LANGUAGE

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

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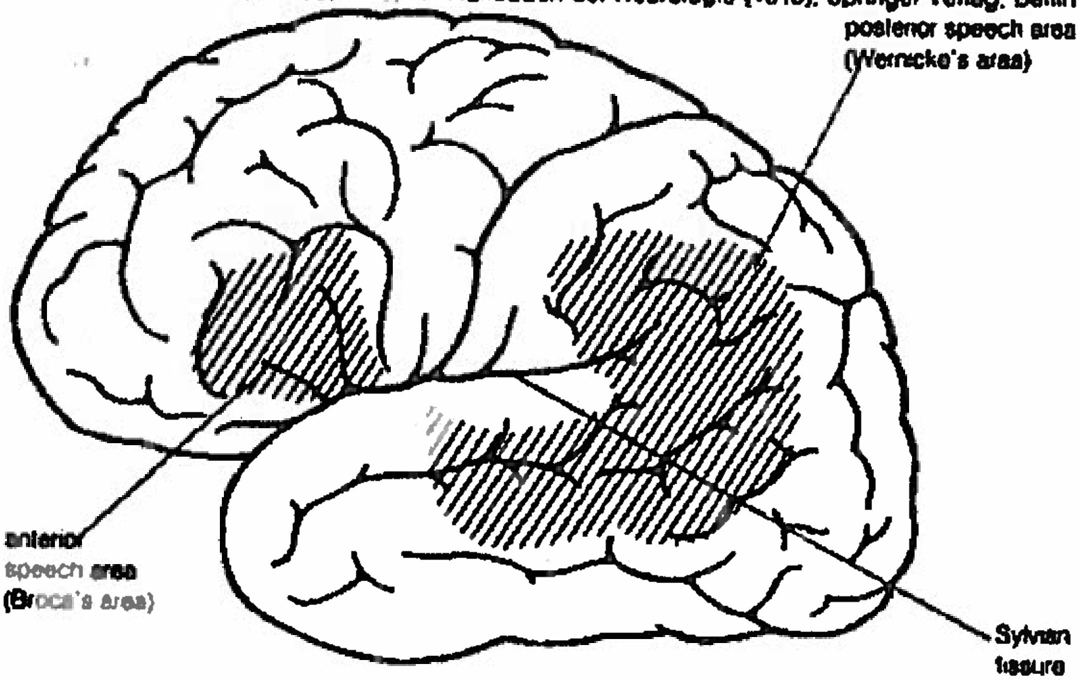

Figure 32: Lateral view of the brain, showing anterior and posterior speech areas (Broca's area and Wernicke's area).

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.

Specialized functions of the right hemisphere

The spatial 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.

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.

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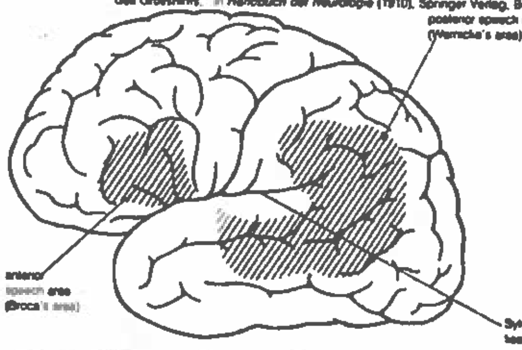

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Broca's and Wernicke's language areas

is divided into two major components named after the pioneers Paul Broca and Carl Wernicke. Broca's area lies in the third frontal convolution, just anterior to the face area of the motor cortex and just above the Sylvian fissure. This is often described as the motor, or expressive, speech area; damage to it results in Broca's aphasia, a language disorder characterized by deliberate, telegraphic speech with very simple grammatical structure though the speaker may be quite clear as to what he wishes to say and may communicate successfully. Wernicke's area is in the superior part of the posterior temporal lobe; it is close to the auditory cortex and is classically considered to be the receptive language, or language comprehension, centre. A patient with Wernicke's aphasia has difficulty understanding language; his own speech is typically fluent but is empty of content and characterized by circumlocutions, a high incidence of vague words like "thing," and sometimes neologisms and senseless "word salad." The entire posterior language area extends into the parietal lobe and is connected to Broca's area by a fibre tract called the arcuate fasciculus. Damage to this tract has been implicated in conduction aphasia, a disorder in which the patient can understand and speak but has difficulty in repeating what is said to him. The suggestion is that, in this condition, language can be comprehended by the posterior zone and spoken by the anterior zone, but it can not be easily shuttled from one to the other.

Distinction between aphasia and apraxia

It is important to note that aphasia is a disorder of language and not of speech (although an apraxia of speech, in which the programming of motor speech output is affected, may accompany aphasia). The writing and reading of aphasic patients, therefore, usually commits the same type of error as their speech, while the reverse is not the case. Isolated disorders of writing (dysgraphia) or, more commonly, reading (dyslexia) may occur as well, but these reflect a disruption of the additional processing required for these activities over and above that required for language.

