

Brain New World: Five Scenarios

- **In a celebrated death penalty case**, a defense attorney convinces a judge to throw out testimony presented by a key eye witness to a grisly murder, arguing that brain scans prove that the witness is unconsciously mixing real and imagined events. Meanwhile, the prosecution produces a court-ordered neurogenetic profile showing that the defendant's brain and genetic characteristics neatly match those of known murderers. A jury finds the defendant guilty, but recommends a lenient sentence after deciding that she was not fully responsible for the crime, since she was motivated by an unconscious, rage-inducing bias against the ethnic group of the victim.
- **For months, a local school board** debates whether to spend a significant portion of its budget on a high-tech brain screening service that promises to identify which preschool children are at high risk of learning disabilities, aggressive behavior, and drug abuse. To save money, the board finally decides to start a pilot program that screens boys only, since studies have shown that boys are at far greater risk of problems than girls.
- **An employee at a high-tech company sues his employer for discrimination** after he is not selected for a training program that involves the use of memory enhancing "cogniceuticals" to quickly develop valuable new skills. In its defense, the company presents studies showing that the employee's test scores suggest he would not get as much out of the program as others with higher scores.
- **A series of deadly auto accidents** prompts the National Highway Safety Transportation Board to recommend that Congress require car manufacturers to install Drowsy Driver Detection Devices ("Stay Awakes") in all models. The devices monitor brain activity for signs of sleepiness, warning drowsy drivers and—if desired—giving their brains an electrical jolt that restores alertness. The Board rejects a proposal to allow the police to monitor the devices, saying that would violate new Cognitive Privacy rules.
- **After intense lobbying by senior citizen and health groups**, Congress expands a federal health insurance program to cover costly brain tissue implants for Alzheimer's patients. Taxpayer, public health, and religious groups decry the move, saying it will increase taxes, divert resources from other important health programs, and put the government in the ethically tenuous business of harvesting the needed cells from embryos and healthy people, and deciding which patients should get treatment first.

Ask the scientists, legal experts, and ethicists tracking the rapidly moving field of cognitive neuroscience what the research might eventually mean for society at large, and these are just a few of the more provocative scenarios they spin. New discoveries about how the human brain works, they predict, will have deep and potentially profound impacts on everyday life, from how we educate children and train adults, to how we treat addiction and disease, to how we define criminal behavior and think about individual responsibility and spirituality.

Many believe our new understanding of the brain will lead to healthier people, more productive citizens, and improved quality of life. But others see darker consequences too, including insidiously persuasive advertising campaigns, “cognitive discrimination,” and sophisticated government mind control efforts. All agree that policy makers—from parents who serve on school boards to those who work in the White House—should be more aware of the policy implications of what one researcher¹ calls “the outrageous proliferation” of new discoveries about the brain.

To explore and help build awareness of the policy implications of cognitive neuroscience, we contacted a diverse group of people—from scientists to mystery novelists—who have some familiarity with the field, and asked them to look into the future. What questions and controversies, we asked, might policy makers be struggling with in 5, 10, and 25 years as a result of new discoveries in this field? While their answers are by no means exhaustive, they reflect the potential that new brain research has to influence many facets of future society. (*For methods used in this project, see Appendix I.*)

Neuroscience: Risks & Rewards

“The huge costs of neurological disorders and injuries, both monetary and personal, themselves justify placing heightened research priority on neuroscience research. In addition, knowledge gained from this research promises to provide answers to questions concerning the relationship between the brain, the mind, and the body, and each of their interrelationships with disease as well. Studies of brain development and plasticity can help us understand childhood and adolescence and suggest improved strategies for learning and teaching.

Conversely, this knowledge raises troubling issues and challenges traditional beliefs concerning free will, autonomy, and the meaning of life. It also exacerbates policy conflicts surrounding informed consent, privacy, discrimination, stigmatization, and the power to modify or control behavior. Without doubt, the neuroscience research and applications that follow will shake the foundations of social thought, giving credence to some theories of human existence and undermining others.”

Robert Blank in *Brain Politics*

What Is Cognitive Neuroscience?

Cognitive Neuroscience is a young², rapidly growing³, and loosely defined field that attempts to link how people think, feel, and act with distinct biological mechanisms in the brain. It is a profoundly interdisciplinary science, drawing researchers from traditional

¹ Gazzaniga, Michael S. *Cognitive Neuroscience: A Reader*. London: Blackwell, 2000. Page 3.

² The term was coined in 1970 and later popularized by Michael Gazzaniga and colleagues.

