V. SERBSKY NATIONAL MEDICAL RESEARCH CENTRE FOR PSYCHIATRY AND NARCOLOGY

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MODELLING SENSORY-ENRICHED ENVIRONMENT IN IN THE PROCESS OF REHABILITATION OF PATIENTS WITH COGNITIVE IMPAIRMENT (ON THE EXAMPLE OF APHASIA DISORDERS)

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INTRODUCTION

The relevance of the study's topic. Cognitive impairment refers to disorders of a wide group of mental functions – memory, speech, gnosis, thinking, attention, reading, writing and counting. The cause of their occurrence is local brain damage and, in most cases, vascular aetiology (Hachinski V., 1994, 2006; Barber R. Et al. 2001; Parfenov V.A. et al., 2012; Kawashima R., 2013; Li X. et al., 2016). Aphasia is included in the triad of the most common types of post-stroke cognitive impairment, along with disorders of executive functions and memory. With damage to the left hemisphere, cognitive impairment usually has a moderate or severe degree (Kivipelto M.et al.,2001; Barker W.W. et al., 2002; Chui H., Skoog I., 2006; Parfenov V.A. et al., 2012; WHO, 2015; Kolykhalov I.V., 2018; Verbitskaya S.V., 2018; Shklovsky V.M. et al., 2021). In cases of incomplete restoration of higher cortical function, the probability of an increase in general cognitive deficit increases, which can reach pre-dement disorders (Verbitskaya S.V., 2008; Parfenov V.A. et al., 2014; Rosen H.J. et al., 2000; Peterson R.C., 2001, 2004, 2014; Sun J.H. et al., 2014). According to WHO forecasts, by 2050, compared with 2018, the number of people with dementia will increase three times and reach 145 million people (WHO, 2015).

The high prevalence of aphasia determines the relevance of further study of its structure and composition of the aphasic syndrome, taking into account the role of the right and left hemispheres in their formation (Luria A.R., 1962; Chomskaya E.L., 2002; Tsvetkova L.S., 2011). Insufficient knowledge of the extra-focal neuropsychological symptoms of the affected and healthy hemisphere in patients with aphasia (Luria R.A., 1962, 1969) makes it difficult to understand the range of preserved and damaged functions. The incompleteness of the description of the neuropsychological picture of the consequences of focal brain damage in patients with aphasia limits the assessment of the compliance of the methods used, the depth of interventions and procedures of speech rehabilitation with the patterns of disorders of higher cortical functions.

The next important area of research is the study of ways to restore speech to develop effective approaches to its restoration. Insufficient consideration of neuroplasticity – the ability of the brain to spontaneously rebuild damaged mental function – and its hemispheric orientation in aphasic disorders (Shklovsky V.M. et al., 2021) affects the effectiveness of neuropsychological rehabilitation. Accumulation and integration of knowledge about aphasia is a necessary step in solving the central task of neuropsychological rehabilitation – increasing the degree of restoration of damaged mental function.

At the present stage of development of neuropsychological rehabilitation of patients with aphasia topical area of research is the development of a methodological approach to the restoration of speech based on the integrated analysis of the psychological and neurophysiological patterns of recovery of language functions (Luria, A. R., 1962; Tsvetkova L. S., 2011; Kusheva E. V., Damulin I. V., 2013; Akhan'kova T.E. et al., 2019; Oujamaa L. Et al., 2009; Grefkes, C., Fink, G. R., 2011; Dijkhuizen, R. M. et al., 2014; Stinear, C. M. et al., 2015; J. Veldema et al., 2017).

The study of the structure of neuropsychological aphasia syndrome and ways to restore speech continue to be relevant areas of domestic and world neuropsychology, which is explained by the high prevalence of aphasia and low statistics of complete speech recovery.

Social significance. Most cases of cognitive impairment are caused by the effects of vascular damage to the brain. Their most common manifestations are aphasias. Limitation of the possibility of verbal communication in patients with aphasia inevitably leads in the long term to a narrowing of the range of interests of the individual, difficulties in setting near and far life goals, increased social isolation, up to seclusion, and limited legal capacity (Tsvetkova L.S., 1988, 2002, 2004; 2011; Kurland B.F. et al., 2016). Chronicling cognitive deficits increases the risk of developing dementia by 1-2% every year (Pulvermüller F. et al., 2001; Moreira Sh.V. et al., 2018).

Aphasia not only reduces the quality of life of the patient himself but also limits the possibility of full-fledged communication with his immediate environment and their employment. In 67% of cases, family members are forced to leave work: 17% – for up to 1 month, 25% – for up to 6 months, 21% – completely. Therefore, the development of methods of neuropsychological rehabilitation is among the priorities in the field of scientific research on ways to restore cognitive impairment.

The creation of effective methodological approaches to restorative speech training in aphasia will help overcome the socio-economic consequences of patients with speech disorders: limitation of the patient's legal capacity, creation of special conditions for his support, the need for guardianship, and part-time employment of family members.

Current status of the problem. Aphasia is defined as a speech and language impairment, "a pathological formation leading to the disintegration of the entire mental sphere, personality and activity of the subject" (Tsvetkova L.S., 2011, p. 25). Clinical neuropsychological practice shows that the symptomatology of aphasic syndromes is not limited to primary and secondary symptoms, which reflect disorders of the neuropsychological factor and its systemic consequences (Luria A.R., 1962, 1969). Along with them, there are non-focal neuropsychological symptoms that fall out of the diagnostic field of a medical (clinical) psychologist, as they are not directly related to the range of damaged functions and the topical location of focal brain damage. The spectrum of non-focal symptoms is little reflected in studies of aphasia, despite the depth of knowledge of the brain organization of higher cortical functions and the principles of hemispheric interaction (Anokhin P.K., 1955, 1970, 1973; Traugott N.N., 1981, 1986). It is assumed, that non-focal symptoms are a manifestation of defect compensation, i.e. tertiary symptoms formed as a result of the spontaneous restructuring of impaired function (Crosson B., Warren L., 1981; Moore B.D. et al., 1988; Papanicolaou et al., 1988a, 1988b; Xing S., 2016; Kourtidou E. et al., 2021). In neuropsychology, comparative studies of tertiary symptoms are necessary, taking into account the extent of the lesion, the nature of the disease, age, and level of education (Traugott N.N., 1981). The issue of the dynamics of tertiary symptoms, their association with the aphasia type and the dynamics of speech recovery is not covered.

Understanding the spectrum of neuropsychological symptoms of aphasic syndrome, including tertiary symptoms and their lateral (hemispheric) sign helps not only in solving the diagnostic problem but also in determining the congruent hemispheric and topical vector of neurocognitive restorative measures.

To date, the problem of restoring aphasic disorders is far from being resolved. The percentage of patients with a level of communication that does not limit their ability to work remains extremely low and does not exceed 15-20%. Most often these are patients with hereditary left-handedness. The traditional neuropsychological approach to speech restoration, developed in Russian neuropsychology, proceeds from the idea of overcoming speech disorders in a roundabout way by relying on preserved levels of function and other mental processes interacting with the affected function. Without denying the deep influence of Russian neuropsychology on the creation of the scientific foundations of neuropsychological rehabilitation, the development of its principles, methodology, and methodological tools, requires updating for several objective reasons.

It has been established that brain plasticity, which is the main factor determining the process of restoring higher cortical functions and the ability to compensate for the defect, persists in adulthood and old age. A new understanding of the age-related framework of brain plasticity is reflected in the concept of late ontogenesis, which refers to the ability of a mature brain to brain rearrangements, to the appearance of new psychological neoplasms. The methodological content of the traditional approach does not sufficiently reflect the mechanism of psychological influences that contribute to the formation of mental neoplasms, and the procedural conditions that contribute to this process.

The traditional approach to speech restoration proceeds from the idea of reducing speech disorders by restructuring the psychological structure of speech mainly along the intrahemispheric pathway. The possibility of interhemispheric cerebral reorganization of damaged speech function is not considered as a way to ensure the completeness of speech recovery (Tsvetkova L.S., 1985, 2011). In the methodology of neuropsychological rehabilitation of speech in patients with intrahemispheric aphasia, the role of the mechanism of interhemispheric interaction is underestimated, which is in certain contradiction with the understanding of the bi-hemispheric nature of the cerebral foundations of speech function. In right-handed people, the bi-hemispheric nature of the speech function is manifested in the dominance of the left hemisphere about the lexical and grammatical level of speech and the right hemisphere about its prosodic, intonation-melodic side (Chomskaya E.D., 2002; Tsvetkova L.S., 1988, 2004). Both hemispheres are involved in the process of speech restoration and to varying degrees, depending on the initial severity of the violation of speech function and the dynamics of its restoration (Schlaug G. et al., 2011). In neuropsychological rehabilitation, the range of parameters has not been sufficiently studied, except the side of brain damage, which determines the leading path of cerebral restructuring of impaired function.

The direction of neuropsychological rehabilitation, which reflects the concept of systemic effects on speech impairment based on intra- and interhemispheric restructuring of function, is based on the use of sensory-enriched media. The modality of the sensory environment has a focal effect on the preserved sides of speech and relies on the activation of a healthy hemisphere. At the moment, the use of sensory-enriched media is exploratory, as are the proposed techniques and methods. Theoretical foundations and an algorithm for modelling sensory-enriched environments have not been developed, and there is no justification for their methodological tools.

Thus, the current state of the degree of development of the problem of neuropsychological mechanisms for the restoration of aphasic disorders, and structural components of aphasic syndrome require theoretical justification and empirical content.

The following issues also remain unresolved in medical psychology: dynamic changes in the structural components of the aphasic syndrome, the hemispheric (lateral) vector of these changes and its connection with the reduction of speech disorders.

The aim of the study. Theoretical and empirical substantiation of a structural-dynamic model of aphasic syndrome for the development of a neuropsychological approach to rehabilitation of patients with aphasia in a modelling sensory-enriched environment.

The object of the study. The role of neuropsychological and neurobiological parameters in the formation and dynamics of neuropsychological syndrome in patients with aphasia.

The subject of the study. The neuropsychological structure of aphasia syndrome and its dynamics during speech rehabilitation in a focus-modelling sensory-enriched environment.

Research hypotheses

Theoretical hypotheses:

1. In the structure of the aphasic syndrome, along with primary and secondary symptoms caused by a violation of the neuropsychological factor, tertiary symptoms are noted, which are a reflection of the mechanisms of intrahemispheric and interhemispheric interaction in compensation for the defect.

2. Tertiary symptoms, which are a manifestation of spontaneous cerebral reorganization of impaired higher mental function, are obligate.

3. The reduction of tertiary symptoms will be selective and determined by the neuropsychological parameters of the aphasic syndrome.

4. A low susceptibility to tertiary symptoms of reduction will be evidence of the completion of the process of entry of the corresponding brain structures into the new brain organization of impaired speech function and a high susceptibility to the incompleteness of this process.

5. Compensation for aphasic defect is expressed in cerebral intra- and interhemispheric rearrangement of impaired speech function, which has patterns determined by several neuropsychological and neurobiological parameters.

6. Strengthening the mechanisms of intra- and interhemispheric intersensory interaction (sensory integration) of the preserved parts of the affected and homologous

parts of the intact hemisphere can be achieved by modelling therapeutic sensory-enriched environments.

7. The modelling sensory-enriched environment will have a different effect on the dynamics of speech disorders and the tertiary symptoms of aphasic syndrome.

8. The methodology of neuropsychological rehabilitation of aphasia, based on taking into account the patterns of intra- and interhemispheric restructuring of impaired higher mental function, has greater comparative rehabilitation effectiveness than the traditional approach to rehabilitation of aphasia, based on the idea of intrahemispheric restructuring of function as the main way to restore it.

***Empirical hypotheses*:**

1. Unilateral lesions of the speech departments of the left hemisphere of the brain lead to the formation of a bipolar picture of aphasic syndrome, which is manifested by associated neuropsychological symptoms characteristic of both the affected area of the brain and the mirror sections of the healthy hemisphere, and functionally related to the affected area of the extra-focal departments of the same hemisphere and homologous structures of the intact hemisphere.

2. The severity and spectrum of pathological symptoms of the intact hemisphere and non-focal parts of the left hemisphere are determined by several neurobiological (profile of manual asymmetry, topic, volume of the lesion) and neuropsychological parameters (type, severity, prescription of aphasia).

3. In patients with aphasia, a positive rehabilitation shift in speech restoration in a modelling sensory-enriched environment can be achieved if the algorithm for modelling the sensory therapeutic environment is relevant to neuropsychological and neurobiological patterns of restoration of higher mental functions and spatial-temporal synchronization of sensory and mental effects.

4. The hemispheric focus of sensory stimulation is determined by the topical characteristics of focal brain damage and the type of aphasia.

5. The type of sensory-enriched environment in different types of aphasia has a selective effectiveness of influencing quantitative and qualitative indicators of speech and mental processes mediated by it.

Research objectives

By the purpose and hypotheses, the following theoretical and empirical tasks are solved:

Theoretical tasks:

1. To conduct a theoretical and methodological analysis of the history, current state and trends in the development of views on aphasic syndromes in modern neuropsychology.

2. To analyze the theoretical foundations, directions and modern neurorehabilitation approaches to speech restoration in patients with aphasia.

3. To give a meaningful interpretation of the mechanism of interhemispheric interaction in the rehabilitation of aphasic disorders.

Empirical tasks:

1. To substantiate and develop neuropsychological diagnostic complexes for the detection of stealing symptoms (oppression) of the intact hemisphere and the preserved parts of the affected hemisphere in patients with aphasia.

2. To determine the patterns of intra- and interhemispheric restructuring (reorganization) of speech function in patients with aphasia.

3. To substantiate a structural and dynamic model of the aphasic syndrome, including the development of a methodology, algorithm and principles for modelling a sensory-enriched environment to restore speech in patients with aphasic disorders.

4. To develop and substantiate methodological complexes for the rehabilitation of patients with aphasia in a modelling music-enriched and polysensory-enriched environment.

5. To substantiate and develop methodological complexes for assessing the dynamics of the speech status of patients with aphasia during rehabilitation in a modelling music-enriched and polysensory-enriched environment.

6. To evaluate the therapeutic effectiveness of the tested approach based on a comparative analysis of the regression dynamics of aphasic disorders in the conditions of speech restoration in a modelling sensory-enriched environment and the traditional neuropsychological and pedagogical approach to speech rehabilitation.

7. To evaluate the comparative effectiveness of speech restoration in monosensory (music-enriched) and polysensory-enriched environments in patients with efferent motor and acoustic-mnestic aphasia with different initial severity of expressive speech disorders.

The methodological basis of the dissertation research were the ideas of post-non-classical rationality about the subject of research as a complex self-developing dynamic system (Stepin B.C., 1989, 2009); the principles of post-non-classical methodology for solving theoretical and applied problems of psychological science; the idea of the syndrome analysis of L.S. Vygotsky and A.R. Luria as a systemic model of post-non-classical rationality, which considers the clinical and psychological the syndrome as a polycausal complex self-developing system; syndrome-forming factor as a multilevel integrative education (Tsvetkova L.S. et al., 2008; Tsvetkova L.S., 2011; Zinchenko Yu.P. et al. 2012; Mezzich J.E. et al., 2013; Salvador-Carulla L et al., 2013).

The theoretical basis of the study were the fundamental provisions of Russian psychology on the cultural and historical nature of the human psyche and the systemic structure of higher mental functions (Vygotsky L.S., 1927, 1984; Luria A.R., 1948, 1962, 1969, 1970); the position on the unity of consciousness and activity in mental reflection (Leontiev A.N. 1959, 1974 1977; Rubinstein S.L., 1946, 1957); the regulation on the principles of development and patterns of decay of higher mental functions (Davidenkov S.N., 1963;. Asratyan E.A., 1953; Anokhin P.K., 1955; Vygotsky L.S., 1984; Luria A.R., 1948, 1962, 1966, 1969, 1973, 1974, 1975); the provisions of neuropsychology and neurophysiology on the dynamic and systemic localization of higher mental functions in the brain (Ukhtomsky A.A., 1927, 1945; Vygotsky L.S., 1927; Anokhin P.K., 1949, 1968, 1970, 1973, 1980; Vvedensky N.E., Ukhtomsky A.A. 1950; Bernstein H.A., 2003); the principle of factorial and syndrome analysis of a defect (Luria A.R., 1947, 1948, 1962, 1969, 1973; Tsvetkova L.S., 1985; 2002; 2011; Chomskaya E.D., 2002); scientific principles rehabilitation training (Tsvetkova L.S., 1972, 1982, 1985, 1988, 2002, 2011).

Novelty and theoretical significance of the study. An original structural and dynamic model of aphasic syndrome has been developed, reflecting the role of mechanisms of intra- and interhemispheric interaction in its formation.

For the first time, a comprehensive study was conducted and the influence of neuropsychological and neurobiological parameters on the formation of the symptom complex of aphasic syndrome was determined.

An original diagnostic set of methods has been developed to identify neuropsychological oppression symptoms of the preserved parts of the left and right hemispheres in patients with aphasia.

A new methodological approach to the rehabilitation of patients with aphasia has been developed, which takes into account the neuropsychological and neurobiological patterns of speech function restoration, the bi-hemispheric symptoms of aphasic syndrome and the role of mechanisms of interhemispheric and intersensory interaction in this process.

The principles were formulated for the first time, and an algorithm and methodological complexes for modelling a music-enriched and polysensory- enriched environment were developed.

For the first time, a comparative study of the effectiveness of speech rehabilitation of patients with aphasia in music-enriched and polysensory-enriched environments and with a traditional approach to speech restoration was conducted.

It is the first neuropshychological work where was analyzed the effect of the time post-onset and volume of focal brain damage in right-handed patients with different types and severity of aphasia on the regression of speech disorders and the dynamics of parameters of cognitive and regulatory functions in other approaches to speech therapy.

The practical significance of the study. The results of the study allow us to answer several important questions of neuropsychology: the role of the mechanism of interhemispheric interaction in the rehabilitation of chronic cognitive disorders and neuropsychological and neurobiological factors in this process.

A new concept of "modelling sensory-enriched environment" is introduced into neuropsychological rehabilitation. The author presents the principles and algorithms of its construction (modelling).

Diagnostic complexes of methods have been developed that make it possible to identify oppression symptoms of the right and left hemispheres and their topical localization.

Methodological complexes have been developed for modelling a music-enriched and polysensory-enriched environment.

The effectiveness of aphasia rehabilitation in music-enriched and polysensory-enriched environments and their selective effectiveness in different types of aphasia is shown.

The developed neuropsychological methodological approach to the rehabilitation of aphasic disorders in a sensory-enriched environment can be used in the work of memory clinics, neurorehabilitation departments and centers, sanatorium institutions, centers of Moscow longevity, in psychological support of persons with dementia and chronic mental disorders accompanied by cognitive decline, as well as for the prevention of pre-dement (pre-dement) disorders.

For the first time, the selectivity of the effects of a music-enriched and polysensory-enriched environment on speech indicators, depending on the type and severity of aphasia, is shown.

Research methods. Within the framework of the dissertation research, clinical psychological and experimental psychological methods were used to assess the dynamics of parameters of higher mental functions during neuropsychological rehabilitation of right-handed patients with different time post-onset, types, and aphasia severity, volume and topic of focal brain damage. A clinical-psychological method was represented by speech techniques that assess speech at the level of words, phrases and monologue, and the methods that evaluated a wide cognitive sphere, including executive functions, as well as the diagnostic complexes for detecting symptoms of depression in healthy parts of the right and left hemispheres. The speech techniques included free and directed phonological associations, methods for evaluating speech in aphasia and the speed of coherent spontaneous speech.

The diagnostic complex for detecting the right hemisphere stealing symptoms consisted of recognition of uncompleted subject images, objects in conditions of visual noise and with incomplete image saturation gradient; identification of familiar faces; retention of schematized faces, retention of difficult-to-visualize graphic images, stereognosis on the non-leading (left) hand, mental rotation of an object in two-dimensional space.

The diagnostic complex for detecting the left hemisphere stealing symptoms included the following methods: objects retention of object (verbalized) images; comparison of a three-dimensional figure and its sweep; stereognosis on the leading (right) hand.

Techniques to assess the state of the cognitive sphere and control functions included the MoCA test, the frontal dysfunction battery (FAB test) and the "retelling the story" subscale of the RBMT-3 test.

With the help of neuropsychological techniques, quantitative and qualitative diagnostics of parameters of the expressive and expressive sides of speech function, regulatory, mnestic and thought processes, visual and tactile gnosis were carried out.

The experimental psychological method was presented by the method of the dichotic listening task, that evaluated the parameters of auditory-speech perception: the index of laterality, the coefficient of the leading ear, and the effectiveness and productivity of auditory-speech perception.

The reliability of the survey results and the personal contribution of the author. The reliability of the scientific statements and conclusions formulated in the dissertation research is confirmed by the use of a set of complementary diagnostic techniques relevant to the purpose and objectives of the study, as well as by attracting sufficient factual material and its versatile analysis, representative sampling of the surveyed, careful quantitative and qualitative analysis, correct application of individual empirical research techniques and methods of statistical processing of the data obtained.

The empirical material of the dissertation is based on a representative sample (177 aphasia patients) and includes the results of the studies performed by the author independently, including 3.136 units of diagnostic assessments and 1.150 individual rehabilitation sessions

The work contains the materials of the author's research, which was conducted in the period from 2010-2024. During this period, the author analyzed extensive psychological, medical and neurobiological literature, and systematized the views of domestic and foreign authors on the nature of aphasia and ways to overcome it. The analysis of modern neuropsychological and neurobiological trends in rehabilitation and the influence of sensory environments on higher human mental functions (HHF) recovery. The theoretical analysis of the issues of violation and restoration of higher mental functions allowed us to formulate the goals, objectives and hypotheses of empirical research.

To verify the proposed provisions, an independent empirical study was conducted, including longitudinal neuropsychological rehabilitation programs in a modelling sensory-enriched environment according to a scientifically based algorithm developed by the author. The study is based on the results of neuropsychological diagnostics, including instrumental ones, in patients with different aphasia types, time post-onset, and structural and topographic characteristics of left hemisphere focal lesions.

The empirical data obtained were processed and analyzed by the applicant and original conclusions were drawn.

Approbation of the work. The main results of the work were reported at 25 international and 15 All-Russian scientific conferences, including the All-Russian Conference "Biopsychosocial approach to the problem of neurorehabilitation" (St. Petersburg, May 22-23, 2015), at the VII International Congress "Neurorehabilitation-2015" (Moscow, June 2-3, 2015), at the XII International Congress "Neuroscience for Medicine and Psychology" (Sudak, June 5-11, 2016), at the All-Russian Congress "Modern concepts of Rehabilitation in psychoneurology: denial of denial" (St. Petersburg, June 9-11, 2016), at the IX International Congress "Neurorehabilitation-

2017" (Moscow, June 1-2, 2017), at the XIII International Congress "Neuroscience for Medicine and Psychology" (Sudak, June 4-10, 2017), at the All-Russian Conference "Methodological and applied problems of medical (clinical) psychology. Polyakov readings (for the 90th anniversary of Yu.F. Polyakov)" (Moscow, March 15-16, 2018), at the XIV International Congress "Neuroscience for Medicine and Psychology" (Sudak, May 30–June 10, 2018), at the international conference "8th International Conference on Cognitive Science" (Svetlogorsk, October 18-21, 2018), at the I International conference "Innovative methods of prevention and correction of developmental disorders in children and adolescents: interprofessional interaction" (Moscow, April 17-18, 2019), at the XV International Congress "Neuroscience for Medicine and Psychology" (Sudak, May 30–June 10, 2019), at the International Congress "Modern Technologies in the diagnosis and therapy of mental and neurological disorders" (St. Petersburg, October 17-18, 2019), at the I National Congress on Cognitive Research, Artificial Intelligence and Neuroinformatics, IX International Conference on Cognitive Science (Moscow, October 10-16, 2020), at the XVI International Congress "Neuroscience for Medicine and Psychology" (Sudak, October 6-16, 2020), at the II International conference "Modern methods of prevention and correction of developmental disorders in children: traditions and innovations" (Moscow, October 22-23, 2020), at the VIII International conference "Medical Psychology (Clinical) Psychology: Historical traditions and modern practice. Multidisciplinary approach in the rehabilitation of patients with aphasia" (St. Petersburg, October 14-16, 2021), at the XVII International Congress "Neuroscience for Medicine and Psychology (Sudak, May 30-June 10, 2021), at the II International conference "Modern methods of prevention and correction of developmental disorders in children: Traditions and innovations" (Moscow, October 22-23, 2020), at the I International scientific and practical conference "Zeigarnik readings. Diagnostics and psychological assistance in modern clinical psychology: the problem of scientific and ethical grounds" (Moscow, November 18-19, 2020), at the III International conference "Defectology in the light of modern neuroscience: theoretical and practical aspects" (Moscow, April 23-24, 2021), at the XVII Congress of psychiatrists of Russia "An interdisciplinary approach to the comobidity of mental disorders disorders: on the way to integrative treatment" (St. Petersburg, May 15-18, 2021), at the VIII International Scientific and practical conference "Medical (Clinical) Psychology: historical traditions and Modern Practice" (St. Petersburg, October 14-16, 2021), at the All-Russian Congress "Psychoneurology: Century XIX – Century XXI" (St. Petersburg, May 13-15, 2022), at the XVIII International Congress "Neuroscience for Medicine and Psychology (Sudak, May 30–June 10, 2022), at the IV International scientific and practical conference "Modern defectology. An interdisciplinary approach to theoretical and practical problems" (Moscow, April 14-15, 2022), at the All-Russian Scientific and Practical Conference "Coronavirus and Public Mental Health: clinical, neurobiological, preventive and organizational aspects" (Moscow, March 30-31, 2022), at the All-Russian Conference "Brain diseases: innovative approaches to diagnosis-stick and treatment (St. Petersburg, October 18-20, 2022), at the XXII All-Russian scientific and practical conference "Polenov readings" (St. Petersburg, April 13-14, 2023), at the V International scientific and practical conference "Innovative methods of diagnosis, prevention and correction of developmental disorders in children and adolescents. The best practices of interprofessional interaction" (Moscow, April 18-19, 2023), at the II All-Russian Scientific and Practical Conference "Information Exchange in Interdisciplinary Research" (Ryazan, April 14, 2023), at the All-Russian Congress "Neuropsychiatry in the interdisciplinary space: from basic research to practice" (St. Petersburg, May 25-26, 2023), at the All-Russian scientific and Practical conference "Brain diseases: modern technologies and development prospects" (Moscow, October 25-27, 2023), at the international scientific and practical conference "Brain, Cognition, language: multidisciplinary approach in neurorehabilitation" (Moscow, April 4-5, 2024).

Publications. On the topic of the dissertation 62 works have published, including one monograph and three methodological recommendations, one information letter approved by the Ministry of Health of the Russian Federation, one program of additional professional education for medical psychologists in medical and psychological counselling offices, 17 articles in peer-reviewed scientific journals, 12 of which are in journals recommended by the Higher Attestation Commission for the publication of the main results of the dissertation research in Psychology, including 9 articles in journals of category K1–K2, of which 6 are included in Scopus, Web of Science even RSCI, 5 articles – included in Scopus, Web of Science.

Dissertation's key tenets to be defended:

1. Structural and dynamic model of aphasia syndrome is a dynamic formation with a strict hierarchy and includes, in addition to primary secondary and tertiary neuropsychological symptoms. Tertiary symptoms are its obligate structural components and reflect the process of spontaneous intra- and interhemispheric reorganization of the damaged speech function/ The presence of tertiary neuropsychological symptoms does not depend on the duration, aphasia type, size and localization of focal brain damage. It is expressed in focal neuropsychological symptoms indicating functional oppression of healthy brain structures of the right and left hemispheres and a high frequency of occurrence of the left ear superiority in auditory perception in right-handed aphasia patients.

2. The topic and dynamic characteristics of tertiary symptoms depend on the completeness of intra- and interhemispheric restructuring of speech function. The dynamics of the tertiary symptoms of the aphasic syndrome are determined by the chain effect of the hemispheric speech function reorganization: 1) weakening of the inhibitory effect of the left hemisphere on the right; 2) activation of the right hemisphere with the simultaneous increase in noise immunity of auditory-speech perception; 3) increased inter- and intrahemispheric interaction in the course of speech processes.

3. The principles and algorithm of modelling a sensory-enriched environment are based on the concept of spontaneous intra- and interhemispheric speech reorganization. The methodology of modelling a sensory-enriched environment with the aim of speech restoration is based on the principles and algorithm of sensory stimulation, aimed at topical sensory stimulation of brain zones, the localization of which is determined by the range and dynamics of the tertiary neuropsychological symptoms of aphasia syndrome.

4. The developed methodological complex for speech restoration in patients with aphasia in a simulated music-enriched environment considers the effect of music on topical foci of brain activation. The methodological complex for speech restoration in a polysensory-enriched environment is based on the activation of the mechanism of intersensory interaction of the visual, tactile, motor and auditory systems involved in the speech processes.

5. Modelling a music-enriched, polysensory-enriched environment has a multi-focus positive effect on the speech, and improves its parameters at the level of words, phrases and text. The polysensory-enriched environment, along with the regression of speech disorders, improves the parameters of other mental processes that are associated with the type of impaired neuropsychological factor.

6. The type of sensory-enriched environment has a selective effect on quantitative and qualitative speech parameters in aphasia patients with different initial severity of expressive speech

The main scientific results.

1. A structural and dynamic model of aphasic syndrome has been developed, reflecting the role of mechanisms of intra- and interhemispheric interaction in its formation (see paragraph 4.5.) (personal contribution of the author is not less than 85%) (Shipkova K.M., 2013, 2024a; Shipkova K.M., Makhankova V.G., 2014; Shipkova K.M., 2015; Akhankova T.E., Shipkova K.M., 2019; Shipkova K.M. et al., 2020; Shklovsky V.M., Shipkova K.M. et al., 2021; Dubinsky A.A., Shipkova K.M. et al., 2021; Shipkova K.M., 2022a; 2022b, 2022c; Bulygina V.G., Shipkova K.M. et al., 2022; Shipkova K.M., Dovzhenko T.V., 2022; Shipkova K.M., Dubinsky A.A., 2023; Shipkova K.M., Bulygina V.G., 2023a, 2023b).

2. The influence of structural and topological characteristics of focal brain damage in patients with different types and time post-onset of aphasia on the formation of a symptomocomplex of tertiary symptoms of aphasia syndrome was determined (see paragraphs 4.1-4.5) (personal contribution of the author of at least 95%) (Shipkova K.M., 2013, 2022a, 2022b, 2022c; Shipkova K.M., Dubinsky A.A., 2023; Shipkova K.M., 2024a).

3. An original diagnostic set of methods has been developed to identify neuropsychological oppression symptoms of the preserved parts of the left and right hemispheres in aphasia patients (see paragraph 3.4.2.) (the author's contribution is at least 95%) (Shipkova K.M., 2023a; Shipkova K.M., Dubinsky A.A., 2023).

4. A new methodological approach to the rehabilitation of patients with aphasia in a modelling sensory-enriched environment has been developed and tested on the basis of the revealed patterns of interhemispheric interaction in the process of speech restoration (see paragraph 5.1.) (performed by the author personally) (Shipkova K.M., 2014, 2018; Shipkova K.M., 2023b; Shipkova K.M. et al., 2023; Shipkova K.M., 2024a).

5. An algorithm has been developed, principles and methodological complexes have been formulated for modeling a music-enriched and polysensory- enriched environment (see paragraphs 5.1, 5.2., 5.3) (performed by the author personally) (Shipkova K.M., 2014, 2018, 2019, 2020, 2021; Shipkova K.M., 2023b; Shipkova K.M.; Shipkova K.M., 2024a).

6. Diagnostic complexes have been developed to assess the dynamics of speech restoration in a music-enriched and polysensory-enriched environment (performed by the author personally) (see paragraphs 3.4.3, 3.4.4.) (Shipkova K.M., 2014, 2018; 2022c; 2024a).

7. The comparative effectiveness of speech restoration in patients with aphasia in a music-enriched and polysensory- enriched environment was evaluated in comparison with the traditional approach to speech therapy of aphasic disorders (see chapters 6, 7) (personal contribution of the author of at least 95%) (Shipkova K.M., 2014, 2018, 2020, 2021, 2024a, 2024b; Shipkova K.M., Dubinsky A.A., 2023).

CHAPTER 1. THEORETICAL AND METHODOLOGICAL ANALYSIS OF THE HISTORY OF DEVELOPMENT AND MODERN VIEWS ON APHASIC SYNDROMES IN NEUROPSYCHOLOGY

The chapter presents the results of an analysis of the history, current state and trends in the development of views on aphasic syndromes in modern neuropsychology.

1.1. The history and current state of the doctrine of aphasia

The history of the development of the doctrine of aphasia has passed through several stages. The first stage of its development was closely connected with the works of P. Broca (1861), K. Wernike (1874), and L. Lichtheim (1885). During this period, the concept of aphasia developed within the framework of the psychology of associationism and the theory of narrow localization (Broca P., 1861), where aphasia was considered as a violation of the associative connection (connectivity) between speech cortical centres. The typology of aphasic disorders was described much later than the clinical observations of aphasic disorders. It took time to make the first generalization of clinical experience, which was carried out by K. Wernike (1874) at the end of the XIX century. The classification identified three types of cortical speech disorders associated with damage to the centres of the "motor image" and "sensory image" of words and the associative connections between them. Motor aphasia (Broca's aphasia), sensory aphasia (Wernicke's aphasia) and conduction aphasia. Motor aphasia was considered a speech disorder caused by damage to the centre of the "motor image of words" located in the third frontal gyrus. Its distinctive feature was the violation of oral articulate speech with a preserved understanding of oral and written speech. Sensory aphasia associated with damage to the centre of the" sensory image " of words located in the first temporal gyrus was considered a violation of understanding of audible speech while preserving speech articulation. Conductor aphasia was presented as a result of a violation of the associative connection between these two speech centres and was expressed in a selective violation of repeated speech (words, sentences) with the preservation of one's speech and its understanding.

The typology of K. Wernike's aphasias was later supplemented by L. Lichtheim (1885) with other forms of aphasia. They were given an updated understanding of the brain bases of speech. In the Wernicke-Lichtheim classification, the dyadic representation of speech brain centres (motor and sensory) is replaced by the horizontal-vertical principle of level analysis of the typology of aphasias (Lichtheim L., 1885). This classification was based on the same theoretical foundations, but it supplemented the typology of aphasic disorders with a group of subcortical and transcortical aphasias.

The occurrence of transcortical motor and sensory aphasia was explained by damage to the association pathways (disconnection syndrome) between the concept centre and the motor or sensory speech centre, respectively. A feature of transcortical motor aphasia was a violation of spontaneous speech with repeated preservation, with transcortical sensory aphasia-a violation of speech comprehension with the preserved perception of speech sounds. Subcortical aphasias in the Wernicke-Lichtheim classification also had two forms – motor and sensory. Subcortical motor aphasia (anarthria) was characterized by a violation not of speech itself, but of speech articulation (in modern speech therapy it is referred to as dysarthria). Subcortical sensory aphasia (pure verbal deafness) was considered a speech disorder caused by a violation of the differentiation of verbal noises, as a result of which, with complete preservation of one's speech, it is not impossible to repeat what was heard (auditory agnosia according to A.R. Luria).

Both the Wernicke and Wernicke-Lichtheim classifications of aphasia were characterized by a simplified understanding of the psychological structure of speech and psychomorphology. These classifications could not explain the whole variety of speech symptoms, and the association of speech disorders with disorders of other mental functions, such as reading, writing, counting, thinking, and voluntary movements.

Rethinking the views on the biological nature of speech disorders occurs at the next stage in the development of aphasiology, which is closely related to the work of the founders of the theory of anti-localization in the late XIX century (Jackshon Jackshon J.H., 1884, 1958). This stage of aphasiology is characterized by the development of the idea of equipotential cortical brain structures. In this theoretical paradigm, aphasia begins to be considered as a complex mental process that has a distributed cortical-subcortical localization in the brain. In contrast to the opinion of apologists of narrow localization, the severity of aphasia is associated not so much with the topic, but with the volume of focal brain damage.

Understanding the level of brain organization of speech gets a different semantic content than in the Wernicke-Lichtheim classification. Speech begins to be considered as a two-level mental structure, consisting of higher and lower levels, each of which is controlled by different brain structures. Propositional speech as the highest level of speech organization is controlled by the cortical structures of the brain, and automated speech as the lowest level of speech is controlled by subcortical brain structures.

In the theory of anti-localization, the subcortical structures of the brain are considered for the first time as an important component of complex mental processes, the basis of speech skills and automatisms. Until the mid-twentieth century, J.H. Jackson's position on the vertical brain organization of the psyche was ignored. Its importance was evaluated later when A.R. Luria (1948) developed the theory of system and dynamic localization of functions, which outlined the place and role of subcortical brain structures in the brain organization of higher mental functions.

Later, the truth of J.H. Jackson's thesis about the brain structure of complex mental processes will be confirmed in experimental studies by W. Penfield and L. Roberts, who revealed that the basal ganglia are directly involved in the coordination of the motor speech zones of the cortex (Penfield W., Roberts L., 1959). According to the views of J.H. Jackson, types of aphasia are a selective violation of the highest or lowest level of speech. Aphasia was considered by J. H. Jackson as a proper speech disorder, and not a violation of articulation. Therefore, dysarthria in this classification of aphasia was not treated as a speech disorder. For the first time, J. H. Jackson begins to analyze aphasic disorders as a combination of positive and negative symptoms. Positive symptoms reflect the preserved aspects of speech, while negative symptoms reflect the disturbed ones. There are two classes of aphasias. The first class of speech disorders is gross violations of oral and written speech, up to its complete absence. This class of speech disorders is similar to the pattern of speech disorders in Broca's aphasia. The second class of speech disorders has the following features: there are many words in speech, but they are incorrectly pronounced. This class of speech disorders has similarities to Wernicke's aphasia and conductor aphasia. The severity of the aphasic defect J.H. Jackson linearly correlates with the extent of the focal lesion.

The classification of aphasias proposed by representatives of the theory of anti-localization, on the one hand, introduced a new understanding of the level analysis of aphasias, which was further continued in the school of aphasiology of A.R. Luria, and on the other hand, remained within the framework of the idea of equipotential brain structures, which greatly hindered the in-depth analysis of the symptomatology of speech disorders.

A further stage in the development of aphasiology is associated with modern ideas about the nature and mechanisms of aphasia. It can be designated as multi-oriented since it is characterized by pluralism in defining the concept of aphasia, its nature, structure and typology of aphasic disorders, and understanding the ways and methodology of speech restoration. The most influential among them are the A.R. Luria aphasia School and the Boston aphasia School (group). This stage of development of aphasiology is also characterized by a change in the clinical analysis of aphasias, and psychological and linguistic analysis of speech disorders.

A.R. Luria's school of aphasiology is widely used in several countries in Eastern and Western Europe, the near abroad, and Latin and North America. The Boston School approach is used in the United States and several Western European countries. Along with these schools, others are not so popular. For example, the European School of Aphasiology was created mainly by representatives of the French and Italian schools, which became widespread in France, Canada, Italy, and Belgium and flourished in the 60–80 years. XX century.

In the Luria School of Aphasiology, aphasia is defined as "a speech disorder that occurs with local lesions of the left hemisphere cortex (in right-handed people) and represents a systemic disorder of various types of speech activity. Aphasia manifests itself in the form of violations of the phonemic, morphological and syntactic structure of speech and understanding of the addressed speech while preserving the movements of the speech apparatus that provides articulate pronunciation, and elementary forms of hearing" (Psychological Dictionary, p. 28-29).

In the post-Luria period, this definition was supplemented and refined by L.S. Tsvetkova (2002, 2010). Aphasia is proposed to be interpreted as a level violation of speech function caused by damage in the speech-functional system, the structure of which includes a violation of the morphophysiological, psychological, linguistic and social levels of speech functioning. In this understanding of aphasia, along with neurophysiological, neuropsychological, and linguistic aspects, the social consequences of speech disorders are also reflected – narrowing of social interests, limiting communication activity, and disintegration of the entire mental sphere of the subject. It seems that this definition of aphasia somewhat blurs the boundaries of the aphasic syndrome since negative social consequences are characteristic not only of aphasic but also of other cognitive disorders.

The Russian school of aphasiology is based on several psychological and psychophysiological theories and concepts developed by L.S. Vygotsky, A.N. Leontiev, A. R. Luria, A.V. Zaporozhets, N.A. Bernstein, P.Ya. Galperin, and then developed by L.S. Tsvetkova, T.V. Akhutina, Zh.M. Glozman, N.M. Pylaeva, A.V. Semenovich, N.N. Polonskaya and others.

The conceptual framework of A. R. Luria's aphasiological school includes:

- the concept of higher human (mental) function (HHF) as a factor of socio-historical development (Vygotsky L.S., 1984);
- an idea of the characteristics of the HHF, the regularities of its development and decay (Vygotsky L. S., 1984);

- the study of functional systems/functional organs as the psychophysiological basis of mental functions representing an integrative unit of brain activity (Anokhin P. K., 1949, 1955, 1968, 1973, 1980);
- the doctrine of the systemic and dynamic localization of higher mental functions in the brain (Luria A. R., 1947, 1948, 1963, 1966, 1969; 1973; Ardila A. et al., 2020).

The conceptual framework of neuropsychology reflects different levels of the brain-psyche system. At the psychological level, HHF are considered as expanded forms of subject activity that arise based on sensory and motor processes. Then, in the course of mastering the subject, they are internalized and transformed into mental actions. Speech plays a leading role in mediating HHF, which makes them conscious and arbitrarily controlled. HHF are formed in vivo and have a complex systemic structure. At the psychophysiological level, the HHF is a functional system that has a vertical (cortical-subcortical) and horizontal (cortical-cortical) organization. These ideas about the psychological structure and morphological basis of HHF led to a revision of ideas about the localization of HHF in the brain.

The basic concepts of Russian neuropsychology are:
- the concept of a factor and its typology;
- the concept of factor analysis;
- the concept of a neuropsychological symptom;
- the concept of neuropsychological disorder syndrome (Luria A.R. 1962, 1966, 1970, 1973, 1975).

A factor (neuropsychological factor) is defined in the school of A.R. Luria (1973) as a proper function of a certain part of the brain, the principle of its psychophysiological activity. Within the framework of the theory of systemic and dynamic localization of HHF in the brain, it is legitimate to speak not about the localization of the function in the brain, but about the factors on which it is built.
The concept of factor is the basis of the concept of neuropsychological syndrome. The syndrome is defined as a natural combination of neuropsychological symptoms caused by a violation in the functioning of the same factor (Luria A. R., 1973; Chomskaya E.D., 2002). The primary neuropsychological symptom is a violation of the direct

function of the damaged factor. HHF as a functional system is a constellation of different brain structures(regions) of the brain, i.e. a system of interrelated factors. Damage to a single factor leads to a systemic consequence - a violation of those HHF, the structure of which includes the damaged factor. These systemic consequences are called secondary neuropsychological symptoms. Thus, the neuropsychological syndrome, like the aphasic syndrome, is interpreted as a natural combination of primary and several secondary symptoms caused by a violation of the same factor (Chomskaya E. D., 2002).

Typology of aphasias in the school of A. R. Luria. Speech disorders manifest themselves in aphasia of different types (forms) and represent different neuropsychological syndromes. Aphasic syndromes are characterized by selectivity in the violation of repetition and understanding of speech, oral and written speech. The type of aphasia is a violation of a separate link in the psychological structure of speech function. Different forms of aphasia have different mechanisms of disturbance and different qualitative compositions of neuropsychological symptoms (Shipkova K.M., Bulygina V.G., 2023b). However, in whatever link the speech damage occurs, it will result in a violation of the speech system as a whole (Table 1).

Syndromic, factor analysis of aphasia in the tradition of Russian neuropsychology includes, following J.H. Jackson, the identification of two groups of neuropsychological symptoms of aphasic syndrome: positive and negative. A similar understanding of the selectivity of cognitive disorders in local brain lesions is reflected in the statement formulated by H.L. Teubert (1960) the principle of double dissociation of functions.

Unlike J. H. Jackson, who considered negative symptoms as single-order disorders, A. R. Luria's classification of aphasias differentiates negative symptoms into primary and secondary (systemic) disorders. A negative symptom is a manifestation of a broken link in the speech functional system. In this case, it qualifies as a primary defect or primary symptom. The formation of a primary defect is based on a violation of a certain factor. Secondary negative symptoms are systemic consequences of a factor disorder. Secondary symptoms reflect the totality of disorders of those higher mental functions, which include the disturbed factor.

Table 1. Types of aphasia and corresponding primary defects according to A.R. Luria (according to Akhutina T. V., 2016)

Type (form) of aphasia	Primary defect	Localization of the lesion
Disorders of speech comprehension (impressive speech)		
Sensory (acoustic-gnostic)	Distinction between phonemes	BA41 and BA42
Acoustic-mnestic	Auditory-speech memory (impaired understanding of the reference meaning of words, narrowing of the lexicon)	Middle temporal gyrus (BA21).
Semantic	Understanding of word forms and logical-grammatical constructions	Temporal-parietal-occipital (TRO zone)
Amnestic	Word selection by meaning	of Temporal-parietal and intemporal-occipital areas
Speech production disorders (expressive speech)		
Afferent motor	articulation selection	Postcentral parietal region
Efferent motor	Kinetic organization of speech, grammatical structuring defect (violation of articulatory switching), kinetic speech apraxia, expressive agrammatism, "telegraphic" speech style.	BA44, Broca
Dynamic	Verbal Planning and Verbal Activity	Prefrontal area

Positive symptoms in the school of A.R. Luria are designated as the preserved sides of the affected function and preserved mental functions, as well as the so-called tertiary symptoms. Under the term tertiary symptoms, it is proposed to consider symptoms that reflect the process of spontaneous (non-directed) compensation, i.e., the restructuring of the affected mental function "at the psychological, morphophysiological levels into a new integrative whole" (Tsvetkova L.S., 2010, p. 150). For example, patients with efferent motor aphasia, to facilitate the process of speech production and inhibit articulatory perseverations when articulating a word, begin to involuntarily tap out the rhythm of the word. This interpretation of tertiary symptoms is ambiguous for the following reasons. Any symptom of a neuropsychological syndrome – is an integral part of it, which means that it manifests itself regardless of the grossness of the defect, its tima post-onset, or the patient's premorbidity. Involuntary rhythmization or movement of the body synchronized with the tempo of speech is rather an individual type of adaptation since it is not typical for the absolute majority of patients with speech articulation disorders. Of course, raising the question of tertiary symptoms is extremely important, but they should be considered not in the context of individual adaptations, but as systemic consequences of a violation of the HHF, its impact on the functioning of preserved parts and functions of the brain, and how this tertiary symptomatology correlates with the recovery process of impaired HHF.

Thus, the school of A.R. Luria gives a new interpretation of the aphasia syndrome, the principle of its classification, and deepens the understanding of the nature of aphasia. A.R. Luria's aphasiological school made a great contribution to the creation of neuro-linguistics in Russia. Linguistic studies of the nature of speech agrammatism in different types of aphasia (Tsvetkova L.S., Glozman Zh. M., 1978), level-based linguistic analysis of speech disorders (Wiesel T.G., Glezerman T. B., 1986) and the linguistic principle of dividing aphasic disorders into violations of the syntagmatic and paradigmatic structure of speech utterance (Akhutina T.V., 2002) determined further changes in the structure of speech utterance. studies of the structure of aphasic disorders at the word, sentence, and text levels.

Boston School of Aphasiology. The Boston Aphasiological Group and its followers consider aphasia as a violation of speech, writing and reading caused by damage to the speech areas of the brain (Geschwind N., 1964, 1965; Goodglass H. et al., 1970, 1972, 1993; Benson D.F., 1979, 1980; Albert M.L. et al., 1981; Alexander A.W. et al., 1991; Schnider A. et al., 1994; Benson D.F., Ardilla A., 1996, etc.).

This classification is based on an empirical principle and is based on a detailed analysis of individual clinical cases. It is designed within the framework of classical ideas of narrow localizationism, the works of K. It is based on taxonomic and comparative analysis of speech disorders (Kertesz A., 1979; Price C. J., 2000). The analysis of the essence and morphophysiological bases of aphasic disorders is replaced by a description of the external picture of disorders. For example, in the Goodglass-Kaplan classification of aphasias (Goodglass H., Kaplan E., 1972), speech disorders are divided into two groups: impaired comprehension and impaired speech reproduction. The first of them includes a violation of understanding of oral and written speech, the second includes a violation of speech articulation, anomia, paraphasias, grammar and syntax disorders, difficulties in repeating what you have heard, impaired smoothness of speech, agraphy, aprosody (loss of voice and violation of timbre).

Due to the lack of convincing grounds for classifying speech disorders, this typology is not widely used, but it has led to a consensus in dividing aphasic disorders into three categories: smooth, non-smooth, and pure aphasia. Speech disorders are differentiated on two grounds: 1) smoothness (preservation of articulation) of speech; and 2) type/level of damage to speech centres.

On the first basis – smoothness, aphasias are divided into smooth (fluent) and non-smooth (non-fluent). According to the type/level of brain damage, aphasias are divided into cortical and transcortical. The aphasic syndromes identified in this approach have the same symptomatic content as those presented in the Wernicke-Lichtheim classification. The category of smooth aphasias includes Wernicke's aphasia, transcortical sensory and conduction aphasia, and anomia (amnestic aphasia in the classification of A. R. Luria). Non-floating aphasias include Broca's aphasia (expressive aphasia), transcortical motor aphasia, and total aphasia (global aphasia). With total aphasia, oral speech and understanding are grossly disrupted. A separate category consists of the so-called pure aphasias, which are represented by pure verbal deafness (auditory agnosia), selective reading (alexia) or writing (agraphia).

An important substantive difference between this typology of aphasias and the school of A.R. Luria is the consideration of aphasia as a separate speech disorder that does not have a systemic connection with gnostic or praxis disorders. For example, speech agraphy in the classification of speech disorders by A. R. Luria is included in the aphasic syndromes: sensory, semantic, and motor types of aphasia. They are considered as a secondary symptom of a violation of the corresponding neuropsychological factors. In the case when agraphy is associated with a violation of letter gnosis, it is considered not as a speech disorder, but as a gnostic disorder and is designated as primary agraphy.

European School of Aphasiology. The European School of Aphasiology is based on a linguistic approach to the analysis of aphasia (Alajouanine T., 1952, 1956; Hecaen H., et al., 1956, 1967; Alajouanine T. et al., 1964; Lhermitte F., 1965a; Lhermitte F. et al., 1965b, 1965c; Hecaen H., 1965, 1972; Vignolo L.A. et al., 1966, 1980; 1984; De Renzi E. et al., 1966, 1980; Lecour A.R., Lhermitte F., 1969, 1979, 1983; Lecour A.R., 1974, 1976; Gainotti G., 1976, 1993; Brown J.W., Hecaen H., 1976; Basso A. et al. 1979, 1989; Mazzocchi F., Vignolo L.A., 1979; Basso A.1992, 1998, 2000; Cappa S., 2000, 2015; etc.). In it, the semiotics (semiology) of aphasias is based on the identification of several aspects of speech disorders: 1) articulate speech; 2) understanding oral speech; 3) written expressive speech; 4) understanding written speech (understanding the read text).

Within the framework of this classification, pure (i.e. isolated) disorders of speech articulation, such as dysarthria, are considered in a single context with speech disorders because, like aphasia, they are a manifestation of speech communication disorders. This understanding of this approach is similar to the views of K. Wernike and L.L. Lichtheim, who consider the morphophysiological basis of speech as a function that has a cortical-subcortical brain basis. At the same time, there is an important indication in the linguistic approach that aphasia is not a static state of speech. In the same patient, at the same time, the semiology of aphasic disorders may be fully or partially associated with the quality of their current speech output or with the current situation in which speech is implemented. For example," the patient's simultaneous ease of pronouncing speech patterns and the inability to describe a story picture or answer a direct question " (Lecour A.R., Lhermitte F., 1979, p. 112). This understanding of the complexity of the pattern of disorders reflects the idea of J. H. Jackson about the level of organization of speech and selective violation of the voluntary and involuntary level of speech in aphasia.

Some Russian aphasiologists share the neurolinguistic principle of analyzing aphasic disorders (Vinarskaya E.N., 1971, 2007), and aphasia is interpreted as "a violation of language ability: both potential and realized by the time of the disease of language experience" (Wiesel T.G., Glezerman T. B., 1986, p .15). In other words, aphasia is considered as a violation of the symbolic level of speech function that occurs as a result of damage to the tertiary fields of the cortex. This view holds in aphasiology, and the debate about whether aphasia is a speech and language disorder continue. This issue is especially actively discussed about semantic aphasia because, in this type of pathology, a violation of understanding complex speech and grammatical constructions is a central speech deficit. According to T.G. Wiesel and T.B. Glezerman, semantic aphasia is not a speech disorder, but a language disorder, which is shared by some other aphasiologists (Tsvetkova L.S., 2011). In this, the authors see its difference from sensory and motor aphasias, in which speech disorders are caused by damage to the gnostic-praxis level of speech. This linguistic classification of aphasias distinguishes two levels of speech disorders: speech itself and language. There is some justification for this view of the typology of speech disorders, but it needs additional arguments about language disorders in some types of aphasia.

Despite the sufficient level of development of aphasiology, the current stage of its development is characterized by a crisis. It is caused by a lack of new ideas and views, disunity, and insufficient integration of psychological, linguistic, neurobiological, and neurophysiological aspects of studying aphasia. As L. S. Tsvetkova rightly notes, "The current crisis in the teaching of aphasia lies in the field of methodology, which generates a scattering of ideas about aphasia that are not sufficiently scientifically reasoned, and the introduction of inadequate methods from other fields of knowledge into the teaching of aphasia" (Tsvetkova L. S., 2002, p. 17).

To date, there is still no consensus on defining the concept of aphasia, understanding its structure, typology, brain mechanisms of speech, and approaches to rehabilitation of speech disorders. Creating new ideas based on previous theoretical views or compiling the views of various schools, dividing aphasias into primary and secondary ones (Ardila A., 2010) does not meet with broad support (Buckingham H.W., 2010; Kertesz A., 2010; Marshall J., 2010) because it does not solve the main problems of aphasiology.

One of its unsolved problems is understanding the nature of aphasia. In the view adopted in Russian neuropsychology, it is considered the result of the disintegration of the speech-functional system. L.S. Tsvetkova suggests looking at aphasia as "a pathological integrative whole formed based on compensatory mechanisms" (Tsvetkova L.S., 2002, p. 21). This integration is the result of the process of compensating for broken components of a functional system at the expense of preserved components and levels of other functional systems, and may also be the result of retraining. In the process of restorative learning, it is much more difficult to restructure this integrative whole than it is to reconstruct a previously broken system. This can explain the low global statistics of complete recovery of aphasic disorders (Bazeko N.P., Alekseenko Yu.V., 2004; Shipkova K.M., 1993, 2015). These facts determine the question of what constitutes aphasia in reality, speech disorders, or already completed compensation for the defect. This has been discussed many times in the past (Jackshon J.H., 1884) and remains controversial to this day (Tsvetkova L. S., 2011).

Another problem of aphasiology is the role of different levels (psychological, morphological, psychophysiological) in the formation of aphasia syndrome.

The next important problem is understanding the morphophysiological structure of aphasia, i.e. understanding the biological and social aspects of aphasia (Tsvetkova L.S., 2002). This includes such aspects of the problem as the role of compensatory processes in the formation of aphasia syndrome, and the role of the right hemisphere in overcoming aphasia.

1.2. Poststroke aphasia in the cortical branches of the middle cerebral artery

According to studies using the Wada method (injecting sodium amytal into the internal carotid artery to temporarily "turn off" the hemisphere-author's note), more than 95% of right-handed people have a dominant left hemisphere in speech (Bloom F. et al., 1988). Aphasia has a different aetiology and can be caused by brain injuries, tumours, inflammatory processes, vascular damage to the brain, and several other causes.

In the neuropsychological tradition of studying aphasic disorders, the main attention is paid to the analysis of violations of the psychological structure of speech, which is natural, and much less to how the aetiology of aphasia and how it affects the picture of aphasic syndrome. For example, with brain tumours in the acute period of the disease, aphasia is accompanied by general brain symptoms - hypertension syndrome. With hypertension syndrome, there is often a general intellectual decline, and memory loss, unusual for the type of aphasia that is indicated in the long-term period of the disease, when it regresses and the local cortical mental deficit is fully exposed.

Traumatic aphasia, which is formed during brain trauma, has a different specificity. It is characterized by a good reverse development of pathological symptoms, which is often explained by a high percentage of brain injuries in young and middle-aged people who do not yet have age-related changes in the vascular system of the brain and have high compensatory capabilities for neuroplastic reconstruction.

The most common cause of aphasia is vascular brain damage (Parfenov V.A. et al., 2012; Hachinski V., 1994, 2006; Barber R. et al. 2001; Kawashima R., 2013; Li X. et al., 2016). Hypertension and atherosclerosis are the most common diseases that cause aphasic disorders. Among vascular aphasias, the absolute majority of cases of vascular aphasia cause ischemic stroke in the basin of the left middle cerebral artery (Parfenov V. A., 2012; Shakhparonova N.V. et al., 2012; Damulin I. V., 2018). In ischemic stroke, aphasia occurs 2 times more often than in hemorrhagic stroke, and its severity is higher.

When analyzing the outcome of vascular aphasias, the state of collateral blood circulation is often underestimated, which is of great importance in the formation and dynamics of the aphasic syndrome, especially in the early recovery period after a stroke. In the case of vascular pathology, in addition to the main collateral circulatory system provided by the circle of Willis, the possibility of spontaneous establishment of anastomoses between the middle, anterior and posterior cerebral arteries is considered an important component of the outcome of aphasia (Stolyarova L.G., 1973; Alajouianine T. et al., 1959).

The severity and persistence of vascular aphasia disorders depend on how much and how many vessels of the middle cerebral artery are affected simultaneously, as well as on vascular damage in other systems (internal carotid, vertebrobasilar, etc.). The presence of persistent, non-regressing aphasic disorders is often explained by incomplete blood supply due to the anterior parts of the circle of Willis and the possibility of reducing the severity of this deficiency through anastomoses of the anterior, middle and posterior cerebral arteries (Schmidt E.V., 1963; Bragina L.K., 1966). With internal carotid artery thrombosis, there is an undefined degree of regression of expressive speech disorders with a significant improvement in impressive speech. In the occlusive process (blockage of blood vessels) in the middle cerebral artery, the reverse development of aphasic disorders is characterized by the "all or nothing" principle. This means that the number of cases of pronounced positive dynamics is proportional to the number of cases with no such dynamics, and the percentage of cases with unexpressed positive dynamics is relatively low. Thus, in general, improvements in speech are noted less frequently in these patients, and gross aphasic syndrome remains unchanged much more often. In addition, when же the dynamics occur, it is more pronounced than in the case of thrombosis. The positive dynamics of speech recovery in case of blockage of the main vessels is explained by the ability to compensate for the lack of blood supply due to vascular anastomoses on the surface of the brain. Statistics on numerous gross speech disorders in the acute period of stroke are explained by the fact that anastomoses do not exist in healthy individuals and their development takes time. When anastomosis is quickly established, a rapid regression of the severity of aphasia occurs (Stolyarova L.G., 1973). Of course, in brain infarcts, spontaneous hemodynamic rearrangement due to collateral blood supply cannot but affect the neurodynamic components of the function, namely, slow down the speed of its course, and cause a rapid increase in mental exhaustion. At the end of hemodynamic adjustment (in the acute and subacute periods of stroke), neurodynamic disorders significantly regress.

Sectional studies of vascular aphasia have shown that severe motor and sensory speech disorders are caused by lesions within the anterior basin (including Broca's area) and posterior basin (including Wernicke's area) of the middle cerebral artery. A mild degree of efferent motor and acoustic-mnestic vascular aphasia is determined by the location of the lesion outside, but in the neighbourhood, with the speech areas. In other words, the areas of the brain that lead to speech deficits in vascular aphasia are much wider than the classical zones of Brock and Wernicke (Shipkova K.M., 2023a). They include a significant part of the frontal, temporal, and parietal regions of the left hemisphere of the brain, and the degree of aphasia severity will largely be determined by the proximity of the affected area to classical speech zones (Luria A. R., 1969; Vinarskaya E.N., 1971; Stolyarova L G., 1973).

The current view on the recovery of atopic disorders after stroke is associated not only with the possibility of rapid restoration of collateral blood supply but also with the processes of neuroplasticity. Neuroplasticity refers to the ability of the brain to change its morphological and neurophysiological structure and /or functions in response to internal or external influences (Damulin I.V., 2018). The prognosis of functional recovery after stroke is determined by the vastness of the penumbra zone (penumbra) ("ischemic penumbra") – the zones surrounding the lesion, in which neurons are in a functionally inhibited, but anatomically preserved state, which is a potential source of restoration of impaired functions (Shakhparonova N.V. et al., 2012; Pekna M. et al., 2012). The smaller the penumbra area, the better the rehabilitation prognosis (Sternberg S., 2011; Kiran S. et al., 2019; Nasios G. et al., 2019). In the penumbral region, partial damage to dendrites is noted, and their function can be restored (Murphy T. H., Corbett D., 2006). A decrease in the functional activity of neurons in the penumbra area occurs due to impaired blood flow, so if collateral blood supply is established quickly, the consequences of dialysis are reversible (Dancause N., 2006).

Another important predictor of speech recovery in patients with post-stroke aphasia is *the volume of dialysis*. Dyaschisis (diaschisis, dynamic dyaschisis) is a well-known phenomenon in which focal functional disorders occur in an anatomically intact area far from the lesion, and a decrease in its severity is observed during the days and weeks after the onset of stroke (Dancause N., 2006; Hartwigsen G., Saur D., 2019). Dialysis affects the functioning of brain structures that do not fall into the zone of temporary inhibition. For example, if in the acute period of aphasia, damage to the left prefrontal region leads to increased activation of homologous parts of the right frontal region and the left temporal region when solving speech problems (Stockert A. et al., 2020), then in the subacute period, patients show positive dynamics in the regression of speech disorders (Saur D. et al., 2006; Stockert A. et al., 2020). The outcome of the subacute period is largely determined by the rate of regression of dialysis and/or the formation of new neuronal connections to replace the broken ones. After a stroke, cerebral reorganization of function occurs throughout the entire period of recovery. In the acute period (first 2-3–weeks) and subacute period (4–6 months) of stroke, brain reorganization of speech occurs spontaneously (Anglade C. E.t al., 2014; Ulanov M. A. et al., 2018; Stefaniak J. D. et al., 2020) and mechanisms of recovery in the contra - and ipsilateral both hemispheres have a similar character (Dancause N., 2006).

In the first phase, immediately after a stroke, there is a decrease in the normal activity in the affected area and in homologous parts of the healthy hemisphere, which is explained by a violation of interhemispheric connections with the focus area (Murphy T. H., Corbett D., 2009). In the second phase, the existing connections in both hemispheres are rearranged. In the healthy hemisphere, it occurs earlier than in the affected one. In the third phase, there is a decrease in activation first in the healthy hemisphere, and then in the damaged one. In patients with noticeable recovery of aphasic disorders, this picture is more pronounced than in patients with less noticeable dynamics (Rijntjes M., 2006).

After a stroke, in addition to the recovery processes in the damaged area, activation of previously inactive brain regions and reorganization of the functional system that provides the damaged function occur, which положитpositively affects the prognosis of speech recovery in aphasia (Belopasova A.A.V.et al., 2013; Dancause N., 2003). This phenomenon is based лежит on axon sprouting, synaptogenesis, and hyperexcitability of cortical neurons (Dancause N.., 2006; Murphy T..H.., Corbett D., 2009).

The next factor determining the prognosis of aphasia is *the duration of the aphasic defect*. Extrapolation of patterns of brain rearrangements characteristic of the initial stages (periods, epochs) to the long-term period is not correct (Saur D. et al. 2006; Ulanov M. A. et al., 2018). The recovery potential is determined by the processes of neuroplasticity, which depend on the time that has passed after a stroke (Yekusheva E.V., Damulin I.V., 2013; Murphy T..H.., Corbett D., 2009). The duration of aphasia largely reflects the depth of neuronal and hemodynamic changes that occur over time. This does not mean that the rehabilitation reserve is exhausted. The possibility of speech reorganization in the delayed period remains, but occurs mainly with directed influence, for example, during direct stimulationмуляции of the brain or speech rehabilitation. When speech disorders are chronicled, the process of their further recovery moves more slowly and requires the use of special methodological techniques.

Vascular aphasia. The typology of aphasias developed by A. R. Luria's School of Aphasiology was created based on studying the consequences of traumatic and tumour brain lesions, i.e. in a neurosurgical clinic (Tonkonogiy I. M., 1967; Wasserman L. I. et al., 1997). The same pattern has developed in foreign aphasiology (Penfield W. et al., 1959; Lecour A.R., Lhermitte F.., 1983; Kolb B., Gibb R., 2008; Kolb B. et al., 2010).

The specifics of vascular aphasia syndromes are insufficiently studied, which creates significant difficulties in their clinical and topical diagnosis. As L. I.

Wasserman et al. rightly notes. (1997, p. 132)"the nature of aphasias in the clinic of vascular cerebral pathology is characterized by a wide variety and differentiation of forms, the degree of severity and frequency of occurrence of individual speech pathology disorders."

The typology of vascular aphasias is reflected in a limited number of studies. The first descriptions of vascular aphasia were presented in the works of P. Marie (1926), P. Broca (1861), and K. Wernike (1874). In these descriptions of individual clinical cases of aphasia, the subject of research was not an analysis of the specifics of vascular aphasia as such, but the question of the relationship between the topic of the lesion and the range of observed speech symptoms. In the first Russian clinical studies, vascular aphasia was studied mainly by neurologists. S. Bain and E.D. Markova (1960), L.G. Stolyarova (1963, 1964, 1973), I. M. Tonkonogiy (1968, 1973, 2007) in the aspect of the influence of the speed and depth of blood supply restoration in the affected area of the brain on the regression of aphasic disorders later – the problem of rehabilitation of vascular cognitive disorders. In foreign studies, neurophysiological and theoretical issues of speech restoration in vascular aphasia were reflected in the works of A. Hillis (2007), M. Hoffmann and R. Chen (2013), etc.

A feature of vascular aphasia is mainly a mixed type of aphasic syndrome because the image in the basin of the middle cerebral artery is characterized by multifocality: localization of lesions in both the anterior and posterior branches of the artery (Tonkonogiy I.M.,1968). This is expressed in the simultaneous presence of two or more types of aphasia. A clear picture of the mixed syndrome is manifested in the acute period of stroke. For example, a combination of motor and sensory aphasias or acoustic-mnestic and sensory aphasias, etc.

Later, in the subacute or delayed stages, there may be a change in the type and severity of aphasia. So, sensory aphasia can transform into acoustic-mnestic or amnesic, or its severity may decreaseтяжести. However, in every second case, aphasia is chronicled (Tsvetkova L. S., 2010; Stefaniak J. D. et al., 2020).

Vascular aphasic syndromes, regardless of the initial topic of the lesion, have several general aphasic symptoms, namely, a violation of the understanding of addressed speech. Therefore, for the differential diagnosis of types of vascular aphasia, the main attention should be directed to assessing the state of the side of speech that clearly shows its deficit depending on the type of speech disorder, namely, to assess oral (expressive) speech (Tonkonogiy I. M., 1968).

