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Influence of developmental teaching methods on the regulation of nervous functions in children with intellectual disability and interhemispheric asymmetry of the brain

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Abstract

Introduction. *The degree of asymmetry in humans and the complication of mechanisms of interhemispheric interaction are formed mainly in the process of learning. However, little attention has been paid to the impact of developmental teaching methods on the regulation of nervous functions in children with intellectual disability. The aim of this article is to study the influence of developmental teaching methods on the regulation of nervous functions in children with mental development disorders and interhemispheric asymmetry of the brain.*

Materials and Methods. *The methodological basis of this research investigation was scholarly works by a number of authors devoted to the study of nervous functions in children with mental development disorders and interhemispheric asymmetry of the brain, regulation of these functions, identifying difficulties, and modeling the system of work with these children. (Boguslavskaya, Miroshnichenko, 2019, Maryutina, Yermolaev 2001, Reuter-Lorenz and others, 2000).*

Results. *The results of the research have shown that we have determined the level of mental development in mentally retarded children aged between 8 and 11 years caused by features of interhemispheric brain organization. We have conducted research of interhemispheric functional asymmetry and interhemispheric interaction in students studying different developmental programs, investigated dynamics of regulation of nervous functions in students aged between 8 and 11 years with impaired mental development and interhemispheric asymmetry. On the basis of the conducted research and work experience, the research findings are presented and a number of recommendations are provided.*

Conclusions. *The results of the research emphasize the necessity of systematic assistance to children with impaired mental development and interhemispheric asymmetry of the brain in the regulation of nervous functions in conditions of developmental learning. The findings should be taken into account in organizing work with this category of children.*

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Keywords

Interhemispheric asymmetry; Regulation of nervous processes; Children with mental retardation; Brain structure; Brain functions; Developmental teaching; Interhemispheric interaction.

Introduction

The problem of age dynamics of functional asymmetry of cerebral hemispheres in recent decades has been intensively studied in foreign and domestic psychology[1] [1–4]. The degree of expression of functional asymmetry in the person [5–7], complication of mechanisms of interhemispheric interaction are formed mainly in the process of training and depend both on features of the individual, and on a method of teaching [8–13].

The modern system of education is focused on the development of the symbolic and sign function of thinking. The age features of the brain associated with advanced development of right hemispheric functions are almost not used in it. Meanwhile, the active use of opportunities of the right hemispheric way of processing information, especially in elementary school, promotes the development of the child's abilities, allows to predict and increase the efficiency of school training [14; 15]. It is necessary to note insufficient attention of researchers to the problem of functional asymmetry of the brain hemispheres in connection with education of children of primary school age (from 8 to 11 years) when educational activity of the child is formed as the leading one. At this age the structure and functions of the brain undergo essential changes[2] [16; 17]. To provide for harmonization of brain functioning, it is necessary to have a differentiated system of selection of techniques for training and development according to the psychophysiological profile of the child, the individual rate of maturation of the nervous system and formation of intra- and interhemispheric connections.

Scientific research on the features of interhemispheric cerebral organization in children aged 8–11 is currently conducted in several directions. First of all, it is the study of functional asymmetry of hemispheres in preschool children in connection with the diagnosis of their readiness for school education. In recent years, the number of studies of interhemispheric brain organization in children with learning difficulties and, in particular, in children with mental development disorders, has been growing[3] [18; 19; 20] The study of the relationship between the features of interhemispheric brain organization in mentally retarded elementary school students and their level of development of intellectual and creative abilities and school performance is intensively developing. The essence of developmental

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learning consists in the fact that its contents, methods and the form of its organization are focused on patterns of child development Currently, the best-known systems of developmental learning are the system of J. B. Zankov and the system of D. B. Elkonin – V. V. Davydov [21].

The goal of developmental learning according to Zankov's system is integrity and maximum efficiency. Zankov identified four basic didactic principles in his system: teaching at a high level of difficulty; the leading role of theoretical knowledge; progression at a brisk pace; and students' awareness of the learning process [1; 22]. It is more difficult to deal with children with mental development disorders as their play activity is leading for a long time already at school age. Considering this, the process of developmental training has a number of features.