³ Over the last decade, the publication of scientific papers using the term has increased from just a few dozen to hundreds a year, while meetings dedicated to the field now attract thousands of researchers. Some of the growth is the result of the “Decade of the Brain,” a concerted effort to funnel resources into brain research in the 1990s.

neurobiology, psychology, computer science, and even philosophy, sociology, and linguistics. John Anderson, a prominent cognitive psychologist at Carnegie Mellon University in Pittsburgh, Pennsylvania, says cognitive neuroscience's widespread attraction to those working in many fields is natural: "Understanding how humans think is important to understanding why certain thought malfunctions occur (clinical psychology), how people behave with other individuals and groups (social psychology), how persuasion works (political science), how economic decisions are made (economics), why certain ways of organizing groups are more effective and stable than others (sociology), or why natural languages have certain features (linguistics)."⁴

New Technologies, New Results

In recent years, advances in cognitive neuroscience have become closely intertwined with advances in imaging and monitoring technologies that allow researchers to observe—sometimes in startling detail—the brain's electrical and biological activity (*See Box 1: A bevy of machines for studying the brain*). These technologies have allowed researchers to detail, for instance, how different parts of our brains "light up" for different activities, such as reading, hearing, and talking. The images have also highlighted how the brains of men and women differ, and even suggested that clues to sexual orientation can be found in the size and activity of different parts of the brain. Imaging has also confirmed that people with certain learning disabilities or brain diseases, such as dyslexia, Parkinson's disease, or schizophrenia, have brains that work in markedly different ways than those of people without the disorders.

While cognitive neuroscience researchers have delved into dozens of provocative questions—from the role of the brain in racial bias to the effectiveness of new teaching methods—the bulk of studies have focused on understanding a few basic functions. These include how we see and hear, how we store and recall memories, how we learn skills, solve problems and understand language, and how emotions are triggered and controlled. In each of these areas, there have been exciting and unexpected discoveries (*see Box 2: A sampling of recent findings from cognitive neuroscience*).

In vision studies, for instance, researchers have found evidence that specific parts of our brain are fine-tuned for recognizing faces, while others perceive color, shapes or lines. Memory researchers are on the trail of locating the parts of the brain that are responsible for storing short- and long-term memories—and have even identified drugs that appear to enhance short-term memory. Others have shown that the act of learning, whether refining a jumpshot, learning to tap the brakes upon seeing a yellow light, or teasing apart a math problem, can rewire the brain's circuitry, even strengthening some connections. There is also evidence that, contrary to conventional wisdom, adult brains can regrow or compensate for areas damaged by disease, injury, or drug abuse.

High Hopes, Practical Problems

Such discoveries have helped raise immense hopes that we can treat or prevent devastating brain illnesses such as Alzheimer's and schizophrenia, improve education and training techniques, and understand the biological basis of addiction, bias, and violence. Many researchers, however, caution that results remain fragmentary and

⁴ Anderson, John R. *Cognitive Psychology and Its Implications*. 5th Edition. New York: Worth Publishers, 2000.

suggestive, if only because the brain is so complicated. The typical human brain contains 100 billion or so neurons, the cells that transmit messages, which in turn interact in countless combinations. There could be 1000 or more brain areas that carry out distinct functions, researchers say, often operating at the same time.

Given such complexity, it is not surprising that studies that rely on imaging technologies remain notoriously difficult to reproduce, making it unclear just how broadly any single finding might apply—or whether it is real at all. “Replication is a big problem,” notes Jim Olds, director of the Krasnow Institute for Advanced Study at George Mason University in Fairfax, Virginia. “There is immense variation in people, and in how researchers operate their equipment, conduct experiments, and interpret results. You can twirl a knob and make virtually any part of the brain light up that you want.” Such variability raises significant questions about the robustness of many studies, he says.

Still, Olds and other researchers note that even controversial findings have a rich history of policy impacts. “One need only look at issues surrounding past innovations of frontal lobotomies, electroshock therapy, and the abuse of psychotropic drugs to see the

Box 1: A bevy of machines for studying the brain

Until recently, researchers studying the structure and function of the brain had to be content with dissecting brains taken from corpses or drawing indirect conclusions from laboratory tests. New technologies, however, allow scientists to literally look inside the skull as people carry out mental tasks. Each technology has strengths and weaknesses. Some provide only two-dimensional data, while others can create 3D images. Some can capture just a detailed snapshot of brain activity at a particular moment, while others are able to produce fuzzier records of brain activity over long periods of time. In the future, new devices, and combinations of existing technologies, are expected to give researchers high-resolution records of brain activity over extended periods of time. Some of the current technologies include:

EEG ~ Electroencephalographs measure the brain’s electrical activity. Among the oldest and cheapest brain sensing technologies.

