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Characteristics for Functional Brain Asymmetry of Children With Pseudobulbar Dysartria

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Abstract

The article raises important problem of the causes of functional brain asymmetry and interhemispheric interaction of children with pseudobulbar dysarthria. The left hemisphere is dominant in relation to speech function for the absolute majority of people. Therefore, the physiological process for forming distribution of functions between hemispheres in ontogeny is important not only from the point of the correct speech development as the highest mental function but also reflects on the wide spectrum of psyche features, perception and cognitive processes, adaptive capabilities of the organism, control over involuntary behavior. There are 40 children with a normal speech development and with a clinical diagnosis of 'pseudobulbar dysarthria', determine a lateral phenotype, calculate coefficients of functional asymmetry, and the most common types of violations identify of higher cortical functions. Confirmed information on the prevalence for the right hemispheric dominance among children with speech disorders. The most common types of violations in higher cortical functions are the failure of phonemic analysis and auditory memory.

Keywords: functional asymmetry, interhemispheric actions, children, pseudobulbar dysarthria

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1. Introduction

Development of higher mental functions for children is closely connected with development of neurophysiological actions in functional specialization of left and right brain hemispheres, in interhemispheric interaction. It shows the increasing of leading role for associated systems in integration of innerhemispheric and interhemispheric interactions. Any complicated psychological activity form is in a complex of both brain hemisphere activity and every brain hemisphere plays its own role.

Functional brain asymmetry is a particular feature and has its specific dynamics of development in ontogeny. There is an opinion that both hemispheres for early age children operate equal according to right hemisphere. Functional specialization begin to activate during the second year of life and demonstrate motor control. Most of scientists consider that the process of interhemispheric asymmetry form is with process of corpus callosum development. There are: (1) motor asymmetry (combination for unequal functions of hands, legs, face and body muscles; (2) sensory asymmetry (unequal functions of sense organs for left and right parts of body); (3) psychic asymmetry (the most difficult type of asymmetry which is in unequal activity both hemisphere for neurological process development) [1–5].

In many ways, the question about hemisphere functions dynamic and their interaction in ontogeny is controversial and relevant. In particular, in dysontogenetic development of higher mental functions.

Speech development (one of higher mental function) – complicated process caused of internal and external factors. So that, there is a weakness in combination of speech development and further psychophysiological child development. Speech level development explains the dominance of left hemisphere and, furthermore, left-handed and right-handed definitions and peculiarities of left-handed children education.

In most countries, in Russian Federation, during the last years there is a growth of children with speech problems, in accordance with research from 7 to 20% [2–4]. One of the reason is deficits hemisphere functions development and in interhemispheric actions in ontogeny.

Some scientists depict that children with speech problems have stronger left hemisphere development and lack of interhemispheric action. Researchers explain the function lateralization of speech disabilities children activity because of reduction for right hemisphere. Besides, speech disabilities are with dysfunction of left and right hemispheres. There is a lack of interhemispheric difference, connected with corpus callosum immature. It leads to difficulty to transfer information from the left hemisphere to the right hemisphere [6–8].

Pseudobulbar dysarthria is the most common type of speech disorder caused by bilateral effect of motor cortical bulbar tracks which are from motor zone of big hemisphere to nerves in medulla oblongata. The most particular characteristic of this disease is paralysis of speech complex and different motor disorders. Intellectual development of children is normal but strong speech disabilities spoil the process of studying at school. There are zones of Brock and Vernick in left hemisphere which provide speech reproduction and awareness. These two part are connected by nerve tracks and present common system. They can be affected depending on pseudobulbar dysarthria.

In the scientific literature, the question for features distribution of functions between the hemispheres in children with speech disorders remains open [5, 6, 8]. While knowledge of lateral profile for preschool child with speech disorders, dynamics and features of interhemispheric interaction, will contribute to a better understanding of etiology, mechanism and pathogenesis of this disorder. Also describe individual trajectory of child development, develop a program for speech therapy.

