The Language of the Brain

Deaf stroke victims have provided surprising clues to the role of the left side of the brain in sign language

By BRUCE BOWER

For much of her life, Sarah M. was an accomplished artist, skilled in painting and the precise brush strokes required to decorate eggshells and ceramics with elaborate designs. The delicate, gentle-looking woman, now 71 years old, was born deaf and communicates with the hand symbols and motions of sign language.

Tragically, her mastery of paint and canvas was blotted out by a stroke that caused massive damage to the right side of her brain. A few discouraging attempts at painting and drawing consisted of haphazard lines and disorganized figures. The right-brain damage disturbed her left-eye perception, and the left side of her drawings was often left blank. Artistic ability, quite literally, abandoned her.

However, to the astonishment of scientists at the Salk Institute for Biological Sciences in San Diego, Sarah M. continues to use sign language flawlessly and in total disregard of the assumption by many scientists that the brain's right hemisphere controls all visual and spatial tasks. Furthermore, her comprehension of American Sign Language, in which a complex grammar is conveyed through hand and arm motions, is good.

A stark contrast is provided by 38-year-old Gail D., also deaf from birth and fluent in sign language. Much of the front part of her left brain hemisphere, including areas thought to control spoken language, was devastated by a stroke. Although no artist, she can still accurately copy simple drawings and abstract figures. But her sign language is now limited to basic nouns and verbs, with none of the shifts in movement and positioning that link signs into sentences or subtly change the meaning of individual signs.

Sarah M., Gail D. and four other deaf people with stroke-induced damage to a cerebral hemisphere have provided neuropsychologists Howard Poizner and Ursula Bellugi and linguist Edward S. Klima with intriguing insights into the organization of language in the brain. The scientists describe their work in *What The Hands Reveal About The Brain* (Bradford Books/MIT Press, 1987).

Three signers with right-hemisphere damage, including Sarah M., have few problems with sign language or written English, report the researchers, but show severe impairment on visual and spatial tasks outside the realm of language. Examples are the ability to assemble colored blocks into preset patterns and to draw and describe with signs the layout of objects in a familiar room.

The three signers with left-side damage do well on these tasks, but each displays a different pattern of sign language breakdown. Gail D. is reduced to the labored production of simple words; Paul D., who has a smaller lesion, is more adept at sign language, but his communication often becomes a "word salad," with overly complex sentences and bizarre word substitutions; and Karen L., with damage to the parietal region next to the frontal lobe, engages in animated and grammatically correct signed conversations but often fails to specify whom or what she is referring to and has difficulty understanding the signed communication of others.

In each case, problems in written English mirror sign-language deficits.

Although the sample is small and similar cases are rare, the investigators suggest that the left brain hemisphere has an "innate predisposition" for language, regardless of the capacity to hear or talk. Sign language disturbances in subjects with left-brain lesions closely match those observed in hearing individuals with damage in the same areas, they note.

Further support comes from the case of a hearing signer whose ability to identify a series of objects in both English and sign language vanished when her left hemisphere was chemically anesthetized, but had no such problems after parts of her right hemisphere were surgically removed (SN: 8/2/86, p.70).

"We're not necessarily saying that every aspect of language is regulated by the left hemisphere," says Poizner. "But grammatical aspects appear to be critically located there."

In Karen L.'s case, frontal lobe areas in the left hemisphere typically associated with language disruption in hearing people were left intact. "It looks like left-hemisphere parietal areas are recruited more for sign than for spoken language," notes Poizner.

He adds that language impairment in the deaf stroke victims, all of whom are right-handed, does not appear to be related to breakdowns in muscle coordination or general perception of gestures. The three subjects with left-brain damage were in the normal range for identifying nonlinguistic pantomimes (of, say, a man miming the use of a saw) and demonstrating nonlinguistic movements, such as waving goodbye or writing one's name.

According to psychologist John C. Marshall of The Radcliffe Infirmary in Oxford, England, the results indicate that the brain employs "modularity with a vengeance." In other words,

parts of the left hemisphere control language, no matter how it is expressed, while right-side regions are involved only in skilled nonlinguistic movements and perceptions. "Space in the service of language falls within the competence of the left hemisphere," says Marshall.

This argument fundamentally questions some long-standing views on how the brain hemispheres function. In 1865, French physician Pierre Paul Broca first proposed that the vast majority of right-handed people "speak" with their left hemispheres. A decade later, British neurologist John Hughlings Jackson produced evidence that the right hemisphere plays a leading role in many visual and spatial abilities. Beginning in the 1960s, studies of a small group of epileptic patients whose brain hemispheres were surgically disconnected provided more evidence for a language-visuospatial split.

But a psychologist involved in the latter studies, Michael S. Gazzaniga of Cornell University Medical Center in New York City, has pointed out that there were wide individual differences among "split-brain" patients. Younger patients, for example, retained abilities such as reading and drawing in both hemispheres. Specific brain systems appear to handle specific tasks, argues Gazzaniga in *The Social Brain* (Basic Books, 1985), but "all brains are not organized the same way." The long tradition of assigning rival functions to the two hemispheres, such as logic and language to the left side and art and intuition to the right side, is misguided, he says.

Nevertheless, says neuropsychologist Diana Van Lancker of the University of California at Los Angeles, there is increasing support for the notion that the right hemisphere is better at recognizing whole patterns, while the left hemisphere excels at analyzing details and separate features of a stimulus. To understand both the grammatical and nonverbal components of language, she maintains, the two sides of the brain have to work together.