CAT ~ Computerized axial tomography, which uses computers to combine a series of X-rays into precise 3D images of the brain.

MRI and fMRI ~ Uses a strong magnetic field to detect molecular changes in the brain. Functional MRI (fMRI) has revolutionized cognitive neuroscience by allowing researchers to track the increased blood flow that identifies active areas of the brain.

MEG ~ Magnetoencephalography measures small magnetic fields emitted by brain active brain cells.

PET and SPECT ~ Positron emission tomography and single-photon-emission computerized tomography create images by tracking the movement of radioactive tracers that are injected into or inhaled by a research subject. Particularly useful for understanding how specific drugs operate within the brain.

sensitivity,” notes Robert Blank, author of *Brain Policy: How the New Neuroscience Will Change Our Lives and Our Politics*, one of the few books examining the policy implications of brain research.⁵ And brain research results already find their way into current debates, he notes. The gay and lesbian rights movement, for instance, quickly seized on preliminary findings suggesting that gay men had different brain characteristics than heterosexual men as supporting the view that gayness is a biologically-driven behavior, not a chosen “lifestyle,” as some insist. Some of their opponents, meanwhile, interpreted the same findings to mean that homosexuality was the result of a brain disorder.

Policy makers need to be aware, Blank says, that neuroscience is shaping an “altered view of the human condition that will reverberate throughout conventional theories of politics” and that future findings “might be used for political or ideological advantage on any side of the political spectrum.” Policy makers who want to be “tough on crime,” for instance, may resist the idea that some criminals or drug addicts cannot be held entirely responsible for their actions. At the same time, they may embrace the same

Box 2: Cognitive Neuroscience: A sampling of recent findings

In a controversial study, Elizabeth Phelps and her colleagues at New York University found that brain areas associated with fear “lit up” more often when one group of white students was shown unfamiliar African-American faces than when they were shown faces of unfamiliar Caucasians. “We may not be consciously aware of our biased behavioral responses,” Phelps notes.

People weighing different kinds of moral dilemmas—such as when it is appropriate to kill one person in order to save others—appear to engage different parts of the brain in coming to a decision, depending on how far removed the person is from the consequences of the action. Jonathan Cohen of Princeton University, one of the researchers involved in the study, says it may help scientists and philosophers understand how cultural values that become ingrained early in life may influence moral choices. (See Cohen et al, *Science*, 14 September 2001, and “Watching How the Brain Works as it Weighs a Moral Dilemma” by Sandra Blakeslee, *New York Times*, 9/25/01.)

Certain chemicals can enhance the brain’s short-term memory, speeding up response times or improving memorization, at least temporarily. “These studies raise the exciting possibility that aspects of working memory may be improved by drugs with selective actions of different neurotransmitter systems, resulting in possible therapeutic benefits for patients with cognitive disorders such as Alzheimer’s disease,” concludes neuroscientist Trevor W. Robbins and colleagues at the University of Cambridge (*Science*, 22 December 2000, pp. 2275-2276).

The link between real and imagined objects may be close. We use different parts of the brain to recognize faces and objects, researchers have found, but draw on the same areas when recalling a real image of a face or object and imagining similar images.

The unconscious mind can process images flashed so quickly that people aren’t aware of them—but whether that means popcorn sellers can up sales by inserting hidden messages into movies remains to be seen.

⁵ *Brain Policy*, page 3

concept to argue that social programs aimed at altering behavior are bound to fail, because they cannot alter behaviors that are deeply seated in the human brain.

Speculating About The Future

Below, researchers and others involved in cognitive neuroscience look ahead and speculate on how future findings may influence near- and long-term policy debates in four broad areas: setting priorities for scientific research, the practice of medicine, education & training, and criminal justice. There are also musings about how new discoveries about the brain may influence everything from international diplomacy to religion.

I. RESEARCH PRIORITIES

The Next 5 Years

Who Receives The Money?

Policy makers are already deeply engaged with the most pressing policy question raised by advances in cognitive neuroscience: which areas within this vast discipline should be encouraged by taxpayer support of research?

The U.S. government currently spends about \$25 billion a year on basic biomedical research, primarily through the National Institutes of Health, with an estimated \$1 billion a year going to brain research and associated technological developments. The Department of Defense, highway safety agencies, and the National Science Foundation also fund research related to the brain and behavior, whether to improve the performance of soldiers, improve highway safety, or reveal basic neurological mechanisms that might lead to more capable computers. Competition for these funds is fierce. Just one-third of the researchers who apply to NIH for brain-related research grants, for instance, will win funds in a typical year.