The complexity of combinations of neuropsychological symptoms in vascular aphasias caused the appearance in Russian neuropsychology of descriptions of patterns of different types of vascular aphasias (Wasserman L. I. et al., 1997). This classification principle is based on empirical clinical experience. Aphasic disorders are evaluated on a 4-point scale of defect severity, indicating the qualitative characteristics of certain aspects of speech that are differential diagnostic symptoms of a certain type of aphasia. For each type of aphasia, a different list of patterns is proposed, which allows you to build a speech profile of patients. This principle of analyzing the structure of the aphasic syndrome is controversial because the declarative nature of the list of patterns simplifies the content of the aphasic syndrome.

Recovery of aphasia after a cerebral stroke is largely determined not only by its etiology, and drug therapy but also by adequate organization of neuropsychological rehabilitation (Shipkova K. M. et al., 2003; Shipkova K. M., 2004, 2014; Shipkova K. M., Dubinsky A. A., 2023). Its determining contribution to speech restoration is proved by numerous domestic and foreign studies (Luria A. R., 1962, 1969, 1973; Tsvetkova L.S., 1985, 2002, 2010; Shklovsky V. M., Vizel T. G., 1997; Gusev E. I., Bogolepova A. N., 2013; Bogolepova A. N., 2013; De Renzi E., 1980; Basso A., 1988, 1992; Wan C. et al., 2014, etc.).

The degree of recovery of post-stroke aphasia is determined in the first weeks after the stroke. Early rehabilitation leads to more significant recovery (Stolyarova L. G., 1973) than delayed rehabilitation (Byl N. et al., 2003; Dancause N., 2006). The idea that rehabilitation is effective in the first 3 months after a stroke, is now regarded as having no serious basis (Korner-Bitensky N., 2013). Speech recovery continues for a long period, both due to spontaneous recovery and against the background of rehabilitation measures carried out at this time (Dobkin B.H., 2003), although the processes of neuroplasticity slow down somewhat over time. In stroke patients, the window for rehabilitation does not remain closed even after years (Dancause N., 2006; Voytek B. et al., 2010).

1.3. The right hemisphere of the brain and aphasia

Biological bases of higher cortical functions. In recent decades, ideas about the structural organization of the brain have changed significantly. The topographical theory of the functional organization of the brain by W. Penfield (Penfield U., Roberts L., 1964), was created in the 60s, some provisions of which are reflected in the concept of the structural and functional organization of the brain by A. R. Luria, in the 80s gradually begins to be replaced by the theory of modular (modular) brain organization of higher mental functions by V. Mountcastle (Edelman J., Mountcastle V. V., 1981; Shipkova K. M., Bulygina V. G., 2023b). Many aspects of the modular theory were subsequently confirmed in neuropsychological, physiological, and biological studies (Fodor J. A., 2008; Sternberg S., 2011).

According to the modular theory, the modules of neurons responsible for different modes of stimulation are spatially separated and mutually inhibit each other – the activity of one module causes inhibition of the other. The module has morphological prerequisites for the convergence of various influences. Modules are combined into larger formations – macro columns.

Thanks to intermodal connections, there are more extensive associations of several brain structures – distributed systems. Distributed systems are dynamic entities that are interconnected by parallel and sequential connections. The function of a distributed system is not localized in any of its parts. Mobile relationships are established within module associations. They can be either synergistic or antagonistic.

Brain plasticity depends on the degree of intermodular interactions and the range of converging influences. The latter are determined by the level of maturation of intracortical inhibition. The cortical neural module is considered an elementary unit of the cortex, in which the process of sensorimotor integration takes place. Thus, modularity theory postulates two principles of brain organization: functional segregation and integration (Friston K.J., Price C.J., 2011).

Module associations act as filters to form a coordinated efferent output. As A. S. Batuev correctly notes," Despite the divergence of researchers in assessing quantitative, structural or functional parameters, and sometimes in understanding the physiological role of cortical modules, the modular principle of neocortical organization should be recognized as a very promising and most well-founded discovery of recent decades " (Batuev A. S., 1984, p. 10).

The modular theory of brain architectonics confirms the principle of the dominant in brain function, formulated earlier by A. A. Ukhtomsky (1945), namely, the position that the dominant is characterized by topographic dispersion and functional connectivity of its forming centres. Unlike the topographical theory of W. Penfield, it makes it possible to explain the possibility of intact brain regions close to the lesion site (perilesional regions), which have different functional specializations, to replace the work of damaged structures.

Another important idea of the mechanisms of hemispheric interaction is the concept of E. A. Kostandov (1983) on the partiality of hemispheric dominance. According to this concept, the functional advantage of one of the hemispheres is temporary, i.e. dynamic, and is determined by a specific stage of mental activity, and not by the function as a whole. For example, in healthy people, when performing conscious, purposeful cognitive and communicative tasks, the same algorithm of the hemispheric dominance vector is observed depending on the stage of activity.

First, speech zones in the left hemisphere are activated, then arousal is generalized and neighbouring cortical regions are activated, then the focus of activity shifts to the right hemisphere and posterior cortical regions (Pavlova L. I., 2017). That is, in the course of performing arbitrary activities, there is a change in dominant-subdominant relations between the frontal, parietal and associative areas of the cortex, and intellectual processes "always involve the frontal parts, but not necessarily the left hemisphere" (Batuev A. S., 1991, p. 214). When automating an intellectual skill, or solving perceptual or mental tasks, the alpha rhythm is activated in the Broca's area, and the focus of maximum activation is shifted to the right frontal areas.

Thus, not only the structural and functional organization of the brain but also the mechanisms regulating interhemispheric interactions, create an objective basis for dynamic intra-and interhemispheric rearrangements of higher cortical functions.

The role of the right hemisphere in changing the strategy of information processing in lesions of the dominant hemisphere. Functional specialization of the hemispheres is manifested in the peculiarities of the strategy of processing modal-specific information. Thus, the right hemisphere uses the strategy of element-by-element scanning of individual visual features in the task of visual evaluation of verbal stimuli (for example, visual evaluation of the graphic image of a letter without its phonetic and linguistic analysis). The left hemisphere evaluates categorical, semantic (semantic) characteristics, using a strategy for identifying essential (significant) features, followed by their categorization and generalization (for example, differentiating letters by phonetic feature). In other words, the degree of participation of each hemisphere is determined by the nature of the task set and the level of information processing necessary for its solution (Balonov L. Ya., Deglin V. L., 1976; Chomskaya E. D., 2002; Rebrova N. P., Chernyshova M. P., 2004). This can be either a perceptual level of processing based on the analysis of perceptual-figurative properties of stimuli, or a categorical (semiotic) level based on the analysis of categorical, semantic properties of information. The first one is more related to the work of right–hemisphere structures, the second one is more related to the work of left-hemisphere structures (Springer S., Deutsch G., 1983; Wasserman L.I. et al., 1997).

In a healthy brain, the mechanism of interhemispheric interaction is represented by the friendly workой of the hemispheres, where one strategy is replaced by another depending on the stage of solving a cognitive problem, so the vector of hemispheric dominance changes at different stages of its solution (Kostandov E.A., 1983; Chomskaya E.D., 2002).

The study of dynamic changes in interhemispheric asymmetry shows that in right-handed people, under certain conditions, the vector of hemispheric dominance can change about solving verbal and nonverbal tasks (Shipkova K.M., 2004, 2014, 2023a). As a rule, changes in the vector of hemispheric dominance are associatedo with the external factors, the most frequentимером которого является локальное поражение parameter of which is local brain damage, in which the verbal aspects of activity can begin to be provided mainly by the right hemisphere, and non – verbal ones-by the left hemisphere (Meerson Ya.A., 1986; Saltzman A.G. et al., 1990 Springer S., Deutsch G., 1983; Polich J.M., 1978).

In cases of damage to the left hemisphere, the information processing strategy changes to that characteristic of the intact hemisphere: sequential selection of details with subsequent summation (Wasserman L.I. et al., 1997; Balashova I.N., Egorov A.Yu., 2007). In contrast, right-hemisphere lesions are rarely accompanied by the patient's ability to switch to a left-hemisphere strategy (Balashova I.N., 2008), which may indicate a certain strategic inertia of the subdominant hemisphere. Thus, the left hemisphere can resort to both strategies of processing stimuli, and, in the case of its dysfunctionality or damage, the non-leading strategy (perceptual) is used as a compensatory one.

In 2/3 of cases in the acute period of left-hemisphere stroke, the right-hemisphere mode of solving cognitive tasks, including verbal and lexical tasks, prevails. In the subacute period (after 2-3-3 months), the left hemisphere mode of problem-solving begins to prevail against the background of speech therapy. According to follow-up observations, after 6 months, the initial left-hemisphere strategy is registered in 2/3 of cases (Balashova I.N., Egorov A.Yu., 2007; Balashova I.N., 2008). This is consistent with the hypothesis about the mechanism of duplication in the brain hemispheres (Tonkonogiy I.M., 1973, 2007; Balonov L.Ya. et al., 1976; Zaidel E., 1976, 1983; Marshall R.S. et al., 1994).

It seems that it is more correct to speak not so much about duplication in the work of the hemispheres but about the possibility of partial replacement of one (damaged) strategy by another (preserved) one, which researchers have repeatedly drawn attention to (Meerson Ya.N., 1986; Wasserman L. I. et al., 1997). The transition to the compensation strategy of the intact hemisphere, which occurs when the brain is damaged, confirms several provisions of the HAROLD neurobiological model (Hemispheric Asymmetry Reduction in Older Adults) (Cabeza R., 2002). It postulates that the decrease in functional hemispheric differentiation that occurs with age, the so-called dedifferentiation, is a consequence of 1) compensation of cognitive deficits; and 2) manifestation of age-related neurophysiological changes in the brain.

Atypical aphasia. In neuropsychological practice, there are often cases of aphasic syndromes, the symptomatology of which fits into the classical types of aphasia. Their peculiarity lies in the fact that extra focal symptoms cover not only functionally preserved areas of the affected hemisphere but also a healthy hemisphere. These aphasias were named atypical aphasia by T.G. Wiesel (2002, 2015). It is proposed to understand atypical aphasia as "the result of an isolated focal lesion of a skill level of a particular speech function and the disintegration of its integrated components" (Wiesel T.G., 2015, p. 250). In essence, this definition of aphasia reflects the modular theory of functional and sensory integration and segregation.

Among atypical Wiesel's aphasias, the group of inversion aphasias identified by T. G. Wiesel is of interest, in which two variants are presented.

In the first variant of inversion aphasia, patients with left-hemisphere damage and aphasia have several right-hemisphere symptoms: difficulties in reproducing musical rhythms, identifying geometric shapes, understanding the emotional content of plot pictures, and mastering the verbal rhythm of their speech.

In the second variant of inversion aphasia, patients with damage to the anterior parts of the brain show symptoms characteristic of damage to the posterior parts of the brain and vice versa. For example, patients with dynamic aphasia caused by the affected area in the prefrontal cortex show symptoms of acoustic-mnestic aphasia, which occurs when the posterior parts of the brain are affected, in turn, patients with acoustic-mnestic aphasia show symptoms of inertia and perseverations.

T.G. Wiesel suggests the following interpretation of extra focal right hemisphere symptoms: "symptoms that do not correspond to the affected hemisphere are detected within the framework of functions with incomplete lateralization, while in cases of impaired function with a more rigid hemispheric reference, the probability of contralateral symptoms is very low" (Wiesel T.G., 2015, p. 248).

This statement is debatable. Studies show that the nature of "inversion" symptoms is not associated with both hemispheres or strict lateralization of function, but with a forced change in its brain substrate when it is damaged as a result of a brain catastrophe. In other words, the appearance of right-hemisphere or left-hemisphere extra focal symptoms is a consequence of the functional replacement of the damaged area with preserved brain structures, which is reflected in a decrease in the proper functions of these brain regions.

Neurobiological studies show that variants of such intra - and interhemispheric substitution are determined by various causes, including the duration of the lesion. The explanatory mechanism of inversion aphasias can be deepened and clarified if possible, factors affecting the reorganization of damaged speech function are comprehensively taken into account.

Despite the controversial interpretation of the author's position on the mechanisms of inversion aphasia, an important fact established in the study of T. G. Wiesel (2015) was the description of extra focal right - and left-hemisphere symptoms in the structure of the aphasic syndrome.

The role of interhemispheric interaction in the formation and dynamics of aphasic syndrome. Vascular aphasia, which occurs when blood circulation is disturbed in the cortical branches of the middle cerebral artery, is accompanied by a change in the architecture of cerebral hemodynamics as a process of compensating for the consequences of stroke by activating vascular anastomoses. The state of collateral blood supply "is especially important for the acute and early recovery period after a brain infarction" (Stolyarova L.G., 1969, p. 133). In the first 3-4-months, major neuroplastic interhemispheric rearrangements occur (Anglade C. et al., 2014), which, with different etiologies of local damage, lead to the formation of blurred boundaries of neuropsychological symptoms and a diffuse picture of neuropsychological syndromes. For example, "пafter severe traumatic brain injury, the most characteristic disorders are those associated with diffuse brain damage, while focal neuropsychological syndromes corresponding to the localization of damage are detected only in 16.5% of cases" (Zakharov V.V., Drozdova E.A., 2013, p. 89).

The right hemisphere plays an important role in the process of restoring the functions of the left hemisphere (Shipkova K.M., 2014, 2023; Shipkova K.M., Bulygina V.G., 2023a). The degree of regressiona of left-hemisphere disorders, including speech disorders, correlates with cortical activity in a healthy right hemisphere (Yekusheva E.V., Damulin I.V., 2013; Oujamaa L. et al., 2009; Grefkes C., Fink G.R., 2011; Dijkhuizen R.M. et al., 2014; Stinear C.M. et al., 2015; Veldema J. et al., 2017).

Functional recovery of speech is largely associated with the maturity of the body, the ability to neuroplastic rearrangements (Basso A. et al., 1989; Kolb B., Gibb R., 2008; Kolb B. et al., 2010; Cocquyt E.M. et al., 2017). The manifestation of such neurophysiological rearrangements in patients with vascular aphasia is an increase in the thickness of the grey matter of the brain in the parietal-temporal parts of the right hemisphere. Such changes do not occur if the patient's stroke is not accompanied by speech disorders (Xing Sh. et al., 2016). It is known that in the perinatal period, when speech development is at the pre-speech stage of ontogenesis, a vascular infarction in the left hemisphere in a significant percentage of cases leads to the establishment of right-hemisphere dominance in speech processes (Lidzba K. et al., 2017). In chronic aphasia (aphasia duration is more than 3-4 months), the level of regional blood flow in the right hemisphere increases when solving lexical tasks (Demeurise G., Capon A., 1991). In patients with left-sided brain damage, the effectiveness of restoring cognitive functions increases with increased energy activity in the right hemisphere, and with its increase in the left hemisphere, the recovery process slows down (Kuznetsova S. M. et al., 2010).

Studies of the dynamics of aphasic syndrome revealed several patterns of brain reorganization of speech in patients with aphasia: 1) regression of aphasia is mainly determined by the involvement of intact parts of the left hemisphere; 2) the depth of interhemispheric reorganization of speech is determined by its initial profile and degree of lateralization; 3) the right hemisphere is mainly involved in the processes of compensation for violations of impressive speech, the rate of reduction of violations of which is faster than the rate of expressive speech (Lendrem W.E.N.D..Y., Lincoln N. B., 1985; Vallar G. et al., 1988; Vallar G., 1990; Basso A., 1992; Cappa S.F., Vallar G., 1992; Mazzoni M. et al., 1992; Gainotti G., 1993).

It was noted that unilateral brain damage causes not only symptoms that indicate the topical location of the lesion but also those that are characteristic of damage to homologous areas and functionally related to the lesion (dynamic dyschisis) (Price C.J. et al., 2001). Little research has been done on the issue of right-brain function suppression in aphasia. This is because traditionally neuropsychological diagnostics is carried out mainly about the range of symptoms determined by the topical focus. This limits the possibility of identifying the degree of functional preservation outside the focal brain regions, including homologous regions of the healthy hemisphere, which is important for assessing the rehabilitation potential (reserve) of a patient with aphasia.

In the 80-90th of the XX century, important facts concerning the right-hemisphere effects caused by aphasia were described and confirmed later in a large number of neuropsychological and neurobiological studiesй.

For example, it was found that in patients with vascular and traumatic aphasia in the task of dichotic listening to the word, the left ear has the advantage of о (Crosson B., Warren L., 1981), and the degree of its severity is determined by the roughness of speech disorders (Moore W.H., Weidner W.E., 1975). In the course of speech recoveryп, the left earослабевает's power weakens (Pettit J.M., Noll J.D., 1979), but not completely (Niccum N.E., 1986). To a considerable extentэтот процесс, this process is determined by the type and duration of aphasia (Shipkova K.M., 2013, 2014, 2022a, 2022b, 2022c; Shipkova K.M., Bulygina V.G., 2023a).

When solving the problem of discrimination of oppositional phonemes, which is associated with the activation of the Wernicke zone, patients with sensory aphasia show right-sidedей выявляется правосторонняя латерализация lateralization of activation with simultaneous decrease and or complete disappearance and activation in theи left hemisphere (Mayorova L. A., 2013).

The study of right hemisphere stealing symptoms in patients with aphasia shows that при нарушенияхspeech disorders of the anterior type (premotor-prefrontal) show symptoms of dysfunction not only of the anterior but also of the temporal and parietal-occipital parts of the right hemisphere. Dysfunctionality of the right hemisphere manifests itself in the form of topological and metric errors when copying figures, structural distortions in the graphic reproduction of nonverbal figures, and violation of auditory non-speech gnosis. In patients with speech disorders mainly of the temporal type, right-hemisphere symptoms are represented by broad parietal and occipital symptoms. This symptom manifests itself in the dysfunction of hearing and non-speech gnosis, difficulties опознания in identifying subject images, contamination when learning difficult-to-visualize figures, metric and structural-topological errors in optical-spatial gnosis (Malyukova N. G., 2002). Right-handed patients with aphasia develop phonological errors characteristic of patients with split-brain syndrome when writing with the left hand (Shipkova K. M. et al., 2003).

In the strict sense of dynamic ditches (ditches) as a temporary inhibition of intact brain structures that are anatomically or functionally related to the affected area, one can speak only when it manifests itself in the acute and subacute periods of the disease. In the delayed period of the disease, when its neurophysiological manifestations have regressed, it cannot be considered as such. If in aphasia the dysfunctionality of the right hemisphere functions in the acute and subacute periods can be interpreted as the effect of dialysis, then its presence in the long-term period of the disease is already evidence of the process of hemispheric reorganization of speech function. The fact that the presence of right-hemisphere symptoms correlates with the positive dynamics of aphasic syndrome confirms that the process of spontaneous brain reorganization of speech is productive (Yekusheva E. V., Damulin I. V., 2013; Oujamaa L. et al., 2009).

The explanatory mechanisms of the appearance of right-hemisphere neuropsychological symptoms in aphasia are reduced to two concepts. The first one considers the possibility of the right hemisphere's participation in speech processes as caused by the left-handedness factor (Luria A. R., 1947, 1973; Balonov L. Ya., Deglin

V. L., 1976). The second one considers the subdominant hemisphere as a structure that is similar to the left hemisphere but with limited speech competence. The second view is confirmed in the fact s array. находит подтверждение в ряде фактовFirst, when the right hemisphere is damaged, a specific linguistic deficit occurs (Wiesel T.G., 2002, 2015; Pulvermüller F., Berthier M..L., 2008; Cappa S..F., 2015, 2000). Secondly, in right-handers with left-hemisphere aphasia, performing lexicon-grammatical tasks, dichoticго listening to the I cause an increased evoked response in the right hemisphere (Cappa S.F., Vallar G., 1992). This picture is not observed in patients with right-hemisphere brain damage and preserved speech and healthy people (Papanicolaou A. C. et al., 1988a, 1988b). Third, recurrent stroke increases the severity of speech disorders in the right hemisphere and/or causes right-hemisphere speech symptoms. For example, a patient with a sufficient level of speech recovery after a left-hemisphere stroke and a recurrent stroke in the right hemisphere may experience a marked regression in the level of speech recovery (Mazzoni M.et al., 1992). A recurrent stroke that affects homologous areas of the Wernicke zone also presents with an anomie symptom (Lee H. et al., 1984).

Approaches based on the systematization of individual observations on the dynamics of aphasic syndrome у in right-handed people confirm the position of E. Seidel (1976, 1983, 1985) about the presence (albeit selective) of speech competence in the right hemisphere and the possibility of its participation in the process понимания of speech understanding (Gainotti G., 1976, 1993; Vallar G. et al., 1988; Vallar G., 1990). At the same time, the statement of M. S. Gazzaniga (1983) about the absence у правого of speech competence in the right hemisphere is not confirmed речевой, although в this model does not deny the possibility of individual differences in this indicator.

The role of the right hemisphere in the restoration of aphasia has been a subject of active discussion by aphasiologists over the past few decades (Shipkova K.M., Bulygina V.G., 2023a; Hécaen H., 1969, 1972; Hécaen H., Ajuriaguerra J., 1976). Points of view on this issue are polar, ranging from the idea of the productive role of the right hemisphere in overcoming aphasia to the direct denial of its constructive role in the regression of aphasic disorders. These representations reflect two types of models of language competence in the right hemisphere.

The first, so-called low-level models,), considers the right hemisphere as a brain structure that is partially involved only in the lexical and grammatical side of speech. These models are based on the idea of E. Zaidel (1976, 1983, 1985) about the limited speech competence of the right hemisphere and are based mainly on the study of the "split" brain syndrome. These data are supported by several neuropsychological studies showing the selectivity of lexical-semantic speech disorders in right hemisphere lesions.

The second type of models –higher-level models), which are more modern, on the contrary, postulate the important role of the right hemisphere in higher language processes, such as understanding complex turns of speech, abstractions, and metaphors. The search for possible ways of consensus leads to the following understanding of the place of the right hemisphere in speech and language processes, namely, its leading role in understanding new, unusual metaphorical turns of speech (Wiesel T. G., 2002). In other cases, for example, when recognising familiar lexical and grammatical codes, speech processes have a bilateral organization (Gainotti G., 2016).

A study of the neurobiological foundations of speech in a healthy brain has shown that speech perception by ear is associated not only with activation of the Wernicke zone, which corresponds to the classical ideas of neuropsychology about the brain organization of auditory-speech perception but also other parts of the same hemisphere, as well as about homologous ones in the subdominant hemisphere (Trachenko O. P., 1986; Basso et al., 1989). In healthy people, the performance of verbal-mnestic tasks (counting in the mind, memorizing text by ear), and tasks for verbal fluency (selecting words according to a certain feature) enhances the interhemispheric межполушарное interaction of the posterior cortex of the left hemisphere and the anterior cortex of the right hemisphere (Ivanitsky G. A. et al., 2002; Danko S. G. et al., 2005).

The involvement of the right hemisphere is found not only in the process of speech perception but also in the process of speech generation. For example, in the task of mentally composing sentences from words, along with the Wernicke zone, activation in the occipital regions of both the left and right hemispheres increases. An important feature is that this amplification occurs not so much about ipsilateral as contralateral connections (Zarapina D. M. et al., 2007). Thus, when composing a word or phrase from perceived phonemes or words, there is a significant increase in the biopotentials of the Wernicke zone and the broad response zone in the contralateral hemisphere: the homologous region and several other parts of it (Zarapina D. M. et al., 2007).

Thus, neurobiological studies confirm the bi-hemispheric nature of the brain representation of speech function.

Dynamics of speech recovery in the early recoveryый period in patients with vascular aphasiaeshow that regardless of the volume of the focus and the type афазии (плавная (of aphasia (fluent), неплавная (, nonfluent), the recovery process is characterized by an advanced regression of disorders in impressive speech, сопровождающимсяaccompanied by an increase in activation of the broad evoked response zone in the right hemisphere. This confirms the ability of the subdominant hemisphere to compensate for violations of the lexical and semantic side of speech (Springer S., Deich G., 1983; Mayorova L.A. et al., 2013; Cappa S.F., Vallar G., 1992; Ansaldo A., 2004).

In patients with positive dynamics of recovery of chronic aphasia, the performance of speech tasks is accompanied by synchronized activation of both homologous and non-homologous zones in the right hemisphere (Kiran S. et al., 2019). A higher level of speech preservation in patients with aphasia positively correlates with a high level of activation both in the speech zones in the left and, which is not typical for healthy people, in the right hemisphere (Wilson S.M., Schneck S.M., 2021).

The topography of lateralization of brain activation zones is determined by the nature of the verbal task: naming, finding grammatical and semantic errors, etc. (Heiss W.D., Thiel A., 2006). The partial discrepancy in different studies зон of brain activation zones when solving speech problems можно can be explained by different types of proposed speech tasks: completing a phrase with a word, choosing a word, naming, etc. At the same time, the results of many studies show that the process of speech recovery is laterally distributed.

Another argument that proves the involvement of the right hemisphere in speech recovery in left-hemisphere aphasia is the deterioration of speech quality in repeated stroke in the right hemisphere (Lee H. et al., 1984; Sarra S. F., Vallar G., 1992; Mazzoni M. et al., 1992; Ansaldo A., 2004; Anglade C. et al., 2014; Ulanov M.A. et al., 2018).

Second argument in favour of right-hemisphere speech competence is the observation of cases with left-hemisphere hemispherectomy in adults, in which patients did not have a significant deterioration in speech quality (Schramm J. et al., 2012).

Longitudinal studies show that in the absolute majority of patients with vascular aphasia, the right hemisphere mode of solving cognitive tasks established after the onset of the disease remains stable after 1 year or more (Balashova I.N., Egorov A. Yu., 2007). In aphasias caused by gliomas of the left frontal and temporal lobes, a stable bilateral picture of the fMRI response when performing lexical tasks persists after several months (Buklina S.B., Batalov A.I., 2018).

The involvement of the right hemisphere in the formation of the aphasic syndrome symptom complex and its dynamics confirms the fundamental psychophysiological patterns of recovery of complex functions and the important role of homologous brain regions described in the school of I. P. Pavlov. In particular, it is shown that the removal of homologous parts of the cortex in a healthy hemisphere, after the process of restoring cortical function has begun, leads to the development of more severe and prolonged consequences than in the case of their preservation (Asratyan E.A., 1953).

Data from numerous neuropsychological studies confirm the important role of interhemispheric interaction in the processes of HHF recovery. Studies have revealed a number, of facts that indicate that the restoration of speech function occurs not only with the participation of preserved structures of the left but also of the right hemisphere.

In patients with severe left-hemisphere aphasia and subsequent positive dynamics of recovery of impressive speech, repeated stroke in the right hemisphere leads to regression of speech indicators (Lhermitte F. et al., 1973; Cambier J. et al., 1983; Anglade C.et al., 2014, etc.).

In the early (subacute) recovery period (the first 3-4 months), patients with aphasia show activation of the right hemisphere when performing lexical and semantic tasks (Cappa S.F., Vallar G., 1992; Ansaldo A., 2004; Shipkova K. M., 2022a, 202b, 2022c).

A high level of speech recovery has a direct correlation with the level of activation in the speech zones of the left and homologous parts of the right hemisphere (Wilson S.M., Schneck S. M., 2021).

In patients with left hemisphere lesions and aphasia, right-hemisphere symptoms of a deficiency in some gnostic processes are detected (Wiesel T. G., 2002, 2015; Malyukova N.G., 2002; Shipkova K.M. et al., 2003).

In the early recovery period, in most patients with post-stroke left-hemisphere aphasia, the dominant thinking strategy becomes the right-hemisphere mode of solving cognitive tasks, which persists after 1 year or more (Balashova I. N., Egorov A.Yu., 2007).

Summary

A comparative analysis of the aphasia classifications of different world aphasiological schools shows that the syndromic approach to the analysis of aphasic syndrome, presented by the school of A. R. Luria, is the most productive in understanding the mechanisms and nature of aphasia. However, the syndrome approach does not pay much attention to the analysis of extra-focal neuropsychological symptoms. They considered either as not directly related to the aphasic syndrome or are interpreted in terms of atypical aphasias, or other concomitant symptoms without sufficient analysis of the causes of their occurrence.

When interpreting the oppression symptoms, the mechanisms of intra - and interhemispheric compensation of the defect, which are indicated already in the early recovery period of aphasia, are not taken into account. Oppression symptoms of healthy brain structures are obligate symptoms of the aphasic symptom complex and indicate the entry of these brain regions into the speech function reorganized as a result of damage. This understanding of the structural components of aphasic syndrome makes it necessary to rethink the methodological approach to rehabilitation in aphasia.

CHAPTER 2. WAYS TO SPEECH RESTORATION IN APHASIA

The chapter outlines the theoretical foundations, directions and modern neurorehabilitation approaches to speech restoration, presents the ways and factors that determine speech restoration, and examines the role of sensory environments in restorative learning and neurophysiological aspects of rehabilitation of speech disorders.

2.1. Ways and factors of speech restoration in patients with aphasia

Focal brain damage is a heterogeneous lesion in which part of the nerve elements located in the nucleus of the lesion is destroyed, located on the periphery – partially, and those located directly near the lesion (perifocal) remain intact, but pass into a state of dynamic dialysis, i.e. temporary functional inhibition. In each clinical case, the ratio of the affected and inactive areas is not the same. In cortical brain lesions, the effect of temporary inhibition, unlike stem lesions, is local, not global. Temporary inhibition of function develops when the perifocal departments are located on the border with the brain centres that organize the work of the damaged mental function. If the boundaries of the nuclear zone of focal damage affect the brain centres of the function, then the function is disrupted (disintegrated). With the disintegration of the mental function, mechanisms for overcoming the defect are triggered, i.e. compensation processes.

Types of ways to restore higher mental functions. The restoration of speech disorders is subject to some psychophysiological patterns (Shipkova K.M. et al., 2023; Whitworth F. et al., 2006; Berlucchi G., 2011):

1. Disinhibition (reactivation, a reversal of diaschisis, a spontaneous recovery) is a spontaneous regression of speech disorders caused by the reverse development of temporary inhibition (diaschisis, diaschisis) of speech function.

2. Vicariate, brain reorganization of function (vicariate, brain reorganization) – intra- or interhemispheric reorganization of speech, in which recovery occurs due to homologous departments of the intact hemisphere and/or intact departments (perilesional regions) of the same hemisphere.

3. Relearning – impaired speech function is "acquired" repeatedly in the process of restorative learning.

4. The restructuring of a function (cognitive relay, reeducation) occurs due to its preserved links (intrasystem restructuring) or the use of new cognitive strategies and alternative ways by relying on preserved mental processes (intersystem restructuring).

5. Substitution (substitution) – compensation of a function based on external supports involving similar mechanisms.

6. Compensation, spontaneous (functional) compensation (compensation, spontaneous compensation, redundancy) – adaptation to a defect using the residual capabilities of the function without focusing on the rehabilitation of violations.

These patterns are reflected in the relevant neuropsychological methodological approaches to the treatment of aphasic disorders. It is controversial to consider the ways of compensation and substitution as a genuine restoration of the violated HHF since it does not provide for the actual process of its restoration. For example, in the recovery of gross speech disorders, up to total aphasia, certain elements of substitution and compensation strategies are used at the initial stages of speech rehabilitation to disinhibit speech.

Many authors regard the presented ways of restoring HHF as different variants of compensation strategies because "the process of restoring violations of complex functions is not automatic, often takes a lot of time, proceeds slowly and has the character of "learning", training a new algorithm of activity" (Asratyan E.A., 1953, p. 415). Further, "compensatory devices ... represent a complex synthesis of diverse ... processes, these are ... activation of duplicating mechanisms, mobilization and activation of spare capabilities, training of intact parts and their functional and structural vicariance, ... conditional reflex restructuring of functions… The latter happens slowly and compensatory adaptations develop gradually" (Asratyan E.A., 1953, p. 425-426).

Factors affecting speech recovery. Recovery of aphasia depends on some factors:

1) etiological – aetiology, severity and prescription of the disease;

2) structurally topological – size, depth, localization, lateralization of the lesion;

3) neuropsychological – the type and initial severity of aphasic disorders;

4) neurorehabilitation – passage of a neurocognitive rehabilitation program (treated/untreated patients);

5) the left-handedness factor - the presence of family left-handedness;

6) demographic – age, gender, level of education (Basso A., 1992).

About the demographic factor, the selectivity of its influence on the prognosis of aphasia was noted. Age alone does not affect the regression of aphasia, but in combination with other factors, for example, etiological, structural and topological, it can become significant (Tsvetkova L.S., 1985; Keenan J. et al., 1974; Messerli P.et al., 1976; Kertesz A. et al., 1977; Kertesz A., 1979; Basso A. et al., 1979, 1992; Sarno M.T., 1980, 1981).

Some authors note that gender differences contribute specifics to the dynamics of recovery of expressive and impressive speech: women, in comparison with men, have a better recovery of oral speech and its understanding (Basso A. et al., 1982; Pizzamiglio L. et al., 1985). However, this parameter requires further study due to the paucity of data on the impact of gender differences on the rehabilitation prognosis of patients with aphasia.

The level of education, of course, is an indirect reflection of the initial level and degree of automation of the speech function, therefore it seems natural that in people with higher education, the dynamics of speech recovery is ahead of those with secondary education (Basso A., 1992). At the same time, if the patient is left-handed or has family left-handedness, then the left-handedness factor is stronger than the influence of the level of education.

Concerning left-handedness, there are numerous confirmations of its determining effect on the rehabilitation prognosis of patients with aphasia. In left-handed people, regression of speech disorders usually occurs spontaneously. Speech communication is completely restored without the need for long-term targeted rehabilitation (Bein E.S., 1961; Kogan V. M., 1962; Luria A.R., 1969; Burlakova M.K., 1991; Tsvetkova L.S., 2002; Khrakovskaya M.G., 2017; Zangwill O., 1947; Subirana A., 1958; Gloning K., 1977; Basso A., 1992).

The severity of the dynamics of aphasia, i.e. the severity of the rehabilitation shift, depends on the aetiology of the disease. In comparison with post-stroke aphasia, brain injury is characterized by a higher rate of regression of speech disorders (Luria A.R., 1969; Alajouanine T., 1957; Kertesz A.et al., 1977; Kertesz A., 1979; Basso A. et al., 1982; Basso A., 1992, 1998, 2000; Basso et al., 1979).

The prescription of the defect is also an important parameter influencing the reduction of aphasic disorders. In patients with aphasia, pronounced recovery dynamics are noted in the first three months, in the next six months it decreases, and a year later it becomes poorly expressed or stagnates (Kertesz A., 1979; Kolb B., Whishaw I.Q., 2003a, 2003b).

Neuropsychological practice shows that the rate of regression of disorders depends on the initial degree of speech impairment. In most cases, in patients with mild aphasia, speech improvement occurs within the first two, with an average degree of six, with a severe degree of ten weeks (Nasios G. et al., 2019). The longer the recovery period of aphasia is, the higher the risk of its chronification becomes.

Regarding the structural and topological factors, it was found that the size, localization, depth and side of the brain lesion have a pronounced effect on the dynamics of aphasic disorders (Lukashevich I.P. et al., 1999). Among the parameters of the structural and topological factor, the depth of the focal lesion is decisive (Selnes O.A. et al., 1983; Mohr L.P. et al., 1978; Brunner R.J. et al., 1982). For example, when subcortical structures are affected, there is no difference between an extensive and a small focus in the rate of regression of aphasic disorders (Demeurisse G. et al., 1987, 1991). In cortical focal lesions, localization and volume are significant parameters and directly affect the severity and dynamics of aphasia (Tsvetkova L.S., 1985; Selnes O.A. et al., 1983). For example, the lesion of the Wernicke zone is characterized by a longer process of regression of disorders in comparison with the lesion of the Broca's zone (Mohr L.P. et al., 1978; Brunner R.J.et al., 1982).

According to the hierarchical model of speech restoration by W.D. Heiss and A.A. Thiel (2006), complete regression of aphasia is associated with the location of the focus on the border with the speech region (perilesional regions), partial speech restoration – with a small lesion in the speech zone, persistent impairment – with its massive damage. The proposed hierarchy of speech restitution confirms the traditional point of view on the influence of localization and volume of cortical lesions on the rehabilitation prognosis of aphasia (Tsvetkova L.S., 2010).

Consideration of these parameters as determining the outcome of aphasia is based on the widespread notion that regression of speech disorders proceeds mainly along the path of intrahemispheric rearrangements.

2.2. Spontaneous speech recovery

There is no generally accepted understanding of function recovery in neuropsychology. Is this a return of the impaired function to its initial level, a marked improvement or partial recovery (Khrakovskaya M.G., 2017)? To a large extent, this makes it difficult to understand the ultimate goal of neurorehabilitation and the tasks facing the neuropsychologist.

The issue of preservation of the damaged function on the neurobiological basis, i.e. its neuronal level, is also insufficiently covered to initiate the process of its restoration. Accounting for the biological foundations and neurophysiological mechanisms of HHF allows us not only to explain the patterns of their recovery process but also to reflect these patterns in the principles and methodology of neuropsychological rehabilitation.

In neuropsychological rehabilitation, depending on whether the recovery process occurs independently, spontaneously or under special conditions with organized exposure, it is customary to distinguish two ways of restoring higher mental functions – spontaneous and directed recovery.

With a spontaneous pathway, the HHF is restored as a result: 1) disinhibition, 2) vicariate, and 3) spontaneous compensation of the defect. With disinhibition and vicariate, the regression of violations occurs up to its initial level, with spontaneous compensation – recovery is, as a rule, partial, and incomplete (Tsvetkova L.S., 1985).

The type of spontaneous recovery path depends to a large extent on the characteristics of the initial parameters of the structural and topological factors. In the case when the predominant pattern of the disorder is not the primary damage to the function, but its inhibition (inactivation), the main task becomes the disinhibition of the function. The neurophysiological mechanism of dialysis consists of an exorbitant protective temporary inhibition of HHF (Morell F., 1967; Finger S. et al., 2004). With dialysis, nerve connections with the affected parts of the brain are severed (Ukhtomsky A.A., 1945; Pavlov I.P., 1949; Berlucchi G., 2011). The dialysis zone captures not only the directly damaged area (the area of the lesion) but also functionally related brain structures. When inhibiting HHF, all types of neuropsychological intervention are secondary, because the main tool for its restoration is the removal of protective inhibition and the restoration of synaptic conduction achieved by drug therapy. Complete recovery of HHF occurs, as a rule, during the first 3-4 months.

In the vicariate, the damaged function is restored by moving to the preserved parts of the brain, which take over the functions of the damaged ones, i.e. structural and functional variation occurs (Asratyan E.A., 1953). In the vicariate, the restoration of function occurs with the participation of the left and right hemispheres. Neuropsychological studies have studied the dependence of the intra- and interhemispheric vicariate on the following parameters: topological characteristics of the affected area (modal specificity/non-specificity of damaged brain structures), structural characteristics of the lesion (volume, depth), one-sidedness/two-sidedness of brain damage, profile of manual asymmetry (left-handedness/right-handedness) (Shipkova K.M., 2013, 2018, 2020, 2021, 2022a; Taub E. et al., 1994).

There are two ideas about the intra- and interhemispheric vicariate time window. According to the popular view in Russian neuropsychology, in patients with aphasia, speech recovery occurs mainly due to preserved nearby parts of the brain, i.e. by intrahemispheric vicariate. This type of vicariate is dominant both in the acute and remote periods of aphasia (Tongonogij I.M., 1968; Tsvetkova L.S., 1985).

According to the second view, the processes of intra- and interhemispheric vicariate are determined to a greater extent by temporal and structural-topological factors. In the acute period, nearby intact departments are activated, both those included and those not included in the cerebral basis of speech (Demeurisse G., Capon A., 1987). This process manifests itself in the fact that in the first two weeks after a stroke, the severity of aphasia decreases, and many patients show significant improvements in speech quality (Pachek G.V., Holland A.L., 1988). In the subacute period, changes occur in the topology of neuronal networks in the direction of expanding the area of brain function capture by connecting homologous parts of the healthy hemisphere to the recovery process (Baird A., Samson S., 2015). With an extensive lesion of the speech areas of the brain, the inclusion of homologous parts of the right hemisphere in the speech recovery process occurs already at an early recovery stage (Baird A., Samson S., 2015). For example, in children with left-sided hemispherectomy (removal of the left hemisphere), speech disorders are restored already in the early recovery period due to the intact hemisphere (Simernitskaya E.G., 1985).

The degree of involvement of the right hemisphere in speech processes has great individual differences and varies from person to person and depends on which side of speech is impaired: lexico-grammatical or motor. In patients with chronic aphasia, the right hemisphere is actively involved in solving lexical and semantic problems (Wiesel T.G., 2002; Zaidel E., 1985; Papanicolaou A.C., 1984; 1987; 1988a; 1988b). The solution of verbal tasks in patients with aphasia for more than 3 months is accompanied by the formation of a stable picture of an expanded evoked response in the right hemisphere. Concerning articulated speech, the data are contradictory. In some works, it is argued that the restoration of articulated speech depends more on the intact parts of the left hemisphere (Vallar G., 1990), in others – the right hemisphere. The latter point of view is reflected in the creation of the method of Melodic Intonation Therapy as the leading method of speech rehabilitation of smooth aphasia (Zumbansen A. et al., 2014).

When modal-specific parts of the cortex are affected, which are mainly associated with the work of perceptual systems, in particular speech zones, the possibility of vicariate is limited, unlike modal-nonspecific areas of the brain. For example, neuropsychological symptoms of local damage to the frontal lobes of the brain (except for massive injuries) quickly regress due to the high functional substitutability of these structures. Symptoms often have a mild, subclinical level of manifestations and are not detected without the use of sensitized neuropsychological tests (Luria A.R., 1962; Tsvetkova L.S., 1982, 1988).

The speech areas of the brain are represented by modal-specific departments. They are located bilaterally in the posterior frontal regions and parietal-temporal cortex are connected by a stable functional connection (Zangwill O., 1947; Subirana A., 1958; Belin P. et al., 1996). Normally, homologous departments perform different functions. For example, the temporal regions of the left hemisphere provide the possibility of differentiated speech perception, and the right hemisphere – differentiated perception of non-speech sounds, noises and melodies. Thus, there is both sensory segregation and sensory integration between homologous departments. In patients with aphasia, activation of the left hemisphere by a speech stimulus generates a reaction not only in the corresponding departments of the left but in symmetrical departments of the opposite hemisphere, i.e. a mirror focus of the response is created.

The formation of mirror foci of arousal in the right hemisphere in aphasic disorders has been described in a large number of studies (Barker W.W. et al., 2002; Raboyeau G.et al. 2008; Habibi A. et al., 2018; van der Meulen I. et al., 2010, etc.). Their formation is explained by the specifics of the psychological structure of speech –

the close connection of verbalization (words) and intonation (prosody), encoding the personal meaning of the message. The provision of the intonation component of speech is associated with the work of the temporal divisions of the subdominant hemisphere (Luria A.R.1949; Tsvetkova L.S. 1972, 1975, 1988, 2002; Wiesel T.G., 2002; Zangwill O. 1947; Lecour A.R., 1976, Lecour A.R. et al., 1979, 1983, etc.). When understanding audible speech, on the one hand, the meaning of the perceived is decoded, on the other hand, its psychological meaning (personal meaning) is decoded, which is objectified in the intonation colouring of the speech message. This shows the sensory integration of speech hemispheric structures.

In patients with aphasia, the subdominant hemisphere often begins to combine both sides of speech perception (Shipkova K.M., 2013, 2022b, 2022c). Whether the combination of functions of homologous brain structures with one hemisphere can be called a vicariate, similar to the vicariate observed during hemispherectomy, is a controversial issue. Rather, this process should be interpreted as a partial functional reorganization of the morphophysiological substrate of speech, rather than a radical one, as in hemispherectomy.

As noted above, the bi-hemispheric nature of the cerebral organization of speech is its distinctive feature, therefore, the course of the compensation process, when in patients with aphasia homologous parts of the healthy hemisphere begin to actively compensate for the deficiency, seems to be a natural way of restoring speech (Xing Sh. et al., 2016).

2.3. Directed speech restoration. Theoretical foundations of relearning

In the Russian school of neuropsychology, the theoretical and methodological foundations of the directed path of recovery are based on the fundamental principles of the theory of activity and functional systems, the doctrine of localization of functions in the brain: the lifetime formation of HHF in subject activity, the primacy of the social in the human psyche, the patterns of development and decay of higher cortical human functions, systemic and dynamic localization of functions in the brain and the idea of HHF as a functional system.

The leading role in the development of a directed pathway for the recovery of aphasic disorders belongs to A.R. Luria (1962, 1969). In the future, the theoretical and methodological foundations of restorative education were deepened and supplemented by L.S. Tsvetkova (1972, 1985, 1988, 2002), V.M. Shklovsky and T.G. Wiesel (1997), T.G. Wiesel (2002, 2015, 2018).

Consideration of the HHF as a functional system introduces an understanding of the distribution of its brain organization, level structure and the variety of ways to reorganize it in case of damage. In this theoretical paradigm, the HHF is considered a system involving its working constellation different, sometimes not having common boundaries, brain regions united functionally to perform a common task. A complex cortical function can be performed in variable ways and this is one of the important features of the HHF as a functional system. The functional system in a healthy person does not show its composite nature, but when it disintegrates as a result of damage, the usual algorithm is disrupted, it is disautomatized and its anatomical multicomponence becomes obvious.

The directed way of restoring functions is also based on the doctrine of systemic and dynamic localization of functions formulated in the works of physiologists – A.A. Ukhtomsky (1945), I.P. Pavlov (1949), S.I. Filimonov (1949), E.A. Asratyan (1953), P.K. Anokhin (1955, 1968, 1973, 1980), S.N. Davidenkova (1963), and psychologists – L.S. Vygotsky (1982), A.N. Leontiev and A.V. Zaporozhets (1945), A.R. Luria (1962), etc. According to the concept of systemic localization of HHF, the cerebral basis of speech is represented by a systemic interconnection of cortical zones that implement its psychological structure: temporal, inferior parietal, temporoparietal-occipital, and posterior frontal. The composition of the interacting zones changes both in violation of the HHF and during restorative retraining.

The process of restructuring the HHF is based on some patterns: 1) with local brain lesions, the HHF does not disintegrate, but disintegrates; 2) damage to any neuropsychological factor included in the structure of the HHF leads to a violation of the corresponding psychological link of function; 3) loss of a link of function is accompanied by its disintegration, a violation of function as a whole; 4) damage to the neuropsychological factor causes simultaneous violation of different HHFs, in the structure which includes this factor, i.e. a violation of the factor forms a neuropsychological syndrome (Luria A.R., 1972). From these patterns of HHFs decay, it follows that the function can be restored either by relying on preserved links or intact HHFs.

The speech function, like other HHFs, is a multireceptor system that requires a constant influx of heterogeneous afferent signals. Their combination forms the afferent field of the function, the leading and spare (reserve) sensory channels. The formation of neuronal inter-analytical connections characteristic of an adult is gradually formed in ontogenesis. In case of a violation of the HHF, the directed restoration of function is achieved by connecting spare differences and restructuring the function according to the intra- or intersystem type.

Intra-system restructuring involves the inclusion of preserved links and preserved sides of a disrupted function, intersystem restructuring involves the inclusion of new links to replace the violated ones (Luria A.R., 1947; Tsvetkova L.S., 1972, 1979, 1988, 2002, 2010; Leontiev A.A., 1974;). Speech restoration in both variants is considered as a process based on the preserved parts of the left hemisphere, i.e. following the intrahemispheric path. Restorative retraining is difficult, requires a long time and does not always achieve automation of the function (Tsvetkova L.S., 2010).

When restoring speech through intra–system restructuring, it is taken into account that in it the leading sensory channels are auditory and speech motor, and the backup ones are visual and visual-spatial. In case of violation of the leading channel (afferentation), it is replaced by a backup one. For example, in efferent motor aphasia, the method of voiced reading is used to switch the patient's attention from pathological fixation on impaired articulation to the semantic level and a preserved visual and auditory sensory channel. Similar ideas about the possibilities of restructuring the HHF due to intrahemispheric brain rearrangements are reflected in some foreign concepts of rehabilitation (Pulvermüller F. et al., 2001, Mac Gregor L.J. et al., 2015; Kurland J. et al., 2016; Stahl B., 2018).

Inter-system restructuring is a different kind of retraining and is based on the ability of the mental function to restructure due to new links instead of the affected ones. For example, with gross violations of the pronunciation side of speech (gross efferent motor aphasia), sound speech is replaced by ideographic speech (Wiesel T.G., 2018). The inclusion of new links creates a new structural construct, the function changes its brain base, psychological structure, and the nature of its course.

The Russian aphasiological school underestimates, and sometimes it seems insignificant, the role of the intact hemisphere in the mechanisms of restructuring functions. Very few studies have been devoted to this issue (Traugott N.N., 1986; Wiesel T.G., 2002, 2015, 2018).

In foreign aphasiology, retraining is considered a process of speech restoration by relying on the preserved level and preserved sides of speech (Lecour A.R. et al., 1983; Whitworth A. et al., 2006). Thus, retraining is understood more narrowly as an in-system restructuring of a function. The techniques, methods, and structure of programmed training in neuropsychological rehabilitation abroad are in many ways similar to those used at the A.R. Luria school.

The restructuring of the HHF is carried out taking into account several groups of principles that reflect the content of the levels of construction of the HHF. Psychophysiological principles are based on the consideration of the HHF as a psychophysiological system, their consideration is an integral part of the approach to restorative learning. These include: 1) the principle of defect qualification is the diagnosis of the mechanism of dysfunction; 2) the principle of a workaround is the restoration of HHF through reliance on preserved analyzer systems and mental functions; 3) the creation of a new functional system to replace the disrupted one – intersystem restructuring of the function; 4) level reconstruction of a damaged function – restoration of function through a preserved (involuntary/arbitrary) level; 5) feedback principle – control (external/internal) throughout the function (Tsvetkova L.S., 1988, 2002).

Psychological principles reflect the behavioural and semantic aspects of the impact on the affected function at an operational and effective level: 1) taking into account the patient's personality – taking into account the patient's premorbid (education, knowledge and skills, interests, personal characteristics, age, profession); 2) reliance on verbal and non–verbal activities; 3) reliance on subject-based activities - restoration of HHF in subject-based activities; 4) the principle of organization of activities - phased planning of patient actions; 5) programming of the activity with its subsequent internalization – automation of new algorithms to replace the damaged ones.

Restorative learning has been called programmed learning (retraining) because the logic of its construction is subordinated to the principle of "from simple to complex". It depends on the dynamics of the recovery process and moves towards a gradual complication of cognitive tasks with the development of simple and then complex speech skills in patients.

Methods of restorative learning reflect the nature and take into account structural disorders of the speech process. Concerning aphasia, this is compliance with the following requirements for the formation of methodological complexes: 1) the adequacy of methodological tools to the mechanism of speech impairment; 2) the bypassing nature of the impact – the impact on the preserved links and the level of function, preserved analyzer systems; 3) the mediationality of the impact on speech through other mental processes – memory, attention, thinking, emotional and volitional sphere; 4) consistency – restoration not of individual operations, but of verbal behaviour as a whole (Tsvetkova L.S., 1988, 2002, 2010).

So, programming training is a scientifically based systematic approach to the recovery of aphasic disorders, based on the integration of neuropsychological, neuro- and psychophysiological research data.

2.3.1. Directed stimulation of speech in patients with aphasia

With incomplete recovery of aphasia, a syndrome of chronic speech disorders is formed within three months. The degree of restoration of function largely depends on the brain plasticity, which is understood as the ability of brain systems to rebuild, and be ready for structural and functional restructuring.

The effect on the mechanisms of brain plasticity can be direct or indirect (Su F., Xu W., 2020; Truzman T. et al., 2021; Wilson S.M., Schneck S.M., 2021). These two possibilities of triggering functional plasticity are reflected in two neurorehabilitation approaches with different theoretical and methodological bases.

The first one proceeds from the fact that the purpose of neurorehabilitation is to activate the preserved neuronal brain structures of the affected HHF and the functionally preserved brain structures associated with it through instrumental and/or functional stimulation, during which the damaged function should be restored in its former most complete form. In this approach, transcranial direct electrical stimulation (tDCS), and transcranial magnetic stimulation (TMS) are used as instrumental stimulation, Intensive Speech Motor Therapy (ILAT), and Constraint-Induced Therapy (CIAT) like functional stimulation.

During direct instrumental stimulation, special importance is attached to strategies aimed at increasing brain plasticity, which manifests itself in the completeness of recovery of impaired HHF (Murphy T.H., Corbett D., 2009). In many ways, the choice of strategies is determined by the vastness of the lesion.

In the presence of small lesion size, attention rules to the structural and functional remodelling of neuronal connections involving neurons located in the area adjacent to the lesion or a state of diaschisis. A necessary condition for remodelling is the complete or partial preservation of the afferent link of the affected function (Damulin I.V., Yekusheva E.V., 2014).

In massive brain lesions resulting from ischemic stroke, the processes of functional restoration are aimed at expanding the capture zone and include areas of the brain located at a distance from the focus and homologous parts of the preserved hemisphere. Experimental data indicate that the lack of activation of the preserved hemisphere reduces the severity of the possibility of a rehabilitation shift (Dancause N., 2006). For example, a favourable outcome of motor disorders in patients with massive damage to the motor cortex was achieved with direct activation of not only the preserved parts of the affected, but also homologous parts of the intact hemisphere (Murphy T.H., Corbett D., 2009), and the positive outcome was higher if stimulation was initiated in the early recovery period (Dancause N., 2006).

In aphasia, direct instrumental stimulation helps to achieve a certain positive rehabilitation shift in the indicators of oral and written speech (Barwood C.H. et al., 2011; Nissim N.R. et al., 2020). However, since it is carried out in conjunction with speech therapy (brain stimulation and speech therapy are carried out at the same time intervals and overlap with each other), it is difficult to assess the independent contribution of direct brain stimulation to the reduction of aphasic disorders, in particular in indicators of general verbal communication, subject and verbal nomination (Shipkova K.M., 2021; Elsner B.et al. 2019).

The theoretical foundations and principles of directed restoration of functions presented in Russian neuropsychology are not shared by all world schools of aphasiology. For example, the importance of observing the principle of a workaround in the rehabilitation of HHF. This principle is not taken into account in direct functional stimulation, as well as in the methodology of Coercive therapy or Intensive speech motor therapy, which were developed based on the model of operant learning (Taub E. et al., 1994; Pulvermüller F.et al., 2001).

Created within the framework of translational neurology, and tested on animals with movement disorders, they were extrapolated to neuropsychological rehabilitation for aphasia. This approach is based not on the principle of restructuring the function, but on the principle of forced retraining. In this approach, the ways of compensation and substitution are considered as unproductive. Proponents of direct functional stimulation consider the non-use or incorrect (disuse) communication algorithm in patients with aphasia as ways leading to the loss of the original neural architecture of speech and depressing, and sometimes blocking, the productivity of its restoration. To avoid this, the patient, within the framework of this approach, is forced (forced) to use speech.

The use of alternative compensatory non-verbal techniques (gestures, commenting on actions), including substitute types of non-verbal communication, is considered unproductive and deliberately devalued. The uselessness of using them as compensation strategies is achieved by putting the patient in conditions where the listener sees only the speaker's face (Shipkova K.M., 2020; Pulvermüller F., Berthier M.L., 2008). The validity of the direct effect on the function used in this approach seems to be deeply controversial, which has been repeatedly proven in the works of representatives of the psychology of activity. The impact on the function "head-on" reduces its rehabilitation reserve, and deprives it of the necessary replacement supports. In addition, the devaluation of alternative communication techniques does not mean that the patient stops using them. They are still involuntarily intertwined in the process of speech communication. The use of the preserved capabilities of the function, in this case, sign language, is a manifestation of the principle of substitution, designated in domestic neuropsychology as a spontaneous restructuring of the function (Leontiev A.N. et al. 1945; Luria A.R., 1947, 1963; 1970; Tsvetkova L.S., 1982, 1985, 1985, 2002, 2004, 2008; Wiesel T.G., 2018).

The maladaptive (negative) effect of neuroplasticity can occur in the case of unjustifiably gross interference in complex mental processes and disrupt sensory and hemispheric spontaneous structural and functional reorganization in them (Damulin I.V., Strutsenko A.A., 2021). Knowledge of the mechanism and time windows of this reorganization makes it possible to avoid decompensation of the defect.

2.3. Sensory environments in the rehabilitation of aphasic disorders

The second neurorehabilitation approach is based on non-instrumental functional brain stimulation. Sensory-enriched media are used for functional stimulation (Shipkova K.M. et al., 2023; Heiss W.D., Thiel A.A., 2006; Vive S. et al., 2020; Mishra A. et al., 2021). The sensory rehabilitation environment is called the sensory enriched environment. Its main goal is to accelerate the interhemispheric restructuring of the HHF and increase the overall effectiveness of neurocognitive rehabilitation programs.

For the first time, the crucial role of the sensory environment in maintaining human mental health was proved by a series of studies of the negative consequences of sensory deprivation for an individual conducted by D.O. Hebb (1949).

A distinctive feature of the rehabilitation sensory-enriched environment is the ability to simulate selective effects on certain brain structures, which allows you to direct and deepen the process of restoring a wide range of damaged cognitive functions (Altenmüller E., Schlaug G., 2013, 2015; Thaut M.H. et al., 2015; Ball N.J. et al., 2019; Zatorre R.J. et al., 2000). An environment enriched with stimuli has a positive effect on synaptic plasticity (neurotrophic and epigenetic factors) and stimulates neurogenesis of hippocampal and some other brain structures (Pysanenko K. et al., 2021; Mishra A. et al., 2021). A sensory-enriched environment, in comparison with a depleted environment, enhances sensory integration, which accelerates the recovery process of HHF (Vive S. et al., 2020; Mishra A. et al., 2021).

The therapeutic sensory environment uses stimuli of certain modalities and takes into account the topical characteristics of the focal lesion and the type of impaired mental function. It allows you to simulate the focal response in certain brain structures. That is, the sensory-enriched environment directs the process of reorganization of damaged HHFs in a certain hemispheric vector.

At the moment, there is no generally accepted definition of the concept of a sensory-enriched environment. The literature mainly describes its functions and forms (types). Based on the meaningful contexts of mentioning this term in the scientific literature, the following definition of this concept is proposed: sensory-enriched environment (sensory–enriched environment) - a modelling sensory restorative and correctional environment aimed at accelerating and deepening the process of hemispheric and interhemispheric restructuring (reorganization) of impaired (dysfunctional) higher mental functions.

The sensory-enriched environment uses multi-modal stimuli and their combinations: visual, auditory, tactile, motor: auditory, auditory, spatial-auditory, visual-tactile, visual-verbal, etc.

Depending on the variety of sensory stimuli used, the enriched medium can act in the form of mono- and polysensory-enriched. The most common type of monosensory medium is a music-enriched medium.

Both forms of sensory-enriched environment are used in the rehabilitation of a wide range of cognitive disorders: memory, attention, thinking, and aphasia.

For the first time, the systematic development of a methodology for the organization of therapeutic sensory environments was undertaken by supporters of the modular theory (Sternberg S., 2011). However, with the rehabilitation approach based on the restoration of HHF in a sensory-enriched environment, there is no in-depth study of the theoretical foundations of the algorithm and principles of sensory stimulation, its methodological techniques are more of a research nature, and the accumulation of facts sometimes outstrips their comprehension.

2.3.2.1. Music-enriched environment and aphasia

The music-enriched environment is used in neurocognitive programs not as a way to create a favourable relaxing atmosphere, which reflects the traditional view of the therapeutic effects of music, but as a tool for influencing neurogenesis and neuronal integration (connectivity) in the damaged brain. The stimulating effect of music is manifested in the fact that when listening to it, involuntary chains of visual, auditory, and verbal associations are generated, and enriched with personal memories and experiences. Sensory-emotional response to music is accompanied by a transcortical response in a wide area of cortical-subcortical structures (Shipkova K.M., 2018, 2019, 2021).

The brain foundations of musical perception. Music perception is a complex, multilevel type of perception (Avdeev L.V. et al., 2006). Its perception is a hierarchically organized process consisting of three levels: 1) sensory – the sensation caused by sound; 2) perceptual – the perception of musical harmony-rhythmic patterns (includes structuring, highlighting the rhythmic pattern of melody, musical harmony of music); 3) emotional-mental – understanding the semantic content and sensory experience of music.

Any music evokes a perceptual and emotional response mainly in the right hemisphere (Pavlygina R.A. et al., 2004; Pavlov A. E., 2007; Bangert M. et al., 2006; Marques C. et al., 2007). Its perceptual processing in non-musicians, unlike musicians, is accompanied by an increased focus of activity in the temporal and temporoparietal regions of the right hemisphere. In musicians, on the contrary, the brain response to music activates the left hemisphere to a greater extent (Pavlov A.E., 2007; Bangert M. et al., 2006; Marques C. et al., 2007; Herholz S.C. et al., 2012).

The focus of the brain response in musical perception (musical perception) is largely determined by the tasks that are solved during the perception of music. For example, in the task of isolating the rhythmic pattern of a melodic series in non-musicians, an evoked response is generated in the occipitotemporal cortex of the right hemisphere, the frontal motor cortex, the varolian bridge and the cerebellum (Vartanov A.V., 2011; Jomori I. et al., 2013). In the case of the so-called imitation of the game (listening to music with the possibility of observing the movements of the musician's fingers), activation of the inferior frontal gyrus and premotor cortex is caused (Carvalho D. et al., 2013). Such a picture of the brain response when simulating a game is associated with the operation of the system of audiovisual mirror neurons (mirror neuron system) located in the frontal lobes of the brain.

The focus of the evoked brain response is also influenced by the rhythmic pattern of the music. Major music causes predominant activation of the left dorsal striatum and bilaterally ventral striatum, minor music causes activation of the right hippocampus and amygdala, and contiguous (neutral) music causes activation of the islet (Altenmüller E., Schlaug G., 2013). There are differences in the strength of the EEG response depending on the severity of the emotional sign of the music. Major music, in comparison with minor music, causes a stronger response in the superior temporal gyrus (Shahin A. et al., 2003).

The genre of music, along with its rhythmic scale, is also a tool for selective activation of the brain. For example, rock music creates a predominantly evoked response in the temporal, central and parietal regions, and classical music in the temporal region (Pavlygina R. A. et al., 2004).

The fact that music of different tempo-rhythmic warehouses and genres can cause a different topical focus of the response in the right hemisphere is of particular importance in the rehabilitation of left hemisphere disorders functions based on the intact right hemisphere.

Music and speech. Due to the branching of its neural networks, musical perception, like speech, is a complex gnostic process. Its perception and processing (recognition of melody, and rhythm) are accompanied by activation of the temporal, frontal and parietal cortex, cerebellum and structures of the limbic system. The participation of these brain structures is also involved in the syntactic and semantic processing of verbal information, arbitrary attention, and episodic and semantic memory. For example, when listening to Mozart's music (the Mozart effect), the level of performance of both verbal and non-verbal tasks increases significantly (Rauscer F.H. et al., 1993; Angel L.A. et al., 2010).

The widespread use of a music-enriched environment in working with aphasia is associated with some objective reasons: the proximity of the psychological structure of musical and verbal perception, a good understanding of the neurophysiological mechanisms of music's effect on brain activity and cognitive processes; (Soria-Urios G. et al., 2011).

For the perception of music, the ability of the human ear to isolate simple tones from an audio signal of any complexity is important. Musical perception distinguishes musical intonations in the sound stream – transitions between sounds of a certain height. Several levels of musical hearing are involved in music perception in different ways:

1) pitch hearing – the ability to distinguish sounds of different heights (an innate human quality);

2) interval hearing (rhythm) – the ability to distinguish musical interval – the distance between notes in height (develops in life);

3) intonation hearing – the ability to identify differences in intonation when performing a work (participates in the perception of speech intonation);

4) emotional hearing – the association of melody with emotional intonation (understanding the emotional sign of music) (Avdeev L.V. et al., 2006).

Different levels of musical hearing are processed by different parts of the hemispheres (Morozov V.P., 2013; Levitin L.C., Tirovolas A.K., 2009). The cerebral basis of interval hearing is the auditory and motor cortex (Fedotchev A.I., Radchenko G.S., 2013), and emotional and intonation hearing is the right temporal cortex. Its damage causes the inability to adequately perceive and identify familiar melodies (amusia), voice, and speech intonation. Monaural listening to phrases with different emotional intonations also shows the advantage of the left ear, i.e. of the right hemisphere, in solving problems of emotional divergence (Morozov V.P. et al., 1998). Normally, there is a wide variation in the degree of development of different levels of musical hearing associated with individual experience and innate abilities of an individual (Morozov V.P., 1998; Shipkova K.M., 2019).

Any music evokes an emotional response, the so-called experience of music (Avdeev L.V. et al., 2006). The neurobiological basis for experiencing music is the structures of the emotional brain. It includes the hippocampus, singular gyrus, and amygdala. In addition to these structures, many authors also include the temporal cortex and striatum (Mitterschiffthaler M.T. et al., 2007), the lower temporal cortex (Jomori I. et al., 2013), the frontal cortex (Altenmüller E., Schlaug G., 2015). The participation of the frontal cortex in the emotional level of musical perception seems to be quite expected because the response to music is the result of a meaningful experience of music by the subject.

The optimal neurophysiological basis for the process of imprinting a trace is created by three integral components of music – melodic, harmonic, and rhythmic. Rhythmic patterns of music mimic the oscillatory rhythmic synchronization codes of neural information processing in the brain so that it becomes a powerful stimulus for the transmission of cognitive-perceptual information and consolidation of the trace. In this sense, a music-enriched environment is an ideal template for declarative and procedural learning (according to J. To Anderson) (Thaut M.H, 2005).

Musicality and singing are rarely tested as manifestations of cognitive deficits, even though they are important indicators of hierarchical disorders in cognitive functioning (Aldridge D., 1993). The preservation of these abilities in aphasia is associated with a positive prognosis of rehabilitation measures.

Music-enriched environment and aphasia. In neuropsychology, the music-enriched environment among sensory-enriched environments became one of the first to be used for several reasons. Firstly, because Music Therapy (MT) has taken a firm place among effective psychotherapeutic techniques. Secondly, the music-enriched environment contributes to the triggering of the neuroplasticity mechanism. In the 80s, a new direction was created in foreign neuropsychology – Neurological Music Therapy (NMT) (Aldridge D., 1993; Thaut M.H., 2005; Koelsch S., 2009).

The observation that singing speech has a positive effect on the dynamics of regression of disorders in patients with Broca's aphasia has aroused increased interest in studying the effects of sound and melody on the rehabilitation of aphasic disorders. This formed the basis of the method of Melodic Intonation Therapy (MIT), created by M.L. Albert, R.W. Sparks and N. Nelm in 1973.

