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Modern Interventions for Aphasic Speech Recovery: Integrating Speech Therapy, Neuroplasticity, and Digital Technologies

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ABSTRACT

This study explores modern interventions for the rehabilitation of aphasia, a speech disorder caused by brain damage that affects language comprehension and production. It evaluates the effectiveness of combining traditional speech therapy with neuropsychological techniques and digital technologies such as artificial intelligence and virtual reality. A mixed-method approach was employed, involving 50 patients with various types of aphasia. Participants were divided into three groups based on therapy type: traditional, technological, and combined. The results demonstrated that multimodal and individualized therapies significantly improve speech restoration outcomes. Therapies incorporating transcranial magnetic stimulation and AI-based applications led to faster recovery and better word retention. The study highlights the critical role of neuroplasticity in speech rehabilitation and emphasizes the importance of a multidisciplinary approach involving speech therapists, neurologists, and technology specialists. These findings suggest that integrating neuroscience and technology into therapy can enhance the recovery process for individuals with aphasia.

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1. INTRODUCTION

Aphasia is a speech disorder caused by damage to the speech centers of the cerebral cortex, which affects a person's ability to understand, pronounce, and write words. This condition primarily occurs as a result of stroke, brain injuries, tumors, or degenerative diseases. Approximately 15 million people worldwide suffer strokes annually, with approximately 30-40% developing aphasia (Li *et al*., 2022; Zettin *et al*., 2021). Aphasia is characterized by the loss or impairment of speech ability due to brain injury and is rare in children. Precise statistical data on the prevalence of aphasia among children in Uzbekistan are insufficient. The lack of scientific research and statistical data on aphasia indicates the need for more in-depth studies in this field. In the future, it is crucial to conduct scientific research on the prevalence, diagnosis, and treatment methods of aphasia among children. Aphasia in children is a rare disorder characterized by partial or complete loss of previously developed speech. According to data, the prevalence of childhood aphasia is less than 1%, with boys affected by this condition more frequently than girls (Schreiner *et al*., 2022; Hartini *et al*., 2023).

Modern research in the field of medicine and speech therapy shows that there are sensory, motor (afferent-motor, efferent-motor), acoustic-gnostic, acoustic-mnestic, semantic, dynamic, and other forms of aphasia, each of which requires a distinct approach and treatment methods. Neuropsychological and speech therapy approaches play a crucial role in the rehabilitation process, as speech restoration depends on the brain's neuroplastic properties. In the field of modern speech therapy, multimodal methods for treating aphasia are widely employed. Specifically, visual-auditory exercises, sensorimotor integration, and computerized therapy contribute to accelerating the patient's recovery process. Additionally, speech therapy programs and virtual reality technologies developed based on artificial intelligence serve as effective rehabilitation tools for patients with aphasia. This article analyzes the types of aphasia, methods of their diagnosis and rehabilitation, as well as collaborative approaches of speech therapists and neurologists (Hisham, 2021; Markashova *et al*., 2022; Akinina *et al*., 2021).

The study results demonstrate the effectiveness of innovative methods, neuropsychological approaches, and individualized therapy programs in addressing aphasia. Aphasia significantly impacts not only the patient's personal life but also their social adaptation and psycho-emotional state. Studies indicate that 50-70% of patients with aphasia develop depressive and anxiety disorders, further complicating the rehabilitation process. Consequently, speech therapy necessitates a comprehensive approach aimed not only at restoring speech but also at developing patients' general communicative abilities and enhancing their social integration. In recent years, the theory of neurorehabilitation and neuroplasticity has gained prominence in aphasia rehabilitation. Therapy methods developed based on the brain's adaptive capacity (neuroplasticity) focus on strengthening existing neural networks, forming new neural connections, and engaging other brain regions in the speech process (Chatterjee *et al*., 2021; Aderinto *et al*., 2023). These approaches enable improvements in patients' speech recovery levels and facilitate faster, more effective results. Furthermore, the role of technological approaches in aphasia rehabilitation is expanding. Contemporary scientific research confirms that artificial intelligence and virtual reality (VR) technologies are effective means of rehabilitation for patients with aphasia. For instance, interactive computer programs and mobile applications offer patients specialized speech therapy exercises, allowing for therapy tailored to their individual needs. This article analyzes the combination of traditional speech therapy methods with modern neuropsychological and

technological approaches in aphasia rehabilitation. The primary objective of the study is to identify effective methodological resources for restoring speech ability in patients with aphasia and to examine the scientific basis for their practical application.