A variety of forces shape the research agenda, from patient groups seeking cures for particular diseases and health insurers seeking to reduce the costs of certain treatments, to researchers seeking to accelerate promising lines of research or purchase new imaging machines. Friction is inevitable. Biologists focused on the genetic underpinnings of brain development, for instance, say their field deserves more funding, while those engaged in other areas question whether gene studies will lead to useful results any time soon.

The competition, however, has only helped drive up the total funding available for brain research in the flush budget climate of recent years, as Congress saw merit in biomedical research in general.⁶ In tight fiscal times, however, the infighting could lead to a research agenda set by the most politically potent—but not necessarily the most scientifically savvy—groups. To defend against that outcome, researchers argue that the best way to hand out most funds is through a merit-review system in which researchers grade the ideas of their peers, rewarding those with the most promising proposals. Critics

⁶ The budget of the National Institute of Neurological Diseases and Stroke, for instance, nearly doubled between 1992 and 2001 to reach its current level of \$1.1 billion.

of peer review, however, say it often fails to recognize high-risk, high-reward research, and that researchers can lose sight of larger social needs in pursuing their work. This long-running debate is likely to intensify as more sectors of society become interested in the potential fruits of brain research.

The Next 10 Years

Research Too Hot To Handle?

As brain researchers forge into politically sensitive areas, such as the biological basis of homosexuality, criminality, bias, or religion, political and religious ideology may exert more pressure on funding priorities. Policy makers could, for instance, impose strict limits on taxpayer-funded studies in some fields, similar to the constraints currently placed on government-funded cell biologists working with stem cells derived from human embryos.

“The further we get from basic biological functions and the closer to questions involving how the brain influences social, economic, and religious interactions, the more sensitive funding decisions will become,” predicts one researcher.

The Next 25 Years

Who Gets To See Your Brain?

As brain research grows, policy makers may be drawn into debates within the science community over data sharing, access, and the privacy of their research subjects. A recent proposal required researchers to deposit all brain images into a central database in order to improve the replication of studies and support broader surveys. This drew strong protests from researchers concerned that competitors would “borrow” their data, or that outsiders would be able to discover the identities of those involved in studies.⁷

Others have raised issues of “cognitive privacy.” Some researchers, for instance, have shown that trained imaging technicians can already—in some cases—look at an image and identify what kind of task a person was involved in when the image was made.⁸ Eventually, researchers may be able to tell at a glance if a person suffers from certain brain disorders. Privacy experts worry that insurance companies, employers, or others could misuse such information.

⁷ Marshall, Eliot. “A Ruckus Over Releasing Images of the Human Brain.” *Science*, 1 September 2000, pp. 1458-1459.

⁸ See “Brain Imaging Technology Can Reveal What A Person Is Thinking About,” covering the work of Kathleen O’Craven of Toronto’s Rotman Research Institute. At www.sciencedaily.com/releases/2000/11/001110073236.htm.

II. Medicine

The Next 5 Years

Meeting Rising Expectations

One of the driving forces behind the growth in brain research over the last few decades has been the hope of treating or preventing the more than 650 brain disorders identified by scientists. These disorders strike an estimated 50 million Americans each year and cost the U.S. economy at least \$500 million annually.⁹ They range from stroke and injury to psychological disorders and Alzheimer's.

Despite remarkable progress in understanding a number of these disorders, however, brain researchers remain far from providing physicians with practical new treatments for the vast majority of brain diseases and injuries. Brain research is going through a difficult transition from being a basic science largely confined to the laboratory to an applied science making its way into hospitals and doctors' offices. Like genetic science, brain science is currently better at diagnosing and describing a problem than treating it.

But the gap between basic research findings and the development of "cures" is often overlooked in popular discussions of brain research—and in the exhortations of researchers, patient advocacy groups, and lawmakers seeking more funding for a particular line of study. Overstating the promise of new research into brain diseases not only unrealistically raises the expectations of funders, patients, and their families, but also could cause a backlash among frustrated policy makers responsible for funding decisions, some researchers warn.

"To read the popular press, you'd think that broken brains are going to be fixed tomorrow, but that's just not true," says Michael Gazzanaga, a prominent cognitive neuroscience researcher at Dartmouth College in Hanover, New Hampshire. "We're so far from that it hurts." If policy makers and the public do not have an accurate view of the strengths and weaknesses of new research results, they will inevitably suffer "policy disillusionment," he predicts, as oversold findings fail to deliver results.

