PROFILES IN SCIENCE | MICHAEL S. GAZZANIGA

Decoding the Brain's Cacophony

Jim Wilson/The New York Times

Michael Gazzaniga: An interview with the neuroscientist and professor of psychology known for his studies, and stories, about the brain's split personality.

By BENEDICT CAREY
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ST. HELENA, Calif. — The scientists exchanged one last look and held their breath.

Everything was ready. The electrode was in place, threaded between the two hemispheres of a living cat's brain; the instruments were tuned to pick up the chatter passing from one half to the other. The only thing left was to listen for that electronic whisper, the brain's own internal code.

The amplifier hissed — the three scientists expectantly leaning closer — and out it came, loud and clear.

"We all live in a yellow submarine, yellow submarine, yellow submarine ...."

"The Beatles' song! We somehow picked up the frequency of a radio station," recalled Michael S. Gazzaniga, chuckling at the 45-year-old memory. "The brain's secret code. Yeah, right!"

Dr. Gazzaniga, 71, now a professor of psychology at the

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Profiles in Science

Michael S. Gazzaniga

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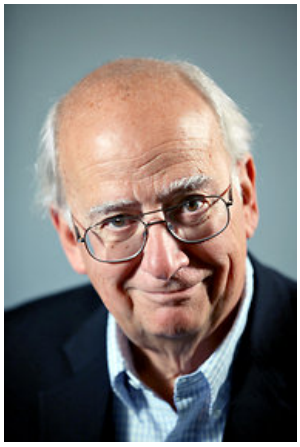

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Michael S. Gazzaniga is a psychology professor at the University of California, Santa Barbara.

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Michael Gazzaniga, in striped shirt, with his family in 1945.

Enlarge This Image

Dr. Gazzaniga as a student at Caltech in 1963.

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University of California, Santa Barbara, is best known for a dazzling series of studies that revealed the brain's split personality, the division of labor between its left and right hemispheres. But he is perhaps next best known for telling stories, many of them about blown experiments, dumb questions and other blunders during his nearly half-century career at the top of his field.

Now, in lectures and a new book, he is spelling out another kind of cautionary tale — a serious one, about the uses of neuroscience in society, particularly in the courtroom.

Brain science "will eventually begin to influence how the public views justice and responsibility," Dr. Gazzaniga said at a recent conference here sponsored by the Edge Foundation.

And there is no guarantee, he added, that its influence will be a good one.

For one thing, brain-scanning technology is not ready for prime time in the legal system; it provides less information than people presume.

For another, new knowledge about neural processes is raising important questions about human responsibility. Scientists now know that the brain runs largely on autopilot; it acts first and asks questions later, often explaining behavior after the fact. So if much of behavior is automatic, then how responsible are people for their actions?

Who's driving this submarine, anyway?

In his new book, "Who's in Charge? Free Will and the Science of the Brain," being published this month by Ecco/HarperCollins, Dr. Gazzaniga (pronounced ga-ZAHN-a-ga) argues that the answer is hidden in plain sight. It's a matter of knowing where to look.

The Split Brain

He began thinking seriously about the nature of responsibility only after many years of goofing off.

Mike Gazzaniga grew up in Glendale, Calif., exploring the open country east of Los Angeles and running occasional experiments in his garage, often with the help of his father, a prominent surgeon. It was fun; the experiments were real attempts to understand biochemistry; and even after joining the Alpha Delta Phi fraternity at Dartmouth (inspiration for the movie "Animal House"), he made time between parties and pranks to track who was doing what in his chosen field, brain science.

In particular, he began to follow studies at the California Institute of Technology suggesting that in animals, developing nerve cells are coded to congregate in specific areas in the brain. This work was captivating for two reasons.

First, it seemed to contradict common wisdom at the time,

LEFT BRAIN, RIGHT BRAIN Dr. Gazzaniga with his colleagues John Sidtis and Jeffrey Holtzman, in lab coats, in the van they used at Dartmouth for studying the brain's hemispheric division of labor.

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which held that specific brain functions like memory were widely — and uniformly — distributed in the brain, not concentrated in discrete regions.

Second, his girlfriend was due to take a summer job right there near Caltech.

He decided to write a letter to the director of the program, the eminent neurobiologist Roger Wolcott Sperry (emphasizing reason No. 1). Could Dr. Sperry use a summer intern? "He said sure," Dr. Gazzaniga said. "I always tell students, 'Go ahead and write directly to the person you want to study with; you just never know.' "

At Caltech that summer after his junior year, he glimpsed his future. He learned about so-called split-brain patients, people with severe epilepsy who had surgery cutting the connections between their left and right hemispheres. The surgery drastically reduced seizures but seemed to leave people otherwise unaffected.

