UDC 376.37-053»465.00/.07»
BBC Ч457.091
GSNTI 14.29.29
Code VAK 13.00.03

T. P. Kalashnikova, G. V. Anisimov, N. A. Savelyeva, M. V. Dovganyuk
Perm, Russia

PATHOGENETIC REASONS OF ARTICULATION DYSPRAXIA IN PRESCHOOL CHILDREN

Abstract. The process of prospective observation of 49 children with articulation dyspraxia shows that the core of pathogenesis of speech deficiencies is made up by gnostic disorders – non-speech and speech auditory disgnosis. Quantitative analysis of electroencephalography (EEG.) allows registering low functional integration of temporo-occipital parts on the right side and inter-hemispheric ties at the ages of 3 to 5 years. Functional severance of temporo-occipital parts of the brain is naturally connected with developmental problems of the non-speech auditory gnosis. Senior preschool children with articulation dyspraxia demonstrate transformation of inter-hemispheric ties which causes optimization of interaction of temporo-occipital parts of the subdominant hemisphere and functional disintegration in fronto-temporal and fronto-central parts of the right hemisphere which is connected with the development of oral and articulatory praxis.
The deficit of inter-hemispheric ties reflecting disorders in the processes of lateralization of the development of speech function stays in the process of ontogenesis.
Disorders of initial stages of comprehension of an auditory signal revealed in the course of the study of cognitive potentials corroborates the previously obtained data of coherent EEG analysis and testifies to the persistence of auditory signal comprehension disorders during all preschool age period.
Keywords: articulation dyspraxia, speech dysontogenesis, coherent analysis of electroencephalography (EEG).
About the author: Kalashnikova Tat'yana Pavlovna, Doctor of Medicine, Associate Professor.
Place of employment: Department of Neurology, Faculty of Pediatry, Perm State Medical Academy.
About the author: Anisimov Grigoriy Vladimirovich, Candidate of Medicine, Assistant Lecturer.
Place of employment: Department of Neurology, Faculty of Pediatry, Perm State Medical Academy.
About the author: Savelyeva Natalia Alexandrovna, Post-graduate Student.
Place of employment: Department of Neurology, Faculty of Pediatry, Perm State Medical Academy.
About the author: Dovganyuk Mariya Vasil'evna, Post-graduate Student.
Place of employment: Department of Neurology, Faculty of Pediatry, Perm State Medical Academy.

Speech development of children is a multicomponent, sophisticated and multilevel process of biological origin and dependent on cultural, social and psychological factors. Speech performs a cognitive, communicative

and regulatory function [3; 5; 12]. Early age speech function is vulnerable, and its impairment has several significant consequences.

Statistics testifies to a considerable amount of speech impairments in children – from 7.5% to 20% [6; 7; 9]. Clinical and neuropsychological manifestations of speech impairments in children have been studied well enough [1; 2; 10]. But historically, speech development disorders were initially studied in the framework of psychiatry, regarding them as a kind of manifestation of general development disorder [12]. Then, investigation and improvement of speech dysontogenesis was referred to the sphere of logopedics and defectology [3; 5; 10]. Neurologic practice has paid inadequate attention to speech development disorders, clinical verification of speech diagnosis and realization of pathogenetic foundations. Not infrequently various clinical variants are designated by one nonspecified term "speech development disorder" [4; 6; 7; 11].

In recent years, interest to the problem of optimal and impaired speech ontogenesis have been growing, which is associated with the formation of cognitive neurology as a branch of research and the growing number of children with speech dysontogenesis and its aftereffects.

But researchers are faced with a number of problems. The first problem is connected with terminological apparatus. Quite often one and the same clinical state in different systems of knowledge is termed differently, which encumbers understanding of the problem under discussion.

Thus, absence of uniformity in terminology and interpretation of speech syndromes bring about absence of a uniform methodological approach to their diagnostics and treatment.

The question of speech sound disorders in children, their clinical significance and influence upon the formation of other higher cortical functions in the process of the child's development needs special discussion. The group of children with speech sound disorders is very heterogeneous and may include patients with clearly marked variants of dysarthria (bulbar, pseudo-bulbar, extrapyramidal, etc.), mechanical dyslalia caused by the peculiarities of composition of maxillofacial region of children from polilingual environment.

Constant transformation of terms denoting speech sound disorders took place in history: dyslalia, phonetical disorders, functional articulation disorders, etc. [8].

Practice shows that there is a numerous group of children with random mild but stable speech sound disorders which may be accompanied by manifestations of innervations deficiency of articulatory muscles. And there are no total polimorphemic speech sound disorders, as in cases of dysarthria, or tone and contractility of articulatory muscles.

The term "developmental apraxia of speech" was introduced in the English special literature [8].