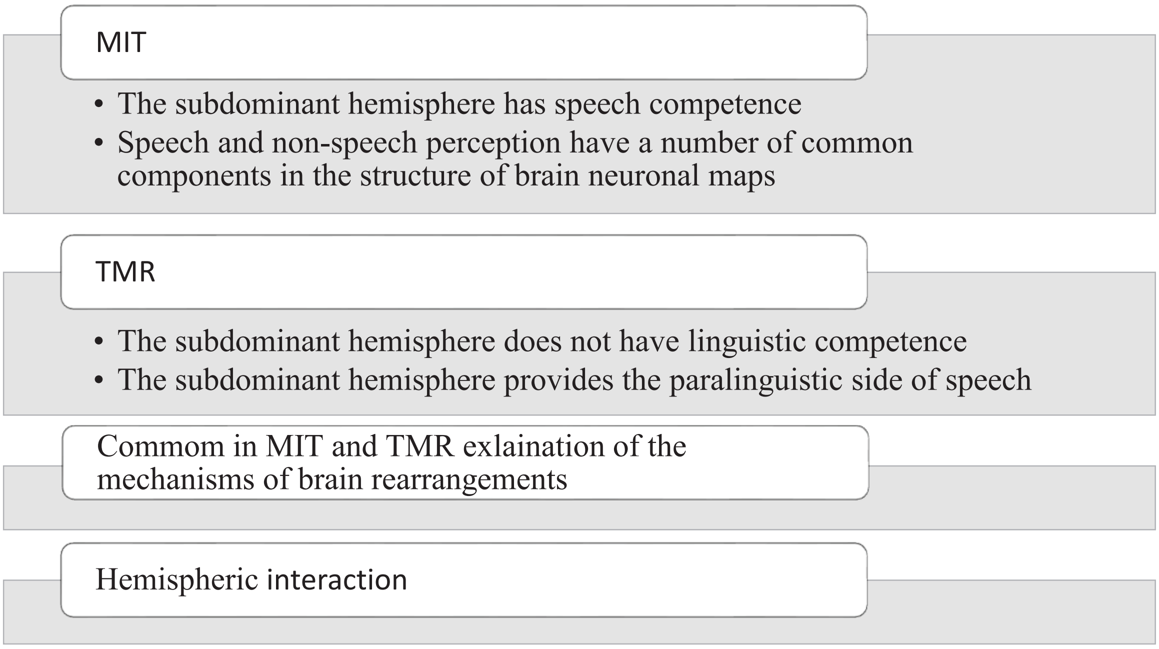

Figure 1. The idea of the brain organization of speech processes, reflected in the techniques and technologies of MIT and TMR therapy

At the moment, this method is recommended by the American Neurological Academy as the central method of restoring articulated speech in non-floating aphasia (Broca's aphasia). The MIT method is based on the involvement of both hemispheres in the process of speech recovery. In disorders of expressive speech in patients with non-floating aphasia, the use of rhythm and melody affects the reduction of speech articulation disorders and improves the quality of spontaneous speech (Peters I., 1999; Herbert S. et al., 2003; Racette A. et al., 2006; Zumbansen A. et al., 2014; Merrett D. et al., 2014).

MIT therapy is based on the hypothesis that the temporal lobes of the right hemisphere, responsible for the musical processing of information, have, in addition to musical and speech abilities, therefore they can compensate for aphasic deficiency (Wilson S.J. et al., 2006) (fig. 1).

Another hypothesis explains the effectiveness of MIT therapy in overcoming speech articulation disorders by the fact that, by triggering a direct three-way interaction between perception, movement and music, the mirror neuron system and auditory-motor coordination are activated with the help of MIT (Racette A. et al., 2006).

The technique of MIT therapy consists of the fact that patients do not speak, but sing a phrase with a bit of exaggerated prosody and accentuated intonation of the word (intoned speech) by increasing the pitch of the sound on the stressed syllable and lowering it on the unstressed syllable. In addition to the speech intonation, MIT therapy actively includes auditory and visual supports.

It is assumed that exaggerating the timbre and general rhythmic pattern of phrases with simultaneous tapping of the rhythm of words with the left hand stimulates the language areas in the right hemisphere. The importance of observing the condition of rhythmization with the left hand is controversial, since there are no differences in the dynamics of regression of speech disorders between rhythm tapping with the right and left hands (Zumbansen A. et al., 2014).

MIT therapy has limitations, it is aimed at overcoming violations of propositional rather than ordinary automated speech (idioms, memorized lyrics from songs, proverbs, sayings, speech patterns, etc.) (Hébert S. et al., 2003). Another version of MIT is called Melodic-rhythmic therapy (Thérapie mélodique est rythmée (TMR) (Breier J.I. et al., 2011) (fig. 1). TMR therapy is based on the denial of speech competence of the right hemisphere, while it uses techniques of intonation and rhythmization of speech (fig.2).

An analysis of the protocols for the patients' management with aphasia using a music-enriched environment in the form of MIT therapy or in combination with traditional speech therapy or active music therapy indicates that this method is more effective in non-floating than in smooth aphasia. With Broca's aphasia, improvements are noted in both articulate speech and vocabulary, and with smooth aphasia, no such effect was noted. There was also no linear relationship between the duration of the course, its intensity and the improvement of speech indicators. The effect of a positive rehabilitation shift is not always achieved with high intensity and duration of exposure (Zumbansen A., Tremblay P., 2019).

As shown by randomized controlled trials, the effectiveness of MIT depends on the prescription of aphasia. In the acute period, its effectiveness is higher than after a year or more (van der Meulen I. et al., 2014).

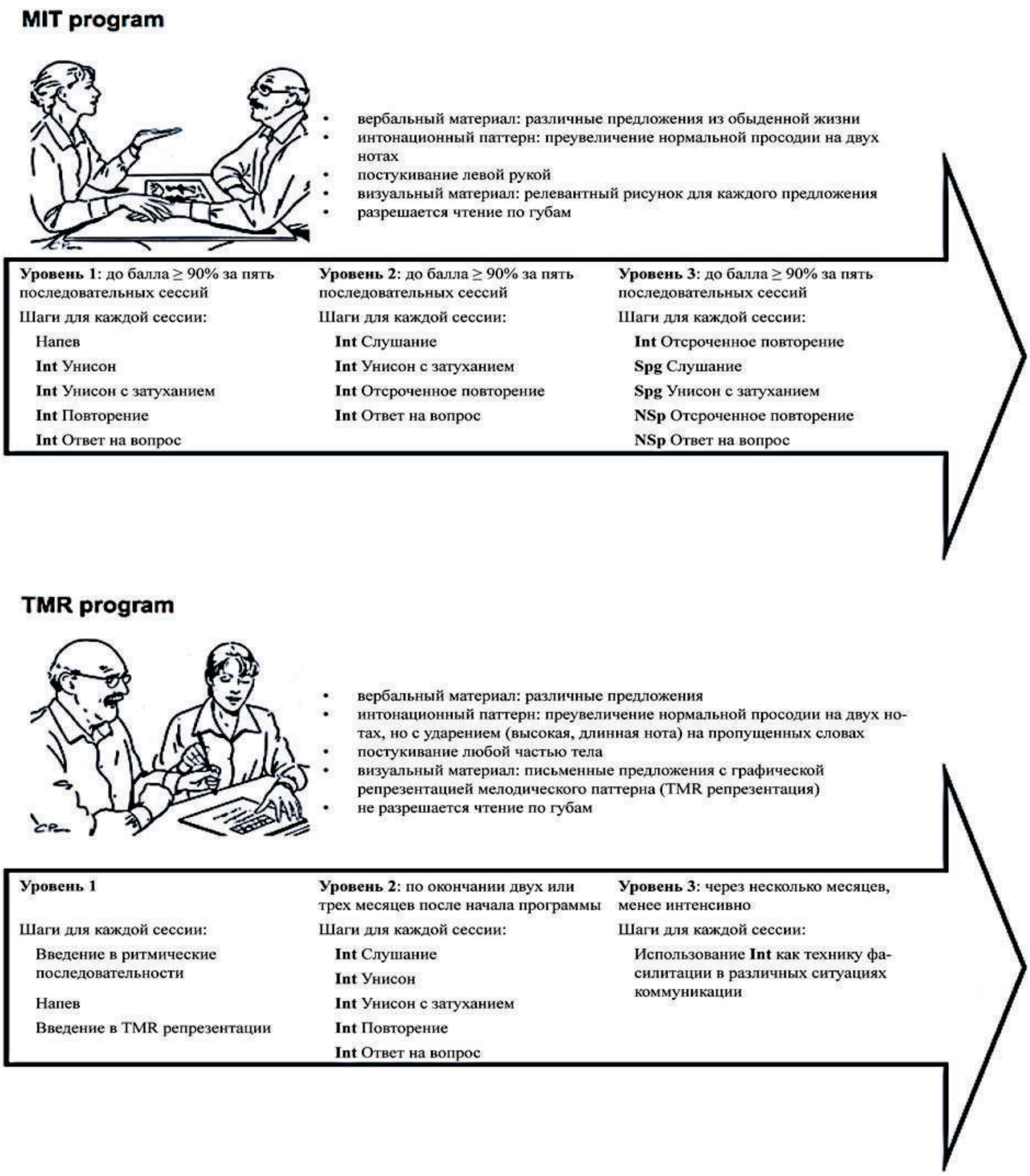

Figure 2. MIT and TMR technology (according to Zumbansen A. et al., 2014)

It is debatable whether interhemispheric rearrangements occur during MIT therapy and TMR therapy. According to the data from functional magnetic resonance imaging (fMRI), and magnetoencephalography (MEG) at MIT, there was no doubt shifting in the focus of hemispheric activity to the right hemisphere (Breier J.I. et al., 2010). This may be explained by the fact that the studies did not pay attention to the volume of focal brain damage in patients with aphasia, which is one of the trigger mechanisms of functional vicariate (Altenmuller E., 2015).

If MIT therapy and TMR therapy are aimed at restoring expressive speech, then passive music therapy is used to overcome violations of both oral speeches.

Systematic (at least 6 months) musical intervention in the form of listening to music according to their musical preferences (at least 1.5 hours per day) It helps to create a mirror right hemisphere focus of response to verbal stimuli. Prolonged exposure to music leads to changes at the morphophysiological level, increasing the volume of grey matter (GMV) (grey matter volume) in the frontal lobes of the brain (Särkämö T. et al., 2008).

Along with the rehabilitation effectiveness, MIT therapy and TMR therapy have weaknesses. They do not indicate the transition from sung speech to normal speech. Therefore, many specialists use these techniques palliatively and apply their elements selectively without strict adherence to the stages.

The rehabilitative effectiveness of musical techniques when working with speech disorders indicates that the neuronal system of speech and musical perception has some common links, which is reflected in the hypothesis of OPERA (Overlap, Precision, Emotion, Repetition, Attention) (Patel A.D., 2014). According to her, the perception of music has many common links with the processing of speech information and a music-enriched environment increases the adaptability and plasticity of the neuronal architectonics of speech function (Cheever T. et al., 2018). This understanding of the influence of music on speech echoes the provisions of the motor-speech hypothesis.

In the motor-speech hypothesis, the positive effect of music on the restoration of aphasia is explained by the action of four non-mutually exclusive causes:

1) exposure to music leads to neuroplastic reorganization of speech function;
2) musical intervention activates the mirror neuron system and multimodal integration;

3) music helps to increase the activity of the speech function in the use of common links of musical perception;
4) music increases the emotional background and contributes to the formation of the patient's motivational readiness for rehabilitation (Merrett D. et al., 2014).

The motor-speech hypothesis touches on important aspects of the commonality of musical and speech perception. At the same time, it does not answer the question of the reasons for the low effectiveness of MIT therapy in the rehabilitation of smooth aphasia, or whether speech regression will occur in patients with aphasia when switching to a normal speaking style. Research shows that the focus of hemispheric activity largely depends on the technique of pronouncing a word: if a word is pronounced in the MIT technique, then this is accompanied by activation of homologous regions of the right hemisphere, if in the usual way of speaking, then the focus of activity moves to the left hemisphere (Belin P. et al., 1996).

A music-enriched environment can contribute not only to compensation but also to the decompensation of an aphasic defect. A meta-analytical systematic review of a sample of 816 patients showed that a short period of musical intervention (<20 weeks) in the form of passive MT (listening to music) has a more significant positive effect than a prolonged intervention (>20 weeks) in the form of active MT (vocalization) (Moreno-Morales C. et al., 2020).

In disorders of impressive speech caused by damage to the left temporal lobe, the music-enriched environment is unfairly rarely used. Perhaps the reason is related to the unsuccessful experience of using MIT in patients with temporal types of aphasia (sensory, acoustic-mnestic), who did not have positive dynamics in speech (Zumbansen A., Tremblay P., 2019).

Taking into account the data from neurobiological studies that show that music perception activates the temporal lobe of the right hemisphere, musical influence should be used as a workaround for restoring disorders of impressive speech.

Modelling a music-enriched environment in working with temporal types of aphasia should not copy the forms, methods and methodological techniques used when working with non-floating aphasia, because these forms of speech disorders are based on different neuropsychological mechanisms. If with non-smooth aphasias this is a rhythmic-melodic strategy, then with smooth aphasias it is a fundamentally different focus target – the sound-differentiating orientation of musical techniques (Shipkova K.M., 2018, 2021, 2023b).

The influence of a music-enriched environment on structural and functional rearrangements in the brain in aphasia. Many instrumental research methods confirm that in aphasia, the music-enriched environment causes a pronounced focus on the activation of the right hemisphere. For example, in patients with Broca's aphasia, the usual process of speech production is accompanied by activation of the left hemisphere in the departments located behind the central gyrus, in the upper temporal and right lower precentral gyrus. When speech is restored by MIT therapy lasting at least six weeks, the focus of brain activation and its shift from the left to the right hemisphere is accompanied by positive dynamics of speech recovery.

Another example. Solving a simple musical problem – determining the emotional sign or tonality of a piece of music, activating the right temporal lobe, simultaneously leads to an improved understanding of the emotional sign of speech intonation (Thompson W.F. et al., 2004). The following example. One of the specific symptoms of impaired expressive speech in Broca's aphasia, well known to aphasiologists, is impaired understanding of syntax (sense of language), but it is little known that this type of aphasia is characterized by an understanding of musical harmony. The success of solving musical syntactic problems (determining harmony in musical phrases in several chords, where one chord is dissonant) serves as a predictor of the success of solving linguistic syntactic problems (for example, finding an error in the phrase "The sailors called the captain and asked for a bottle of good rum") (Schlaug G. et al., 2008). These facts show the closeness of the functional and structural connection between speech and musical processes.

The structural community of musical perception and speech has contributed to the widespread use of music therapy as a form of targeted stimulation of brain structures involved in cognitive, behavioural and speech processes (Rosen H.J. et al., 2000; Moreno S., 2009). For example, when processing auditory and speech information, activation of the gyrus of Heschl and planum temporale occurs (Keenan J.P. et al., 2001; Johansson V.V., 2011). When performing movements, including speech articulation – the inferior frontal gyrus, primary motor cortex, and cerebellum (Amunts K. et al., 1997; Gaser C., Schlaug G., 2003; Hutchinson S. et al., 2003; Luders E. et al., 2004; Tomaino C.M., 2012.; Wan C. et al., 2014). When solving musical tasks requiring the participation of control functions, there is an increase in activation of the frontal lobes (Amunts K. et al., 1997), and when performing two-handed movements, the corpus callosum (Schlaug G. et al., 1995). Thus, numerous data confirm the similarity of brain activity zones when performing speech and non-speech tasks.

In aphasia, daily musical intervention initiated in the subacute period in the form of simple listening to music after 3-6 months leads to structural changes at the cortical-subcortical level. There is a selective increase in the volume of grey matter in some speech fields (BA8, BA10, BA32), the anterior cingulate cortex, and the right striatum. The increase in the volume of grey matter (GMW) and white matter (WM) of the brain correlates with positive dynamics in solving mnestic and speech tasks (Särkämö T. et al., 2008).

MIT therapy also affects structural changes in the brain, strengthening the integration links between the frontal and temporal cortex. This, in turn, leads to an increase in GMW in the left (Breier J.I. et al., 2011) and right hemispheres (Särkämö T. et al., 2008). In patients with Broca's aphasia, the process of frontal-temporal integration directly correlates with improved indicators of verbal memory volume, speech quality and directed attention.

Thus, systematic rhythmic-melodic therapeutic intervention in the rehabilitation of patients with aphasia is an accelerator for the formation of new and strengthening preserved neuronal connections and a trigger for neuroplasticity (Gaser C., Schlaug G., 2003; Soria-Urios G. et al., 2011; McDermott O. et al., 2013). Music-enriched environment creates the necessary morphological basis, contributing to the formation of positive rehabilitation shift (Shipkova K. M., 2018, 2019, 2020; Hyde, K. L. et al., 2009; Habibi A. et al., 2018).

2.3.2.2. Modelling polysensory-enriched environment and aphasia

A polysensory-enriched environment is more widely introduced into the therapy of neurodegenerative diseases than non-progressive cognitive disorders such as aphasia. A possible explanation for this is that traditionally, visual and auditory supports have been used in speech therapy of aphasic disorders. In a polysensory-enriched environment, unlike a monosensory one, different types of sensory stimuli are used simultaneously. Their place and role are explained by the task of a specific stage of a rehabilitation, correctional or habilitation program, in which combinations of sensory stimuli change during recovery work.

The main goal of the polysensory environment is to activate intersensory and hemispheric connectivity. Compared to monomodal stimulation, polymodal stimulation contributes to a greater volume of capture of preserved brain structures in both hemispheres, and the expansion of the sensory geography of activated brain structures strengthens intermodal and interhemispheric integration. In aphasic disorders, strengthening the integration connections of the neocortex should help accelerate the processing of intra- and interhemispheric speech rearrangement and restoration.

However, modelling of polysensory environments involves not only the involvement of all preserved sensory systems but also taking into account the structure of the neuropsychological syndrome, the prescription and topography of the lesion, neurophysiological mechanisms of intra- and interhemispheric compensation for aphasic disorders (Shipkova K.M., 2023b). For today, the theoretical foundations and methodology for modelling polysensory- and music-enriched environments have not yet been developed and are exploratory.

It must be admitted that the study of several of these issues in neuroscience is significantly ahead of neuropsychological research in this field.

Neurobiological studies show that in a polysensory-enriched environment, regression of post-stroke cognitive and motor disorders in stroke, positive dynamics in speech is associated with an increase in the volume of grey and white matter: GMW in the frontal and parietal cortex, cerebellum and the volume of white matter connecting these departments and the pathways exiting them (Grau-Olivares M. et al., 2010; Dang C. et al., 2013; Fan F. et al., 2013). An increase in the complexity of the dendritic system is accompanied by positive dynamics in the cognitive and motor status of the patient (Biernaskie J., Corbett D., 2001). Thus, the exposure to a polysensory-enriched environment on the structural parameters of the large hemispheres is similar to the effect of a music-enriched environment.

The experience of using polysensory-enriched environment in translational neurology shows that an environment enriched with both auditory and visual stimulation affects not only the regression of cognitive deficits but also a decrease in the volume of the lesion (Maegele M. et al., 2005a; Maegele M. et al., 2005b).

In neuropsychological practice, the issue of a systematic approach to sensory stimulation in aphasia is practically insufficiently covered. One of the first works in Russian neuropsychological rehabilitation was a study by E.S. Berdnikovich et al. (2013), in which targeted sensory stimulation was applied to patients in the acute and early recovery periods with sensor-motor aphasia. Patients split into three groups based on the leading sensory channel: visual, auditory, and kinesthetic. Visual artists selected bright pictures and words that characterize the visual characteristics of objects (shape, colour, etc.). The audials worked with sound stimuli that differ in volume, timbre and intonation, as well as musical compositions, and poems. The kinesthetics dealt with tactile stimuli. As the study showed, the allocation of the leading sensory channel as a support for speech recovery improved the rate of regression of speech disorders, with higher rates observed in visual and kinesthetics.

This methodological approach to sensory stimulation gives reason to talk about polymodal rather than monomodal stimulation since the methodological techniques require the patient to switch from one modality to another when solving problems. The division of sensory channels into leading and auxiliary channels proposed by the authors took place in line with the classical psychological tradition. An important point of the study is the special attention of the neuropsychologist, and speech therapist to individual differences in the leading channel of perception. Along with this, the work does not reflect the complexity and consistency in the organization of restorative materials and does not provide evidence for assigning patients to a particular sensory group through the leading channel of perception, which limits the possibility of extrapolating these data.

Of course, there are still many unresolved problems in aphasiology, many fundamental debatable issues. At the same time, practical aphasiology is in urgent need of new theoretical and methodological developments to increase the effectiveness of rehabilitation programs and accelerate the rehabilitation process of aphasic disorders.

Summary

The development of rehabilitation approaches to speech restoration in a sensory-enriched environment is a definite vector towards recognizing the importance of mechanisms of not only intrahemispheric but also interhemispheric interaction in speech restoration.

The use of sensory media in neuropsychological rehabilitation is not new. In the traditional approach to speech restoration in aphasia, reliance on preserved sensory systems has always been considered an essential component of the recovery process, but it did not place special emphasis on hemispheric processes.

At the present stage of the development of aphasiology, classical concepts were renewed by neurobiological research that deepened the understanding of the influence of sensory-enriched environments on structural and morphological brain restoration, including high cortical functions, for example, speech. A progressive development in this direction has been the development of rehabilitation approaches to speech restoration in a sensory-enriched environment.

To date, proven speech therapy methods in a monosensory-enriched environment have been created and introduced into the world of aphasiological practice. Their examples are Melodic Intonation therapy and neurological music therapy. Unlike a music-enriched environment, the possibilities of a polysensory-enriched environment have been little explored. The multisensory environment makes it possible to increase the capture zone of preserved brain structures and expand the sensory support of the impaired HHF, which creates potentially greater opportunities for the restoration of higher mental functions.

Despite the existing experience of using a sensory-enriched environment in neuropsychological practice, the issues of determining the scientific foundations, methodology, principles and algorithms for their modelling remain unresolved. Solving these issues is extremely important, as they contribute to the development of new scientifically based methodological approaches to the restoration of cognitive impairment in patients with local brain lesions.

CHAPTER 3. ORGANIZATION, MATERIAL, STAGES AND RESEARCH METHODS

This chapter describes the organization and conditions of the study, the stages and basic psychological methods of the study, including diagnostic complexes for detecting stealing symptoms of the right and left hemispheres and methodological complexes for assessing the dynamics of the speech status of patients with aphasia during rehabilitation in a modelling music-enriched and polysensory-enriched environment.

3.1. Organization of the study

The study of patients with aphasia was conducted based on the GBU "Center for Speech Pathology and Neurorehabilitation" of the Moscow Department of Health (Center) and consisted of a preliminary and three main stages.

The main criteria for the inclusion of patients in the study were:

– local lesion of the left hemisphere of vascular origin: organic personality and behaviour disorders caused by disease, trauma (damage) and brain dysfunction (F.07.8); other organic personality and behaviour disorders related to vascular brain disease (F07.81);

– structural MRI examination;

– the safety of vision and hearing;

– age 25-65 years;

– a history of right-handedness;

– time post-onset of aphasia from 6 months to 6 years;

– predominant efferent motor and acoustic-mnestic aphasia of mild/moderate severity;

– stay in a day hospital and a day hospital;

– the written informed consent of the patient to participate in the study.

The main exclusion criteria were:

– right hemisphere and bilateral brain lesions;

– damage to the occipital regions of the brain;

– progressive neurodegenerative brain diseases (dementia, progressive aphasia);

– repeated stroke;

– early (acute, subacute) recovery period of the disease (<6 months);

– epilepsy;

– sensorineural hearing loss/traumatic deafness;

– auditory agnosia;

– amusia;

– history of alcoholism/drug addiction;

– failure by the patient to comply with the protocol conditions;

– lack of written informed consent of the patient.

At the preliminary stage, patients who met the criteria for inclusion in the study were selected and the patients underwent neuropsychological diagnostics to qualify the type and severity of aphasia. If the criteria were met, patients were included in the waiting list to participate in further stages of work.

At the first stage of the study, diagnostic complexes were created to identify stealing symptoms of the right and left hemispheres and a structural and dynamic model of aphasic syndrome.

The second stage involved the development of an algorithm and principles for modelling a sensory-enriched environment and a methodological approach to speech therapy in a modelling music-enriched environment, including its testing. A diagnostic complex was created to assess the dynamics of speech recovery in patients with aphasia in a music-enriched environment and to evaluate the comparative rehabilitation effectiveness of the tested and traditional approach.

At the third stage, a methodological approach to speech therapy of aphasic disorders in a polysensory-enriched environment was developed and tested, including a diagnostic complex for determining the dynamics of speech recovery in a polysensory environment and evaluating the comparative effectiveness of the tested approach and traditional speech therapy.

The control group of the second and third stages of the study consisted of patients who underwent traditional speech therapy at the same rehabilitation centre. For the control group, the criteria for inclusion and exclusion were the same.

The study was approved by the Ethics Committee of the Center (Protocol No. 6 dated 01/13/2021) and the clinical section of the Local Ethics Committee of the Federal State Budgetary Institution "V.P. Serbsky National Medical Research Center for Psychiatry and Narcology" of the Ministry of Health of the Russian Federation (Protocol No. 35/1 dated 11.10.2021).

3.2. Research material

Out of 687 patients of the preliminary stage, 177 patients with efferent motor and acoustic-mnestic aphasia of moderate and mild degree were included in the further stages of the study. The total number of observations for all stages of the study amounted to 3,136 units.

The vast majority of patients at all stages were men (Table 2). At stage 1, they represented 80.09% of the sample, at stage 2 – in the main and control groups 74.04% and 69.57%, respectively, at stage 3 – 68.00% and 68.52%.

The average age of patients at 1st stage of the study was 51.88±7.64 years, the 2nd stage of the study were 53.97±9.55 years (main group) and 52.99±4.93 years (control group), the 3rd stages of the study were 51.53±9.07 years and 52.74±8.24 years, respectively.

Table 2. Socio-demographic characteristics of patients with aphasia at stages 1st, 2nd and 3rd of the study

Socio-demographic characteristics	Stage 1	stage 2		stage 3	
		The main group	The control group	The main group	The control group
Men (person (%)	89 (80,09)	20 (74,04)	32 (69,57)	34 (68,00)	37 (68,52)
Women (person (%)	21 (19,09)	7 (25,93)	14 (30,43)	16 (32,00)	17 (31,48)
Total (person)	110	27	36	50	54
Age (years)	51,88±7,64	53,97±9,55	52,99±4,93	51,53±9,07	52,74±8,24
Higher education (person (%)	91 (82,72)	22 (81,48)	35 (76,08)	36 (72,00)	31 (57,41)
Secondary specialized education (person (%)	19 (17,27)	5 (18,51)	11 (23,91)	14 (28,00)	23 (42,59)

The patients had higher or secondary specialized education. People with higher education made up the majority. In the 1st stage of the study, they represented 82.72% of the sample, at the 2nd stage – 81.48% in the main group and 76.08% in the control group, at the 3rd stage – 72.00% and 57.41%, respectively.

3.3. Stages of the study

Preliminary stage

Patients who met the selection criteria were included in the 1st stage of the study at the 1st week of admission to the Center, and in the 2nd and 3rd stages – at the 2nd week of stay. The latter was done intentionally to assess the patient's ability to withstand the required amount of rehabilitation load. In case of detection of increased fatigue, a marked decrease in performance, instability of somatic status, and exacerbation of chronic diseases, the patient was excluded from participation in the 2nd and 3rd stages of the study.

Stage 1 of the study

At this stage, diagnostic complexes were developed and tested to identify stealing symptoms of the right and left hemispheres, which included a methodology for evaluating speech in aphasia, a dichotic listening task, and a diagnostic complex for detecting symptoms of stealing from the right and left hemispheres (Table 3). Given the time intensity of the techniques, neuropsychological diagnostics were performed for 3 consecutive days. On day 1, a speech assessment technique for aphasia, on day 2, a dichotic listening technique and a diagnostic complex for detecting symptoms of the left hemisphere, on day 3 – a diagnostic complex to identify stealing symptoms of the right hemisphere.

Table 3. Methods of the 1st stage of the study

Methods	Dichotic listening task	Diagnostic complex for detecting stealing symptoms of the right hemisphere	Diagnostic complex for detecting stealing symptoms of the left hemisphere	Speech assessment in aphasia	Total observations
Efferent motor aphasia (person)	58	39	39	58	–
Acoustic-mnestic aphasia (person)	52	44	44	52	–
Total (person)	110	83	83	110	–
Total observations (1st and 2nd assessment)	220	166	166	220	772

To assess the dynamics of the studied parameters of the HHF, all diagnostic complexes and techniques were carried out twice: 1st measurement – before the start of rehabilitation, and 2nd measurement – after the end of the rehabilitation course.

83 patients were examined with diagnostic complexes to identify stealing symptoms of the right and left hemispheres, of which 73 patients were subsequently included in the 2nd stage of the study as the main and control groups. Due to the instability of the somatic status, 10 patients were excluded from participating in other stages of the research project. Out of 83 57 patients had efferent motor aphasia, and 53 patients had acoustic-mnestic aphasia. Methods of dichotic listening and speech evaluation in aphasia were performed in 110 patients. The total number of observations at the 1st stage of the study was 772 units.

Stage 2 of the study

At the 2nd stage of the study, the principles and algorithm for modelling a sensory-enriched environment were developed, and a methodological approach to speech therapy in a modelling music-enriched environment and a diagnostic complex for evaluating the dynamics of speech recovery in a mono-sensor-enriched environment were created. A study of the comparative effectiveness of the tested and traditional approach to speech therapy has been conducted.

The course of therapy in a music-enriched environment had a duration of five weeks and consisted of 15 rehabilitation sessions conducted three times a week. 27 patients participated in the course of speech restoration in a music-enriched environment: 13 patients with efferent motor aphasia and 14 patients with acoustic-mnestic aphasia. The total number of individual rehabilitation sessions was 405 units (Table 4). The control group, which underwent a course of traditional speech therapy, included 46 patients, including 20 people with efferent motor and 26 patients with acoustic-mnestic aphasia.

The diagnostic complex of the 2nd stage of the study included the methodology of dichotic listening, speech assessment in aphasia, the speed of coherent spontaneous speech, and directed (phonological) and free verbal associations. The diagnosis was carried out twice: 1st assessment before the start and 2nd after the completion of the rehabilitation course.

Table 4. Methods of the 2nd stage of the study

Mehtods	Dichotic listening task	Speech assessment in aphasia	The speed of spontaneous speech	Free oral verbal associations	Controlled oral verbal associations	Total observations/rehabilitation sessions
The main group						
Efferent motor aphasia (person)	13	13	13	13	13	–
Acoustic-mnestic aphasia (person)	14	14	14	14	14	–
Total observations (1st. and 2nd. measurement)	27	27	27	27	27	–
Rehabilitation sessions(total)	–	–	–	–		405
The control group						
Efferent motor aphasia (person)	20	20	20	20	20	–
Acoustic-mnestic aphasia (person)	26	26	26	26	26	–
Total (person)	46	46	46	46	46	–
Total observations (1st. and 2nd. assessment)	146	146	146	146	146	730

After completing the course of speech therapy, the effectiveness of speech recovery in a modelling music-enriched environment and the traditional approach to speech therapy were evaluated. The total number of observations in the 2nd stage of the study was 730 units.

Stage 3 of the study

At the 3rd stage of the study, a methodological approach to speech therapy in a multisensory enriched environment was developed and tested. A diagnostic complex was created to measure the dynamics of speech recovery, which, in comparison with the 2nd stage of the study, included a much larger number of techniques (Table 5).

Table 5. Methods of the 3rd stage of the study

Methods	Dichotic listening task	Speech assessment in aphasia	The speed of spontaneous speech	Free oral verbal associations	Controlled oral verbal associations	MoCA-test	FAB test	RBM-3 "retelling the story"	Total score
The main group									
Efferent motor aphasia (person)	26	26	29	29	29	26	26	26	–
Acoustic-mnestic aphasia (person)	21	21	21	21	21	21	21	21	–
Total (person)	47	47	50	50	50	47	47	47	–
Total rehabilitation sessions	–	–	–	–	–	–	–		750
The control group									
Efferent motor aphasia (person)	24	24	24	24	24	24	24	24	–
Acoustic-mnestic aphasia (person)	30	30	30	30	30	30	30	30	–
Total (person)	54	54	54	54	54	54	54	54	–
Total assessments (1st. and 2nd. assessment)	202	202	208	208	208	202	202	202	1634

The speech therapy course included 15 rehabilitation sessions, conducted at intervals of 3 times a week for five weeks. The course was conducted on 50 patients: 29 patients with efferent motor and 21 acoustic-mnestic aphasia patients. A total of 750 individual rehabilitation sessions were conducted. The control group consisted of 54 patients who underwent a course of traditional speech therapy: 24 patients with efferent motor therapy and 30 patients with acoustic-mnestic aphasia.

The diagnostic complex for assessing speech recovery included methods of dichotic listening, assessment of speech in aphasia, speed of coherent spontaneous speech, MoCA test, FAB test, the "retelling of a story" subscale of the RBM-3 test, free and directed (phonological) verbal associations. Due to the forced early discharge of 3 patients of the main group with efferent motor aphasia, some diagnostic complex methods were not repeated. Therefore, the total number of repeated observations according to these methods decreased from 29 to 26 assessments.

The diagnosis of the main and control groups was carried out twice. Fist measurement before the start and second one just after the completion of the course of speech rehabilitation.

The total number of observations according to the methods of the diagnostic complex of the 3rd stage of the study amounted to 1,634 units.

3.4. Research methods

3.4.1. The dichotic listening task

The dichotic listening to monosyllabic words (Kimoura D., 1961) is a non-invasive method for determining the profile (vector) of hemispheric auditory-speech asymmetry and allows you to determine the lateralization of the dominant hemisphere on the side of the leading ear, as well as dynamic changes in these parameters.

The technique consists in synchronous binaural presentation of a pair of stimuli in such a way that each ear receives a stimulus through its own audio channel. In patients with aphasia, the technique has a number of limitations: patients with gross and sensory aphasia are excluded, because they have objective difficulties in complying with the study protocol (Shipkova K.M., 2013).

The dichotic listening technique has a number of variants and procedural modifications. Sounds, syllables, and words can be used as stimuli. Stimuli can be delivered synchronously and against a background of noise. The instruction may require attention in both channels, to one of the auditory channels, repetition of only those words that were clearly recognized, etc. (Kimoura D., 1961; Sparks R. et al., 1970; Johnson J. et al., 1977; Crosson B., Warren L., 1981; Cameron S. et al., 2016; D'Anselmo A. et al., 2016; Hugdahl K. et al., 2016; Prete G. et al., 2018; Voyer D. et al., 2019; Westerhausen R., 2019; Purdy M., McCullagh J., 2020; Gorecka M.et al., 2020; Studer-Luethi B., 2021; Liao L.et al., 2022).

The procedure of the methodology. The technique was used in the Russian version in the modification of B. Kotik (Kotik B.S., 1974; Azarova E.A., Kotik-Fritgut B.S., 2021). Words are delivered to both ears in synchronized paired series. The words within the series are not repeated. There are a total of 16 paired series of 4 words each. The total number of stimuli for both ears is 128 words (64x2). The interval between the presentation of stimuli is 20 seconds. The volume of the stimulus is 40dB ±2. Three training samples are presented to adapt to the research procedure. The instruction requires attention to both audio channels and playback of all retained words.

In the vast majority of healthy right-handers, the effect of the right ear is recorded during dichotic listening, i.e. the predominant reproduction of words perceived by the right ear. The effect of the right ear is expressed in a slightly larger, on average by 2-6%, amount of information reproduced from the right ear (Bragina N.N., Dobrokhotova T.A., 1988; Costa M. et al., 2016). Such a picture of the response is considered as evidence of "the dominance of the structures of the left hemisphere in the identification of verbal stimuli" (O.P. Trachenko, 1986, p. 133). The peculiarity of the right ear effect is that it manifests itself only in conditions of dichotic listening (Tzourio-Mazoyer N. et al., 2018). The mechanism of the effect is explained by the fact that the cross-conducting pathways from the right ear to the left hemisphere have a higher efficiency in transmitting a speech signal compared to ipsilateral ones (Kimoura D., 1961). This means that the right ear effect is typical for healthy right-handed individuals.

In contrast to the norm, focal brain lesions cause the formation of a different picture of the auditory-speech laterality vector. Removal of the left temporal lobe, not accompanied by aphasia, causes the effect of oppression of the right ear during dichotic listening (hearth effect, left shift effect, left ear effect) (lesion effect) (Linebaugh C., 1978). When the right ear is depressed, there is an increase in the efficiency of reproducing words from the left auditory canal (Kimoura D., 1961). The severity of the left ear effect is associated with the coarseness of aphasia and over time tends to increase the degree of manifestations (Sarah S.F., Vallar G., 1992). The extreme manifestations of the hearth effect are expressed in complete disregard of the right ear (pure right ear extinction). Complete disregard of the right ear is called the effect of absolute dominance of the left ear.

The effect of oppression of the right ear is characteristic of both smooth aphasia (Wernicke's aphasia) and non-smooth (Brock's aphasia) (Shipkova K.M., 2013, 2022a, 2022b, 2022c; Crosson B., Warren L., 1981; Moore B.D. et al., 1988; Papanicolaou A.S. et al., 1988a, 1988b; Xing Sh., 2016; Kourtidou E. et al., 2021). In Wernicke's post-stroke aphasia, a dual response pattern is often observed: in some cases, the focal effect, in others, the oppression of the ipsilateral (left) ear. The latter is usually explained by the peculiarities of the interhemispheric processing of the speech signal (Sparks R. et al., 1970), and a picture of oppression of the ipsilateral ear with probable damage to the callosal connections or structures of the left associative cortex.

The effect of the left shift is regarded as a manifestation of spontaneous cerebral reorganization of speech due to homologous parts of the healthy hemisphere and is considered a favorable factor in speech recovery (Shipkova K.M., 2014, 2018; Hartwigsen G.et al., 2017; Lukic S. et al., 2017).

In the study, the methods of dichotic listening were determined by:

1. The index of laterality (the value and sign of the coefficient of the right ear) (Kpu) (Westerhausen R., 2019). The laterality index is calculated using the formula Kpu=$\frac{\text{Kp}-\text{Kl}}{\text{Kp}+\text{Kl}}$ (Kp i– the number of words reproduced from the right ear; Kl – the number of words reproduced from the left ear) (Johnson J. et al., 1977). A positive Kpu sign (Kpu+) indicates the leading right ear, a negative (Kpu–) indicates the left. The maximum value of the laterality index is "+1" indicates the absolute dominance of

the right ear (absolute dominance of the left hemisphere in speech processes), and the minimum value ("-1") indicates the absolute dominance of the left ear (absolute dominance of the right hemisphere in speech processes). A parameter of auditory-speech ambidextrity is a coefficient equal to zero.

2. The ratio of cases with the advantage of the right and left ear is Pp/Pl (Pp is the number of cases with the leading right ear, Pl is the number of cases with the leading left ear)

3. The frequency of occurrence of the effect of absolute dominance of the right/left ear is the number of cases with the effect of completely ignoring the right/left ear.

4. Productivity of the right and left ear – the number of words reproduced from the right (ΣPU) and left (ΣLU) auditory channels.

5. The coefficient of productivity (total) (Kpr) is the ratio of the total number of words reproduced from both auditory channels to the total number of auditory stimuli presented. The calculation formula is Kpr = $\frac{\sum pr}{128} \times 100\%$ (∑pr – the total number of correct answers).

6. The number of mistakes made (ΣO).

7. The efficiency index (Ief) and its level. The performance index was calculated by the formula Ief=$\frac{\sum pr - \sum o}{\sum pr + \sum o} \times 100\%$ (∑pr – number of correct answers, ∑O – number of errors) The gradation of the Ief level is determined empirically – by the actual range of the spread of the error rate (ΣO).

The methodology was carried out for participants at all stages of the study.

3.4.2. Diagnostic complexes for detecting stealing symptoms of the right and left hemispheres

The clinical and psychological method using a syndromic and qualitative analysis of the spectrum of non-speech neuropsychological symptoms was implemented by the developed diagnostic complexes, whose task was to detect functional deficiency of intact brain structures of the left and right hemispheres. The complexes included 11 methods consisting of 74 tasks.

Diagnostic complex for detecting stealing symptoms of the right hemisphere

The presented diagnostic complex included techniques, the validity and reliability of which in relation to right hemisphere dysfunctions (disorders) was confirmed in a large number of neuropsychological studies (Shipkova K.M., 2023a).

The complex's instrumentation revealed oppression symptoms of the occipital, parietal and temporal parts of the right hemisphere, i.e. both homologous and non-homologous to the speech parts of the left hemisphere. It was taken into account that the right hemisphere is the leading one in recognizing and remembering faces ("living" objects), unfamiliar (unfamiliar), complex and difficult-to-visualize objects (images), perceiving an object in complicated perceptual conditions (masking noise) and evaluating its shape, spatial and individual characteristics, as well as in noise immunity of perception, regardless of stimulus modalities (Luria A.R., 1962; Babenkova S.V., 1971; Tonkonogii I.M., 1973; Simernitskaya E.G., 1978; Wasserman L. et al., 1997; Tonkonogii I.M., Pointe A., 2007; Hécaen H., Ajuriaguerra J., 1956; Kolb B., Whishaw Q., 2003).

Methods with low reliability, validity, and controversial interpretation regarding the hemispheric vector of some neuropsychological symptoms and the results of which could be influenced by the general cultural awareness of the patient were not included. On this basis, the diagnostic complex did not include methods of perception of simple and complex rhythms (Luria A.R., 1947, 1973; Traugott N.N., 1981; Wasserman L.I. et al., 1997), Retention of positive and negative words (Chomskaya E.D., Batova N.Ya., 1992), recognition melodies, memorizing realistic faces (Luria A.R., 1969; Wasserman L.I. et al., 1997; Goldberg E., 2003) and graphic techniques (independent drawing and copying of a three-dimensional object).

To determine an adequate level of complexity of the stimulus material for those techniques that do not have a standardized set of stimuli and/or are rarely used in neuropsychological diagnostics in clinical and psychological practice, the diagnostic complex was tested in two stages. At the 1st (preliminary) stage, the stimulus material of the melody recognition technique was tested on 23 patients with aphasia and the technique was excluded because the different age composition of patients made it difficult to select a single melody content equally familiar to patients of different ages, which increased the likelihood of obtaining artifacts. At the second stage, the diagnostic complex was performed on 24 healthy middle-aged and elderly people. It was found that the Retention test for 3 schematized faces has too high a level of complexity and 93% of healthy people cannot cope with it, so it was later excluded. After the completion of the second stage of the testing of the complex, the composition of the methods and their incentive material were finally determined. The diagnostic battery includes 8 methods consisting of 60 tasks (Shipkova K.M., 2023a).

Methods of the diagnostic complex

Occipital region

Visual gnosis:

1). *Recognition of uncompleted subject images* (9 tasks). The technique includes the identification of silhouette contour undefined object images of everyday (frequency) objects (Wasserman L.I. et al., 1997). It is aimed at assessing the preservation of image representations (visual gestalt) and the possibility of perceiving a generalized object image of an object in complicated perceptual conditions.

2). *Recognition of objects in conditions of visual noise* (interference) (12 tasks) (Tonkonogii I.M., 1973). The noise immunity of visual perception is determined in conditions of high (P 0.35) (6 tasks), medium (P 0.25) noise level (6 tasks).

3). *Recognition of objects with incomplete image saturation gradient* (9 tasks) (Wasserman L.I. et al., 1997). The possibility of identifying object images in different conditions of visual perception is evaluated: from 5%, 10% and 20% of the contour of the object.

4). *Identification of familiar faces* (9 tasks) (Wasserman L.I. et al., 1997). The preservation of facial gnosis is determined.

Occipito-parietal region

Visual memory:

5). *Retention of schematized faces* (6 tasks: 1 face – 3 tasks, 2 faces – 3 tasks) (Wasserman L.I. et al., 1997) is aimed at assessing the preservation of facial gestalt retention (Kolb B., Whishaw Q., 2003). Procedure: the exposure time of the stimulus is 30 seconds. Then you need to find incentives among distractors.

6). *Retention of 9 difficult-to-visualize graphic images (figures)* (3 tasks) (Wasserman L.I. et al., 1997). The possibility of retaining stimuli in memory with a low possibility of their verbal mediation is diagnosed. The procedure is the same.

Inferior parietal region

Tactile gnosis:

7). *Stereognosis on the non-leading (left) hand* (5 tasks). The possibility of identifying the shape when feeling the object with the left hand is evaluated. Procedure: the identification time was not limited. If it is difficult to name the object, it is proposed to depict the visual outline of the figure.

Parietal region

Spatial gnosis:

8). *Mental rotation of an object in two-dimensional space (7 tasks)* (Wasserman L.I. et al., 1997) evaluates projection representations, the possibility of mental imagination of spatial transformations of a figure.

The diagnostic complex was presented in the described sequence. The task completion time was not limited

Diagnostic complex for detecting stealing symptoms of the left hemisphere

The diagnostic complex was aimed at assessing the functioning of mental processes located outside the boundaries of the lesion, and included methods with high validity and reliability that identify non-speech left hemisphere deficiency (Shipkova K.M., 2023a). In patients, the lesion nucleus was located within the boundaries of the speech zone of the left hemisphere: in efferent motor aphasia – in the posterior frontal regions; in acoustic-mnestic aphasia – in the middle temporal region of the left hemisphere.

Since the criteria for inclusion in the study was the absence of visual agnosia, the methods aimed at diagnosing pronounced gnostic disorders were not used (Kok E.P., 1967). Along with this, sensitized methods of assessing visual subject gnosis were included, which made it possible to identify unexpressed symptoms of gnostic deficiency associated with inhibition of the functions of the occipital and parietal parts of the left hemisphere.

The diagnostic complex did not include the methods of "perception of simple and complex rhythms", Goldstein-Shearer figures, since there is a controversial interpretation of the hemispheric sign of neuropsychological symptoms detected with their help (Luria A.R., 1973, Traugott N.N., 1981; Korsakova N.K., Moskovichute L.I., 1988; Wasserman L.I. et al., 1997).

The diagnostic complex was tested in 2 stages. At stage 1 (preliminary), it was performed in 19 patients with aphasia and 10 healthy individuals. After assessing the level of complexity of the stimulus material of the techniques and its subsequent refinement for the stereognosis research methodology, the stimulus material of stereognostic samples was finally determined at stage 2. The final composition of the diagnostic complex includes 3 methods consisting of 14 tasks.

Methods of the diagnostic complex

Occipital region

Visual memory:

1). *Retention of 9 object (verbalized) images (3 tasks)* (Wasserman L.I. et al., 1997). Reveals the amount of visual memory for subject stimuli. The exposure time is 30 seconds. Then you need to find incentives among distractors.

Parietal region

2). *Comparison of a three-dimensional figure and its sweep* (6 tasks) (Wasserman L.I. et al., 1997). The possibility of comparing a three-dimensional and planar shape (sweep) is evaluated.

Inferior parietal region

Tactile gnosis:

3). *Stereognosis on the leading (right) hand (5 tasks)*. The possibility of identifying the shape is determined when feeling the object with the right hand. If it is difficult to name an object, it is proposed to draw a visual outline of the figure.

The diagnostic complex was presented in the sequence described above. The task completion time was not limited.

3.4.3. Diagnostic complex for assessing the dynamics of speech recovery during speech rehabilitation in a modelling music-enriched environment

The complex included techniques that allow evaluating 5 aspects of speech: 1. qualitative and quantitative assessment of impressive and expressive speech; 2. directed verbal associations (verbal fluency of directed speech flow); 3. free verbal associations (verbal fluency of non-directional speech flow); 4. verbal fluency of coherent (phrasal) spontaneous speech on models of making up a story based on a plot picture; 5. indicator (profile) of auditory-speech asymmetry (Shipkova K.M., 2014, 2018, 2024a).

The methodology of speech assessment in aphasia and associative techniques allows you to measure the dynamics of speech recovery at the level of a word, phrase, text and the tempo characteristic of oral speech. The reason for including in the diagnostic block, along with the methods of evaluating speech in aphasia, methods of free and directed associations was explained by the fact that for patients with aphasia, verbal fluency is a sensitive tool for measuring speech dynamics (Shipkova K.M., Dubinsky A.A., 2023). The technique of dichotic listening, which was part of the diagnostic complex, allows us to determine the relationship between the dynamics of indicators of auditory-speech asymmetry and regression of speech disorders (Shipkova K.M., 2004, 2013, 2014, 2022a, 2022b, 2022c).

Speech assessment in aphasia

The method of speech assessment in aphasia (MOR) is designed for quantitative and qualitative analysis of understanding (impressive speech) and oral (expressive) speech. The technique makes it possible to assess the severity of a speech defect and the dynamics of speech recovery (Tsvetkova L.S. et al., 1981). The subscales of the MOR methodology (5 scales of impressive speech and 5 scales of expressive speech) include 181 samples that evaluate impressive and expressive speech at three levels: 1) at the word level (naming/understanding the word), 2) at the sentence level (composing /understanding phrases / instructions), 3) at the text level (dialogue/writing a story) (Application 1).

The "naming of objects" subscale evaluates the objects nomination of words of various frequencies and the volume of an active subject vocabulary, the pronounced deficiency of which is characteristic of patients with acoustic-mnestic aphasia.

The “naming verbs” subscale reveals violations of verbal nomination, the selective deficiency of which is specific for patients with efferent motor aphasia.

The "phrasing" subscale determines the severity of deficits in phrasal speech: incorrect word order and/or omission, agrammatism, verbal paraphasias.

The "making up a story" subscale measures the quality of monologue speech: the coherence of the narrative, the complexity and length (expansion) of phrases, the correctness of the choice of lexical means and grammar (agrammatism).

The maximum value of each subscale is 30 points. The maximum MOR score is 300 points. For each correct answer according to the subscales " objects naming", "verbs naming", "showing objects", "showing verbs", 1 point is awarded. In the subscales "phrasing", "understanding instructions", which consist of 15 samples, 2 points are assigned for each correct answer, and 1 point for a partially correct answer (for example, for a correct phrase with grammatical, lexical errors or understood 2 times). In the "understanding instructions" subscale, 3 points are awarded for the correct answer, and 1.5 points for following the instruction after its repetition. In the dialog subscale, each correctly understood question and an adequate answer is estimated at 3 points, a partially correct answer or a question understood twice is 1.5 points. The same score is given for the "understanding instructions" subscale. In the "making up a story" subscale, it takes 5 minutes to compose a coherent story based on a given plot picture. When evaluating a story, the following factors are taken into account:1) the length of phrases; 2) the complexity of grammatical constructions; 3) violation of coherence and semantic incompleteness; 4) unproductive words; 5) verbal paraphasias; 6) agrammatism. Penalty points are awarded for errors in paragraphs 3-6.

Thus, the score for this subscale is the difference between the score of points 1-2 and points 3-6.

The final score of the MOR allows you to determine the severity of aphasia. The scale of gradation of the degree of aphasic defect: <90 points – a very rough degree, 90-160 – a rough degree, 161-230 – an average degree, >230 points – a mild degree of aphasia.

All participants in the study had a final MOR score in 1 measurement (before the course of rehabilitation) – MOR 1 and a MOR score in 2nd measurement (just after the course) – MOR 2. The final of expressive and impressive speech and scores of subscales of expressive speech were calculated: "naming objects", "naming actions", "composing phrases", "composing a story".

Measuring the magnitude of the rehabilitation shift in individual subscales allows us to determine the selectivity of the influence of the methodological approach to speech therapy on the restoration of oral speech at the levels of word, phrase, text, as well as its pace, and the same course of data processing and analysis allows us to assess the comparative effectiveness of speech restoration with different methodological approaches to speech therapy.

Free and controlled oral verbal associations

The technique of free associations is a classic diagnostic tool in psychology. The technique of phonological (literal) associations was proposed by J.G. Borkowski et al. (1976) for the study of cognitive functioning. Both methods measure the productivity of associations, which is normally more than 12 words/min (Barry D. et al., 2010). In the methodology of free associations, it is proposed to name as many words as possible in 1 minute, except for proper names and single–root words, in phonological verbal associations - words with a certain letter. For the accuracy of data fixation, the ability to record stops (pauses) of the speech stream, audio recording of responses was conducted. Phonological associations were investigated by the subscale of verbal fluency of the MoCa test (Nasreddine M.D. et al., 2005).

The speed of spontaneous speech

The method assessed the rate of monological (coherent) speech – the number of words/min when performing the task of the subscale "making up a story" according to the plot picture of the MOR technique (Shipkova K.M., 2014, 2018, 2024a). This indicator reflected such aspects of oral speech as the speed of finding the right word, the ease of pronouncing it and the pace of coherent monologue. For the accuracy of data fixation, an audio recording of the patients' speech was conducted, followed by its translation into a text format.

The dichotic listening task

In this diagnostic complex, the dichotic listening technique determined the profile of auditory-speech asymmetry – the index of laterality (the value and sign of the coefficient of the right ear) (Kpu), the coefficient of productivity (Kpr) and the efficiency index (Ief) of auditory and speech perception:

1). The index of laterality (Kpu) – Kpr = $\frac{Kp-Kl}{Kp+Kl}$ (Kp – the number of words reproduced from the right ear; Kl – the number of words reproduced from the left ear) (Johnson J. et al., 1977).

2). The coefficient of productivity (total) (Kpr) is the ratio of the total number of words reproduced from both auditory channels to the total number of auditory stimuli presented – Kpr = $\frac{\sum pr}{128} \times 100\%$). (∑pr – the total number of correct answers/

3). The efficiency index (Ief). The performance index was calculated by the formula Ief=$\frac{\sum pr-\sum o}{\sum pr+\sum o} \times 100\%$ (∑PR – number of correct answers, ∑O – number of errors). The gradation of the efficiency level was determined based on the actual spread of the sample data (Shipkova K.M., 2022c).

The studied 13 parameters, including 10 speech parameters and 3 auditory-speech perception ones, made it possible to assess the impact of a music-enriched environment on:

1) regression of speech deficit in expressive and impressive speech, including in patients with different initial severity of oral speech disorders;

2) the dynamics of quantitative and qualitative indicators of auditory and speech perception;

3) the speed of coherent oral speech;

4) the dynamics of productivity of verbal associations.

The main and control groups of the diagnostic complex methods were carried out twice for two consecutive days: before the start (1st measurement) and after the completion of the rehabilitation course (2nd measurement). On the first diagnostic day, the methodology for assessing speech and the speed of coherent spontaneous speech was carried out, on the second day – the methodology of dichotic listening and the methodology of directed (phonological) and free verbal associations.

3.4.4. Diagnostic complex for assessing the dynamics of speech recovery during speech rehabilitation in a modelling polysensory-enriched environment

The diagnostic complex of the 3rd stage of the study was expanded, supplemented with a number of other tools and redesigned in relation to a number of analyzed parameters. Diagnostic battery techniques reflected the sensory stimulation vectors that were involved in speech therapy in a modelling polysensory-enriched environment (Shipkova K.M., 2024a).

The MOR technique assessed the dynamics of speech recovery at the level of a word, phrase, text, and the method of speed of spontaneous speech – the tempo characteristic of oral speech.

The methodology of free and directed associations at this stage of the study was aimed not only at evaluating the productivity of the free and directed associative series, but also at analyzing the verbal strategies used by patients in word selection, i.e., along with quantitative and qualitative analysis of the structure of the verbal series was carried out.

In addition to speech processes, the diagnostic complex assessed indicators of general cognitive functioning, auditory-speech memory, and regulatory processes. This task was solved by using the MOCa test, the "retelling the story" subscale of the RBMT-3 test and the FAB-test, respectively.

The method of dichotic listening was used to identify the relationship between the dynamics of the restoration of speech and other cognitive functions with indicators of auditory and speech perception.

Speech assessment in aphasia

Just as in the diagnostic complex aimed at assessing the dynamics of speech recovery in a music–enriched environment, when determining the regression of disorders in patients with aphasia during neuropsychological rehabilitation in a modelling polysensory-enriched environment, all patients had a final score of MOR in 1st. measurement (before the start of rehabilitation) – MOR1 and a score of MOR in 2nd assessment (after rehabilitation) – MOR2. Along with the final scores of expressive and impressive speech productions, the scores of the subscales of expressive speech were calculated: "naming objects", "naming actions", "composing phrases", "composing a story".

The speed of spontaneous speech

The rate of monologue speech (words/min) was estimated when performing the task of the subscale of "making up a story" of the MOR methodology. To accurately record the response, an audio recording of the patient's speech was conducted, followed by its translation into a text format (Shipkova K.M., 2014, 2018, 2024a).

Free and controlled (phonological) oral verbal associations

At the 3rd stage of the study, in order to in-depth analyze the process of speech restoration in a sensory-enriched environment, the range of quantitative and qualitative parameters to be evaluated was expanded.

Quantitative parameters of the associative series

1. *Productivity of associations* – words/ min

2. *Flexibility of associations* – the number of semantic fields in the associative series.

3. *Semantic organization of the associative series* – the number of semantic pairs (for free associations).

4. *The level of verbal perseverations* is the number of repetitions (perseverations) of words. Gradation of levels: zero level (norm) – no perseverations, low level – 1 repetition, medium level – 2 repetitions, high level – 3 repetitions or more.

5. *The level of stability of the tempo of associations i*s the number of pauses (stops). The interval between words of more than 4 seconds was considered a pause: zero level (norm) – no pauses, high level – 1-2 pauses, medium level – 3-4 pauses, low level – 5 pauses or more (Shipkova K.M., 2024a).

Qualitative (structural) parameters of a free and directed phonological associative series

The qualitative parameters of verbal associations determined the number of semantic fields and the level of categorical, functional and visual semantics, which reflected the number of this type of semantic pairs in the associative series: zero level – the absence of this type of pairs, low level – 1-2 pairs, medium – 3-4 pairs, high – 5 pairs or more.

Categorical semantics was understood as the relationship "genus–species" (for example, fruit–apple) or "species-species" (for example, apple–pear) between two sequentially named words.

Under functional semantics are words united by a functional connection (for example, boat–fish, axe–firewood, etc.), under visual – grouping of words by situational adjacency (for example, table–vase, window–curtain, etc.).

The semantic field was considered to be a verbal series of two or more semantically related words. If there were other pairs of words of the same semantic field in a row, then they were considered elements of the same field.

When assigning semantic pairs to the category of functional and visual communication, the method of experts was used, which were 7 undergraduate students of the Faculty of Correctional Pedagogy and Special Psychology of the Moscow Institute of Psychoanalysis. The affiliation of a semantic pair to a functional or visual connection was accepted if the opinions of at least 5 experts coincided.

Qualitative parameters of directed associations revealed the level of use of alphabetic and syllabic phonological strategies. With the letter strategy, the pairs of words in the chain had the same initial letter, but different letter composition of the first syllable (for example, whale–wheel), with the syllabic strategy – the same first syllable (for example, whale–cypress). The levels of phonological strategies were determined by the number of corresponding verbal pairs in the associative series: zero level – 0 pairs (lack of an appropriate strategy); low level – 1-2 pairs; – average level – 3-4 pairs – high level – 5 pairs or more (Shipkova K.M., 2024a).

The dichotic listening task

At this stage of the study, three indicators of auditory-speech perception were studied: the profile of auditory-speech asymmetry (laterality index), productivity index, efficiency index:

1) The index of laterality (Kpu) – Kpu=$\frac{Kp-Kl}{Kp+Kl}$ (Kp – the number of words reproduced from the right ear; Kl – the number of words reproduced from the left ear) (Johnson J. et al., 1977);

2) The coefficient of productivity (total) (Kpr) is the ratio of the total number of words reproduced from both auditory channels to the total number of auditory stimuli presented (Kpr = $\frac{\sum pr}{128} \times 100\%$ (∑pr – the total number of correct answers);

3) The efficiency index (Ief) – Ief=$\frac{\sum pr - \sum o}{\sum pr + \sum o} \times 100\%$(∑PR – number of correct answers, ∑O – number of errors).

The relationship of their indicators with the dynamics of speech recovery and other mental functions, including regulatory processes, was evaluated (Shipkova K.M. 2014, 2018; 2023a, 2023b, 2024a).

A Frontal assessment battery (FAB test)

The frontal assessment battery (FAB test) is aimed at identifying violations of programming and control of activity and the severity of cognitive disorders associated with impaired functioning of the anterior brain and frontal-subcortical connections. The test evaluates the safety of control functions, attention, memory, verbal thinking, speech, and voluntary movements. The maximum score is 18 points. Gradation of the degree of violation of regulatory processes: 18 points – the norm (absence of violations); 16-17 – mild degree of violations; 14-15 – moderate degree of violations; 10-13 – marked violations (Dubois B. et al., 2000).

The Montreal cognitive assessment test (MOCa test)

The MoCa test is a tool for assessing the state of a wide cognitive sphere: visual-spatial functions, subject nomination, auditory-speech memory, attention, speech, verbal-logical thinking, orientation in place, time and space. The maximum score on the test is 30 points. The degree of severity of cognitive impairment is determined according to the accepted scheme: 26-30 points – the norm; ≥25 points – cognitive impairment (Nasreddine Z.S. et al., 2005).

The "retelling of the story" subscale of the RBMT-3 test

The "retelling the story" subscale of the RBMT-3 test (the Rivermead Behavioral Memory Test Third Edition) (Wilson B., 2012) measures the volume of direct auditory memory. The content of the story is a summary of the sequence of events in the format of a newspaper note. The patient needs to memorize the text he has heard and reproduce it with detailed details. The maximum raw score is 21 units.

Thus, the diagnostic complex investigated 23 parameters, including 17 speech parameters (8 parameters of the MOR method, 8 parameters of verbal associations, the speed of coherent spontaneous speech), 3 parameters of auditory perception (Kpu, Kpr, Ief), 3 parameters of cognitive functioning, including regulatory processes (MoCA test, FAB test, RBMT test-3).

The studied speech parameters, cognitive and regulatory processes, and auditory-speech perception made it possible to assess the impact of a polysensory-enriched environment on:

1) the dynamics of recovery of expressive and impressive speech, including in patients with different initial severity of oral speech disorders;

2) productivity and structural organization of the verbal associative series;

3) the speed of coherent spontaneous speech;

4) the dynamics of quantitative and qualitative parameters of auditory and speech perception;

5) the severity of the rehabilitation shifts in cognitive and regulatory processes.

In the main and control groups, the diagnostic complex was performed twice for 2 consecutive days: before the start (1^{st} measurement) and after the end of the speech rehabilitation course (2^{nd} measurement). On the first day, the methodology for assessing speech and the speed of coherent spontaneous speech was carried out, on the second day – the methodology of dichotic listening, the MoCA test, the FAB test, the RBM-3 test of the retelling of a story subscale and the methods of free and directed verbal associations.

3.5. Methods of statistical data processing

The empirical data obtained during the study were statistically processed by specialized application software packages SPSS-21.0 and the Microsoft Excel Statistical software package for Windows.

The array of initial data in the work was prepared in such a way that it was possible to compare the entire available set of information in groups formed by any qualitative and quantitative indicators, including those obtained during the analysis.

In accordance with the goals and objectives of the study, as well as taking into account the specifics of the analyzed variables, the following statistical operations were performed:

– determining the types of data distributions;

– building histograms of the data spread;

– calculation of frequency tables, both one-dimensional and multi-level;

– calculation of descriptive statistics: averages, standard deviation, mode, median, spread of data;

– verification of statistical hypotheses based on the Student's t-test for indicators whose distribution type corresponded to the requirements of a normal distribution;

– Pearson correlation coefficient (r-criterion) for data corresponding to a normal distribution;

– comparison of groups using the Mann-Whitney U-test for dependent and independent samples for indicators whose distribution type did not meet the requirements of a normal distribution;

– Pearson 's criterion $\chi 2$ with Yates-correction for continuity;

– Fisher's angular transformation (φ-criterion) for comparing samples according to a qualitatively determined feature;

– Spearman's rank correlation coefficient (rs criterion) for data whose distribution did not meet the requirements of a normal distribution;

– Wilcoxon's Z-test for paired samples;

– analysis of conjugacy tables;

– k-means cluster analysis to identify homogeneous groups classified according to a given attribute.

The results of the mathematical and statistical analysis were presented in tabular and graphical form.

Summary

The chapter describes diagnostic complexes designed to identify stealing symptoms in the right and left hemispheres. The procedure for their implementation is described.

The reasons for the inclusion and non-inclusion criteria in diagnostic complex methods, the stages of preliminary verification of stimulus materials in aphasia patients and healthy controls are presented.

The relevance of diagnostic techniques to empirical research tasks is given.

Diagnostic complexes to identify the dynamics of speech restoration in a music-enriched and polysensory-enriched environment are described.

The description of quantitative and qualitative parameters of speech and cognitive processes assessment and methods of statistical processing of the study data are presented.

CHAPTER 4. STEALING SYMPTOMS OF THE RIGHT AND LEFT HEMISPHERES IN PATIENTS WITH APHASIA

The chapter presents the results of solving the following empirical problems: 1) determination of the patterns of intra- and interhemispheric restructuring of speech function in patients with aphasia, 2) substantiation of the structural and dynamic model of aphasic syndrome.

4.1. The role of the temporal regions of the right hemisphere in speech perception in patients with aphasia

To solve the tasks set in the study to determine the patterns of intra- and interhemispheric restructuring of speech function in 110 patients of the 1st stage of the study, data from 1st measurement of dichotic listening techniques and speech assessment in aphasia were analyzed.

According to the results of dichotic listening task, four patients with auditory-speech ambidexterity (Kpu=0) were excluded from 110 patients. Therefore, the total number of patients who were ncluded in the subsequent analysis was 106: 56 patients with efferent motor aphasia and 50 patients with acoustic-mnestic aphasia. The numerical composition of the groups, the ratio of patients with varying degrees of aphasia, the duration of the defect, the volume of focal brain damage, and the score of MOR1 are presented in Table 6.

To determine the effect of the form of aphasia on the cerebral reorganization of speech function, patients were divided into groups of patients with acoustic-mnestic and efferent motor aphasia. When dividing into groups, it was not taken into account what type of speech therapy the patients underwent, because the general patterns of hemispheric rearrangements of speech function were studied. In the group of patients with efferent motor aphasia, the ratio of "moderate vs mild aphasia" was 27 people vs 29 people, in the group with acoustic-mnestic aphasia – 23 people vs 27 people. and had significant intergroup differences (U=1395.21, p>0.05). During the analysis of the parameters of dichotic listening in groups with different types of aphasia, the effect on auditory and speech perception of prescription, the volume of focal brain damage and the severity of aphasic defect were assessed.

Table 6. Distribution of the patients with efferent motor and acoustic-mnestic aphasia by severity and time post-onset, MOR1 score, volume of focal brain lesions

Aphasia type	Per son	Me dium de gree (per son)	Mild de gree (per son)	Time post-on set (mo nths) M±m	≤12 mo nths (per son)	≥13 mo nths (per son)	Lesion size (M±m)		MOR 1 (score)	
							≤20cm^3	>20cm^3	M±m	Mo
Efferent motor aphasia	56	27	29	27,75 ±2,65	17	39	14,53 ±1,63	60,75 ±11,23	228,40 ±3,72	224
Acoustic-mnestic aphasia	50	23	27	23,76 ±2,75	21	29	11,61 ±1,18	55,14 ±5,52	224,86 ±4,37	231
Total (person)	106	50	56	–	38	68	–	–	–	–

Note: MOR1 is the total score according to the speech assessment for aphasia in 1st measurement (before the speech rehabilitation course).