The focus of developmental education according to the system of D. B. Elkonin – V. V. Davydov system, is restructuring of the learning activity of the child at the level of the contents and forms of its organization in order to provide emergence of new psychological qualities – theoretical thinking, reflection, independency in the solution of various educational tasks, etc. [21].

The development of the problem of functional asymmetry of the cerebral hemispheres and interhemispheric interaction in younger students with mental developmental disabilities aged 8–11 studying according to different developmental programs is just beginning. Meanwhile, consideration of the dynamics of interhemispheric asymmetry of the brain and interhemispheric interaction during the period of school education under different developmental programs will make it possible to identify the most preferred strategies of perception and processing of information in students of different age and typological groups, optimize the learning process, develop the intellectual and creative abilities of a child. Based on this, we determined the need to study interhemispheric asymmetry of the brain in children with intellectual disability of 8–11 years old in the conditions of developmental learning.

Considering the above, our aim was to study functional asymmetry of the cerebral hemispheres and peculiarities of mental development of 8–11 year old students under different developmental programs.

Methods

From the above, it follows that teaching children with mental development disabilities of 8–11 years under the developmental program of D. B. Elkonin – V. V. Davydov activates to a greater extent right hemispheric brain systems. Education of children with mental development disorders of 8–11 years old according to the developmental program of J. B. Zankov activates left hemispheric brain systems to a greater extent. Further it follows that the correlation between the type of functional asymmetry of the cerebral hemispheres and the features of the training program will determine the level of mental development in these children studying in different developmental programs. Children with mental development disorders of 8–11 years old with a right hemispheric thinking style who study according to the developmental program of D. B. Elkonin – V. V. Davydov, and with the left hemispheric style, studying according to the developmental program of J. B. Zankov, will have a relatively higher level of intellectual development as compared to other types of functional asymmetry of the cerebral hemispheres. And also it is necessary to note individual features of functional asymmetry of cerebral hemispheres in younger schoolchildren, caused by features of interhemispheric interaction

at the differences in the structure of mental development in them will be formed by teaching them different developmental programs.

The above determined the following research objectives:

– to compare the dynamics of hemispheric activity in children with intellectual developmental disabilities of 8–11 years studying according to the developmental programs of D. B. Elkonin – V. V. Davydov, J. B. Zankov and the general education program, in the process of learning;

– to investigate interrelation of features of interhemispheric cerebral organization with the general level of intellectual development in children studying according to different educational programs;

– to reveal typological features of brain functional asymmetry in children with intellectual development disorders of 8–11 years old studying according to different educational programs and their correlation with the structure of intellectual development.

The object of the study was the pupils of the junior classes of special auxiliary schools No. 6 and 12 and of the main school No. 57 at the ASPU. In general, the sample of respondents was divided into two groups.

To solve the tasks set, we conducted a study of the features of interhemispheric interaction and the level of intelligence in mentally retarded children aged 8–11 who study according to the developmental programs of L. V. Zankov and D. B. Elkonin – V. V. Davydov, by the traditional program in the process of teaching children from grades I to III.

The study was conducted with the help of approved test methods.

To determine the functional state in the study was used M. Lusher color test; to diagnose the level of intelligence – Wechsler test (children's version); to diagnose the individual structure of mental development of younger students as an indicator of learning efficiency in the study was used group intellectual test consisting of seven subtests (execution of instructions, arithmetic tasks, addition of sentences, determination of similarity and difference of concepts, number series, establishment of analogies, symbols).

A total of 131 children aged between 8 and 11 years participated in the study, including 73 healthy schoolchildren and 58 children with mild mental retardation.

The degree of mental retardation was assessed on the basis of medical indications, degree of social adaptation, degree of intellectual functioning and mastery of the school programme while studying in a special educational institution.

Each category of examinees was divided into 2 age groups: 8–9 years old and 10–11 years old.

Control group of healthy schoolchildren:

– 8–9 years old 38 children, including 20 girls and 18 boys;

– 10–11 years old 35 children including 17 girls and 18 boys;

Experimental group of children with mental retardation:

– 8–9 years – 28 children, including 11 girls and 17 boys;

– 10–11 years – 25 children, including 12 girls and 13 boys.