The closest term in our home logopedic literature is "cortical dysarthria", though acceptability of the

term is being challenged by a number of scholars [7; 8].

In the International Classification of Diseases (*ICD*) this variant of speech dysontogenesis is identified as "specific speech articulation disorder" in the form of frequent and persistent impairment of speech sounds, omissions, replacements and distortion of speech sounds accompanied by difficulty in understanding by the surrounding people. It is stressed that the reason of disorders of articulation development is unknown, but it is associated with impairment of fine differentiation of motor kinesthetic positions of the tongue, palate and lips and manifests itself in 10% of children younger than 8 years of age and in 5% of children older than 8 years of age. Thus, *the International Classification of Diseases defines the mechanism of the specific* speech articulation disorder in the form of kinesthetic dyspraxia.

Thus, all above mentioned terms denote an identical speech disorder manifested in impairment of sound articulation which is based on disorders in higher cortical functions associated with the formation of praxis. Still nowadays home literature contains practically no neurophysiological research devoted to the mechanisms of formation of articulation praxis at different stages of the child's development.

The aim of our research consists in studying the dynamics of inner-hemispheric and inter-hemispheric functional integration according to quantitative evaluation of electroencephalography (EEG) and cognitive event related potentials (CERP) in preschool children with articulation dyspraxia.

The united complex investigation of children included clinical-anamnesis, neuro-psychological and neuro-physiological observation. Neuro-physiological observation consisted in clinical and quantitative evaluation of EEG according to the data of average power coherence (APC) and a study of the components of APC while providing auditory stimuli in conditions of passive comprehension and singling out the significant stimulus in the situation of a deviant event («Odd-ball paradigm»). By the level of APC it is possible to evaluate the formation of inter-zone ties, single out zones with deficient, sufficient and optimal functional integration. The data obtained in the process of analysis of clinical manifestations of anamnesis show that prelinguistic development and use of first word combinations and sentences did not differ in time in children with articulation dyspraxia from normally developing children.

Neuropsychological testing of 3 – 5 year old children revealed statistically significant impairment of auditory gnosis, phonemic analysis and kinesthetic praxis (apraxia of posture). In the process of prospective observation optimization of speech auditory gnosis took place by 6 – 7 years of age, but impairment of phonemic analysis and kinesthetic praxis still remained.

These are two interconnected functions. Phonemic analysis is primary in relation to oral and articulatory kinesthetic praxis; its function is connected with the temporal lobe of

the dominant hemisphere. Phonemic analysis disorder is the primary neuropsychological syndrome bringing about distortion of the sound composition and spelling of a word, which, in its turn, may lead to problems in denoting objects, impairment of comprehension of complex sentences and underdevelopment of coherent speech (there is no support in the phonemic system of language). Taken together, all this causes impairment of the generalizing function of language.

Phonemic analysis is connected with controlling articulation positions characteristic of a certain sound. Kinesthetic articulation dyspraxia, also affective apraxia or apraxia of posture, leads to distorting speech sounds as a result of deformation of the necessary articulation position.

Thus, two mechanisms lie at the basis of pathogenesis of children with articulation dyspraxia – originally, it is the phonemic analysis disorder, which later causes inefficiency of the kinesthetic articulation praxis. And construction of phrases and syllabic word structure are not impaired.

Neuropsychological syndromes were compared with the results of EEG parameters analysis. At an early age (3 – 5 years), children with articulation dyspraxia demonstrate deficit of temporo-occipital ties in the right hemisphere (electrode pair O2-T4) in comparison with normally developing peers (Fig. 1).

The temporo-occipital parts are responsible for correlation of the image of an object with non-speech sounds, i.e. they are connected with one of the basic neuropsychological mechanisms of speech formation – non-speech auditory gnosis. Impairment of inter-hemispheric ties with low functional integration was also typical, which is manifested by low values of coherence in inter-hemispheric electrode pairs.

At the ages of 6 – 7, restoration of the temporo-occipital ties of the subdominant (right) hemisphere, responsible for the formation of non-speech auditory gnosis, takes place (Fig. 2). But there forms deficit of functional integration of central occipital parts of the dominant (left) hemisphere associated with the development of speech auditory gnosis and phonemic analysis. This may be a result of impairment of inter-hemispheric ties. The transfer of the auditory gnosis dominating regulation from right to left is damaged.