The influence of neurophychological and neurobiological parameters on the profile of auditory-speech asymmetry in patients with different aphasia types

The frequency of occurrence of the focal effect (i.e., the leading left ear) in patients with efferent motor and acoustic-mnestic aphasia with small and large focal lesions of the left hemisphere of the brain was analyzed.

Statistical analysis for comparing two samples by a qualitatively determined feature was carried out using the Fisher φ–criterion with Yates correction for continuity.

In both types of aphasia, a significant number of cases with the focal effect (Kpu–) were detected, regardless of the time post-onset and metric characteristics of the focal brain lesion (Shipkova K.M.,2022a). However, the incidence of Kp– in patients with temporal lesions of the left hemisphere (patients with acoustic-mnestic aphasia) was 1.6 times higher than in patients with lesions of the posterior frontal brain (patients with efferent motor aphasia) (Table 7).

Table 7. Frequency of occurrence of Kpu+ and Kpu– in patients with efferent motor and acoustic-mnestic aphasias with small and large sizes of focal brain damage and aphasia post-onset less or more than one year

Time post-onset	≤12 months Frequency (%)		≥13 months Frequency (%)		Total (%)
Lesion size	small ≤20cm³	large >20cm³	small ≤20cm³	large >20cm³	
Efferent motor aphasia					
Kpu+	67	25	80	51	54
Kpu–	33	75	20	49	46
Acoustic-mnestic aphasia					
Kpu+	18	23	67	19	28
Kpu–	82	77	33	81	72
φ-criteria	**2,29****	0,86	0,50	**2,71****	**2,79*****
p level	0,011	>0,05	>0,05	0,002	0,001

Note: ** – p<0,01, *** – p<0,001.

The number of cases with the focal effect was 72% in the group with acoustic-mnestic aphasia and 46% in the group with efferent motor aphasia. At the same time, the incidence of the leading right ear was 1.9 times higher in patients with lesions of the posterior frontal brain than in patients with lesions of the left temporal lobe, 54% vs 28%, respectively. The intergroup differences in the ratio of the frequency of occurrence of the leading left and right ear were significant (φ=2.79, p=0.001).

Further, the frequency of occurrence of the left ear effect was analyzed in patients with aphasia with a small (≤20 cm3) and large lesion (>20 cm3) and with aphasia duration of less than (≤12 months) and more than 1 year (>12 months).

The division of patients into subgroups along the border of 1 year was dictated by the data that in vascular brain damage, active brain restructuring occurs in the first-year post-onset (Shipkova K.M., 2013, 2022a, 2022b, 2022c; Anglade C. et al., 2014; Ulanov M.A. et al., 2018; Stefaniak J.D. et al.; 2020).

The division of patients into subgroups according to the volume of the lesion along the border of 20 cm3 was explained by the fact that the volume of affected brain tissue exceeding this value is associated with increased integration of interhemispheric mechanisms that enhance the role of the healthy hemisphere in defect compensation (Altenmüller E., Schlaug G., 2015).

In patients with acoustic-mnestic aphasia and a small lesion in the first year of the disease, 82% of cases had a focal effect (Kpu–). In patients with efferent motor aphasia, on the contrary, the leading left ear was significantly less common – in 33% of the sample (φ=2.29, p=0.011) (Table 6). This meant that with small lesions of the temporal brain in the early stages, a clear picture of the dominance of the right hemisphere in auditory perception was formed. Unlike patients with acoustic-mnestic aphasia, almost 2/3 (67%) of patients with efferent motor aphasia with the same size of the focal lesion and the duration of the defect retained the typical right-handed profile of auditory-speech asymmetry – the advantage of the right ear (Figure 3). In patients of both groups with an extensive lesion with the time post-onset of up to one-year, the ratio "Kpu+ vs Kpu–" was 1:3. The effect of the lesion was observed in 77% of patients with acoustic-mnestic aphasia and 75% of patients with efferent motor aphasia. This indicated that with extensive brain damage, regardless of the type of aphasia, the dominance of the right hemisphere in auditory perception was established in the early stages of the disease. With massive lesions, but with the time post-onset more than one-year, significant differences were observed between the groups (φ=2.71, p=0.002) (Table 6).

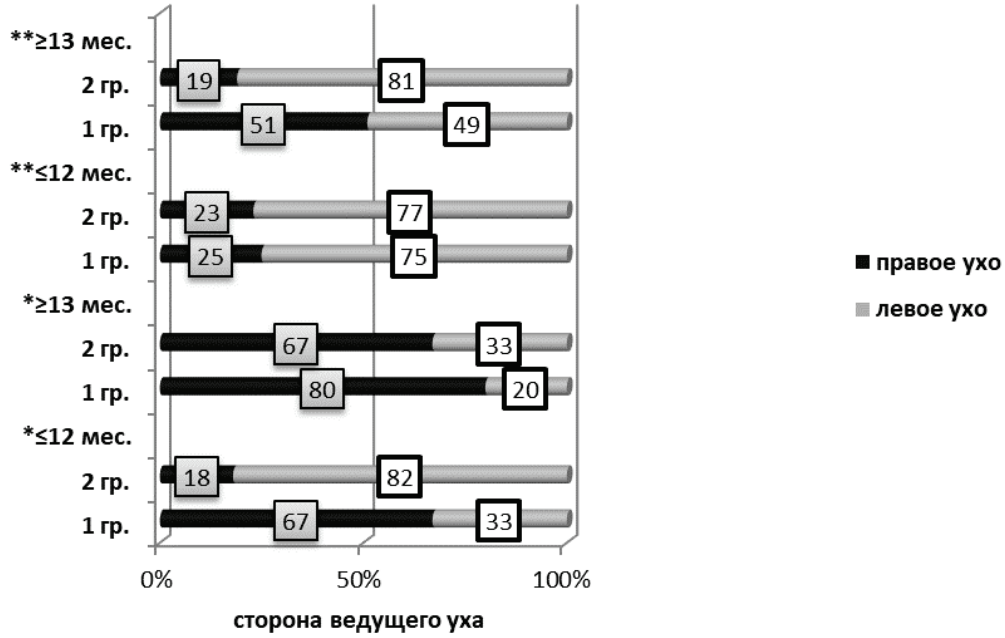

Figure 3. Frequency of occurrence of the side of the leading ear in patients with efferent motor and acoustic-mnestic aphasia with different defect duration and volume of focal brain damage (in %)

Note: * – lesion <20 cm3, ** – lesion >20 cm3. Group 1 – efferent motor aphasia, group 2 – acoustic-mnestic aphasia.

In patients with efferent motor aphasia, the frequency of occurrence of the leading right and left ears was equalized – the ratio of "Kpu+ vs Kpu–" was 51% vs 49%. In the group with acoustic-mnestic aphasia, the absolute majority of patients had the effect of the leading left ear – 19% vs 81%. This indicated that in patients with aphasia with an extensive lesion in the long-term period of the disease, the frequency of occurrence of the leading left ear depended on the type of aphasia and the topical characteristics of the focal lesion. In patients with efferent motor aphasia, the frequency of occurrence of the leading left ear decreased with an increase in the prescription of speech disorders, in patients with damage to the left temporal lobes of the brain, it remained, as with the prescription of aphasia up to one year, within the limits of high values (Shipkova K.M., 2022a).

The profile of auditory-speech asymmetry and the effectiveness of speech perception in the dichotic listening task

The next step in data processing was to analyze the relationship between the Kpu sign and the dichotic listening efficiency index (Ief). This allowed us to evaluate the effect of the vector of lateral auditory perception on the effectiveness of dichotic listening in patients with aphasia. The discovery of a positive relationship between high Ief score and the leading left ear would be evidence that the interhemispheric reorganization of speech occurs with the establishment of right-hemisphere dominance in speech processes and contributes to the process of speech restoration.

To this end, the conjugation of the Kpu sign and the number of errors in the task of dichotic listening to monosyllabic words was studied in patients with aphasia. The entire cumulative sample of patients, without separation by type of aphasia, was distributed by Ief levels. The efficiency index was determined by the proportion of errors made and calculated using the formula Ief=$\frac{\sum pr - \sum o}{\sum pr + \sum o} \times 100\%$ (∑PR – number of correct answers, ∑O – number of errors) (Shipkova K.M., 2022b, 2022c).

The gradation of the Ief levels was determined by the actual extent of the data spread. The maximum number of errors did not exceed 25% of the total volume of test stimuli and amounted to 32 errors. Based on this, three gradations of the level of efficiency of auditory and speech perception in the task of dichotic listening were identified: level I (high level) – ≤8% of errors; level II (medium level) – ≤9≤12% of errors; level III (low level) – ≤13≤25% of errors (Table 7).

The distribution of patients with the leading left ear at levels I –III was 54% vs 15% vs 31%, respectively, with the leading right ear – 29% vs 35.5% vs 35.5%. The determination of the theoretical and empirical frequency of occurrence of cases with Kpu+ and Kpu– in levels I, II and III of the effectiveness of auditory perception using the Pearson criterion$\chi 2$ revealed significant differences between patients with the leading left and right ear ($\chi 2$ =8.71, $p<0.05$) (Table 8). The high level of Ief was represented in 72% of cases (33 people) by patients with the leading left ear, which was 2.5 times higher than the number of patients with the leading left ear – 28% (13 people). The average level of Ief was represented by 62% of patients with the leading right ear (16 people) and 1.5 times fewer patients with the leading left ear – 38% (9 people). A low level of Ief had a comparable number of cases with the leading left and right ear – 46% (19 people) vs 54% (16 people). The explanation of why in level III the percentage of patients with the leading left ear was 1.2 higher than with the right ear may be determined by the incompleteness of interhemispheric restructuring, which increased the competition of auditory channels in speech perception (Shipkova K.M., 2022b). Taking into account that the volume of perception narrows with aphasia (Shipkova K.M., 1993), this could increase the difficulty of speech perception and, accordingly, increase the number of erroneous responses.

Table 8. Distribution of patients with aphasia according to the level of the index of effectiveness of auditory and speech perception. The proportion of mistakes made when reproducing dichotically presented monosyllabic words (N=106)

The efficiency index	Number of errors	Errors (%)	Kpu+ (per son)	% (per son)	Kpu– (per son)	% (per son)	Total (pe son)	χ^2 criteria
I high	0-10	≤8	13	29	33	54	46	**8,71***
II medium	11-15	≤9 ≤12	16	35,5	9	15	25	
III low	≥16≤33	≤13≤25	16	35,5	19	31	35	
Total (person)	–	–	45	–	61	–	106	

Note: * – p<0,05.

Summing up the analysis of the effectiveness of auditory-speech perception in patients with different profiles of the dominant ear, it should be noted that the vast majority of cases of a high level of effectiveness of auditory-speech perception occurred in patients with the left ear advantage. This indicated that the right-hemisphere vector of auditory-speech asymmetry (patients with the left ear advantage) contributed to an increase in the accuracy of word perception in conditions of competition of speech channels. Conversely, the left-hemisphere vector of auditory-speech asymmetry (patients with the right ear advantage) made it difficult to perceive words in conditions of dichotic listening.

The right ear coefficient in patients with the same degree of aphasia severity and lesion sizes. Analysis of cases of absolute dominance

Further, the values of Kpu were compared between a group of patients with efferent motor and acoustic-mnestic aphasia, who had the same initial degree of severity of aphasia and the volume of the focal lesion. This made it possible to identify the relationship between the value of Kpu, the aphasia type, and the volume of brain damage. The cases with the effect of absolute dominance and its specificity for different aphasia types were also analyzed.

To this end, groups with efferent motor and acoustic-mnestic aphasia were equalized according to the parameters of the volume of the hearth (the ratio "small/large hearth"), time post-onset (the ratio "the time post-onset up to one year/more than one year") and the degree of severity of aphasia (the ratio "medium/mild degree of aphasia"). For representativeness, the sample was formed by random selection. From the bank of 106 assessments of the 1st stage of the study, 86 cases were included in the further analysis.

The statistical analysis was carried out using the Student's t-test for independent groups (Table 9). It was revealed that in all types of aphasia with the time post-onset of less than one year, the left ear advantage was established. Patients with efferent motor aphasia reproduced 17% more words from the left ear than from the right, with acoustic-mnestic aphasia by 41%, and there were no significant differences between the groups ($t=-1.13$, $p>0.05$).

When the speech defect was more than one-year-old, multidirectional response distribution vectors were detected concerning the index of the leading ear ($t=-2.58$, $p=0.014$). In patients with efferent motor aphasia, an unexpressed advantage of the right ear was established ($Kpu=0.002\pm0.12$). That meant that the advantage of the right auditory canal was located within the boundaries of the auditory-auditory ambidextry and did not reach the lower limit values typical for the right-handed norm (Kpu=0.02) (Dobrokhotova T.A., Bragina N.N., 1994). In patients with acoustic-mnestic aphasia, there was a pronounced advantage of the left ear (Kpu=–0.46±0.13).

Table 9. Kpu values in groups of patients with efferent motor and acoustic-mnestic aphasias, equalized by the numbers with the degrees of aphasia, time post-onset and lesion size

Aphasia type	Time post-onset		Lesion size	
	≤12 months	>12 months	≤20cm3	>20 cm3
Kpu	M (SD)		M (SD)	
Efferent motor aphasia	–0,17 (0,15)	0,002 (0,12)	0,27 (0,14)	–0,16 (0,11)
Acoustic-mnestic aphasia	–0,41 (0,14)	–0,46 (0,13)	–0,28 (0,18)	–0,50 (0,12)
t–criteria	–1,13	**–2,58****	**–2,37***	**–1,99***
p level	0,072	0,014	0,025	0,050

Note: * – p<0,05,** – p<0,01.

The influence of the metric characteristics of the focus on the value of Kpu depended on the type of aphasic disorder (Shipkova K.M., 2022a). In the group with acoustic-mnestic aphasia, pronounced superiority of the left ear was recorded in both small (Kpu=0.28±0.18) and extensive focal brain damage (Kpu=–0.50±0.12). With a small focus, patients reproduced 28% more words from the left than from the right ear, with a large focus – 50%.

Patients with efferent motor aphasia, on the contrary, with small lesions demonstrated a pronounced advantage of the right ear (Kpu=0.27±0.14) and reproduced on average 27% more words from the right than from the left ear (t=-2.37, p=0.025). In the case of extensive foci, although, like the group with acoustic-mnestic aphasia, the advantage of the left ear (Kpu=–0.16±0.11) was demonstrated, but its advantage over the right was less pronounced. Patients with efferent motor aphasia reproduced 16% more words from the left ear than from the right ear, which was more than 3 times lower than in patients with acoustic-mnestic aphasia (t=–1.99, p=0.050) (Table 9).

The analysis of cases of absolute dominance, i.e. complete disregard of one ear, was a reflection of the depth of the interhemispheric restructuring of speech.

The effect of absolute dominance of the left ear (Kpu=–1) was three times more often recorded in the group with acoustic-mnestic (72% of all cases) than with efferent motor aphasia of the same severity (28% of all observations) (φ=3.42, p<0.001). The effect of absolute dominance of the right ear (Kpu=1) was equally rare in both groups (Fig. 4).

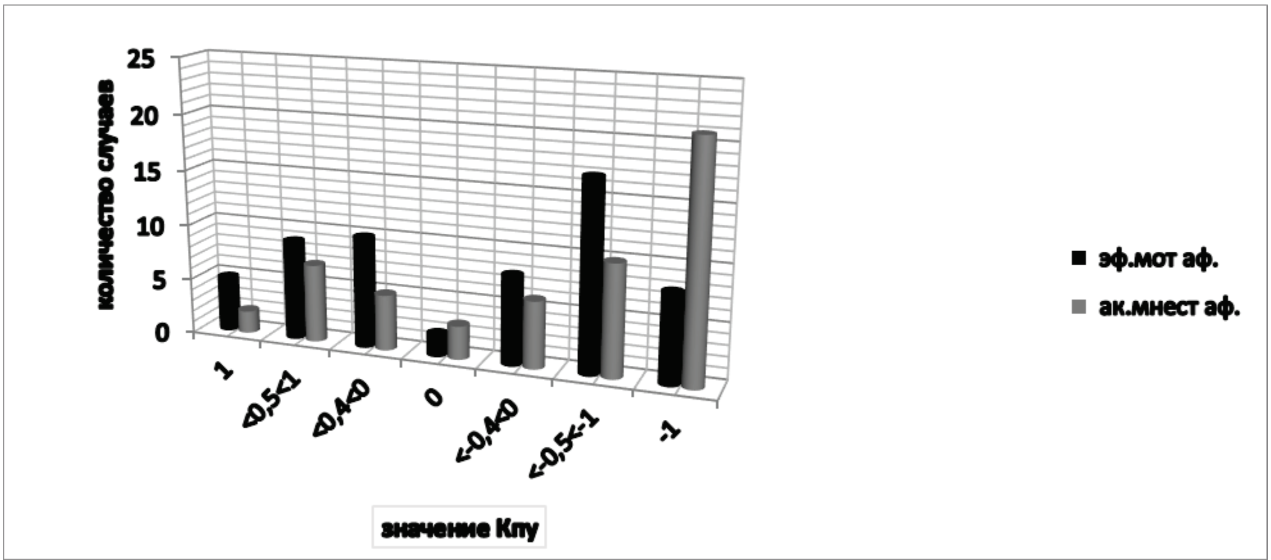

Figure 4. Distribution of patients with efferent motor and acoustic-mnestic aphasias according to the value of Kpu in the dichotic listening to monosyllabic words

Thus, in patients with acoustic-mnestic, in contrast to patients with efferent motor aphasia, higher negative values of Kpu and the effect of absolute dominance of the left ear were significantly more often detected (Shipkova K.M., 2022a).

The relationship between the parameters of dichotic listening task and the dynamics of speech recovery in patients with efferent motor and acoustic-mnestic aphasia

At the next stage, the closeness of the relationship between the number of words reproduced from the right and left ears and the MOR score was determined. The severity of this relationship was determined in patients with acoustic-mnestic and efferent motor aphasia, regardless of what type of speech therapy the patients underwent. Measurement according to the methods was carried out twice – before the speech rehabilitation course (1st assessment) and after its completion (2nd assessement).

The choice of the number of words reproduced from the right and left auditory channels as an indicator of the dynamics of the vector of speech asymmetry was not accidental. All patients were right-handed and did not have hereditary left-handedness, therefore, as for the majority of healthy right-handers, they had to demonstrate the advantage of the right ear. It was necessary to determine how close the initial relationship between the productivity of the right or left ears and the aphasia severity was and how the closeness of this relationship changed during the positive dynamics of speech recovery.

The same sample of patients, consisting of 106 people, was analyzed to the studied indicators. The total number of observations in the 1st and 2nd measurements was 424 assessments: 212 using the dichotic listening task and 212 using the speech assessment in aphasia.

To assess the correlation between the number of words reproduced from the right and left ears and the score of the MOHR technique, Spearman's rs rank correlation coefficient was used for data that did not meet the requirements for the normality of the distribution.

The results of 1st assessment. The ratio "right ear vs left ear" in the group with efferent motor aphasia was 12.32 words vs 15.20 words (Table 10). That is when the posterior frontal parts of the left hemisphere were affected, patients reproduced 1.23 times fewer words from the right than from the left ear. This indicator in the group with acoustic-mnestic aphasia was 7.53 words vs 17.67 words. That indicated that the group with acoustic-mnestic aphasia resorted 2.34 times more often to playing words from the left ear.

Table 10. The number of words recalled from the right and left ear, and MOR_1 score in patients with efferent motor and acoustic-mnestic aphasias. 1st assessment

Aphasia type	Parameter	M	SD
Efferent motor aphasia	$МОР_1$	228,10	28,75
	ΣПУ	12,32	10,58
	ΣЛУ	15,20	10,89
Acoustic-mnestic aphasia	$МОР_1$	220,31	34,02
	ΣПУ	7,53	12,04
	ΣЛУ	17,67	13,06

Note: $МОР_1$ – the speech assessment in aphasia. 1st assessment (before the speech rehabilitation course).

At the same time, the values of the MOR1 score of both groups indicated that before the start of speech rehabilitation, the same degree of aphasia was noted in both groups. In the group with efferent motor aphasia, a direct correlation was revealed between the MOR1 score and the productivity of the right ear ($r_s=0.58$, $p<0.001$) (Table 11). This meant that the lighter the initial degree of severity of the speech disorder, i.e., the higher the MOR1 score, the higher the occurrence of the leading right ear, characteristic of the right-handed normals.

A different picture was formed in the group with acoustic-mnestic aphasia. A weak correlation was found between the MOR1 score and the productivity of the right ear ($r_s=0.35$, $p<0.05$), and no correlation was found with the productivity of the left ear ($r_s=0.06$, $p>0.05$) (Table 11). The latter fact was important since it was with acoustic-mnestic aphasia that the highest percentage of cases with the leading left ear was noted. This may indicate that with damage to the temporal parts of the brain, the advantage of the left ear is formed regardless of how pronounced the speech defect is, and the interhemispheric rearrangement of speech is a common mechanism for compensating for the defect (Shipkova K.M., 2022c).

Table 11. Correlation between the number of words reproduced from the right and left ear and the MOR 1 score in the group with efferent motor and acoustic-mnestic aphasia (rs-criteria)

Aphasia type	Parameters	ΣПУ	ΣЛУ
Efferent motor aphasia	MOR1	**0,58*** **	−0,21
	ΣPU	–	**−0,61*** **
Acoustic-mnestic aphasia	MOR1	**0,35***	0,06
	ΣPU	–	**−0,59*** **

Note: ΣPU – the number of words recalled from the right ear, ΣLU – the number of words recalled from the left ear, MOR1 – the speech assessment in aphasia. 1st assessment (before the speech rehabilitation course), * – $p<0.05$, ** – $p<0.01$, *** – $p<0.001$.

The results of 2nd asessment. Repeated diagnosis, which was carried out five weeks later, immediately after the completion of speech rehabilitation, did not reveal a single case of a change in the initial profile of auditory-speech asymmetry. In all 106 patients, the side of the leading ear did not change, and the profile of auditory-speech asymmetry was stable and indicated the depth of interhemispheric reorganization of speech.

A comparative analysis of speech dynamics was performed in patients with the same side of the leading ear and different types of aphasia, as well as the severity of the rehabilitation shift in groups among patients with different sides of the leading ear (Table 12).

In statistical data processing, the Student's t-test for related samples and the Student's t-test for unrelated samples were used to identify intra-group differences for conducting intergroup comparisons.

In the group with efferent motor (t=1.72, p>0.05) and acoustic-mnestic aphasia (t=1.63, p>0.05), positive dynamics of speech parameters (MOR2 – MOR1) was observed in both patients with the leading right and patients with the leading left ear.

Table 12. Dynamics of quantitative indicators of speech in patients with efferent motor and acoustic-mnestic aphasia with different profiles of auditory-speech asymmetry. 2nd assessment

Aphasia type	Kpu–		Kpu+		t-criteria
	MOR1 M (SD)	MOR_2–MOR_1 M (SD)	MOR2 M (SD)	MOR_2–MOR_1 M (SD)	
Efferent motor aphasia	222,00 (30,21)	11,15 (1,24)	237,00 (23,02)	8,75 (0,74)	1,72 p>0,05
Acoustic-mnestic aphasia	238,00 (33,32)	17,57 (1,98)	236,00 (30,04)	11,50 (3,26)	1,63 p>0,05
t–criteria	**2,75****		0,74		–
p level	0,008		0,062		–

*Note*** – p<0,01.

Patients with the leading right ear of both groups showed commensurate positive dynamics and there were no significant differences in the dynamics of speech recovery (t=0.74, p>0.05).

The picture was different for patients with the leading left ear. In patients with the leading left ear and acoustic-mnestic aphasia, there was a more pronounced regression of speech disorders than in patients with efferent motor aphasia with the same profile of auditory-speech asymmetry (t=2.75, p=0.008). It is important to note that in the 1st assessment in patients with acoustic-mnestic aphasia, there was no correlation between the productivity of the left ear and the MOR1 score. Thus, in patients with acoustic-mnestic aphasia, the correlation was established during speech rehabilitation and with positive dynamics of speech recovery (Shipkova K.M., 2022c).

Productivity of the right and left ear and productivity of free and controlled oral verbal associations

In the next step, the closeness of the relationship between the productivity of recalling words from the right and left ear and the productivity of free and controlled verbal associations (words/min) was analyzed in both groups of aphasics. Both methods assessed the mobility of speech processes. In the method of directed phonological associations, unlike free ones, it was required to select words for a given letter.

Since the data satisfied the requirements for the normality of the distribution, the Pearson r-criterion was used in statistical processing.

The results of the 1st and 2nd assessments were analyzed. The sample included 122 patients in the 1st, 2nd and 3rd stages of the study. A total of 488 assessments were processed: 244 for 1st and 2nd assessments according to both methods (Table 13).

Table 13. Correlation of productivity of free and controlled verbal associations with productivity of the left and right ear. 1st and 2nd assessment

Parameter	Assessment (number)	Productivity of free verbal associations			Productivity of controlled verbal association		
		1st assessment	r-criteria	p level	2nd assessment	r-criteria	p level
Productivity of the right ear.	122	1	0,009	0,918	1	0,061	0,505
	122	2	0,004	0,965	2	0,014	0,867
Productivity of the left ear	122	1	**0,213***	0,018	1	**0,260****	0,004
	122	2	0,140	0,099	2	**0,218****	0,010

Note: * – p<0,05, ** – p<0,01.

Initially, patients with aphasia had a positive correlation between the productivity of the left ear and the productivity of free (r=0.213, p=0.018) and controlled associations (r=0.260, p=0.004). In the 2nd assessment, a positive correlation was maintained between the productivity of the left ear and directional associations ($r=0.218$, $p=0.010$) and was not observed for free associations ($r=0.140$, $p>0.05$).

Neither before nor after speech rehabilitation was there a correlation between the productivity of the right ear and the productivity of free ($r=0.009$ (1st assessment), $r=0.06$ (2nd assessment), $p>0.05$) and directional associations ($r=0.004$ (1 assessment), $r=0.014$ (2nd assessment), $p>0.05$).

Thus, patients with the leading left ear had a positive relationship between the productivity of the left ear and the productivity of free and directed associations, unlike patients with the leading right ear, who did not have such a relationship either before or after speech therapy. In the course of speech therapy, the conjugation of the productivity of the left ear with the productivity of directed associations remained, unlike free ones.

We turn to the presentation of data on the stealing symptoms of the right hemisphere and non-focal parts of the left hemisphere in aphasia patients.

4.2. The right hemisphere stealing symptoms

A diagnostic complex to identify symptoms of right hemisphere oppression was performed in 83 patients with aphasia, 27 of whom were part of the patients of the 2nd stage of the study (they underwent speech rehabilitation in a music-enriched environment).

When processing the obtained data, a sample of patients was subjected to cluster analysis according to the domain of visual memory. End-to-end clustering, without dividing patients by type of aphasia and into those who underwent speech therapy in a music-enriched environment and traditional speech therapy, was carried out intentionally to identify the universality of the mechanisms that determine the occurrence of stealing symptoms and their dynamics during speech rehabilitation, regardless of the approach in which it was conducted and the form of aphasia.

Diagnosis of the stealing symptoms of the right and left hemispheres revealed that in patients with aphasia, the most vulnerable domain was the domain of visual memory, which was the basis for clustering data based on the effectiveness of right-hemisphere and left-hemisphere visual tests.

To identify homogeneous groups, which will include patients with different types of aphasia with similar severity of symptoms of stealing from the right and left hemispheres, a clustering procedure (using the k-means method) was performed based on the performance of visual tests of diagnostic complexes to identify stealing symptoms of the right and left hemispheres: *retention of 9 difficult-to-visualize graphic images (figures), 9 object (verbalized) images (3 tasks), schematized faces (6 tasks:1 face – 3 tasks, 2 faces – 3 tasks), recognition of underexposed subject images (9 tasks), recognition of 6 objects in conditions of visual noise (interference) (12 tasks), recognition of objects with incomplete image saturation gradient (9 tasks), identification of persons (9 tasks).* Data processing was carried out by the SPSS 21.0 software package.

Three clusters were identified that had differences in the combination of the severity of two right- and two left-hemisphere oppression symptoms of the occipital and parietal brain regions:

Cluster 3 was characterized by high memory score for retention of 9 difficult-to-visualize graphic images (figures) and object images, for comparison of a three-dimensional figure with its sweep and a medium stereognosis score of the non-leading (left) hand.

Cluster 1 was characterized by low memory score for retention of 9 difficult-to-visualize graphic images (figures) and objects, low score for comparison of a three-dimensional figure and its sweep and high stereognosis score of the left-hand;

Cluster 2 was characterized by a medium memory score for retention of 9 difficult-to-visualize graphic images (figures) and objects ones, for comparison of a three-dimensional figure and its sweep and a low score for stereognosis on the non-leading (left) hand;

Cluster 3 was characterized by high memory score for retention of 9 difficult-to-visualize graphic images (figures) and objects, for comparison of a three-dimensional figure with its sweep and a low stereognosis score of the non-leading (left) hand.

Table 14. Demographic characteristics, lesion sizes and the profile of auditory-speech asymmetry (Kpu) in patients with efferent motor and acoustic-mnestic aphasia patients of 1st ,2nd and 3rd clusters. 1st assessment (N=83)

Parameter	M/cluster			SD/cluster			χ^2 criteria	p level
Cluster number	1	2	3	1	2	3		
Age (years)	51,00	52,64	49,94	10,65	9,36	9,21	1,740	0,419
Time post-onset (months)	12,77	20,77	18,76	16,03	17,50	18,69	4,519	0,982
Lesion size(cm3)	58,49	52,62	81,47	48,65	35,64	108,85	0,036	0,983
Kpu	–0,19	–0,20	–0,04	0,78	0,74	0,71	0,472	0,790

There were no significant differences in age ($\chi2$=1,740, p>0.05), time post-onset ($\chi2$=4,519, p>0.05), and lesion sizes ($\chi2$=0.036, p>0.05) between patients of different clusters (Table 14). There were no significant differences between the clusters in the number of cases with the left and right ear advantages ($\chi2$=0.472, p>0.05).

Thus, the composition of patients in different clusters made it possible to eliminate the influence of age, aphasia time post-onset, the size and the profile of auditory-speech asymmetry on the presence of stealing symptoms. That made it possible to consider the revealed picture of right- and left-hemisphere dysfunctions as an objective pattern of the consequences of speech impairment, not determined by a demographic factor, the profile of auditory-speech asymmetry and morphometric characteristics of lesion sizes and its time post-onset.

If oppression symptoms of the right and left hemispheres are detected in patients with aphasia and their low susceptibility to regression is shown against the background of positive dynamics of speech recovery, this will be the argument for considering these symptoms as tertiary, which are the result of compensation of a speech impairment during intra- and interhemispheric reorganization of impaired speech function.

Stealing symptoms of the right hemisphere and their dynamics during speech recovery

Stealing symptoms of the occipital-parietal brain regions of the right hemisphere. Retention of schematized faces. Retention of difficult-to-visualize graphic images (figures).1st assessment

Recognition of familiar faces did not reveal significant differences between clusters ($\chi 2$=0.975, p>0.05) (Table 16). In cluster 1, the average score was 6.92, in cluster 2 – 6.87, in cluster 3 – 6.82.

Table 16. Differences in the severity of stealing symptoms of the occipital and parietal lobes of the right hemisphere and speech disorders in aphasia patients of clusters 1, 2 and 3. 1st assessment (N=83)

Task	χ^2 criteria	P level
Oppression symptoms of the occipital regions of the right hemisphere		
Retention of schematized 1 face	1,388	0,500
Retention of schematized 2 faces	4,307	0,116
Retention of difficult-to-visualize graphic images (figures)	**59,596*****	<0,001
Recognition of uncompleted subject images	0,985	0,611
Recognition of objects in conditions with a P 0,35 degree of visual noise	0,324	0,851
Recognition of objects in conditions with a P 0,25 degree of visual noise	0,079	0,961
Recognition of objects with incomplete (5%) image saturation gradient	1,455	0,483
Recognition of objects with incomplete (10%) image saturation gradient	0,832	0,660
Recognition of objects with incomplete (20%) image saturation gradient	0,881	0,644
Identification of familiar faces	0,975	0,614
Oppression symptoms of the parietal regions of the right hemisphere		
Stereognosis on the non-leading (left) hand	**6,733****	0,035
Mental rotation of an object in two-dimensional space	4,473	0,107
MOR_1 (score)	**5,835***	0,049

Note: * – p<0,05, * – p<0,01, *** – p<0,001.

Recognition of objects in conditions of visual noise (interference). Patients of all clusters had difficulty identifying objects in conditions of noisy visual field (Table 16). For example, when recognizing objects with a 5% saturation gradient in cluster 1, the average score was 1.54, in cluster 2 – 1.55 and in cluster 3 – 1.18 points. With an increase in the saturation gradient to 20%, the possibility of recognizing an object in the 1st cluster increased to 2.31, in the 2nd cluster – to 2.60, in the 3rd cluster – 2.35 points. There were no significant differences between the clusters in terms of recognizing objects in conditions of visual noise, with an incomplete saturation gradient and underexposed subject images.

The severity of symptoms of occipital oppression was not the same in different clusters. Cluster 3 patients had the lowest values in recognizing objects with an incomplete 5% saturation gradient of the image, and cluster 1 patients – in recognizing objects with a P 0.35 degree of visual noise and incomplete subject images. Although no significant differences were found between the clusters according to these indicators, it allowed us to assume that the severity of the topical focus of dysfunctionality in the healthy hemisphere had a certain unevenness in the severity of oppression symptoms.

Stealing symptoms of the parietal regions of the right hemisphere. Mental rotation of an object in two-dimensional space. Stereognosis on the non-leading (left) hand. 1st assessment

The task of *mental rotation in two-dimensional space* was the least difficult for all patients. She found the relative preservation of spatial representations in the entire sample. 5.75 samples out of 7 samples were performed in cluster 1, 5.35 in cluster 2, and 6.47 points in cluster 3 (Table 15). Differences in performance between clusters were insignificant ($\chi2=4.473$, $p>0.05$) (Table 16).

Stereognosis on the non-leading (left) hand. In patients of cluster 2, the difficulty of identifying objects with the left hand was significantly more pronounced than in patients of clusters 1 and 3 ($\chi2=6.733$, $p=0.035$). In cluster 2, patients recognized an average of 2.75 subjects out of 5 subjects, in cluster 3 – 3.47, in cluster 1 – 3.54 points.

Thus, the diagnosis of oppression symptoms of the right hemisphere in patients with aphasia revealed a spectrum of symptoms indicating the dysfunctionality of the occipital and parietal regions of the right hemisphere.

The MOR1 index in patients of different clusters

Intercluster differences in the severity of aphasia were significant ($\chi 2$ =5.835, p=0.049) (Table 16). Cluster 1 patients had a significantly lower MOR1 index (196±38.43) than patients in cluster 2 (210.36 ±39.49) and cluster 3 (230.60±33.27) (Table 15).

It should be noted that the oppression symptoms of the occipital regions of the right hemisphere were common to all clusters: difficulty identifying an object in conditions of incomplete saturation gradient (indistinctness of the outline of the object), in conditions of visual noise, difficulty remembering faces and recognizing familiar faces. These symptoms were typical for patients with different types, severity and duration of aphasia, with different morphometric and topographic parameters of the focal lesion.

Concerning parietal and occipitoparietal symptoms, namely memory for difficult-to–visualize figures and tactile gnosis on the ignorant (left) hand, significant differences between clusters were found – in patients with greater severity of speech disorders, greater severity of oppression symptoms of the occipito-parietal and parietal lobes regions of the right hemisphere was also noted.

Dynamics of stealing symptoms of the right hemisphere. 2nd assessment

Repeated assessment was performed after the end of the speech rehabilitation course, i.e. five weeks after 1st assessment.

During speech rehabilitation, the results of right-hemisphere samples increased slightly in all clusters but did not regress (Table 17).

Table 17. Stealing symptoms of the occipital and parietal regions of the right hemisphere and the severity of speech disorders in patients of clusters 1, 2, 3. 2nd assessment (points) (N=83)

Task	Score max.	M/cluster			SD/cluster		
		1	2	3	1	2	3
Oppression symptoms of the occipital regions of the right hemisphere							
Retention of schematized 1 face	3	1,92	2,02	2,00	0,76	0,91	1,06
Retention of schematized 2 faces	6	1,38	1,77	2,88	1,71	1,58	1,76
Retention of 9 difficult-to-visualize graphic images (figures)	27	9,85	15,13	20,35	4,16	2,69	2,74
Total (score)	36	13,15	18,92	25,23	6,63	5,18	5,56
Recognition of uncompleted subject images	9	7,54	7,38	7,59	1,39	1,47	1,18
Recognition of objects in conditions with a P 0,35 degree of visual noise	6	0,54	1,53	2,06	0,97	2,17	2,36
Recognition of objects in conditions with a P 0,25 degree of visual noise	6	3,85	3,96	4,12	1,91	1,71	1,50
Recognition of objects with incomplete (5%) image saturation gradient	3	1,85	1,79	1,53	1,07	1,06	1,12
Recognition of objects with incomplete (10%) image saturation gradient	3	2,15	2,40	2,35	1,07	0,86	1,00
Recognition of objects with incomplete (20%) image saturation gradient	3	2,38	2,72	2,65	0,96	0,60	0,79
Identification of familiar faces	9	7,15	7,09	7,12	1,99	1,73	1,50
Oppression symptoms of the parietal regions of the right hemisphere							
Stereognosis on the non-leading (left) hand	5	3,69	3,21	3,53	1,65	1,31	1,01
Mental rotation of an object in two-dimensional space	7	5,83	5,69	6,53	2,04	1,69	0,87
MOR_2 (score)	300	210,35	224,02	243,27	39,74	39,59	33,21

Oppression symptoms in the occipital regions of the right hemisphere in aphasia patients persisted, were detected after the rehabilitation and did not show intercluster differences in the tasks of recognizing faces and objects in sensitized perception conditions (visual noise, incomplete contour).

A different picture was formed concerning the dynamics of parietal and occipital symptoms. There were significant differences in retention of difficult-to-visualize figures ($\chi2=42.500$, $p<0.001$) (Table 18). At the same time, in the 2nd assessment, in comparison with the 1st assessment, there were no intercluster differences in stereognosis on the left hand ($\chi2=3.207$, $p>0.05$), however, there were differences between clusters in retention of 2 schematized faces ($\chi2=7.230$, $p=0.027$).

Table 18. Differences in the severity of stealing symptoms of the occipital and parietal regions of the right hemisphere and speech disorders between clusters 1, 2 and 3. 2nd assessment (N=83)

Task	χ^2 criteria	P level
Oppression symptoms of the occipital regions of the right hemisphere		
Retention of schematized 1 face	0,316	0,854
Retention of schematized 2 faces	**7,230***	0,027
Retention of difficult-to-visualize graphic images (figures)	**42,500*****	<0,001
Recognition of uncompleted subject images	0,299	0,861
Recognition of objects in conditions with a P 0,35 degree of visual noise	3,461	0,177
Recognition of objects in conditions with a P 0,25 degree of visual noise	0,067	0,967
Recognition of objects with incomplete (5%) image saturation gradient	0,863	0,650
Recognition of objects with incomplete (10%) image saturation gradient	0,668	0,716
Recognition of objects with incomplete (20%) image saturation gradient	1,716	0,424
Identification of familiar faces	0,176	0,916
Oppression symptoms of the parietal regions of the right hemisphere		
Stereognosis on the non-leading (left) hand	3,207	0,201
Mental rotation of an object in two-dimensional space	3,309	0,191
MOR_2 (score)	4,361	0,113

Note: * – p<0,05, *** – p<0,001.

Thus, the repeated diagnosis of the stealing symptoms of right hemisphere revealed that the right-hemisphere neuropsychological symptoms showed unexpressed positive dynamics about individual occipital and parietal symptoms, and most of the right-hemisphere symptoms were stable. In patients of all clusters, symptoms of right hemisphere oppression were followed by positive dynamics of speech recovery. By the end of the speech rehabilitation course, as was the case in the 1st assessment, there were no intercluster differences in the MOR2 score ($\chi2=4.361$, $p>0.05$) (Table 18).

The above suggests that the positive dynamics of speech recovery in patients with aphasia were accompanied by a change in the topographic foci of intercluster differences concerning oppression symptoms of the right hemisphere – the appearance of intercluster differences in occipital symptoms (retention of 2 faces) and their weakening with the parietal (regression of intercluster differences in stereognosis on the left hand).

4.3. The left hemisphere stealing symptoms

Stealing symptoms of the occipital regions of the left hemisphere

Visual object memory. 1st and 2nd assessments

The presence of oppression in the occipital regions of the left hemisphere was revealed by the task of retention 9 object images (Table 19). Patients were asked to perform three similar tasks (the table shows the final score for completing 3 tasks).

In all patients with aphasia, there was a narrowing of the volume of visual object memory. In cluster 1 it was 5.00 elements, in cluster 2 – 5.96 elements, and cluster 3 – 6.84 elements. In the 1st assessment, the differences between the clusters were significant ($\chi2=18.76$, $p<0.001$) (Table 20).

Even though after the completion of speech rehabilitation, positive dynamics in visual object memory were noted in all clusters, differences between clusters remained ($\chi2=13.10$, $p=0.001$).

Table 19. Stealing symptoms of the occipital and parietal regions of the left hemisphere and the severity of speech disorders in patients of clusters 1, 2, 3. 1st and 2nd assessments (in points) (N=83)

Task	Score max.	M/cluster			SD/cluster		
		1	2	3	1	2	3
Oppression symptoms of the occipital regions of the left hemisphere							
Retention of 9 object (verbalized) images 1st assessment	27	15,00	17,89	20,53	3,70	2,61	2,45
Retention of 9 object (verbalized) images 2nd assessment	27	16,08	18,92	21,06	3,66	3,43	3,01
Oppression symptoms of the parietal regions of the left hemisphere							
Comparison of a three-dimensional figure and its sweep1st assessment	6	3,62	4,34	5,47	2,36	1,95	1,12
Comparison of a three-dimensional figure and its sweep 2nd assessment	6	3,92	4,79	5,65	2,06	1,50	1,00
Stereognosis on the leading (right) hand 1st assessment[1]	5	2,80	3,30	4,18	1,62	1,47	0,75
Stereognosis on the leading (right) hand 2nd assessment[1]	5	3,33	3,57	4,36	1,22	1,63	0,81
MOR_1 (score)	300	196,00	210,36	230,60	38,43	39,49	33,27
MOR_2 (score)	300	210,35	224,02	243,27	39,74	39,59	33,21

Note: here and in Table 20 [1] – the task was performed in 58 patients.

Stealing symptoms of the parietal regions of the left hemisphere. 1st and 2nd assessments

The symptoms of oppression of the parietal parts of the dominant hemisphere were revealed by the task of correlating a three-dimensional figure with its sweep and diagnosing stereognosis on the right hand.

Correlation of a three-dimensional fugure with its sweep

The task of mental potation in three-dimensional space revealed difficulties in patients of all clusters, but their severity was different. Cluster 1 had the lowest values (3.62 points) than in 2 (4.34 points) and 3 clusters (5.47 points) (Table 19). Intercluster differences in 1 assessment were significant (χ2=7,503, p=0.023) (Table 20). The dysfunctionality of the parietal parts of the left hemisphere was persistent and showed no significant regression during speech rehabilitation, which determined the preservation of intercluster differences after completion of the course of speech rehabilitation (χ2=9.049, p=0.011).

Table 20. Differences in the severity of stealing symptoms of the occipital and parietal lobes of the left hemisphere and speech disorders in aphasia patients of clusters 1, 2, 3. 1st and 2nd assessments (N=83)

Task	Asssessment number	χ^2 criteria	P level
Symptoms of oppression of the occipital regions of the left hemisphere			
Retention of 9 object (verbalized) images	1	**18,76*** **	<0,001
Retention of 9 object (verbalized) images	2	**13,10*** **	0,001
Symptoms of oppression of the parietal regions of the left hemisphere			
Comparison of a three-dimensional figure and its sweep	1	**7,503***	0,023
Comparison of a three-dimensional figure and its sweep	2	**9,049***	0,011
Stereognosis on the leading (right) hand[1]	1	4,897	0,086
Stereognosis on the leading (right) hand [1]	2	3,935	0,140
MOR_1 (score)	300	**5,835***	0,049
MOR_2 (score)	300	4,361	0,113

Note: *– p<0,05, *** – p<0,001.

Stereognosis on the leading (right) hand

Stereognosis was diagnosed in those patients who were not diagnosed with paresis in their right arm during neurological examination. Out of a sample of 83 patients with aphasia, it was possible to diagnose stereognosis on the right arm in 58 patients. All 116 assessments (58 people X2) were analyzed, including 1 and 2 ones.

The initial state of tactile gnosis revealed an unexpressed astereognosis in the right hand in all the study's participants. Intercluster differences were absent both on measurement ($\chi2=4.897$, $p>0.05$) and on repeated diagnosis ($\chi2=3.935$, $p>0.05$) (Table 20). Thus, patients of all clusters initially showed an unexpressed decrease in stereognosis on the right arm, which was stable over time and not susceptible to reduction.

Thus, after the completion of speech rehabilitation, against the background of positive dynamics of speech recovery in all clusters and the absence in the 2nd assessment of intercluster differences in the MP score ($\chi2=4.361$, $p>0.05$) that occurred before the start of rehabilitation ($\chi2=5.835$, $p=0.049$) (Table 20), concerning symptoms of oppression occipital and upper parietal sections of the left hemisphere (correlation of a three-dimensional figure with a scan) intercluster differences persisted.

The general picture of the dynamics of stealing symptoms of the right and left hemispheres in patients with aphasia of different clusters

The positive dynamics of speech recovery in patients with different demographic parameters, type and duration of aphasia, topical and metric characteristics of focal lesion of the left hemisphere of the brain occurred against the background of low susceptibility to reduction of symptoms of oppression of the occipital and parietal parts of the brain and the preservation of several intercluster differences.

Symptoms of oppression of the occipital hemispheres were more pronounced in patients of clusters 1 and 2, compared with cluster 3. At the same time, patients in cluster 3 had significantly higher MOR1 score compared to the patients in clusters 1 and 2. That means that with a lower severity of speech disorders, there were also less pronounced symptoms of oppression of the occipital structures of the brain.

Clustering of stealing symptoms of the extra-focal parts of the left hemisphere and symptoms of oppression of the right hemisphere in patients with aphasia made it possible to determine their topographic foci and dynamics during speech recovery.

After speech rehabilitation, intercluster differences concerning individual right-hemisphere parietal symptoms (stereognosis on the left hand) were levelled, and differences with other right-hemisphere occipital symptoms deepened (retention of schematized 2 faces). Left-hemisphere symptoms were more resistant to fluctuations in speech parameters compared to the right-hemisphere ones. All the intercluster differences in left-hemisphere symptoms identified in the 1st assessment remained after the speech rehabilitation course.

Along with this, some symptoms were identified that did not have intercluster differences or a linear relationship with the severity of speech disorders. It was important to find out if there was a relationship between these symptoms of oppression, along with others, and the dynamics of speech recovery. Therefore, an analysis of the relationship of the entire pool of stealing symptoms was further carried out without dividing them into clusters with the dynamics of speech recovery.

4.4. Stealing symptoms of the left and right hemispheres and dynamics of speech recovery

To identify the flexible and rigid links of the new brain organization of speech function that developed as a result of aphasia, further analysis of the symptoms of oppression was carried out without dividing the sample into clusters.

The definition of the topic of brain structures that, as a result of an aphasic defect, are included in the implementation of speech processes was based on the following understanding of the relationship between speech restoration and the dynamics of non-focal neuropsychological symptoms. Flexible links of the speech function reflect the incompleteness of the process of their integration into the new brain architectonics and psychological structure of speech, therefore, unlike rigid ones, they should be characterized by instability of connection (conjugation) with regression of aphasic disorders. Rigid links, on the contrary, should show stability or a positive correlation with the dynamics of speech recovery.

The identification of the hemispheric topography of rigid and flexible links allowed, at further stages of the study, to approach the development of a scientifically based algorithm, principles and methodological techniques for the rehabilitation of aphasic disorders, taking into account neuropsychological and neurobiological patterns of interhemispheric reorganization of impaired speech function.

The relationship between the MOR score and oppression symptoms of left hemisphere. 1st assessment

To identify the relationship between speech recovery and the dynamics of stealing symptoms of the left hemisphere results of 1st and 2nd assessments of a diagnostic complex aimed at identifying oppression symptoms of the left hemisphere were compared with the results of two speech methods: the speech assessment in aphasia and the speed of spontaneous speech.

The 83 patients' data from the 1st study's stage were analyzed (166 assessments).

Statistical analysis was performed using Pearson's r-test for data whose distribution corresponded to the normal distribution.

A positive correlation was noted between the MOR1 score and many stealing stealing symptoms of the occipital and parietal parts of the left hemisphere: dysfunction of visual object memory (memorization of 9 object images) ($r=0.250$, $p=0.023$), spatial thinking (correlation of a three-dimensional figure and its unfolding) (r=0.354, p<0.001) and tactile gnosis on the leading (right) hand (r=0.374, p=0.004) (Table 21).

Thus, the greater severity of speech disorders was accompanied by the greater severity of oppression symptoms in the occipital and parietal regions of the left hemisphere.

The relationship between the MOR score and symptoms of right hemisphere oppression. 1st assessment

Table 21. Correlation of stealing symptoms of the right and left hemispheres and MOR score before and after the speech rehabilitation course. 1st and 2nd assessment (N=83)

Task	Number of cases	Pearson's r–criteria	p level
Correlation of stealing symptoms of the right and left hemispheres in 1st assessment and MOR_1 score			
Recognition of objects in conditions with a P 0,25 degree of visual noise	83	**0,246****	0,025
Recognition of uncompleted subject images	83	**0,249***	0,023
Mental rotation of an object in two-dimensional space	83	**0,227***	0,042
Retention of 9 object (verbalized) images	83	**0,250***	0,023
Comparison of a three-dimensional figure and its sweep	83	**0,354****	<0,001
Stereognosis on the leading (right) hand	58	**0,374***	0,004
Correlation of stealing symptoms of the right and left hemispheres in 2nd assessment and MOR_2 score			
Recognition of objects in conditions with a P 0,25 degree of visual noise	83	**0,216***	0,050
Recognition of uncompleted subject images	83	0,207	0,608
Mental rotation of an object in two-dimensional space	83	0,168	0,135
Retention of 9 object (verbalized) images	83	0,583	0,62
Comparison of a three-dimensional figure and its sweep	83	**0,279***	0,011
Stereognosis on the leading (right) hand	58	**0,271***	0,041

Note: * – p<0,05, ** – p<0,01.

A positive relationship was revealed between the MOR1 score and dysfunction of visual gnosis and spatial thinking according to the right hemisphere type. A correlation was found between the severity of speech disorders in the 1st assessment and the dysfunction of visual object gnosis: recognition of an object in conditions of visual noise (in conditions of P 0.25 degree of visual noise) (r=0.246, p=0.025), incompleteness of the visual image (underexposed subject images) (r=0.249, p=0.023). The correlation of the MOR score in 1 assessment and indicators of spatial thinking (mental rotation of an object in two-dimensional space) was also revealed (r=0.227, p=0.042) (Table 21).

Thus, the severity of speech disorders correlated with the severity of symptoms of oppression in the occipital and parietal regions of the right hemisphere.

The relationship between the MOR score and symptoms oppression of in the right hemisphere. 2nd assessment

In patients with aphasia, during speech rehabilitation and positive dynamics of speech recovery, the topical focus of symptoms of right hemisphere oppression narrowed. That was reflected in the weakening of many correlations noted in the 1st assessment. The correlation of the MOR score observed in the 1st assessment with the recognition of underexposed object images (r=0.207, p>0.05) and the mental rotation of the object in two-dimensional space (r=0.168, p>0.05) was not revealed (Table 20). At the same time, in the 2nd assessment, the conjugation of the severity of speech disorders with the difficulty of visual object gnosis (recognition of objects in conditions of P 0.25 degree of visual noise) remained (r=0.216, p=0.050).

Thus, before rehabilitation, the severity of speech disorders correlated with the severity of oppression symptoms in the parietal and occipital regions of the right hemisphere. After rehabilitation, against the background of improved speech, a selective positive correlation of the MOR2 score with some symptoms of stealing from the occipital regions of the subdominant hemisphere (recognition of objects in conditions of visual noise) remained. That indicated that in patients with aphasia, some structures of the occipital sections of the right hemisphere were part of the rigid links of the new cerebral basis of speech function, in contrast to the parietal sections, which represented its flexible links.

The relationship between the MOR score and oppression symptoms of left hemisphere. 2^{nd} assessment

The opposite pattern was observed for the symptoms of left-hemisphere oppression. The correlation of the Mwith the stealing symptoms of the parietal regions of the left hemisphere persisted. Repeated diagnosis revealed the correlation of positive dynamics of speech recovery with a decrease in the severity of symptoms of spatial thinking dysfunction (correlation of a three-dimensional figure and its unfolding) ($r=0.279$, $p=0.011$) and tactile gnosis on the right (leading) hand ($r=0.271$, $p=0.041$) (Table 21). The oppression symptoms of the occipital regions of the left hemisphere (memorization of 9 subject images) were persistent and in the 2^{nd} assessment did not reveal a correlation with the dynamics of speech recovery ($r=0.583$, $p>0.05$).

The preservation after speech rehabilitation of a positive correlation between the MOR2 score and the severity of stealing symptoms of the parietal and occipital regions of the left hemisphere indicated the completeness of inclusion. The left-hemisphere structures are integrated into the reorganized brain and psychological structure of speech.

The relationship between the dynamics of the speed of spontaneous speech and the oppression symptoms of the right and left hemispheres. 1^{st} and 2^{nd} assessment

Another indicator evaluating speech recovery in patients with aphasia was the rate of coherent spontaneous speech. It was determined by the number of words/min uttered by the patient when composing a story based on a plot picture in the "making up a story" subscale of the MOR method. This indicator reflected the speed of finding the right word, the ease of pronouncing it and the pace of coherent monologue speech.

The assessment of this indicator in the 1st and 2nd assessments was carried out in 70 patients of the 1st, 2nd and 3rd stages of the study. There are 140 assessments in total (70 people X2).

Table 22. Correlation of the speed of spontaneous speech with the stealing symptoms of the right and left hemispheres before and after the speech rehabilitation course. 1st and 2nd assessment (N=70)

Task	Number of cases	Pearson's r–criteria	p level
The right-hemisphere symptoms			
Recognition of objects in conditions with a P 0,25 degree of visual noise	1	**0,288***	0,016
Recognition of objects in conditions with a P 0,25 degree of visual noise	2	**0,293***	0,014
Recognition of uncompleted object images	1	–0,032	0, 803
Recognition of uncompleted object images	2	**0,240***	0,045
Retention of 9 difficult-to-visualize graphic images	1	**0,252***	0,036
Retention of 9 difficult-to-visualize graphic images	2	0,111	0,319
The left-hemisphere symptoms			
Retention of 9 object (verbalized) images	1	**0,245***	0,026
Retention of 9 object (verbalized) images	2	0,205	0,62
Comparison of a three-dimensional figure and its sweep	1	**0,360****	0,002
Comparison of a three-dimensional figure and its sweep	2	**0,289***	0,015

Note: * – p<0,05, ** – p<0,01.

Before the start of rehabilitation, patients with aphasia showed a correlation between the speed of speech and the success of recognizing objects in conditions of visual noise (r=0.288, p=0.016), retention of difficult-to-visualize figures (r=0.252, p=0.036) and object images (r=0.245, p=0.026), correlation of a three-dimensional figure and its sweep (r=0.360, p=0.002) (Table 22). At the same time, there was no correlation between the speed of speech in aphasia patients and the difficulty of recognizing incomplete object images (r=-0.032, p>0.05), retention of difficult-to-visualize figures (r=0.111, p>0.05). These tasks were equally difficult for all patients

After rehabilitation, there was a positive correlation between the speed of coherent speech and the severity of difficulties recognizing objects in conditions of visual noise (r=0.293, p=0.014) and a positive correlation was established with the recognition of uncompleted subject images (r=0.240, p=0.045). There was a positive correlation between the stealing symptoms in the parietal regions of the dominant hemisphere – the correlation of a three-dimensional figure and its sweep (r=0.289, p=0.015).

Thus, the dynamics of the speed of spontaneous speech revealed a positive correlation with the stealing symptoms in the occipital regions of the right hemisphere and parietal ones of the left hemisphere.

The results obtained confirm the changes in the lateral vector of stealing symptoms and their topics detected in patients with aphasia during cluster analysis during the positive dynamics of the MOR2 score. Another indicator of speech dynamics, the speed of coherent spontaneous speech, also showed a positive correlation with the regression of some symptoms of stealing from the occipital regions of the right and parietal ones of the left hemisphere. These data make it possible to deepen the understanding of the differentiated contribution of individual aspects of visual and spatial gnosis to the regression of aphasic disorders and the structural characteristics of aphasia syndrome.

4.5. Structural and dynamic model of aphasia syndrome

Diagnostics of the profile of auditory-speech asymmetry in patients with aphasia, the spectrum of right- and left-hemisphere non-speech symptoms, the dynamics of speech recovery during speech rehabilitation and its association with right- and left-hemisphere symptoms revealed some patterns of speech recovery in aphasia.

1. *Interhemispheric and intrahemispheric reorganization (vicariate) of speech in patients with aphasia are universal mechanisms of brain plasticity, the two-sided process of restoring impaired higher mental function.*

Patients with efferent motor and acoustic-mnestic aphasia who participated in the study had mild to moderate severity of aphasic disorders, different ages and extent of focal brain damage. All patients were right-handed and did not have hereditary left-handedness. It is well-known that right-handers are characterised by the superiority of the right ear in the dichotic listening task, i.e. the dominance of the right ear and the left hemisphere in speech processes (Simernitskaya E.G., 1978, 1985; Dobrokhotova T.A., Bragina N.N., 1994; Shipkova K.M.., 2013, 2024a; Dubinskiy A.A., Shipkova K.M. et al., 2021; Shipkova K.M., Dubinsky A.A., 2023; Shipkova K.M., Bulygina V.G., 2023a, 2023b; Kimoura D., 1961; Sparks R. et al., 1970).

In the vast majority of patients with aphasia, the advantage of the left ear in auditory and speech perception was revealed, unlike healthy right-hander controls, which are characterized by a leading right ear. The advantage of the left ear was a manifestation of the established process of cerebral vicariate of speech function and the establishment of right-hemisphere dominance in speech processes, which confirms the data of other studies, including our own (Shipkova K.M., 2013, 2015, 2018, 2022a; 2022b, 2022c; Crosson B., Warren L., 1981; Richter M. et al., 2008).

The high frequency of the hearth effect, which was observed in the task of dichotic listening to monosyllabic words in patients of the early recovery period (up to 1 year) with mild to moderate aphasia, indicated that the process of cerebral hemispheric reorganization involving homologous brain regions occurred already in the early stages of speech recovery (Shipkova K.M. et al., 2020), which does not confirm the claims about the possibility of hemispheric vicariate only in cases of gross speech disorders (Johnson J. et al., 1977). Since the age of patients were represented by mature and elderly age people, the widespread idea of a decrease in brain plasticity with ageing (Tsvetkova L.S., 2002, 2011) indicates an overestimation of the importance of the influence of the age factor on the mechanisms of brain plasticity.

2. *The chronological sequence of the change of one type of cerebral reorganization of speech function by another is determined by the influence of several neuropsychological and neurobiological parameters: the type of aphasia, the degree of severity of disorders, the prescription and volume of focal lesion, the profile of the leading hand.*

Intra- and interhemispheric reorganization of the impaired function revealed a dependence on many neuropsychological and neurobiological parameters: type of aphasia, prescription of the defect, metric characteristics of the lesion (Shipkova K.M., 2022a, 2022b, 2022c).

In patients with efferent motor aphasia with small foci of different ages, the advantage of the right ear prevailed, which indicated a cerebral reorganization of speech along the path of intrahemispheric restructuring at the expense of neighbouring intact sections of the left hemisphere. With massive foci in the early stages (up to 1 year), speech restoration followed the path of interhemispheric restructuring, which was confirmed by the formation of the focal effect of the leading left ear in most patients and the gradual regression of such cases for more than 1 year, when every second patient dominated the right ear typical for healthy right-handers. Neurophysiological patterns of restoration of cerebral hemodynamics in vascular brain lesions allow us to give the following explanation for the duration of the process of including healthy parts of the affected hemisphere in compensation for speech disorders. Temporary characteristics of compensation for the consequences of massive vascular brain lesions are associated with the rate of restoration of collateral circulation by forming anastomoses (Stolyarova L.G., 1963, 1973; Thin-legged I.M., 1968; Parfenov V.A. et al., 2012; Damulin I.V., Ekusheva E.V., 2016; Damulin I.V., Strutsenko A.A., 2018). Anastomoses are a trigger for spontaneous cerebral reorganizations of speech function (Anglade C. et al., 2014; Stefaniak J.D. et al., 2020; Ulanov M.A. et al., 2018). In addition, the compensation rate depends on the size of the penumbra zone (Kiran S.et al, 2019; Nasios G. et al. 2019; Sternberg S., 2011; Damulin I.V., Strutsenko A.A., 2021). Thus, the readiness of healthy brain structures was determined by the depth of inhibition of healthy structures and/or the rate of formation of anastomoses. This makes it possible to explain the reason for the establishment of the leading left ear in the early recovery period in most patients with efferent motor aphasia and the equalization of the frequency of cases with the leading right and left ears with a speech defect of more than 1 year.

In patients with acoustic-mnestic aphasia and extensive focal lesion of the left temporal lobe, the leading left ear was characteristic of the absolute majority of patients with speech disorders of varying duration. This indicated the limited possibilities of functional replacement of the structures of the left temporal lobe at the expense of nearby departments, and thus the vector of hemispheric restructuring of speech function differed from the characteristic lesion of the posterior frontal sections of the left hemisphere.

For small foci of different ages, an uneven pattern of frequency of occurrence of the leading left and right ear was characteristic. In the early period, the process of speech restoration took place along the path of interhemispheric reorganization of speech, as evidenced by the high frequency of cases of the left ear advantage in the time post-onset of more than one year. There was a transition from interhemispheric to intrahemispheric restructuring, which emerged in a high quantity of cases with the leading right ear.

Thus, in acoustic-mnestic aphasia, the vector of the vicariate was determined to a large extent by the volume of the focal lesion. In the first year, with small foci, the interhemispheric reorganization took place along the path of interhemispheric restructuring and the establishment of the leading left ear, and a year later returned to the right ear advantage characteristic to healthy right-handers. In massive foci, regardless of the time post-onset, the cerebral reorganization of speech function followed the path of interhemispheric restructuring, which was indirect evidence of the deep compensatory capabilities of homologous departments of the subdominant hemisphere.

The establishment of the leading left ear and right hemisphere dominance in speech in patients with aphasia was productive. In patients with the leading left ear, the effectiveness of auditory-speech perception in the task of dichotic listening was higher than in patients with the leading right ear, which confirms the data on the effect on the completeness of speech function restoration from the preservation of interhemispheric connections between homologous parts of the brain (Thiel A. et al., 2014; Kroll H. et al., 2017; Matsuura A. et al., 2017).

The effect on the vector of auditory-speech asymmetry of the type of aphasia, the vastness and prescription of brain damage is partially consistent with the model of cerebral plasticity by H. Karbe et al. (1998), in which the effect of left shift (establishment of the leading left ear) is considered as a manifestation of bidirectional disinhibition of brain structures: 1) departments adjacent to the affected area (perilesional regions), 2) homologous departments of the intact hemisphere. The differences in the change of the predominant vector of auditory-speech asymmetry in patients with different types of aphasia were a reflection of the unequal degree of interchangeability of the temporal and posterior frontal parts of the brain due to nearby intact structures. As the study showed, the possibility of interchangeability of the posterior frontal sections was higher than that of the temporal sections of the speech cortex. Depending on the time post-onset, the patient groups with efferent motor and acoustic-mnestic aphasia had a different chronological sequence of changing the predominant vector of asymmetry in the coordinates "left hemisphere –right hemisphere".

The results obtained are consistent with the concepts developed within the framework of high-level models of speech competence of the right hemisphere, in which the bilaterality of the cerebral organization of speech is postulated (Saur D. et al., 2006; Turkeltaub P.E. et al., 2011; Gainotti G., 2016; Kiran S., Thompson C.K., 2019; Stefaniak J.D. et al., 2020; Pasquini L. et al., 2022). The data also confirm that the homotypic process of auditory-speech perception activates, along with the Wernicke zone, homologous regions in the right hemisphere (Trachenko O.P., 1986).

3. The interhemispheric and intrahemispheric reorganization of the damaged speech function leads to the appearance of stealing symptoms, functionally related to the lesion of the damaged hemisphere and homologous regions in the intact one. One of the theoretical hypotheses of the study was that tertiary symptoms are the other side of the mechanisms of intra- and interhemispheric interaction in defect compensation and are obligate. At the same time, one of the empirical hypotheses was the assumption that unilateral damage to the speech departments of the left hemisphere of the brain leads to the formation of a bipolar picture of aphasic syndrome, which manifests associated neuropsychological symptoms characteristic of both the affected area of the brain and functionally related extracellular departments of the same hemisphere and homologous structures of the intact hemisphere.

As is known, the interaction of the hemispheres is subject to some principles: the principle of complementarity (complementarity), reciprocity (mutual inhibition in the work of the hemispheres) and damping (increasing the noise immunity of one hemisphere when breaking the other) (Traugott N.N., 1981, 1986). The principle of complementarity means that the hemispheres do not duplicate but functionally complement each other. The reciprocity principle reflects the mechanism of mutual inhibition of the hemispheres, and the damping principle ensures the functional reliability of the hemispheres in complicated (sensitized) conditions.

These studies allow, based on these principles, to approach the answer to the question of what is the trigger mechanism of the left shift effect. The model suggested by H. Karbe et al. (1998) does not answer the question. According to the results obtained, unilateral brain damage leads to a change in the homotypic pattern of interhemispheric interaction, causing a chain effect of hemispheric restructuring of damaged speech function:

- weakening of the inhibitory effect of the left hemisphere on the right hemisphere;
- disinhibition of the right hemisphere with a simultaneous increase in its noise immunity;
- strengthening of interhemispheric connectivity (interhemispheric interaction) and intrahemispheric connectivity (intrahemispheric interaction) between partially damaged areas in the affected area and or adjacent brain regions (perilesional regions) with functionally related intra- and interhemispheric structures (Fig. 5).