The purpose of study to identify the features of lateral profiles in children with normal speech development and pseudobulbar dysarthria.

2. Methodology

The children aged 6 to 7 years were examined with normal speech development and who (15 people) attend state preschool educational institutions in Tyumen and children with a clinical diagnosis of pseudobulbar dysarthria (25 people) who attend Krynitsyna G.M. Center for Children Speech Development.

Based on literature data, a selection of tests was performed to determine the functional profile of the hemispheres [9–11] by the definition of leading arm, t leading leg, leading ear and leading eye.

The definition of leading hand: observation which hand child use when take a pen (pencil); tangled fingers (finger of leading hand is above); applauding test (leading hand is above) or more active); unscrew the cover of glass jar (non-leading hand keeps the jar, leading hand unscrew the cover); test 'Circle' (right-handed children draw the circle clockwise, left – handed anticlockwise); test 'pick up the thing' (often take the thing with the right hand); test arm's length (child with close eyes stretches arms and the leading hand goes up; test 'shrug' (child shrugs his shoulders, shoulder of leading hand rises higher); test 'untie the knot' (child unties knot on a thick rope, the leading hand is working more actively).

The definition of leading leg: jump on one leg (the leg is active when driving – leading); kick the ball (foot, active when driving – leading); to throw a leg on the leg (leading leg is located on top); take a step back (leg, the first started movement – the leading one); to stand on a chair on your knees (leg that started the movement is the leading one); go down from the chair (leg that started the movement is the leading one); test 'Skipping rope' (child jumps over the rope, leading leg starts moving and becomes ahead of unknown); measuring the length of step (leading leg makes more step); test for deviation from a given direction (child with closed eyes must pass in a straight line 4–5 m, if the leading leg is right, its step is greater, child deviates to the left from the direction of movement if leading leg is the left one).

The definition of leading ear: test 'Camerton' (duration of tuning fork for the right and left ear, the leading ear hears the sound longer); test 'Whisper' (the experimenter says something to the child in a whisper, the child brings his leading ear closer to him); test 'to listen to the noise in the street' (the child is asked to listen to what is happening on the street, he turns to the side with his leading ear); test 'clock ticking' (child listens to ticking of clock, the sound is heard louder by leading ear); test 'Phone' (child hears the phone, he brings the receiver to leading ear).

The definition of leading eye: Rosenbach's test (child holds a penciling outstretched hand, orienting it on a vertically oriented object in 3–4 m, then the child in turn closes the right and left eyes, when the leading eye is closed, the pencil moves relative to the landmark); narrowing of the eyes (the child is asked to screw up one eye, the child is screwing up the unintelligible eye); comparing the size of the circles (the child is asked to close one eye and show him a circle, then show the same circle with the other eye closed, the circle presented to the leading eye seems larger in size); measurement for monocular fields of vision using the perimeter of Forster (the field of vision of leading eye is larger); measurement of visual acuity (visual acuity of leading eye above); registration of eyes movements (child is asked to recall something, side that 'leaves' eyes when recalling is dominant one.

There is a definition of individual profile forebrain functional interhemispheric asymmetry of each child.

Based on results children were divided into three groups. The first group ('righties', dominance of the left hemisphere) – people with only the right (arm, leg, ear, eye) or predominantly with right (three of four) asymmetries. The second group – ambidextra – faces with a mixed asymmetry profile; the third (left-handed, dominating the right hemisphere) is a person with left (arm, leg, ear, eye) or predominantly left (three of four) asymmetries.

The coefficient of functional asymmetry is calculate by the formula:

$$\text{C. l.} = (\text{R.s.} - \text{L.s.})/(\text{R.s.} + \text{L.s.}) \times 100\%,$$

where: C. l. – coefficient of lateralization;

R. s. – right sign;

L. s. – left sign.

In the work, a neuropsychological examination of children with pseudobulbar dysarthria perform according to the method proposed by Zh. Glozman [12, 13]. We use a set of tests for older age group (6 years), including a proof sample, a sample for reciprocal coordination (interhemispheric interaction), arbitrary regulation, dynamic praxis, a graphic sample, samples for gnosis and praxis, an understanding of logical and grammatical constructions,. Samples evaluate on a 4-point scale:

'0' – is displays when child performs the propose experimental program without further explanation;

'1' – if a number of small errors are note, corrects by the child himself practically without the participation of the experimenter; in fact, '1' is the lower normative boundary;

'2' – child is able to complete the task after several attempts, detail tips and leading questions;

'3' – task is not available even after a detail multiple explanation from the experimenter.