Children in the experimental group were selected on the basis of accompanying documents with an approved diagnosis of mild mental retardation. After reviewing the results of clinical, laboratory, pedagogical and psychological examinations, a voluntary agreement was signed with family members and caregivers for the child's participation in the research.

Experimental psychological methods aimed at analysing preferences (motor and sensory) for performing certain behavioral acts, which allow determining not only the degree of interhemispheric asymmetry, but also using, for the first time, our proposed modification to determine interhemispheric interaction. Techniques for assessing interhemispheric interaction are considerably less developed than those aimed at determining interhemispheric asymmetry.

The functional studies were conducted in the morning, under conditions that comply with the hygiene requirements for educational institutions (SanPiN 2.4.2.2821-10, 2013). The ethical requirements outlined in the Declaration of Helsinki were observed during the study.

Since the aim of our study was to make a comparative analysis of the functional asymmetry of normal school children and children of the same age with mild mental retardation, we developed our original test questionnaire adapted for our study based on the well-known tests – the Edinburgh test and the Bragina and Dobrohotova (1988) method. In our test questionnaire we kept the first 10 questions of the Edinburgh test which we added to the 4 questions of the Bragina and Dobrohotova (1988) test. Thus, our test-questionnaire consists of fourteen questions about the preference for using the right or left hand when performing certain actions, such as writing, drawing, sewing, brushing hair, brushing teeth, using a spoon or fork, etc. (Table 1).

Table 1

Student questionnaire

	Action to be performed	**Left hand**	**Right hand**
1.	Which hand do you write with?		
2.	Which hand do you draw with?		
3.	Which hand do you throw a ball with?		
4.	Which hand do you use to catch a ball?		
5.	Which hand do you hold scissors with?		
6.	Which hand do you hold your toothbrush in?		
7.	Which hand do you hold the dinner spoon in?		
8.	Which hand do you hold the comb?		
9.	With which hand do you open the lid of a box (box of chocolates)?		
10.	Which hand do you hold the hammer with when you hammer a nail?		
11.	The finger of the leading hand rests on top when the fingers are intertwined (lock)		
12.	"Napoleon's pose (the hand that goes first to the forearm of the other hand and rests on top of it is considered the leading hand)		
13.	Applause test (the leading hand is more active and mobile, it makes striking movements against the palm of the nonleading hand)		
14.	Which hand you pick up an object from the floor		

Based on the results of the presented test-questionnaire, the coefficient of functional asymmetry (CFA), the coefficient of manual (motor) asymmetry (CMA) and the coefficient of general asymmetry (CGA) are calculated according to the following formulas:

$$CFA = \frac{N(right) - N(left)}{N\,m}$$

Where CFA is the coefficient of functional asymmetry, N(right) and N(left) the number of "+" signs in the "Right hand" and "Left hand" columns respectively, Nm is the number of tests offered.

$$CMA = \frac{N(right)}{N(left)}$$

$$CGA = \frac{CFA+CMA}{2}$$

Where CGA is the coefficient of overall asymmetry, the arithmetic mean of the CFA and CMA coefficients.

Statistical processing of the results of the study was carried out using the Spearman correlation coefficient.

Results

The frequency of response options to the test-questionnaire to determine motor (manual) asymmetry in the group of healthy children is presented in Table 2.

Table 2

The frequency of response options to the test-questionnaire to determine motor (manual) asymmetry in the group of healthy children

N test question	Leading hand (%)		
	Right	Left	Both hands
1	83,8	16,2	0
2	83,8	16,2	0
3	73	10,8	16,2
4	75,7	16,2	8,1
5	75,7	16,2	8,1
6	83,8	13,5	2,7
7	75,7	13,5	10,8
8	75,7	18,9	5,4
9	82,8	14,3	2,9
10	85,3	11,8	2,9
11	56,8	43,2	0
12	54,1	45,9	0
13	86,5	13,5	0
14	85,3	14,7	0

