Neurolinguistics

The study of the relationship between language and the brain is called neurolinguistics. Although this is a relatively recent term, the field of study dates back to the nineteenth century. Establishing the location of language in the brain was an early challenge, but one event incidentally provided a clue.

In September 1848, near Cavendish, Vermont, a construction foreman called Phineas P. Gage was in charge of a construction crew blasting away rocks to lay a new stretch of railway line. As Mr. Gage pushed an iron tamping rod into the blasting hole in a rock, some gunpowder accidentally exploded and sent the three-and-a-half-foot long tamping rod up through his upper left cheek and out from the top of his forehead. The rod landed about fifty yards away. Mr. Gage suffered the type of injury from which, it was assumed, no one could recover. However, a month later, he was up and about, with no apparent damage to his senses or his speech. The medical evidence was clear. A huge metal rod had gone through the front part of Mr. Gage's brain, but his language abilities were unaffected. He was a medical marvel. The point of this rather amazing tale is that, while language may be located in the brain, it clearly is not situated right at the front. Language Areas in the Brain Since that time, a number of discoveries have been made about the specific parts in the brain that are related to language functions. We now know that the most important parts are in areas around the left ear. In order to describe them in greater detail, we need to look more closely at some of the gray matter. So, take a head, remove hair, scalp, skull, then disconnect the brain stem (connecting the brain to the spinal cord) and cut the corpus callosum (connecting the two hemispheres). If we disregard a certain amount of other material, we will basically be left with two parts, the left hemisphere and the right hemisphere.

Broca's Area

The part is technically described as the “anterior speech cortex” or, more usually, as Broca’s area. Paul Broca, a French surgeon, reported in the 1860s that damage to this specific part of the brain was related to extreme difficulty in producing spoken language. It was noted that damage to the corresponding area on the right hemisphere had no such effect. This finding was first used to argue that language ability must be located in the left hemisphere and since then has been treated as an indication that Broca’s area is crucially involved in the generation of spoken language.

Wernicke’s Area

The part is the “posterior speech cortex,” or Wernicke’s area. Carl Wernicke was a German doctor who, in the 1870s, reported that damage to this part of the brain was found among patients who had speech comprehension difficulties. This finding confirmed the left hemisphere location of language ability and led to the view that Wernicke’s area is part of the brain crucially involved in the understanding of spoken language.

The Motor Cortex and the Arcuate Fasciculus is an area that generally controls movement of the muscles (for moving hands, feet, arms, etc.). The part of the motor cortex that is close to Broca’s area controls the articulatory muscles of the face, jaw, tongue and larynx and hence the physical articulation of speech. In the 1950s, two neurosurgeons, Penfield and Roberts (1959) found that, by applying small amounts of electrical current to specific parts of the brain, they could identify areas where the electrical stimulation would interfere with speech production. The part shown as (4) in Figure 12.1 is a bundle of nerve fibers called the arcuate fasciculus. This was also one of Wernicke’s discoveries and is now known to form a crucial connection between Wernicke’s and Broca’s areas. The Localization View Having identified these four components, it is tempting to conclude that specific aspects of language ability can be accorded specific locations in the brain. This is called the localization view and it has been used to suggest that the brain activity involved in hearing a word, understanding it, then saying it, would follow a definite pattern. The word is

heard and comprehended via Wernicke's area. This signal is then transferred via the arcuate fasciculus to Broca's area where preparations are made to generate a spoken version of the word. A signal is then sent to part of the motor cortex to physically articulate the word. This is certainly an oversimplified version of what may actually take place, but it is consistent with much of what we understand about simple language processing in the brain. It is probably best to think of any proposal concerning processing pathways in the brain as some form of metaphor that may turn out to be inadequate once we learn more about how the brain functions. The "pathway" metaphor seems quite appealing in an electronic age when we are familiar with the process of sending signals through electrical circuits. In an earlier age, dominated more by mechanical technology, Sigmund Freud subtly employed a "steam engine" metaphor to account for aspects of the brain's activity when he wrote of the effects of repression "building up pressure" to the point of "sudden release." Even earlier, Aristotle's metaphor was of the brain as a cold sponge that kept the blood cool. In a sense, we are forced to use metaphors mainly because we cannot obtain direct physical evidence of linguistic processes in the brain. Because we have no direct access, we generally have to rely on what we can discover through indirect methods. Most of these methods involve attempts to work out how the system is working from clues picked up when the system has problems or malfunctions.