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РАХМАНОВА МАХЛИЁ ИЛХОМОВНА
Авторские сказки как средство развития речевой активности 59

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NEUROLINGUISTIC ANALYSIS: LANGUAGE AND BRAIN

Po'latxonova Hilolaxon Shuhratxon qizi,
O'zbekiston davlat jahon tillari universiteti
Ingliz tili amaliy aspektlari kafedrasi o'qituvchisi

Language is a uniquely human ability, supported by complicated neurological processes. Neurolinguistics is an interdisciplinary study that blends linguistics, psychology, and neuroscience to understand how language is represented and processed by the brain. Neurolinguistic research dates back to the nineteenth century, specifically to the pioneering work of Paul Broca and Carl Wernicke, who discovered a correlation between localised brain injury and language difficulties. Their findings established the classical localizationist viewpoint, which has since evolved into more complicated network-based models of language processing. Non-invasive neuroimaging technologies such as functional Magnetic Resonance Imaging (fMRI), Electroencephalography (EEG), Magnetoencephalography (MEG), and Positron Emission Tomography (PET) have transformed the field in the twenty-first century, allowing researchers to examine the timing and localisation of brain activity during linguistic tasks with unprecedented accuracy.

This article provides a complete introduction of neurolinguistic analysis, beginning with the basic methodological approaches utilised in experimental research, which include both behavioural and neurophysiological techniques. We then look at significant empirical results on the neural basis of phonological, syntactic, and semantic processing, as well as the brain's extraordinary adaptability in bilingualism and language recovery after neurological impairment. We also look at clinical and technological applications, such as diagnosing and treating language disorders, as well as the implications for computational models and artificial intelligence.

We discuss new trends and difficulties in the area, emphasising the value of interdisciplinary collaboration in improving theoretical models and expanding our understanding of the neurolinguistic architecture of the human brain. By combining many research strands, this article hopes to contribute to a more integrated and nuanced understanding of how language is neurologically instantiated and cognitively used.

The branch of neurolinguistics has experienced substantial theoretical and methodological changes since its start. Early research in the nineteenth century provided a foundational understanding of how particular brain regions contribute to language processes. Broca discovered the role of the left inferior frontal gyrus in speech production[1], while Wernicke proved that the posterior superior temporal gyrus is essential for language comprehension. These findings supported the conventional paradigm of brain-language organisation, which stated that separate cortical areas are specialised for certain linguistic functions[2].

However, further empirical discoveries began to call into question this rigid localizationist viewpoint. Geschwind proposed a concept emphasising the role of white matter pathways, such as the arcuate fasciculus, in connecting language-related areas and facilitating integrated language processing[3]. Hickok and Poeppel introduced the dual-stream model of speech processing, which distinguishes between a dorsal stream (mapping sound to articulation) and a ventral stream (mapping sound to meaning)[4]. This model has received widespread support from functional neuroimaging and electrophysiological evidence, and it continues to lead contemporary research into the functional architecture of language in the brain.

In terms of methodology, the development of non-invasive neuroimaging technologies has been critical. Functional Magnetic Resonance Imaging (fMRI) enables high spatial resolution in identifying

[1] Broca, P. (1861). Remarques sur le siège de la faculté du langage articulé, suivies d'une observation d'aphémie (perte de la parole). *Bulletin de la Société Anatomique de Paris*, 6, 330–357.

[2] Wernicke, C. (1874). Der aphasische Symptomencomplex: Eine psychologische Studie auf anatomischer Basis. *Cohn & Weigert*.

[3] Geschwind, N. (1970). The organization of language and the brain. *Science*, 170(3961), 940–944.

[4] Hickok, G., & Poeppel, D. (2004). Dorsal and ventral streams: A framework for understanding aspects of the functional anatomy of language. *Cognition*, 92(1–2), 67–99.

active brain regions during linguistic tasks[1], whereas Electroencephalography (EEG) and Event-Related Potentials (ERP) provide fine-grained temporal information about language processing stages. For example, the N400 component is consistently connected with semantic anomaly identification[2], whereas the P600 and Left Anterior Negativity (LAN) are associated with syntactic processing and reanalysis[3].

Studies on bilingualism and second language acquisition have contributed to a better understanding of neurolinguistics. Abutalebi and Green found that multilingual language control engages not only traditional language areas, but also the prefrontal cortex and anterior cingulate cortex, which are engaged in cognitive control and conflict monitoring[4]. Studies utilising fMRI and MEG have demonstrated that the timing of language acquisition and proficiency level have a major influence on brain representation[5].