As we can see from the data in Table 2, pupils perform most of the actions with the right hand. In the first test (writing) children's right hand was dominant in 83.8 % of cases and left hand in 16.2 %. In the second test the number of children who preferred to draw with the right hand

was 83.8 %, the left hand 16.2 %, the same as in the first test. We obtained some variety from the results of the third test. When throwing the ball 73 % of children had the right hand and 10.8 % the left hand; we also found a small number of children using both hands (16.2 %). Analysis of answers to the fourth and fifth questions has revealed that 75.7 % of children prefer to hold scissors and tooth-brush in the right hand, 16.2 % – in the left hand, and the number of children able to perform this action with both hands made 8.1 %. When asked about the use of a spoon the majority of children answered that they hold it in their right hand (83.8 %), 13.5 % in the left hand and 2.7 % of children are able to hold a spoon in both their right and left hand. A slightly different picture was obtained for the seventh test. The number of children able to hold a comb in both right and left hand increases (up to 10.8 %) as compared to previous tests, although the majority of children are right-handed – 75.7 %, 13.5 % are left-handed. In the next test, the number of children using their left hand to open the lid of the box increased to 18.9 %, which exceeds the number of left-handed children in the previous tests. The right hand is dominant in 75.7 % of cases, and a small number of children using both hands was found – 5.4%. For the hammer, the right hand is dominant in 82.8% of cases and the left hand in 14.33% of cases; there are also children able to hold the hammer in both hands – 2.9%. In the "lock" test, the right hand was dominant in 56.8% of cases and the left hand in 43.2%. In the "Napoleon Pose" test, the right hand was dominant in 54.1% of children and the left hand in 45.9%. In the clap test, in which students were asked to clap their hands, the right hand was dominant in 86.5% of children and the left hand in only 13.5%. The right hand raises an object from the floor with 85.3% of students, while 14.7% do it with the left hand.

The following table shows the results of motor (manual) asymmetry in the group of children with mental retardation. (Table 3).

Table 3

The results of motor (manual) asymmetry in the group of children with mental retardation

N Test question	Leading hand (%)		
	Right	Left	Both hands
1	73,2	26,8	0
2	68,9	25,9	5,2
3	74,4	18,9	6,4
4	73,8	23,1	3,1
5	91,8	8,2	0
6	76.8	18,6	4,6
7	88,9	6,3	4,8
8	93,6	6,4	0
9	38,6	36,8	24,6
10	86,6	13,7	0
11	65,8	34,2	0
12	56,6	43,4	0
13	43,8	56,2	0
14	40,9	44,8	14,3

As we can see from the data in Table 3, as in the previous study, students perform most of the actions with the right hand (tests 1–10). In the first test (writing), children's right hand was dominant in 73.2 % of cases and left hand in 26.8 %. In the second test, the number of children who preferred to draw with the right hand was 68.9 % as in the first case, the left hand was 25.9 % and 5.2 % of mentally retarded children could draw with both hands. Approximately the same trend holds for the third test. When throwing the ball 74.4 % of children had the right hand as the leading hand, 18.9 % had the left hand, and a small number of children using both hands, 6.4 %, were also detected. Analysis of answers to the fourth question has revealed that 73.8 % of children prefer to hold scissors in the right hand, 23.1 % of children – in the left hand and 3.1 % can use both hands if necessary. 91.8 % of children prefer to hold a toothbrush in the right hand and 8.2 % in the left hand.

When asked about spoon use, the majority of children answered that they hold a spoon in their right hand (88.9 %), 6.3 % hold it in their left hand and 4.8 % of children can hold a spoon in both right and left hands.

A somewhat different picture was obtained for the eighth test. No children were found able to hold a comb in both right and left hands, although the majority of children are right-handed – 93.6 %, 6.4 % are left-handed. In the next test, the number of children using the left and right hand to open the lid of the box was approximately equal – 38.6 % and 36.8 % respectively, with 24.6 % of test takers using both hands. When using a hammer, the right hand dominates in 86.6 % of cases and the left hand in 13.7 %. In the “lock” test, the right hand was dominant in 65.8 % of cases and the left hand in 34.2 %. In the “Napoleon's Pose” test, the right hand was dominant in 56.6 % of children, and the left hand in 43.4 %. In the clap test, in which students were asked to clap their hands, the right hand was dominant in 43.8 % of children and the left hand in 56.2 %. The right hand raises an object from the floor with 40.9 % of pupils, 44.8 % do it with the left hand and 14.3 % perform the action with both hands.

