FUNCTIONAL SPECIALIZATION OF THE BRAIN HEMISPHERES IN LANGUAGE PROCESSING

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ABSTRACT

This article analyzes the language processing processes of the left and right hemispheres of the human brain, their functional specialization and neuropsychological basis. In particular, based on scientific literature, it emphasizes the dominance of the left hemisphere in the processing of language structure and the role of the right hemisphere in understanding pragmatic and contextual aspects. The results obtained through modern neurobiological studies, aphasia syndromes and neuroimaging methods are also discussed.

Introduction: Functional specialization of language and cerebral hemispheres (extended scientific statement) Language is one of the most complex and highly organized cognitive functions of a person, which is not only a means of communication, but also the main mechanism of thinking, memory and social interaction. The implementation of language activity relies on a complex functional integration between various structures of the central nervous system. In particular, the functional distribution between the cerebral hemispheres - that is, the phenomenon of lateralization - is of great theoretical and practical importance in language processing. The concept of cerebral lateralization. Cerebral lateralization (functional specialization) is understood as the uneven distribution of cognitive functions between the left and right hemispheres of the brain. Although anatomically the hemispheres are almost symmetrical, from a functional point of view they differ significantly. This differentiation was formed as a result of evolutionary development and serves to increase the efficiency of the human brain. Language functions are mainly localized in the left hemisphere, which is widely confirmed in the sciences of neurolinguistics and neuropsychology. For this reason, the left hemisphere is often described as the “dominant hemisphere”. According to statistics, in 90–95% of right-handed individuals, and in about 60–70% of left-handed individuals, language functions are associated with the left hemisphere. Functional differences between the left and right hemispheres. The left hemisphere specializes in analytical and sequential processing. This hemisphere: structurally analyzes language units; processes phonological and grammatical rules; effectively manages logical and sequential information. In this regard, the left hemisphere dominates in processing the formal components of language (phonology, morphology, syntax). The right hemisphere specializes in more global (holistic) processing: understanding contextual meanings; perceiving emotional nuances (prosody); performs functions such as understanding the pragmatic aspects of speech. For example, the role of the

right hemisphere in understanding irony, metaphor, or hidden meaning is incomparable. Therefore, a full and adequate perception of language is ensured not by the activity of only one hemisphere, but by their mutual cooperation. The concept of the dominant hemisphere The concept of the "dominant hemisphere" means in which hemisphere language functions are dominant. This dominance depends on individual characteristics (for example, handedness - right or left-handedness), genetic factors, and developmental processes. The dominant hemisphere performs the following functions: speech development; speech comprehension; integration of written and spoken language; organization of linguistic signs into a logical system. However, according to modern neuroscience approaches, language is not "located" in only one hemisphere, but is implemented through widely distributed neural systems. Both hemispheres are involved in these systems, but their functional contribution is different. Interhemispheric interaction Information exchange between the left and right hemispheres occurs through the corpus callosum. This structure coordinates the activity of the two hemispheres, allowing for complex language processing. For example:

the left hemisphere determines the grammatical structure of a sentence, while the right hemisphere fills in its emotional tone and context. Thus, the process of understanding and developing language is based on multi-level and multi-component neural integration.

Scientific research and modern approaches. Studies conducted using modern neuroimaging methods (fMRI, PET, EEG) show that brain activity during language processing is dynamic and flexible. That is, when necessary, the right hemisphere can compensate for some of the functions of the left hemisphere (the phenomenon of neuroplasticity). Also, according to the "dual-stream model", language processing occurs through: ventral stream (semantic processing), dorsal stream (phonological and articulatory processes), and although these systems are mainly located in the left hemisphere, they work in collaboration with the right hemisphere. The role of the left hemisphere in language processing (an extended scientific analysis) The left hemisphere is the main neurobiological substrate for language processing in the human brain. Neurolinguistic and cognitive neuroscience studies show that most language-related processes are localized in the left hemisphere, which is described as the phenomenon of "left-hemisphere dominance". This dominance is especially pronounced in right-handed individuals and ensures the systematic processing of phonological, morphosyntactic and semantic components of language. Although the participation of the right hemisphere in language processes was previously considered to be unrelated to right-hemisphere language, modern studies have shown that

1. Pragmatic analysis

Understanding the hidden meaning of speech, irony and metaphors is associated with the right hemisphere.

2. Prosody

Elements of speech tone, stress, rhythm and intonation are processed by the right hemisphere.