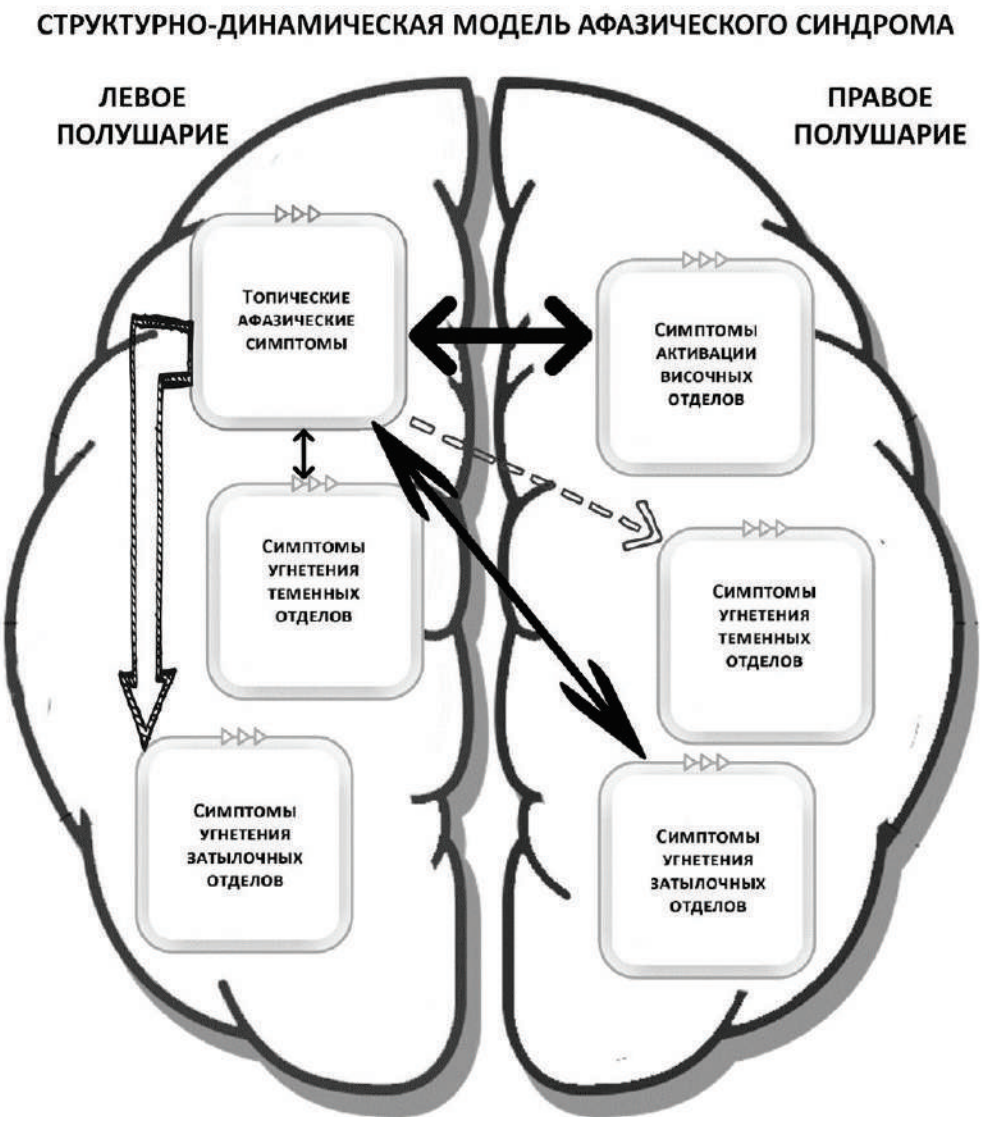

Figure 5. Structural and dynamic model of aphasia syndrome

This is proved by several facts established in the study.

Neuropsychological symptoms were observed in patients with aphasia, indicating the activation of the temporal lobe area of the intact hemisphere. This was manifested in a large percentage of cases of the leading left ear in patients with aphasia and a high index of the effectiveness of speech perception with this profile of auditory-speech asymmetry, which indicated a weakening of reciprocal inhibition from the damaged left hemisphere and a simultaneous increase in the noise immunity of the healthy right hemisphere. Thus, a decrease in the inhibitory effect from the left hemisphere increased the possibility of the right hemisphere's participation in the defect compensation process and was a positive process. In other words, in aphasia, the restructuring of the impaired function occurred due to the weakening of the principles of complementarity and damping, which confirms the results of many other studies (Clarke S. et al., 2015; Su F., Xu W., 2020).

Interhemispheric and intrahemispheric reorganization of speech function in patients with aphasia was followed by the appearance apart from the activation symptoms the oppression symptoms in both hemispheres. The peculiarity of the topography of tertiary symptoms was that in patients with different aphasia types, regardless of the lesion size and time post-onset, oppression symptoms of the occipital and parietal parts of both hemispheres were observed.

Right-hemisphere stealing symptoms were expressed in difficulties of visual object gnosis in sensitized conditions of perception (incompleteness of the image contour, saturation gradient of the object image, recognition in conditions of visual noise), memory for faces and hard-to-visualize figures, difficulties of spatial rotation in two-dimensional space and stereognosis on the left hand.

Left-hemisphere stealing symptoms manifested themselves in a deficit of mirror areas, which were manifested in a deficit of visual object memory, difficulties in correlation with a three-dimensional figure with its sweep, and stereognosis on the right hand.

The topical (topographic) characteristics of neuropsychological deficiency testified to the bi-hemispheric pattern of the stealing symptoms and reflected the dysfunctional state of the non-focal parts of the damaged hemisphere and the homologous parts of the right hemisphere. That is confirmed by data from other works, including ours and previously performed research, which revealed symptoms of dysfunctionality of the temporal, parietal and occipital sections of the right hemisphere in patients with vascular aphasia (Malyukova N.G., 2002; Shipkova K.M. et al., 2003). The data also confirm the results of some neurophysiological studies that have revealed that in patients with aphasia, when performing speech tasks, there is an increase in activation of the right hemisphere: in patients with efferent motor aphasia, there is a switching of functional brain load to the parietal, temporal, parietal-temporal-occipital and occipital lobes, in patients with acoustic-mnestic aphasia – parietal and occipital regions of the right hemisphere (Belopasova A.V. et al., 2013).

3. *The brain structures that are part of the rigid links of the new cerebral basis of the reorganized damaged speech function were characterized by the stability of established connections, and neuropsychological oppression symptoms in these brain structures revealed stability or positive correlation with regression of speech disorders, unlike flexible links, which were characterized by instability of correlation dependencies*. The oppression symptoms showed a weak susceptibility to marked regression. No complete regression of these non-aphasic symptoms was noted in any observation. That is consistent with longitudinal studies of patients with aphasia, in which it was found that the profile of sensory asymmetry established in the first months after stroke remains stable after one year or more. Moreover, the right hemisphere mode of solving cognitive tasks (Balashova I.N., Egorov A.Yu., 2007) and the performance of lexical tasks in patients with brain lesions in the left hemisphere demonstrates a stable bilateral pattern of fMRI response upon repeated diagnosis procedure several months later (Buklina S.B., Batalov A.I., 2018).

The study obtained new data that deepened and developed ideas about the intra- and interhemispheric restructuring of speech function in aphasic disorders and allowed us to determine the topography of brain structures involved in speech reorganization processing.

The stealing symptoms, which are characterized by the instability of the correlation with the dynamics of speech recovery, reflected the functional deficiency of brain structures that are flexible links of the rebuilt speech function. The instability of correlations was a manifestation of the incompleteness of integrating these structures into a reorganized speech-brain system. These included the parietal regions of the right hemisphere. Rigid links, on the contrary, showed a positive correlation with the dynamics of speech recovery or stability in the severity of oppression symptoms in the brain regions representing them. These included the occipital lobe of the right hemisphere and the extraversion parietal and occipital cortex of the left hemisphere. The observed symptoms indicate the entry of individual psychological links of the processing of visual and spatial perception into the rigid links of the reorganized speech function.

If the participation of the occipital divisions of the left hemisphere of the brain and the temporal divisions of the right hemisphere in speech processes has been sufficiently studied in neuropsychology (Luria A.R., 1948, 1969; Tsvetkova L.S., 1972, 1973; 2011; Shipkova K.M., Makhankova V.G., 2014; Shipkova K.M., 2015; Akhan'kova T.E., Shipkova K.M., 2019; Shklovsky V.M., Shipkova K.M. et al., 2021; Bulygina V.G., Shipkova K.M. et al.., 2022; Shipkova K.M., Dovzhenko T.V., 2022; Basso A., 2003; Kolb B., Whishaw I.Q., 2003, etc.), and therefore their involvement in the process of speech repair is understandable, then the participation of the occipital regions of the right hemisphere requires special analysis. In several studies of the adult norm, it has been shown that the performance of lexical tasks for verbal fluency (the selection of words with a certain feature) (Scratch DM et al., 2007), sentence construction (Ivanitsky G.A. et al., 2002; Danko S.G. et al., 2005) leads to bilateral activation of the brain. This gives reason to say that the oppression symptoms in the occipital regions of the right hemisphere were a manifestation of the inclusion of individual links in the process of visual perception in the restoration of the psychological structure of speech function. This confirms that speech restoration occurs due to the preserved sections of the neuronal system of speech function in the left hemisphere and the formation of new intralateral connections in it (Kuznetsova S.M., 2010; Martin R.C. et al., 2010; Mahon B., Canton J., 2011; Kiran S. et al., 2019), as well as due to homologous sections of the right hemisphere (Saur D. et al., 2006; Turkeltaub P.E. et al., 2011; Kiran S., Thompson C.K., 2019; Stefaniak J.D. et al., 2020; Pasquini L. et al., 2022) with simultaneous strengthening of the mechanism of hemispheric integration.

The presented results confirm the hypothesis put forward in the study that the reduction of tertiary symptoms is selective and is determined by the neuropsychological parameters of the aphasic syndrome – the type, duration, and severity of the speech defect and neurobiological parameters – the profile of manual asymmetry, volume and topic of brain damage. The data obtained allow us to conclude that speech restoration in patients with aphasia is a laterally distributed process.

Summary

The results presented in this part of the study made it possible to identify patterns of intra- and interhemispheric restructuring of speech function, the role of neurobiological (topic, volume of focal lesion, profile of manual asymmetry) and neuropsychological parameters (type, prescription and severity of aphasic defect) in this process and to develop a structural and dynamic model of aphasic syndrome. Unilateral focal brain damage accompanied by aphasia causes a chain effect of hemispheric reorganisation of damaged speech function. The weakening of the inhibitory effect of the left hemisphere on the right hemisphere; activation of the right hemisphere with a simultaneous increase in its noise immunity concerning auditory perception; strengthening of interhemispheric and intrahemispheric connectivity.

It reveals that the aphasic syndrome consists apart from the primary symptom, which is a consequence of a violation of the neuropsychological factor, and secondary symptoms, which are systemic consequences of the primary defect, include tertiary symptoms. Tertiary symptoms reflect the process of spontaneous compensation of aphasic defect, are formed in the early recovery period and are expressed in oppression symptoms and activation of healthy brain regions. Right-handed aphasia patients are characterized by symptoms of activation of the right temporal lobe and oppression symptoms of the occipital and parietal regions of both hemispheres.

The activation and oppression symptoms are dynamic. The dynamic characteristics of activation symptoms are determined by the time post-onset, volume and topic of local brain damage. The dynamics of the oppression symptoms are

determined by the depth and completeness of the process of integrating the corresponding brain structures into the new architecture of the reorganized speech function.

Brain structures, which are rigid links of the reorganized speech function, reveal the stability of manifestations of stealing symptoms or the conjugation of reduction of oppression symptoms with the restoration of speech.

Flexible links are characterized by the incompleteness of the process of integrating the corresponding brain structures into the cerebral basis of speech, oppression symptoms in these brain departments are characterized by the lack of a stable connection with the reduction of speech disorders.

The presence of right- and left-hemisphere neuropsychological symptoms in the structure of aphasic syndrome gives reason to conclude that the process of speech recovery in aphasia patients is a bilaterally distributed.

CHAPTER 5. AN APPROACH TO SPEECH RESTORATION IN PATIENTS WITH APHASIA IN A MODELLING SENSORY-ENRICHED ENVIRONMENT

This chapter presents the results of solving the following empirical problems: 1) development of methodology, algorithm and principles of modelling sensory-enriched environments for the rehabilitation of patients with aphasic disorders; 2) development and substantiation of methodological complexes for the rehabilitation of patients with aphasia in a modelling music-enriched and polysensory-enriched environment.

5.1. Principles and algorithm for modelling a sensory-enriched environment

Neuroplasticity is the ability of nervous tissue to undergo structural and functional restructuring. This is a characteristic of the brain, characteristic of both normal development, ageing, and pathology. The positive value of the plasticity of the nervous system is to ensure the normal development of function and its reorganization in case of damage (Gusev E.I., Kamchatnov P.R., 2004; Kostandi M., 2007; Kadykov A.S. et al., 2019; Shipkova K.M. et al., 2023).

The reorganization of a damaged functional system is one of the structural and functional mechanisms of neuroplasticity (Damulin I.V., Yekusheva E.V., 2016). Several data indicate a relationship between better recovery and more significant activation of homologous zones of the intact hemisphere, although this depends on the duration of the defect and the type of impaired function (Rijntjes M., 2006). In rehabilitation, it is important to take into account the dynamics of neuroplastic changes. In the acute period of stroke, activation of the right hemisphere may not lead to functional improvement due to the strengthening of the principle of reciprocity in the interaction of the hemispheres (Traugott N.N., 1981). In the future, with the weakening of the pathological mutual inhibition of the hemispheres, this is manifested by a significant restoration of damaged function (Dancause N., 2006).

Sensory integration, created by a sensory-enriched environment, activates neuroplastic processes, forming predetermined patterns of activity in the brain structures responsible for the functioning of the damaged function.

The purpose of sensory stimulation through sensory enrichment of the environment is to create an extensive zone of evoked brain potentials relevant to the lesions and regions functionally related to the damaged zone.

The stimulated sensory environment aims to deepen the process of intersensory and interpsychic interaction by creating a directed activation of target brain structures involved in the cerebral reorganization of the damaged higher mental function. The deepening of intra- and interhemispheric interaction (connectivity) is achieved by using the principles of modelling a sensory-enriched environment.

It was pointed out above that the principles and algorithms for modelling sensory-enriched environments in neuropsychological rehabilitation have not yet been developed, although there is sufficient experience in their application in rehabilitation work with adults with organic pathology and in correctional work with children with organic disorders, delayed mental development, dyslexia, autism (Zhuravkina I.V., Shipkova K.M., 2014; Shipkova K.M., 2014, 2018; Gilmor T., 1999; Rosen H.J. et al., 2000; Thompson B.M., Andrews S.R., 2000; Särkämö T. et al., 2008; Schlaug G. et al., 2008; Vervoort J. et al., 2008; Gerritsen J., 2010; Mishra A. et al., 2021).

Modelling the sensory rehabilitation environment as a tool for the rehabilitation work of a neuropsychologist means the formation of a given sensory space.

Significant characteristics of the modelling sensory therapeutic environment are the *frequency, intensity, duration and direction of stimulation.* They, in turn, are determined by rehabilitation tasks, the initial rudeness of the violation of higher mental function, premorbid, emotional and personal characteristics of the patient and his current somatic status (Shipkova K.M., 2023b, 2024a).

The modelling of the sensory environment is built on many psycho- and neurophysiological, psychological and psychological-pedagogical principles that accept the psychological, psycho- and neurophysiological patterns of restoration of higher mental functions. Many scientifically based principles of reeducation were developed in the 70-80 years at the aphasiologically school of A.R. Luria and L.S. Tsvetkova (Tsvetkova L.S., 1972, 1975, 1985; Akhutina T.V., 1989; Tsvetkova L.S., 2002, 2010).

The principle of relying on non-damaged mental functions interacting with the destroyed one comes from the understanding that speech mediates the processes of perception, thinking, and complex synthetic activities such as reading, writing, and counting. Activation of preserved mental processes creates favourable conditions for indirect effects on impaired speech function.

The principle of relying on the preserved level of the damaged function is aimed at using its preserved level in the process of speech restoration. For example, in case of violation of an arbitrary level, speech is restored through reliance on speech stereotypes, automatism, ordinary speech, and the so-called disinhibition of speech, which helps initiate the recovery process in motor and temporal aphasias.

The principle of using preserved analyzer systems as support in reeducation takes into account that in case of violation of the leading afferentation of the higher mental function, the process of its restoration is built by attracting preserved reserve afferentations included in the afferent field of the damaged function. For example, in primary alexia, which occurs as a result of the disintegration of the visual image of the letter and leads to the inability to read, reading is restored through reliance on a preserved tactile analyzer (Tsvetkova L.S., 1985, 2002).

The principle of relying on preserved forms of verbal and non-verbal activity allows you to use preserved behavioural skills, and strengthened actions in the rehabilitation process and transfer the impaired function to a safe level.

The principle of reliance on objective activity takes into account that verbal communication is one of the forms of objective activity and its restoration should also be organized in the context of objective verbal and non-verbal activities.

The principle of taking into account the volume and degree of diversity of the material is based on several didactic rules that determine that the volume of the material, complexity and novelty should not overload attention and take into account that in aphasia patients the storage capacity in perception narrows (Shipkova K.M., 1993; Tsvetkova L.S., 2002).

The principle of taking into account the complexity of the material determines that the rehabilitation program is built in the direction "from simple to complex" and begins with the use of known, previously accessible (understandable, familiar) tasks about their complexity.

Thus, the principles of rehabilitation training represent a strict methodological organization of neuropsychological rehabilitation work.

When modelling sensory environments, in addition to these principles, it is necessary to use others, which are not noticed in the traditional approach to relearning. The principles of modelling sensory-enriched environments complement the typology of principles of relearning. These principles were developed on our empirical research (Dubinskiy A.A., Shipkova K.M. et al., 2021; Shipkova K.M., Dubinsky A.A., 2023; Shipkova K.M., 2023b, 2024a) and neuroscience data on the effects of sensory environment on hemispheric activity.

Principles of modelling sensory-enriched environments in relearning (reeducation)

Over the past few decades, neuropsychological knowledge has been greatly enriched with new data on brain plasticity, the brain foundations of the recovery of higher mental functions, including speech processes. These data have been received by neuropsychological science, neuroscience, neuropsychiatry, and clinical and translational neurology. Therefore, there is an objective need to update the typology of the principles of restorative reeducation, to develop methodological approaches to the restoration of cognitive functions, which would reflect modern data from neuropsychology and related sciences.

In particular, the traditional principles of reeducation do not consider such aspects of the restoration of higher mental functions as 1) patterns of formation of new sensory skills, instead of impaired ones; 2) the role of a sensory-enriched environment in the cognitive functions recovery; 3) the formation of new intersensory hemispheric connections based on the restoration of function by simultaneously including homologous regions of the non-damaged hemisphere and preserved cortex of the affected hemisphere in the recovery process; 4) the formation of new neuronal connections by deepening interhemispheric interaction.

Therefore, *three new principles* have been formulated that reflect the scientific foundations of modelling sensory-enriched environments and expand the typology of principles of relearning developed at the National School of Neuropsychological Rehabilitation. These principles reflect the goals, objectives and didactics of the use of sensory-enriched media in the restorative retraining of patients not only with aphasia but also with disorders of other higher mental functions (Shipkova K.M., 2023b, 2024a).

The principle of the topical approach to the algorithm of sensory stimulation. The sequence of inclusion of certain sensory stimuli into a sensory-enriched environment is dictated by the topic of brain damage. The phasing in the expansion of the zone and hemispheric vectors of sensory stimulation reflects the patterns of the process of intra- and interhemispheric restructuring of speech function. The initial focus of sensory stimulation activates preserved brain structures near the lesion site or the lesion itself in the case of a small lesion area and/or partial damage to neuronal structures inside it. Further, the zone of sensory stimulation, while maintaining the same vector of hemispheric laterality, expands, and stimuli are included in the sensory environment that activates the preserved structures of the same hemisphere, which are functionally connected to the affected area of the brain. Last of all, sensory stimuli are included, activating homologous regions in the healthy hemisphere, and interhemispheric connections.

The principle of spatial-temporal synchronization of sensory and psychic functions. Activation of inter- and/or interhemispheric connections created by the sensory environment forms the functional readiness of the corresponding brain structures, which are activated by functional tasks corresponding to the impaired neuropsychological factor. For example, in acoustic-mnestic aphasia, sensory stimulation creates a target activation in the temporal and occipital regions in the hemispheres. Then, the created activation centre is supported by solving the tasks of selecting a word with the appropriate visual and auditory sign. That ensures the synchronization of sensory and mental effects.

The principle of dosing sensory stimulation develops and complements the principle of the volume and degree of diversity of the stimulus material. The principle considers the patterns of formation of new neuronal connections. Sensory stimulation should have a sufficient duration to form a trace effect of a functional topical effect (Batuev A.S., 1984, 2001; Hebb D.O., 1950). Compliance with this principle avoids decompensation of the defect, i.e. deterioration of the function due to excessive sensory load.

An algorithm for modelling a sensory-enriched environment

The developed algorithm for modelling a sensory-enriched environment is built according to aspects of aphasia: clinical, neurobiological and neuropsychological.

The algorithm takes into account the topical location of the lesion, its volume, and the prescription of brain damage (Bein E.S., Markova E.D., 1960; Stolyarova L.G., 1963, 1964, 1973; Thin-legged I.M., 1968, 1973, 2007; Shklovsky V.M., Wiesel T.G., 1997; Hillis A., 2007; Hoffmann M., Chen R., 2013). The steps of sensory stimulation reflect the vector of spontaneous brain rearrangements characteristic of the early and late recovery period. It is taken into account that in the early period, speech restoration followed the path of intrahemispheric restructuring with the involvement of the preserved parts of the affected hemisphere. In the delayed period, with the incomplete recovery of higher mental function, recovery occurs mainly due to homologous sections of the intact hemisphere. Thus, the sequential implementation of the steps of sensory stimulation repeats the changes in the pattern of brain restructuring: intrahemispheric reorganization in the early period and interhemispheric reorganization in the late period.

The algorithm for modelling a sensory-enriched environment is built on neuropsychological and neurobiological patterns of spontaneous hemispheric reorganization of impaired speech function (Tsvetkova, 1985; Papanicolaou A.C., 1984, 1987, 1988a; 1988b; Zaidel E., 1985; Barker W.W. et al., 2002; Raboyeau G. et al. 2008; van der Meulen I. et al., 2010; Habibi A. et al., 2018, etc.). Modeling the sensory environment activates the stored reserve afferentations of the damaged function and the mental functions interacting with it. The impaired function is considered not lost but disintegrated. This idea of the picture of a violation of the HHF, adopted at the school of A.R. Luria, means that the HHF damage is always partial, not total. It occurs due to a violation of one of its psychological links as a result the function becomes de-automated, and the degree of its executive control increases.

The design of the sensory environment is based on the principles of modelling sensory-enriched environments that accelerate the formation of new neural systems to replace the disrupted ones: the principle of a topical approach to the algorithm of sensory stimulation, the principle of spatial-temporal synchronization of sensory-mental effects and the principle of dosage of sensory stimulation.

Finally, when creating the algorithm, the experience of some rehabilitation programs was taken into account, which caused a maladaptive effect – deterioration of function due to sensory overload (Moreno-Morales C. et al., 2020).

Thus, the developed four-stage algorithm for modelling a sensory-enriched environment reflected clinical, neurobiological and neuropsychological aspects of aphasia (Fig.6).

In the first stage, sensory stimulation is aimed at activating the areas of the brain directly adjacent to the affected area. For example, if the lesion area is located in the left temporal region, then sensory stimulation of this stage will be represented by visual and tactile stimuli.

At stage II, the task is to strengthen the intersensory connections between the affected area and functionally related structures of the same hemisphere. At this stage, continuing the previous example, the topography of the brain activation zones expands and includes the parietal and posterior frontal regions of the same hemisphere because they, along with the left temporal region, participate in the implementation of several HHF: speech, reading, writing, counting.

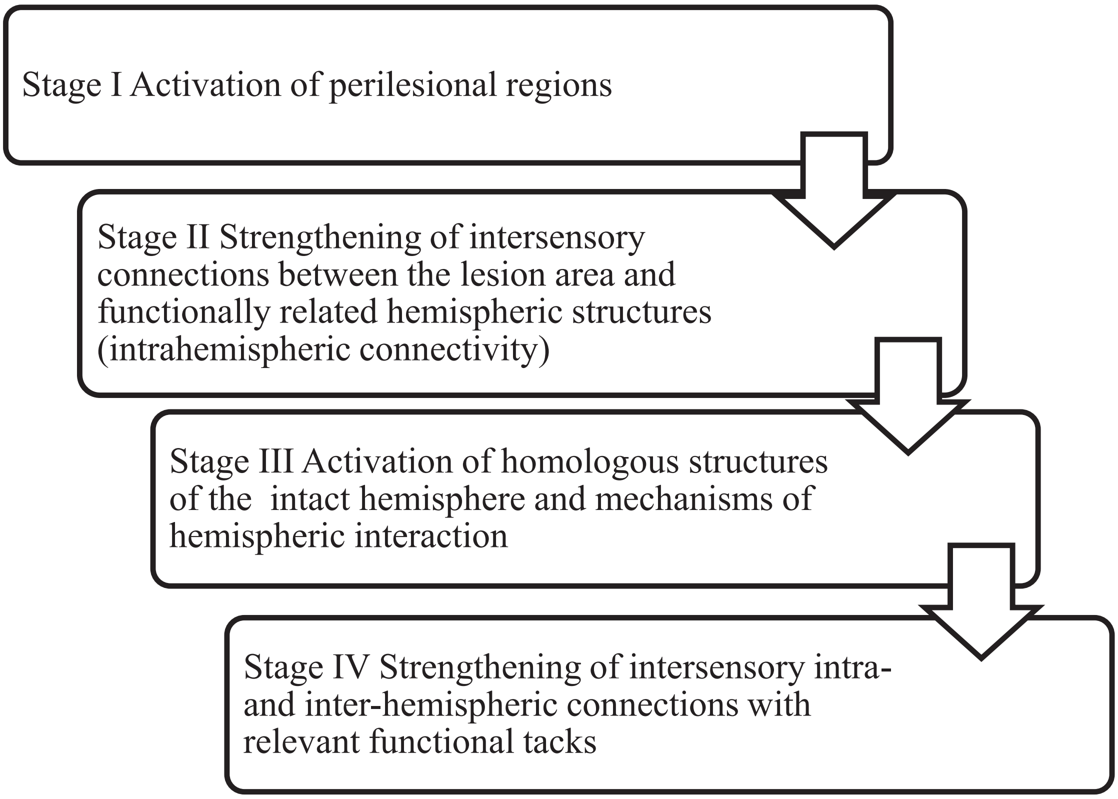

Figure 6. Algorithm for modeling a sensory-enriched environment

At stage III, the sensory stimulation zone continues to expand and involves homologous sections of the right hemisphere. These include not only the mirror regions in the intact hemisphere but also homologous to non-damaged regions of the left hemisphere that are functionally related to the focal lesion. In our example, these were the temporal and the parietal, occipital and posterior frontal regions of the right hemisphere. Sensory stimulation enhances the interaction between the mirror regions of the hemispheres.

At stage IV, the activation zone consists of performing functional language tasks which are relevant to the impaired factor. In the case of acoustic-mnestic aphasia, these will be tasks aimed at overcoming the subject nominative deficit (word selection, word selection and set, classification of words by attribute, etc.) in the case of sensory aphasia, tasks for phonetic differentiation of similar words based on visual and sound context, etc. (Shipkova K.M., 2023b, 2024a).

The steps of the algorithm are the parts of each rehabilitation session. It is repeated from session to session throughout the 5-week rehabilitation program.

The multivector algorithm of hemispheric sensory stimulation differs from the division of methods of restorative training into so-called general and special methods adopted in domestic neuropsychological rehabilitation, in which special attention is not paid to the hemispheric vector of sensory load (Tsvetkova L.S., 1972, 1975, 1985). In this methodological approach, the hemispheric vector of sensory stimulation is the key point in modelling an enriched therapeutic environment.

For patients in the delayed period of the defect, this algorithm contributes to the deepening of the already existing process of brain restructuring of the damaged mental function. For patients in the early stage of recovery, the presented algorithm allows to direct the process of restructuring in a defined hemispheric vector. The direction and deepening of the process of restructuring the impaired function are achieved by the temporary conjugation of the topical focus and the hemispheric vector of sensory stimulation and relevant speech load.

5.2. A methodological complex for speech restoration in patients with aphasia in a modelling music-enriched environment

The music-enriched environment is used in working with patients with aphasia due to the proximity of the psychological structure of musical and verbal perception and a good understanding of the neurophysiological mechanisms of music's effect on human brain activity and cognitive processes (Zhuravkina I.V., Shipkova K.M., 2014; Shipkova K.M., 2018, 2019; 2020; 2021; Peters I., 1999; Hubert S. et al., 2003;

Racette A. et al., 2006; Wilson S.J. et al., 2006; Soria-Urios G. et al., 2011; Zumbansen A. et al., 2014; Merrett D. et al., 2014).

The music-enriched environment includes three interrelated components: sensory, emotional and regulatory. Perception, understanding (i.e. comprehension of a musical idea) and emotional experience of music are accompanied by synchronized activation of the structures of the first, second and third blocks of the brain (Luria A.R., 1973). Thus, music creates a psychological and mental readiness of the patient for a directed functional rehabilitation load.

When developing methodological techniques for speech rehabilitation in a music-enriched environment, the bi-hemispheric nature of the cerebral organization of speech and the role of the subdominant hemisphere in ensuring its intonation and melodic characteristics were taken into account (Luria A.R. 1949; Tsvetkova L.S. 1972, 1975, 1988, 2002; Zangwill O. 1947; Lecour A.R., 1976, Lecour A.R. et al., 1979, 1983, etc.).

The similarity of the brain bases of speech and musical perception was taken into account (Rauscer F.H. et al., 1993; Angel L.A. et al., 2010; Soria-Urios G. et al., 2011). It was taken into account that the perception of music in non-musicians is associated with activation of the temporal, temporoparietal parts of the right hemisphere and several subcortical structures (Pavlov A.E., 2007; Bangert M. et al., 2006; Marques C. et al., 2007; Herholz S.C., Zatorre R.J., 2012).

The choice of musical material for modelling a sensory-enriched environment was based on neurophysiological data on the topical effects of music of different genres and modes (Pavlygina R.A. et al., 2004; Pavlov A.E., 2007; Vartanov A.V., 2011; Bangert M. et al., 2006; Marques C. et al., 2007; Herholz S.C., Zatorre R.J., 2012; Altenmüller E., Schlaug G., 2013; Jomori I. et al., 2013; Carvalho D. et al., 2013). Attention was paid to that the brain response during listening to music is defined by the person's cognitive experience, the rhythmic warehouse of music and the conditions of listening to it: major music generates the focus of the response in the temporal parts of the right hemisphere (Shahin A. et al., 2003), contiguous (neutral in sign) - in the insula, minor – subcortical nuclei (Altenmüller E., Schlaug G., 2013), and listening to music while watching a musician play (imitation of the game) – in the frontal lobes of the brain.

Development of methodical complex was carried out based on the data from neuropsychological studies on the effect of duration of tempo-rhythmic and melodic influence of music on the processes neuro reparation (Gaser C, Schlaug G., 2003; Särkämö, T. et al., 2008; Hyde, K. L. et al., 2009; Soria-Urios G. et al., 2011; McDermott O. et al., 2013; Habibi A. et al., 2018) and the dynamics of recovery of speech in aphasic patients (Thompson W. F. et al., 2004; M. H Thaut, 2005; Särkämö, T. et al., 2008; Moreno S., 2009; Breier, J. I. et al., 2011; van der Meulen, I. et al., 2014; Zumbansen A., Tremblay P., 2019; Moreno-Morales C. et al., 2020). To enhance the emotional response to music, which is expressed in the activation of frontal and subcortical structures (Mitterschiffthaler M.T. et al., 2007; Altenmüller E., Schlaug G., 2013; Jomori I. et al., 2013), information was collected on the patient's musical preferences.

The methodological complex consisted of 3 blocks. The techniques included in the blocks reflected the algorithm for modelling a sensory-enriched environment. Tasks 1 and 2 of the blocks consisted of pre-preparation for speech functional load by non-speech auditory stimulation. The 1st block consisted mainly of receptive techniques, and the 2nd block consisted of active ones. The third block was the final one and its focus was to synchronize the musical effect with the performance of speech tasks relevant to the type of aphasia (Shipkova K.M., 2023b, 2024a).

Within the framework of one rehabilitation session, no more than three receptive and the same number of active musical methods were used. That made it possible to observe the principle of dosage of sensory stimulation and to observe the uniformity of functional activation of both hemispheres.

The musical material for receptive and active techniques was short musical fragments (1-3 min), which did not overload the patient's attention, but were sufficient to understand his emotional content, musical structure and mood. The selection of musical works for methods 1 and 2 of the block is carried out by their popularity (familiarity, recognition) and low complexity (understanding accessibility). The selection criteria are directed by the fact that the familiarity of music anticipates the further development of a musical theme, and musical apperception activates auditory attention, long-term memory, regulatory functions, and thinking. The works of classical pop music fully met these requirements.

Block 1. Receptive methods represented the input group of techniques. The receptive form of music perception involves an active, directed analysis of music without singing and active music-making.

Receptive musical techniques:

– *semantic analysis of music* – determination of the number of semantic parts in a musical fragment (highlighting the plot, plot development, finale);

– *musical differential analysis* – determination of the types of musical instruments that sound in an orchestral performance (e.g. brass, bowed, percussion);

– *musical quantitative analysis* – estimation of the number of repetitions of a musical theme (for example, the chorus of a song);

– *emotional analysis of music* – determination of the emotional power and sign of music;

– *correlation of the sound and perceptual image of music* (selection of a plot picture corresponding to the emotional sign of music);

– *musical sensitization* – identification of the identity of two musical works performed in different musical styles (for example, pop music and academic music), on different instruments, etc.;

– *imitation of the musical instrument play* – listening to a piece of music while watching the movements of the musician.

Block 2. Active musical methods. The active form of music perception involves directed auditory-motor reactions and singing.

Active musical techniques:

– *reflected music playback* – singing from memory (a cappella) of the listened melody;

– *conjugate/reflected reproduction of a musical rhythm* – synchronous/delayed repetition of the heard rhythm from memory;

– *conjugate differentiated repetition of the rhythm* – synchronous tapping of the rhythm of the musical part of a separate musical instrument that sounds in an orchestral (ensemble) performance (for example, a percussion instrument);

– *musical identification* – recognition and singing of a song fragment (for example, the chorus of a familiar cappella song).

To comply with the principle of a topical approach to the algorithm of sensory stimulation, techniques relevant to the lesion topic and the type of aphasia were selected from blocks 1 and 2. For example, in efferent motor aphasia, a game simulation technique was used, which was not used in acoustic-mnestic aphasia. On the contrary, the method of musical differential and quantitative analysis was used in acoustic-mnestic aphasia. Techniques for correlating the sound and perceptual image of music, musical sensitization, and semantic analysis of music were used for all types of aphasia.

Block 3. In this block, a technique was developed, designated *as "musical speech expression",* which was implemented in full at each session throughout the rehabilitation course. The patient was tasked with compiling a story based on plot pictures (works of classical painting) accompanied by a consonantal musical accompaniment. The paintings were not repeated from session to session, and their set was the same for all patients. The technique included the sequential execution of three tasks, which differed from each other by an emotional sign in the following order – positive, negative, and neutral. The abrupt change of the plot and music from a positive to a negative sign created the effect of distracting the patient's attention from his speech defect and directed it to the content of the plot, which was supposed to increase the volume of speech production.

The stimulus material of the musical speech expression technique. The musical and visual material used in the methodological complex was evaluated by the method experts. The experts were 20 healthy people aged 51.3±15.6 years of higher and secondary special education who did not have special musical and artistic training. Experts evaluated each painting and musical fragment for compliance with positive, negative and neutral emotional signs. Of the 59 subject paintings by famous Russian artists of the XVIII-XX centuries. and 37 classical instrumental musical works in orchestral and ensemble performance, 45 subject paintings and 21 musical works were selected. Paintings with a pronounced tragic plot, and scenes of violence (death, execution scenes, cruelty, etc.) were excluded from the selection in advance. The criterion for choosing the stimulus material was the coincidence of answers from at least 15 experts.

Table 23. Stimulus material of the musical speech expression technique

Emotional sign of music	Painting. Artist	Composer. A piece of music.
Positive	"Moscow courtyard". Polenov V.D.	Glazunov A.K. Symphony No. 7 in Fa major. Essay 77.
	"Maslenitsa". Kustodiev B.M.	Alyabyev A.A. Quintet in Si major for flute, oboe, clarinet, bassoon and piano. Adagio Allegro
	"March." The artist Levitan I.I.	Glazunov A.K. Seasons. Essay 67.3. Variation No. 2. Ice.
	"Over the city." The artist Chagall M.Z.	Prokofiev S.S. Ballet "Cinderella". The magic of spring.
	"Spring". Plastov	A.A. Shostakovich D.D. Symphony No. 5. II. Allegretto.
Negative	"An unequal marriage. Pukirev V.V.	Tchaikovsky P.I. Suite No. 3 in Sol major.Op.55. Theme with variations of I. Elegie. Andantino molto cantabile
	"Above eternal rest." Levitan I.I.	Glazunov A.K. Symphony No. 1 in Mi major. Essay 5. III. Adagio.
	"The Black Sea". Aivazovsky I.K.	Tchaikovsky P.I. "Francesca da Rimini". Essay 32.
	" A wet meadow". Vasiliev F.A.	Tchaikovsky P.I. Symphonic fantasy "Fate". Essay 77.
	"The last pub at the outpost." Perov V.G.	Bortnyansky D.S. Concert symphony in Si bemolle major. I. Allegro maestoso.
Neutral	"A veranda wrapped in grapes." Shchedrin S.F.	Glinka M.I. Pathetic trio in D minor for clarinet, oboe and piano. II. Scherzo. Vivacissimo
	"View of Birju and Admiralty from the Peter and Paul fortresses." Alexeyev F.Ja.	Balakirev M.A. Symphony Apostille .1. Largo Allegro vivo.
	"By the sea. Family." Zhilinsky D.D.	Sviridov G.V. Suite "Time ahead". IV. Little foxtrot.
	"The rooks have arrived." Artist Savrasov A.K.	Tchaikovsky P.I. Suite No. 3 in Sol major. Essay 55. Theme with variations. IV. Andante con moto.
	"Night on the Dnieper". Kuindzhi A.I.	Balakirev M.A. Symphonic poem "Rus".

The musical material could be repeated from session to session if the patient liked the piece of music, and could be replaced with an emotionally identical one if the music or the sound of some musical instrument was unpleasant (bowed, wind, percussion instruments).

The procedure of the technique of musical speech expression. At first, the patients carefully examined the painting with musical accompaniment (3-4 minutes). The volume of the music did not exceed 20-25 dB and was sufficient to be audible, but not to feel discomfort from its loud sound and allow you to speak against the background of the music. After viewing the painting, it was necessary to compose a short story based on it. The musical accompaniment was not interrupted. After the first task, the second was given, and then the third. The total duration of the functional load was 30-35 minutes. Examples of stimulative visual and musical material are presented in Table 23.

Thus, the methodological complexes of the modelling music of the enriched environment represented a programmed sensory-mental stimulation aimed at restoring speech in patients with acoustic-mnestic and efferent motor aphasia.

5.3. A methodological complex for speech restoration in patients with aphasia in a modelling polysensory-enriched environment

Unlike a monosensory environment, an example of which is a music-enriched environment, in a polysensory-enriched environment, different types of sensory stimuli are used simultaneously: visual, auditory, tactile, auditory-motor and others. The saturation of the therapeutic space with multimodal stimuli creates the effect of cumulative sensory impact. The patient's fulfilment of sensory tasks set by the neuropsychologist is aimed at activating intersensory and interhemispheric integration.

The presented complexes of methods of a polysensory-enriched therapeutic environment for patients with efferent motor and acoustic-mnestic aphasia made it possible to create a bi-hemispheric sensory and cognitive readiness for directed action on an aphasic defect. Methods of rehabilitation complexes were based on the principles of functioning of the dominant and subdominant hemispheres. When selecting techniques, the principle of reliance on preserved analyzer systems and mental functions interacting with the damaged one was considered (Tsvetkova L.S., 1985, 2002, 2010). The complexes were created taking on the formulated principles and a four-step algorithm for modelling a sensory-enriched environment (Shipkova K.M., 2023b, 2024a).

A methodological complex for speech restoration in patients with efferent motor aphasia in a modelling polysensory-enriched environment

The complex consisted of three blocks of techniques.

1 Block. The focus of the topical sensory load of this methodological block was the lower frontal regions of the left hemisphere of the brain. Their activation was carried out using techniques based on performing movements of the contralateral and ipsilateral arm lesion (lateral methods of motor stimulation).

Lateral motor stimulation methods (performed with the right hand):

– *playback of a preset rhythm pattern* (simple/accented);

– *repetition of the rhythm* in compliance with its rhythm and volume;

– *reproduction of the rhythmic pattern of a word /phrase* (with the emphasis on a stressed syllable/word) – tapping the rhythm of a phrase without pronouncing it (silently);

– *repetition of a serial series of 3-4 movements*, followed by switching to the reverse sequence.

Block 2. The methods of this block were aimed at implementing the II and III stages of the algorithm for modelling the sensory environment. The focal topical sensory load was supplemented by methods of stimulation of other topical areas: temporal, parietal and occipital regions of the left hemisphere and homologous to them of the right hemisphere. They were represented by techniques of bipolar motor, auditory-motor, tactile and visual stimulation.

The methods of bi-hemispheric motor stimulation are based on performing a motor task with both hands with gradual complication with visual and auditory control of movements:

– *synchronous graphical hand movements* – simultaneous drawing of identical geometric shapes with both hands in the same direction (from left to right) and in different directions (one hand performs movement in the same vector, the second in the opposite direction);

– *synchronous reciprocal movements* – one hand rotates clockwise, the other counterclockwise;

– *synchronous reciprocal rhythmic movements with switching to the reverse order of movements* – one hand is 1 stroke, the other is 2 strokes with a program change to the reverse order with gradual complication (the number of strokes increases and the rhythm of movements accelerates);

– *synchronous reciprocal graphic movements* – simultaneous drawing of different geometric shapes with your hands.

The methods of bi-hemispheric auditory-motor stimulation are aimed at activating the interaction of motor and auditory analyzers. This is achieved by performing synthetic activities, an example of which is singing:

– *singing* – singing to the music / a cappella of popular songs, taking into account individual preferences (performed together with a specialist).

Tactile stimulation techniques include one-handed and two-handed techniques. They were aimed at strengthening the process of interhemispheric interaction of the parietal and parietal-temporal hemispheres.

One-handed methods:

– verbal stereognosis is the naming of the tactile quality of an object felt with the left hand.

Methods of bipolar tactile stimulation:

– *two-handed (distributed) tactile gnosis* - one hand determines the shape of the figure, and the other finds its appropriate place on the Seguin board;

– *bimanual stereognosis* – identification and naming of three-dimensional objects, numbers and letters when feeling with both hands.

Methods of bi-hemispheric visual stimulation. The techniques were aimed at enhancing the connectivity of the occipital hemispheres and the auditory speech cortex:

– *searching for hidden images/circulating images in the right and left visual fields;*

– *finding differences in a pair of subject-based multicomponent plot paintings.*

The duration of block 1 and 2 was 25-35 minutes. The number of techniques of bi-hemispheric auditory, auditory-motor, tactile and visual stimulation was equalized within the framework of one rehabilitation session to create uniformity of activation of brain structures included in the neuroarchitectonics of speech function.

Block 3. In this block, the task was to strengthen activated intra- and interhemispheric connections during the performance of functional speech tasks relevant to the mechanism of aphasia.

Speech methods of functional stimulation:

– *insert a missing verb into a sentence;*

– *verbal associations – to match a verb to a noun;*

– *add a missed ending;*

– *compose a story based on a series of plot paintings.*

These speech techniques have long been used in aphasiology practice and have proven to be effective methods of speech restoration in this type of aphasia (Tsvetkova L.S., 1972, 1985, 2002; 2010; Shklovsky V.M., Wiesel T.G., 1997). The duration of the speech load was 30-35 minutes. Thus, the total duration of the rehabilitation session was 55-70 minutes. The rehabilitation course consisted of 15 individual sessions conducted three times a week for five weeks.

A methodological complex for speech restoration in patients with acoustic-mnestic aphasia in a modelling polysensory-enriched environment

The complex consisted of two methodological blocks. The logic of their construction reflected the algorithm and principles of modelling a sensory-enriched environment.

Block 1. The task of this block of techniques was to implement the I, II and III stages of the sensory stimulation algorithm. The choice of methods in this block took into account that in patients with acoustic-mnestic aphasia, during the delayed period of aphasia, there is a persistent change in the profile of auditory-speech asymmetry and the advantage of the left ear in speech perception is established (Shipkova K.M., 2022a, 2022b, 2022c). To enhance the activation of the temporal structures of the right hemisphere of the brain, techniques aimed at performing non-verbal auditory tasks were used, which reflected the functional specialization of the temporal divisions of the right hemisphere of the brain. The methodological block includes techniques of right-hemisphere auditory and bi-hemispheric auditory, auditory-motor, tactile and visual stimulation.

Methods of right-hemisphere auditory stimulation:

– *identification of the emotional sign of speech/musical intonation* - determination of the emotional sign of a musical fragment/phrase;

– *identification of subject sounds of living/inanimate objects* (sounds of objects, nature, animals, transport, household noises, etc.);

– *auditory discrimination – differentiation of sounds of one subject field* (for example, a mechanical/electric saw; stadium/ auditorium noise; rain/downpour noise, etc.);

– *imitation sound pattern of speech intonation* – copying the intonation of the heard phrase.

Techniques of bi-hemispheric auditory and auditory-motor stimulation. Auditory techniques of this group represent receptive musical techniques, auditory-motor techniques – active musical techniques.

Receptive musical methods. The receptive form of music perception involves an active, directed analysis of music without singing and actively playing music. In the methodological complex, they represent the input group of techniques.

Receptive musical techniques:

– *semantic analysis of music* – determining the number of semantic parts in a musical fragment (highlighting the semantic parts of a musical fragment: the beginning, the development of the plot, the finale);

– *musical differential analysis* – determination of the types of musical instruments that sound in an orchestral performance (for example, brass, bowed, percussion);

– *musical quantitative analysis* – estimation of the number of repetitions of a musical theme (for example, the melody of the chorus of a song);

– *emotional analysis of music* – determination of the power and emotional sign of music;

– *correlation of the sound and perceptual image of music* (selection of a plot picture corresponding to the emotional sign of music);

– *musical sensitization* – identification of the identity of two musical works performed in different musical styles (for example, pop music and academic music), on different instruments, etc.

Active musical techniques. The active form of music perception presupposed directed auditory-motor reactions and singing.

Active musical techniques:

– *reflected music playback* – singing from memory (a cappella) of the listened melody;

– *conjugate/reflected reproduction of a musical rhythm* – synchronous/delayed repetition of the heard rhythm from memory;

– *conjugate differentiated repetition of rhythm* – synchronous tapping of the melodic rhythm of a musical part of a musical instrument that sounds in an orchestral (ensemble) performance (for example, percussion instruments);

– *musical identification* – recognition and singing of a song fragment (for example, the chorus of a familiar cappella song).

The techniques of bipolar tactile and visual stimulation were identical to those used when working with patients with efferent motor aphasia.

Within the framework of one rehabilitation session, the number of techniques of bi-hemispheric auditory, auditory-motor, tactile and visual stimulation was equalized, and the choice of certain active and receptive methods was determined by the subjective preferences and cognitive abilities of the patient. The duration of the polysensory stimulation was 25-35 minutes.

Block 2. In this block, the task is the same as in the one described above (in strengthening activated intra- and interhemispheric connections during the performance of functional speech tasks relevant to the mechanism of aphasia). That is, the methods of the 2nd block were aimed at implementing the IV stage of the sensory stimulation algorithm.

Speech methods of 2nd block:

– *insert a missing noun into a sentence;*

– *to match a noun to a verb;*

– *select subject nouns with a given taste attribute*: sour, sweet, salty, etc.;

– *pick up nouns with a given visual feature* – yellow fruits, blue/black berries, transparent materials, tall animals, rounded objects, etc.;

– *pick up nouns with a given tactile feature* – soft, hard, fluffy, rough, etc.

The methods based on working with visual, tactile, and gustatory signs occupied most of the functional speech load, which was a significant difference between the presented methodological organization of rehabilitation work with acoustic-mnestic aphasia from the traditional approach to speech rehabilitation. In the traditional approach, the main tools for overcoming verbal lexical deficit are the methods of semantic grid and contextual prompting (introducing a word into a semantic context) (Tsvetkova L.S., 1985, 2002; 2010).

The duration of all blocks' methods was 30-35 minutes. The total duration of one rehabilitation session was 55-70 minutes. The rehabilitation course consisted of 15 sessions held three times a week for five weeks.

Thus, the modelling polysensory-enriched environment represented directed sensory-mental stimulation, built into account neuropsychological and neurobiological patterns of speech recovery in aphasics.

Summary

The new methodological approach develops the theoretical and methodological foundations of Russian neuropsychological rehabilitation taking into account the data of neuroscience accumulated over the last quarter of a century in the field of studying the patterns of poststroke speech recovery.

The developed methodological approach to the rehabilitation of patients with aphasia is based on the modelling of a sensory-enriched therapeutic environment, which aims to deepen sensory and interpsychic integration, which makes it possible to strengthen the mechanisms of intra- and interhemispheric interaction during speech recovery.

The principles and algorithm of modelling a sensory-enriched environment reflect the neuropsychological and neurobiological patterns of violation and restoration of higher mental functions.

The developed methodological complexes for modelling a music-enriched and polysensory therapeutic environment for patients with efferent motor and acoustic-mnestic aphasia take into account the mechanisms of speech impairment and the effect on the process of cerebral rearrangement of speech of different time post-onset and topics of brain damage in aphasias.

Speech recovery in patients with aphasia in a modelling sensory-enriched environment was aimed at increasing the depth of speech restoration, improving the communicative capabilities of patients and the quality of their lives.

CHAPTER 6. APPROBATION OF AN APPROACH TO REHABILITATION OF APHASIC DISORDERS IN A MODELLING MUSIC-ENRICHED ENVIRONMENT

This chapter describes the results of a study aimed at solving the following tasks: 1) evaluation of the comparative therapeutic effectiveness of the tested approach based on a comparative analysis of the regression dynamics of aphasic disorders in the conditions of speech restoration in a modelling sensory-enriched environment and the traditional neuropsychological and pedagogical approach to speech rehabilitation; 2) evaluation of the effectiveness of speech restoration in a monosensory (music-enriched) environment in patients with efferent motor and acoustic-mnestic aphasia with different initial severity of expressive speech disorders.

6.1. Research procedure and data analysis

In the main group, the rehabilitation course included 15 individual rehabilitation sessions lasting 1-1.5 hours each. Sessions were held in the morning or afternoon. No therapeutic or other measures were carried out with the patient one hour before their start to reduce the risk of overwork by the beginning of the lesson. The course was conducted three times a week for five weeks. Before the start of the rehabilitation course, a selection of musical fragments of different emotional signs was listened to by the patient. The patient selected the fragments he liked, which used as a stimulus during sessions. That strategy reduced the risk of side effects of music on speech production and undesirable effects of exposure to a music-enriched environment. The sessions were held in a separate room individually in a quiet environment. A total of 405 rehabilitation sessions were conducted.

The course of speech therapy in a modelling music-enriched environment complemented the course of traditional speech therapy. Traditional speech therapy was performed for all the patients of the main and control groups.

The rehabilitation course was conducted on 27 patients of the main group: 13 patients with efferent motor aphasia and 14 patients with acoustic-mnestic aphasia.

The control group included 46 patients: 20 patients with efferent motor aphasia and 26 patients with acoustic-mnestic aphasia.

Neuropsychological assessment of speech and auditory perception was performed twice: before and after the rehabilitation course. The total number of observations (main and control group) according to all methods of the diagnostic complex amounted to 730 assessments.

In the comparative analysis of the rehabilitation shift, for parameters whose empirical distributions did not differ from the normal distribution the parametric Student's t-test was used. For data that does not correspond to a normal distribution– the nonparametric U-test is the Mann-Whitney criteria.

6.2. Dynamics of speech recovery in patients with aphasia in a music enriched environment and during traditional approach to speech therapy

Characteristics of the main and control groups

The absolute majority of patients in the main and control groups were men (20 and 32 people, respectively) with higher education (22 and 35 people, respectively) (Table 24). Among patients with acoustic-mnestic aphasia in the main group, men accounted for 71.43%, among patients with efferent motor aphasia – 76.92%, and in the control group – 76.92% and 60.00%, respectively. In the main group, among patients with acoustic-mnestic aphasia, 64.28% were represented by persons with higher education, among patients with efferent motor aphasia – 100%, in the main group – 80.77% and 70.00%, respectively.

Table 24. Distribution of patients with aphasia of the main and control groups with different types of aphasia by gender and level of education

Group	Number (person)	Gender		Education	
		men (%)	women (%)	higher (%)	secondary special (%)
Main group					
Acoustic-mnestic aphasia	14	10(71,43)	4 (28,57)	9 (64,28)	5 (35,71)
Efferent motor aphasia	13	10 (76,92	3 (23,08)	13(100,00)	0 (0,00)
Total (person)	27	20	7	22	5
Control group					
Acoustic-mnestic aphasia	26	20 (76,92)	6 (23,08)	21 (80,77)	5 (19,23)
Efferent motor aphasia	20	12 (60,00)	8 (40,00)	14 (70,00)	6 (30,00)
Total (person)	46	32	14	35	11

Table 25. Distribution of the main and control groups by age and time post-onset

Parameter	Group	M (SD)	t-criteria	p level
Acoustic-mnestic aphasia				
Age (years)	main	54,71 (6,88)	0,18	0,859
	control	55,12 (6,74)		
Time post-onset of aphasia (months)	main	14,00 (6,46)	0,23	0,822
	control	14,54 (7,54)		
Efferent motor aphasia				
Age (years)	main	53,23 (12,23)	0,62	0,542
	control	50,85 (9,86)		
Time post-onset of aphasia (months)	main	14,31 (7,12)	0,27	0,790
	control	14,90 (5,53)		

There were no significant differences in age and time post-onset between patients with the same aphasia type in the main and control groups, which made it possible to eliminate the possibility of the influence of these variables on the results of the study (Table 25).

6.2.1. Dynamics of speech recovery in patients with efferent motor aphasia in a music-enriched environment and during traditional speech therapy

Quantitative parameters of speech and auditory perception of the main and control groups.1st assessment

Table 26. Parameters of speech and auditory-speech perception in patients with efferent motor aphasia of the main and control groups before the speech rehabilitation course (in points). 1st assessment

Parameter	Group	M (SD)	t-criteria	p level
MOR_1 (score)	main	227,65 (33,62)	0,38	0,703
	control	231,77 (27,54)		
Impressive speech (five subscales total score)	main	129,15 (14,40)	0,46	0,645
	control	131,30 (11,97)		
Expressive speech (five subscales total score)	main	95,91 (23,39)	0,45	0,655
	control	99,19 (18,28)		
“Phrasing" subscale	main	15,88 (6,55)	0,68	0,502
	control	17,50 (6,76)		
“Making up a story”subscale	main	5,68 (4,79)	0,27	0,787
	control	6,18 (5,34)		
“Naming objects” subscale	main	25,96 (5,52)	–0,82	0,417
	control	27,23 (3,33)		
“Naming verbs”subscale	main	23,92 (6,07)	0,15	0,883
	control	23,63 (5,32)		
Free oral verbal associations (productivity)	main	14,46 (4,67)	0,79	0,435
	control	16,05 (6,17)		
Controlled oral verbal associations (productivity)	main	8,38 (2,63)	0,24	0,814
	control	8,15 (2,87)		
Speed of spontaneous speech	main	29,46 (11,59)	0,42	0,675
	control	31,10 (10,41)		
Index of laterality (Kpu)	main	0,07 (0,67)	0,79	0,437
	control	–0,13 (0,72)		
Efficiency index (Ief)	main	33,75% (26,10)	0,16	0,870
	control	35,35% (26,66)		
Coefficient of productivity (Kpr)	main	20,73% (10,81)	0,13	0,895
	control	21,21% (8,74)		

The empirical distributions of the values of the studied parameters were previously checked for the normality of the distribution, which made it possible to evaluate the data using the Student's parametric t-criteria.

Before the start of the rehabilitation course, the initial parameters of patients with efferent motor aphasia of both groups did not have significant differences in any of the studied parameters of speech and auditory perception (Table 26).

A retest assessment was conducted five weeks later just after completing the speech rehabilitation course.

Comparative analysis of quantitative and qualitative parameters of speech and auditory-speech perception in patients with efferent motor aphasia after undergoing a course of speech rehabilitation in a modelling music-enriched environment and traditional speech therapy

The course of speech rehabilitation in a modelling music-enriched environment, as well as traditional speech therapy, had a significant impact on the regression of speech disorders. Patients with aphasia revealed several shared and specific features between traditional speech therapy and the modelling music-enriched environment on the quality of speech and auditory perception (Application 3, 4).

Shared features of the dynamics of speech recovery in patients with efferent motor aphasia of *the main and control groups* were revealed in speech perception and regress of speech troubles.

The methodical approach to speech rehabilitation did not affect the parameters of auditory-speech perception in patients with efferent motor aphasia. The profile of auditory-speech asymmetry (laterality index) ($t=0.28$, $p>0.05$), the coefficient of productivity ($t=0.86$, $p>0.05$) and efficiency index ($t=0.45$, $p>0.05$) of auditory-speech perception did not change during speech therapy in a music-enriched environment. The same pattern was observed in patients of the control group concerning the same parameters ($t=–0.21$, $t=1.29$, $t=0.25$, $p>0.05$, respectively). There were no intergroup differences in these parameters ($p>0.05$) (Table 27).

Table 27. Parameters of auditory and speech perception in patients with efferent motor aphasia of the main and control groups after the speech rehabilitation course

Parameter	Group	M (SD)	Comparison between 1st and 2nd assessment		t-criteria	p level
			t-criteria	p level		
Index of laterality (Kpu)	main	0,10 (0,74)	0,28	0,784	1,14	0,266
	control	–0,21 (0,72)	1,41	0,177		
Efficiency index (Ief)	main	37,03 (24,22)	0,45	0,661	0,03	0,977
	control	36,25 (21,29)	0,25	0,804		
Coefficient of productivity (Kpr)	main	22,32 (7,34)	0,86	0,408	0,07	0,944
	control	22,52 (8,39)	1,29	0,215		

Both approaches made it possible to achieve a significant rehabilitation shift in the dynamics of speech. The severity of the positive dynamics within the groups was of the same order (t=0.001, p>0.05) (Table 28). The MOR score in the main (t=8.51, p<0.001) and control groups (t=5.13, p<0.001) statistically significantly differed from the MOR score in the 1st assessment. In both groups, positive dynamics were observed in all parameters of expressive speech: subject and verbal nomination, phrasal and monologue speech. In the main group, the increase (1st vs 2nd assessment) in the subscales of expressive speech, he scored 1.6 points in the subscale "naming objects" (25.96 vs 27.56), 1.89 points in the subscale "naming verbs" (23.9 vs 25.81), 1.07 points in the subscale "phrasing" (18.88 vs 17.81), 4.13 points in the subscale "making up a story" (5.68 vs 9.81).

In the control group, in the same subscales of expressive speech, the increase in parameters was 1.02 points (27.23 vs 28.25), 1.08 points (23.63 vs 25.43), 2.85 points (17.50 vs 20.35), 1.28 points (6.18 vs 7.46), respectively.

After completing the rehabilitation course, the productivity of free verbal associations increased in both groups. The increase in the parameter in the main group (1 assessment vs 2 assessments) was 5.69 words (14.46 vs 20.15), and in the control group – 1.40 words (16.05 vs 17.45). Although in the main group, the increase in the productivity of free associations was more than four times higher than the dynamics of the control group, the intergroup values in the 2nd assessment did not reach the level of significance (t=1.25, p >0.05).

Table 28. Speech parameters in patients with efferent motor aphasia of the main and control groups after underdoing the course of speech rehabilitation

Parameter	Group	M (SD)	Comparison between 1st and 2nd assessment		t-criteria	p level
			t-criteria	p level		
MOR_2 (score)	main	243,16 (34,86)	**8,51*******	<0,001	0,001	0,997
	control	243,13 (25,14)	**5,13*******	<0,001		
Impressive speech (five subscales total score)	main	134,50 (17,53)	1,70	0,114	0,22	0,828
	control	135,60 (11,40)	**4,79*******	<0,001		
Expressive speech (five subscales total score)	main	106,35 (24,35)	**7,69*******	<0,001	0,17	0,869
	control	107,51 (15,98)	**4,59*******	<0,001		
"Naming objects" subscale	main	27,56 (4,64)	**3,90****	0,002	–0,58	0,568
	control	28,25 (2,16)	**2,45****	0,024		
"Naming verbs" subscale	main	25,21 (5,00)	**3,23****	0,007	0,23	0,821
	control	25,43 (3,91)	**3,12****	0,006		
"Phrasing" subscale	main	17,81 (7,20)	**3,62****	0,003	1,15	0,260
	control	20,35 (5,50)	**3,08****	0,006		
"Making up a story" subscale	main	9,31 (6,26)	**3,52****	0,004	0,92	0,364
	control	7,46 (5,20)	**3,54****	0,002		
Free oral verbal associations (productivity)	main	20,15 (6,27)	**5,79*******	< 0,001	1,25	0,219
	control	17,45 (6,07)	**3,50****	0,002		
Controlled oral verbal associations (productivity)	main	10,92 (2,53)	**6,88*******	< 0,001	**2,41****	0,022
	control	8,89 (2,25)	1,96	0,065		
Speed of spontaneous speech	main	40,08 (14,45)	**3,62****	0,004	1,48	0,149
	control	33,50 (11,02)	1,57	0,133		

Note: ** – p<0,01, ** – p<0,001.

Along with the general features of regression of aphasic disorders, specific features of speech dynamics were noted in the main group.

The music-enriched environment did not affect impressive speech: the effectiveness of performing tasks for understanding oral speech did not change ($t=1.70$, $p>0.05$). That distinguished the main group from the control group, in which there were significant positive dynamics in impressive speech ($t=4.79$, $p<0.001$), but the intergroup differences were unreliable ($t=0.22$, $p>0.05$).

The main group had increased productivity of directed associations ($t=6.88$, $p<0.001$), while the control group did not ($t=1.96$, $p>0.05$). The intergroup differences were significant ($t=2.41$, $p>0.05$). Earlier in the study, evidence was obtained that an increase in the productivity of directional associations is associated with the establishment of right-hemisphere dominance in auditory and speech perception. Therefore, an increase in the productivity of directed associations in patients with efferent motor aphasia of the main group can be regarded as a deepening of the process of interhemispheric reorganization of speech function during speech therapy in a music-enriched environment.

In patients with efferent motor aphasia undergoing speech rehabilitation in a music-enriched environment, the rate of coherent spontaneous speech significantly increased ($t=3.62$, $p=0.004$). In comparison with the initial values, the increase in the parameter was 10.62 words (29.46 vs 40.08). There were no positive dynamics in the control group ($t=1.57$, $p>0.05$). The intergroup differences were significant ($t=2.41$, $p=0.022$).

Thus, in patients of the main group with efferent motor aphasia, the dynamics of speech recovery had both general and specific features in comparison with patients undergoing traditional speech therapy. The music-enriched environment, as well as traditional speech therapy, made it possible to achieve a significant rehabilitation shift in expressive speech at the level of words, phrases and text.

In contrast to the traditional approach, the music-enriched environment contributed to an increase in the productivity of directed associations and the speed of coherent spontaneous speech in patients with efferent motor aphasia. The speed of speech is a characteristic of both the speed of finding the right word and its pronunciation. It is known that in efferent motor aphasia, perseverations in speech are the central symptom of these speech disorders. An increase in the speed of oral speech means that speech therapy in a music-enriched environment reduces the frequency of speech perseverations. Examples of changes in the oral speech of patients are given in Application 4.

Summing up the presentation of the data, it needs to be mentioned that during therapy in a music-enriched environment, patients with efferent motor aphasia had a wide range of speech parameters that revealed more pronounced positive dynamics than with the traditional approach to speech therapy.

6.2.2. Dynamics of speech recovery in patients with acoustic-mnestic aphasia in a music-enriched environment and during traditional speech therapy

Quantitative parameters of speech and auditory perception of the main and control groups. 1st assessment

The empirical distributions of the values of the studied parameters were previously checked for the normality of the distribution, which made it possible to evaluate the data using the Student's parametric t-criteria (Application 5, 6).

Initially, there were no differences between the groups in terms of index of laterality ($p>0.05$), coefficient of productivity ($p>0.05$), efficiency index ($p>0.05$), impressive speech ($p>0.05$), naming objects ($p>0.05$) and naming verbs ($p>0.05$) (Table 29).

The groups also did not differ in the productivity of free ($p>0.05$) and directed ($p>0.05$) associations, the speed of coherent spontaneous speech ($p>0.05$).

During the formation of the main and control groups, for several objective reasons, it was not always possible to maintain the uniformity of their composition about the percentage of patients with varying degrees of aphasia. That was an account that patients with a mild degree of defect did not always agree to undergo a rehabilitation course in a music-enriched environment and liked the traditional form of speech rehabilitation familiar to them.

Table 29. Speech and auditory perception parameters in patients with acoustic-mnestic aphasia of the main and the control groups before the speech rehabilitation course

Parameter	Group	M (SD)	t-criteria	p level
MOR_1 (score)	main	218,96 (32,69)	**2,29***	0,028
	control	240,73 (26,42)		
Impressive speech (five subscales total score)	main	123,96 (18,05)	1,04	0,304
	control	129,60 (15,34)		
Expressive speech (five subscales total score)	main	95,00 (17,84)	**3,11****	0,004
	control	111,15 (14,43)		
"Naming objects" subscale	main	25,32 (3,85)	0,82	0,417
	control	27,12 (3,03)		
subscale"Naming verbs"subscale	main	23,04 (5,61)	0,15	0,883
	control	25,15 (3,52)		
"Phrasing" subscale	main	14,79 (5,66)	**3,71***	< 0,001
	control	21,56 (5,42)		
"Making up a story"	main	7,18 (3,17)	**2,30***	0,027
	control	11,59 (6,76)		
Free oral verbal associations (productivity)	main	16,50 (3,55)	1,74	0,090
	control	19,38 (5,62)		
Controlled oral verbal associations(productivity)	main	7,93 (1,69)	1,37	0,179
	control	9,15 (3,09)		
Speed of spontaneous speech	main	31,64 (13,99)	1,70	0,098
	control	40,08 (15,50)		
Index of laterality (Kpu)	main	0,23 (0,78)	0,10	0,920
	control	0,20 (0,73)		
Efficiency index (Ief)	main	34,48 (34,43)	0,31	0,759
	control	37,88(31,24)		
Coefficient of productivity (Kpr)	main	19,52 (9,28)	0,21	0,837
	control	20,17 (9,15)		

Note: * – p<0,05, ** – p<0,01.

In this regard, the number of cases with mild aphasia was 22% lower in the main group. In the main group, the ratio of "moderate vs mild aphasia" was 57% vs 43% versus 35% vs 65% in the control group.

That predetermined the initial differences between the groups in the subscales "phrasing" (t=3.71, p<0.001), "making up a story" (t=2.30, p=0.027), and, as a result, in the score of expressive speech (t=3.11, p =0.004) and MOR1(t=2.29, p=0.028).

Taking that into account, the analysis of the rehabilitation shift assessed, along with the intergroup differences, the intra-group dynamics on these scales/subscales.

A retest assessment of speech and auditory perception in patients of both groups was carried out five weeks later, just after the completion of the speech rehabilitation course (Application 5, 6).