These findings have also aided clinical neurolinguistic research. Aphasias–language deficiencies caused by brain damage–have been reclassified using more dynamic and network-based theories of brain activity. Turkeltaub et al.[6] and Fridriksson et al.[7] found that recovery from aphasia requires both perilesional recruitment and contralateral hemisphere compensation, demonstrating the brain's adaptability.

The literature also demonstrates an increasing interest in applying neurolinguistic discoveries to artificial intelligence (AI) and natural language processing (NLP). Poeppel et al., for example, advocate for more alignment between computer models and biological data, emphasising that human-like language understanding in machines necessitates replicating the hierarchical, context-dependent, and time-sensitive components of human language processing[8].

In conclusion, the literature emphasises the diversity and complexity of the neurolinguistic landscape. Theoretical models have evolved from modular and localised perspectives to more distributed and interactive frameworks, and methodological advances continue to improve our understanding of how language is embedded in and enacted by the brain.

Neurolinguistic analysis is an interdisciplinary field that has helped us learn a lot about how the brain processes language. The results of neuroimaging, lesion investigations, and behavioural trials all point to a change from traditional localizationist ideas to a more network-based, integrative view of language processing. These changes not only improve theoretical models, but they also have real-world effects on diagnosis, treatment, and technology use.

One of the most important things we've learnt from recent studies is that language processing isn't limited to certain areas; it's spread out throughout a network that includes the frontal, temporal, parietal, and subcortical structures. For instance, Broca's and Wernicke's regions are still important hubs, but we now know how they fit into bigger circuits like the dorsal and ventral streams, which are responsible for integrating auditory and motor information and processing meaning, respectively. This has helped us understand language operations like phonological decoding, syntactic parsing, and semantic integration better.

Electrophysiological investigations have also shown how temporal dynamics can give us more detailed information about how we understand and produce language in real time. Finding ERP components like the N400 and P600 gives us a time-sensitive look at how the brain reacts to semantic and grammatical errors. These results show that the brain can foresee and adapt, which means that language processing isn't only reactive; it also incorporates anticipatory systems that are impacted by context and what you already know.

Talking about bilingualism and learning a new language shows even more how flexible and adaptable the brain is. The fact that executive control

[1] Friederici, A. D. (2011). The brain basis of language processing: From structure to function. *Physiological Reviews*, 91(4), 1357–1392.Журналы физиологии+3UPV/EHU+3PubMed+3

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areas are involved in bilingual people shows how language is connected to other mental processes. The age at which a person learns a second language and how well they speak it both affect how the brain is organised. This supports the Critical Period Hypothesis, but it also acknowledges that people can learn a second language at any age, even if their brains are wired differently.

Neurolinguistic research has helped us better define, locate, and treat language impairments in clinical settings, especially in people with aphasia, developmental language abnormalities, and neurodegenerative diseases. Functional reorganisation, in which other parts of the brain make up for injured language centres, gives hope for neurorehabilitation treatments. Combining neuroimaging and behavioural therapy in multimodal techniques has shown promise in improving recovery outcomes and making treatment plans that are unique to each person.

The merging of neurolinguistics with artificial intelligence is important because it leads to new ways of thinking about both theory and technology. Human language processing can help make NLP systems that make greater sense to the brain, and AI-powered technologies can help with language diagnosis and rehabilitation. But there are still problems with making sure that computational models accurately show how human language is non-linear, depending on context, and embodied.

Even with these improvements, there are still a lot of unanswered concerns and methodological problems. For example, combining data from different types of imaging (such EEG and fMRI) requires strong analytical frameworks to deal with disparities in spatial and temporal resolution. There aren't enough cross-linguistic investigations, which makes it harder to apply the results to different language systems. Also, the ethical issues that come up in neurolinguistic research, especially in clinical and AI settings, make it important to think carefully about privacy, permission, and how brain-based language data might be misused.

The talk about neurolinguistic analysis shows that it is a discipline that is both interesting in theory and useful in practice. Combining linguistic theory with cutting-edge neuroscience has helped us learn more about how language is stored in the brain and has opened up new possibilities for using this knowledge in healthcare and technology. To solve present problems and move research in new areas, people from different fields will need to keep working together.

The combination of research findings from neurolinguistic studies uncovers several essential insights into the brain underpinnings of language processing. Decades of experimental study utilising neuroimaging, lesion investigations, and electrophysiological approaches have yielded the following significant results:

1. *Unique neural pathways for linguistic elements*

Neuroimaging research demonstrates that distinct elements of language–phonology, syntax, and semantics - are linked to specialised yet interconnected cerebral regions:

Phonological processing engages the superior temporal gyrus and the supramarginal gyrus, especially within the left hemisphere.