3. Understanding context

The right hemisphere is important in understanding the general content of a text or speech.

1. Phonological processing

Phonological processing involves the process of identifying, distinguishing and integrating speech sounds (phonemes) into meaningful units. The superior temporal gyrus of the left hemisphere (especially the posterior part) plays an important role in these processes.

Phonological decoding includes the following stages:

• analysis of the acoustic signal;

• separation into phonemes;

• matching phonemes with lexical units.

Modern neuroimaging studies (fMRI) show that the left temporal regions are significantly activated when performing phonological tasks. This confirms that the left hemisphere is specialized for processing speech sounds with high accuracy.

2. Grammatical (morphosyntactic) structure

The left hemisphere is crucial for processing the grammatical system of language. Morphosyntactic processing involves the identification of word forms (morphology) and their order and interconnection within a sentence (syntax).

The following neural networks are involved in these processes:

• inferior frontal gyrus (lower part of the frontal lobe);

• posterior temporal cortex;

• pathways interconnected with parietal regions.

The left hemisphere has the property of processing grammatical rules sequentially and hierarchically. For example, it is this hemisphere that is actively involved in understanding complex sentence constructions. Damage to these areas is manifested by agrammatism (violation of grammatical structures).

3. Semantic analysis

Semantic processing involves understanding the meaning of language units, relating them to context, and making logical interpretations. The middle and inferior temporal areas of the left hemisphere and the angular gyrus play a key role in semantic analysis.

Semantic processes include:

• storing and retrieving the meaning of lexical units;

• identifying semantic relationships between words;

• integrating meaning at the sentence and text levels.

The left hemisphere is particularly good at processing explicit, lexical, and conventional meanings. Damage to this hemisphere can lead to semantic paraphasias (incorrect use of words) or distortions of meaning.

4. Main language centers

The left hemisphere contains several important cortical centers associated with language, which form a functional network:

Broca's area

Located in the lower part of the frontal lobe, it is involved in speech production, articulation, and the formation of grammatical structures. Damage to this area results in Broca's aphasia, in which speech is slow and disjointed, but comprehension is relatively intact.

Wernicke's area

Located in the upper posterior part of the temporal lobe, it plays a key role in speech comprehension and semantic processing. Damage to this area results in Wernicke's aphasia, in which speech is fluent but incoherent and incomprehensible.

Arcuate fasciculus

A major nerve fiber tract connecting Broca's and Wernicke's areas, providing integration between speech comprehension and production. When this pathway is damaged, conduction aphasia occurs, in which the patient has difficulty repeating words he or she hears.

Neuropsychological evidence

The specialization of the cerebral hemispheres for language has been studied through the following methods:

1. Aphasia studies

Broca's and Wernicke's aphasias occur when the left hemisphere is damaged, indicating that it is the main center for language.

2. Split-brain studies

After callosotomy, the connection between the hemispheres is disrupted, which allows us to study their separate functions.

3. Neuroimaging

fMRI and PET technologies help to determine which brain regions are activated during language activity.

Modern views

In recent years, it has been found that language processing is not limited to the activity of only one hemisphere, but is carried out through complex neural networks. According to this model:

- Left hemisphere - structural and linguistic aspects
- Right hemisphere - contextual and emotional aspects

Both hemispheres work together in language processing.

Conclusion: The functional specialization of the cerebral hemispheres in language processing is one of the important aspects of human cognitive activity. The left hemisphere controls the main linguistic components of language, while the right hemisphere complements the contextual and emotional aspects of speech. Modern scientific research shows that these processes are integrated

List of used literature:

1.Friederici, A. D. (2011). The brain basis of language processing: from structure to function. Physiological Reviews.
2.Hickok, G., & Poeppel, D. (2007). The cortical organization of speech processing. Nature Reviews Neuroscience.
3.Gazzaniga, M. S. (2000). Cerebral specialization and interhemispheric communication. Brain.
4.Kolb, B., & Whishaw, I. Q. (2015). An Introduction to Brain and Behavior. Worth Publishers.
5.Levelt, W. J. M. (1989). Speaking: From intention to articulation. MIT Press.
6.Kandel, E. R., et al. (2013). Principles of Neural Science. McGraw-Hill.
7.Лурия, А. Р. (1973). Основы нейропсихологии. Москва.
8.Geschwind, N. (1970). The organization of language and the brain. Science