Comparative analysis of quantitative and qualitative parameters of speech and auditory-speech perception in patients with acoustic-mnestic aphasia after undergoing a course of speech rehabilitation in a modelling music-enriched environment and traditional speech therapy

In patients of the main group with acoustic-mnestic aphasia, the course of speech therapy had no significant effect on the laterality coefficient (t=0.56, p>0.05) and the efficiency index (t=0.27, p>0.05). An identical pattern was observed in patients of the control group (t=0.73, t=1.96, p>0.05, respectively) (Table 30).

Table 30. Parameters of auditory-speech perception in patients with acoustic-mnestic aphasia of the main and control groups after completion the course of speech rehabilitation

Parameter	Group	M (SD)	Comparison between 1st and 2nd assessments		t-criteria	p level
			t-criteria	p level		
Index of laterality (Kpu)	main	–0,19 (0,87)	0,56	0,58	0,03	0,975
	control	–0,17 (0,75)	0,73	0,472		
Efficiency index (Ief)	main	34,48 (34,43)	0,27	0,788	0,31	0,759
	control	44,28 (23,99)	1,96	0,062		
Coefficient of productivity (Kpr)	main	22,51 (10,68)	2,02	0,064	0,37	0,717
	control	23,74 (9,54)	**3,65*** **	<0,001		

Note: *** – p<0,001.

After the completion of therapy, the profile of auditory-speech asymmetry did not change in both groups, but the productivity of speech perception changed. In the main group, the increase in the productivity of auditory perception was 2.99% (19.52%

vs 22.51%) and was within the boundaries of the trend (t=2.02, p=0.064). In the control group, the dynamics of productivity were significant (t=3.65, p<0.001) and amounted to 3.57% (20.17% vs 23.74%), but there were no significant intergroup differences (t=0.37, p>0.05). That means that different methodological approaches had a positive effect on the productivity of auditory and speech perception: in the control group, it increased, and in the main one the dynamics were insignificant.

Several common features were found in the dynamics of speech recovery in patients with acoustic-mnestic aphasia *of the main and control groups*. Speech comprehension improved equally in both groups (t=1.13, p>0.05) (Table 31). In the main group, the increase in the parameter of impressive speech (1st vs 2nd assessment) was 6.38 points (123.96 vs 130.34) (t=3.70, p=0.003), in the control group – 5.48 points (129.60 vs 135.08) (t=4.12, p<0.001). The positive dynamics in both groups were significant.

Speech therapy in a music-enriched environment and traditional therapy equally contributed to the expansion of the volume of active subject (t=0.58, p>0.05) and verbal vocabulary (t=0.23, p>0.05). In the main group, the growth of the index of the subscale "naming of objects" (1 assessment vs 2 assessment) It was 2.25 points (25.12 vs 27.57) (t=4.17, p<0.001), in the control group – 1.08 points (27.12 vs 28.20) (t=3.25, p=0.003). In the main group, the index of the subscale "naming actions" increased by 2.17 points (23.04 vs 25.21) (t=5.51, p<0.001), in the control group – 1.00 point (25.15 vs 26.15) (t=3.39, p=0.002) (Table 31).

Both approaches to speech therapy improved the index of the subscale "phrasing". In the main group, it increased by 2.82 points (14.79 vs 17.61) (t=5.51, p<0.001), in the control group – by 1.34 points (21.56 vs 22.90) (t=2.59, p=0.016). Despite the positive dynamics of recovery of phrasal speech in both groups, intergroup differences remained in favor of the control group (t=3.11, p=0.003), which was explained by the presence of an initially higher proportion of patients with mild aphasia.

Table 31. Speech parameters (in points) in patients with acoustic-mnestic aphasia of the main and control groups after completion of the course of speech rehabilitation

Parameter	Group	M (SD)	Comparison between 1st and 2nd assessments		t-criteria	p level
			t-criteria	p level		
MOR_2 (score)	main	237,27 (30,63)	**7,63*****	<0,001	1,84	0,074
	control	252,34 (21,63)	**5,32*****	<0,001		
Impressive speech (five subscales total score)	main	130,04 (13,86)	**3,70****	0,003	1,13	0,264
	control	135,08 (13,17)	**4,12*****	<0,001		
Expressive speech (five subscales total score)	main	107,23 (18,55)	**7,34*****	<0,001	**2,02****	0,050
	control	117,24 (12,64)	**5,32*****	<0,001		
“Naming objects” subscale	main	27,57 (3,64)	**4,17*****	<0,001	0,58	0,568
	control	28,20 (2,06)	**3,25****	0,003		
"Naming verbs" subscale	main	25,21 (5,08)	**4,34*****	<0,001	0,23	0,821
	control	26,15 (2,88)	**3,39****	0,002		
“Phrasing” subscale	main	17,61 (5,44)	**5,51*****	<0,001	**3,11*****	0,003
	control	22,90 (5,06)	**2,59****	0,016		
“Making up a story” subscale	main	10,55 (5,32)	**3,22****	0,007	0,99	0,326
	control	12,42 (6,23)	0,94	0,357		
Free oral verbal associations (productivity)	main	20,57 (4,97)	**5,17*****	<0,001	0,54	0,591
	control	21,50 (5,26)	**3,72*****	<0,001		
Controlled oral verbal associations(productivity)	main	9,71 (2,27)	**5,96*****	<0,001	0,68	0,503
	control	10,38 (3,32)	**3,58*****	<0,001		
Speed of spontaneous speech	main	37,43 (12,57)	1,61	0,132	0,22	0,828
	control	38,27 (11,07)	0,70	0,490		

Note: ** – p<0,01, ***– p<0,001.

In the 2nd assessment, the productivity of free and directed associations increased in the main and control groups. At the same time, as before rehabilitation, there were no intergroup differences in both free (t =0.54, p>0.05) and directed associations (t=0.68, p>0.05). In the main group, the increase in productivity of free associations (words/min) was 4.07 words (16.50 vs 20.57) (t =5.17, p <0.001), in the control group – 2.02 words (19.38 vs 21.50) (t =3.72, p<0.001). The productivity of directed associations in the main group increased by 1.78 words (7.93 vs 9.91) (t=5.96, p<0.001), in the control group – by 1.23 words (9.15 vs 10.38) (t=3.58, p<0.001).

Finally, the methodological approach to rehabilitation did not affect the speed of coherent spontaneous speech in patients with acoustic-mnestic aphasia. After completion of the rehabilitation course, as before therapy, the speech rate of patients in both groups did not differ (t=0.22, p>0.05).

Along with the general features of regression of aphasic disorders, *several specific features in speech recovery were determined in the main group.*

In patients with acoustic-mnestic aphasia, speech therapy in a music-enriched environment had a stimulating effect on monological speech (t=3.22, p=0.007). The increase in the index of the "making up a story" subscale was 2.84 points (7.71 vs. 10.55) versus 0.83 points in the control group (11.59 vs. 12.42). If at the beginning of rehabilitation significant intergroup differences in monologue speech were revealed and the control group exceeded the main group by 4.41 points in the 1st assessment, then in the 2nd assessment – by 1.87 points and the intergroup differences were already insignificant (t=0.99, p>0.05). With the traditional approach, within the framework of the 1st rehabilitation course, no significant improvement in spontaneous monologue speech was achieved.

Speech therapy in a music-enriched environment helped to reduce the severity of speech disorders. The gradation of the severity of an aphasic defect in the MOR method defines a limit of 230 points as a transition from moderate to mild severity of the defect. At the time of the start of rehabilitation, the MOR1 index of the main group was 218.96 points and there was a significant difference between the groups in favor of the control group. After completion of the rehabilitation program, the MOR2 index of the main group was 237.27 points and there were no longer any intergroup differences (t=1.84, p>0.05). This indicated that the ratio of "moderate vs mild aphasia" in the main group changed towards an increase in the proportion of patients with a mild defect. In the control group, there was also a significant increase in the MOR2 score (252.34 points) (t=5.32, p<0.001), but it was 1.6 times lower (11.61 points) than in the main group (18.61 points).

Evaluation of the effectiveness of speech rehabilitation of patients with acoustic-mnestic aphasia in a modelling music-enriched environment revealed a significant decrease in the severity of aphasic defect and a higher rate of regression of speech disorders than with the traditional approach to speech restoration in aphasia (Shipkova

K.M., 2024b). Examples of the dynamics of speech recovery in patients of the main group are given in Application 7.

6.2.3. The effect of the severity of expressive speech impairments in patients with aphasia on the rehabilitation shift during speech therapy in a modelling music-enriched environment

The next step was to conduct a comparative analysis of the dynamics of speech recovery in patients of the main and control groups who differed in the severity of expressive speech disorders. The division of groups according to the score of expressive speech was directed by the fact that this score is the sum of points for five subscales of expressive speech of the MOR method and includes an assessment of speech at the level of words, phrases and text. Therefore, it is a parameter of the level of restoration of speech communication. To identify the influence of the methodological approach to speech therapy on the regression of aphasic disorders, depending on the initial parameter of expressive speech, patients in the main and control groups with different types of aphasia were combined. Then the main and control groups were quarticized according to the score of expressive speech, and then each group was divided into two subgroups of the 50th percentile.

Subgroup 1 of each group included patients of the 1st and 2nd quartiles – patients with a low score of expressive speech (≤104.00 points). Subgroup 2 included patients of the 3rd and 4th quartiles – patients with a high score of expressive speech (>104.00 points).

Subgroup 1 of the main (Table 32) and control groups (Table 33) included patients with moderate aphasia, and subgroup 2 – with mild aphasic defect.

The common features of both groups were that subgroup 2 of both groups significantly exceeded the parameters of subgroup 1 about the following parameters:

the speed of coherent spontaneous speech, impressive speech, productivity of free associations, and the index of efficiency of auditory and speech perception (Fig. 7, 8).

Table 32. Speech and auditory perception parameters in patients of subgroups 1 and 2 of the main group before the speech rehabilitation course

Parameter	Subgroup 1 (low score)		Subgroup 2 (high score)		U-criteria	p level
	M	SD	M	SD		
Impressive speech (five subscales total score)	83,07	6,27	114,03	11,33	**0,00*** **	<0,001
Expressive speech (five subscales total score)	120,96	16,19	133,65	11,45	**105,50** **	0,014
MOR_1(score)	205,98	21,10	247,72	19,40	**34,00*** **	<0,001
Free oral verbal associations (productivity)	13,25	5,05	19,59	5,51	**79,50** **	0,002
Controlled oral verbal associations (productivity)	7,50	2,11	9,15	3,18	137,50	0,094
Speed of spontaneous speech	26,64	15,34	34,85	**7,53**	**50,50***	0,049
Index of laterality (Kpu)	–0,27	0,78	0,12	0,65	61,50	0,150
Efficiency index (Ief)	19,31	32,49	47,61	22,40	**44,50** **	0,024
Coefficient of productivity (Kpr)	16,78	8,57	22,25	8,64	115,00	0,117

Note: ** – p<0,01, ***– p<0,001.

Table 33. Speech and auditory perception parameters in patients of subgroups 1 and 2 of the control group before the speech rehabilitation course

Parameter	Subgroup 1 (low score)		Subgroup 2 (high score)		U-criteria	p level
	M	SD	M	SD		
Impressive speech(five subscales total score)	81,72	11,90	113,31	10,95	**0,00*** **	<0,001
Expressive speech(five subscales total score)	118,9 2	16,01	134,43	10,81	**248,50*** **	<0,001
MOR1(score)	202,7 0	23,75	247,85	18,47	**83,00*** **	<0,001
Free oral verbal associations (productivity)	14,46	4,78	18,47	5,42	**364,00** **	0,004
Controlled oral verbal associations (productivity)	7,54	1,88	9,04	2,98	**425,00** **	0,031
Speed of spontaneous speech	28,33	11,58	38,94	14,04	**104,50** **	0,013
Index of laterality (Kpu)	–0,34	0,69	0,00	0,71	385,00	0,075
Efficiency index (Ief)	22,67	31,72	39,43	31,01	**364,50** **	0,030
Coefficient of productivity (Kpr)	19,95	9,03	24,77	8,38	**369,50** **	0,035

Note: ** – p<0,01, *** – p<0,001.

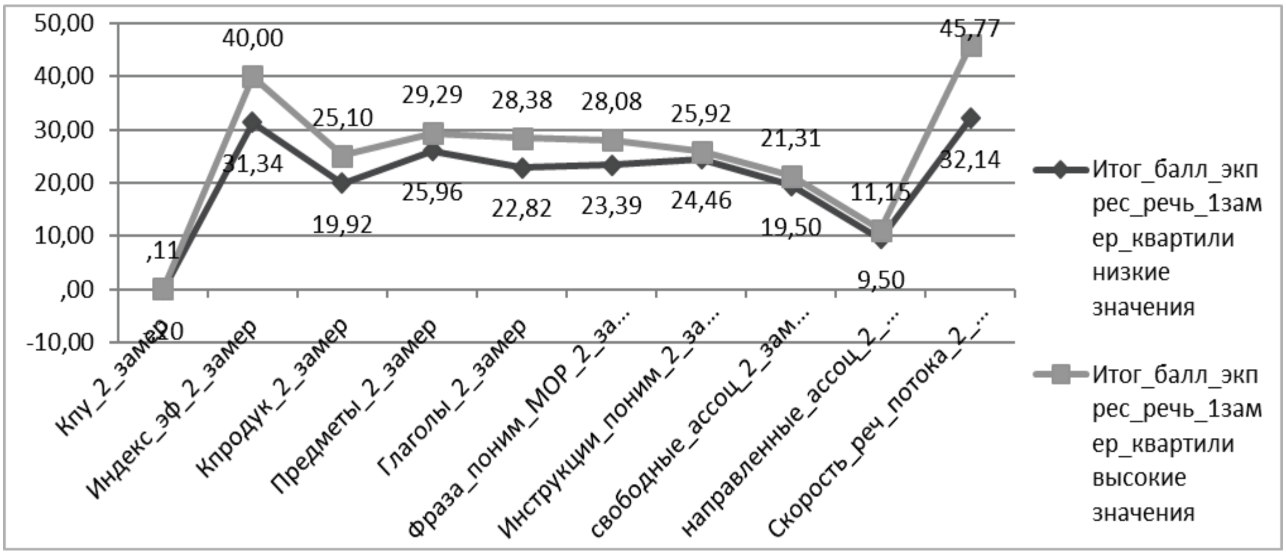

Figure 7. Dynamics of speech, auditory-speech perception and productivity of free and directed associations in patients of the main group with low and high score of expressive speech

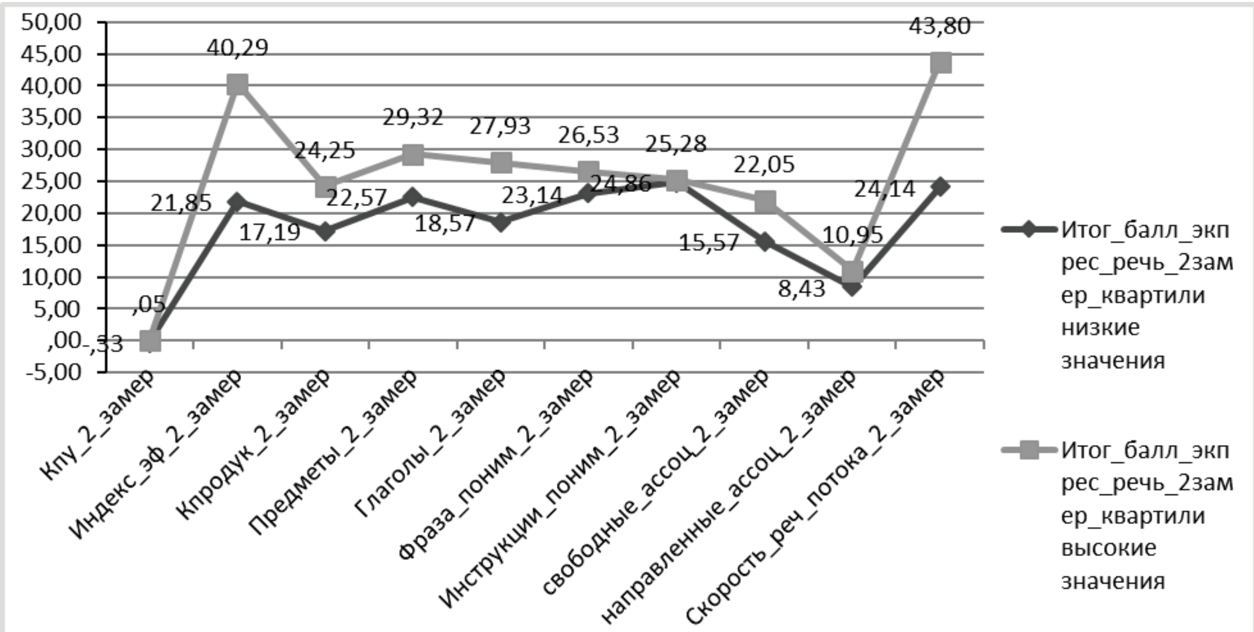

Figure 8. Dynamics of speech, auditory-speech perception and productivity of free and directed associations in patients of the control group with initially low and high score of expressive speech

Subgroups 1 and 2 did not differ in the index of laterality, which means that the subgroups had a single-order number of patients with leading left and right ears.

The unique difference between the main and the control groups was that subgroups 1 and 2 also did not differ in the coefficient of productivity of auditory and verbal perception and the productivity of controlled associations.

Dynamics of speech and auditory-speech perception parameters in patients with initially low and high scores of expressive speech during speech rehabilitation in a modelling music-enriched environment and traditional speech therapy

Because the empirical distributions of the values of the studied parameters did not correspond to the normality of the distribution, statistical analysis of intra- and inter-group differences in the level of the studied trait was carried out using the nonparametric Mann-Whitney U-test.

The dynamics of parameters in the subgroups of *the main and control groups revealed a certain commonality* concerning the parameters of auditory and speech perception:

1. The approach in which speech rehabilitation was carried out did not affect the profile of auditory-speech asymmetry (Fig. 7, 8).

2. Both approaches increased the effectiveness of auditory-speech perception. If there were significant differences in this parameter between the subgroups before the start of rehabilitation, then after the completion of the rehabilitation course they were no longer noted ($U=146.00$, $p>0.05$) (Table 34).

3. After speech therapy in a music-enriched environment and traditional speech therapy, significant differences in expressive speech score remained between subgroups 1 and 2 of the main and control groups. In the main group, the ratio "subgroup 1 vs subgroup 2" was 93.76 vs 120.86 ($U=18.00$, $p<0.001$), in the control group – 94.48 vs 119.55 ($U=14.00$, $p<0.001$) (Table 34).

4. Within the framework of both approaches, speech therapy led to positive dynamics of speech recovery, however, significant differences between subgroups 1 and 2 persisted at all levels of speech: words, phrases and text.

5. In both groups, there continued to be differences between subgroups in the speed of coherent expanded speech.

Along with common features, distinctive features were identified in the dynamics of speech parameters. In the main group, differences in the scale of impressive speech remained between subgroups 1 and 2 after completion of therapy (U=35.00, p =0.007), in contrast to the control group (U=131.00, p>0.05) (Table 34).

Table 34. Auditory perception, expressive and impressive speech parameters in the 2[nd] assessment in patients of the main and control groups with an initially low and high score of expressive speech

Parameter	Main group (subgroups)		U–criteria	p level	Control group (subgroups)		U–criteria	p level
	1	2			1	2		
Index of laterality (Kpu)	–0,20	0,12	67,00	0,243	–0,49	–0,06	119,50	0,149
Efficiency index (Ief)	31,34	40,00	75,50	0,452	31,53	39,69	146,00	0,516
Coefficient of productivity (Kpr)	19,92	25,1	58,00	0,109	19,99	24,61	123,50	0,189
“Naming objects” subscale	25,96	29,29	**44,00****	0,015	26,25	28,93	**81,00****	0,002
"Naming verbs" subscale	22,82	28,38	**36,00****	0,007	22,13	27,15	**45,00*****	<0,001
“Phrasing” subscale	14,50	21,15	**32,00****	0,004	16,13	23,79	**42,00*****	<0,001
“Making up a story” subscale	7,29	12,75	**38,50****	0,011	5,27	12,02	**47,50*****	0,001
Expressive speech (five subscales total score)	93,76	120,86	**18,00*****	<0,001	94,48	119,55	**14,00*****	<0,001
Impressive speech (five subscales total score)	125,57	139,31	**35,00****	0,007	127,38	138,10	131,00	0,068
Free oral verbal associations (productivity)	19,50	21,31	74,50	0,420	15,42	21,26	**91,50****	0,005
Controlled oral verbal associations (productivity)	9,50	11,15	56,00	0,085	8,58	10,15	135,50	0,085
Speed of spontaneous speech	32,14	45,77	**36,50****	0,008	30,50	38,21	**119,00***	0,033

Note: * – p<0,05, ** – p<0,01, *** – p<0,001.

Table 35. Dynamics of speech parameters in patients of subgroups 1 and 2 of the main and control groups

Parameter	Main group M (SD)	Control group M (SD)	U–criteria	p level
Subgroup 2				
“Naming objects” subscale	29,29 (1,92)	28,93 (1,00)	**119,50****	0,013
"Naming verbs" subscale	28,38 (1,85)	27,15 (2,28)	145,50	0,071
“Phrasing” subscale	21,15 (4,87)	23,79 (4,10)	155,00	0,115
“Making up a story” subscale	12,75 (5,88)	12,02 (5,87)	201,50	0,642
Expressive speech (five subscales total score)	120,86 (11,60)	119,55 (10,06)	211,00	0,812
Impressive speech (five subscales total score)	136,46 (8,99)	133,65 (11,45)	194,00	0,521
Free oral verbal associations (productivity)	21,31 (4,91)	21,26 (5,11)	162,00	0,160
MOR_2 (score)	262,48 (16,64)	257,67 (15,36)	212,00	0,830
Controlled oral verbal associations (productivity)	11,15 (2,41)	10,15 (3,07)	182,50	0,356
Speed of spontaneous speech	45,77 (6,38)	38,21 (10,10)	**91,00****	0,002
Subgroup 1				
“Naming objects” subscale	25,96 (4,90)	26,25 (2,98)	73,00	0,569
"Naming verbs" subscale	22,82 (6,04)	22,13 (3,20)	72,50	0,552
“Phrasing” subscale	14,50 (5,72)	16,13 (4,12)	69,00	0,439
“Making up a story” subscale	7,29 (3,96)	5,27 (4,45)	50,50	0,084
Expressive speech (five subscales total score)	93,76 (19,66)	94,48 (9,08)	83,00	0,959
Impressive speech (five subscales total score)	117,18 (16,25)	120,96 (16,19)	75,50	0,662
Free oral verbal associations (productivity)	19,50 (5,85)	15,42 (6,14)	54,00	0,122
MOR_2 (score)	219,33 (28,42)	221,88 (21,44)	82,00	0,918
Controlled oral verbal associations (productivity)	9,50 (2,24)	8,58 (2,35)	64,50	0,311
Speed of spontaneous speech	32,14 (14,85)	30,50 (12,38)	75,00	0,642

Note: ** – p<0,01.

Unlike traditional speech therapy, the music-enriched environment allowed, within the framework of one rehabilitation course, to increase the productivity of free associations in patients with moderate aphasia to the level of patients with mild speech disorders (U=74.50, p>0.05) (Table 34). In the control group, on the contrary, the differences between subgroups 1 and 2 persisted (U=91.50, p=0.005).

A comparison of the rehabilitation shift between subgroups 2 of the main and control groups showed that a music-enriched environment is an effective tool of speech therapy for patients with an initially high score of expressive speech (Table 35).

It contributed to a more pronounced improvement in the subject nominative deficit (U=119.50, p=0.013) and the speed of coherent spontaneous speech (U=91.00, p=0.002) than with the traditional approach. Based on the fact that the primary symptom of efferent motor aphasia consists of difficulties in speech switching, and acoustic-mnestic aphasia – difficulties of word ecphoria, the increase in the speed of coherent spontaneous speech in patients with aphasia indicated that the music-enriched environment created an activating effect on the expressive speech of patients with different types of aphasia. Patients with efferent motor aphasia increased the speed of articulatory switching, with acoustic-mnestic aphasia - the speed of finding the right word.

6.3. Quantitative and qualitative parameters of speech restoration in music-enriched environment

The developed methodological approach to speech therapy in modelling music-enriched environment lay on the base of Russian neuropsychology school and related sciences: neurobiology, neurophysiology, and neurology (Shipkova K.M., 2014, 2018, 2020, 2021, 2024a, 2024b; Shipkova K.M. et al., 2023). It includes the theoretical principles of Russian neuropsychology on the patterns of impairment and recovery of higher mental functions described in the school of L.S. Vygotsky and A.R. Luria (Luria, 1949, 1966, 1973; Vygotsky L.S., 1984a, 1984b; Simernitskaya 1985; Tsvetkova 1982, 1985, 2010; Akhutina, 1989, 2002). The methodology of the approach took into account the bi-hemispheric nature of the cerebral organization of speech, the leading role of the right hemisphere in ensuring its intonation and melodic characteristics (Luria A.R.1949; Tsvetkova L.S. 1972, 1975,1988, 2002; Wiesel T.G., Glezerman T.B., 1986; Zangwill O. 1947; Lecour A.R., 1976, Lecour A.R. et al., 1979, 1983, etc.). The methodological approach took into account the knowledge of common links in the psychological structure of speech and musical perception and the commonality of their brain bases (Rauscer F.H. et al., 1993; Angel L.A. et al., 2010; Soria-Urios G. et al., 2011; Patel A.D., 2014).

The algorithm of modelling a music-enriched environment created in compliance with the clinical and physiological patterns of spontaneous hemispheric reorganization of impaired speech function (Tsvetkova L.S., 1985; Zaidel E., 1985; Papanicolaou A.C., 1984; 1987; 1988a; 1988b; Barker W.W. et al., 2002; Raboyeau G.et al. 2008; van der Meulen I. et al., 2010; Habibi A. et al., 2018; et al.).

The approach took into account the clinical aspect of aphasia, in particular the features of the etiopathogenesis of post-stroke aphasia (Bein E.S., Markova E.D., 1960; Stolyarova L.G., 1963, 1964, 1973; Thin-legged I.M., 1968, 1973, 2007; Hillis A., 2007; Hoffmann M., Chen R., 2013; Damulin I.V., 2018). When developing a methodological complex of a modelling music-enriched environment, it was taken into account that the patients participating in the study had chronic aphasic disorder (Saur D. et al., 2006; Sternberg S., 2011; Anglade C. et al., 2014; Ulanov M.A. et al., 2018; Kiran S.et al., 2019; Nasios G. et al., 2019; Stefaniak J.D. et al., 2020).

The choice of musical material for the formation of a music-enriched environment was based on neurophysiological data on the topical effect of different genres and modes of music on the focus of the brain response (Pavlygina R.A. et al., 2004; Pavlov A.E., 2007; Vartanov A.V., 2011; Bangert M. et al., 2006; Marques C. et al., 2007; Herholz S.C., Zatorre R.J., 2012; Altenmüller E., Schlaug G., 2013; Jomori I. et al., 2013; Carvalho D. et al., 2013).

To avoid the effect of decompensation due to excessive sensory stimulation, data on the optimal duration of musical exposure and its tempo-rhythmic characteristics on the processes of neuropreparation were taken into account (Gaser C., Schlaug G., 2003; Hyde K.L. et al., 2009; Soria-Urios G. et al., 2011; McDermott O. et al., 2013; Habibi A. et al., 2018) and the effectiveness of speech restoration in patients with aphasia (Thompson W.F. et al., 2004; Thaut M.H., 2005; Särkämö T. et al., 2008; Moreno S., 2009; Breier J.I. et al., 2011; van der Meule I. et al., 2014; Zumbansen A., Tremblay P., 2019; Moreno-Morales C. et al., 2020).

The results of testing the methodological approach to speech therapy in a music-enriched environment confirmed the correctness of the developed algorithm and methodological complex, which was proved by two groups of facts.

Firstly, the rehabilitation of aphasic disorders in a music-enriched environment did not change the established profile of auditory-speech asymmetry. That meant that the developed algorithm and methodological tools for sensory stimulation by a music-enriched environment did not destroy the new brain architectonics of speech function that had developed as a result of the brain catastrophe.

Secondly, the modelling music–enriched environment, without changing the brain organization of speech, made it possible to strengthen the topical foci of influence on the hemispheric links of the speech system and achieve a significant regression of speech disorders at all levels of speech: words, phrases, text - and the productivity of free associations. That confirms OPERA's hypothesis about the familiar links in the psychological structure and brain foundations of speech and musical perception (Patel A.D., 2014). In patients with aphasia, the nominative function of speech improved and revealed the positive dynamics of object naming.
Taking into account that the weakness of verbal nomination is a specific symptom of efferent motor aphasia and acoustic-mnestic one, this indicated that the music-enriched environment contributed to the regression of the deficit of active vocabulary, expanding its volume by strengthening intermodal integration intra- and interhemispheric connections of speech function. The data obtained confirms the motor-speech hypothesis about the shared links in the psychological structure of speech and musical perception (Merrett D. et al., 2014).

The presence of some shared features in the dynamics of regression of speech disorders during speech therapy within the framework of new and traditional approaches indicated that the bipolar activation of brain structures, which was created by a music-enriched environment, is comparable in effectiveness with speech restoration along the path of intrahemispheric restructuring implemented within the framework of the traditional approach.

Along with the general features of speech dynamics, the rehabilitation shift created by the modelling music-enriched environment had qualitative advantages. They consisted of a more pronounced rate of regression of the degree of speech disorders and a broader range of speech parameters with positive dynamics. The degree of recovery of disorders is a quantitative characteristic of the rehabilitation shift. In a music-enriched environment in patients with different types of aphasia, regression of speech disorders from moderate to mild severity was achieved within a single rehabilitation course and was not observed with the traditional approach to speech therapy. The tempo characteristic of the restoration of expressive speech is an indirect reflection of the depth of the cerebral reorganization of speech and the integration links between the elements of its functional system.

The music-enriched environment had an activating effect on the speed of coherent speech in patients with mild speech disorders. It is known that in the syndrome of efferent motor aphasia, speech perseverations are the primary symptom of a speech defect and inevitably lead to the syllabic utterance of words, and, naturally, to a slowdown in the pace of speech. The music-enriched environment, due to the involuntary desire of patients to congruence the tempo and rhythm of their speech with consonantal musical accompaniment, contributed to increased control over the speed of speech articulatory switches. That reduced the severity of the chanting of speech and increased its speed. The neuropsychologist guided the patients not by exaggerating the melodic rhythm of the word, as in MIT technology, but by the usual manner of speaking. The new approach made it possible to achieve pronounced and stable positive dynamics in the speed of speech switching, unlike the MIT technique, where the effect of smoothness of speech production is maintained by constant control and decreases if the conjugation of pronouncing a word is not observed with exaggeration of the melody of the word (Peters I., 1999; Herbert S. et al., 2003; Racette A. et al., 2006; Zumbansen A. et al., 2014; Merrett D. et al., 2014).

In patients with efferent motor aphasia, speech therapy in a modelling music-enriched environment increased the regulatory control of speech production: the productivity of directed associations increased. That indicated increased control over speech (Faroqi-Shah Y., Milman L., 2018; Patra A. et al. 2020; Bose A. et al., 2022; Shipkova K.M., Dubinsky A.A., 2023; Shipkova K.M., 2024a).

In patients with acoustic-mnestic aphasia, the music-enriched environment made a significant impact on the quality of monological speech: the expansion and lexical fullness of phrases (Shipkova K.M., 2024b). Unlike the MIT technique, which does not improve the quality of speech production in patients with lesions of the left temporal lobe (Zumbansen A., Tremblay P., 2019), the music-enriched environment contributed to a decrease in speech deficit, which confirms the idea of the role of the right hemisphere in the processes of lexical and grammatical structuring (Zaidel E., 1985; Papanicolaou A.C., 1984; 1987; 1988a; 1988b). In patients with acoustic-mnestic aphasia, the pronounced positive dynamics in monologue speech could explained by the fact that the musical material used during therapy was classical music, which, as is known, creates a local brain response in non-musicians, such as the study participants, in the temporal, central and parietal regions of the brain (Pavlygina R. A. and others, 2004). Sensory stimulation techniques, which preceded the musical speech expression, activated the brain structures involved in speech communication and took into account that during speech processing there is a change in dominant-subdominant relationships: the focus of hemispheric activity shifts from the left hemisphere (at the initial stage) to the right hemisphere and the posterior cortex (at subsequent stages of speech tasks) (Batuev A.S., 1991; Pavlova L.I., 2017).Thus, the modelling music-enriched environment created an activation focus in the brain structures of the right hemisphere, congruent to the focus of brain activation in healthy people when they performed communicative tasks, which led to a significant shift in the restoration of expanded narrative speech in patients with acoustic-mnestic aphasia(Shipkova K.M., 2014, 2018, 2020, 2021, 2024a, 2024b).

The results confirm the concept of E.A. Kostandov (1983) that the advantage of one of the hemispheres in any complex mental activity, including speech, is partial and is determined by a specific stage of its course. The positive effect of a music-enriched environment on speech recovery in patients with aphasia has proven the influence of music on the adaptability and plasticity of the neuronal brain organization of speech function (Merrett D. et al., 2014; Cheever T. et al., 2018).

Summary

The approbation of a new approach to the rehabilitation of patients with aphasia in a modelling music–enriched environment, based on the gradual activation of intrahemispheric brain structures functionally related to the lesion and homologous to them in the intact hemisphere by musical stimulation methods contributed to the revival of intermodal auditory-motor, visual-verbal, auditory-visual connections and integration hemispheric connections, and has shown its effectiveness in restoring all levels of speech: words, phrases and text - in patients with efferent motor and acoustic-mnestic aphasia.

The speech therapy in a modelling music-enriched environment provided not only a regression of speech disorders commensurate with the traditional approach in oral speech and active vocabulary of patients with aphasia, which combined approaches in the direction of the rehabilitation shift but also in other aspects of speech, which was not achieved with traditional therapy within the framework of one rehabilitation course: improvement of nomological speech and productivity of directed associations in patients with acoustic-mnestic and efferent motor aphasia, respectively. Thus, in speech therapy with a music-enriched environment, the spectrum of positive dynamics was wider than in traditional speech therapy.

The methodological tools used in the new approach increased general and speech regulatory control in patients with efferent motor aphasia. The patients improved the tempo characteristics of speech and the productivity of directed verbal associations. Increasing regulatory control made it possible to slow down the perseverations that arise in oral speech and increase the speed of speech, as well as maintain the focus of verbal search and thereby increase the productivity of directed associations.

In patients with acoustic-mnestic aphasia, in comparison with patients with efferent motor aphasia, the speech therapy in a modelling music-enriched environment did not have a specific effect on the tempo characteristics of speech but significantly

affected the quality of coherent monological speech: lexical fullness and unfoldment of phrases. This indicates the indirect influence of the music-enriched environment on the strengthening and deepening of intermodal and interhemispheric interaction created by the directed influence of musical methods of speech rehabilitation.

In contrast to the traditional approach to speech therapy, the bi-hemispheric activation of brain structures, including intermodal intra- and interhemispheric connections modelled by a music-enriched environment, contributed to a pronounced increase in the rate of regression of speech disorders in patients with aphasia from moderate to mild severity of aphasic defect.

The results of the study confirm the hypothesis put forward about the possibility of a modelling music-enriched environment to enhance the mechanisms of intra- and interhemispheric sensory integration and thereby achieve greater comparative effectiveness in speech restoration than with the traditional approach to speech therapy

These studies also confirm the hypothesis put forward about the selective influence of a music-enriched environment on speech parameters in patients with different types of aphasia.

CHAPTER 7. APPROBATION OF AN APPROACH TO REHABILITATION OF PATIENTS WITH APHASIA IN A MODELLING POLYSENSORY-ENRICHED ENVIRONMENT

This chapter presents the results of solving the following tasks:

1. Evaluation of the therapeutic effectiveness of the tested approach based on a comparative analysis of the regression dynamics of aphasic disorders in the conditions of speech restoration in a modelling sensory-enriched environment and the traditional neuropsychological and pedagogical approach to speech rehabilitation.
2. Evaluation of the comparative effectiveness of speech restoration in a polysensory-enriched environment in patients with efferent motor and acoustic-mnestic aphasia with different initial severity of expressive speech disorders.

7.1. Research procedure and data analysis

All patients in the main and control groups performed the course of traditional speech therapy. The course of speech therapy in a modelling polysensory-enriched environment complemented traditional speech therapy.

In the main group, the rehabilitation course included 15 individual rehabilitation sessions lasting 55-70 minutes each. Sessions were held at the same time in the morning, afternoon or early evening hours. Speech therapy and/or physical therapy classes were not conducted one hour before the start of the neurorehabilitation session to avoid mental and physical fatigue of the patient by the beginning of work with a neuropsychologist. The course was conducted three times a week for five weeks. The methodological content of the rehabilitation course corresponded to the developed principles and algorithms for modelling sensory-enriched environments. The sessions were held in the form of individual lessons in a separate room. Speech therapy in a polysensory-enriched environment was performed on 50 patients of the main group: 29

patients with efferent motor aphasia and 21 patients with acoustic-mnestic aphasia. A total of 750 individual rehabilitation sessions were conducted (15 individual sessions X 50 people). Due to the forced early discharge of 3 patients with efferent motor aphasia, only part of the diagnostic complex techniques was repeated: free and directed associations, and assessment of the speed of coherent spontaneous speech. Therefore, in the fragments of the study, which reflect the results of other diagnostic techniques, the number of patients with efferent motor aphasia decreased from 29 to 26 people.

The control group included 54 patients: 24 patients with efferent motor aphasia and 30 patients with acoustic-mnestic aphasia.

Each patient of the main and control groups was evaluated by 8 methods twice: before and after speech rehabilitation. The total number of observations according to all methods of the diagnostic complex amounted to 1,634 units.

When conducting a comparative analysis of the intra-group and intergroup dynamics of the studied parameters, the empirical distributions of which did not differ from the normal distribution, the parametric Student's t-test was used. For data that do not correspond to a normal distribution– the nonparametric U-Mann-Whitney criteria and the Pearson $\chi 2$ criteria. To assess the intra-group dynamics of different types of semantic and phonological organization of the associative series, the Wilcoxon Z-test for paired samples was used.

7.2. Dynamics of speech recovery in patients with aphasia in a polysensory-enriched environment and during traditional approach to speech therapy

Main and control groups characteristics

The total sample size of patients with aphasia (main and control groups) in this part of the study was 104 people: the main group – 50 patients, and the control group – 54 patients. Of these, 53 patients with efferent motor aphasia: the main group – 29 people, the control group – 24. The sample of patients with acoustic-mnestic aphasia consisted of 51 people: the main group – of 21 people, and the control group – of 30 (Table 36).

There were no differences in the age of patients with acoustic-mnestic ($t=-1.32$, $p>0.05$) and efferent motor aphasia ($t=0.20$, $p>0.05$) between the main and control groups.

Table 36. Socio-demographic parameters and aphasia time post-onset in patients of the main and control groups with different aphasia types

Parameter	Group	Aphasia type	M (SD)	t-criteria	p level
Age (years)	main	acoustic-mnestic	52,33 (9,47)	–1,32	0,193
	control	acoustic-mnestic	55,27 (6,43)		
	main	efferent motor	50,73 (8,67)	0,20	0,844
	control	efferent motor	50,21(10,05)		
Time post-onset of aphasia (months)	main	acoustic-mnestic	22,52(19,82)	–0,31	0,757
	control		24,23(18,94)		
	main	efferent motor	27,62(18,93)	0,52	0,605
	control		24,75(20,04)		
–	–	–	–	χ^2-criteria	–
Men/women	main	acoustic-mnestic	16/5	2,59	0,459
	control		22/8		
	main	efferent motor	18/11		
	control		15/9		
Higher/secondary special education	main	acoustic-mnestic	16/5	1,68	0,641
	control		24/6		
	main	efferent motor	20/9		
	control		17/7		

The groups did not differ in the ratio of "men/women" ($\chi2=2.59$, $p>0.05$). This ratio among patients with acoustic-mnestic aphasia in the main group was 16/5 people and in the control group – 22/8 people. Among the patients of the main group with efferent motor aphasia, the ratio was 18/11 people, and in the control group – 15/9 people.

There were no differences in the patient's level of education between the groups ($\chi2=1.68$, $p>0.05$). The ratio of "higher/secondary specialized education" in patients with acoustic-mnestic aphasia of the main group among the patients was 16/5 people, and the control group – was 24/6 people. Among the patients with efferent motor aphasia of the main group – 20/9 people, and the control group – 17/7 people.

The groups did not differ in the duration of the aphasic defect (t=–0.31, p>0.05). In the main group, in patients with acoustic-mnestic aphasia, the prescription of aphasia was 22.52 ±19.82 years, in patients with efferent motor aphasia – 27.62±18.93 years, in the control group – 24.23±18.94 years and 24.75±20.04 years, respectively.

Thus, initially, the main and control groups did not differ in the prescription of aphasia and socio-demographic parameters: age, education, and gender distribution.

7.2.1 Dynamics of speech recovery in patients with efferent motor aphasia in a polysensory-enriched environment and during traditional speech therapy

Quantitative and qualitative speech and auditory-speech perception parameters, cognitive and regulatory functions of patients with efferent motor aphasia of the main and control groups before speech rehabilitation. 1st assessment

Quantitative speech parameters. The MOR score. The speed of spontaneous speech. 1st assessment

According to the results of 1st assessment, patients with efferent motor aphasia in both groups had the same initial lexical and grammatical problems (Application 8). At the beginning of speech rehabilitation, the main and control groups did not differ in MOR1 score (t=1.65, p>0.05) (Table 37). In the 1st assessment, there were no differences in the score of impressive (t=1.44, p>0.05) and expressive speech (t =1.46, p>0.05). There were no significant differences between the groups in the active vocabulary of the subject (t=0.28, p>0.05) and verbal nomination (t=1.69, p>0.05), grammar of phrases (t=0.81, p>0.05), except the subscale "making up a story" (t. In the "making up a story" subscale, the main group had a higher score (10.98) than the control group (5.48) (t=3.87, p<0.001). The formation of groups took into account the MOR score and not subscales of the method, therefore, it was not possible to anticipate and take into account this circumstance in advance at the stage of group formation.

Table 37. Parameters of the MOR method, the speed of spontaneous speech in the main and control groups of patients with efferent motor aphasia (in points).1st assessment

Parameter	Group				t-criteria	p level
	main	control	main	control		
	M		SD			
“Naming objects” subscale	26,69	26,40	3,73	3,75	0,28	0,781
"Naming verbs" subscale	24,96	22,69	4,12	5,36	1,69	0,098
“Phrasing” subscale	17,81	16,63	3,58	6,49	0,81	0,424
“Making up a story” subscale	10,98	5,48	4,92	5,12	**3,87*****	<0,001
Expressive speech (five subscales total score)	103,89	96,49	16,61	19,11	1,46	0,150
Impressive speech (five subscales total score)	130,23	122,85	17,37	18,78	1,44	0,155
MOR_1 (score)	235,83	221,48	26,94	34,47	1,65	0,106
Speed of spontaneous speech	29,85	27,75	12,99	11,99	0,59	0,557

Note: ***– p<0,001.

There were no differences in the rate of coherent spontaneous speech between the main and control groups (t=0.59, p>0.05). The speech rate in the main group was 29.85 words/min, and in the control group – 27.75 words/min.

Quantitative and qualitative parameters of free and controlled associations. 1st assessment

Free associations. Quantitative parameters. 1st assessment

At the beginning of the speech rehabilitation course, there were no differences in the productivity of associations between the main and control groups (Table 38).

Table 38. Quantitative parameters of free associations of the main and control groups of patients with efferent motor aphasia. 1st assessment

Parameter	Level	Group				U-criteria	p level
		main		control			
		frequency	%	frequency	%		
Verbal perseverations	high	0	0,00	0	0,00	318,00	0,41
	medium	1	3,44	0	0,00		
	low	5	17,24	3	12,50		
	zero	23	79,32	21	87,50		
Stability of the tempo of associations	high	5	17,24	9	37,50	250,50	0,65
	medium	16	55,17	6	25,00		
	low	8	27,59	6	25,00		
	zero	0	0,00	3	12,50		
Flexibility of associations	–	M	Me	M	Me	t-criteria	p level
		4,59	4,00	2,71	3,00	**4,30*** **	<0,001
Productivity of associations	–	17,59	17,00	17,25	17,50	0,23	0,82

Note: ***– p<0,001.

In the main group, the productivity of free associations was 17.25 words/min, in the control group – 17.5 words/min (t=0.23, p>0.05).

There was a high degree of verbal control in groups (U=318.00, p>0.05). There were no cases of high levels of verbal perseveration in them. Even though the main group was two times less likely to a high level and the medium (average) level of stability of the association rate was much more frequent than in the control group, the difference between them was not significant (U=250.50, p>0.05).

Along with this, there were initial differences between the groups in associative flexibility (U=4.30, p<0.001) and semantic organization of the verbal series (U=3.93, p<0.001). In the free-associative series of the main group, there were more semantic fields (4.00 vs 3.00 (Me) and higher semantic organization of the associative series (number of semantic pairs) (8.00 vs 4.00 (Me).

Free associations. Quality parameters.1st assessment

A specific feature of the free associations of patients with efferent motor aphasia was the rare use of functional semantic connections (Fig. 9).

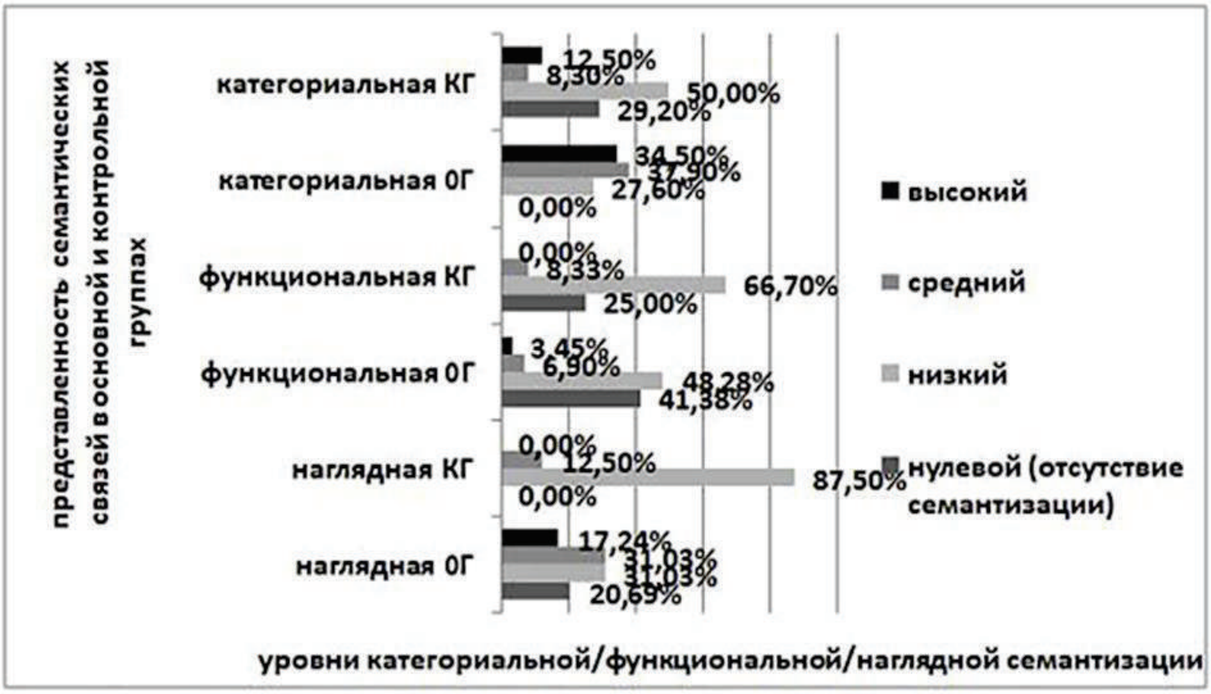

Figure 9. Levels of categorical, functional and visual semantics in the main and control groups of patients with efferent motor aphasia in the free associations task. Before speech rehabilitation

Note: ОГ - the main group, КГ - the control group.

The initial ratio of "zero/low/medium/high level of functional semantics" of the associative series in the main and control groups did not differ ($\chi2=2.69$, $p>0.05$) (Table 39). Along with this, there were intergroup differences in the use of other types of verbal communication. The level of categorical semantics, and the differences between the groups were significant ($\chi2=17.48$, $p=0.001$). In the main group, the medium and high levels of categorical semantics are shown as 2/3 of the main and 1/5 of the control group. Low level was in almost 1/3 of the main and 1/2 of the control group. A zero level of categorical semantics was recorded in a third of the patients in the control, while no cases were noted in the main group.

Table 39. Qualitative parameters of free associations of the main and control groups of patients with efferent motor aphasia. 1st assessment

Parameter	Level	Group				χ^2 criteria	p level
		main		control			
		frequency	%	frequency	%		
Level of categorical semantics	high	10	34,48	3	12,50	**17,48*** **	0,001
	medium	11	37,93	2	8,33		
	low	8	27,59	12	50,00		
	zero	0	0,00	7	29,17		
Level of functional semantics	high	1	3,45	3	12,50	2,69	0,443
	medium	2	6,90	2	8,33		
	low	14	48,28	12	50,00		
	zero	12	41,38	0	0,00		
Level of visual semantics	high	5	17,24	0	0,00	**18,49*** **	<0,001
	medium	9	31,03	3	12,50		
	low	9	31,03	21	87,50		
	zero	6	20,69	0	0,00		
Semantic organization	–	M	Me	M	Me	t-criteria	p level
		8,21	8,00	4,63	4,00	**3,93*** **	<0,001

Note: ** – p<0,01, ***– p<0,001.

Intergroup differences were also noted in visual connections ($\chi2=18.49$, $p<0.001$). In the main group, the ratio of "medium and high vs low and zero level" was 1:1, and in the control group – 1:7. In other words, in the main group three times more frequently were verbal chains based on a visual feature.

Thus, patients of both groups rarely resorted to building functional verbal chains and tended to form categorical and visual associative connections to a greater extent, and they were more common in the main group than in the control group.

Controlled phonological associations. Quantitative parameters.1st assessment

The main and control groups had no initial differences in the stability of the association rate ($U=307.50$, $p>0.05$) and the level of verbal perseverations ($U=294.00$, $p>0.05$) (Table 40).

The vast majority of patients in both groups had an average association rate.

The study participants retained speech control, as evidenced by the zero level of verbal perseverations in the main and control groups.

At the same time, the productivity of directed associations in the main group was lower than in the control group (7.00 vs 8.50 (Me) ($t=-2.66$, $p=0.01$).

Controlled phonological associations. Quality parameters.1st assessment

Patients of the main and control groups often used letter and syllabic strategies at the same time (Fig. 10). Before the start of speech therapy, there were no intergroup differences in the levels of use of the letter strategy ($\chi2=0.797$, $p>0.05$). Patients of both groups followed the instructions and did not name words with a different letter, or proper names, but in the main group, the syllabic strategy was used less often ($\chi2=13.26$, $p=0.01$) (Table 40).

Table 40. Quantitative and qualitative parameters of controlled phonological associations of the main and control groups of patients with efferent motor aphasia. 1st assessment

Parameter	Level	Group				U-criteria	p level
		main		control			
		frequency	%	frequency	%		
Verbal perseverations	high	1	3,45	0	0,00	294,00	0,22
	medium	0	0,00	0	0,00		
	low	5	17,24	9	37,50		
	zero	23	79,31	15	62,50		
Stability of the tempo of associations	high	2	6,90	3	12,50	307,50	0,36
	medium	23	79,31	15	62,50		
	low	3	10,34	6	25,00		
	zero	1	3,45	0	0,00		
Level of alphabetic phonological strategy	high	20	68,97	17	70,83	0,80	0,67
	medium	7	24,14	4	16,6		
	low	2	6,90	3	12,50		
	zero	0	0,00	0	0,00		
Level of syllabic phonological strategy	high	0	0,00	4	16,67	**13,26****	0,01
	medium	5	17,24	10	41,67		
	low	12	41,38	8	33,33		
	zero	12	41,38	2	8,33		
Productivity of associations	–	M	Me	M	Me	t-criteria	p level
		7,10	7,00	9,33	8,50	–2,66	0,01

Note: ** – p<0,01.

It should be recalled that before the rehabilitation course, both groups equalized by the ratio "medium/mild degree of aphasia". That explained the lack of differences between the groups in most quantitative parameters.

Unlike quantitative parameters, the structural parameters of the verbal associative series represent qualitative characteristics of the process of verbal associations, so it was impossible to equalize the samples according to these parameters before the start of the study. In this regard, when assessing the rehabilitation shift in the 2nd assessment, both intergroup differences and intra-group dynamics of parameters were evaluated.

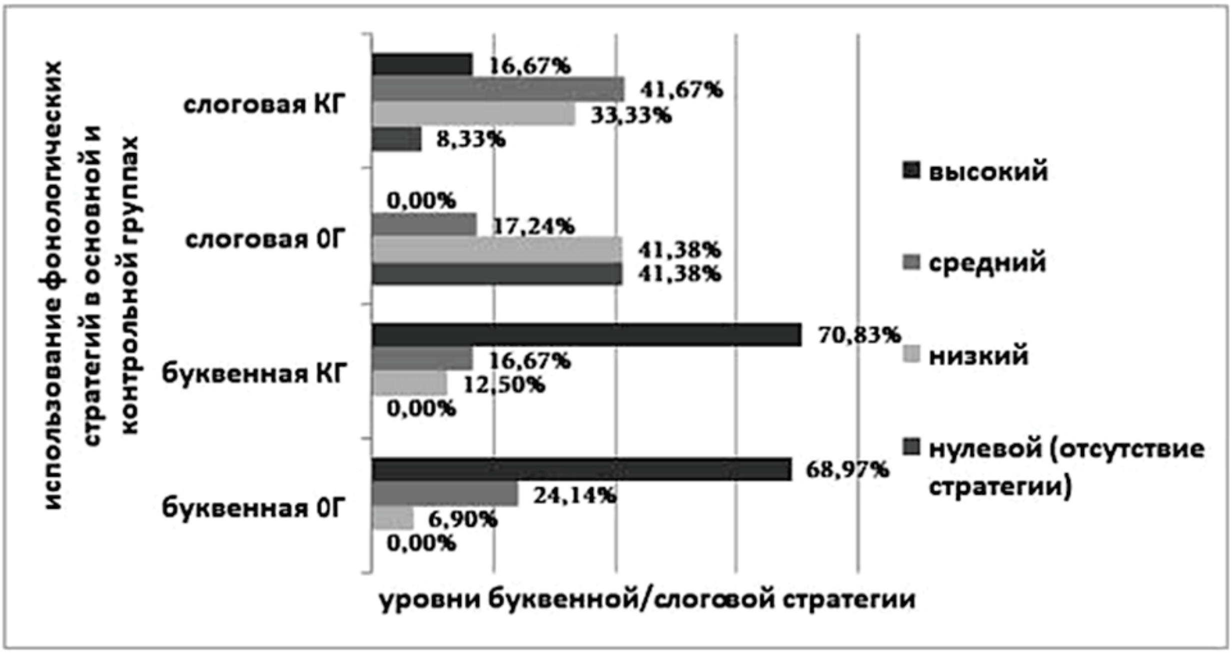

Figure 10. Strategies for word selection in phonological associations in the main and control groups of patients with efferent motor aphasia. Before the speech rehabilitation course

Note: ОГ – the main group, КГ – the control group.

Index of laterality, efficiency and productivity coefficient of auditory and speech perception. 1st assessment

There were no intergroup differences in the efficiency index (t=1.22, p>0.05), which meant that the proportion of errors in dichotic listening to words was the same in both groups. The groups had a commensurate ratio of patients with "leading left vs right ear" (t =–0.33, p>0.05) (Table 41).

The only parameter that revealed intergroup differences was the coefficient of productivity (t=2.88, p=0.006). It was higher in patients of the main group. That meant that patients in this group produced more words than the control group – 26.83 vs 20.88 words.

Table 41. Parameters of dichotic listening in the main and control groups of patients with efferent motor aphasia. 1st assessment

Parameter	Group				t-criteria	p level
	main	control	main	control		
	M		SD			
Index of laterality (Kpu)	–0,23	–0,17	0,61	0,66	–0,33	0,746
Efficiency index (Ief)	43,31	33,65	24,51	31,13	1,22	0,227
Coefficient of productivity (Kpr)	26,83	20,88	6,06	8,45	**2,88****	0,006

Note: ** – p<0,01.

The state of cognitive and regulatory functions.1st assessment

The cognitive functioning and executive control of the patients were assessed by the MoCA

test, the Frontal battery (FAB-test) and the "retelling of the story" subscale of the RBMT-3 test.

The main and control groups of patients with efferent motor aphasia had no significant differences in the state of cognitive functions (t=–0.56, p>0.05) (Table 42). In the main group, the score on the MoCAtest was 24.50, the control group - 24.92 points, which indicated the presence of mild cognitive impairment in patients.

Table 42. Parameters of the MoCA test, FAB test, RBMT-3 of the main and control groups of patients with efferent motor aphasia. 1st assessment

Parameter	Group				t-criteria	p level
	main	control	main	control		
	M		SD			
MoCA-test (score)	24,50	24,92	2,89	2,34	–0,56	0,580
FAB test(score)	15,92	15,92	1,60	1,18	0,02	0,987
Subscale «retelling of the story» RBMT-3	5,46	4,65	1,65	1,79	1,67	0,101

There were no differences in the "retelling of the story" subscale in the RBMT-3 test in the groups ($t=1.67$, $p>0.05$). The ratio of the "main vs control group" was 5.46 points vs 4.65 points, and the parameters indicated a pronounced narrowing of the volume of direct auditory-speech memory in patients with efferent motor aphasia of both groups.

Before the start of speech therapy, there were no differences in the state of regulatory processes between the groups ($t=0.02$, $p>0.05$). In the main group, the FAB test score was 15.92, and in the control group – 15.92 points, which corresponded to a mild degree of violations of regulatory processes.

In conclusion, the presentation of all data from 1st assessment of patients with efferent motor aphasia of the main and control groups should be noted that of all the assessed speech (including free and controlled associations, the speed of spontaneous speech), cognitive, executive and auditory perception parameters, the following *intergroup differences* were observed:

1) in the main group, a higher score was noted for the subscale "making up a story" of the MOR method;

2) in the main group, the coefficient of productivity of auditory and speech perception was higher than in the control;

3) lower rates of phonological controlled associations were observed in the main group;

4) in the main group, the frequency of categorical and visual associative links in free associations was higher.

Quantitative and qualitative e parameters of speech, auditory-speech perception, cognitive and regulatory functions of patients with efferent motor aphasia of the main and control groups after completion of the course of speech rehabilitation. 2nd assessment

The index of laterality, efficiency and productivity coefficient of auditory and speech perception. 2nd assessment

In patients with efferent motor aphasia, the type of speech therapy performed did not affect the profile of auditory-speech asymmetry. After the rehabilitation course, as before, there were no intergroup differences in the laterality index (t=0.15, p>0.05) (Table 43).

Table 43. Parameters of dichotic listening task of the main and control groups of patients with efferent motor aphasia. 2nd assessment

Parameter	Group				t-criteria	p level
	main	control	main	control		
	M		SD			
Index of laterality (Kpu)	–0,12	–0,15	0,63	0,67	0,15	0,884
Efficiency index (Ief)	51,73	36,32	23,21	22,52	**2,38****	0,021
Coefficient of productivity (Kpr)	29,75	22,80	5,70	9,66	**3,13****	0,003

Note: ** – p<0,01.

At the same time, differences in the auditory and speech perception effectiveness appeared between the groups, which did not exist before therapy. In the main group, compared to the control group, the number of erroneous responses significantly decreased (t=2.38, p=0.021). In the main group, the increase in Ief was 4.4 times higher than in the control group – 8.52 vs 1.92 units.

In the 2nd assessment of the main group, as before therapy, there was a higher index of auditory-speech perception productivity (t=3.13, p=0.003), and the increase in the parameter was 1.5 times higher than in the control group: 2.79 vs 1.92 words.

Thus, after completing the course of speech rehabilitation, in the absence of intergroup differences in the profile of auditory-speech laterality, the main group significantly exceeded the control group in terms of productivity and effectiveness of auditory-speech perception (Application 9, 10).

Quantitative parameters of speech The MOR score. The speed of spontaneous speech. 2nd assessment

In the absence of intergroup differences in the speed of spontaneous (t=1.27, p>0.05) and the index of impressive speech (t=1.71, p>0.05), in the main group, there was a more pronounced dynamics of oral speech recovery (t=2.40, p=0.020) and a higher MOR2 score (t=2.10, p=0.041) (Table 44).

Table 44. Parameters of the MOR, the speed of spontaneous speech in the main and control groups of patients with efferent motor aphasia (in points). 2nd assessment

Parameter	Group				t-ctiteria	p level
	main	control	main	control		
	M		SD			
Naming objects" subscale	27,75	27,44	2,82	3,01	0,37	0,710
"Naming verbs" subscale	26,33	24,10	3,45	4,85	1,88	0,066
"Phrasing" subscale	20,17	19,13	4,54	5,76	0,72	0,477
"Making up a story" subscale	13,05	6,68	5,39	5,05	**4,30*****	< 0,001
Expressive speech (five subscales total score)	112,61	101,32	14,93	18,26	**2,40****	0,020
Impressive speech (five subscales total score)	136,20	128,52	13,49	18,10	1,71	0,094
MOR_1 (score)	249,47	231,78	25,80	33,45	**2,10****	0,041
Speed of spontaneous speech	35,19	30,13	15,49	12,52	1,27	0,212

Note: ** – p<0,01, ***– p<0,001.

Before the course of speech rehabilitation, there were no differences in the score of MOR1 and index of expressive speech between the groups, except for the "making up a story" subscale. After that the parameters in the main group were higher than in the control. The subscale that determined the intergroup differences in the MOR2 score was the "making up a story" subscale (t=4.30, p<0.001). There were intergroup differences in favour of the higher score in the main group before the start of therapy. However, that did not affect the differences between groups according to the score of MOR1 and expressive speech. After therapy, the increase in the score in the main group on the "making up a story" subscale was 1.7 times ahead of the control: 2.07 vs 1.20. The score for "making up a story" is a qualitative and quantitative assessment of spontaneous speech

The score for making up a story is a qualitative and quantitative assessment of spontaneous monologue speech and is composed of the sum of marks for the length of phrases, syntactic and grammatical complexity of sentences and penalties for agrammatism, unproductive words, and verbal and literal paraphasias. The pronounced positive dynamics of this parameter in the main compared to the control group, the lexical and grammatical side of speech significantly improved in patients.

Quantitative and qualitative parameters of free and controlled associations. 2nd assessment

Free associations. Quantitative parameters. 2nd assessment

After the course of speech therapy, there were commensurate positive dynamics in the productivity of verbal associations in both groups (t=0.29, p>0.05) (Table 45). The ratio of productivity of associations "before vs after therapy" in the main group was 17.25 vs 20.34 (t=–2.71, p=0.01), and in the control group – 17.5 vs 19.88 (t=–4.53, p<0.001).

The intra-group dynamics of the verbal perseverations index had no intergroup differences (U=324.00, p>0.05), and were specified by a slight increase in the parameter in both the main (t=–1.67, p>0.05) and control groups (t=–1.73, p>0.05) (Table 45).

Table 45. Quantitative parameters of free associations of the main and control groups of patients with efferent motor aphasia. 2nd assessment

Parameter	Уровень	Group				U-criteria	p level
		main		control			
		frequency	%	frequency	%		
Verbal perseverations	high	0	0,00	0	0,00	324,00	0,19
	medium	0	0,00	0	0,00		
	low	2	6,09	0	0,00		
	zero	27	93,10	24	100,00		
	Z-criteria (p)	–1,67 (0,10)		–1,73 (0,08)			
Stability of the tempo of associations	high	14	48,28	9	37,50	241,50	0,04
	medium	5	17,24	15	62,50		
	low	4	13,79	0	0,00		
	zero	6	20,69	0	0,00		
	Z-criteria (p)	–3,74 (<0,001)		0,00 (1,00)		–	–
Productivity of associations	–	M	Me	M	Me	t-criteria	p level
	–	20,34	20,00	19,88	23,50	0,29	0,78
	t-criteria (p)	–2,71 (0,01)		–4,53 (<0,001)			
Flexibility of associations	–	4,90	5,00	4,13	3,50	1,67	0,10
	t-criteria (p)	–0,79 (0,43)		–3,30 (0,003)			

The dynamics of other quantitative parameters of free associations revealed a dependence on the type of speech therapy performed. The intergroup differences in the rehabilitation shift in the stability of the rate of free associations were significant (U=241.50, p=0.04). In the main group, the parameters increased (Z=–3.74, p<0.001), and in the control group, there were no positive dynamics (Z =0.00, p>0.05).

At the same time, the flexibility and semantic organization of the associative series did not change in the main group (respectively, t= –0.79, t=–1.28, p>0.05). On the contrary, in the control group, the parameters increased (respectively t=–3.30, p=0.003; t=–5.55, p<0.001). With traditional speech therapy, the number of semantic fields increased 1.5 times and by the end of therapy, the value of the parameter did not differ from the main group (t=1.67 p>0.05) (Table 46).

However, the semantic organization of the associative series in the control group remained lower (control vs main group 6.00 vs 9.00 (Me) (t=2.26, p=0.01). That indicated that in the control group, an increase in the number of semantic fields did not mean an increase in the length of semantic chains: the fields were small and short (Shipkova K.M., Dubinsky A.A., 2023).

Table 46. Qualitative parameters of free associations of the main and control groups of patients with efferent motor aphasia. 2nd assessment

Parameter	Level	Group				U-criteria	p level
		main		control			
		frequency	%	frequency	%		
Level of categorical semantics	high	14	48,28	3	12,50	10,62	0,01
	medium	9	31,03	9	37,50		
	low	5	17,24	12	50,00		
	zero	1	3,45	0	0,00		
	Z-criteria (p)	–0,74 (0,46)		–3,07 (0,001)			
Level of functional semantics	high	0	0,00	0	0,00	8,01	0,02
	medium	4	13,79	3	12,5		
	low	13	44,83	19	79,17		
	zero	12	41,38	2	8,33		
	Z-criteria (p)	0,00 (1,00)		–1,67 (0,10)			
Level of visual semantics	high	7	24,14	0	0,00	9,54	0,02
	medium	8	27,59	7	29,17		
	low	12	41,38	17	70,83		
	zero	2	6,90	0	0,00		
	Z-criteria (p)	–0,96 (0,33)		–1,27 (0,21)			
Semantic organization	–	M	Me	M	Me	t-criteria	p level
		9,21	9,00	6,54	6,00	2,66	0,01
	t-criteria (p)	–1,28 (0,21)		–5,55 (<0,001)			

Free associations. Quality parameters. 2nd assessment

Speech therapy in a modelling polysensory-enriched environment did not significantly affect the structural characteristics of the free associations' range of patients with efferent motor aphasia. Despite the increase in the number of cases of medium and high levels of categorical and visual semantics, there was no significant rehabilitation shift in the use of categorical (Z=–0.74, p>0.05) and visual strategies (Z=–0.96, p>0.05) (Table 46).

