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RESEARCH ARTICLE

LANGUAGE LATERALIZATION IN THE HUMAN BRAIN: A RAPID REVIEW OF THE LITERATURE

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ABSTRACT

This paper offers a brief overview of how the human brain lateralizes language. The link between the brain and linguistic learning is a fascinating but challenging field of study. This paper offers evidence to substantiate the theory regarding language lateralization in the brain and provides a cohesive yet clear summary of the most significant forms of lateralization of the considerable number that have been identified.

INTRODUCTION

The human brain

The brain is one of the most important parts of the human anatomy and plays a key role in controlling human behaviour. The brain also has the ability to guide and direct every single part of our body. The infinite power and capacity of the brain reinforces the fact that the brain is indeed an extremely sophisticated structure. The shape of the human brain resembles two halves with a gap between them. The two cerebral hemispheres are referred to as the left and right hemispheres respectively. The cerebral hemispheres are connected by the corpus callosum. The surface of the cerebral hemispheres is referred to as the cortex while the "grey matter" areas lie inside the cerebral hemispheres. Both the cortical and sub-cortical areas play a key role in language. However, the cortical area is perhaps the most crucial for language learning (Obler and Gjerlow, 1999, pp.16-18; Sinatra and Gemake, 1983, p.34). The elements that make up the nervous systems are known as neurons, each of which consists of a cell body. These neurons are interconnected by axons and dendrite and a number of dendrites are connected to each neuron. These extensions carry impulses towards or away from the cell body and control the movement of a number of muscle fibres (Lieberman, 2000, p.21).

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Language lateralization in the brain

Language is obviously an essential tool in everyday human activities as people communicate with each other through language. The study of both linguistics and neurology has made significant contributions to our understanding of language. In particular, neurolinguists have attempted to investigate the relationship between language and the brain. However, research in the field of linguistics and neurology is rather difficult due to the limited availability of data (Whitaker, 1971). The study of the relationship between language and the brain began in the nineteenth century. In 1836, Dax read a short paper at a medical society meeting in Montpellier, France.

He had seen many patients suffering from loss of speech as a result of brain damage, a condition known as aphasia. Dax summarised these observations and presented his conclusions at the conference by claiming that "each half of the brain controls different functions; speech is controlled by the left half of the brain" (Springer and Deutsch, 1981). One of the main neurolinguistics schools is the localizationist school. The localizationist approach suggests that language is localised in different areas of the human brain. In effect, both cortical and sub-cortical parts of the lefthemisphere are associated with language. This notion is supported by many scholars, such as Broca and Wernicke. Broca and Wernicke studied two types of brain damaged patients; Brocaargued that non-fluent patients should show signs of brain injury in Broca's area while Wernicke argued that fluent patients should show signs of brain damage in Wernicke's area. Broca's aphasia is located in the lower area of the left frontal lobe, while Wernicke's aphasia is located posterior to Broca's area (see Figure 1). In contrast to this theory, the connectionist school argues against the localizationist hypothesis and instead focuses on cognitive abilities, such as memory and attention. Connectionists study the brain as a series of interconnected areas. For instance, connectionist scholars design models of brain processing using computer networks as an analogy, a technique referred to as "Parallel Distributed Processing" (Obler and Gjerlow, 1999, pp.9-11).

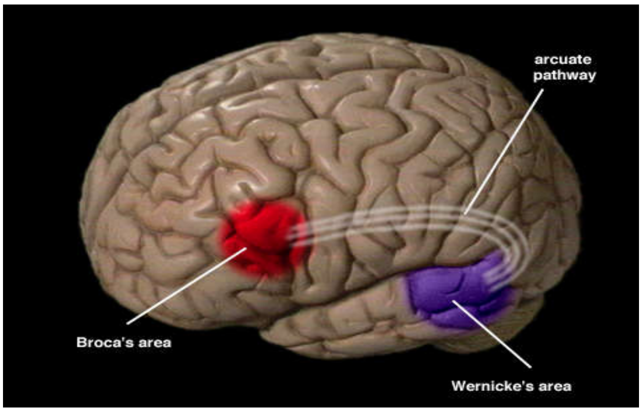

Figure 1.