The Next 10 Years

Who Receives New treatments, And Who Pays For Them?

When and if brain research findings do mature into widespread practical treatments, they will inevitably become part of the long-running debate over the access to and cost of medical care, analysts predict. Already, some researchers note, the use of relatively expensive imaging equipment to diagnose brain disorders has risen dramatically, at a cost up to tens of thousands of dollars per patient for some kinds of imaging. But that development is just the tip of the iceberg. Far more dramatic interventions—from the implants of electrodes and fresh brain tissue to the widespread brain screening of children—are already being tested and discussed.

⁹ Blank, page 2.

The Next 25 Years**When Are We Dead?**

After a lengthy and contentious debate sparked by the development of machines that could keep people “alive” in the absence of brain function, three decades ago the United States began to adopt a legal definition of death that was linked to the concept of the “whole brain death.” Under this concept, a person could be considered dead if they were unresponsive, lacked reflexes, could not breathe on their own, and showed no measurable electrical activity in the cerebral cortex; in essence, their entire brain had died, even though machines could still keep their heart and lungs working. Prior to the development of the brain death concept, death was defined as the cessation of breathing and blood flow.¹⁰

Some studies, however, suggest that the whole brain has not necessarily ceased functioning in those declared “brain dead.” Given the brain’s complexity, pockets of tissue can remain active even after a person has become unresponsive or has lost higher brain functioning. Under the current definition, then, these people may not be dead. In contrast, even people who do meet the brain death definition have been kept alive, by the thousands, when families are unwilling to withdraw life support machines.

Such problems could lead policy makers to consider another definition of death, known as “partial” or “higher” brain death. This definition would rely on our growing understanding of the brain to identify those areas that are essential to defining us as human; when they cease to function, a person would cease to be alive. Under the higher brain death definition, however, many people considered to be alive today could be considered dead, including those in extended comas, people with advanced Alzheimer’s disease, and babies born with incomplete brains.

“Increased understanding of the brain may prompt us to revisit a number of issues we thought had been settled, such as the definition of brain death,” says Blank. Such discussions could raise a number of thorny questions, he notes. Could insurers, for instance, refuse to pay the life support costs of a person who they say has lost higher brain function, but is being kept biologically alive on a machine? Could a lawyer refuse to execute the will of a person who has been declared brain dead, but is still on life support?

III. EDUCATION & TRAINING**The Next 5 Years****Can Brain Research Help Today’s Teachers?**

In recent years, some educators have embraced “brain-based learning,” looking to new findings in cognitive neuroscience to inform and guide their work in the classroom.¹¹ Some are fascinated by work on “critical periods,” the idea that there are key learning

¹⁰ Blank, *Brain Politics*, page 36

¹¹ See Cromley, Jennifer. “What About The Brain?” in *Learning to Think, Learning to Learn: What the Science of Thinking and Education Learning Has to Offer Adult Education*. NIFL Literacy Leader Fellowship Program Reports, Volume IV, No. 1. Washington, D.C.: NIFL, 2000. Pages 203-207.

periods during a child's development, with some researchers arguing that learning during ages 1 to 3 is critical to future success.¹² Others seek to apply ideas about the varying functions of the left and right parts of the brain, which some see as separate sources of creative and analytical skills. A few educators want to know what researchers can teach them about learning disabilities, such as reading and writing problems.

Many psychologists and neuroscientists, however, are skeptical that such approaches are currently practical.¹³ Linking basic neuroscience discoveries to specific teaching practices is "a bridge too far," believes John Bruer of the James S. McDonnell Foundation in St. Louis, Missouri, a major brain research funder. So far, "there is no direct connection between biology of the brain and how we teach," concludes Jennifer Cromley, a researcher with the National Institute for Literacy Leadership in Washington, D.C.

The Next 10 Years

Who Will Decide What Works?

Despite skepticism, some researchers say basic brain research will soon have a significant impact in at least one area: identifying and teaching children with learning disabilities. "Integrative neuroscience is definitely entering the special education equation," says Olds of the Krasnow Institute, one of many centers involved in such research. Particularly promising, researchers in field say, is research revealing key differences in the brain activation patterns of children who have trouble learning to recognize words or letters.¹⁴

Some of the researchers involved in these studies have gone one step further, helping to found companies to develop and market specific teaching aides that they claim produce measurable improvements in learning. In the most notable case, researchers have helped develop a computer-aided learning program called FastForward, sold by Scientific Learning of California, that has been purchased by school systems across the country.

