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PECULIARITIES OF FORMATION AND DISTRIBUTION OF THE PROFILE OF FUNCTIONAL INTERHEMISPHERIC BRAIN ASYMMETRY IN MENTALLY RETARDED CHILDREN

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The study of the dynamics of interhemispheric relations during adaptation to changing environmental conditions, as well as during brain lesions or functional disorders in the activity of any structures, has revealed a predominant increase in the activation of the right hemisphere. Studies by different authors also show that many pathological brain states are characterized by a deviation of the functional brain asymmetry profile from that recorded in a normally functioning CNS. In our research, we tried to trace the peculiarities of the formation of individual asymmetry profile under the influence of sensory deprivation in children with hearing pathology.

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Introduction. Modern ideas about the functioning of the whole brain define it as a dynamic system capable of functional rearrangements of its current activity. Functional rearrangements set priority levels and weights of connections between brain structures involved in the current activity in such a way that the current activity is implemented in the most efficient way, in terms of motivation, and in the most minimized way, in terms of energy expenditure. The possibilities for this are inherent in the properties of the brain to combine rigidly fixed and plastic forms of structural organization and functional activity [1–3]. As a result, a certain type of intracerebral and interhemispheric interactions is formed during normal development of the organism in the process of interaction with the outside world, which, in turn, forms a certain type of functional brain asymmetry (FBA). Such a normal type of FBA (genetically predetermined) is characterized in humans by the formation of dominance of the right hand, right eye, dominance of the left hemisphere in the perception of verbal information, and the right hemisphere – in the service of reasoning activity, etc. Such a species-specific (for humans) profile of FBA has been studied in sufficient detail [4–7].

The normal formation of the nervous system in ontogenesis determines the formation of the brain and its interhemispheric and intersensory interactions under conditions of normally incoming efferent influences. At deprivation of any

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afferentations conditions of non-standard functioning arise and as a result adaptive-compensatory mechanisms of the nervous system can be triggered to restore the equilibrium interaction of the organism with the environment. The result of such adaptive restructuring is the organization of intersensory and interhemispheric interactions at a different level, which is reflected in the formation of the individual asymmetry profile.

The study of the dynamics of interhemispheric relations during adaptation to changing environmental conditions, as well as during brain lesions or functional disorders in the activity of any structures, has revealed a predominant increase in the activation of the right hemisphere [8–12].

Studies by different authors also show that many pathological brain states are characterized by a deviation of the FBA profile from that recorded in a normally functioning CNS [13–18].

In our research we tried to trace the peculiarities of the formation of individual asymmetry profile under the influence of sensory deprivation in children with hearing pathology.

Materials and Methods. The object of the study – schoolchildren aged from 8 to 11 years with normal and mild mental retardation. 36 children with mental retardation took part in the research. The control group consisted of 42 normally developing children. The children were divided into subgroups: 8–9 years old and 10–11 years old.

When determining the individual asymmetry profile (IAP) of the brain, the combination of motor (hand, foot) and sensory (vision, hearing) asymmetries – symmetries inherent in each person was taken into account, and the peculiarities of psychosensory asymmetry were considered [7]. Motor and sensory asymmetries were evaluated by the well-known tests of Luria [2] questionnaire Kovjazina M.S. and others [16].

In the study of psychosensory asymmetry, we adopted the Kinsbourne hypothesis [16, 17], which explains the direction of eye movements in response to a speech signal by preferential activation of the hemisphere responsible for the mental activity being realized at the moment.

The basis for the choice of specific research methods was the possibility of their application both in the group of healthy children and in the group of children with hearing pathology. This made it possible to conduct the research according to a unified program, which allows us to perform a comparative analysis of the obtained results.

When identifying characteristic trends in the formation of the individual asymmetry profile in these children and their normal peers, the relative coefficients of stability of dominance of each of the motor, sensory, and psychosensory functions (the ratio of the number of samples with stable laterization to the total number of samples, %) for each type of IAP were calculated. On the basis of these values, the average stability of dominance of a given asymmetry profile was calculated. Formation was considered stable with a ratio of more than 75%.

Due to the fact, that not all possible types of FBA profile distributions were encountered in our sample, we focused on the analysis of the most frequently encountered ones, there were four of them:

I – right-lateral and II – left-lateral types, including profiles, in which all four features or three out of four are unilateral (i.e. one hemisphere dominates in the organization of motor and sensory functions);

III – ambidextrous type, including profiles, in which four or three traits are ambidextrous (i.e. there is no clear hemispheric dominance in the organization of motor and sensory functions);

IV – partial type, when motor and sensory functions are dispersed in different hemispheres.