On the contrary, after a course of traditional speech therapy, a selective rehabilitation shift was observed. In the absence, as in the main group, of positive dynamics in the application of the visual strategy (Z=–1.27, p>0.05), the level of categorical semantics increased in it (Z=–3.07, p=0.001), but a high percentage of patients with a low level of use of this strategy did not eliminate intergroup differences in favour of the main group (χ2=10.62, p=0.01).

Figure 11. The levels of use of different types of semantic links in the free associations task in the main and control groups of patients with efferent motor aphasia. Parameters after the course of speech rehabilitation

Note: ОГ – main group, КГ – control group.

The picture was different concerning the use of a functional strategy. Against the background of insignificant intra-group dynamics ($Z=-1.67$, $p>0.05$), her index after therapy became higher than in the main group ($\chi2=8.01$, $p=0.018$). In the main group, as before therapy, patients rarely resorted to building functional verbal chains ($Z=0.00$, $p>0.05$), and after the rehabilitation course, the frequency of cases of ignoring this strategy increased two times, which was five times higher than the same parameter in the control group (Fig. 11).

Controlled phonological associations. Quantitative parameters.2nd assessment

Both approaches to rehabilitation (polysensory therapy and traditional speech therapy) equally contributed to a decrease in the frequency of verbal perseverations in phonological associations ($U=307.50$, $p>0.05$), which indicated an increase in speech regulatory control (Table 47). In the control group, the number of verbal perseverations decreased significantly ($Z=-3.00$, $p<0.001$), in the main group, the positive dynamics were within the boundaries of the trend ($Z=-1.90$, $p=0.05$).
Along with this, neither polysensory nor traditional therapy significantly affected the stability of the tempo of directed phonological associations.

There were no positive dynamics in this parameter either in the main group ($Z=-0.22$, $p>0.05$) or in the control groups ($Z=-0.78$, $p>0.05$), and there were no intergroup differences ($U=324.00$, $p>0.05$).

The only parameter that found a connection with the type of speech therapy was the productivity of directed associations. Unlike traditional therapy ($t=-1.00$, $p>0.05$), polysensory therapy increased the productivity of directed associations ($t=-4.74$, $p<0.001$). In the main group, which had lower productivity of controlled associations in 1st assessment compared to the control group, after therapy, there were no differences with the control group (9.00 words vs 9.00 words (Me), respectively) ($t=-1.31$, $p>0.05$).

Table 47. Quantitative and qualitative parameters of directional phonological associations of the main and control groups of patients with efferent motor aphasia. 2nd assessment

Parameter	Level	Group				U-criteria	p level
		main		control			
		frequency	%	frequency	%		
Verbal perseverations	high	0	0,00	0	0,00	324,00	0,19
	medium	0	0,00	0	0,00		
	low	2	6,90	0	0,00		
	zero	27	93,10	24	100,00		
	Z-criteria (p)	–1,90 (0,05)		–3,00 (<0,001)			
Stability of the tempo of associations	high	6	20,69	3	12,50	307,50	0,36
	medium	17	58,62	12	50,00		
	low	6	20,69	9	37,50		
	zero	0	0,00	0	0,00		
	Z-criteria (p)	–0,22 (0,83)		–0,78 (0,44)			
Level of alphabetic phonological strategy	high	24	82,76	22	91,73	315,00	0,32
	medium	3	10,34	2	8,31		
	low	2	6,90	0	0,00		
	zero	0	0,00	0	0,00		
	Z-criteria (p)	–0,97(0,33)		–1,90 (0,06)			
Level of syllabic phonological strategy	high	3	10,31	0	0,00	298,00	0,34
	medium	12	41,43	8	33,33		
	low	9	31,01	14	58,33		
	zero	5	17,22	2	8,33		
	Z-criteria (p)	–3,26 (0,001)		–1,80 (0,07)			
Productivity of associations	–	M	Me	M	Me	t-criteria	p level
		8,69	9,00	9,67	9,00	–1,31	0,20
	t-criteria(p)	–4,74 (<0,001)		–1,00 (0,33)			

Controlled phonological associations. Quality parameters. 2nd assessment

The qualitative parameters of phonological associations showed selective sensitivity to different types of speech therapy.

Patients of the main and control groups after the course of speech therapy, as before, resorted to the simultaneous use of letter and syllabic strategies (Table 47). There were no intergroup differences in these parameters (U=315.00, p=0.32; U=298.00, p=0.34, respectively), but the orientation and severity of intra-group dynamics were different (Fig. 12). Polysensory therapy increased the frequency of using a syllabic strategy, while traditional therapy increased the frequency of using a letter strategy. In the main group, the frequency of the syllabic strategy increased (Z=–3.26, p=0.001) and there were no dynamics in the letter strategy (Z=–0.97, p>0.05) (Table 47). In the control group, on the contrary, there were no positive dynamics in the syllabic strategy (Z=—1.80, p>0.05), and the positive dynamics in the letter strategy were within the boundaries of the trend (Z=–1.90, p=0.06).

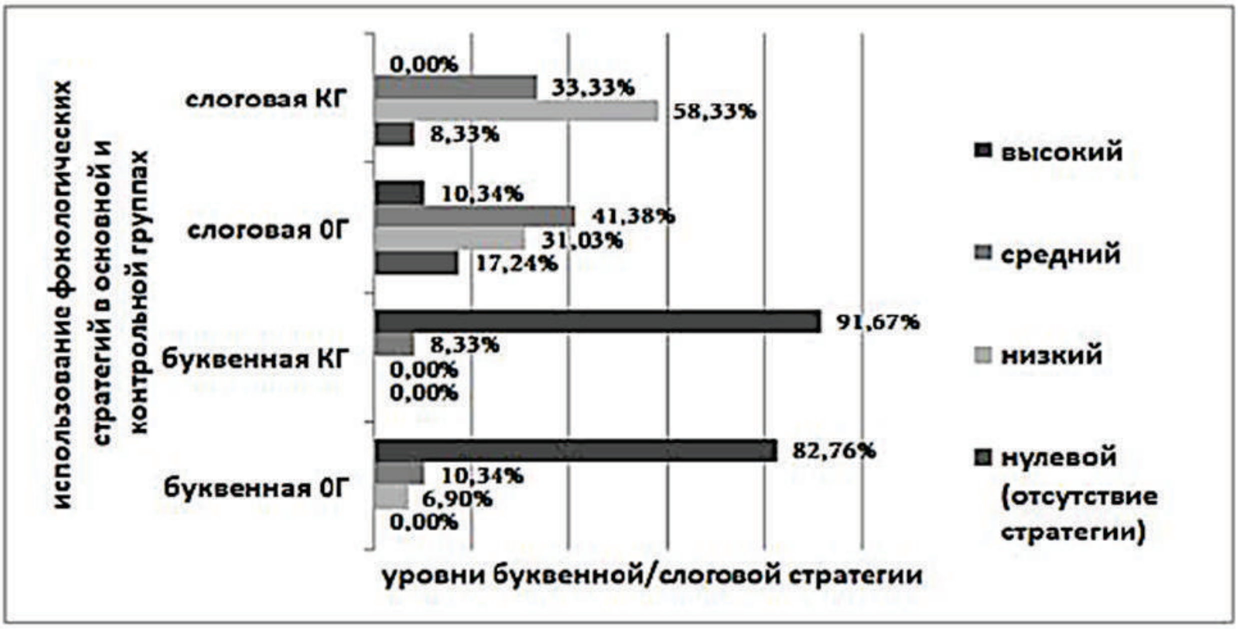

Figure 12. Strategies for word selection in phonological associations in the main and control groups of patients with efferent motor aphasia. Parameters after the course of speech rehabilitation

Note: ОГ – the main group, КГ – the control group.

The state of cognitive and regulatory functions.2nd assessment

The type of speech therapy did not affect the parameter of general cognitive functioning determined by the MoCA-test: there were no intergroup differences in the

MoCA test score (t=1.24, p>0.05) (Table 48). The ratio "the main group vs control group" was 25.81 points vs 25.00 points.

Table 48. The parameters of the MoCA test, FAB test, and RBMT-3 in the main and control groups of patients with efferent motor aphasia. 2[nd] assessment

Parameter	Group				t-criteria	p level
	main	control	main	control		
	M		SD			
MoCA-test (score)	25,81	25,00	2,64	1,89	1,24	0,223
FAB test(score)	17,00	16,21	0,80	1,28	**2,64****	0,011
Subscale «retelling of the story» RBMT-3	7,37	5,13	1,65	1,40	**5,16*****	<0,001

Note: ** – p<0,01, ***– p<0,001.

7.2.2. Dynamics of speech recovery in patients with acoustic-mnestic aphasia in a polysensory-enriched environment and during traditional speech therapy

Quantitative and qualitative parameters of speech, auditory-speech perception, cognitive and regulatory functions of patients with acoustic-mnestic aphasia of the main and control groups before speech rehabilitation. 1[st] assessment

Quantitative parameters of speech. The MOR score. The speed of spontaneous speech.1[st] assessment

At the start point of the speech rehabilitation course, there were no differences between the groups in the index of impressive (t=-0.28, p>0.05) and expressive speech (t=-1.10, p>0.05).). There were no intergroup differences in the MOR1 score (t=-1.18, p>0.05). However, the number of patients with a mild degree of aphasia was slightly higher in the control group. The ratio of "control vs main groups" was 233.88 points vs 222.93 points (the lower limit of the mild severity of aphasia is 230 points – author's note) (Table 49).

At the beginning of the rehabilitation course, the groups did not differ in the speed of coherent spontaneous speech (t=0.08, p>0.05). In the main group, the speed of oral speech was 39.05 words/min, and in the control – 38.70 words/min.

Thus, initially, patients with acoustic-mnestic aphasia of both groups had the same level of recovery of expressive, impressive speech and the speed of speech flow (Application 10).

Table 49. Parameters of the MOR method, the speed of spontaneous speech in the main and control groups of patients with acoustic-mnestic aphasia (in points). 1st assessment

Parameter	Group				t-criteria	p level
	main	control	main	control		
	M		SD			
1st assessment (before rehabilitation)						
Naming objects" subscale	25,98	26,50	3,86	3,25	–0,52	0,602
"Naming verbs" subscale	24,90	24,48	4,34	3,75	0,37	0,713
"Phrasing" subscale	18,29	20,37	5,12	5,91	–1,31	0,198
"Making up a story" subscale	10,26	10,48	4,73	6,91	-0,13	0,899
Expressive speech (five subscales total score)	102,19	107,33	16,24	16,68	–1,10	0,279
Impressive speech (five subscales total score)	120,74	122,33	20,16	20,19	–0,28	0,782
MOR_1 (score)	222,93	233,88	34,22	31,48	–1,18	0,244
Speed of spontaneous speech	39,05	38,70	16,38	14,87	0,08	0,938

Quantitative and qualitative parameters of free and controlled associations.1st assessment

Free associations. Quantitative parameters. 1st assessment

Before the start of speech therapy in both groups, there were no significant differences in the parameter of the semantic organization of the free-associative series (t=-1.92, p>0.05), productivity of associations (t=-0.50, p>0.05) and stability of the pace of associations (t=2.05, p>0.05) (Table 50).

Table 50. Quantitative parameters of free associations of the main and control groups of patients with acoustic-mnestic aphasia. 1st assessment

Parameter	Level	Group				χ^2 ctrteria	p level
		main		control			
		frequency	%	frequency	%		
Verbal perseverations	high	0	0,00	0	0,00	**11,12****	0,004
	medium	5	19,23	0	0,00		
	low	6	23,08	0	0,00		
	zero	15	57,69	20	100,00		
Stability of the tempo of associations	high	9	34,62	6	30,00	2,05	0,562
	medium	12	46,15	8	40,00		
	low	4	15,38	6	30,00		
	zero	1	3,85	0	0,00		
Flexibility of associations	–	M	Me	M	Me	t-criteria	p level
		4,42	4,00	2,95	3,00	**2,45****	0,018
Productivity of associations	–	21,08	22,00	21,95	25,50	–0,50	0,623

Note: ** – p<0,01.

In the main group, the number of semantic pairs in the free-associative series was 9.27, and in the control group – 12.05. The productivity of associations was 21.08 words/min, in the control group – 21.95 words/min. A low and medium level of stability of the association rate was typical for 61.53% of patients in the main and 70.00% of the control group.

Above it, the flexibility of the associative series was higher in the main group (t=2.45, p=0.018) and the frequency of verbal perseverations (t=11.12, p=0.004).

Free associations. Quality parameters. 1st assessment

The acoustic-mnestic aphasia patients of both groups used rarely visual and frequently made categorical verbal chains (Fig. 13). The vast majority of individuals in both groups (57.69% of the main and 70.00% of the control groups) showed low or zero visual semantics pairs (t=4.07, p>0.05) (Table 51).

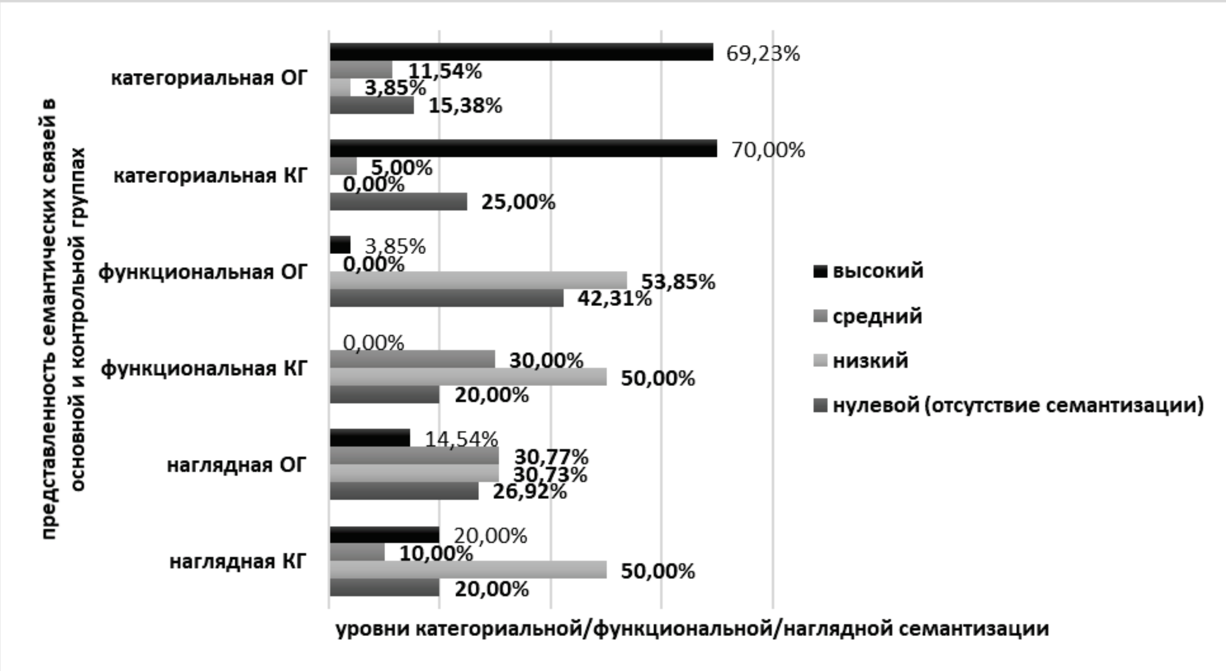

Figure 13. Levels of categorical, functional and visual links in the free associations task in the main and control groups of patients with acoustic-mnestic aphasia. Parameters before the speech rehabilitation course

Note: ОГ - the main group, КГ - the control group.

The only qualitative difference between the two groups was a higher percentage of cases with non-use (ignoring) of the functional strategy by patients of the main group (t=10.33, p=0.016).

Summing up the presentation of quantitative and qualitative parameters of free associations, it should be noted that by the beginning of rehabilitation, the main group differed from the control group in greater mobility of associations, greater frequency of verbal perseverations and greater frequency of non-use of a functional strategy in free verbal association.

Table 51. Qualitative parameters of free associations of the main and control groups of patients with acoustic-mnestic aphasia. 1st assessment

Parameter	Level	Group				χ^2 criteria	p level
		main		control			
		frequency	%	frequency	%		
Level of categorical semantics	high	18	69,23	14	70,00	1,86	0,602
	medium	3	11,54	1	5,00		
	low	1	3,85	0	0,00		
	zero	4	15,38	5	25,00		
Level of functional semantics	high	1	3,85	0	0,00	**10,33****	0,016
	medium	0	0,00	6	30,00		
	low	14	53,85	10	50,00		
	zero	11	42,31	4	20,00		
Level of visual semantics	high	3	11,54	0	0,00	4,07	0,254
	medium	8	30,77	6	30,00		
	low	8	30,77	10	50,00		
	zero	7	26,92	4	20,00		
Semantic organization	–	M	Me	M	Me	t-criteria	p level
	–	9,27	10,00	12,05	14,50	–1,92	0,061

Note: ** – p<0,01.

At the same time, 2/3 of the individuals in both groups revealed a high level of categorical semantics (t=1.86, p>0.05). It was just noted above that the structural parameters of the verbal associative series represent qualitative characteristics of the process of verbal associations, which did not allow to fully equalize the samples according to these parameters before the start of the study. Therefore, when assessing the rehabilitation shift, both inter-group comparisons and studies of intra-group dynamics of parameters were carried out.

Quantitative and qualitative parameters of directional phonological associations. 1st assessment

Controlled phonological associations. Quantitative parameters.1st assessment

Patients with acoustic-mnestic aphasia of the main and control groups did not differ in the productivity of directed phonological associations (12.04 vs 9.30 words/min, respectively) ($t=1.90$, $p>0.05$) (Table 52).

Table 52. Quantitative and qualitative parameters of controlled phonological associations of the main and control groups of patients with acoustic-mnestic aphasia. 1st assessment

Parameter	Level	Group				t-criteria	p level
		main		control			
		frequency	%	frequency	%		
Verbal perseverations	high	0	0,00	0	0,00	2,88	0,237
	medium	3	11,54	3	15,00		
	low	4	15,39	7	35,00		
	zero	19	73,08	10	50,0		
Stability of the tempo of associations	high	11	42,31	11	55,00	3,50	0,321
	medium	10	38,46	8	40,00		
	low	4	15,38	0	0,00		
	zero	1	3,85	1	5,00		
Level of alphabetic phonological strategy	high	11	42,31	5	25,00	3,76	0,153
	medium	7	26,92	11	55,0		
	low	8	30,77	4	20,00		
	zero	0	0,00	0	0,00		
Level of syllabic phonological strategy	high	3	11,54	0	0,00	3,16	0,368
	medium	5	19,23	4	20,00		
	low	8	30,77	8	40,00		
	zero	10	38,46	8	40,00		
Productivity of associations	–	M	Me	M	Me	1,90	0,064
		12,04	13,00	9,30	10,00		

Both groups had a commensurate stability of the tempo of association (t=3.50, p>0.05). The vast majority of patients in the main (80.77%) and control groups (95.00%) revealed medium or high level, which indicated rare stops during naming consonant words.

The groups did not differ in the frequency of verbal perseverations (t=2.88, p>0.05). 73.08% of patients in the main and 50.00% of the control groups had no verbal perseverations.

High parameters of productivity, stability and low rates of verbal perseverations in both groups indicated that at the start point of the rehabilitation course, patients of both groups had the same level of speech recovery concerning active vocabulary and short-term auditory memory.

Controlled phonological associations. Quality parameters. 1st assessment

There were no differences between the main and control groups of acoustic-mnestic aphasia patients in the levels of alphabetic (t=3.76, p>0.05) and syllabic strategies (t=3.16, p>0.05) (Fig.14).

Patients of both groups often used both strategies at the same time, but the syllabic strategy was equally rarely resorted to. The ratio of the "main vs control group" in the frequencies of the medium and high levels of the alphabetic strategy was 69.23 vs 80.00%. The ratio of the "main vs control group" in the frequencies of the low and zero levels of the syllabic strategy is 69.23 vs 80.00%, respectively.

Thus, by the start point of speech therapy, patients with acoustic-mnestic aphasia of both groups in the phonological controlled associations task often used a letter-based word selection strategy and rarely a syllabic one.

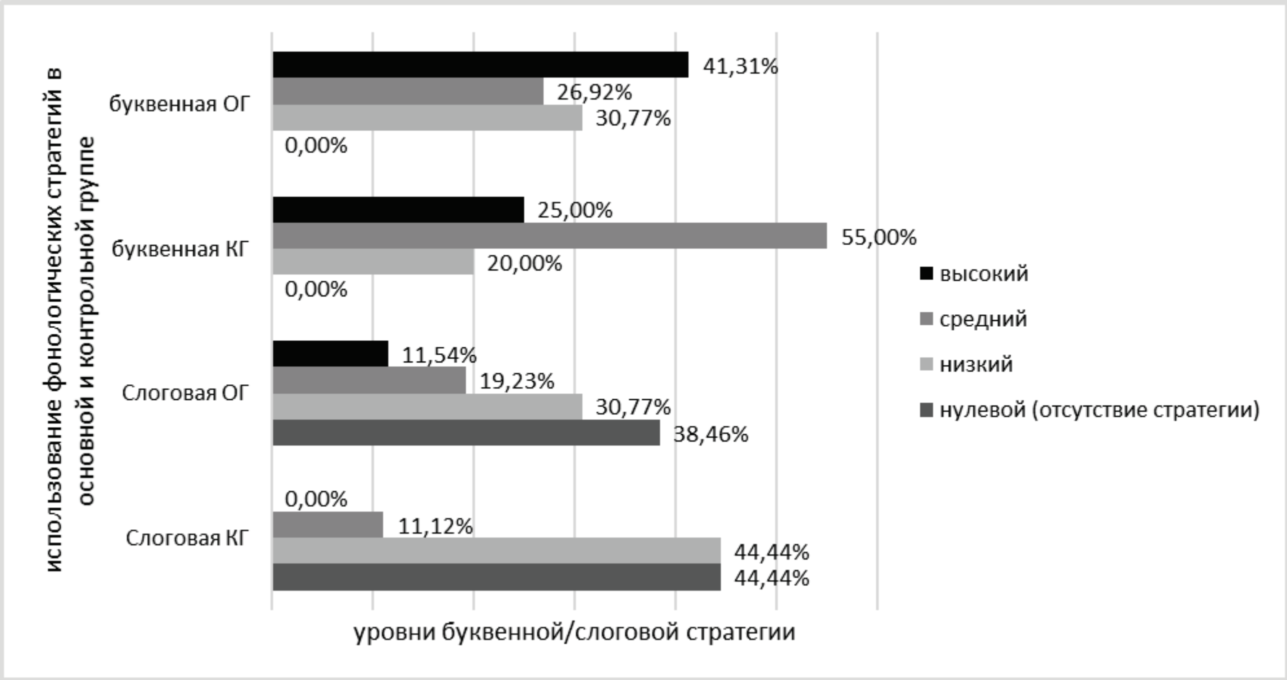

Figure 14. Strategies for word selection in phonological associations in the main and control groups of patients with acoustic-mnestic aphasia. Before the speech rehabilitation course

Note: ОГ – the main group, КГ – the control group.

The index of laterality, efficiency and productivity coefficient of auditory and speech perception. 1st assessment

All the parameters of dichotic listening did not reveal significant differences between the main and control groups.

There was the same ratio of patients with left and right ear advantages, in the absence of intergroup differences in the laterality index (t=–1.53, p>0.05) (Table 53).

The groups did not differ in the productivity of auditory and speech perception (t=0.97, p>0.05) (Table 53). The ratio of the "main vs control group" in terms of the number of words played was 21.13 vs 18.68 words.

At the beginning of speech rehabilitation, the groups also did not differ in terms of efficiency index. That meant that patients in both groups made a single-order number of erroneous responses (t=1.69, p>0.05).

Table 53. Parameters of dichotic listening in the main and control groups of patients with acoustic-mnestic aphasia. 1st assessment

Parameter	Group				t-criteria	p level
	main	control	main	control		
	M		SD			
1st assessment (before rehabilitation)						
Index of laterality (Kpu)	–0,53	–0,23	0,63	0,74	–1,53	0,133
Efficiency index (Ief)	45,41	28,74	31,05	36,97	1,69	0,097
Coefficient of productivity (Kpr)	21,13	18,68	8,56	9,17	0,97	0,338

The state of cognitive and regulatory functions. 1st assessment

In the main and control groups, there was the same level of regulatory functions decrease (t=1.21, p>0.05) (Table 54). In the main group, the FAB test score was 15.43, in the control group – 15.90 points

Table 54. The parameters of the MoCA test, FAB test, and RBMT-3 in the main and control groups of patients with acoustic-mnestic aphasia. 1st assessment

Parameter	Group				t-criteria	p level
	main	control	main	control		
	M		SD			
1st assessment (before rehabilitation)						
MoCA-test (score)	22,57	20,57	3,49	2,37	**2,45****	0,018
FAB test(score)	15,43	15,90	1,08	1,54	–1,21	0,232
Subscale «retelling of the story» RBMT-3	4,50	5,77	1,85	2,13	**–2,20****	0,032

Note: ** – p<0,01.

Along with the same level of executive functions, the groups differed in the severity of cognitive deficits (t=2.45, p=0.018). It was less pronounced in the main than in the control group. The ratio of the "main vs control group" in the MoCA test was 22.57 vs 20.57 points.

Along with the same level of executive function damage, the groups differed in the severity of cognitive deficits (t=2.45, p=0.018). It was less pronounced in the main than in the control group. In the MoCA test the ratio of the "main vs control group" was 22.57 vs 20.57 points. Since the severity of speech disorders rather than the severity of general cognitive deficits was the main point in groups' formation, the equalization of groups according to this parameter went beyond the scope of the tasks set in the study.

Despite a lower score on the MoCA the control group was ahead of the main one in the "retelling of the story" subscale of the RBMT-3 test (t=-2.20, p=0.032). The main group initially had a smaller short-term memory volume.

All the data of the 1st assessment of patients with acoustic-mnestic aphasia of the main and control groups notes that speech tasks, (including free and controlled associations, the speed of spontaneous speech), cognitive, regulatory and auditory perception parameters observed some intergroup differences:

1) in the main group, the flexibility of the free-associative series was higher, the frequency of using a functional strategy was lower, and the frequency of verbal perseverations was higher;

2) the main group had lower scores on the "retelling of the story " subscale of the RBMT-3 test;

3) the main group had higher scores on the MoCA test.

As in other cases, when there were initial differences between groups in several parameters. Therefore, in the 2nd assessment to assess the rehabilitation shift intergroup differences and intra-group dynamics were analyzed.

Quantitative and qualitative parameters of speech, auditory-speech perception, cognitive and regulatory functions of patients with acoustic-mnestic aphasia of the main and control groups after completion of the course of speech rehabilitation. 2nd assessment

The index of laterality, efficiency and productivity coefficient of auditory and speech perception. 2nd assessment

The type of speech therapy did not affect the dynamics of the parameters "laterality index" (t=–1.84, p>0.05) and "coefficient of productivity " (t=0.88, p>0.05) of both groups and, as in the 1st assessment, there were no differences in parameters between the groups (Table 55).

Table 55. Parameters of the dichotic listening task of the main and control groups of patients with acoustic-mnestic aphasia. 2nd assessment

Parameter	Group				t-criteria	p level
	main	control	main	control		
	M		SD			
Index of laterality (Kpu)	–0,52	–0,17	0,64	0,71	–1,84	0,072
Efficiency index (Ief)	52,41	35,51	31,23	28,18	**2,02****	0,049
Coefficient of productivity (Kpr)	24,78	22,50	8,47	9,59	0,88	0,386

Note: ** – p<0,01.

At the same time, speech rehabilitation in a polysensory-enriched environment increased the Ief of auditory-speech perception, and in the main group after the speech therapy course, its parameter became 1.5 times higher than in the control group (t=12.02, p=0.049). The auditory-speech perception in the main group increased, and the patients were less likely to make mistakes in the dichotic listening task.

Thus, the type of speech therapy performed had a selective effect on the parameters of auditory-speech perception in patients with acoustic-mnestic aphasia. Traditional speech therapy did not affect any of the studied parameters. Speech therapy in a polysensory-enriched environment did not change the vector of auditory-speech asymmetry and the productivity of speech perception but increased its effectiveness (Application 11).

Quantitative parameters of speech. The MOR score. The speed of spontaneous speech. 2nd assessment

Both groups of patients with acoustic-mnestic aphasia noted the same severity of positive dynamics of speech recovery (t=0.10, p>0.05). The ratio of the "main vs control group" according to the MOR2 score was 243.28 points vs 242.44 points, respectively (Table 56).

Table 56. Parameters of the MOR method, the speed of spontaneous speech in the main and control groups of patients with acoustic-mnestic aphasia. 2nd assessment

Parameter	Group				t-criteria	p level
	main	control	main	control		
	M		SD			
Naming objects" subscale	25,98	27,88	3,86	2,05	**–2,29****	0,026
"Naming verbs" subscale	24,90	25,58	4,34	3,17	–0,65	0,522
"Phrasing" subscale	18,38	21,58	4,89	5,77	**–2,07****	0,044
"Making up a story" subscale	10,35	11,34	4,56	6,45	–0,60	0,548
Expressive speech (five subscales total score)	102,19	105,03	16,24	22,56	–0,49	0,624
Impressive speech (five subscales total score)	128,95	129,95	19,22	16,84	–0,20	0,845
MOR_1 (score)	243,28	242,44	33,63	28,22	0,10	0,924
Speed of spontaneous speech	54,71	37,23	19,39	11,41	**4,05*****	<0,001

Note: ** – p<0,01, *** – p<0,001.

The vector that determined the positive rehabilitation shift was different within the groups. In the main group, the dynamics of regression of violations was ahead of the control group in the "naming of objects" subscale (t=–2.29, p=0.026). The control group, in turn, was ahead of the main group in the "phrasing" subscale (t=–2.07, p=0.044). The absence of significant intergroup differences in the MP2 score indicated that in comparison with the speech therapy in a polysensory-enriched environment, the traditional approach did not achieve a pronounced rehabilitation shift in speech recovery of the patients with acoustic-mnestic aphasia. The increase in the "naming of objects" subscale was not sufficient to form intergroup differences in the score of MOR2.

The speech therapy in a polysensory-enriched environment created an activating effect on the flexibility of speech processing (t=4.05, p<0.001). In the main group, the rate of spontaneous speech was 1.5 times higher than that of the control: 54.71 words/min and 37.23 words/min, respectively. The patients with acoustic-mnestic aphasia in the main group differed from ones with efferent motor aphasia in the same group, who after the rehabilitation course showed no differences with those of the control group in the speed of spontaneous speech.

Quantitative and qualitative parameters of free and controlled associations. 2nd assessment

Free associations. Quantitative parameters. 2nd assessment

In the main (t=–3.92, p=0.001) and control groups (t=–2.14, p=0.046), speech therapy significantly increased the productivity of free associations and, at the 2nd assessment, the rehabilitation shift in this parameter had no intergroup differences (t=0.71, p>0.05) (Table 57). The increase in the productivity of associations in the main group was 4.46 words (1st vs 2nd assessment – 25.54 words vs 21.08 words), in the control group – 2.25 words (1st vs 2nd assessment – 4.20 words vs 21.95 words) (Table 57).

Table 57. Quantitative parameters of free associations in the main and control groups of patients with acoustic-mnestic aphasia. 2nd assessment

Parameter	Level	Group				χ2-criteria	p level
		main		control			
		frequency	%	frequency	%		
Verbal perseverations	high	0	0,00	0	0,00	5,22	0,074
	medium	3	11,54	0	0,00		
	low	4	15,38	8	40,00		
	zero	19	73,08	12	60,00		
	t-criteria(p)	1,69 (0,103)		1,00 (0,317)			
Stability of the tempo of associations	high	7	26,92	6	30,00	2,89	0,408
	medium	12	46,51	5	25,00		
	low	1	7,69	4	20,00		
	zero	5	19,23	5	25,00		
	t-criteria(p)	**–2,18**** (0,030)		**–2,63**** (0,009)		–	–
Productivity of associations	–	M	Me	M	Me	t-criteria	p level
		25,54	27,00	24,20	26,00	0,71	0,479
	t-criteria(p)	**–3,92*****(0,001)		**–2,14****(0,046)			
Flexibility of associations	–	4,42	5,00	4,35	5,00	0,16	0,873
	t-criteria(p)	**5,20***** (<0,001)		**7,06***** (<0,001)			

Note: ** – p<0,01, *** – p<0,001.

After the rehabilitation course, the previously existing differences between the groups in the frequency of verbal perseverations regressed (t=5.22, p>0.05). That was explained not by an improvement in the parameter in the main group (it remained at the same level) but by a decrease in the parameter in the control group (Table 57).

An assessment of the intra-group dynamics of the "semantic organization" parameter of the associative series showed that the methodological approach to speech therapy did not significantly affect the parameters of the main group (t=-0.88, p>0.05) and control groups (t=0.64, p>0.05) and intergroup differences (t=-0.52, p>0.05) (Table 58).

Table 58. Qualitative parameters of free associations of the main and control groups of patients with acoustic-mnestic aphasia. 2nd assessment

Parameter	Level	Group				χ2-criteria	p level
		main		control			
		frequeny	%	frequency	%		
Level of categorical semantics	high	22	86,62	17	85,00	6,98	0,073
	medium	3	6,52	0	0,00		
	low	0	0,00	3	15,00		
	zero	1	3,85	0	0,00		
	t-criteria (p)	**2,15***(0,029)		1,85 (0,412)			
Level of functional semantics	high	2	7,69	0	0,00	**12,06****	0,007
	medium	9	34,62	0	0,00		
	low	3	11,54	7	35,00		
	zero	12	46,15	13	65,00		
	t-critetia (p)	1,52 (0,093)		**2,84**** (0,008)			
Level of visual semantics	high	4	15,38	6	30,00	7,09	0,069
	medium	7	26,92	1	5,00		
	low	10	38,46	12	60,00		
	zero	5	19,23	1	5,00		
	t-criteria (p)	1,31 (0,214)		**2,19*** (0,039)			
Semantic organization	–	M	Me	M	Me	t-criteria	p level
	–	10,62	17,00	11,50	11,00	–0,52	0,606
	t-criteria (p)	–0,88 (0,385)		0,64 (0,531)			

Note: * – p<0,05, ** – p<0,01.

After therapy, there were no differences in association mobility between the groups (t=0.16, p>0.05) with pronounced intra-group dynamics in both the main group (t=5.20, p<0.001) and the control group (t=0.06, p<0.001).

The of growth of associative flexibility in the main and control groups and the same rate of semantic organization of the free verbal series indicated an increase in the number of semantic fields while maintaining the same length of verbal associative chains.

Free associations. Quality parameters. 2nd assessment

In the 2nd assessment, there were no intergroup differences in the level of categorical (χ2 =6.98, p>0.05) and visual (χ2=7.09, p>0.05) semantics. At the same time, the intergroup difference was revealed concerning functional semantics in the free-associative series ($\chi2=12.06$, $p=0.007$), which could explain by the different nature of the intra-group dynamics of parameters during different types of speech therapy (Fig. 15).

In the main group, the frequency of a high level of categorical semantics (t =2.15, p=0.029) significantly increased compared to the parameter before rehabilitation, in the absence of positive dynamics in the use of functional (t=1.52, p>0.05) and visual (t=1.31, p>0.05) strategies (Table 58).

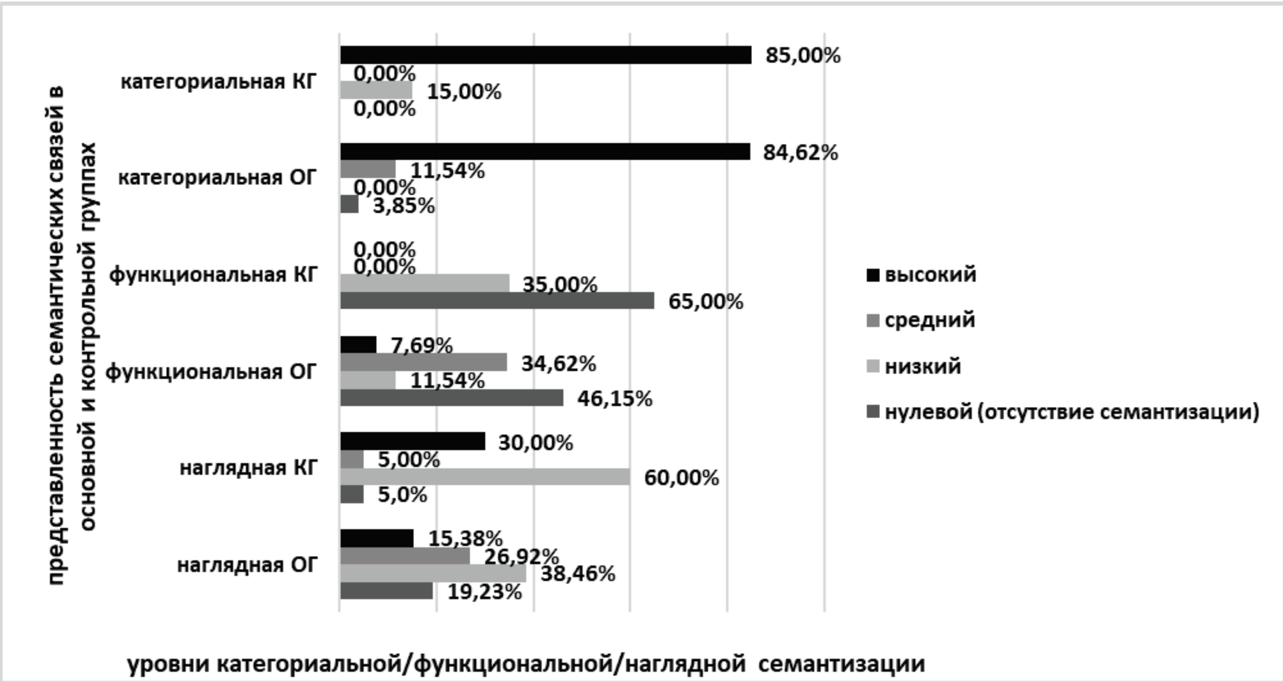

Figure 15. Levels of categorical, functional and visual links in the free associations task in the main and control groups of patients with acoustic-mnestic aphasia. Parameters after the speech rehabilitation course

Note: ОГ - the main group, КГ - the control group.

In the control group, there was also a selective rehabilitation shift in the structural characteristics of the associative series – the frequency of functional strategy decreased (t=2.84, p=0.008) was observed in the main group, whose parameters did not significantly change. That explains the appearance of intergroup differences in the

2nd assessment. In the control group, the frequency of the visual strategy (t=2.19, p =0.039) also increased.

Concerning the quantitative parameters of free associations, a certain generality of the therapeutic effects of different methodological approaches to speech restoration in patients with acoustic-mnestic aphasia is noticeable: 1) during speech therapy, the pace, productivity and mobility of free associations increased; 2) the parameters "semantic organization" of the associative series and "level of verbal perseverations" had a slight positive dynamic during speech rehabilitation.

The structural characteristics of the free-associative series in the main and control groups had a different vector of positive dynamics.

A distinctive feature of the main group was the categorical structuring strengthening. That distinguished the patients with acoustic-mnestic aphasia from those with efferent motor aphasia in the same group and the control group patients, who revealed no positive dynamics.

The patients with acoustic-mnestic aphasia in the control group, in contrast to the main one, were characterized by an increase in the frequency of using visuals and a decrease in the frequency of functional strategy during speech therapy.

Controlled phonological associations. Quantitative parameters. 2nd assessment

Speech rehabilitation in a polysensory-enriched environment (Z=–0.71, p>0.05) and traditional speech therapy (Z=0.010, p>0.05) did not have a significant effect on the level of verbal perseveration but had a selective effect on the stability of the rate of controlled associations (Table 59).

In the main group, the parameters decreased (Z=–2.18, p=0.030), and in the control group, they increased (Z=–2.62, p=0.009), which led to the appearance of previously unnoticed intergroup differences (t=15.04, p=0.001).

Table 59. Quantitative and qualitative parameters of controlled phonological associations of the main and control groups with acoustic-mnestic aphasia. 2nd assessment

Parameter	level	Group				t-criteria	p level
		main		control			
		frequency	%	frequency	%		
Verbal perseverations	high	0	0,00	0	0,00	1,78	0,411
	medium	1	3,85	3	15,00		
	low	10	38,46	7	35,00		
	zero	15	57,69	10	50,00		
	Z-criteria (p)	–0,71 (0,477)		0,00 (1,000)			
Stability of the tempo of associations	high	4	15,38	13	65,00	**15,04*** **	0,001
	medium	13	50,00	7	35,00		
	low	9	34,62	0	0,00		
	zero	0	0,00	0	0,00		
	Z-criteria (p)	**–2,18*** (0,030)		**–2,62**** (0,009)			
Level of alphabetic phonological strategy	high	15	57,69	0	0,00	**17,76*** **	<0,001
	medium	8	30,77	17	85,00		
	low	3	11,54	3	15,00		
	zero	0	0,00%	0	0,00		
	Z-criteria (p)	– 0,17 (0,867)		–0,67(0,503)			
Level of syllabic phonological strategy	high	3	11,54	0	0,00	**10,28***	0,016
	medium	7	26,92	3	15,00		
	low	11	42,31	17	85,00		
	zero	5	19,23	0	0,00		
	Z-criteria (p)	–0,904 (0,366)		**–2,50**** (0,001)			
Productivity of associations	–	M	Me	M	Me	t-criteria	p level
		12,81	12,00	10,90	11,00	**2,04***	0,048
	Z-criteria (p)	–1,19 (0,233)		**–2,99**** (0,003)			

Note: * – p<0,05, ** – p<0,01.

The comparatively higher number of pauses made by the main group when selecting words was accompanied by a higher productivity index of the directed associative series (t=2.04, p=0.048). After the speech therapy course, the productivity of phonological associations in the main group was 12.81 words/min, and in the control group – 10.90 words/min.

Controlled phonological associations. Quality parameters. 2nd assessment

After the course of polysensory and traditional speech rehabilitation, as before, patients used both letter and syllabic strategies at the same time when selecting phonological associations. At the same time, there was a difference between the groups – the main group began to resort to a verbal strategy more often (t=10.28, p=0.016) (Table 59). In it, the frequency of occurrence of the average level increased 1.4 times and the frequency of occurrence of the zero level of the syllabic strategy decreased two times (Fig. 16). The absolute majority of patients in the control group, despite the positive dynamics of this parameter (Z=–2.50, p=0.001), the stability of the pace of associations.

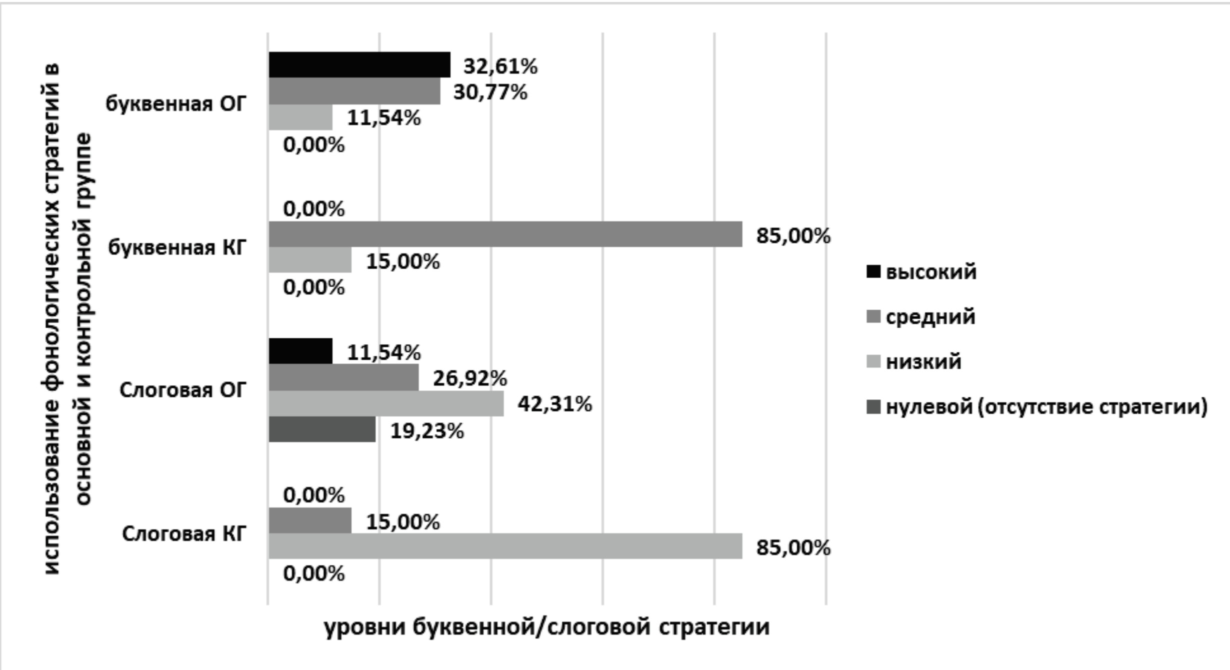

Figure 14. Strategies for word selection in phonological associations in the main and control groups of patients with acoustic-mnestic aphasia. After the speech rehabilitation course

Note: ОГ – the main group, КГ – the control group.

Summing up the results of quantitative and qualitative parameters of controlled phonological associations of patients with acoustic-mnestic aphasia, both approaches to speech therapy of aphasic disorders did not have a significant effect on the level of verbal perseverations but had different influence on the stability of their tempo, productivity and word selection strategies.

Speech therapy in a polysensory-enriched environment reduced the stability of the tempo of controlled associations and increased the productivity and frequency of using a complex phonological strategy – syllabic.

Patients of the control group showed lower parameters of productivity of phonological associations and the level of syllabic strategy, but higher parameters had a low level of syllabic strategy.

The state of cognitive and regulatory functions.2nd assessment

There were no intergroup differences in the parameters of regulatory functions ($t=0.04$, $p>0.05$). That was explained by their primary preservation in acoustic-mnestic aphasia syndrome (Table 60). The influence of the type of speech therapy on the cognitive functioning of patients with acoustic-mnestic aphasia revealed intergroup differences ($t=4.26$, $p<0.001$). In the main group, the MoCA test score was 24.19 points, and in the control one – 20.93 points. Concerning the 1st assessment score, the increase was 1.62 points, in the control group – 0.36 points.

After the therapy, the cognitive state in the main group was within the limits of the adult norm, and the control group indicated a slight cognitive decline.

Pronounced intergroup differences revealed the parameters of auditory and speech memory. Before the therapy, the main group patients had lower verbal memory scores, and the ratio "main group vs control group" was 5.77 points vs 4.50 points. After the therapy, there were no intergroup differences ($t=1.76$, $p>0.05$), and the ratio was already 6.88 points vs 5.82 points. By the end of the therapy, the main group observed an increase in short-term verbal memory of 2.38 points. The control group showed slight negative dynamics (-0.05 points).

Table 60. The parameters of the MoCA test, FAB test, RBMT-3 in the main and control groups of patients with acoustic-mnestic aphasia. 2nd assessment

Parameter	Group				t-criteria	p level.
	main	control	main	control		
	M		SD			
MoCA-test (score)	24,19	20,93	3,33	2,13	**4,26*** **	<0,001
FAB test(score)	16,38	16,37	1,32	1,33	0,04	0,970
Subscale «retelling of the story» RBMT-3	6,88	5,82	2,23	2,04	1,76	0,084

Note: *** – p<0,001.

Thus, speech therapy in a multisensory-enriched environment improved general cognitive functioning and auditory-speech memory of patients with acoustic-mnestic aphasia.

7.2.3. The effect of the severity of expressive speech disorders on the rehabilitation shift in patients with aphasia during speech therapy in a modelling polysensory-enriched environment and with a traditional approach to speech therapy

The study analyzed the comparative effectiveness of speech recovery in aphasia patients, who differed in the initial parameter of expressive speech, regardless of the type of aphasic disorder. That allowed us to evaluate the influence of a methodological approach to speech rehabilitation on the rehabilitation shift in patients with different baselines of expressive speech, regardless of what aphasia type the participants had.

For this purpose, the main and control groups were quartilized according to the score of expressive speech in 1st assessment. After this, each group was split into two subgroups of the 50th percentile. Subgroup 1 of the main and control groups included patients of quartiles 1 and 2 – patients with a low score of expressive speech (≤106.50 points). Patients of the 3rd and 4th quartiles formed subgroup 2 – patients with a high score of expressive speech (>106.50 points).

Characteristics of speech and auditory perception parameters of subgroups 1 and 2 of the main and control groups. 1st assessment

Subgroup 1 consisted of patients with moderate aphasia (160-230 points). The average score of MOR1 in the main group was 207.57 points (Table 61), and in the control – 204.09 points (Table 62). Subgroup 2 of both groups included patients with mild-severity of speech disorders (author's note: mild aphasia – >230 points). The average MOR2 score in the main group was 251.62 points, in the control group – 254.52 points.

Table 61. Parameters of speech and auditory perception in patients of subgroups 1 and 2 of the main group. 1st assessment

Parameter	Subgroup 1		Subgroup 2		t-criteria	p level
	M	SD	M	SD		
Expressive speech (five subscales total score)	90,11	13,02	115,60	6,07	**–8,66*** **	<0,0001
Impressive speech (five subscales total score)	115,52	20,58	136,02	10,36	**–4,34*** **	<0,0001
MOR_1 (score)	207,57	28,19	251,62	11,85	**–7,04*** **	<0,0001
Free associations (productivity)	15,74	4,63	20,29	5,70	**–3,00** **	0,004
Controlled associations (productivity)	7,83	9,75	5,08	4,90	–1,32	0,193
Speed of spontaneous speech	29,61	38,13	13,10	16,08	**–1,99* **	0,053
Index of laterality (Kpu)	–0,57	–0,16	0,56	0,65	**–2,35* **	0,023
Efficiency index (Ief)	50,05	38,69	30,27	23,47	1,44	0,156
Coefficient of productivity (Kpr)	23,44	8,81	25,10	6,67	–0,73	0,469

Note: * – p<0,05, ** – p<0,01, *** – p<0,01.

In the main and control groups, *the differences between the subgroups had several unique and distinctive features*. Some common features were the following:

1) subgroup 2 of both groups characterized by higher rates of spontaneous speech, productivity of free associations and greater preservation of impressive speech;

2) subgroups 1 and 2 had no differences in the parameters of the index of efficiency and productivity of auditory perception. That indicated that patients with high and low scores of expressive speech of both groups in the dichotic listening task reproduced a single-order number of words and made errors.

Table 62. Parameters of speech and auditory perception in patients of subgroups 1 and 2 of the control group. 1st assessment

Parameter	Subgroup 1		Subgroup 2		t-criteria	p level
	M	SD	M	SD		
Expressive speech (five subscales total score)	87,85	10,91	118,30	9,63	**–10,84*** **	<0,0001
Impressive speech (five subscales total score)	114,18	20,28	131,60	13,78	**–3,66*** **	0,001
MOR_1 (score)	204,09	25,29	254,52	16,23	**–8,64*** **	<0,0001
Free associations (productivity)	15,57	6,14	20,69	5,52	**–3,22** **	0,002
Controlled associations (productivity)	8,32	3,40	10,15	3,17	**–2,04* **	0,046
Speed of spontaneous speech	27,07	10,61	41,12	14,99	**–4,00*** **	<0,0001
Index of laterality (Kpu)	–0,27	0,73	–0,13	0,66	–0,74	0,462
Efficiency index (Ief)	27,88	34,20	35,08	33,76	–0,67	0,504
Coefficient of productivity (Kpr)	17,87	8,56	21,57	8,90	–1,56	0,125

Note: * – p<0,05, ** – p<0,01, *** – p<0,001.

The distinctive features were the following:

1) the subgroups in the main group differed in the index of laterality. Subgroup 2 showed a higher proportion of patients with the right ear advantage than Subgroup 1 – with the left ear advantage (t=–2.35, p=0.023) (Table 61). That differences were not observed in the control group (t=–0.74, p>0.05) (Table 62).

2) in the control group, the subgroups differed in the productivity of controlled associations (t=–2.04, p=0.046), which was not revealed in the main group (t=–1.32, p>0.05).

Dynamics of speech and auditory perception parameters in patients with initially low and high scores of expressive speech during speech rehabilitation in a modelling polysensory-enriched environment and traditional speech therapy

Speech therapy in a polysensory-enriched environment and traditional speech therapy had a positive effect on the dynamics of most speech parameters, and polysensory therapy and individual parameters of auditory and speech perception (Fig.17, 18).

The common features in the rehabilitation shift in the intra-group dynamics of speech parameters of both groups were as follows:

1) there were differences between subgroups in the severity of violations of expressive speech at all levels: words, phrases, text;

2) there were differences in the severity of violations of impressive speech;

3) subgroups 1 and 2 in the main and control groups continued to differ in the MOR2 score;

4) differences between subgroups in the productivity of free associations persisted.

Thus, patients of the subgroups with a high score of expressive speech who underwent speech therapy in a polysensory-enriched environment and traditional speech therapy continued to outperform the subgroup with a low score of expressive speech in terms of subject and verbal nomination parameters, story composition, expressive and impressive speech score, and productivity of free associations.

Concerning the parameters of auditory-speech perception, specific features of the rehabilitation shift were noted, which were related to the methodological approach to speech recovery.

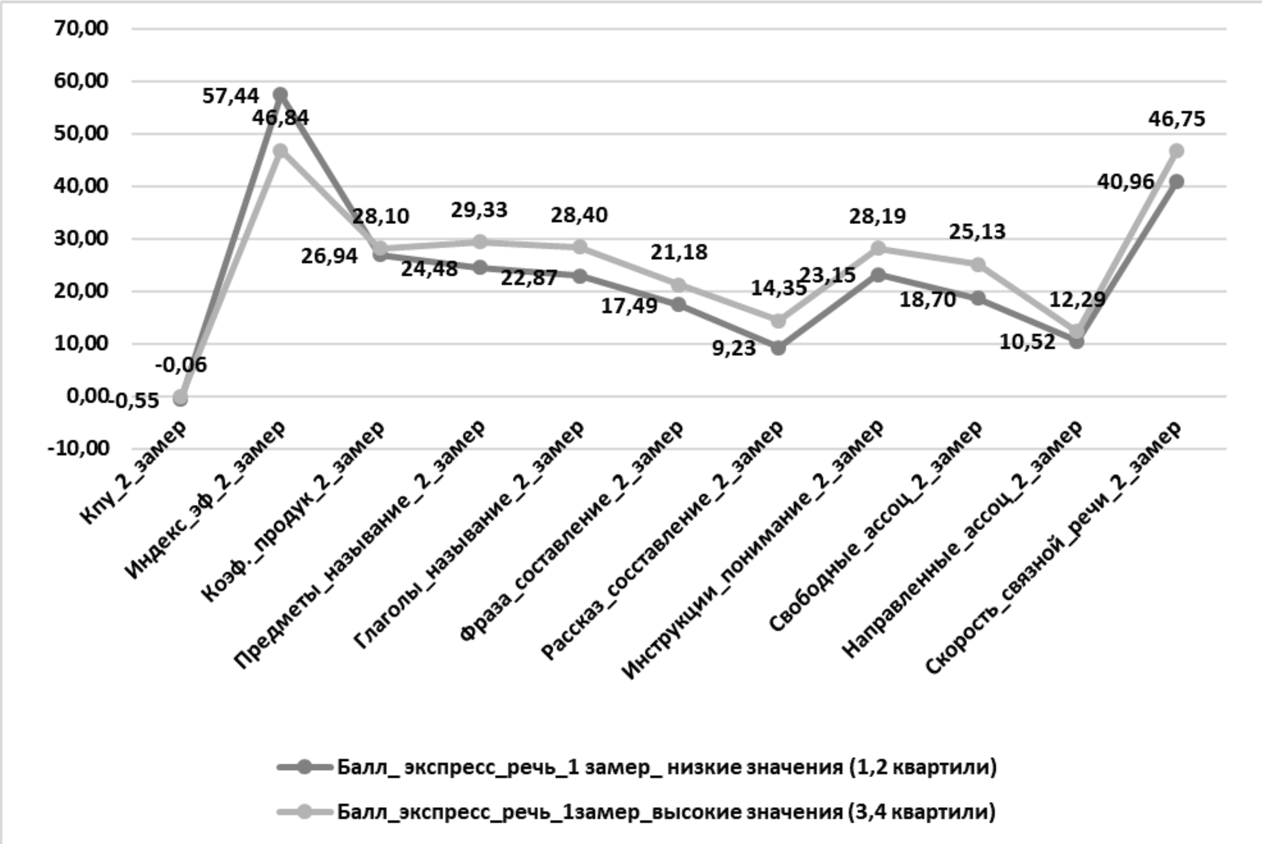

Figure 17. Parameters of auditory and speech perception, expressive and impressive speech, the speed of spontaneous speech, and the productivity of associations of patients in the main group with an initial low and high score of expressive speech. 2nd assessment

The specific features of the dynamics *of the main group* were revealed in the following:

1) in the subgroup with a high score of expressive speech, after completion of speech therapy, there was a decrease in the Kpu index towards a weakening of the advantage of the right ear. If before therapy the Kpu value was 0.56, then after it – –0.06. That meant that a decrease in the severity of speech disorders went to the establishment of auditory-speech ambidexterity in speech perception;

2) in the subgroup with a low score of expressive speech, there was a marked increase in the speed of coherent speech flow. After therapy, the previously existing differences between the subgroups were no longer noted (t=–1.01, p>0.05) (Table 63);

3) in the subgroup with a low score of expressive speech, after completing the rehabilitation course, the degree of speech recovery was 225.46 points. That meant that the patients were on the borderline of transition to the mild level of aphasic disorder. There was no such pattern in the control group.

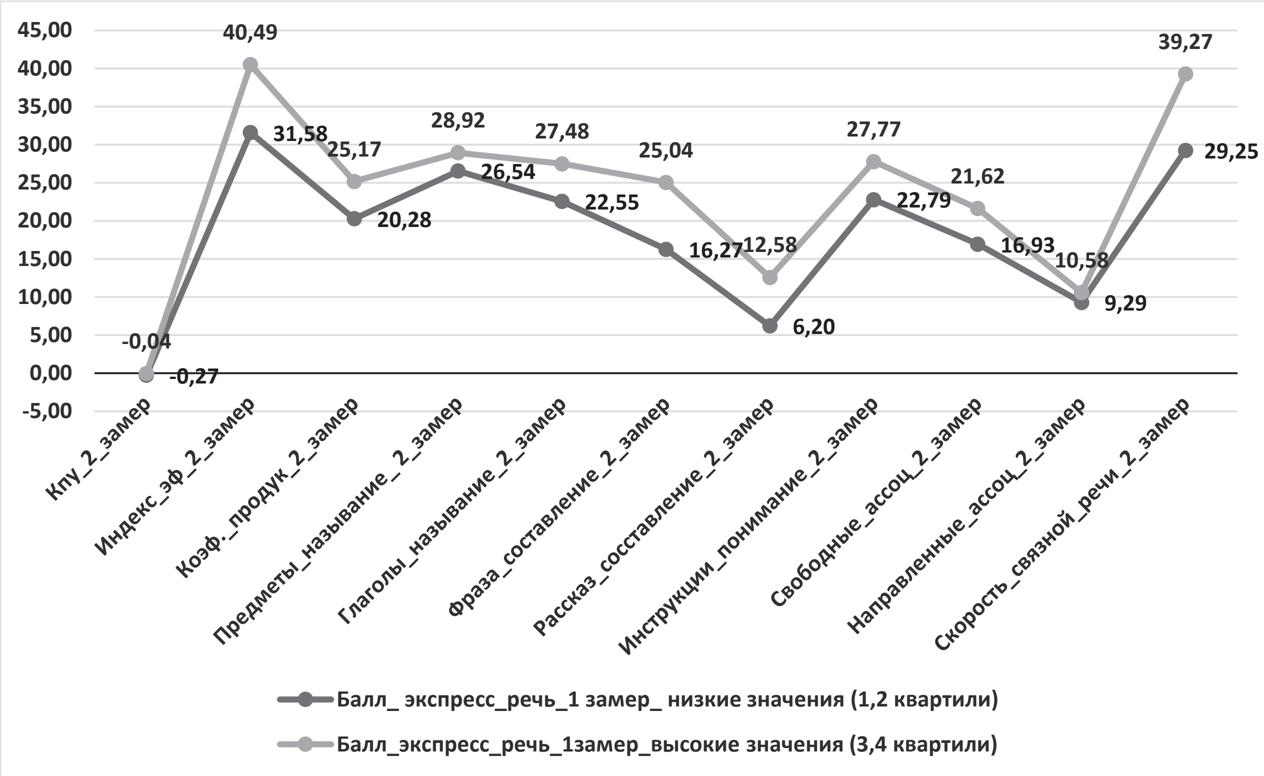

Figure 18. Parameters of auditory and speech perception, expressive and impressive speech, the speed of spontaneous speech, and the productivity of associations of patients in the control group with an initial low and high score of expressive speech. 2nd assessment

Table 63. Parameters of auditory and verbal perception, expressive and impressive speech, the speed of coherent spontaneous speech, and free and controlled verbal associations of patients in the main group with an initially low and high score of expressive speech. 2nd assessment

Parameter	Main group (M (SD)		t–criteria	p level
	subgroup 1	subgroup 2		
Index of laterality (Kpu)	–0,55 (0,58)	–0,06(0,65)	**–2,73*****	0,009
Efficiency index (Ief)	57,44(30,89)	46,84 (21,54)	1,37	0,178
Coefficient of productivity (Kpr)	26,94 (8,17)	28,10 (6,76)	–0,53	0,597
Naming objects" subscale	24,48 (3,30)	29,33 (0,84)	**–6,97*****	<0,0001
"Naming verbs" subscale	22,87 (3,69)	28,40 (1,32)	**–6,90*****	<0,0001
"Phrasing" subscale	17,49 (5,08)	21,18 (3,65)	**–2,87*****	0,006
"Making up a story" subscale	9,23 (4,05)	14,35 (4,92)	**–3,88*****	<0,0001
Expressive speech (five subscales total score)	95,81 (13,21)	119,58 (7,75)	**–7,39*****	<0,0001
Impressive speech (five subscales total score)	123,46 (18,41)	142,07 (6,68)	**–4,65*****	<0,0001
MOR_2 (score)	225,46 (27,86)	267,05 (10,01)	**–6,87*****	<0,0001
Free associations (productivity)	18,70 (4,89)	25,13 (7,90)	**–3,34*****	0,002
Controlled associations (productivity)	10,52 (4,62)	12,29 (4,91)	–1,27	0,210
Speed of spontaneous speech	40,96 (18,57)	46,75 (20,82)	–1,01	0,320

Note: subgroup 1 – patients with an initial low score of expressive speech, subgroup 2 – patients with an initial high score of expressive speech, * – p<0.05, ** – p<0.01, *** – p<0.001.

The dynamics in the control group consisted of the increase in the productivity of controlled associations in subgroup 1. By the end of the course of traditional speech therapy, differences between the subgroups were not observed longer (t=–1.47, p>0.05) (Table 64).

The rate of the rehabilitation shifts in subgroup 1 of the main was much higher than in the control group in the speed of spontaneous speech (t=2.69, p=0.010), productivity (t=2.93, p=0.005) and the efficiency indexes (t=3.25, p=0.002) (Table 65). In comparison with the control group, subgroup 2 of the main group had higher parameters of MOR2 (t =2.03, p=0.048) and impressive speech (t=1.97, p=0.055) but a lower parameter for the subscale "phrasing" (t=-3.93, p<0.0001) (Table 66).

Table 64. Parameters of auditory and verbal perception, expressive and impressive speech, the speed of coherent spontaneous speech, and free and controlled verbal associations of patients in the control group with an initially low and high score of expressive speech. 2nd assessment

Параметр	Main group (M (SD)		t–criteria	p level
	subgroup 1	subgroup 2		
Index of laterality (Kpu)	–0,27 (0,71)	–0,04(0,64)	–1,24	0,221
Efficiency index (Ief)	31,58 (25,99)	40,49 (24,81)	–1,29	0,204
Coefficient of productivity (Kpr)	20,28(25,17)	7,99 (10,52)	–1,93	0,059
Naming objects" subscale	26,54 (28,92)	2,90 (1,07)	**–3,95*** **	<0,0001
"Naming verbs" subscale	22,55 (27,48)	3,88(2,27)	**–5,64*** **	<0,0001
"Phrasing" subscale	16,27 (25,04)	4,31(3,30)	**–8,35*** **	<0,0001
"Making up a story" subscale	6,20 (12,58)	4,49 (6,30)	**–4,31*** **	<0,0001
Expressive speech (five subscales total score)	90,61 (19,37)	117,13 (10,95)	**–6,13*** **	<0,0001
Impressive speech (five subscales total score)	122,25 (19,06)	136,92 (11,07)	**–3,42*** **	0,001
MOR_2 (score)	217,09 (27,58)	259,90 (14,28)	**–7,08*** **	<0,0001
Free associations (productivity)	16,93 (7,13)	21,62 (5,21)	**–2,74*** **	0,008
Controlled associations (productivity)	9,29 (3,23)	10,58 (3,24)	–1,47	0,149
Speed of spontaneous speech	29,25 (12,36)	39,27 (10,15)	**–3,24*** **	0,002

Note: * – p<0,05, ** – p<0,01, *** – p<0,001.

Table 65. The dynamics of the rehabilitation shift in speech parameters in patients of subgroups 1 of the main and control groups. 2nd assessment

Parameter	Main group M(SD)	Control group M(SD)	t–criteria	p level
Index of laterality (Kpu)	–0,55 (0,58)	–0,27 (0,71)	–1,52	0,135
Efficiency index (Ief)	57,44 (30,89)	31,58 (25,99)	**3,25***	0,002
Coefficient of productivity (Kpr)	26,94 (8,17)	20,28 (7,99)	**2,93***	0,005
Naming objects" subscale	24,48 (3,30)	26,54 (2,90)	**–2,37***	0,022
"Naming verbs" subscale	22,87 (3,69)	22,55 (3,88)	0,30	0,769
"Phrasing" subscale	17,49 (5,08)	16,27 (4,31)	0,93	0,356
"Making up a story" subscale	9,23 (4,05)	6,20 (4,49)	2,51	0,015
Expressive speech (five subscales total score)	95,81 (13,51)	90,61 (19,37)	1,09	0,282
Impressive speech (five subscales total score)	123,46 (18,41)	122,25 (19,06)	0,23	0,820
MOR_2 (score)	225,46 (27,86)	217,09 (27,58)	1,07	0,288
Free associations (productivity)	18,70 (4,89)	16,93 (7,13)	1,01	0,318
Controlled associations (productivity)	10,52 (4,62)	9,29 (3,23)	1,12	0,268
Speed of spontaneous speech	40,96 (18,57)	29,25 (12,36)	**2,69****	0,010

Note: subgroup 1 – patients with an initial low score of expressive speech.

Thereby, speech therapy in a modelling multisensory-enriched environment and traditional speech therapy contributed to positive dynamics in expressive speech. Unlike the traditional approach to speech aphasia therapy, it allowed within the framework of one rehabilitation course to shift from a moderate to a mild degree of aphasia. It created an activating effect on the speech of patients with both moderate and mild aphasia. It revealed a more profound resource for speech restoration than the music-enriched environment, which showed relatively greater sensitivity to speech rehabilitation of patients with mild aphasia impairment.