Critics, however, say that FastForward's marketing overstates its effectiveness, and that it has not been adequately tested in controlled studies. As a result of the controversy, the National Institutes of Health is sponsoring one of the first studies of its kind, which will compare FastForward's effectiveness to that of other approaches.

Researchers predict that the controversy is likely to be just the first of many similar episodes, as school boards and teachers face the question of whether to buy—and how to evaluate—educational aides that make scientific claims of effectiveness.

The Next 25 Years

Who Gets To Think Faster?

In the past few years, researchers have begun homing in on chemicals and electrical stimulation techniques that—in the laboratory at least—appear to speed up brain

¹² Barinaga, Marcia. A Critical Issue for the Brain. *Science*, June 23, 2000, p. 2116.

¹³ See, for instance, "Brain Research Oversold, Experts Say," *Washington Post*, March 13, 2001.

¹⁴ For instance, the work of Elise Temple at Stanford University, showing that "children as young as 8 fail to activate critical [brain] areas used for understanding the sounds of letters of the alphabet. See Trei, Lisa. "Differences in children's brain activity offer clues to causes of dyslexia." *Stanford Report*, February 14, 2001.

function. Researchers led by Jordan Grafman of the National Institute of Neurological Disorders and Stroke, for instance, have shown that a brain stimulation technique known as repetitive transcranial magnetic stimulation (rTMS)—which uses a magnetic field to create electric currents in the outer layer of the brain—can temporarily speed up physical reaction times, the ability to name a picture, or the time it takes to solve a puzzle.¹⁵ Other researchers have found that certain chemicals can enhance a subject’s ability to memorize shapes, at least for a short time.¹⁶

Such studies raise the possibility that researchers might eventually create “cogniceuticals” or devices that can enhance brain function. While researchers might originally develop such approaches to treat brain disorders, companies might also find a ready market for those looking for a cognitive edge at work or in the classroom. This is what happened as human growth hormone, originally employed to treat dwarfism, is now abused by parents hoping to produce football stars and models. And policy makers could soon face demands to make such aids available to everyone, not just those who can afford them.

God & The Brain?

Although not a distinct policy issue, perhaps the most provocative challenge posed by new brain research will be the profound questions it raises about the nature of spirituality. A few years ago, for instance, researchers, political commentators, and religious leaders packed a symposium on “Neuroscience and the Human Spirit” organized by a Washington think-tank, the Ethics and Public Policy Center (see world.std.com/~twc/neurosci.htm). More recently, scientists have published papers exploring the neuroscience of mystical experiences, and published books with titles like *Why God Won’t Go Away: Brain Science and the Biology of Belief* (Ballantine, 2001). In that tome, Andrew Norberg and his coauthors suggest that religious practice, such as prayer and chanting, essentially disable a part of the brain that allows people to create a sharp distinction between self and nonself, inducing a feeling of being “at one with the world” or “in the presence of God.”

IV. THE JUSTICE SYSTEM

The Next 5 Years

Faulty Memories?

Detectives, criminal lawyers, and mystery writers have long known that eyewitness testimony is, at best, unreliable. And psychologists have long shown that not only do different people often have different memories of the same event, but that those

¹⁵ See Helmuth, Laura. “Boosting Brain Activity From the Outside In.” *Science*, 18 May 2001, pp. 1284-1286. See also Lisanby, SH et al. “Transcranial magnetic stimulation: Applications in basic neuroscience.” *International Journal of Neuropsychopharmacology*, Volume 3 No. 3, 2000, pp 259-273.

¹⁶ Robbins, Trevor W. “Boosting Working Memory,” *Science*, 22 December 2000, pp. 2275-2276.

memories can be molded, warped, or wiped away by subsequent events.¹⁷ Other studies have shown that some people who claim to have “recovered” memories of childhood abuse appear to have constructed these memories from a combination of real and imagined events, often under the influence of an authority figure such as a therapist. In a similar vein, researchers have been able to convince study subjects that they have certain memories of childhood events, even though the events never occurred.¹⁸

The assault on the reliability of eyewitness testimony, however, could reach new heights as brain research continues to unravel the mystery of how we store and reconstruct memories. “There is no question that some clever attorneys are going to seize on research findings in an effort to discredit or bolster eyewitness testimony,” says *Brain Politics* author Robert Blank. Eventually, brain imaging might even suggest whether a memory is real or faulty, as researchers learn which parts of the brain are involved in memory and which parts foster imagination. Although that day is probably long off, judges already face the question of how and when to allow the findings of brain research into the courtroom. Should defendants undergoing court-ordered psychiatric exams, for instance, also have their brains imaged to look for possible disorders?