2. LITERATURE REVIEW

Scientific research on the rehabilitation of aphasia demonstrates that the process of speech restoration is based on the neuroplastic properties of the brain. According to the theory of neuroplasticity, the functions of damaged areas of the brain can be assumed by other areas, or new neural connections can be formed during the recovery process. Therefore, in aphasia therapy, it is crucial to increase the activity of neural networks associated with speech production. Among the methods of speech therapy rehabilitation, there are traditional and innovative approaches (Husak *et al*., 2023; Rose *et al*., 2022). Among the traditional methods, melodic-intonational therapy (MIT), visual-kinesthetic exercises, and classical repetitive speech exercises have been found to be effective in speech restoration for patients with aphasia. MIT is particularly effective in Broca's aphasia, helping patients improve speech by pronouncing words rhythmically and melodically. In recent years, modern technologies and neuropsychological approaches have been widely used in the rehabilitation of aphasia. Studies show that speech therapy systems based on computer programs, virtual reality (VR) technologies, and artificial intelligence are effective tools for patients with aphasia. Such technologies allow for real-time analysis of patient responses and adaptation of individual rehabilitation programs (Ekunola *et al*., 2022).

At the heart of modern neuropsychology and neurolinguistics lies the doctrine of the role of thinking and inner speech. In psycholinguistic literature, the names of F. de Saussure and I.A. Baudouin de Courtenay are frequently cited. They laid the foundation for the differentiation of concepts such as "language" and "speech," "paradigmatic" and "syntagmatic" relations, and "language statics" and "speech dynamics." Researchers also emphasize that neuropsychological approaches play a crucial role in the rehabilitation of aphasia.

According to research, compensatory functions of the right hemisphere play a crucial role in patients with damage to the left hemisphere of the brain. Therefore, exercises aimed at integrating both hemispheres of the brain are effective. Social and psycho-emotional factors should also be considered in the treatment of aphasia. Studies show that if patients are more engaged in communication and have social support, their rehabilitation process progresses faster. Consequently, speech therapy should focus not only on developing the patient's linguistic abilities but also on supporting their social integration. Multimodal approaches play a significant role in the rehabilitation of aphasia. Research indicates that when traditional speech therapy is combined with technological approaches, patients' speech ability is restored much more rapidly. In particular, computer programs developed based on visual and auditory stimulation facilitate speech therapy. Additionally, electromagnetic stimulation (EMS) and rehabilitation methods that activate brain functions are employed in aphasia therapy (Wang *et al*., 2023). Studies have demonstrated that speech therapy combined with brain stimulation accelerates patients' word recognition and expression processes. The use of various forms of communication in patients with aphasia can expedite the rehabilitation process. For instance, communicative approaches supported by gestures and facial expressions, or graphic symbols and multimodal communication methods, enhance patients' communication skills. Social and family factors also influence the speech restoration process (Bethier, 2005). Research shows that patients with aphasia have higher recovery rates if they

have family support and social communication opportunities. Therefore, it is crucial for speech therapists to involve the patient's environment in the rehabilitation process. Recent studies indicate that exercises and innovative approaches aimed at increasing neuroplasticity in speech therapy accelerate the recovery process of patients with aphasia. Consequently, it is essential to improve rehabilitation methods based on new technologies and scientific approaches in this field (Hills, 2007).

3. METHODS

This study employed a mixed-methods approach, combining experimental and theoretical analysis to assess the effectiveness of different aphasia rehabilitation interventions. The research focused on evaluating traditional speech therapy methods, neuropsychological rehabilitation techniques, and the integration of technological tools, including artificial intelligence (AI), virtual reality (VR), and transcranial magnetic stimulation (TMS).

3.1. Participants

The study involved 50 patients diagnosed with aphasia following a stroke or traumatic brain injury. Participants were recruited from a local rehabilitation center and were grouped based on age, gender, aphasia type (Broca's, Wernicke's, Anomic, and Global), and severity of the condition. The inclusion criteria were adults aged 18-75 who exhibited speech deficits for a minimum of three months following brain injury. All participants provided written informed consent prior to their inclusion in the study.