Back at Dartmouth, he couldn't stop thinking about it: Totally unaffected? Combing the literature, he found that the best attempt to detect an effect had found no changes in thinking or perception among 26 patients who had had the surgery at the University of Rochester.

Could that be possible? Mr. Gazzaniga was so eager to test the patients' perceptions himself that he wrote another letter, this time to the surgeon — and got permission to do so.

"It's spring break, I get all my gear together, I get all the way over there, and the guy changes his mind," Dr. Gazzaniga said. "Like, 'Hey, buddy, go home!' "

After graduating, he headed straight for Caltech.

"It wasn't just ambition, it was something else — he was gutsy," said Mitch Glickstein, who was in Dr. Sperry's lab at the time and is completing a book, "Neuroscience: A Historical Introduction." "Here's this junior in college, he knows all about the split-brain patients, and he's ready to do original research. At 20 years old."

Caltech in those days was like a frat house for Nobel Prize contenders. Here's Richard Feynman, the physicist, parking himself in the lab unannounced and making wisecracks about the experiments. There's Dr. Sperry, annoyed, wondering how to one-up Dr. Feynman. One afternoon Dr. Sperry's young student scrambled out into the hallway on all fours after an escaped lab animal and nearly kneecapped Linus Pauling, the eminent chemist. ("Why don't you try anesthetizing a bowl of jelly instead?" Dr. Pauling remarked icily.)

And then there were the experiments, each one a snapshot into the dark box of the brain. In the early 1960s, Dr. Gazzaniga, then a graduate student, teamed with Dr. Sperry and Dr. Joseph Bogen, a brain surgeon, to publish a string of reports that dramatically demonstrated hemispheric specialization in humans.

The researchers devised a way to flash a picture of a bicycle to the right hemisphere alone. When split-brain patients were asked what they saw, they replied, "Nothing": Because of the severed connection, the left hemisphere, where language is centered, got no visual input and no information from the right hemisphere. So the right hemisphere — which "saw" the bike — had no language to name it.

But here was the kicker: The right hemisphere could direct the hand it controls to draw the

bicycle.

In other studies, the three scientists showed that the right hemisphere could also identify objects by touch, correctly selecting, say, a toothbrush or a spoon by feel after seeing the image of one.

The implications were soon clear. The left hemisphere was the intellectual, the wordsmith; it could be severed from the right without loss of I.Q. The right side was the artist, the visual-spatial expert.

The findings demolished the theory that specific functions were widely and uniformly supported in the brain. It also put "left brain/right brain" into the common language, as shorthand for types of skills and types of people. Still, in a field defined by incremental, often arcane advances, the Caltech team had achieved a moon shot.

Dr. Gazzaniga, now all of 25, could write his own ticket. He soon had a grant for a study to record the electronic chatter between the two hemispheres in the brain of a cat.

The Interpreter

The Beatles song that surged through the receiver in that experiment provided Dr. Gazzaniga with something almost as valuable as insight: a good story. Yet it also served as a rude reminder that he and his colleagues were missing something important in their assumptions about the brain.

"The question, ultimately, was why?" Dr. Gazzaniga said. "Why, if we have these separate systems, is it that the brain has a sense of unity?"

Even as he built his early triumph into a career, moving from Caltech to U.C. Santa Barbara and eventually to Dartmouth, with several stops along the way, the same question hung in the air, without a satisfactory answer. In the late 1970s, with the psychologist and linguist George A. Miller, he founded the field of cognitive neuroscience, a marriage of psychology and biology aimed at solving just such puzzles.

It didn't happen, at least not quickly. In the decades to follow, brain scientists found that the left brain-right brain split is only the most obvious division of labor; in fact, the brain contains a swarm of specialized modules, each performing a special skill — calculating a distance, parsing a voice tone — and all of them running at the same time, communicating in widely distributed networks, often across hemispheres.

In short, the brain sustains a sense of unity not just in the presence of its left and right co-pilots. It does so amid a cacophony of competing voices, the neural equivalent of open outcry at the Chicago Board of Trade.

How?

It turned out, yet again, that people who'd had the split-brain surgery helped provide an answer. Dr. Gazzaniga, now at Dartmouth, performed more of his signature experiments — this time with an added twist. In one study, for instance, he and Joseph LeDoux, then a graduate student, showed a patient two pictures: The man's left hemisphere saw a chicken claw; his right saw a snow scene. Afterward, the man chose the most appropriate matches from an array of pictures visible to both hemispheres. He chose a chicken to go with the claw, and a shovel to go with the snow. So far, so good.