Motor movements and language mechanisms are controlled by common areas of the brain. According to Thompson and Green (1982, pp.166-172), "At the cortical area, the cortex seems to be a primary area for the generation of language and also is involved in the sequencing of motor movements and the decoding of speech sounds. At the sub-cortical region, there seems to be a common mechanism for focusing attention, a mechanism important for motor learning, memory and language". According to Obler and Gjerlow (1999, pp.22-24), there are several essential areas of the brain which are responsible for different language skills. More specifically, the area located at the back of the frontal lobe is concerned with generating movement while the area in the front of the parietal lobe and across the Rolandic fissure is responsible for sending sensory information. The area in the occipital lobe is related to the perception of visual stimuli while auditory stimuli are processed in the temporal lobe. (See Figure 2)

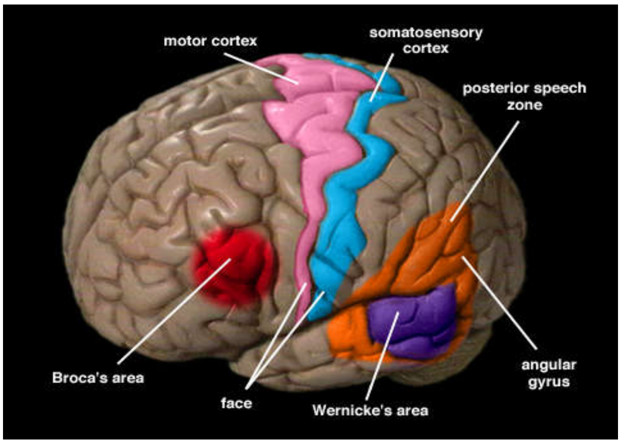

Figure 2.

It is evident that there is a strong link between language usage and the brain. More specifically, both spoken and written language is correlated to different areas of the brain. As such, a brain that is free from damage will enable an individual to use language without difficulty. However, any kind of language deficit implies that an injury has been incurred by some part of the brain. Different types of language disorders are thus related to different kinds of aphasia. Luria (1962) noted that the improvement in the ability to perceive sound and to hear speech requires the closest participation of articulation. During the first years of speech development, a child should hear speech sounds with the participation of articulation. However, the failure of the child to produce or to hear speech sounds may provide evidence to suggest the child has some form of brain damage.

The concept of lateralization

According to Lubin (1969, pp.34-36), many research studies in the areas of brain organisation and functioning emerged during the nineteenth century. These research studies were primarily based on the relationship between brain damage and intelligence, brain damage and recovery, language and thought, and the lateralization of cerebral functioning. According to Holder (2005), the term brain lateralization refers to the fact that "the two halves of the human brain are not exactly alike. Each hemisphere has function specialisation. Some functions are localised in one half of the brain. In humans, the most obvious functional specialisation is speech and language abilities".

How to investigate lateralization of brain functions?

One of the most crucial differences between the human brain and that of other vertebrate is the appearance of hemispheric dominance or language specialisation. In humans, we can identify a behavioural function that is localised in one of the two hemispheres (Lenneberg, 1967, p.66). Language lateralization in the human brain can be analysed and proven in a variety of different ways. The main aim of these techniques is to determine which hemisphere is dominant in terms of language. Obler and Gjerlow (1999) and Murre (2001) suggest that the most important methods in testing lateralization are the following:

Split-brain patients

Some patients with epilepsy can live normal lives by undergoing an operation known as a "commissurotomy", a procedure that severs the connection between the two hemispheres. If split-brain patients reach for an unseen object using their left hand, they may not be able to name the object. This shows the dominance of the left hemisphere (See Figure 3, 4).

Sodium amytal testing

Using this technique, sodium amytal is injected into the artery that leads to the side of the brain. This method is referred to as the Wada test. If the sodium amytal "is delivered to the language side of the brain, a temporary paralysis of language function is experienced". (See Figure 5)

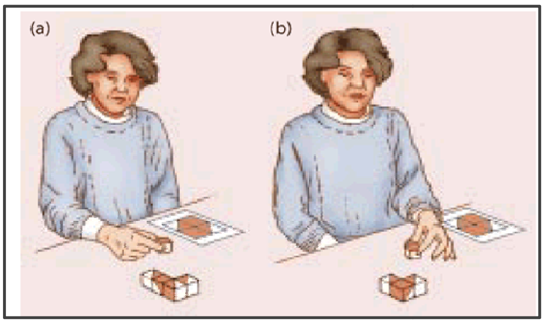

Figure 3.

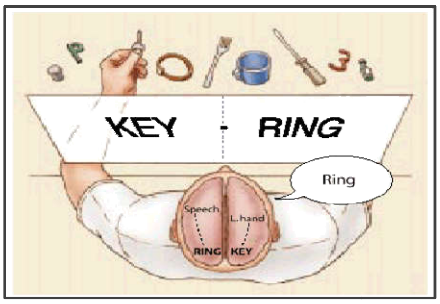

Figure 4.

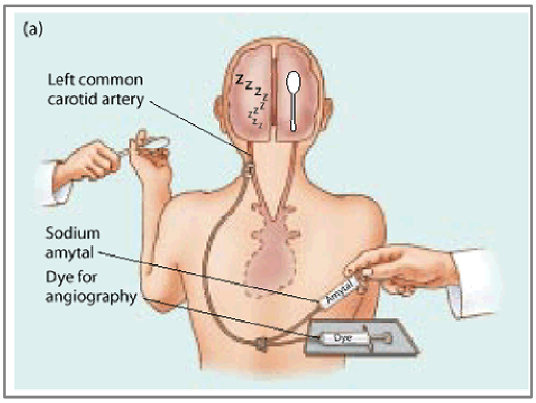

Figure 5.