One particular form of dyslexia deserves mention, as it is a clear example of a disconnection syndrome—a disorder resulting from the disconnection of two areas of the brain rather than from damage to a "centre." This is dyslexia without dysgraphia, or letter-by-letter reading, so called because it is not associated with writing disturbance and because the patients tend to attempt to read by spelling words out loud letter by letter. It usually results from a lesion in the posterior part of the left hemisphere that disconnects the visual areas of the brain from the language areas. This renders the language areas effectively blind, so that they cannot be brought to bear on visible language such as the written word. Writing is unaffected because the right hand is still connected to the left hemisphere, and, if letters can be spoken out loud correctly (which is not always the case), the patient will be able to hear himself say them and reintegrate them into words. Disconnection syndromes are an important concept in understanding behavioral disorders associated with brain damage. The possibility that deficits are caused by disconnection must always be borne in mind.

MEMORY

Memory is one of the most widely studied cognitive functions, and a number of different aspects of memory are recognized. The labels short-term memory, primary memory, and working memory refer to the temporary storage of information that is necessary for the performance of many cognitive tasks. In order to understand this sentence, for example, a reader must maintain the first half of the sentence in working memory while reading the second half. This working memory has been graphically described as the memory one uses to hold a telephone number in mind after looking it up in a directory and while dialing. The capacity of working memory is limited, and it decays if not rehearsed. Long-term memory, secondary memory, and reference memory refer to the storage of information for longer periods. The capacity of long-term memory is very large—in practice unlimited—and it can endure indefinitely. In addition, psychologists distinguish episodic memory, a memory of specific events or episodes normally described by the verb remember, from [illegible] memory, a knowledge of facts normally said to be [illegible] rather than remembered.

Almost certainly, memory is stored over wide [illegible] the brain rather than in any single location. [illegible] amnesia, a disorder of memory, can occur after [illegible] ized bilateral lesions in the limbic system—not[illegible] hippocampus on the medial side of the temporal [illegible] some parts of the thalamus, and their connections [illegible] probably implies that these structures, rather than [illegible] constituting a memory store, are important in the [illegible] down of memories and in their recall when needed. [illegible] ory impairment resulting from damage in these [illegible] a disorder of long-term episodic memory and is pr[illegible] nantly an anterograde amnesia—that is, it typically [illegible] the memory of events occurring after the illness [illegible] dent causing the amnesia more than it does memor[illegible] the past. Substantial retrograde amnesia (loss of the [illegible] ory of events occurring before the onset of amnesia) [illegible] if ever occurs without significant anterograde amn[illegible] a result of brain damage, although it may occur al[illegible] psychiatric illness.

Although amnesia is a disorder of long-term ep[illegible] memory and leaves short-term and semantic memor[illegible] tact, both of the latter can be affected by brain dam[illegible] Some parietal lobe lesions may affect short-term me[illegible] without affecting long-term memory; this fact has [illegible] tributed to a revision of the old theory that there [illegible] distinct short- and long-term stores, the latter bein[illegible] cessible only via the former. It has been suggested [illegible] short-term memory impairment—at least for verbal [illegible] terial—can be further subdivided into auditory and v[illegible] domains; however, these disorders manifest themselve[illegible] difficulty in understanding spoken and written lang[illegible] rather than in memory impairment (*i.e.*, they appear [illegible] like aphasia and dyslexia). Impairment of semantic m[illegible] ory, too, results in an impairment that resembles a [illegible] of concepts or a language deficit more than it resem[illegible] what would usually be described as a memory imp[illegible] ment. Some forms of visual agnosia have been interpr[illegible] as semantic memory impairment, since the patients [illegible] unable to recognize objects such as chairs because they [illegible] longer "know" what chairs are or what they look like [illegible] can no longer access that knowledge).

EXECUTIVE FUNCTIONS OF THE FRONTAL LOBES

The frontal lobes are the part of the brain most remo[illegible] from sensory input and whose functions are most diffic[illegible] to capture. They can be thought of as the executive th[illegible] controls and directs the operation of the brain system[illegible] dealing with cognitive function. Indeed, the deficits [illegible] after frontal lobe damage have been described as a "dys[illegible] executive syndrome."

Frontal lobe damage can affect people in any of several ways, and the results are at once subtle and drastic. On the one hand, they may have difficulty initiating behaviour, in extreme cases being virtually unable to move or speak but more often simply having difficulty in getting started on a task. On the other, they may perseverate, being apparently unable to stop a behaviour once started. Rather than appearing apathetic and hypoactive, they are uninhibited, rude, and boorish. Such people may also have difficulty in planning and problem solving and may be incapable of creative thinking. Mild cases of this deficit can be revealed by a difficulty in solving mental arithmetic problems that are couched in words, even though it can be shown that the patient is capable of remembering the question and performing the required calculation. In such cases it appears that the patient simply cannot work out what to do, a difficulty described as a failure to select the appropriate cognitive strategy.

A unifying theme in these disorders is the notion of inadequate control or organization of pieces of behaviour that may in themselves be well formed. Frontal lobe patients are easily distracted. Although their deficits may be superficially less dramatic than those associated with posterior lesions, they can have a drastic effect on everyday function. Irritability and personality change are also frequently seen after frontal lobe damage. (G.Rs.)