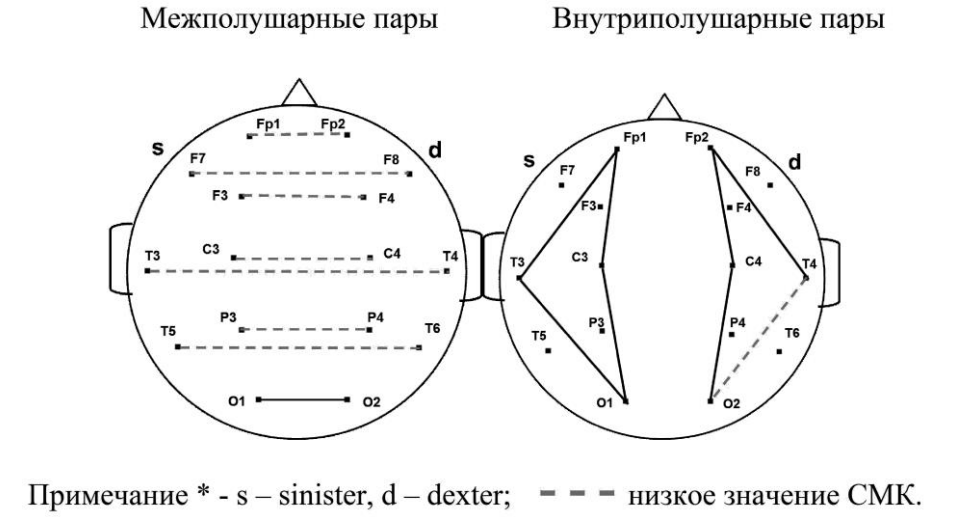

Figure 1. Average power coherence (APC) parameters (μV^2/Hz) on Intra-hemispheric and Inter-hemispheric pairs in children with articulation dyspraxia at the ages of 3 – 5

Inter-hemispheric pairs Intra-hemispheric pairs

Note: - s – sinister, в – dexter; --- low value APC

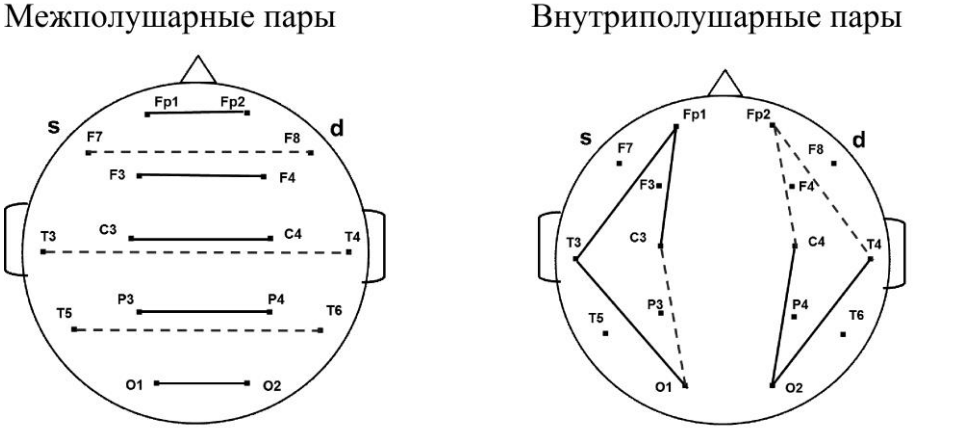

Figure 2. Average power coherence (APC) parameters (μV^2/Hz) on Intra-hemispheric and Inter-hemispheric pairs in children with articulation dyspraxia at the ages of 6 – 7

The same children at the ages of 6 – 7 revealed areas with low functional integration – fronto-temporal and fronto-central parts of the right (subdominant) hemisphere connected with the development of dynamic oral

praxis. Impairment of fronto-temporal ties may reflect poor conductance through the arcuate fasciculus which connects temporal lobes with premotor parts of the temporal cortex (area 6 according to Brodmann).

Functional organization of the brain in the process of ontogenesis presupposes three vectors of development – from the back (occipital) parts to front (temporal) ones, from right to left and from bottom to top.

The results of quantitative EEG show a slowdown of development of inter-hemispheric area ties in the front regions of the brain in comparison with normally developing peers.

In addition, we revealed inappropriate formation of intra-hemispheric area ties in stratigically important for speech development regions – temporo-occipital ones on the right at early stages of ontogenesis, temporo-occipital on the left and fronto-temporal ones on the right.

The impairment of correct formation of the inter-area ties in children with speech syndromes may be regarded as neurophysiological component of pathogenesis.

We also revealed the peculiarities of spatial-temporal organization of the brain in children in terms of dominant hemisphere.

Children with articulation dyspraxia and left-handedness at the ages of 3-5 had inadequate integration of central occipital parts of the dominant (left) hemisphere. Similar changes of APC have been observed in the group as a whole in the subdominant right hemisphere only. Thus, children with articulation dyspraxia and left-handedness have impairments of the same functional ties, only mirrored on the counter-lateral side.