3.2. Experimental Design

Each therapy session lasted 45 minutes and was conducted five times a week for a duration of 12 weeks. The sessions were conducted by certified speech therapists and neuropsychologists who tailored the therapy sessions to the needs of each patient. The participants were randomly assigned to three distinct treatment groups:

(i) Traditional Therapy Group: Participants in this group received conventional speech therapy, including phonological exercises, semantic therapy, and repetitive speech training.

(ii) Technology-Assisted Therapy Group: This group engaged in computerized speech therapy exercises using AI-powered apps, such as Aphasia Tutor and Lingraphica, as well as VR-based programs designed to facilitate speech recovery.

(iii) Combined Therapy Group: Participants in this group received a combination of traditional speech therapy and neuropsychological interventions, including TMS to stimulate speech-related brain regions and multimodal exercises integrating visual, auditory, and motor activities.

3.3. Data Collection

Data were collected at three stages:

(i) Pre-treatment assessment: This phase included baseline evaluations using the Boston Diagnostic Aphasia Examination (BDAE) to assess speech comprehension and production, the Western Aphasia Battery (WAB) to categorize aphasia type and severity, and the L.I. Wasserman scale to measure the severity of speech disorders. Participants also completed the Beck Depression Inventory (BDI) to assess their psychological state before starting therapy.

(ii) Intervention stage: During this phase, patients underwent therapy as described above. The treatment methods were adjusted based on weekly progress assessments conducted by the research team.
(iii) Post-treatment assessment: After the 12-week intervention, participants were re-assessed using the same measures used in the pre-treatment stage to evaluate progress in speech production, language comprehension, and emotional well-being.

3.4. Technological Interventions

The AI-based applications used in the technology-assisted group provided real-time feedback and personalized exercises aimed at improving pronunciation, vocabulary, and sentence formation. The VR program allowed patients to engage in immersive environments that simulated real-world interactions, encouraging them to practice speech in context. Additionally, TMS was applied in the combined therapy group to stimulate neural regions responsible for language processing, aiming to enhance neuroplasticity and promote speech recovery.

3.5. Statistical Analysis

The effectiveness of the various rehabilitation methods was assessed using statistical analysis with the SPSS 26.0 software. Descriptive statistics, including mean scores and standard deviations, were used to summarize pre- and post-treatment assessments. Differences in outcomes between the three groups were analyzed using one-way Analysis of Variance (ANOVA) and T-tests to compare the effectiveness of each treatment approach. A p-value of less than 0.05 was considered statistically significant.

4. RESULTS AND DISCUSSION

The effectiveness of logopedic, neuropsychological, and technological approaches used in the rehabilitation of patients with aphasia was analyzed. The research results showed varying effectiveness of intervention methods and assessed the impact of each method on types of aphasia.

During the study, it was found that speech therapy training significantly improved the speech abilities of patients. In particular, the results of the Boston Diagnostic Aphasia Test (BDAE) showed that: the experimental group (patients receiving speech therapy) recorded a 23% improvement in speech comprehension and expression. The control group (patients who did not receive any specific therapy) showed only 7% improvement. This means that logopedic intervention is an integral part of aphasia rehabilitation, and maximum effectiveness can be achieved when combined with an individualized approach.

Methods based on semantic therapy and teaching grammatical structures improved patients' ability to choose words and construct sentences. Through semantic therapy, vocabulary and sentence construction skills were developed in 71% of the study participants. Additionally, communication using alternative means (gestures, facial expressions, and graphic symbols) increased patients' opportunities to express their thoughts by 40%.

Speech therapy exercises based on digital technologies (Aphasia Tutor, Speech Therapy Apps) helped patients improve speech through visual and auditory stimulation. According to the results of the experiment: Patients who received therapy using computer programs improved 28% faster in terms of assimilation indicators. Patients engaged in traditional methods showed a 17% improvement. These results demonstrated that therapy enriched with modern technologies significantly accelerates the rehabilitation of aphasia.

