HEMISPHERIC ASYMMETRY, HANDEDNESS, AND CEREBRAL DOMINANCE

Broca's declaration that the left hemisphere is predominantly responsible for language-related behaviour is only the clearest and most dramatic example of an asymmetry of function in the human brain. This functional asymmetry is related to hand preference and probably to anatomical differences, although neither relationship is simple.

Evidence from a number of converging sources, notably the high incidence of the language disturbance known as aphasia after left- but not right-hemisphere damage, indicates that the left hemisphere is dominant for the comprehension and expression of language in close to 99 percent of right-handed people. At least 60 percent of left-handed and ambidextrous people also have left-hemisphere language, but up to 30 percent have predominantly right-hemisphere language. The remainder have language represented to some degree in both hemispheres.

The posterior temporal region of the brain, which in the dominant hemisphere is one of the regions responsible for language, is physically asymmetrical; specifically, the area known as the planum temporale is larger in the left hemisphere in most people. This asymmetry is more common in right-handers, while left-handed individuals are likely to have more nearly symmetrical brains. Reduced anatomical asymmetry has also been found in people with right-hemisphere dominance for speech and in some developmental dyslexics (people with reading disorders). These results point to some relationship between handedness, cerebral dominance for language, anatomical asymmetry in the temporal lobe, and some aspects of language competence. Certainly, there is a tendency for right-handedness, left-hemisphere dominance for language, and a larger left planum temporale to go together. However, there are exceptions; for example, a few right-handers are right-hemisphere dominant for speech, and some right-handers who have left-hemisphere speech do not have a larger left planum temporale. In subjects who are atypical in one of these respects—for example, by being left-handed—the relationship between handedness, cerebral dominance, and anatomical asymmetry is much less consistent. It follows, therefore, that language is not invariably located in the hemisphere opposite the dominant hand or in the hemisphere with the larger planum temporale.

Studies of patients in whom the corpus callosum (the bundle of nerve fibres connecting the two halves of the brain) has been severed, allowing the two hemispheres to function largely independently, have revealed that the right hemisphere has more language competence than was hitherto supposed. These patients show evidence of comprehension of words presented to the isolated right hemisphere, although that hemisphere is not able to initiate speech. The speech of patients with a lesion of the right hemisphere may lack normal melodic quality, and they may have difficulty expressing and understanding such things as emotional overtones. They may also have difficulty appreciating some of the more subtle, connotative aspects of language, such as puns, figures of speech, and jokes. Nevertheless, the dominance of the left hemisphere for language, particularly the syntactic aspects of language and language output, is the clearest example yet discovered of the lateralization of higher cortical function.

The left hemisphere also appears to be more involved than the right in the programming of complex sequences of movement and in some aspects of awareness of one's own body. Thus, the disorders known as ideomotor and ideational apraxia are more common after left-hemisphere damage. In these disorders, the patient has difficulty carrying out actions involving several movements or the manipulation of objects in an appropriate and skillful way. The difficulty appears to be in programming the motor system to run off the sequence of movements required to perform a complex action in the appropriate order and with the appropriate timing.

A third category of deficits associated with left-hemisphere damage, disorder of the body image, is much more difficult to define. It includes a disorder called finger agnosia, in which the individual does not appear to "know" which finger is which, being unable to indicate which one the examiner touches without the aid of vision. Confusion of right and left is also found after left-hemisphere damage, making it appear that the left hemisphere is largely responsible for collating somatosensory information into a special awareness of the body called the body image. The phenomenon of the phantom limb, whereby patients "feel" sensations in amputated limbs, indicates that the brain's internal representation of the body may persist intact for some time after the loss of a body part. This internal representation appears to be maintained chiefly by the left hemisphere.

The special functions of the right hemisphere were recognized later than those of the left hemisphere, although a case of "imperception" reported by the English neurologist John Hughlings Jackson in 1876 foreshadowed later findings. Jackson's patient, who had a lesion in the posterior part of the right hemisphere, lost her way in familiar surroundings, failed to recognize familiar places and people, and had difficulty in dressing herself—all of which became well-recognized consequences of right-hemisphere damage. The right hemisphere, then, appears to be specialized for some aspects of higher-level visual perception, spatial orientation, and route finding (sense of direction), and it probably plays a dominant role in the recognition of objects and faces. The specialization of the right hemisphere, however, is less absolute than that of the left hemisphere in that these skills are less lateralized than language.

Specialized functions of the right hemisphere

There has been considerable speculation as to why the human brain should be functionally asymmetrical. Initially, both functional and anatomical asymmetry were thought, like language, to be a uniquely human trait, but less pronounced asymmetries have now been found in lower animals. One suggestion is that it is necessary to have language represented in a single hemisphere to avoid competition between the hemispheres for control of the muscles involved in speech. Another suggestion is that it is efficient to have the language system represented in a restricted area on one side of the brain because information needs to be transferred over short distances and fewer connections. A third suggestion is that the dominance of the left hemisphere over the right hand and skilled movement preceded its dominance over language. According to this view, language subsequently developed in the same hemisphere because language implies speech, which requires precise programming of sequences of movement in the articulatory musculature. All these views have something to recommend them, but none has been conclusively proved correct or has been generally accepted. Also, there remain some facts that are difficult to explain by any theory. For example, all the above theories would predict that bilateral and, in some cases, right-hemisphere language representation would be disadvantageous, but this does not seem to be generally true.

LANGUAGE

The language area of the brain surrounds the Sylvian fissure in the dominant hemisphere (Figure 32). This area

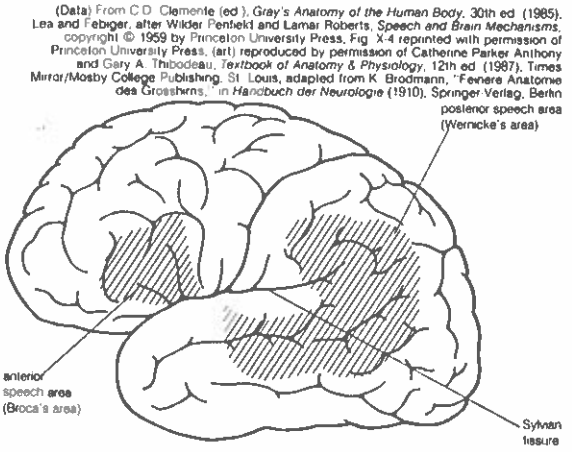

Figure 32: Lateral view of the brain, showing anterior and posterior speech areas (Broca's area and Wernicke's area).