Results and Discussion. Quantitative data on the study of sensory and motor asymmetries, peculiarities of psychosensory asymmetry of mentally retarded children and their normal peers are summarized in Tabs. 1–5.

The obtained results show that in mentally retarded children aged 8 to 9 years the left eye dominates, the coefficient of stability of dominance of this eye is high, despite the absence of pure ambidextrous children, the coefficient of ambidextrous manifestation is rather high (Tab. 1).

Table 1

Percentage of normally developing and mentally retarded children by leading eye

Age	Patology						Normal					
In years	Leading eye			Pre-dominance stability coefficient		Ambidecstria coefficient	Leading eye			Pre-dominance stability coefficient		Ambidecstria coefficient
	D	S	A	D	S		D	S	A	D	S	
8 to 9	39	61	–	1.26	1.97	1.1	56	38	6	0.75	0.51	0.22
10 to 11	49	42	9	1.02	0.88	0.99	67	33	–	1	0.49	0.25

Note: D – right eye; S – left eye; A – ambidextrous.

In normally developing children, the distribution of subjects is different: the leading eye of a part of the subjects is the right eye, in 6% of cases pure ambidextrous eyes were identified, and the ambidextrous coefficient in the whole group decreased.

In the next age group from 10 to 11 years old, there was a smoothing of visual asymmetry in subjects with mild mental retardation (Tab. 1), but its increase in normally developing children. At this age, the right eye is the leading eye in the majority of subjects.

Table 2

Age distribution (in %) of normally developing and mentally retarded children (quantitative index and estimated coefficient of the leading ear)

Age	Patology				Normal			
In years	S	D	A	CLE	S	D	A	CLE
8 to 9	53.8	15.4	30.8	33.3	37.5	25	37.5	6.25
10 to11	46.1	30.8	23.1	11.5	13.64	63.64	22.72	–43.2

Note: D – right ear; S – left ear; A – ambidextrous; CLE – left ear coefficient.

As follows from Tab. 2, the left ear functionally predominates in children with mild mental retardation in both age groups (8 to 9 and 10 to 11 years). However, with age, the frequency of children with left ear dominance decreases slightly (from 53.8% to 46.1%), while the frequency of children with right ear dominance increases twofold (from 15.4 to 30.8). At the same time, the number of children with no predominance of one or the other ear is decreasing (from 30.8% to 23.1%). The left ear dominance rate in children with mental retardation decreases significantly with age (from 33.3% to 11.5%). In normally developing schoolchildren, initially between the ages of 8 and 9, a slight left ear dominance over the right ear is found, but with age, the number of children with left ear dominance and the number of children with functional ambidextrous hearing decreases, and the number of schoolchildren with right ear dominance increases significantly (from 25 to 63.64%). The left ear coefficient in normal developmental children changes from 6.25 to 43.2%, i.e. the insignificant predominance of the left ear at the age of 8 to 9 years is replaced by the functional dominance of the right ear.

Table 3

Age distribution (in %) of children by leading hand and right hand ratio (normally developing and mentally retarded children)

Age	Patology				Normal			
In years	right-handed	left-handed	ambidextria	Rhc	right-handed	left-handed	ambidextria	Rhc
8 to 9	77	23	–	36.5	90	–	10	42.5
10 to 11	84	16	–	37	95	5	–	57

Note: Rhc – right-handedness coefficient.

The distribution shows that there is a higher percentage of left-handed children with pathology (Tab. 3). In both age groups of children with mild mental retardation and children with normal development, the right hand dominates (the number of trials performed by the right hand is greater than the number of trials performed by the left hand), and the predominance of the right hand increases with age. However, while in children with mild mental retardation the right handedness ratio in the two age groups is below average (according to Fedoruk's classification [5]), in the group of normally developing children it is average for schoolchildren aged 8 to 9 years and above average in the group of children aged 10 to 11 years.

Table 4

Percentage distribution of subjects by leading leg and right leg dominance ratio

Age	Patology				Normal			
In years	D	S	A	Rlc	D	S	A	Rlc
8 to 9	85	15	–	31.6	80	10	10	40
10 to 11	44	36	20	10.7	66.5	2,5	31	24.6

Note: D – right leg; S – left leg; A – ambidextrous; Krl – coefficient of dominance of the right leg.

The study of functional asymmetry of legs in the majority of children in both groups also revealed the predominance of the right leg over the left one (Tab. 4). In addition, ambidextrous is also found here and the percentage of such children increases with age. As can be seen from Tab. 4, the coefficient of right leg dominance is not very high both in children with mild mental retardation and in healthy preschoolers, and it decreases with age.