"The findings suggest that although the left hemisphere knows best *what* is being said, the right hemisphere is figuring out *how* it is meant and *who* is saying it," explains Van Lancker.

In a study that will appear later this year in NEUROPSYCHOLOGIA, Van Lancker and UCLA colleague Jody Kreiman report that the recognition of familiar voices – one important "channel" of nonverbal information in speech – is rooted in the right hemisphere. They tested 32 people with damage to one or both sides of the brain and 110 healthy comparison subjects, all of them right-handed. Participants heard 4-second tape recordings of the voices of 25 famous male entertainers and politicians, including Johnny Carson, Maurice Chevalier and W.C. Fields, and were asked to match each voice to the correct photograph and name caption from among four choices.

Right-brain damage toward the back of the head (in the parietal region) markedly interfered with familiar voice recognition. Yet despite numerous speech and language problems, left-brain-damaged subjects performed as well as healthy controls.

Damage to either hemisphere, however, created substantial difficulty in telling whether pairs of unfamiliar voices were from different speakers or the same person.

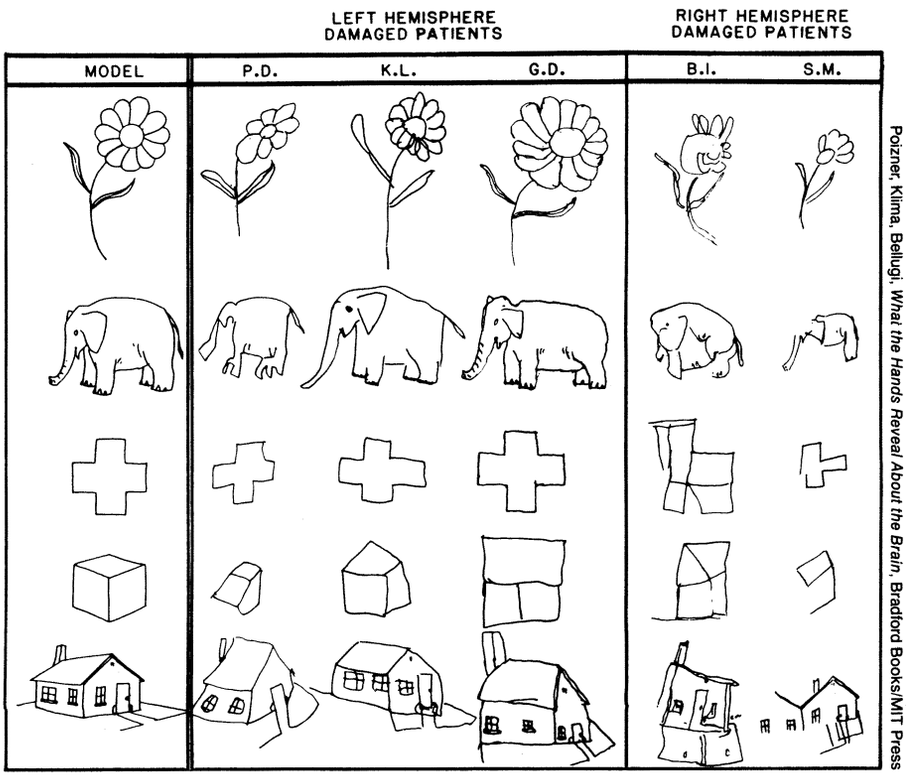
Van Lancker offers the "tentative hypothesis" that recognizing a familiar voice engages right-brain mechanisms that identify the overall voice pattern of a known speaker. This is exemplified by the split-second ability to recognize a close friend or relative over the telephone after hearing them utter the word "hello." Unfamiliar voice discrimination, she suggests, requires both overall pattern recognition and the left-sided analysis of voice features such as pitch and loudness.

Recent studies of brain-damaged patients by Van Lancker and other researchers also indicate that the right hemisphere is critical for making inferences beyond the literal meaning of words. This includes understanding idiomatic expressions and metaphors, recognizing the emotional tone in speech and appreciating the humor in jokes. There is also evidence that the right hemisphere is superior to the left in recognizing emotional facial expression.

The Salk Institute data are not out of sync with Van Lancker's hypothesis, says Poizner. The investigation homed in on a left-hemisphere specialization for the features of a visual and spatial grammar. Nonverbal aspects of signed communication that may be regulated by the right side of the brain have not yet been studied, he says.

Van Lancker cautions that studies of right-handers with brain damage do not apply to left-handers, whose hemispheric specializations are less predictable and may be distributed more evenly across the two halves of the brain. Even some right-handers with left-handed relatives fall into this category, she says.

But the voice recognition results have, in her opinion, important clinical implications. Right-brain-damaged patients may be confused by the strangeness of formerly familiar voices and phrases, says Van Lancker, and tests for this deficit should be routinely administered. Conversely, left-brain-damaged patients are not "empty upstairs" even if they have severe language problems. "They often can recognize familiar voices and phrases and understand emotional meanings underlying spoken words," says Van Lancker. "This comes as very encouraging news to their families." □



Poizner, Klima, Bellugi, *What the Hands Reveal About the Brain*, Bradford Books/MIT Press

The drawings from a model by right-lesioned signers show more distortion and failure to indicate perspective than those of left-lesioned signers. The visual and spatial skills of a third right-lesioned patient (not shown here), who had been an airplane mechanic as well as doing carpentry and building models as a hobby, were better preserved.