Whole-Brain Interpreter

A cognitive neuroscientist seeks to make theoretical headway among split brains

By BRUCE BOWER

As a neuropsychology graduate student at the California Institute of Technology in 1962, Michael S. Gazzaniga experienced what he calls "one of those unforgettable moments in life." A man came to his laboratory for testing after having had his corpus callosum—the bundle of nerve fibers that connects the left and right hemispheres of the brain—surgically severed in a last-ditch attempt to quell his frequent epileptic fits.

The charming, take-charge World War II veteran—known in the scientific literature as W.J.—easily named and described colors, letters, and other information flashed briefly to the right side of his visual field. Information about the right visual field is processed by the left brain hemisphere; therefore, simply put, W.J.'s left hemisphere needed no help handling basic tasks requiring verbal responses.

Then came the moment of truth for Gazzaniga and his colleagues, led by the late neuropsychologist and Nobel laureate Roger W. Sperry. The scientists flashed items in W.J.'s left visual field and waited for the responses of his right hemisphere. Sperry's studies of cats and other animals with surgically separated brains suggested that information available to one side remained off-limits to the other. Some scientists at the time doubted that such findings applied to people.

As the anxious investigators looked on, W.J. acted as though he had suddenly gone blind. He insisted that he could not see bursts of light, boldface letters, or anything else presented to him. Yet his left hand, under the control of his right hemisphere, pushed down on a telegraph key each time a visual stimulus appeared, just as the scientists had instructed him to do.

This striking result filled Gazzaniga and his coworkers with excitement. They had demonstrated that the human brain is a duplex operation. They proposed that the brain's right side lacked the left side's penchant for labeling the world with words.

W.J.'s case led to the systematic study of more patients whose brain hemispheres do not communicate, and thus it heralded a generation of scientific efforts aimed at uncovering how the brain produces memory, reasoning, emotion, and other elements of mental life.

A menagerie of scientific disciplines quickly began to rub shoulders—and sometimes fray nerves—in this common quest.

By the early 1970s, researchers had demonstrated right brain superiority at performing visual and spatial tasks, such as drawing three-dimensional shapes, and left brain specialization for language, speech, and problem solving. These findings quickly blossomed into a popular view of the brain as a biological odd couple: the stuffy, logical left side and the creative, free-spirited right side.

At the same time, W.J. and the split-brain patients who followed him launched Gazzaniga into the upper echelon of a hybrid field, now referred to as cognitive neuroscience. He has served as editor of the JOURNAL OF COGNITIVE NEUROSCIENCE since its inception in 1989 and is editor-in-chief of *The Cognitive Neurosciences* (1995, MIT Press), a 1,447-page, 92-chapter foray into current knowledge about how brains make minds.

Gazzaniga currently conducts his research at the Center for Neuroscience at the University of California, Davis, and has directed the facility since it was founded in 1990. He plans to leave Davis soon to direct a new cognitive neuroscience department at Dartmouth College in Hanover, N.H.

"Mike is highly ambitious, impatient, and has tremendous scientific stature," says Mark McNamee, dean of the division of biological sciences at UC-Davis. "We would have liked him to stay longer."

"I'm looking forward to seeing how cognitive neuroscience plays out in the next 5 to 10 years," Gazzaniga says. "There have been incredible technological advances in brain imaging, but as yet we don't have a tool for understanding the basic principles of brain and cognitive function."

To that end, he considers one of his greatest administrative challenges the nurturing of collaboration between biologically oriented brain researchers and psychologically oriented cognitive scientists.

"A lot of what passes for cognitive neuroscience right now consists of brain researchers who stumble on a finding and immediately extrapolate it to some cognitive function without considering what cognitive scientists already know about that function," he contends. "There's an arrogance among some neuroscientists that cognitive research is easy, but it's hard, it's real hard."

More than 35 years of split-brain research has made Gazzaniga sensitive to the difficulties of understanding the brain-mind connection. Complex descriptions of brain structures or processes linked to various mental feats often mask scientists' lack of guiding principles for how the 3 pounds of neural tissue inside the human skull really works, he asserts.