Table 5

Age distribution of the subjects (in %) by psychosensory asymmetry asymmetry of normally developing children and children with mild mental retardation

Methodology	Age	Patology		Normal	
	in years	eye movement		eye movement	
		to the left	to the right	to the left	to the right
Actualization of the image	8 to 9	38	31	40	19
Auditory perception	10 to 11	49	17	55	20
Hearing perception	8 to 9	33	26	39	25
Visual perception	10 to 11	46	43	59	7
Actualization of the image	8 to 9	33	19	35	24
Kinesthetic perception	10 to 11	46	46	62	11

Tab. 5 shows the percentage of visually registered clear lateral eye movements. The data in Tab. 5 show that all subjects at the age of 8–9 years have a dominance of the right hemisphere in eye movements to the left when actualizing images of auditory and visual-spatial perception. No statistically significant differences are found in the asymmetry of normally developing children and children with a mild degree of mental retardation (8–9 years old) in this form of psychosensory asymmetry. At the age of 9–11 years the dominance of the right hemisphere in actualizing images of visual-spatial and auditory perception is observed only in normally developing children. Among subjects with a mild degree of mental retardation of 10–11 years of age, equal distribution in the participation of brain hemispheres in the realization of visual-spatial perception is noted.

When determining the brain IPA, all four asymmetry profiles were found in hearing-impaired preschoolers, while in healthy children – only two (Tab. 6). The left-lateral and ambidextral profiles were absent.

Children with right-lateral type of IPA (42.5% mentally retarded and 67.7% normally developing) made up a large group. Among them, only 11% of subjects with pathology and 23% of healthy children are full right-handed.

Left-lateral and ambidextral asymmetry profiles were detected in only 9% of children with mild mental retardation.

The partial type of laterization included significant groups of subjects with pathology and normally developing schoolchildren (48.5% and 32.3%, respectively).

The data of Tab. 7 show that children with a mild degree of mental retardation are characterized by delayed formation of laterization of interhemispheric asymmetry as compared to similar processes in their normally developing peers.

Table 6

Distribution of laterization types in asymmetry groups of normally developing children and mildly mentally retarded children (in % of the total number of subjects)

Type of laterization	Patology	Normal
I	42.5	67.7
II	6	–
III	3	–
IV	48.5	32.3

Table 7

Average coefficients of stability of dominance of sensorimotor and psychosensory functions in mentally retarded children and normally developing peers (in %)

FIA profile	Lateralization of motor and sensory functions		Lateralization of psychosensory functions	
	patology	normal	patology	normal
I	80	83	47.5	67
II	79	–	100	–
III	63.5	–	–	–
IV	74	76	41.5	51

Moreover, insufficient expression of laterization is noted not so much at the level of individual motor and sensory functions as at the level of psychosensory asymmetry. Thus, the indicators of the right-lateral type of FIA in mentally retarded children are 80% vs. 83% in normally developing children in sensorimotor functions, and in psychosensory asymmetry – 47.5% vs. 67%, respectively.

The conducted studies of children with a mild degree of mental retardation and in normality allow us to evaluate the peculiarities of formation and distribution of the FIA profile in schoolchildren with pathology. The profile of functional interhemispheric asymmetry was determined by the totality of motor (hand, foot), sensory (eye, ear) signs of FA taking into account psychosensory asymmetry.

In the course of analyzing the results obtained in assessing sensory functional asymmetry in children with mild mental retardation and their normally developing peers, a number of differences were revealed.

Thus, among mentally retarded children at the age of 8–9 years the left eye functionally dominates, but in the next age subgroup this dominance decreases. Among the majority of healthy schoolchildren up to the age of 10 years the right eye dominates and this dominance increases with age.

Thus, the dominance of the right hemisphere revealed in the studies, apparently, can be explained by the well-known fact that adaptation processes are predominantly realized by the right hemisphere, where the activity, including autonomic regulation, of the hypothalamus is more pronounced [11]. These differences are especially significant in comparison with normally developing children.

The most significant differences between the studied groups are manifested in the distribution of functional asymmetry of ear dominance, and these differences increase with age. Among children under 10 years of age, the predominance of left-sided asymmetry was revealed in the general subgroups (pathology and norm) (more significant in the group of children with pathology, the left ear remains dominant at the next age stage in the majority of children with pathology – 46.1%, and in hearing children it dominates only in a small part (13.64%) with a significant increase in the dominance of the left hemisphere in the realization of auditory functions.

Thus, the data on the functional asymmetry of the auditory analyzer also show that in children with mild mental retardation the right (adaptation) hemisphere dominates in providing sensory functions compared to the left hemisphere in healthy children.

The study of the dynamics of interhemispheric relations during adaptation to changing environmental conditions, as well as during brain lesions or functional deviations in the activity of any structures from the norm, has revealed a predominant increase in the activation of the right hemisphere [3, 4, 9, 10].