Table 66. Dynamics of the rehabilitation shift in speech parameters in patients of subgroups 2 of the main and control groups. 2nd assessment

Параметр	Main group M(SD)	Contrpl group M(SD)	t–criteria	p level
Index of laterality (Kpu)	–0,06 (0,65)	–0,04 (0,64)	–0,12	0,907
Efficiency index (Ief)	46,84 (21,54)	40,49 (24,81)	0,96	0,340
Coefficient of productivity (Kpr)	28,10 (6,76)	25,17 (10,52)	1,16	0,252
Naming objects” subscale	29,33 (0,84)	28,92 (1,07)	1,48	0,145
"Naming verbs" subscale	28,40 (1,32)	27,48 (2,27)	1,73	0,090
“Phrasing” subscale	21,18 (3,65)	25,04 (3,30)	**–3,93***	<0,0001
“Making up a story” subscale	14,35 (4,92)	12,58 (6,30)	1,10	0,276
Expressive speech (five subscales total score)	119,58 (7,95)	117,13 (10,95)	0,90	0,373
Impressive speech (five subscales total score)	142,07 (6,68)	136,92 (11,07)	**1,97***	0,055
MOR_2 (score)	267,05(10,01)	259,90 (14,28)	**2,03***	0,048
Free associations (productivity)	25,13 (7,90)	21,62 (5,21)	1,87	0,068
Controlled associations (productivity)	12,29 (4,91)	10,58 (3,24)	1,47	0,149
Speed of spontaneous speech	46,75 (20,82)	39,27 (10,15)	1,63	0,109

Note: subgroup 2 – patients with an initial high score of expressive speech.

7.3. Quantitative and qualitative parameters of speech restoration in polysensory-enriched environment

The methodological approach to speech recovery in aphasia is based on the developed principles of modelling the sensory therapeutic environment that considers the topography of focal brain lesions and neuropsychological and neurobiological patterns of speech restoration (Shipkova K.M., 2023b; Shipkova K.M. et al., 2023).

The central principle of modelling a polysensory-enriched environment is the spatial-temporal synchronization of sensory and mental effects. The main goal of polysensory-enrichment of the environment is to enhance the intersensory and interhemispheric integration of brain structures that are part of the new cerebral basis of damaged speech function. The deepening of the integration links created by the modelling polysensory-therapeutic environment was supposed to improve the process of speech recovery in aphasia patients (Shipkova K.M., 2024a).

The main and control groups included right-handed patients who did not have congenital left-handedness. The choice of acoustic-mnestic and efferent motor aphasia as models was not accidental. It was due to two reasons: 1) the high frequency of these speech aphasia types in the practice of clinical psychologists, and 2) the difference in the predominant side of the speech defect – oral speech or speech comprehension.

In efferent motor aphasia, which occurs when the posterior frontal parts of the left hemisphere are affected (in right-handers), the pronouncing side of speech is disrupted with the primary preservation of impressive speech. Violations of oral speech are expressed in verbal perseverations, violations of grammatical structuring, and expressive agrammatism. That affects the quality of the patient's oral speech. It becomes sparse, with short phrases, often incomplete, pronounced verbal deficits, and syntactic and grammatical errors. The prosodic (pronouncing) side of speech is grossly violated, and chanting of speech appears.

In acoustic-mnestic aphasia associated with damage to the middle sections of the left temporal lobe, the opposite picture of the speech defect is observed. With the preservation of the pronunciation side of speech, there is a pronounced deficit of subject nomination associated with impaired auditory-speech memory and the connection between the word and its image representation (Luria A.R., 1948, 1962; Tsvetkova L.S., 2011). In the speech of patients, the desired word is often replaced by another one that does not always exactly correspond to the desired meaning (verbal paraphasia). Due to the pronounced lexical deficit, oral speech suffers a second time, in which there is a decrease in the rate of speech, frequent stops of the speech flow due to the "loss" of the word, and simplification of the lexical composition of phrases. The understanding of the reversed speech is disrupted, the so-called alienation of the meaning of the word, when the word loses its substantive relevance.

The dynamics of speech disorders were analyzed from the point of view of quantitative and qualitative assessment of regression of disorders and evaluated based on methods of quantitative assessment of speech, the speed of coherent spontaneous speech, free and directed phonological associations, and parameters of auditory perception. The diagnostic complex included many tests that made it possible to assess the influence of a polysensory-enriched environment on mental processes mediated by speech: the MoCA-test, the FAB test, and the "retelling of the story" subscale of the RBMT-3 test. Thus, the diagnostic tools made it possible to investigate various aspects of the recovery process and to give a comprehensive assessment of the effectiveness of rehabilitation of aphasic disorders in a polysensory-enriched environment.

A comparative analysis of the rehabilitation shifts in patients with aphasia during speech therapy in a sensory-enriched environment and with the traditional approach revealed common and specific features in the dynamics of speech, cognitive and regulatory functions.

The polysensory-enriched environment increased the noise immunity of auditory and speech perception. After completion of therapy, the number of errors in the dichotic perception of words decreased in patients. This effect was not significant with the traditional approach. It is known that in the dichotic perception of verbal information, competition of the auditory channels arises, and a sufficient level of arbitrary attention and regulatory control is required to weaken the interference of the auditory channels. After completing the rehabilitation course, the patients in the main group made significantly fewer mistakes, which indicated the strengthening of speech regulation and auditory control.

Sensory-enrichment of the rehabilitation environment had a focal effect on the state of cognitive functioning and executive functions. The vector of the predominant rehabilitation shift formed in a modelling sensory-enriched environment was determined by the type of aphasia and impaired neuropsychological factor. In patients with efferent motor aphasia, polysensory therapy improved the state of regulatory functions in patients with acoustic-mnestic aphasia – the level of general cognitive functioning. By the end of the rehabilitation course in patients of the main group, the MoCA-test score corresponded to the lower limit of the adult norm (subnormal), while with traditional therapy within the framework of one course of speech therapy dynamics were not achieved. The deepening of sensory integration created by a polysensory-enriched environment has improved auditory and speech memory. Regardless of the type of aphasia, the volume of short-term auditory-speech memory increased in patients, which confirms the data of other studies that have revealed the positive effect of sensory enrichment of the environment on the regression of a wide range of cognitive processes, including memory (Karbe H., Thiel A., 1998; Kolb B. et al., 2008; Richter M. et al., 2008; Särkämö T. et al., 2008; Moreno S., 2009; Hyde K. L. et al., 2009; Breier J.I. et al., 2010; Kolb B. et al., 2010; Herholz S.C et al., 2012; Cocquyt E.M. et al., 2017).

Both methodological approaches to speech therapy made it possible to achieve positive dynamics, however, with speech therapy in a sensory-enriched environment, it had a relatively high severity, and its orientation depended on the initial degree of severity of aphasia and its type.

In patients with moderate aphasia, the polysensory-enriched environment increased the speed of coherent spontaneous speech and improved the subject nomination. By the end of the rehabilitation course, the degree of speech recovery was at the borderline of the transition from moderate to mild aphasia, which was not achieved with the traditional approach.

Patients with mild aphasia showed a more pronounced regression of disorders of impressive speech than with traditional speech therapy.

By the end of the rehabilitation course, the speech profiles of patients with moderate and mild aphasia had become closer, which was not observed during traditional therapy.

Along with the general features of the recovery process in patients with different severity of aphasia, there was a specificity in the vectors of speech dynamics determined by the type of aphasia.

In patients with efferent motor aphasia, polysensory speech therapy, in comparison with the traditional approach, contributed to a more pronounced regression of disorders of oral monological speech, and in patients with acoustic-mnestic aphasia – a more pronounced increase in the speed of coherent spontaneous speech.

The modelling polysensory-enriched environment had a positive effect on the quantitative and qualitative characteristics of the active vocabulary of patients with aphasia. In efferent motor aphasia, the stability of the pace and productivity of free associations increased, the length of semantic chains increased, and the frequency of using categorical and visual associative strategies increased. In patients with acoustic-mnestic aphasia, the mobility of free associations and the level of use of the categorical strategy increased (Shipkova K.M., 2024a). The brain basis for the formation of verbal connections is the strength of the inter-analytical interaction between the auditory, visual and motor systems (Tsvetkova L.S., 2011). An increase in the frequency of categorical connections in patients with acoustic-mnestic and efferent motor aphasia who underwent a course of polysensory speech therapy, and in patients with efferent motor aphasia also visual connections (subject-context) proves that the modelling polysensory-enriched environment strengthens the interanalytical connections between the temporal and visual cortex and increases the adaptability and plasticity of the neuronal basis speech function (Merrett D. et al., 2014; Cheever T. et al., 2018). Traditional speech therapy had a greater impact on strengthening the connections between the temporal and motor cortex, which was reflected in the increased use of functional associative connections. Thus, polysensory speech therapy has enhanced the sensory integration of the temporo-occipital brain regions (Shipkova K.M., Dubinsky A.A., 2023), which normally participate in solving speech tasks, including composing phrases (Ivanitsky G.A. et al., 2002; Danko S.G. et al., 2005; Scratch D.M. et al., 2007).

In patients with aphasia, the productivity of directed phonological associations was initially lower than that of free associations, which is consistent with data from other studies (Henry J.D., Crawford J.R., 2004; Baldo J.V. et al., 2010; Friesen D.S. et al., 2015; Patra A., 2020; Bose A. et al., 2022). What was common for patients undergoing therapy in a polysensory-enriched environment, in contrast to traditional therapy, was an increase in the productivity of phonological associations and the frequency of using a syllabic strategy. In comparison with the alphabetic strategy, the syllabic one is a more complex way of selecting a word based on phonetic characteristics. It requires verbal control and a sufficient amount of memory to keep a whole syllable in memory (Shipkova K.M., 1993). The increase in the frequency of syllabic strategy has become additional evidence of strengthening auditory-speech memory, which, as is known, along with attention, is the basis of learning.

Summary

The approbation of a new methodological approach to speech rehabilitation in a modelling polysensory-enriched environment has shown its high therapeutic effectiveness. The patients who participated in the study had chronic speech impairment. With the same initial socio-demographic characteristics, the severity of aphasic disorders, and the duration of the rehabilitation course, patients undergoing speech rehabilitation in a polysensory-enriched environment showed higher rates of rehabilitation shift than those who received traditional speech therapy.

The modelling polysensory-enriched environment activated the vocabulary of patients with efferent motor and acoustic-mnestic aphasias. The frequency of using the categorial strategy in word selection increased, which was not noted in patients undergoing traditional speech therapy, and who more often resorted to a functional verbal search strategy. The traditional approach to speech rehabilitation in aphasia enhanced the functional integration of the temporal and frontal structures of the left hemisphere and polysensory speech therapy - the temporal and occipital brain regions, which, as had been shown in some studies, become structural elements of a new cerebral basis of reorganized speech function in patients with aphasia.

The polysensory-enriched environment improved speech in patients with moderate aphasia. By the end of the rehabilitation course, after five weeks, the patients were at the stage of transition to a mild degree of aphasia. Such pronounced dynamics were not observed in patients undergoing traditional speech rehabilitation.

The sensory-enriched environment had different effects on cognitive functioning and behaviour regulation, depending on the type of aphasia. In patients with efferent motor function, the parameters of regulatory functions improved, in patients with acoustic-mnestic aphasia – general cognitive functioning, which by the end of the rehabilitation course corresponded to the lower limit of the adult norm.

RESUME

The dissertation research is devoted to solving an urgent scientific and practical problem – the development of a methodological approach to the rehabilitation of patients with aphasia in a simulated sensory–enriched environment to increase the effectiveness of speech recovery. The choice of the research topic is due to the high prevalence of aphasia among patients with focal brain lesions, including vascular pathology, insufficient investigation of the structure of the aphasic syndrome, topical foci and the spectrum of its non-focal neuropsychological symptoms. The issues of dynamic changes in the structural components of aphasia syndrome, their hemispheric (lateral) vector and their connection with the reduction of speech disorders, as well as the range of neuropsychological and neurobiological parameters determining the leading path of cerebral reorganization of speech function, and parameters affecting speech restoration, relevant methodological approaches to speech therapy remain unresolved. Thus, the current state of the degree of development of the problem of structural components of aphasia syndrome, neuropsychological mechanisms for the restoration of aphasic disorders and methodological approaches to overcoming speech disorders required theoretical justification and empirical content. The study consisted of a preliminary and three stages of empirical research.

At the preliminary stage, the selection of patients who met the criteria for inclusion in the study was carried out. Of 687 patients, 177 right-handed patients with efferent motor and acoustic-mnestic aphasia of moderate and mild degree were included in the further stages of the study, with a total number of observations at all stages of 3136 units.

At the first stage of the study, a theoretical and methodological analysis of the history and modern concepts of speech impairment and restoration in patients with aphasia, justification and development of diagnostic complexes for detecting stealing symptoms of the right and left hemispheres and justification of the structural and dynamic model of aphasic syndrome. The study involved 110 patients (53 patients with efferent motor and 53 people with acoustic-mnestic aphasia). The total number of observations was 772 units. The analysis of existing ideas about the brain organization of speech processes and the structure of aphasic syndromes made it possible to identify and justify the choice of diagnostic techniques aimed at the topical diagnosis of preserved higher mental functions that have a functional connection with the course of verbal processes.

The diagnostic complex for detecting symptoms of stealing from the right hemisphere included techniques that allowed for identifying oppression symptoms of the occipital and parietal regions of the subdominant hemisphere. It included recognition of objects with incomplete image saturation gradient and in conditions of visual noise (interference); retention of schematized faces of schematized faces and difficult-to-visualize figures; mental rotation in two-dimensional space; and stereognosis on a non-leading (left) hand.

The diagnostic complex for detecting stealing symptoms of the left hemisphere was aimed at identifying stealing symptoms in the occipital and parietal regions: retention of subject (verbalized) images, comparison of a three-dimensional figure and its sweep, and stereognosis on the leading (right) hand.

The assessment of the profile of auditory-speech asymmetry (side of the leading ear) and parameters of auditory-speech perception was carried out using the dichotic listening task. The speech dynamics were assessed using speech assessment in aphasia, free and controlled verbal associations, and the speed of spontaneous speech. The data obtained allowed us to identify some patterns of speech recovery in aphasia: 1). Interhemispheric and intrahemispheric reorganization (vicariate) of speech in patients with aphasia are universal mechanisms of brain plasticity, two sides of the process of restoring impaired higher mental function. 2). The chronological sequence of the change of one type of cerebral reorganization of speech function by another is determined by the influence of several neuropsychological and neurobiological parameters: the type of aphasia, the degree of severity of speech disorders, the time post-onset and volume of the focal lesion. 3). The inter- and intrahemispheric reorganization of the impaired speech function leads to the appearance of stealing symptoms (tertiary symptoms) functionally related to the lesion of the damaged hemisphere and homologous zones in the intact one. The revealed patterns allowed us to describe the chain effect of hemispheric restructuring of the damaged speech function, leading to the appearance of tertiary symptoms: weakening of the inhibitory effect of the left hemisphere on the right one; activation of the right hemisphere with a simultaneous increase in its noise immunity concerning auditory perception; strengthening of interhemispheric (interhemispheric interaction) and intrahemispheric connectivity (intrahemispheric interaction) about speech processes between partially damaged areas in the affected lobe and or adjacent regions with functionally related intra- and interhemispheric structures. The presence of a chain effect of interhemispheric restructuring of speech function is proved by the symptom of activation of the temporal lobe of the right hemisphere (the establishment of the leading left ear in auditory-speech perception) with a simultaneous increase in the effectiveness of auditory-speech perception and the appearance of oppression symptoms of healthy occipital and parietal regions of both hemispheres.

Based on the obtained empirical data, *a structural and dynamic model of the aphasic syndrome* was substantiated. In addition to the primary and secondary symptoms of speech dysfunction, the structural components of the aphasia syndrome are considered tertiary symptoms representing the process of compensating speech impairment due to the preserved cerebral lobes of the right and left hemispheres. Tertiary neuropsychological symptoms are characterized by dynamism and determined by the speech restoration process and reveal the completeness of the integration of the corresponding brain structures into the functional system of the damaged speech function. The stealing symptoms, which are characterized by instability in connection with the dynamics of speech recovery (parietal sections of the right hemisphere) reflect the functional deficiency of brain structures that are flexible links of the new cerebral organization of speech function with the still incomplete process of their integration into a new reorganized speech system. Rigid links (occipital regions of the right and left hemispheres, parietal sections of the left hemisphere) show stability in the severity of oppression symptoms of the brain regions representing them (occipital sections of the left hemisphere) or regression in their severity simultaneously with positive dynamics of speech recovery (occipital sections of the right and parietal sections of the left hemisphere). The topography of the stealing symptoms indicates the entry of some psychological parts of visual and spatial perception functions into the rigid links of the reorganized speech function. The data allowed us to conclude that speech recovery in aphasia patients is a bilaterally distributed process.

At the second stage, an algorithm, principles of modelling a sensory-enriched environment and a methodological complex for speech therapy in a modelling music-enriched environment were developed. A diagnostic complex has been formed and justified to assess the dynamics of speech recovery in patients with aphasia in an enriched environment. The comparative rehabilitation effectiveness of the tested and traditional approach was evaluated, including the dynamics of speech recovery in patients with different initial severity of expressive (oral) speech disorders. The study involved 70 patients (27 patients of the main group with efferent motor (13 patients) and acoustic-mnestic aphasia (14 patients) and 46 patients of the control group – 20 and 26 patients, respectively). 405 individual rehabilitation sessions were conducted. 730 observation units were performed.

The paper formulates the definition of *the term "sensory enriched environment",* which means *a simulated sensory recovery and correction environment aimed at accelerating and deepening the process of hemispheric and interhemispheric restructuring (reorganization) of impaired (dysfunctional) higher brain functions.* A theoretical analysis of research in the field of neuroscience (neuropsychology, neurophysiology, neurobiology) has allowed us to *formulate some new principles for modelling a sensory-enriched environment*, which expand the typology of traditional ones of relearning therapy developed at the National School of Neuropsychological Rehabilitation and reflect the goals, objectives and didactics of using sensory-enriched environments in the restorative retraining process of cognitive impairment, including speech. *The principle of the topical approach to the algorithm of sensory stimulation* determines the sequence of inclusion of a certain type of sensory stimuli in a sensory-enriched environment, which is dictated by the topic of brain damage. *The principle of* *spatial-temporal synchronization of sensory and psychic functions* involves the creation of functional readiness of the corresponding brain structures of the affected function by simultaneously activating (synchronizing) their inter-analytical and interhemispheric connections. *The principle of dosing sensory stimulation* reflects the patterns of formation of the trace effect of functional topical effects in the creation of new neuronal connections.

The purpose of sensory stimulation through sensory enrichment of the environment was to create a wide zone of evoked brain response relevant to the topical location of the lesion and brain regions functionally related to the lesion zone. The simulated sensory environment was aimed at deepening the process of intersensory and interpsychic interaction by activating preserved brain structures involved in the brain reorganization of the damaged higher mental function. The deepening of intra- and interhemispheric interaction (connectivity) was achieved by implementing sensory-enriched environment principles. The algorithm for modelling the sensory-enriched environment was developed based on the data obtained in the study on the intra- and interhemispheric restructuring of speech function and the influence of neuropsychological and neurobiological parameters on this process and the principles of modelling sensory-enriched environments. The algorithm consists of four stages and takes into account the vector of spontaneous brain rearrangements, which are characteristic of the early and late recovery period: in the early period, the process of speech restoration follows mainly the path of intrahemispheric restructuring due to preserved departments of the same hemisphere, in the delayed period with incomplete restoration of higher mental function – to a greater extent due to homologous departments of intact hemispheres. The developed methodological complex for a music-enriched environment included three interrelated components: sensory, emotional and regulatory, and blocks of receptive, active methods of musical stimulation and synchronization of musical effects with the performance of relevant speech tasks. The methodological techniques counted the bi-hemispheric nature of the cerebral organization of speech, and the topical impact of music of different genres and modes. A block of techniques for lateral and bi-hemispheric sensory stimulation and a speech block of techniques were developed, including a method of musical speech expression, in which the stimulus material was selected and pre-evaluated using the expert method to match the musical material to the visual one. The procedure for carrying out the techniques is presented in detail. The developed and substantiated diagnostic complex for assessing the dynamics of speech recovery included methods of dichotic listening, speech assessment in aphasia, the speed of coherent spontaneous speech, and directed (phonological) and free verbal associations. To test and evaluate the effectiveness of the developed methodological approach, a rehabilitation course (15 individual sessions, 3 times a week for 5 weeks) was conducted for patients of the main group with efferent motor and acoustic-mnestic aphasia, which undergoing in addition to this speech therapy the traditional speech course. The total number of individual rehabilitation sessions was 405 units. The control group of patients underwent only a course of traditional speech therapy. The total number of observations in the second stage of the study was 730 units.

An analysis of the dynamics of speech recovery in patients with efferent motor aphasia in a music-enriched environment and during traditional speech therapy revealed that the main and control groups, who did not have differences in speech and auditory perception at the beginning of the course of speech therapy, revealed several common and distinctive features in the dynamics of speech and other cognitive processes after the course of speech.

The commonality changes in speech status were expressed in the stability of the established profile of auditory-speech asymmetry, and a pronounced rehabilitation shift in all indicators of expressive speech: subject and verbal naming, phrasal and monological speech. Along with this, patients of the main group with efferent motor aphasia showed the growth of the speed of spontaneous speech and the productivity of controlled associations. The growth of expressive speech meant a decrease in the frequency of speech perseverations, which are specific to efferent motor aphasia. An increase in the productivity of phonological associations meant that speech therapy in a music-enriched environment increased the regulatory control of speech production.

Further, the dynamics of speech and auditory perception parameters in patients with acoustic-mnestic aphasia were analyzed during a course of speech rehabilitation in a modelling music-enriched environment and traditional speech therapy. Before the rehabilitation, the percentage of patients with mild aphasia in the main group was lower than in the control, because patients tended more to the traditional form of speech therapy. Thus, along with the analysis of similarities and differences between the groups, the intra-group dynamics of indicators were carried out.

The common features in the vector and magnitude of the rehabilitation shift in the groups were the improvement of impressive and expressive speech (subject and verbal naming, phrasal speech), and the productivity of free and controlled associations.

At the final stage of the analysis of empirical data of the second stage of the study, the main and control groups, including patients with acoustic-mnestic and efferent motor aphasia, were quantified according to the score of expressive speech. After that, each group was divided into two subgroups of 50 percentile. Subgroup 1 of each group included patients of quartiles 1 and 2 – patients with a low score of expressive speech (patients with moderate severity of aphasia). Subgroup 2 included patients of the 3rd and 4th quartiles – patients with a high score of expressive speech (patients with mild aphasia). Empirical research data showed that in patients with aphasia with a low score of expressive speech, speech therapy in a music-enriched environment created a positive rehabilitation shift comparable to the traditional approach to speech therapy while increasing the productivity of free associations to the level of patients with mild aphasia. In patients with a high score of expressive speech, speech restoration in a music-enriched environment, in contrast to the traditional approach, created a pronounced activating effect on the regression of subject nominative deficit and an increase in the speed of spontaneous speech. An increase in the rate of expressive speech in patients with aphasia indicated that the music–enriched environment had an activating effect on reducing the severity of the primary symptoms of aphasic syndromes - difficulties in speech switching in patients with efferent motor aphasia and the rate of word euphoria in patients with acoustic-mnestic aphasia.

At the third stage, the development of a methodological complex for speech therapy of aphasic disorders in a polysensory-enriched environment was carried out, including the development and justification of a diagnostic complex for determining the dynamics of speech recovery in a polysensory environment with an assessment of the comparative effectiveness of the tested approach and traditional speech therapy, including an observation of the dynamics of speech recovery in patients with different initial degrees of expressive speech disorders. The study involved 104 patients with aphasia, of which 50 patients from the main group (29 patients with efferent motor aphasia and 21 patients with acoustic-mnestic aphasia) and 54 patients from the control group (24 and 30 people, respectively). The methodological complex (including the procedure) for conducting speech therapy in a polysensory-enriched environment consisted of three blocks of techniques. In the 1st block, the methodological tools were aimed at lateral motor stimulation. In the 2nd block, the tasks of the second and third stages of sensory stimulation (bi-hemispheric motor, auditory-motor, visual, tactile stimulation). In the 3rd block, speech techniques aimed at implementing the fourth stage of the sensory stimulation algorithm were presented. The rehabilitation course in a polysensory-enriched environment consisted of 15 individual sessions conducted 3 times a week for 5 weeks. A total of 750 individual rehabilitation sessions were done. The total number of observations according to the methods of the diagnostic complex of this stage of the study amounted to 1,634 units. At the beginning of the rehabilitation course, the main group of patients with efferent motor aphasia did not differ from the control group for most speech parameters, including the productivity of free and controlled associations, the speed of spontaneous speech, and cognitive, regulatory and auditory perception parameters. The dynamics of speech during therapy in the main and control groups revealed many common features, which were expressed by maintaining the initial profile of auditory-speech asymmetry, a common increase in the speed of speech, impressive speech, general cognitive functioning, productivity of verbal associations, including structural characteristics of a free-associative series.

The specific features of the rehabilitation shift in patients of the main group with efferent motor aphasia were an increase in the rate of free verbal associations, productivity and frequency of using the syllabic strategy in directed phonological associations, improvement of regulatory control and an increase in the volume of short-term auditory memory. Patients with acoustic-mnestic aphasia of the main group, who also at the beginning of speech therapy did not differ from the control group in most speech parameters, including the profile of auditory-speech asymmetry, the productivity of free and directed associations, the speed of coherent spontaneous speech, regulatory processes, except for higher indicators on the MoCA test, mobility of the associative series and lower an indicator of auditory and speech memory. The specificity of the effect of a polysensory-enriched environment on the speech processes of patients with acoustic-mnestic aphasia was expressed in the fact that with a one-order improvement in the indicators of expressive and impressive speech, including the stability of tempo, productivity and mobility of free associations, and maintaining the previous profile of auditory-speech asymmetry, the speed in the main group increased to a greater extent coherent spontaneous speech, general cognitive functioning, auditory-speech memory, the categorical structuring of the free-associative series and the frequency of using the syllabic strategy in directed phonological associations. Along with this, speech therapy in a polysensory-enriched environment improved the indicators of general cognitive functioning and auditory-speech memory of patients with acoustic-mnestic aphasia.

The final analysis of *the third stage* of the study was to assess the dynamics of speech recovery in patients with initially low and high rates of expressive speech on the same basis as in the 2^{nd} stage of the study.

During therapy in a polysensory-enriched environment in patients with a high score of expressive speech, the positive dynamics of restoration of impressive speech outstripped the dynamics in patients undergoing traditional therapy and accompanied by an increase in the number of cases of auditory-speech ambidexterity (lack of advantage of any ear in speech perception).

For patients with a low score of expressive speech, restorative speech therapy in a polysensory-enriched environment, in comparison with the traditional approach, had a pronounced positive effect on increasing the speed of coherent spontaneous speech, increasing the efficiency (noise immunity) of auditory-speech perception, and also created favourable conditions for accelerating the rate of regression of aphasic defect from moderate to mild severity.

Thus, the music-enriched and polysensory-enriched environment in the speech therapy of patients with aphasic disorders of varying severity created conditions for a wider range of positive dynamics than with the traditional approach to reeducation of patients with aphasia.

The theoretical and empirical hypotheses of the study have been fully confirmed.

CONCLUSIONS

1. Speech recovery in aphasics with focal brain lesions is accompanied by spontaneous intra- and interhemispheric cerebral speech reorganization. The predominant hemispheric speech reorganization is determined by the volume, topic of focal brain lesion, and aphasia time post-onset. The rearrangement process is carried out due to intact regions of the left and the right hemispheres, which take part in functional participation in speech comprehension and production and whose participation positively affects the regression of speech deficit in patients with aphasia.

2. Neuropsychological diagnostics of the functional state of the preserved parts of the damaged and healthy hemisphere allows us to identify a range of tertiary neuropsychological symptoms, which are expressed in symptoms of depression of healthy brain structures of both hemispheres and reflect a change in the topography of the cerebral bases of the affected speech function.

3. Aphasia syndrome is a structurally dynamic formation that includes, along with primary and secondary symptoms, many tertiary ones, which manifest themselves in symptoms of theft of preserved parts of the brain and a high frequency of occurrence of the leading left ear in right-handed people. The presence of tertiary symptoms as part of the aphasic syndrome is obligate, does not depend on the type, duration and severity of aphasia, the volume of focal brain damage and reflects the process of spontaneous compensation of a speech defect.

4. Tertiary symptoms are manifested in low parameters of visual memory, including objects, retention of difficult-to-visualize figures and faces, visual and tactile gnosis, spatial thinking and the establishment of the left ear superiority in speech-auditory perception. The chronological sequence of the change of one type of hemispheric lateralization of auditory-speech perception to another concerning the side of the leading ear depends on the aphasia type, its severity, and the time post onset and volume of the focal lesion.

5. Regression in the severity of tertiary symptoms during speech recovery or the absence of dynamic changes in their parameters with speech improvement indicates the completeness of the entry of the corresponding brain regions into the new architecture of the damaged speech function. The lack of connection between the dynamics of tertiary symptoms and changes in speech parameters reflects the incompleteness of integrating the relevant brain regions into the reorganized structure of the speech functional system. The topical and dynamic characteristics of tertiary symptoms are determined by the completeness of intra- and interhemispheric rearrangement of speech function. The dynamics of the tertiary symptoms of aphasic syndrome are determined by the chain effect of hemispheric reorganization of speech function: 1) weakening of the inhibitory effect of the left hemisphere on the right; 2) activation of the right hemisphere with simultaneous increase in noise immunity of auditory-speech perception; 3) strengthening of inter- and intrahemispheric interaction in speech processing.

6. The positive dynamics of speech recovery in patients with aphasia in modelling music-enriched and polysensory-enriched environments come through the relevance of hemispheric and topical focus of sensory stimulation. The principles of spatial-temporal synchronization of sensory and psychic functions, and the topical approach to the algorithm of sensory stimulation and the dosing of sensory stimulation, are aimed at strengthening intersensory and interpsychic interaction.

7. The algorithm for modelling a sensory-enriched environment consists of enhancing initially sensory stimulation of the cerebral zones of the affected hemisphere, which are determined by the circle of left-hemisphere tertiary neuropsychological symptoms, then expands the area of sensory stimulation by activating homologous sections of the preserved right hemisphere, followed by strengthening interhemispheric integration links.

8. The methodological complex of speech rehabilitation of patients with aphasia in a music-enriched environment should take the neurophysiology of the impact of the genre and mode of music on the topical focus of the brain response and the specifics of an aphasic syndrome. The methodological complex of speech rehabilitation in a

polysensory-enriched environment should include consistent stimulation of preserved sensory systems involved in the implementation of speech function, with a central focus on the one determined by the localization of focal brain damage.

9. Methodological complexes for assessing the dynamics of the speech status of patients with aphasia in the process of speech rehabilitation in a music-enriched and polysensory-enriched environment assess the quantitative and qualitative dynamics of speech parameters at the word level, including the structural organization of verbal lexicon, phrase, text, speech tempo, auditory-speech asymmetry profile, as well as the state of cognitive processes and control functions.

10. Speech recovery in a polysensory-enriched environment and with the traditional approach improves the parameters of expressive and impressive speech while maintaining the brain architecture of the reorganized speech function, which reveals the preservation of the original profile of auditory-speech asymmetry in aphasia patients. At the same time, unlike the traditional approach, speech rehabilitation in a polysensory-enriched environment has a multi-focus positive effect on speech parameters: the categorical structuring of the free-associative series improves, which indicates the strengthening of integration links between the occipital and temporal cortex, the frequency of using syllabic strategy in phonological controlled associations increases, which display an improvement in speech control and verbal memory, the noise immunity of auditory-speech perception increases.

11. Unlike traditional speech therapy, a polysensory-enriched environment improves the performance of both speech and other mental processes that are associated with the type of impaired neuropsychological factor: in patients with acoustic-mnestic aphasia, the volume of auditory-speech memory and the parameters of general cognitive functioning increases, in patients with efferent motor aphasia – regulatory functions and productivity auditory-speech perception.

12. Speech recovery in a music-enriched environment and with a traditional approach to speech therapy in patients with different aphasia types improves impressive speech. Expands the active vocabulary, including the productivity of free verbal associations, which indicates an increase in intermodal integration

intrahemispheric connections of speech, while not affecting the established profile of auditory-speech asymmetry and the effectiveness of auditory-speech perception. Along with that, a music-enriched environment has a more pronounced effect than traditional speech therapy on the regression of monologue speech disorders in those aspects of speech function, which are associated with the primary symptom of aphasia syndrome. In patients with acoustic-mnestic aphasia, the lexical fullness and expansion of phrases improve, which indicates an increase in auditory-speech memory. In patients with efferent motor aphasia, the speed of spontaneous speech improves, which shows a decrease in the aphasia severity.

13. In patients with a low index of expressive speech, speech therapy in a music–enriched environment increases the productivity of free associations. In patients with a high score – the speed of coherent spontaneous speech, which indicates an increase in the speed of articulatory switching in patients with efferent motor aphasia and the speed of finding the right word in patients with acoustic-mnestic aphasia and increases the productivity of the subject naming. In patients with a high index of expressive speech, speech therapy in a polysensory-enriched environment shows a more pronounced regression of disorders of impressive speech. In patients with aphasia with a low index of expressive speech, speech therapy in a polysensory-enriched milieu increases the speed of coherent spontaneous speech and noise immunity of auditory-speech perception. By the end of the rehabilitation course, the speech profile of patients with low expressive speech parameters approaches to those with high indicators, which is not remarking traditional therapy.

PRACTICAL RECOMMENDATIONS

1. To ensure the completeness and depth of recovery of aphasia disorder, an algorithm, principles and rehabilitation methods must account for neuropsychological and neurobiological patterns of recovery of higher mental functions. Obligatory it must include sensory-enrichment of the therapeutic environment as a factor contributing to an increase in the rate of reduction of speech disorders.

2. The algorithm of sensory stimulation should reflect the chronology of interhemispheric reorganization during the spontaneous compensation of speech disorders. Therefore, it is based on the activation of the brain regions lying on the border with the lesion area and the preserved parts of the damaged side of the brain, and then on the sequential sensory stimulation of intra- and interhemispheric connections. Strengthening intrahemispheric connections is a priority for patients with aphasia and time post-onset of less than one, and interhemispheric connections – of more than one year.

3. Sensory stimulation techniques are a system of methods. The use of a separate technique will not have high rehabilitation results. They must be applied comprehensively and with the principle of a volume of sensory stimulation and synchronization of sensory-mental effects to achieve a significant rehabilitation shift.

4. A set relevant to he mechanism of speech impairment techniques must be chosen working with a definite aphasia type. Blocks of methods must be implemented in full when using a sensory stimulation (music-enriched, polysensory-enriched).

5. It is inappropriate to use a music-enriched environment for patients with hearing disorders or congenital amusia.

6. When assessing the dynamics of speech recovery, it is advisable to apply simultaneously with methods for quantifying speech dynamics methods evaluating other mental processes mediated by speech, which reflect dynamic changes in the state of speech processes. Assessment should be evaluated once every 4-5 weeks during the rehabilitation course.

7. The length of sensory stimulation of more than five weeks decreases its effectiveness. To prevent side effects, it is impractical to exceed the duration.

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APPLICATIONS

APPLICATION 1

The PROTOCOL of the METHOD of SPEECH ASSESSMENT in APHASIA

Socio-demographic data
Name/Surname
Age
Education
Profession
Clinical data
Topic and volume of focal lesion
Time post onset of stroke/aphasia
Neurological diagnosis
Neuropsychological data:
Aphasia type
The degree of severity of speech disorders
The presence of family lefthanders
Profile of the leading hand

SPEECH ASSESSMENT

1.1 IMPRESSIVE SPEECH

Dialogue
Dialogic speech

Questions	Score (answer)	Score (understanding)	Notes
1. How do you feel?			
2. Do you have a headache?			
3. How did you sleep?			
4. How many people do you have in your ward?			
5. Have you been examined by a doctor today?			
6. What did you have for breakfast today?			

7. Where do you live?			
8. What did you do last night? ?			
9. What is the weather like today and what was it like yesterday			
10. What do you like to do in your free time?			

The score for the answers in the dialogue (in points):

3 p. – a normative answer; adequate in meaning, grammatical correct answer, without verbal and literal substitutions,
без вербальных и литеральных замен.
1,5 p. – literal paraphasias that do not interfere with understanding the answer; either an echolalic principle; or agrammatism; or an answer in one word to a question that requires an answer in a phrase
0 б. – no response; either an inadequate response in meaning; or literal or verbal substitutions that distort a word or sentence beyond recognition/

The score for understanding the questions of the dialogue (in points):
3 p. –adequate understanding from the first time (adequate verbal or non-verbal response, for example, gestural).
1,5 p. –the answer to only part of the question (for example, when asked "What was the weather like today and what was it like yesterday?" the answer is "Yesterday was bad"); either a gesture response that does not allow us to say with certainty that the question is understood correctly; or understanding the question after repeated presentation.
0 б. – the inadequate answer, it is impossible to understand the question from two presentations or the question is understood from the third repetition.

Understanding the instructions

Instructions	Score	Notes
1. Close your eyes		
2.Raise the left hand		
3. Take a pencil and tap three times		
4.Take the paper clip and put it in your pocket		
5. Build a triangle out of sticks		

6. Draw a circle and a square in the paper		
7.Show the paperclip with a stick		
8.Place the pen to the right of the book		
9. Take a book, put a paper list in it and put it on the edge of the table		
10. Put a box in front of you, put the chopsticks in it and give it to me.		

The score for understanding the instrutions (in points):

3 p. – the action was performed correctly (the instruction was correctly understood).

1,5 p. – the action was performed correctly after repeated presentation (the instruction is understood correctly after repeated presentation)

0 p. – the action was not performed after two or three repetitions of the instruction

Understanding phrases, logical-grammatical and prepositional constructions

Phrases	Score	Notes
1.MOTHER WASHES THE GLASS		
2. GRANDMA CUTS BREAD		
3. A BOY READS A NEWSPAPER		
4. A BOY DRAWS A CAT		
5. THE BOY IS LYING ON THE CARPET		
6. THE OILCLOTH IS COVERED WITH A TABLECLOTH		
7. THE BOY WAS SAVED BY A GIRL		
8. THE BOY IS SAVED BY THE GIRL		
9. THE GIRL SAVED THE BOY IS		
10. THE CAR IS TRANSPORTED BY A TRACTOR		
11. A TRACTOR IS TRANSPORTING THE CAR		
12. THE BARREL IN FRONT OF THE BOX		
13. A BOX ON THE BARREL		
14. THERE IS A BARREL IN THE BOX		
15. THERE IS A BARREL ON THE BOX		
16. THE BOX BEHIND THE		

BARREL		

The score for understanding the phrases (in points):

2 p. – showing the correct picture/
1 p. – showing the correct picture from the second presentation.
0 p. – the display of the correct picture is not achieved after two or threerepetition of the phrase.

Understanding of object words

Words	Score	Notes
1. BOTTLE 2. CAT 3. WOMAN 4. APPLE		
5. GOAT 6. GRASS 7. BARREL		
8. COLLAR 9. BOW 10. BELT		
11. FISH – BAG 12. LETTER – DOOR 13. AIRPLANE –FLOWER		
14. MOWER – FIREWOOD 15. BEAR – DOT 16.KIDNEY – BOWL 17.GRASS – BARREL		
18. SLEEVE – SUSPENDER 19. GLOVES – POCKET 20. BOW – BALL		
21. APPLE – CAT – WOMAN 22. LETTER – BOTTLE – DOOR 23. FLOWER – FISH– BAG		
24. DOT – BEAR – MOWER 25. GRASS – DAUGHTER – BOWL 26. GOAT – FIREWOOD – KIDNEY		

27. TIE – SLEEVE – SUSPENDERS 28. COLLAR – POCKET – BOW 29. MITTENS – SCARF – SLEEVE 30. TIE – BELT – COLLAR		

The score for understanding the object words (in points):

1 p. – the correct display of pictures in the right order at a single presentation.

0,5 p. – correct display from the second presentation; or a change in the words order or the impossibility ща correction the error when drawing attention to it.

0 p. – the incorrect words order after two presentations or in the correct display is after three presentations.

Understanding the meaning of words denoting actions

Words	Score	Notes
1. WORKS 2. ERASES 3. PLAYING 4. RIDES		
5. READING 6. POURING 7. DIGGING		
8. PUTS 9. ROLLING 10. CARRIING		
11. COOKS– WATCHES 12. JUMPS –SINGS 13. WATERING – RIDES		
14. SMEARS – HITS 15. ROLLS – WAVES 16. DRINKING – COUNTS 17. DIGS – VIETS		
18. TWISTS – CARRIES 19. PULLS – THROWS 20.LEADS – PUTS		
21. SINGINS – WORKING –WATCHING 22.BIKING – COOKING WATERING 23.WASHING –SELLINGS PLAYING		
24. RIDING –WAVING – DRINKING 25. POURING –COUNTING –DIGGING 26. SMEARS – HITS – READS		

27. PUTS – LEADS – PULLS 28. HOLDS – PUTS – ROLLS 29. THROWS – HANGS – CARRIES 30. PUTS – TWISTS – LEADS		

The score for understanding the words denoting actions (in points):

1 p. – the correct display of pictures in the right order at a single presentation.

0,5 p. –correct display from the second presentation; or a change in the order of display, and it is impossible to correct the error when drawing attention to it.

0 p. – the inability to display correctly in the right order after two presentations or the display is carried out after three presentations.

1.2 EXPRESSIVE SPEECH

Naming objects

Objects	Score	Notes
1. A MOTHER 2. A FATHER 3. A HOUSE 4. A TRUCK 5. A ROAD		
6. A GIRL 7. A BOOK 8. TV 9. BREAD 10. A TABLE		
11. A CLOCK 12. THE MOON 13. A KNIFE 14.A COAT 15. A BALL		
16. A BED 17. THE SUN 18. STAIRS 19.GLASSES 20.A PENCIL		
21. A SIEVE 22. A BIKE WHEEL 23. A PEN 24. A WHEEL 25. A SHOVEL		

26. A CROCODILE 27. A CANDLE 28.A CLOTHESPIN 29. A POT 30.A VACUUM CLEANER		

The score for objects naming (in points):

1 p. –correct naming, the score does not decrease for an inaccurate grammatical form (for example, a case change).

0,5 p. –with the correct name after a contextual hint; with literal paraphasias, omissions, inserts of sounds that do not distort the sound outline as a whole (the word is recognizable); either with chanted utterance (non-artistic genesis); or with close verbal paraphasias; or when responding with a phrase, if it is impossible to correct the error after repeating the instructions "answer in one word"/

0 p. –the impossibility of naming, gross literal and verbal paraphasias, actualization of the word at the prompt of the first sound or syllable.

Naming actions

Actions	Score	Notes
1. WALKING 2. DRINKING 3. WRITES 4. RUNNING 5. SITTING		
6. READS 7. SLEEPING 8. EATS 9. STAYING 10. TALKING		
11. SEWS 12. CATCHES 13. FLYING 14. WASHES 15. DRESSES		
16. FEEDS 17. SWIMMIMG 18. OPENS /CLOSES 19. CRYINS 20. BUILDS		

21. DIGS 22. STROKING 23. DRAWS 24. KNITS 25. CUTS		
26. SWEEPS/COMBS 28. RUBS 29. TIES 30. SCOOPS		

The score for action naming (in points):

1 p. –correct naming, the score does not decrease for an inaccurate grammatical form (for example, a case change).

0,5 p. –with the correct name after a contextual hint; with literal paraphasias, omissions, inserts of sounds that do not distort the sound outline as a whole (the word is recognizable); either with chanted utterance (non-artistic genesis); or with close verbal paraphasias; or when responding with a phrase, if it is impossible to correct the error after repeating the instructions "answer in one word."

0 p. – the impossibility of naming, gross literal and verbal paraphasias, actualization of the word at the prompt of the first sound or syllable

Phrasing (composing phrases)

Phrases	Score	Notes
1. The boy washes his hands		
2. A girl cuts sausage		
3. The boy hammers a nail		
4. Children make a snowman		
5. The cat drinks milk		
6. Boys playing ball		
7. The boy runs to the tree		
8. The boy climbs over the fence		
9. The sun sets behind the clouds		
10. A woman puts a rug near the bed.		
11. Farmers load hay onto a car		
12. The boy gives the seat to an old woman		
13. A girl visits a sick friend		
14. The doctor invites the patient to go to the cabinet.		
15. A boy carries a ladder to		

remove a ball from a tree		

The score for phrasing (in points):

2 p. – a grammatically correct phrase adequate in meaning (the score for literal paraphasias does not decrease, which do not interfere with understanding the sentence).

1 p. – there are mistakes, but the goal of communication is generally achieved: coarse agrammatism; or coarse verbal paraphasias; stylistically unjustified word order; omission of the subject or secondary member of the sentence.

0 p. – the inability to make a sentence, or a rude agrammatic construction that distorts the meaning of the phrase.

Make up a story

The score for making up a story (in points):

1 p. – an adequate meaning phase of 1-4 words.

2 p. – a phrase of 5-7 words.

3 p. – a phrase of 8-12 words.

4 p. – a phrase of more than 12 words.

Grammatical complexity of phrases (a score is added to the score for the length of phrases):

1 p. – a complex subordinate clause/

2 p. – compound sentence, adverbial and participial phrases.

Penalties:
1 p. – violation of coherence, gaps in presentation, semantic incompleteness
0.5 p. – for every three unproductive words, expressions, verbal paraphasia or a grammatical error.

TOTAL MOR SCORE (max. 300 points)

APPLICATION 2

INITIAL VALUES OF DEMOGRAPHIC AND SPEECH PARAMETERS IN GROUPS OF PATIENTS WITH EFFERENT MOTOR APHASIA WHO UNDERWENT SPEECH THERAPY IN A MUSIC-ENRICHED ENVIRONMENT AND TRADITIONAL SPEECH THERAPY

Parameter	Main group			Control group			t	p
	M	SD	Me	M	SD	Me		
Age	53,23	12,23	56,00	50,85	9,86	53,00	0,62	0,542
Time post-onset (months)	14,31	7,12	13,00	14,90	5,53	16,00	-0,27	0,790
Index of laterality (Kpu)	0,07	0,67	-0,22	-0,13	0,72	-0,27	0,79	0,437
Efficiency index (Ief)	33,75	26,10	25,93	35,35	26,66	41,18	-0,16	0,870
Coefficient of productivity (Kpr)	20,73	10,81	18,75	21,21	8,74	21,88	-0,13	0,895
“Naming objects” subscale	25,96	5,52	27,50	27,23	3,33	28,50	-0,82	0,417
“Naming verbs”subscale	23,92	6,07	25,50	23,63	5,32	24,75	0,15	0,883
“Phrasing" subscale	15,88	6,55	14,00	17,50	6,76	19,50	-0,68	0,502
“Making up a story”subscale	5,68	4,79	5,50	6,18	5,34	5,00	-0,27	0,787
Expressive speech(total score)	95,91	23,39	99,50	99,19	18,28	100,50	-0,45	0,655
Phrases (understanding)	24,23	4,54	24,00	24,28	5,01	24,50	-0,03	0,980
Instructions (understanding))	25,50	3,29	26,50	25,33	4,62	27,00	0,12	0,907
Impressive speech (total score)	129,15	14,40	129,50	131,30	11,97	131,75	-0,46	0,645
MOR 1 score	227,65	33,62	233,00	231,77	27,54	234,00	-0,38	0,703
Free oral verbal associations	14,46	4,67	13,00	16,05	6,17	15,00	-0,79	0,435
Controlled oral verbal associations	8,38	2,63	7,00	8,15	2,87	7,00	0,24	0,814
Speed of spontaneous speech	29,46	11,59	32,00	31,10	10,41	30,50	-0,42	0,675

APPLICATION 2

INITIAL VALUES OF DEMOGRAPHIC AND SPEECH PARAMETERS IN GROUPS OF PATIENTS WITH EFFERENT MOTOR APHASIA WHO UNDERWENT SPEECH THERAPY IN A MUSIC-ENRICHED ENVIRONMENT AND TRADITIONAL SPEECH THERAPY

Parameter	Main group			Control group			t	p
	M	SD	Me	M	SD	Me		
Age	53,23	12,23	56,00	50,85	9,86	53,00	0,62	0,542
Time post-onset (months)	14,31	7,12	13,00	14,90	5,53	16,00	-0,27	0,790
Index of laterality (Kpu)	0,07	0,67	-0,22	-0,13	0,72	-0,27	0,79	0,437
Efficiency index (Ief)	33,75	26,10	25,93	35,35	26,66	41,18	-0,16	0,870
Coefficient of productivity (Kpr)	20,73	10,81	18,75	21,21	8,74	21,88	-0,13	0,895
“Naming objects” subscale	25,96	5,52	27,50	27,23	3,33	28,50	-0,82	0,417
“Naming verbs”subscale	23,92	6,07	25,50	23,63	5,32	24,75	0,15	0,883
“Phrasing" subscale	15,88	6,55	14,00	17,50	6,76	19,50	-0,68	0,502
“Making up a story”subscale	5,68	4,79	5,50	6,18	5,34	5,00	-0,27	0,787
Expressive speech(total score)	95,91	23,39	99,50	99,19	18,28	100,50	-0,45	0,655
Phrases (understanding)	24,23	4,54	24,00	24,28	5,01	24,50	-0,03	0,980
Instructions (understanding))	25,50	3,29	26,50	25,33	4,62	27,00	0,12	0,907
Impressive speech (total score)	129,15	14,40	129,50	131,30	11,97	131,75	-0,46	0,645
MOR 1 score	227,65	33,62	233,00	231,77	27,54	234,00	-0,38	0,703
Free oral verbal associations	14,46	4,67	13,00	16,05	6,17	15,00	-0,79	0,435
Controlled oral verbal associations	8,38	2,63	7,00	8,15	2,87	7,00	0,24	0,814
Speed of spontaneous speech	29,46	11,59	32,00	31,10	10,41	30,50	-0,42	0,675

APPLICATION 4

CLINICAL EXAMPLES OF THE DYNAMICS OF ORAL SPEECH RESTORATION IN PATIENTS WITH EFFERENT MOTOR APHASIA DURING SPEECH THERAPY IN A MODELLING MUSIC-ENRICHED ENVIRONMENT

Speech samples of patients with efferent motor aphasia of the main group

Speech samples of the 1st and 15th (final) rehabilitation sessions are presented. They are given with excerpts. The author's style and speech errors have been preserved.

Patient T., 61 years, high education level, efferent motor aphasia, time post-onset 6 months.

1st Session. The painting “Moscow courtyard” (Artist Polenov V.D.). Musical consonance Glazunov A.K. “Symphony No. 7. in Fa major. Essay 77”. ... The sky is shaky ... it shines ... it's alive ... well ... it's quiet ... peaceful… how do you want to live by yourself…The old days. Now it's a different way to live ... well ... well, in general, the village is big ... the churches are beautiful ... and poverty and wealth… Both poverty and wealth."

15th Session. The painting "Above eternal rest". (Artist Levitan I.I.). Musical consonance Tchaikovsky P.I. Suite No. 3 in Sol major. Essay 55”. ... The old cemetery. That's why they've been living for many years, because the crosses are a little bit crooked, but... not... not... not-good-looking. Generally unkempt. In general, it is always quiet at the temple...".

Patient Sh., 50 years, special education level, mild efferent motor aphasia, 4 years old aphasia.

1st Session. Painting “Moscow courtyard” (Artist Polenov V.D.). Musical consonance Glazunov A.K. Symphony No. 7 in Fa major. Essay 77. “On the right ... left ... left ... left ... left ... garden. The garden in front of the crowbar, and the house is old in general.... Then... this painting also shows an old barn. A church is depicted in the distance... well, read at home. The bell tower...”

15th Session. The painting “The last pub at the outpost” (Artist Perov V.G.). Musical consonance: Bortnyansky D.S. “Concert symphony in Si bemolle major. I. Allegro maestoso. “... They went into a pub to eat, drink quickly, and the woman stayed in the wood. Their coachmen, no, not coachmen, but peasants who were carrying a woman, they threw hay to the horses and went to have a snack or a drink...”

Note: a hyphen in words means the syllabic pronunciation of a word caused by perceptual difficulties, ellipsis – stops in speech.

APPLICATION 5

INITIAL VALUES OF DEMOGRAPHIC AND SPEECH PARAMETERS IN GROUPS OF PATIENTS WITH ACOUSTIC-MNESTIC APHASIA WHO UNDERWENT SPEECH THERAPY IN A MUSIC-ENRICHED ENVIRONMENT AND TRADITIONAL SPEECH THERAPY

Parameter	Main group			Control group			t	p
	M	SD	Me	M	SD	Me		
Age	54,71	6,88	55,00	55,12	6,74	55,50	-0,18	0,859
Time post-onset (months)	14,00	6,46	12,00	14,54	7,54	15,00	-0,23	0,822
Index of laterality (Kpu)	-0,23	0,78	-0,56	-0,20	0,73	-0,15	-0,10	0,920
Efficiency index (Ief)	32,18	36,10	50,48	31,12	37,78	38,46	0,08	0,933
Coefficient of productivity (Kpr)	19,52	9,28	18,75	20,17	9,15	21,88	-0,21	0,837
“Naming objects” subscale	25,32	3,85	25,50	27,12	3,03	28,00	-1,62	0,112
“Naming verbs”subscale	23,04	5,61	23,25	25,15	3,52	25,00	-1,47	0,150
“Phrasing" subscale	14,79	5,66	14,00	21,56	5,42	23,00	-3,71***	0,001
“Making up a story”subscale	7,18	3,17	7,00	11,59	6,76	10,00	-2,30*	0,027
Expressive speech(total score)	95,00	17,84	90,65	111,15	14,43	113,25	-3,11**	0,004
Phrases (understanding)	23,79	5,04	25,50	24,77	4,96	26,00	-0,60	0,555
Instructions (understanding))	24,07	5,38	26,25	24,65	5,32	25,50	-0,33	0,744
Impressive speech (total score)	123,96	18,05	124,25	129,60	15,34	132,00	-1,04	0,304
MOR 1 score	218,96	32,69	215,50	240,73	26,42	246,50	-2,29*	0,028
Free oral verbal associations	16,50	3,55	16,50	19,38	5,62	20,00	-1,74	0,090
Controlled oral verbal associations	7,93	1,69	8,00	9,15	3,09	9,00	-1,37	0,179
Speed of spontaneous speech	31,64	13,99	34,50	40,08	15,50	35,50	-1,70	0,098

APPLICATION 6

DYNAMICS OF SPEECH PARAMETERS IN GROUPS OF PATIENTS WITH ACOUSTIC-MNESTIC APHASIA, THOSE WHO HAVE COMPLETED A COURSE OF SPEECH THERAPY IN A MUSIC-ENRICHED ENVIRONMENT AND TRADITIONAL SPEECH THERAPY

Parameter	Main group			Control group			t	p
	M	SD	Me	M	SD	Me		
Index of laterality (Kpu)	-0,19	0,87	-0,71	-0,18	0,73	-0,20	-0,03	0,975
Efficiency index (Ief)	34,48	34,43	38,86	37,88	31,24	45,46	-0,31	0,759
Coefficient of productivity (Kpr)	22,51	10,68	19,14	23,74	9,54	25,00	-0,37	0,717
“Naming objects” subscale	27,57	3,64	29,75	28,21	2,06	28,75	-0,71	0,480
“Naming verbs”subscale	25,21	5,00	27,75	26,15	2,90	26,25	-0,76	0,455
“Phrasing" subscale	17,61	5,44	17,50	22,90	4,96	24,00	-3,11	0,003
“Making up a story”subscale	10,48	5,12	10,10	12,42	6,23	11,60	-0,99	0,326
Expressive speech(total score)	107,23	18,55	110,50	117,24	12,64	116,75	-2,02*	0,050
Phrases (understanding)	25,46	4,87	27,25	25,94	4,22	27,00	-0,32	0,748
Instructions (understanding))	23,75	5,50	25,50	26,46	4,57	28,50	-1,67	0,104
Impressive speech (total score)	130,04	13,86	130,00	135,08	13,17	137,50	-1,13	0,264
MOR 2 score	237,27	29,82	240,25	252,34	21,63	257,75	-1,84	0,074
Free oral verbal associations	20,57	4,97	20,00	21,50	5,26	22,00	-0,54	0,591
Controlled oral verbal associations	9,71	2,27	9,50	10,38	3,30	11,00	-0,68	0,503
Speed of spontaneous speech	37,43	12,57	39,50	38,27	11,09	36,00	-0,22	0,828

APPENDIX 7

CLINICAL EXAMPLES OF THE DYNAMICS OF ORAL SPEECH IN PATIENTS WITH ACOUSTIC-MNESTIC APHASIA DURING SPEECH THERAPY IN A MODELLING MUSIC-ENRICHED ENVIRONMENT

Speech samples of patients with acoustic-mnestic aphasia of the main group

Excerpts from protocols 1 and 15 of the (final) rehabilitation session of the core group. Examples are given with excerpts. Speech errors and tempo characteristics of oral speech are preserved.

Patient M., 54 years, high education level, moderate acoustic-mnestic aphasia, time post-onset 8 months.

1st session. The painting "Moscow courtyard" (Artist Polenov V.D.). Musical consonance Glazunov A.K. "Symphony No. 7. in Fa major. Essay 77". ... Moscow courtyards ... some churches ... Village…Moscow, Moscow courtyard…Here is a two-storey house available..."

15th session. "A wet meadow" (Artist Vasiliev F.A.) Musical consonance Tchaikovsky P.I. "Symphonic fantasy "Fate". "The day is approaching evening. There are clouds in the sky. Moreover, the rays from the sun are very low, that is, it is really evening. There is a small fog, a haze. Apparently, they are expecting rain, because clouds form rain clouds. In addition, free-standing bushes are most likely shown. It shows some kind of structure, from where goats or cows are then driven out to the meadow to graze them...".

Patient A., 62 years, special education level, moderate acoustic-mnestic aphasia, time post-onset 18 months.

1st session. The painting "Maslenitsa" (Artist Kustodiev B.M.). Musical consonance Alyabyev A.A. "Quintet in Si major for flute, oboe, clarinet, bassoon and piano". It's also a good day. A beautiful sunny day... it was already sunset…The clouds are coming... so... sunset... red. Here... these ... trees are standing in frost all around..."

15th session. The painting "Above eternal rest". (Artist Levitan I.I.). Musical consonance Tchaikovsky P.I. "Suite No. 3 in Sol major. Essay 55". ... There is a small church on the shore of the river, on the island. There is a cemetery behind it and a hermit probably lives in this church… It gives the impression that it is so deserted. People are rare, so it is located so far away from life, you can say..."

Note: ellipsis marks stops in speech caused by word search

APPLICATION 8

INITIAL VALUES OF DEMOGRAPHIC AND SPEECH PARAMETERS IN GROUPS OF PATIENTS WITH EFFERENT MOTOR APHASIA WHO UNDERWENT SPEECH THERAPY IN A POLYSENSORY-ENRICHED ENVIRONMENT AND TRADITIONAL SPEECH THERAPY

Parameter	Main group		Control group		t	p
	M	SD	M	SD		
Age	50,73	8,67	50,21	10,05	0,20	0,844
Time post-onset (months)	27,62	18,93	24,75	20,04	0,52	0,605
Index of laterality (Kpu)	-0,23	0,61	-0,17	0,66	-0,33	0,746
Efficiency index (Ief)	43,31	24,51	33,65	31,13	1,22	0,227
Coefficient of productivity (Kpr)	26,83	6,06	20,88	8,45	2,88**	0,006
“Naming objects” subscale	26,69	3,73	26,40	3,75	0,28	0,781
“Naming verbs”subscale	24,96	4,12	22,69	5,36	1,69	0,098
“Phrasing" subscale	17,81	3,58	16,63	6,49	0,81	0,424
“Making up a story”subscale	10,98	4,92	5,48	5,12	3,87***	>0,0001
Expressive speech(total score)	103,89	16,61	96,49	19,11	1,46	0,150
Phrases (understanding)	24,63	3,99	23,52	4,92	0,88	0,382
Instructions (understanding))	25,60	3,94	24,88	4,20	0,63	0,534
Impressive speech (total score)	130,23	17,37	122,85	18,78	1,44	0,155
MOR 1 score	235,83	26,94	221,48	34,47	1,65	0,106
Free oral verbal associations	17,27	4,94	15,00	6,30	1,42	0,161

Parameter	Main group		Control group		t	p
	M	SD	M	SD		
Controlled oral verbal associations	8,65	4,71	7,92	2,87	0,66	0,511
Speed of spontaneous speech	29,85	12,99	27,75	11,99	0,59	0,557
MoCA-test (score)	24,50	2,89	24,92	2,34	-0,56	0,580
FAB test(score)	15,92	1,60	15,92	1,18	0,02	0,987
Subscale «retelling of the story» RBMT-3	5,46	1,65	4,65	1,79	1,67	0,101

APPLICATION 9

DYNAMICS OF SPEECH PARAMETERS IN GROUPS OF PATIENTS WITH EFFERENT MOTOR APHASIA, THOSE WHO HAVE COMPLETED A COURSE OF SPEECH THERAPY IN A POLYSENSORY-ENRICHED ENVIRONMENT AND TRADITIONAL SPEECH THERAPY

Parameter	Main group		Control group		t	p
	M	SD	M	SD		
Index of laterality (Kpu)	-0,12	0,63	-0,15	0,67	0,15	0,884
Efficiency index (Ief)	51,73	23,21	36,32	22,52	2,38*	0,021
Coefficient of productivity (Kpr)	29,75	5,70	22,80	9,66	3,13**	0,003
“Naming objects” subscale	27,75	2,82	27,44	3,01	0,37	0,710
“Naming verbs”subscale	26,33	3,45	24,10	4,85	1,88	0,066
“Phrasing" subscale	20,17	4,54	19,13	5,76	0,72	0,477
“Making up a story”subscale	13,05	5,39	6,68	5,05	4,30***	>0,0001
Expressive speech(total score)	112,61	14,93	101,32	18,26	2,40*	0,020
Phrases (understanding)	25,98	3,78	25,10	3,70	0,83	0,412
Instructions (understanding))	26,50	3,60	25,35	4,40	1,01	0,317
Impressive speech (total score)	136,20	13,49	128,52	18,10	1,71	0,094
MOR 2 score	249,47	25,80	231,78	33,45	2,10	0,041
Free oral verbal associations	20,38	5,46	16,17	6,36	2,52*	0,015
Controlled oral verbal associations	11,62	4,73	8,50	2,38	2,91**	0,006

Parameter	Main group		Control group		t	p
	M	SD	M	SD		
Speed of spontaneous speech	35,19	15,49	30,13	12,52	1,27	0,212
MoCA-test (score)	25,81	2,64	25,00	1,89	1,24	0,223
FAB test(score)	17,00	0,80	16,21	1,28	2,64**	0,011
Subscale «retelling of the story» RBMT-3	7,37	1,65	5,13	1,40	5,16***	>0,0001

APPLICATION 10

INITIAL VALUES OF DEMOGRAPHIC AND SPEECH PARAMETERS IN GROUPS OF PATIENTS WITH ACOUSTIC-MNESTIC APHASIA WHO UNDERWENT SPEECH THERAPY IN A POLYSENSORY-ENRICHED ENVIRONMENT AND TRADITIONAL SPEECH THERAPY

Parameter	Main group		Control group		t	p
	M	SD	M	SD		
Age	52,33	9,47	55,27	6,43	-1,32	0,193
Time post-onset (months)	22,52	19,82	24,23	18,94	-0,31	0,757
Index of laterality (Kpu)	-0,53	0,63	-0,23	0,74	-1,53	0,133
Efficiency index (Ief)	45,41	31,05	28,74	36,97	1,69	0,097
Coefficient of productivity (Kpr)	21,13	8,56	18,68	9,17	0,97	0,338
“Naming objects” subscale	25,98	3,86	26,50	3,25	-0,52	0,602
“Naming verbs”subscale	24,90	4,34	24,48	3,75	0,37	0,713
“Phrasing" subscale	18,29	5,12	20,37	5,91	-1,31	0,198
“Making up a story”subscale	10,26	4,73	10,48	6,91	-0,13	0,899
Expressive speech(total score)	102,19	16,24	107,33	16,68	-1,10	0,279
Phrases (understanding)	23,17	5,26	23,85	5,40	-0,45	0,655
Instructions (understanding))	22,45	5,91	24,02	5,65	-0,95	0,345
Impressive speech (total score)	120,74	20,16	122,33	20,19	-0,28	0,782
MOR 1 score	222,93	34,22	233,88	31,48	-1,18	0,244
Free oral verbal associations	19,05	6,39	20,47	5,32	-0,86	0,392
Controlled oral verbal associations	9,00	5,51	10,23	3,46	-0,98	0,331

Parameter	Main group		Control group		t	p
	M	SD	M	SD		
Speed of spontaneous speech	39,05	16,38	38,70	14,87	0,08	0,938
MoCA-test (score)	22,57	3,49	20,57	2,37	2,45**	0,018
FAB test(score)	15,43	1,08	15,90	1,54	-1,21	0,232
Subscale «retelling of the story» RBMT-3	4,50	1,85	5,77	2,13	-2,20*	0,032

APPLICATION 11

DYNAMICS OF SPEECH PARAMETERS IN GROUPS OF PATIENTS WITH ACOUSTIC-MNESTIC APHASIA, THOSE WHO HAVE COMPLETED A COURSE OF SPEECH THERAPY IN A POLYSENSORY-ENRICHED ENVIRONMENT AND TRADITIONAL SPEECH THERAPY

Parameter	Main group		Control group		t	p
	M	SD	M	SD		
Index of laterality (Kpu)	-0,52	0,64	-0,17	0,71	-1,84	0,072
Efficiency index (Ief)	52,41	31,23	35,51	28,18	2,02*	0,049
Coefficient of productivity (Kpr)	24,78	8,47	22,50	9,59	0,88	0,386
“Naming objects” subscale	25,98	3,86	27,88	2,05	-2,29*	0,026
“Naming verbs”subscale	24,90	4,34	25,58	3,17	-0,65	0,522
“Phrasing" subscale	18,38	4,89	21,58	5,77	-2,07*	0,044
“Making up a story”subscale	10,35	4,56	11,34	6,45	-0,60	0,548
Expressive speech(total score)	102,19	16,24	105,03	22,56	-0,49	0,624
Phrases (understanding)	24,33	4,96	24,57	5,01	-0,16	0,870
Instructions (understanding))	24,76	5,57	25,05	5,44	-0,18	0,855
Impressive speech (total score)	128,95	19,22	129,95	16,84	-0,20	0,845
MOR 2 score	243,28	33,63	242,44	28,22	0,10	0,924
Free oral verbal associations	23,95	8,82	21,60	5,93	1,14	0,260
Controlled oral verbal associations	11,19	5,01	11,03	3,48	0,13	0,895
Speed of spontaneous speech	54,71	19,39	37,23	11,41	4,05***	>0,0001

Parameter	Main group		Control group		t	p
	M	SD	M	SD		
MOCa-тест	24,19	3,33	20,93	2,13	4,26***	>0,0001
Тест FAB	16,38	1,32	16,37	1,33	0,04	0,970
RIVERMEAD (пересказ рассказа)	6,88	2,23	5,82	2,04	1,76	0,084