Split-brain studies provide a case in point.

For at least a decade after the first report on W.J., researchers emphasized that a divided brain yields two separate modes of conscious thought. "But that merely leaves us with two systems we don't understand instead of one," the Davis scientist remarks.

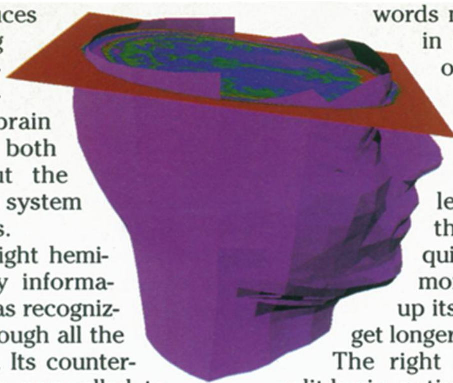
Nonetheless, W.J. and dozens of other patients with surgically separated hemispheres have provided much insight into human brain organization, in Gazzaniga's view. Sophisticated equipment for taking images of living brains currently attracts much attention, but other technological innovations have also transformed split-brain research, Gazzaniga holds.

Study participants now look into devices through which a picture of an item is projected to one eye or the other. The picture undergoes continuous, precise shifts in positioning to counteract the observer's eye movements, so it stays in the right or left half of the visual field. In this way, an image can be projected for extended periods to a single hemisphere.

Hemispheric differences have proven more complex than scientists originally suspected or than left brain–right brain popularizers portrayed them. Findings now suggest that clipping the corpus callosum—a structure that in fact connects only the halves of the brain's outer layer,

Science Service, Inc. is collaborating with JSTOR to digitize, preserve, and extend access to *Science News*.
www.jstor.org

or cortex—indeed produces two systems for handling sensations and perceptions, according to Gazzaniga. However, a brain mechanism shared by both hemispheres metes out the amount of attention each system can draw on, he theorizes.



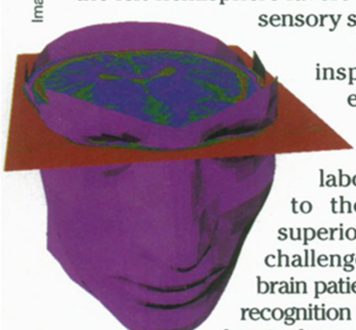
In this scenario, the right hemisphere handles sensory information in basic ways, such as recognizing faces and sorting through all the pieces of a visual scene. Its counterpart on the left appears compelled to analyze and group sensations in ways that allow for finer-grained decisions.

A study conducted by Gazzaniga and his colleagues and published in the March 1995 PSYCHOLOGICAL SCIENCE offers a peek at the contrasting approaches of the two hemispheres. Three split-brain patients and 10 people with no neurological problems attempted to identify unique elements in visual arrays presented to one side of the visual field. So-called standard search trials contained a black circle surrounded by clusters of gray circles and black squares, each about equal in number. Guided search trials presented a black circle with a few black squares and a much larger number of gray circles; this pattern enabled volunteers to home in on the black circle by concentrating only on the small group of black items.

Split-brain patients and controls were adept at using either hemisphere to conduct standard searches. On guided search trials, the control group responded more quickly than they had on standard searches, though just as accurately, regardless of which side of their brains the researchers recruited. But split-brain volunteers showed comparable improvement only when using their left hemispheres.

Results such as these indicate that the right hemisphere contains mechanisms for soaking up the raw material of sensory experience, Gazzaniga suggests, whereas the left hemisphere favors more complex sensory strategies.

Images: Cliff Kussmaul

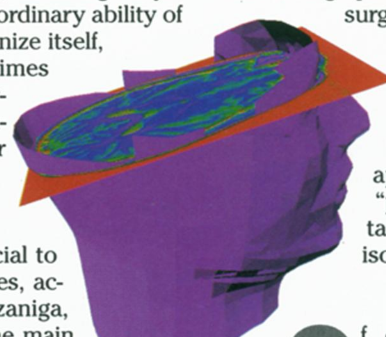


Upon closer inspection, an even subtler hemispheric division of labor contributes to the left brain's superiority at verbal challenges. Most split-brain patients show word recognition only in the left hemisphere. But a few can use either hemisphere for this task, the Davis scientist holds. Even in these cases, the right brain deals with words far less adeptly than the left brain.