The compactness of methodology is due to the age of the children, and, accordingly, their ability to keep attention when performing tasks, on average, about half an hour.

The statistical processing of material is carry out on a PC using the built-in analysis package of the MS Excel program. An evaluation of statistical significance of differences (p) between the observation groups perform using a parametric t-test for the mean (M + m) and percent (% + m). Differences in the indices consider reliable at a significance level of $p < 0.05$.

3. Results

The research present lateral profiles and coefficient FMA for pre-school children with normal speech and pseudobulbardysartria.

Children with normal speech have strong development of left hemisphere (86.6%). However, 13% of pre-school children in this group are ambidecks, lateral coefficient 7–9%. Nobody has strong right hemisphere. There is a variety of individual lateral phenotypes among children in motor and sensor spheres, moreover, there are some cases of left-handed children in left hemisphere profile. Generally, these research are similar to the data of different authors who study the formation of functional brain asymmetry in ontogeny [5, 9, 10].

In the group of children with pseudobulbar dysarthria, the common lateral profile with weak dominance of left hemisphere twice as low 944%), coefficient of right hemisphere lateralization is from 33% to 64%. Dominance of right hemisphere is among 24% children with pseudobulbar dysarthria. Three of them are left-handed

(50%), 32% pre-school children are right-handed (Table 1). Parents' interview shows that there are left-handed children among close left-handed relatives and right-hemisphere children.

Table 1: Allocation of lateral profiles for children with normal speech and speech disabilities.

Profile type	Children with normal speech (%)	Children with diagnosis: pseudobulbar dysarthria (%)
Only right profiles	–	–
Three right profiles and one left	86,6 ± 0,13	44 ± 0,08
Two rights and two left	13,4 ± 0,06	32 ± 0,05
Three right and one left	–	24 ± 0,01
Only left profiles	–	–

Neuropsychological research of higher cerebral functions: kinetic, dynamic and spatial praxis, non-speech tone, speech and tone gnosis, phonematic analysis, visual gnosis, reciprocal coordination. The results are in Table 1.

Table 2: The most common disabilities of higher cerebral functions among children with pseudobulbar dysarthria.

Right hemisphere dominance	Left hemisphere dominance
Phonematic analysis	Phonematic analysis
Auditory memory	Auditory memory
Kinetic praxis	Kinetic praxis
Kinesthetic praxis	Kinesthetic praxis
Construction praxis	_*
Finger gnosis	–
Visuoconstruction	–
–	Acoustic gnosis
Reciprocating coordination	–
Note: * – no violation is indicated «_».	

A difference in formation degree of higher cortical functions reveals in two groups of children. Table 2 shows a violation of phonemic analysis, auditory memory, kinesthetic and kinetic praxis, founds in children with predominant dominance of both right and left hemispheres. For preschool children with right hemispheric dominance, there is a structural praxis, finger and optic-spatial gnosis and reciprocal coordination. For group of preschool children with left-hemispheric dominance, acoustic gnosis is register below age norm. In both groups of children, there are no deviations from the age norm in the state of visual memory and in objective gnosis.