We revealed high APC of tempo-ro-central areas on the right associated with the development of dynamic articulation praxis. This fact may be the result of compensatory mechanisms in terms of fronto-temporal parts of the brain in children with articulation dyspraxia on the background of interaction deficit of occipital central areas associated with the development of auditory gnosis. And activization of areas responsible for the development of articulation praxis may optimize the impaired phonemic analysis.

The APC parameters corroborate impairment of the processes of auditory gnosis on the right (interval P2 – N2), initial stages of perception of the auditory stimulus on the background of physically preserved hearing (peak P1) mainly in the left hemisphere. On the left, there was also damage of integrative activity of the frontal areas (peak N3). The revealed peculiarities of auditory perception and gnosis were preserved by the end of the preschool period. Analysis of cognitive event related potentials (CERP) parameters manifested peculiarities of integrative activity and information procession of the stimulus associated to a large degree with initial stages of perception and gnostic functions in children with articulation dyspraxia. A pathogenetic model of articulation dyspraxia was worked out as a result of the undertaken analysis.

Gnostic disorders are in the focus of pathogenesis. Development disorder of phonemic analysis causes kin-

esthetic dyspraxia, which is manifested in low functional integration of temporo-occipital parts on the right, severance of inter-hemispheric interaction defined by quantitative EEG analysis, and impairment of auditory perception at initial stages according to CERP results.

In the process of ontogenesis, deficit of inter-zonal ties moves to the frontal parts (fronto-temporal and fronto-central) of both hemispheres. Impairments of initial stages of perception of the auditory stimulus are preserved during the whole preschool period.

References

1. Vizel', T. G. Neyropsikhologicheskoe blits-obsledovanie. Testy po issledovaniyu vysshikh psikhicheskikh funktsiy / T. G. Vizel'. — M. : V. Sekachev, 2012. — 24 s.
2. Vizel', T. G. Osnovy neyropsikhologii / T. G. Vizel'. — M. : Astrel', 2005. —384 s.
3. Volkova, L. S. Logopediya : ucheb. dlya studentov defektologicheskogo fak. ped. vuzov / L. S. Volkova, S. N. Shakhovskoy. — M. : VLADOS, 1998. — 680 s.
4. Volodin, N. N. Osobennosti rechevogo razvitiya v rannem vozraste u detey s posledstviyami perinatal'noy patolo-gii nervnoy sistemy. Rannyaya diagno-stika rechevykh narusheniy i ikh korrek-tsiya : metod. rekomendatsii / N. N. Volodin, V. M. Shklovskiy, N. N. Zavadenko, M. I. Medvedev [i dr.]. — M., 2005. — 19 s.
5. Grigor'eva, L. P. Rol' verbal'nogo kodirovaniya v opoznanii zritel'nykh obrazov u detey s razlichnymi vidami psikhicheskogo dizontogeneza / L. P. Grigor'eva, E. A. Vishneva // Sistemnaya psikhologiya i sotsiologiya. — 2012. — № 6. — S. 86—96.
6. Zavadenko, N. N. Disfaziya razvitiya u detey: perspektivy neyrotroficheskoy terapii / N. N. Zavadenko, E. V. Kozlova // Zhurnal nevrologii i psikhiatrii im. S. S. Korsakova. — 2013. — № 5. — Vyp. 2. — S. 43—47.
7. Kalashnikova, T. P. Kognitivnye narusheniya u detey : ucheb. posobie / T. P. Kalashnikova, G. V. Anisimov, Yu. I. Kravtsov, T. G. Vizel' [i dr.]. — Perm', 2010. — 122 s.
8. Kornev, A. N. Osobennosti intellektual'nogo razvitiya detey s motornoy alaliey / A. N. Kornev // Metody izu-cheniya i preodoleniya rechevykh ras-stroystv. — SPb., 1994. — S. 3—12.
9. Kornev, A. N. O neyropsikhologicheskikh mekhanizmakh fonologicheskikh narusheniy pri motornoy alalii / A. N. Kornev // Defektologiya: sovremennye problemy obucheniya i vospitaniya : tez. dokl. — SPb., 1994. — S. 81—83.
10. Levina, R. E. Kharakteristika obshchego nedorazvitiya rechi u detey / R. E. Levina // Logopediya segodnya. — 2009. — № 1. — S. 6—19.
11. Skvortsov, I. A. Razvitie nervnoy sistemy u detey v norme i patologii / I. A. Skvortsov, N. A. Ermolenko. — M., 2003. — S. 249—267.
12. Fotekova, T. A. Sostoyanie verbal'nykh i neverbal'nykh funktsiy pri obshchem nedorazvitii rechi i zaderzhke psikhicheskogo razvitiya: neyropsikhologiche-skiy analiz : avtoref. dis. … d-ra psikhol. nauk / Fotekova T. A. — M., 2003. — 42 s.