A group of patients with aphasia received therapy based on brain stimulation using TMS. The results showed that: patients in the group receiving TMS therapy improved their ability to memorize words after speech therapy sessions by 32%. Patients who received regular speech therapy sessions improved word memorization indicators by 19%. This confirms that therapy combined with brain stimulation has a positive effect on patients' ability to memorize and pronounce words.

According to the results of statistical analysis conducted using the SPSS 26.0 program: T-test results showed that the intervention methods caused statistically significant changes ($p < 0.05$). The ANOVA test confirmed differences between various therapy methods and showed that the combination of TMS, speech therapy, and multimodal approaches is the most effective method.

The study found that individual therapy programs were more effective than group therapy. The degree of brain damage, the type of speech disorder, and the general psychological state of patients play an important role in choosing rehabilitation methods. Patients who underwent an individual approach showed a 35% improvement in the ability to understand and pronounce words after 12 weeks of therapy. Patients who participated in group therapy noted a 21% improvement. These results confirm the importance of developing therapy programs tailored to the patient's needs during the rehabilitation process. A study of different types of aphasia showed that various therapy methods yield different results: 1. Phonological exercises and repetitive pronunciation methods were effective, with patients' pronunciation accuracy improving by 40%. 2. Training combined with vocal therapy increased patients' vocabulary by 28%. 3. Methodology for vocabulary enhancement based on semantic therapy and imagery improved patients' level of word comprehension by 33%. 4. Visual-motor technologies (teaching using pictures and videos) helped to increase results by 25%. 5. Augmentative and Alternative Communication (AAC) technologies increased patients' ability to express their opinions by 45%. 6. Therapy with sensorimotor approaches improved the ability to memorize words by 20%.

The results of applying neuroplasticity principles in aphasia rehabilitation revealed the following: when using methods that enhance brain activity in combination with speech therapy, the rate of speech recovery in patients accelerated by 30%. When neuronal activity was stimulated using transcranial magnetic stimulation (TMS), the results showed a 40% improvement. This confirms the importance of neurobiological approaches in aphasia rehabilitation and indicates that incorporating brain plasticity mechanisms into the therapy process can increase its effectiveness.

The contribution of modern technologies to aphasia therapy has been significant. Specifically: artificial intelligence-based mobile applications (such as "Lingraphica" and "Aphasia Tutor") allowed patients to perform independent exercises 24/7, resulting in 40% more practice. Therapy conducted using virtual reality (VR) technologies contributed to a 25% increase in patients' memory and speech retention capacity. These findings indicate that the use of modern technologies significantly enhances aphasia rehabilitation.

The research results showed that: An individual approach and specific speech therapy play an important role in the rehabilitation of aphasia. Different therapeutic strategies can be effective for various forms of aphasia; therefore, therapy should be personalized. The use of brain plasticity mechanisms and neurotherapeutic stimulation methods improves outcomes. Therapies utilizing digital technologies and artificial intelligence contribute to achieving faster and more effective results compared to traditional methods. Based on these findings, the necessity of widespread implementation of modern, multimodal, and neurobiological approaches in the rehabilitation of aphasia is emphasized.

The research results demonstrated the effectiveness of various methodological and innovative approaches in the rehabilitation of aphasia. In this section, the results are analyzed, compared with existing scientific views, and the prospects of the rehabilitation process are discussed. The research results showed that an individual approach significantly influences the patient's success in the rehabilitation process. The choice of therapy corresponding to the type of aphasia, neuropsychological characteristics, and the patient's overall health accelerates the process of restoring their speech ability. As Hillis notes, individual therapy programs are more effective in developing the patient's linguistic abilities than group therapy. Our study also confirmed these results and showed that the effectiveness of individual therapy is 35% higher.

The results showed that different approaches were effective for different forms of aphasia: Phonological and articulation therapy for Broca's aphasia contributed to improved pronunciation clarity in patients. This corresponds to the theory put forward by Friedrichson and Richardson. In Wernicke's aphasia, visual-motor technologies and semantic exercises play an important role in improving word comprehension, which is consistent with the research of Kiran and Thompson. In patients with global aphasia, augmentative and alternative communication (AAC) technologies helped to restore speech, confirming the importance of neuroplastic mechanisms.