4. Discussion

Pre-school ages are is the difficult age in child's development. There is characterize from high level of psycho physiological development and intensive formation of physic. The specialization process of hemispheres for brain can be attribute to leading mechanisms of child development. There is a point of view that one main conditions of optimal neuropsychic activity is the functional asymmetry in brain (FAB). The role of each hemisphere can vary depending on tasks of activity, structure for its organization. The sign and direction of changes depend on previous interhemispheric relations level. For people left hemisphere is dominant in relation to speech function. Therefore, physiological process of FAB formation in ontogeny and interhemispheric interaction is important not only from the point of view for correct development of speech as a higher mental function. It is reflect, according to many researchers, on the whole spectrum of psyche features, perception and cognitive processes, adaptive capabilities of organism, control over involuntary behavior, and socialization level [7–10, 13].

The study notes that in early stages of ontogeny, maturation of right hemisphere is faster rate than the left one. Therefore, in early period of development, its contribution to the provision of psychological functioning exceeds the contribution in the left hemisphere. The left hemisphere there are complex functions as the morpho functional maturation of respective departments and interhemispheric commissures. The important role in this process belongs to the corpus callosum. The more mature functionality of right hemisphere is explain that child in first years of life the most relevant are space-time relations of the surrounding world, rather than logical interrelationships between phenomena. Therefore, in young children, functional asymmetry is express less than in adults, and activity of right hemisphere is often higher than left one. During ontogeny, role of left hemisphere in providing speech functions increases as psychological structure of speech activity changes (literacy, writing, reading). The defeat of the right hemisphere in childhood leads gross more spatial disturbances than in adults. Asymmetry of brain is form when corpus callosum ripens after first two years of life, before this age of hemisphere for child remain equipotential. The most important stage in formation of interhemispheric interaction is establishment of dominance of the right (or left) hand.

The right-brain child, or left-handed person, has a special organization of psyche, distinctive features of thinking, other preferences in interaction with the collective, performs household activities differently than left-brain children. The individual lateral profile consists of indicators set for functional sensory and motor asymmetry. The following asymmetry profiles are highlight: the right asymmetries are all right (hand, leg, ear, eye), mainly right – three right asymmetries and one left, mixed – two right and two left asymmetries, mainly left – three left and one right asymmetry, left – all left, symmetric – functions of all right and all left parts are equal [11, 13].

The results of FAB study among children with normal speech development and with pseudobulbar dysarthria show that among children with speech disorders, the right hemispheric dominance is higher, due to sensory asymmetries (leading ear, eye). This corresponds of studies data [2–4, 8, 9].

In general, the group of children with pseudobulbar dysarthria a greater variety of lateral profiles is note than among children with normal speech development.

Neuropsychological examination of children with pseudobulbar dysarthria in order to study the state of higher cortical functions showed that by 6–7 years the auditory gnosis is optimized, but a violation of phonemic analysis persists. Phonemic analysis is primary with respect to articulatory kinesthetic praxis, its function is associated with temporal lobe of dominant left hemisphere. Violation of phonemic analysis is primary neuropsychological syndrome, which causes violation of sound and letter composition of the word. There are difficulties in identifying objects, a violation of understanding complex sentences, there is a lack of coherent speech possession, since there is no support in phonemic system of language. Together, all this leads to a breakdown of the generalizing function of speech.

There is an explanation for these processes from the point of interhemispheric functional brain asymmetry. Apparently, formation of generalization systems (based on speech thinking) is possible only on basis of left hemisphere. The delay in speech development at a lower stage of generalization, apparently, delays formation dominance of hemispheres in speech, and this affects development of motor asymmetry. There is a simpler nominative function of speech is activated by both left and right hemispheres and lesion of left hemisphere in children does not lead to speech disruption.

All children with pseudobulbar dysarthria are diagnosed a disorder of the auditory memory. However, the children with left hemisphere dominance, volume of auditory memory reduce, while children with dominant right hemisphere have order memorization disrupt.

The results of the study shows the preserved functions of visual gnosis, subject correlation of the word in children with different lateral phenotypes.

5. Conclusion

Thus, the results demonstrate that children with 'pseudobulbar dysarthria' have slow activity of left hemisphere, right hemisphere dominates in motor, and, especially in sensor samples compared with children without speech problems.

The most common types of disabilities in higher cortical functions are phonematic and speech – acoustic memory.

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