Along with the studies of sensory functions, motor functional asymmetry was analyzed, in the manifestation of which the predominance of the right hand over the left hand and the right leg over the left leg was revealed in the majority of children, with the right hand predominating in more children than the right leg. In the age group of children from 8 to 9 years old, right-hand asymmetry among mentally retarded schoolchildren is observed to a lesser extent than among their normally developing peers. Unlike normally developing children, they have a more significant role of the right hemisphere in the realization of this function. With age (10–11 years) the share of the left hemisphere in the formation of this function increases in the group of healthy children, which is not observed in the other group.

The revealed peculiarities may indicate a general difficulty in the formation of functional interhemispheric brain asymmetry in mentally retarded children.

In the manifestation of psychosensory asymmetry in subjects with pathology in the age period from 10 to 11 years, a tendency to smoothing of psychosensory asymmetry in the function of visual-spatial representations was revealed.

Summarizing the data of the study of functional asymmetries, we note that the number of children with right-hemispheric localization of sensory and motor functions in the groups of mentally retarded and normally developing on average is respectively 32% and 21%, with left-hemispheric localization – 46% and 63%.

With the undoubtedly leading role of the left hemisphere in children of both categories, we note that the specific weight of the contribution of the hemispheres to sensorimotor activity is different: in children with a mild degree of mental retardation, the contribution of the right hemisphere is more pronounced than in their healthy peers, which is explained by the redistribution of hemispheric functions under the influence of sensory deprivation.

Conclusion. Thus, it has been established that in children with a mild degree of mental retardation compared to normally developing children there is a redistribution of functions between the right and left hemispheres of the brain in the formation of functional asymmetry of sensory systems with increased dominance of the right hemisphere in these functions. Sensory disorder is reflected in the formation of motor functional asymmetry, which is expressed in the greater activetion of the right hemisphere in the realization of this function in mentally retarded children compared to their normally developing peers. The peculiarities of psychosensory asymmetry formation under the influence of sensorimotor disorders characterized by increasing ambidextrousness in the realization of visual and kinesthetic reactions functions in mentally retarded children have also been revealed.

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Թ. Յու. ԱԶԱՏՅԱՆ

ՄՏԱՎՈՐ ՀԵՏԱՄՆԱՑՈՒԹՅՈՒՆ ՈՒՆԵՑՈՂ ԵՐԵԽԱՆԵՐԻ ԳԼԽՈՒՂԵՂԻ ՖՈՒՆԿՑԻՈՆԱԼ ՄԻՋԿԻՍԱԳՆԱԴԱՅԻՆ ԱՆՀԱՄԱՉԱՓՈՒԹՅԱՆ ԿԱԶՄԱՎՈՐՄԱՆ ԵՎ ԲԱՇԽՄԱՆ ԱՌԱՆՁՆԱՀԱՏԿՈՒԹՅՈՒՆՆԵՐԸ.

Հոդվածում ներկայացված են տվյալներ գլխուղեղի աշխատանքի վերաբերյալ՝ սահմանելով այն որպես դինամիկ համակարգ, որն ընդունակ է ընթացիկ գործունեության ֆունկցիոնալ վերադասավորումների: Բացահայտվել են մտավոր հետամնացություն ունեցող երեխաների գլխուղեղի ֆունկցիոնալ միջկիսագնդային անհամաչափության պրոֆիլի ձևավորման և բաշխման առանձնահատկությունները: Հաստատվել է, որ թեթև աստիճանի մտավոր հետամնացություն ունեցող երեխաների մոտ, համեմատած նորմալ զարգացող երեխաների հետ, ֆունկցիաների վերաբաշխումը տեղի է ունենում ուղեղի աջ և ձախ կիսագնդերի միջև աջ կիսագնդի դոմինանտության պայմաններում:

Т. Ю. АЗАТЯН

ОСОБЕННОСТИ ФОРМИРОВАНИЯ И РАСПРЕДЕЛЕНИЯ ПРОФИЛЯ ФУНКЦИОНАЛЬНОЙ МЕЖПОЛУШАРНОЙ АСИММЕТРИИ МОЗГА У УМСТВЕННО ОТСТАЛЫХ ДЕТЕЙ

В статье представленные данные о функционировании целостного мозга определяют его как динамическую систему, способную к функциональным перестройкам текущей деятельности. Выявлены особенности формирования и распределения профиля функциональной межполушарной асимметрии мозга у умственно отсталых детей. Установлено, что у детей с легкой степенью умственной отсталости по сравнению с нормально развивающимися детьми происходит перераспределение функций между правым и левым полушариями головного мозга при формировании функциональной асимметрии сенсорных систем с повышенным доминированием правого полушария в этих функциях.