To determine latent signs of left-handedness, which are most often unknown to the subject himself and are not influenced by learning, the tests “intertwining of fingers”, “crossing of hands on the chest” and “applauding” were used. According to the data obtained, they supplement the data on the presence of signs of motor asymmetry in the subjects (N. N. Bragina, T. A. Dobrohotova, 1988).

A study conducted to determine left- and right-handedness yielded the following results: among normally developing children aged 8–11 there were 56 right-handed children (77 %), 14 left-handed children (19 %), and three ambidextrous children (3) or 4 %. Of the 8–9 year olds, 76.3 % or 29 children were right-handed, 18.4 % or 7 children were left-handed, and two ambidextrous children were identified, accounting for 5.3 %. In the 10-11 year old group right-handed children accounted for 80 % or 28 children, left-handed – 17.1 % or 6 children, and one ambidextrous child was detected, accounting for 2.9 %.

The same calculations for mentally disabled children revealed the following numbers: right-handed – 41 children or 70.7 %, left-handed – 15 children or 25.9 %, ambidextrous – two (2) or 3.4 %. A breakdown by age group showed that at ages 8–9 years were right-handed – 67.8 % or 19 children, left-handed – 25 % or 7 children, and 2 ambidextrous children were identified, representing 7.2 %. In the 10–11-year-old age group, right-handed children comprised 72 % or 18 children and left-handed children comprised 28 % or 7 children. There were no ambidextrous children in this group.

The same data is presented more clearly in the form of a diagram.