For instance, each isolated hemisphere can recognize a specific letter in genuine words more easily than in nonsense words or in random letter strings. But the right hemisphere takes longer than the left to perform this task and requires considerably more time to "make up its mind" as words get longer.

The right hemispheres of split-brain patients also consistently falter on grammatical tasks, such as changing verb tenses, constructing plurals, and indicating possessives. Such findings support the notion that the left brain harbors an evolved mechanism for understanding grammatical principles common to all spoken languages, Gazzaniga asserts.

Several split-brain patients can also identify orally many items presented to their right hemispheres, Gazzaniga says. This illustrates an extraordinary ability of the split brain to reorganize itself, he maintains, sometimes resulting in the emergence of limited right-brain speech 10 years or more after surgery.



Perhaps most crucial to the human species, according to Gazzaniga, the left brain houses the main components of people's ability to interpret the behavior and emotional states of themselves and others, as well as to make inferences about how the world works.

"From an evolutionary perspective, our brains have evolved to make decisions that enhance reproductive success," he maintains. "There seems to be a left-brain mechanism that's constantly trying to find relationships between events that you encounter in the world and constantly assessing where you stand in relation to others."

Gazzaniga suspects that this left-brain system, which he dubbed the "interpreter" nearly 20 years ago, also allows conscious feelings to arise in response to largely automatic trains of thought that run through mental life.

This interpretive bent first appeared in tests of split-brain patients shown two pictures simultaneously, one to each hemisphere. Participants then perused an assortment of additional pictures and chose the item most closely related to each of the original pictures.

For instance, one man had a picture of a chicken claw flashed to his left hemisphere and a picture of a snow scene presented to his right hemisphere. From the ensuing selection of pictures, he correctly chose a shovel with his left hand (controlled by the right hemisphere) and a chicken with his right hand (controlled by the left hemisphere). When asked to explain his choices, he responded: "Oh, that's simple. The chicken claw goes with the chicken, and you need a shovel to clean out the chicken shed."

Gazzaniga concluded that the left brain observed the left hand's choice of a shovel—which stemmed from the right brain's nonverbal, inaccessible knowledge—and proffered an explanation based its own fowl information.

Further work indicates that the left-brain interpreter can influence memory, sometimes for the worse, Gazzaniga adds. In one study, investigators presented novel pictures to the left hemisphere of split-brain patients. When these new pictures shared elements or themes with a picture the patients had already studied, the patients often mistakenly identified the new ones as having been seen previously.

The interpreter may not always be correct, but it wields considerable problem-solving punch. Following callosal surgery, the left hemisphere retains all its former ability to discern causal connections in testing situations, such as knowing that "bleed" is an appropriate follow-up to "pin" and "finger." Such tasks regularly stymie the isolated right hemisphere.

Of course, the road from brain to mind remains largely unlit. When asked why evolution would endow the human brain with dual hemispheres for making crucial decisions, Gazzaniga leans back in his chair, rests his hands on his head, and smiles.

"Yeah," he says with a laugh. "That's the kind of question you like to ask of the other guy."

He expects some of the mystery to disappear if universities promote the interdisciplinary coalitions needed to put meat on the bones of cognitive neuroscience.

"I have a little pet idea," Gazzaniga remarks conspiratorially. "Molecular biology is so well worked out that it ought to get out of the university and go across the road to the [industrial] park. Big molecular biology programs are expensive and stifling, and they don't understand this business of trying to study something that's largely unknown."

The unknowns of cognitive neuroscience may emit a friendlier glow to scientists of all stripes once someone synthesizes existing findings into a more powerful theory of how "brain enables mind," Gazzaniga acknowledges.

It's difficult to predict when such a synthesis will emerge. "When it does," he remarks, "it will take us to another level." □