The Next 10 Years

Are You Responsible?

Brain research is casting new light on the biological characteristics of addiction, bias, and violence, and in some cases raising challenges to the notion that we are always in control of our behavior. In the long-term, such findings could undermine current conceptions of legal responsibility, just as past advances in the understanding of mental illnesses have created exemptions from punishment for those convicted of committing a crime while insane or suffering from “diminished capacity.”

“The ‘devil made me do it’ defense of the past has now become ‘my genes made me do it,’ ‘my junk-food diet made me do it,’ or ‘my neurons made me do it,’” notes Blank in *Brain Politics*. Two areas where brain research finding may be “on a collision course with national policy initiatives” he notes, are the prosecution of drug users and those who commit “hate crimes.”

As addiction is better understood, he notes, current treatments may be abandoned, and sentencing regimes revisited to examine the proper balance between punishment and treatment. For hate crimes, policy makers may need to revisit underlying concepts. “The assumption is that the perpetrators of such acts are conscious of the reasons they hate and are capable of controlling their hatred and fears,” says Blank. But some studies suggest

¹⁷ In some of the most troubling studies, psychologists have shown that a person’s ability to pick a supposed miscreant out of a police lineup can be heavily influenced by how the lineup is constructed, whether or not they were shown pictures of the number one suspect beforehand, and comments made during the selection process. Other studies have shown that observers can completely miss major events—such as a man dressed in a gorilla suit walking through the middle of a ball-throwing game—if the observer is focused on something else, such as the ball.

¹⁸ The best-known research into repressed memories has been conducted by Elizabeth Loftus of the University of Washington, who helped defend a number of people from accusations, based on repressed memories, that they had been involved in torture, sexual abuse, and Satanic cults.

that people are often unconscious of biases based on skin color or ethnicity,¹⁹ while others show that the portion of the brain responsible for controlling emotions can be bypassed in highly-charged situations.

Such findings suggest that bias or hatred may somehow become deeply ingrained in the brain from a very early age, perhaps explaining the long-lasting conflicts between different social and ethnic groups in various parts of the world. Although such knowledge may not “excuse hatred or fear,” Blank notes, “it does clarify that we are not dealing with free will or rational, conscious action.” How judges and juries might respond to such arguments, however, is uncertain.

The Next 25 Years

Who Is Lying?

From ancient tortures designed to reveal witches to modern polygraph tests that attempt to uncover physiological clues to deception, people have long sought a surefire way to tell who’s lying, and who’s not. Most of these efforts, however, have fallen short. The results of polygraph tests, for instance, are not considered reliable enough to be admitted into court, although investigators say they can play a valuable role in smoking out potential wrongdoers.

Could new brain imaging technologies move a step beyond the polygraph, catching telltale signs of deception invisible to other techniques? Researchers are not sure, but a few are beginning to look into the matter—sometimes with funding from military and intelligence agencies that have a life-or-death interest in accurate information.

The development of robust lie-detecting technology would have vast implications—in and out of the courtroom. Could judges, for instance, require both defendants and witnesses to be hooked up, against their will? Could employers use the techniques in hiring? Could diplomats and business negotiators be able to look across the table and know at a glance who they can trust, and who they can’t? Would politicians feel forced to undergo testing as part of their campaigns or the political appointment process?

Open Questions

These are by no means all of the questions raised by advances in cognitive neuroscience—just a few of the more provocative or compelling. But they suggest how efforts to cross what one researcher has called “the ultimate interior human frontier” may influence how we view ourselves and the world. Cognitive neuroscience is, in effect, a sophisticated form of self-scrutiny and introspection, an effort to both strip humanness down to its bare biological essentials and, at the same time, to see it holistically, as the

¹⁹ In one controversial study, for instance, the brain area associated with fear “lit up” more often when one group of white students was shown unfamiliar African-American faces than when they were shown faces of unfamiliar whites. The research was conducted by Elizabeth Loftus and colleagues at New York University and elsewhere. “We may not be consciously aware of our biased behavioral responses,” Phelps notes. For an introduction to her research, see “Understanding the Cognitive and Neural Mechanisms Underlying Social Evaluation,” www.jsmf.org/pages/programs/bomb/essays/Phelps.html. See also, Phelps, E. A. et al. “Performance on Indirect Measures of Race Evaluation Predicts Amygdala Activation” in *Journal of Cognitive Neuroscience*, Volume 12 No. 5, 2000, pp. 729-738; and “Student helps explore neural basis of racial evaluation,” MIT Tech Talk, 9/20/2000 (web.mit.edu).

product of an enormously complex set of biological and social mechanisms. Whether such self-awareness will ultimately serve society—or help fracture it—will depend on the wisdom, farsightedness, and political savvy of our leaders.