Dichotic listening techniques of auditory stimuli

This method is based on the fact that the right ear is more strongly linked to the left hemisphere, while the left ear is more strongly linked to the right hemisphere. Therefore, this information shows which hemisphere is dominant for language (See Figure 6).

Brain damage

Many studies argue that approximately 97% of people use the left hemisphere to control language while only 3%use the right hemisphere. According to Broca, damage to the left hemisphere affects language production, since language is represented in the left hemisphere.

Tachistoscopic presentation of visual stimuli

Tachistoscopic presentation can indicate which side of the brain is dominant for language. "Information about the right visual field is sent by both eyes to the left hemisphere and information about the left visual field is sent by both eyes to the right hemisphere". Thus, information in the left hemisphere will be processed more accurately.

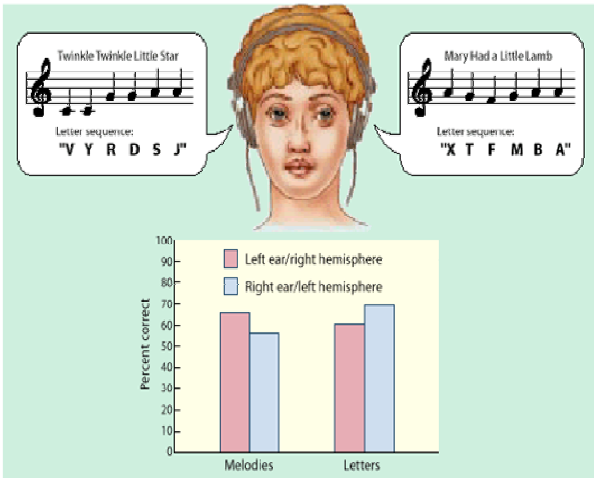

Figure 6.

Types of lateralization

The different patterns of lateralization in the brain can be delineated as follows:

Handedness and brain lateralization:

The term "handedness" refers to the hand that performs faster or more precisely during manual tests or the hand that a person prefers to use. The handedness of a person is opposite to the specialized hemisphere. In other words, "a right-handed person probably has a left-hemispheric language specialization" (Holder, 2005).

Infancy speech lateralization

The measurement of lateralization in children is quite difficult for a number of reasons. For instance, techniques that are commonly applied to adults, such as dichotic listening ortachistoscopic stimuli, are simply inappropriate for use on infants. Infant speech also has many different characteristics and the speech patterns of a child depend on the familiarity and the unfamiliarity of a certain stimulus word. When infants listen to speech, their eyes move from left to right (Segalowitz, 1983, pp.223-227).

Sex-differences lateralization

There are also a number of differences between male speech and female speech. For example, "Girl infants vocalise the full range of phonemes earlier, they speak the first words earlier, and they develop vocabularies earlier. However, boy infants do not have an early superiority of such skills". Some authors also believe that the left hemisphere in girls matures more quickly than in boys (Segalowitz, 1977, pp.298-299).

Sign language lateralization

According to Segalowitz (1983), a deaf man who learned sign language before learning to use vocal speech lost his ability to sign when he incurred a brain injury.In effect, damage to the right hemisphere might harm signing ability, which indicates that sign language is localised in both the right and left hemisphere (Segalowitz, 1983, pp.292-293).

Limitations of brain lateralization studies

The study of the relationship between language and the brain requires comprehensive knowledge of both language and the brain. Researchers have tried to gain a clearer view of the lateralization of language in the brain but there are many limitations to these types of studies. For instance, many researchers "lack a full understanding of how nerve connections from the sensory systems reach the brain". Further still, few studies adopt a valid technique that will offer precise results of lateralization. Researchers have also emphasized that the measurement of speech sound is very complex (Sinatra and Gemake, 1983, pp.32-34).

Conclusion

Overall, this paper has discussed how different types of language abilities are connected to different areas in the brain. Thus, damage to any part of the brain has the potential to affect language abilities. The two hemispheres of the brain perform different functions with language most commonly being localised in the left hemisphere. This provides evidence that the brain is indeed a highly complex structure. Studies of the lateralization of language in the brain are rather limited and very few research studies address all aspects of the relationship between language and the brain. Thus, linguists, neurologists and other scholars should collaborate with one another in order to conduct several cohesive studies on these phenomena. In addition, the application of advanced new technology may facilitate researchers in developing a clearer view of the structure and functionality of the brain and its associated processes.

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