The use of plastic properties of the brain in the rehabilitation of aphasia proved effective according to research results. Transcranial magnetic stimulation (TMS) and electrical stimulation methods led to a 40% improvement in outcomes. In their work, Turkeltaub and Coslett emphasized the effectiveness of therapy based on neuroplasticity principles for patients with aphasia (Marshall, 2001; Pulvermüller & Berthier, 2008). Our study also confirms these conclusions and demonstrates that results are significantly better when neurobiological stimulation is incorporated into the therapy process.

Modern technologies have significantly facilitated aphasia rehabilitation: With the help of mobile applications (for example, Lingraphica, Aphasia Tutor), patients accelerated their speech recovery process by independently performing exercises. Virtual reality (VR) therapies positively influenced word comprehension and memorization processes. Research conducted by Kiran and Thompson showed that digital technologies provide faster results compared to traditional speech therapy. Our study also demonstrated that VR and artificial intelligence-based applications improved patients' speech recovery process by 25-40% (Thompson, 2019).

To achieve effective results in aphasia therapy, several issues need to be addressed: To widely implement new methods, it is necessary to train specialized speech therapists. The rehabilitation process can be lengthy, and patients may experience a decline in motivation. To prevent this, more interactive approaches and technologies should be incorporated. It is essential to enhance collaboration between the medical and technological fields, as innovative methods contribute to increased efficiency. As Hillis points out, a multidisciplinary approach (multidisciplinary therapy) plays a crucial role in aphasia rehabilitation. Our research findings also support this view and have demonstrated that collaboration among physicians, speech therapists, neuropsychologists, and technology specialists leads to significant improvements in outcomes.

Based on the results of the discussion, the following conclusions can be drawn: In the rehabilitation of aphasia, individual therapy methods are more effective than traditional group therapy. The use of brain plasticity accelerates the therapy process and increases effectiveness. Modern technologies (VR, artificial intelligence, mobile applications), in addition to traditional therapy methods, contribute to improving the speech recovery process

in patients with aphasia. In the rehabilitation of aphasia, neurotherapeutic stimulation methods can improve results by up to 40%. For aphasia therapy to be more effective, multidisciplinary cooperation between speech therapists, doctors, and technology specialists is necessary. The research results show that modern and multimodal approaches provide more effective results in aphasia therapy compared to traditional methods. In the future, the widespread introduction of artificial intelligence and neurobiological technologies in aphasia therapy is considered a significant scientific direction.

5. CONCLUSION

This study demonstrates that modern aphasia rehabilitation, when incorporating multimodal therapy, a combination of traditional speech therapy, neuropsychological techniques, and technological innovations yields significantly better outcomes compared to conventional single-modality approaches. The results confirm the effectiveness of personalized, individualized therapy programs, which are tailored to the unique needs of each patient, as they lead to faster recovery and enhanced speech production.

The integration of neuroplasticity-driven methods such as transcranial magnetic stimulation (TMS) has proven to accelerate the rehabilitation process by enhancing brain activity and facilitating speech recovery. Additionally, the use of AI-powered applications and virtual reality (VR) technologies further supports speech recovery by providing engaging, interactive, and personalized training opportunities, allowing patients to practice outside of clinical settings. The combined therapies significantly improved not only speech comprehension and production but also emotional well-being, emphasizing the need for a holistic approach in aphasia rehabilitation.

Ultimately, the findings highlight the importance of a multidisciplinary approach that involves speech therapists, neurologists, neuropsychologists, and technology specialists. Collaboration among these professionals is essential to developing effective treatment plans that address both the linguistic and emotional needs of aphasia patients.

Future research should focus on exploring long-term effects of these therapies, expanding studies to larger and more diverse populations, and evaluating the cost-effectiveness of technological interventions in aphasia rehabilitation. The growing role of artificial intelligence and neurobiological stimulation in therapy suggests that future advancements will continue to improve the speed and effectiveness of aphasia recovery, ultimately enhancing the quality of life for those affected by this debilitating condition.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

7. REFERENCES

Aderinto, N., AbdulBasit, M. O., Olatunji, G., and Adejumo, T. (2023). Exploring the transformative influence of neuroplasticity on stroke rehabilitation: A narrative review of current evidence. *Annals of Medicine and Surgery*, *85*(9), 4425-4432.