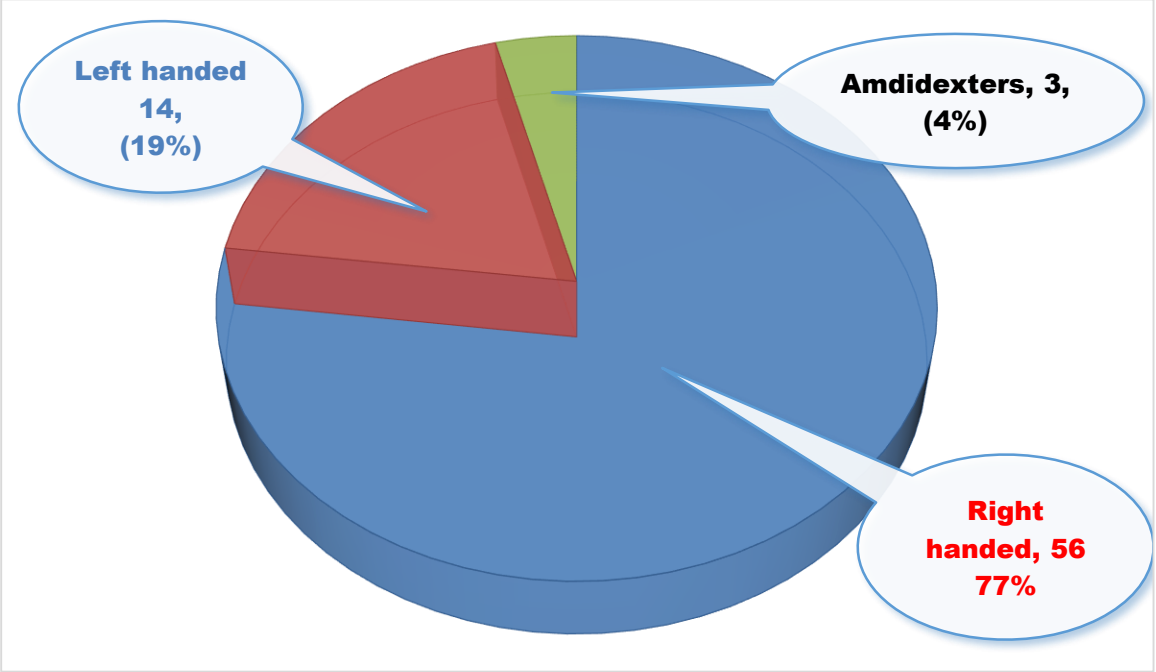

Fig. 1. Distribution of children in the control group by manual preference

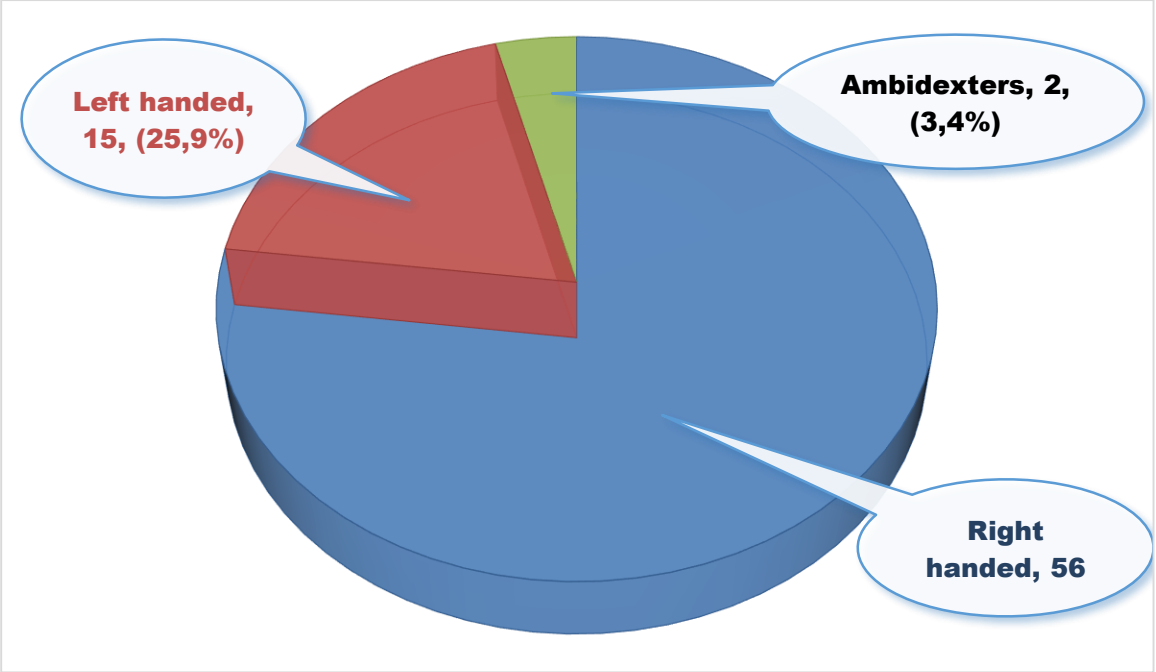

Fig. 2. Distribution of children in the experimental group by manual preference

Familial left-handedness is found in less than a third of the children surveyed.

Responses to questions about manual preferences for various subject activities showed that 38 % of children with intellectual disabilities were left-handed or ambidextrous, with a predominance of boys among these children.

For each child, we calculated the CFA (Coefficient of Functional Asymmetry), CMA (Coefficient of Motor Hand Asymmetry) and COA (Coefficient of General Asymmetry) (Table 4).

Table 4

Child Coefficients

Asymmetry coefficients	Control	Experiment
CFA	41,7	25
CMA	55,8	40
CGA	48,75	32.8

Note:
CFA – Coefficient of Functional Asymmetry,
CMA – Coefficient of Motor Hand Asymmetry,
COA – Coefficient of General Asymmetry.

Averaged results calculated for the groups as a whole showed that in the group of children with mild mental retardation, the different types of asymmetry were less pronounced, which may indicate a weak degree of differentiation of hemispheric functions and their more pronounced equipotentiality.

Discussion

Our findings suggest left hemispheric dominance in school children, both in the Bragina and Dobrohotova tests, and in the Edinburgh questionnaire. Although manual asymmetry coefficient and handedness coefficient are related to each other, right-handed dominance, as revealed by the results of the answers to the questions, and the nature of sensory asymmetry are not consistent with each other.

The presence of a left-sided profile of individual brain asymmetry in a third of boys and about 40 % of girls is caused, as a rule, by impaired left hemisphere functions manifested in a global, undifferentiated left hemisphere response to meaningful and insignificant visual stimuli.

In addition, we noted isolated inconsistencies in the responses to the questionnaire and the actual preference for right and left handedness. On this basis, we considered it necessary to conduct additional research in order to improve the Edinburgh questionnaire and developed an adapted test questionnaire.