But then Dr. Gazzaniga asked him why he chose those items — and struck gold. The man had a ready answer for one choice: The chicken goes with the claw. His left hemisphere had seen the claw, after all. Yet it had not seen the picture of the snow, only the shovel. Looking down at the picture of the shovel, the man said, "And you need a shovel to clean out the chicken shed."

The left hemisphere was just concocting an explanation, Dr. Gazzaniga said. In studies in the 1980s and '90s, he and others showed that the pattern was consistent: The left

hemisphere takes what information it has and delivers a coherent tale to conscious awareness. It happens continually in daily life, and most everyone has caught himself or herself in the act — overhearing a fragment of gossip, for instance, and filling in the blanks with assumptions.

The brain's cacophony of competing voices feels coherent because some module or network somewhere in the left hemisphere is providing a running narration. "It only took me 25 years to ask the right question to figure it out," Dr. Gazzaniga said.

"One of the toughest things in any science, but especially in neuroscience, is to weed out the ideas that are really pleasing but unencumbered by truth," said Thomas Carew, former president of the Society for Neuroscience and dean of the New York University School of Arts and Sciences. "Mike Gazzaniga is one of those in the field who's been able to do that."

Dr. Gazzaniga decided to call the left-brain narrating system "the interpreter." The storyteller found the storyteller.

Emergent Properties

Knowing the breed well, he also understood its power. The interpreter creates the illusion of a meaningful script, as well as a coherent self. Working on the fly, it furiously reconstructs not only what happened but why, inserting motives here, intentions there — based on limited, sometimes flawed information.

One implication of this is a familiar staple of psychotherapy and literature: We are not who we think we are. We narrate our lives, shading every last detail, and even changing the script retrospectively, depending on the event, most of the time subconsciously. The storyteller never stops, except perhaps during deep sleep.

But another implication has to do with responsibility. If our sense of control is built on an unreliable account from automatic brain processes, how much control do we really have? Are there thresholds of responsibility, for instance, that can be determined by studying neural circuits? Dr. Gazzaniga and his wife, Charlotte, raised six children, so like any parents they had to determine levels of responsibility on the fly, just to get someone to set the table.

Yet questions like these became increasingly difficult to ignore for Dr. Gazzaniga, as he took on a more prominent role advising policy makers on the applications of brain science. He was appointed to a Congressional technology panel in 1991; in 2002, he took a position on the President's Council on Bioethics. And in 2007, he became the founding director of the John D. and Catherine T. MacArthur Foundation's Research Network on Law and Neuroscience, which tracks and evaluates applications in the legal system.

There, in particular, brain science has had a growing impact. In recent years lawyers have begun to present brain images as evidence, usually to mitigate responsibility for a crime or to test veracity of testimony, as in a polygraph; increasingly, those images have been admitted. And more are coming: In imaging studies, for instance, neuroscientists have identified cortical areas that are highly active when people suppress impulses or other behaviors.

But there are clear shortcomings in the application of each of these methods in courtrooms. Brain images are snapshots, for one thing; they capture a brain state at only one moment in time and say nothing about its function before or after. For another, the images vary widely among people with healthy brains — that is, a "high" level of activity in one person may be normal in another. Can brain science tell exactly where automatic processes end and self-directed "responsible" ones end?

Not now and not likely ever, Dr. Gazzaniga argues in his book. Social constructs like good judgment and free will are even further removed, and trying to define them in terms of biological processes is, in the end, a fool's game.

"My contention is that, ultimately, responsibility is a contract between two people rather

than a property of the brain, and determinism has no meaning in this context," he writes in "Who's in Charge?"

Like generosity and pettiness, like love and suspiciousness, responsibility is what he calls a "strongly emergent" property — a property that, though derived from biological mechanisms, is fundamentally distinct and obeys different laws, as do ice and water.

Dr. Gazzaniga is not the first scientist making this case. It is far from a settled matter, in part because researchers do not yet have a complete picture of how automatic and deliberate systems interact biologically.

"I see Gazzaniga's point, and it would indeed be easiest if we could ignore conclusions derived from brain science and psychology when it comes to legal issues," said Ap Dijksterhuis, a psychologist at Radboud University Nijmegen, in the Netherlands, in an e-mail. "However, I do not think we can do this forever, and at some point, some key legal concepts such as accountability or responsibility will have to be redefined."

Until then, Dr. Gazzaniga's advice is to look for them where they've always been: in the hearts and moral intuitions of human beings, in their laws and customs.

And, it should be said, in their stories.

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