Syntactic processing activates Broca's region (BA 44/45), along with contributions from the posterior superior temporal sulcus and the anterior temporal lobe.

Semantic processing predominantly engages the middle and inferior temporal gyri, along with the angular gyrus.

These findings endorse the functional segregation and integration of language processes, indicating that comprehension and production are facilitated by dispersed brain networks rather than isolated regions.

2. *Language processing temporal dynamics*

Electrophysiological evidence, especially ERPs, has clarified brain language processing timing:

Semantic incongruity peaks around 400 milliseconds following stimulus onset in the N400 component.

P600 is linked to syntactic abnormalities and reanalysis.

Left Anterior Negativity (LAN) affects early syntactic organisation.

These components show that sentence comprehension involves temporally different and hierarchically organised semantic and syntactic processes.

3. *Neuroplasticity, bilingual language representation*

According to bilingual studies, the brain's language systems adjust to age, proficiency, and frequency of use:

Early bilinguals have language-overlapping brain representations in classical language domains.

Late bilinguals rely more on executive control regions such the dorsolateral prefrontal cortex and anterior cingulate cortex, resulting in more activation differentiation.

Functional MRI shows that proficiency, not age, predicts language neural overlap.

4. *Brain reorganisation and language recovery*

Researchers have found that the brain can reorganise language skills in clinical populations with

language disorders like aphasia:

Perilesional recruitment in the dominant hemisphere and compensatory activation in homologous right hemisphere areas occurs after recovery.

As language therapy progresses, fMRI and MEG studies show brain activation patterns changing.

These discoveries demonstrate the brain's amazing functional reorganisation, enabling personalised recovery.

5. *Technology and clinical diagnostics applications*

Neuroimaging and electrophysiology are used more in:

Helping diagnose aphasia, dyslexia, and developmental language impairments.

Decoding language-related neural signals in brain-computer interfaces helps severely motor-impaired people communicate.

AI uses biologically inspired language processing models to increase machine language understanding.

These findings show that neurolinguistic research can be applied outside academia.

Neurolinguistic analysis has contributed greatly to our understanding of how language is processed, represented, and recovered in the human brain. This interdisciplinary discipline, founded on both classical and modern neuroscience, has progressed from early localizationist models to more extensive network-based frameworks. Neuroimaging and electrophysiological investigations demonstrate that language processing occurs across functionally specialised yet interconnected regions, with temporal dynamics playing an important role in real-time comprehension and creation.

Bilingual language acquisition and post-injury recovery demonstrate the brain's extraordinary flexibility, with cortical reorganisation and executive control systems supporting language functioning. These findings have significant implications for clinical practice, providing novel techniques to identifying and treating language disorders such as aphasia and dyslexia. Furthermore, breakthroughs in neurolinguistics are having an increasing impact on technological progress, particularly in brain-computer interfaces and AI-driven language models, emphasising the practical importance of aligning artificial systems with human cerebral architecture.

Despite its accomplishments, the discipline still confronts technical and theoretical hurdles, such as integrating multimodal imaging data, the need for more cross-linguistic research, and ethical concerns in clinical and AI settings. Continued interdisciplinary collaboration will be required to resolve these challenges and further understand the complex relationships between language and the brain.

To summarise, neurolinguistics not only advances our scientific understanding of the cognitive and neurological systems that underpin language, but it also opens up new avenues for novel applications in medicine, education, and technology. It is a vibrant and expanding topic that promises to make significant contributions to both theoretical linguistics and practical neuroscience in the next years.

Rezyume. Ushbu maqolada neyrolingvistika fanining asosiy yo'nalishlari tahlil qilinadi. Til inson miyasida qanday tarzda qayta ishlanishi, saqlanishi va tiklanishi haqidagi neyroilmiy va lingvistik yondashuvlar ko'rib chiqiladi. Ushbu maqola neyrolingvistik tadqiqotlarning hozirgi holati va istiqbollarini keng qamrovli tarzda ko'rsatib beradi.

Resume. This article explores on the interdisciplinary topic of neurolinguistics, specifically how language is processed, represented, and recovered in the brain. This review seeks to provide a complete overview of current neurolinguistic ideas and practices, with a focus on the brain's dynamic plasticity in supporting language.

Резюме. В статье рассматривается междисциплинарная область нейролингвистики, исследующая, как язык обрабатывается, представляется и восстанавливается в мозге человека. Цель статьи – дать всесторонний обзор современных теорий и практик нейролингвистики, подчеркнув динамическую адаптивность мозга в поддержке языковой деятельности.