Thus, we distinguish between two types of laterality that we encountered in our study: pathological and functional. Pathological laterality, associated with changes in interhemispheric interaction underlying the integration of brain functions, is, in our opinion, compensatory in mental retardation due to organic brain damage. In children with mental retardation, the immaturity of the integrative and trigger structures of the left hemisphere is noted, which also leads to pathological laterality.

Functional laterality is not inherently pathological, it does not contradict the laws of normal mental development, including

intellectual development; on the contrary, many researchers believe that right hemisphere dominance promotes creative personal development. We believe that reproductive teaching methods appealing to the left hemisphere can create stereotypical approaches to creativity in children by the age of 9–11. Right-hemisphere functions include precise perception and memory of stimuli that cannot be easily verbalised or are too complex to be labeled with words. Because the right hemisphere is figurative, sensory, information processing is global. We refer to right hemisphere dominance as a functional type of laterality.

Conclusions

The information obtained in the data must be taken into account when organizing the learning process in the elementary school when working with mentally retarded children, when forming classes, when choosing programs, methods of teaching, when organizing psychological and pedagogical support.

The age features of the brain associated with advanced development of right hemispheric functions are almost not used in it. Meanwhile, the active use of opportunities of the right hemispheric way of processing information, especially in elementary school, promotes the development of the child's abilities, allows to predict and increase the efficiency of school training.

In the course of widespread research on functional asymmetry of the brain, it has become increasingly clear that the notion of autonomy of each hemisphere in providing for different human activities and that the splitting of the brain results in a situation where a person receives two brains instead of one is untenable.

Clinical experience shows that neither the left nor the right hemisphere is at an advantage. Regardless of which side of the brain is affected, patients with focal brain damage show reduced or even impossible social adaptation.

The functional contributions of the right and left hemispheres to the formation of the human psyche are assumed to be different because the hemispheres in their paired work function differently in time. The paired work is carried out in the present tense, so that the right hemisphere relies on the past, the left on the future tense. Therefore, the preservation of paired hemispheric functioning and structural integrity of the brain is the main condition, without which full-fledged mental activity cannot be formed.

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Научная статья / Research Full Article
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Влияние методов развивающего обучения на регуляцию нервных функций у детей с умственной отсталостью и межполушарной асимметрией мозга

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Проблема и цель. *В процессе обучения проявляется степень выраженности функциональной асимметрии у человека и происходит усложнение механизмов межполушарного взаимодействия. Однако вопрос влияние методов развивающего обучения на регуляцию нервных функций детей с нарушением умственного развития мало разработан. Цель работы – исследование влияния методов развивающего обучения на регуляцию нервных функций у детей с нарушениями умственного развития и межполушарной асимметрией мозга.*

Методология. *Методологической основой послужили работы ряда авторов, посвященные исследованию нервных функций у детей с нарушениями умственного развития и межполушарной асимметрией мозга, регуляции этих функций, выявлению трудностей, а также моделированию системы работы с этими детьми.*

Результаты. *По результатам исследования был определен уровень умственного развития у умственно отсталых детей 8–11 лет, обусловленный особенностями межполушарной мозговой организации. Проведено исследование межполушарной функциональной асимметрии и межполушарного взаимодействия у школьников, обучающихся по различным развивающим программам, исследована динамика регуляции нервных функций у школьников 8–11 лет с нарушением умственного развития и межполушарной асимметрией. На основе проведенных исследований и опыта работы представлены пути решения некоторых аспектов проблемы и предложен ряд рекомендаций.*

Заключение. *В заключении отмечается необходимость оказания систематической помощи детям с нарушениями умственного развития и межполушарной асимметрией мозга при регуляции нервных функций в условиях развивающего обучения.*

Ключевые слова: *межполушарная асимметрия; регуляция нервных процессов; дети с нарушением умственного развития; структура мозга; функции мозга; развивающее обучение; межполушарное взаимодействие.*

Библиографическая ссылка: Азатян Т. Ю. Влияние методов развивающего обучения на регуляцию нервных функций у детей с умственной отсталостью и межполушарной асимметрией мозга // Science for Education Today. – 2022. – Т. 12, № 3. – С. 116–131. DOI: http://dx.doi.org/10.15293/2658-6762.2203.06

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