Recommended Reading

Anderson, John R. *Cognitive Psychology and its Implications*. 5th Edition. New York: Worth Publishers, 2000. Good introductory textbook.

Gazzaniga, Michael S. et al. *Cognitive Neuroscience: The Biology of the Mind*. New York: WW Norton, 1999. Introductory textbook by a founder of the field.

Blank, Robert H. *Brain Policy: How the New Neuroscience Will Change Our Lives and Our Politics*. Washington: Georgetown University Press, 1999. One of the few authors to extensively address the policy issues associated with neuroscience.

Shermer, Michael. “Is God All In The Mind?” A review of *Why God Won’t Go Away* by Andrew Newberg et al. *Science*, 6 July 2001, p. 54. A short introduction of a fascinating topic.

Albright, Thomas D. et al. Cognitive Neuroscience. *Current Opinions in Neurobiology*, Volume 10, 2000, pp. 612-624. A detailed overview of the field from some senior scientists.

Further Reading

In addition to those books, articles and web pages referenced in footnotes, the following resources may be useful for understanding current advances and issues in neuroscience.

Schacter, Daniel. *Memory, Brain, and Belief*. Cambridge, MA: Harvard University Press, 2000.

Gazzaniga, Michael S. *Cognitive Neuroscience: A Reader*. London: Blackwell, 2000.

Lane, Richard D. *Cognitive Neuroscience of Emotion*. New York: Oxford University Press, 2000.

Solso, Robert L. *Mind and Brain Sciences in the 21st Century*. Cambridge, MA: MIT Press, 1999.

Kosslyn, Stephen. *Frontiers in Cognitive Neuroscience*. Cambridge, MA: MIT Press, 1995.

Phelps, Elizabeth A. et al. "Performance on Indirect Measures of Race Evaluation Predicts Amygdala Activation." *Journal of Cognitive Neurosciences*, Volume 12 No. 5, 2000, pp. 729-738.

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Munro, Neil. "Brain Politics." At www.pbs.org/wgbh/pages/frontline/shows/medicating/readings/brainpolitics.html

Helmuth, Laura. "Boosting Brain Activity From the Outside In." *Science*, 18 May 2001, pp. 1284-1286.

Kandel, Eric et al. "Neuroscience: Breaking Down Scientific Barriers to the Study of Brain and Mind." *Science*, 10 November 2000, pp. 1113-1120.

Rugg, Michael. "Memories are Made of This." *Science*, 21 August 1998, pp. 1151-1152.

De Gelder, Beatrice. "More to seeing than meets the eye." *Science*, 18 August 2000, pp. 1148-1149.

Posner, M.I. et al. "Cognitive neuroscience: Origins and promise." *Psychological Bulletin*, Vol. 126 No. 6, 2000, pp. 873-889.

Lisanby, SH et al. "Transcranial magnetic stimulation: Applications in basic neuroscience." *International Journal of Neuropsychopharmacology*, Volume 3 No. 3, 2000, pp 259-273.

Raichle, Marcus. "Bold Insights." *Nature*, 12 July 2001, pp. 128-129.

Robertson, Lynn C. "Color my I's blue." *Nature*, 29 March 2001, pp. 533-534.

Appendix I.

Methods

To survey the neuroscience community about the policy implications of their work, we:

- 1) Posted notices requesting opinions, recommended reading, and leads to knowledgeable sources on electronic bulletin boards read by neuroscience professionals, including CogNet and listservs maintained by professional societies.
- 2) Conducted phone or email interviews with about a dozen neuroscientists or non-scientists with a strong interest in and understanding of current neuroscience.
- 3) Completed a literature review of current scientific literature, textbooks, and popular literature.

In posing our questions, we asked respondents to anticipate policy developments that might occur within the next 5 years, within the next 10 years, and within the next 25 years. We also encouraged them to be provocative in the hope of stimulating a broad discussion.

About the Author

David Malakoff covers discoveries and the politics of science for Science magazine in Washington, D.C. He has written for a wide range of newspapers, magazines, and private clients on public policy, science, and environmental issues. He is a 1986 graduate of the College of the Atlantic in Bar Harbor, Maine.