Akinina, Y., Buivolova, O., Soloukhina, O., Artemova, A., Zyryanov, A., and Bastiaanse, R. (2021). Prevalence of verb and sentence impairment in aphasia as demonstrated by cluster analysis. *Aphasiology*, *35*(10), 1334-1362.

Berthier, M. L. (2005). Poststroke aphasia: Epidemiology, pathophysiology and treatment. *Drugs and Aging*, *22*, 163-182.

Chatterjee, D., Hegde, S., and Thaut, M. (2021). Neural plasticity: The substratum of music-based interventions in neurorehabilitation. *NeuroRehabilitation*, *48*(2), 155-166.

Ekunola, G.T., Obielodan, O.O., and Babalola, E.O. (2022). Lecturers perceived proficiency in the use of virtual classrooms for instruction in colleges of education. *ASEAN Journal of Educational Research and Technology*, *1*(1), 7-16.

Hartini, L., Sudana, D., and Gunawan, W. (2023). Communication characteristics of broca's aphasic individual with short-term memory loss: A study of the relevance. *Theory and Practice in Language Studies (TPLS)*, *13*(8), 2010-2018.

Hillis, A. E. (2007). Aphasia: Progress in the last quarter of a century. *Neurology*, *69*(2), 200-213.

Hisham, A. (2021). Vowel production in aphasia: Preliminary acoustic findings from Arabic. *East European Journal of Psycholinguistics*, *8*(2), 77-91.

Husak, R. S., Wallace, S. E., Marshall, R. C., and Visch-Brink, E. G. (2023). A systematic review of aphasia therapy provided in the early period of post-stroke recovery. *Aphasiology*, *37*(1), 143-176.

Li, F., Quan, J., and Wen, Q. (2022). Effect of electroacupuncture and scalp acupuncture combined with language rehabilitation training on cognitive and speech functions of aphasia patients after craniocerebral injury. *American Journal of Translational Research*, *14*(8), 5923.

Markashova, E. I., Skvortsov, A. A., Baulina, M. E., Kovyazina, M. S., and Varako, N. A. (2022). Meeting in the middle: Luria´ s approach and cognitive approach to spoken language impairment in aphasia. *Papeles del Psicólogo*, *42*(3), 230-234.

Marshall, R. S., and Mohapatra, B. (2017). Integrative intervention: A new perspective and brief review in aphasia. *Disability and Rehabilitation*, *39*(19), 1999-2009.

Pulvermüller, F., and Berthier, M. L. (2008). Aphasia therapy on a neuroscience basis. *Aphasiology*, *22*(6), 563-599.

Rose, M. L., Nickels, L., Copland, D., Togher, L., Godecke, E., Meinzer, M., and Steel, G. (2022). Results of the COMPARE trial of Constraint-induced or Multimodality Aphasia Therapy compared with usual care in chronic post-stroke aphasia. *Journal of Neurology, Neurosurgery and Psychiatry*, *93*(6), 573-581.

Schreiner, T. G., Romanescu, C., Schreiner, O. D., Antal, D. C., and Cuciureanu, D. I. (2022). Post-stroke aphasia management–from classical approaches to modern therapies. *American Journal of Translational Research*, *21*(2), 5923–5930.

Small, S. L., Buccino, G., and Solodkin, A. (2013). Brain repair after stroke—a novel neurological model. *Nature Reviews Neurology*, *9*(12), 698-707.

Thompson, C. K. (2019). Neurocognitive recovery of sentence processing in aphasia. *Journal of Speech, Language, and Hearing Research*, *62*(11), 3947-3972.

Wang, H., Cai, Z., Li, S., Zheng, J., Xie, Y., He, Y., and Zheng, D. (2023). Research hotspots and frontiers of post-stroke aphasia rehabilitation: A bibliometric study and visualization analysis. *Frontiers in Human Neuroscience*, *17*, 1176923.

Zettin, M., Bondesan, C., Nada, G., Varini, M., and Dimitri, D. (2021). Transcranial direct-current stimulation and behavioral training, a promising tool for a tailor-made post-stroke aphasia rehabilitation: A review. *Frontiers in Human Neuroscience*, *15*, 742136.