonistic neuropeptides. But when the high wore off, the levels of dopamine and serotonin fell below sober levels. That sets up a "neuron-adaptive response," Koob explained: The rat's hunger for more drugs is, in effect, an effort to re-establish more normal brain chemistry.

Given the epidemic of methamphetamine use in some parts of the West, the judges said their dockets are often crowded with meth-related cases. Koob, chair of the Committee on the Neurobiology of Addictive Disorders at The Scripps Research Institute and editor-in-chief for the *Journal of Addiction Medicine*, acknowledged the challenge confronting them. "Anything I tell you about cocaine," he said, "meth does it worse."

Whether they're hooked on meth or booze, addicts take drugs to avoid withdrawal, he explained. When they can't access drugs, the hypothalamus pumps out the stress hormone corticotropin release factor (CRF). Pharmacological research is now exploring drugs that can block the stress-inducing effect CRF to mitigate the severe discomfort of withdrawal. Drugs may be discovered that can block both the highs and the lows associated with street drugs and alcohol.

"I'm very excited about the potential of CRF antagonists to be effective in alcohol addiction, but we still have a long way to go," Koob said. He added that the effects of heavy, long-term methamphetamine use may be so devastating that recovery is all but impossible.

Memory

The human memory is a pillar of the judicial system—and the system is structured to allow for its foibles and imperfections. But imaging and other tools of neuroscience are offering new insights into the reliability of witnesses, investigators, and suspects.

Stark, whose lab focuses on the cognitive neuroscience of learning and memory, told the judges of a study related to eyewitnesses. The test subjects were asked to watch a film of an auto collision. Later, they were asked about what they'd seen.

Some subjects were asked: How fast was the white car going when it *hit* the black car? The average answer: 34 miles per hour. Other subjects were asked: How fast was the white car going when it *smashed into* the black car? The average answer: 41 mph. The two questions differed only slightly, but if the study had been a court case and the speed limit had been 35 mph, the variation might have been enough to change the verdict from not guilty to guilty. The point, Stark told the judges, is that memory is malleable.

Time passes and recollections fade; studies have shown that more than 40% of subjects experience "major distortion" in memory 32 months after an event, he said. The mind often tries to compensate

by reconstructing events from the bits and pieces that are left in memory, and that creates opportunity for those who wish to manipulate memory. "Misinformation after the fact can distort memories," he said. "You'll remember what you're told to remember."

Some humans are so suggestible that even traumatic memories can be planted in their brains, Stark said. But imaging allows researchers to see that "true" memories light up visual centers located at the back of the brain; false memories tend to light up auditory regions.

Brain Death, Persistent Vegetative State, and Minimally Conscious State

Terry Schiavo collapsed suddenly in 1990, and for the next 15 years, she was in a persistent vegetative state, kept alive by nutrition provided through a feeding tube. In 2005, the nation watched transfixed as her husband and parents fought in legal and government venues over whether her feeding tube should be removed and other efforts to keep her alive withdrawn. In effect, it was a fight over the nature of her consciousness.

Dr. Michael A. Williams talks to the judges about brain damage

Dr. Michael A. Williams, who chairs the American Academy of Neurology's Ethics, Law, and Humanities Committee, told judges at the seminar that science has made great advances in keeping patients alive after profound brain trauma—and in determining substantive differences between minimally conscious state, persistent vegetative state and brain death. But the differences are often not clear to the public, or to journalists and court personnel, and that raises the risk of agonizing confusion. Indeed, he said that scans alone aren't always sufficient to make the distinction, and that observation over time by trained professionals is crucial.

"There are tremendous emotional responses to cases like [Schiavo's]," said Williams, who serves also as medical director of LifeBridge Health Brain & Spine Institute in Baltimore. "You have to understand the science to make good decisions. If our science isn't good, our legal reasoning and our ethical reasoning isn't going to be good."

The case of a patient who suffers a brain injury and falls into a coma may evolve in three principal directions, Williams said:

Brain death often results suddenly after a severe injury. The patient's eyes do not open, and the pupils show no response to light, and no responses or reflexes at all. The patient cannot breathe,

except with aid of a ventilator. Electroencephalography—an EEG—shows a flat line, with no brain activity.

Patients in persistent vegetative state (PVS) show no signs whatever of self- or environmental awareness, Williams said. They may move, but the movements are meaningless; they may smile or cry or moan, but these are random or reflexive. They show no consistent sign of attention or intention. The condition may be temporary, as the patient recovers from severe brain damage, or permanent if the patient does not recover.

Minimally conscious state (MCS), first described in 1995, is characterized by irregular awareness in the patient, including evidence of self- or environmental awareness. Some MCS patients can follow simple commands or signal answers to simple yes/no questions. Some can make intelligible verbalization. The state can last months, even years.

"If I could teach judges," Williams said, "I would teach them to use goals of care." In order words, first assess what the patient wants, or would want, and then build a treatment plan aimed at that goal.

Williams added: "If the goal of treating patients is to allow as many of them to improve as possible, while simultaneously respecting their autonomy by way of surrogates or living wills, then it is short short-sighted to condemn decisions like Michael Schiavo's or the decision of the judge who found his decision [to remove the feeding tube] consistent with Florida law."

During the conference and afterward, judges made clear that issues with links to neuroscience already are emerging in their courtrooms. Judge Brian Boatright, who handles juvenile court duties in Jefferson County, Colorado, said he recently saw a case in which some young men allegedly committed a bank robbery, and the defense, citing deficits in brain development related to their youth, argued that they were not guilty by reason of insanity.

"Emerging issues in neuroscience are emerging issues in the courtroom," Boatright said. "The basic understanding provided at the seminar was tremendously helpful in raising the baseline of our knowledge....It gave us a heads-up on what's coming down the line."

District Court Judge Deborah E. Schumacher of Nevada's 2nd Judicial District in Reno, offered a similar assessment.

"In a couple of generations, we're going to have a much different jurisprudence that we have now," she said. "...I don't know what it is going to look like, but it's going to look different than what we have now."

AAAS and the Dana Center are planning four new conferences in 2008 on emerging neuroscience issues in the courts. The next one will be in early May at the headquarters of the American Bar Association in Chicago.

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http://www.aaas.org//news/releases/2008/0115neuroscience.shtml