CEREBRAL HEMISPHERES FUNCTIONAL ASYMMETRY IN THE EDUCATION OF NATURAL SPECIALTIES AND HUMANITIES STUDENTS

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Summary

The functional asymmetry of the human brain hemispheres (motor, sensory and mental) reflects the difference in the distribution of neuropsychological functions between its right and left hemispheres. Both hemispheres are involved in the implementation of any types of mental activity or regulation of vegetative physiological processes, but each of them provides different aspects of this activity and some processes domination. Persons with left-hemisphere and right-hemisphere thinking differ in the features of perception, analysis, and reproduction of information, which is important in the process of students' educational activities.

That is why the aim of this investigation was to conduct a comparative analysis of the types of the brain hemispheres dominance in students of natural and humanities education who study at the biological and philosophical faculties of the Ivan Franko National University of Lviv and proposed methodological approaches for development and activation both (left and right) brain hemispheres.

Methods used in the study: determining the coefficient of functional asymmetry of the brain; general scientific (analysis and synthesis), methods of theoretical research (from abstract to concrete).

It was shown that most of the student are dominated by the left brain hemisphere but organizing of the educational process needs to use methods of educational activities aimed at the development and activation both (left and right) brain hemispheres.

Key words: morphological asymmetry; sensory asymmetry; mental asymmetry, motor asymmetry; student educational activities, control the quality of learning; methodological approaches to teaching.

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1. Introduction

The cerebral hemispheres functional asymmetry is one of the conditions necessary for the higher nervous activity of a person processes realization. Although the right and left brain's hemispheres generally have a similar structure and symmetrical projections of sensory pathways, each of them is characterized by morphological features and specializes in the implementation of certain functions of the cortex of the large hemispheres. Using the method of intrauterine fMRI of the fetus was found that the functional connectome (a collective set of functional

connections in the brain) is formed in the prenatal period from the 20th to the 40th week of gestation and further determines the adult motor and cognitive behavior *(Cara et al., 2022; De Asis-Cruz et al., 2021; Turk et al., 2019)*.

Morphological and functional asymmetry of the cerebral hemispheres is present not only in humans, but also in many animals at different levels of biological organization *(Gómez-Robles et al., 2016)*. A comparative morpho-functional analysis of the brain hemispheres of humans, chimpanzees and rhesus macaques revealed the most asymmetric connections in the frontal, parietal and temporal cortex of the human left hemisphere, which may be the anatomical (structural) basis for language development and tool using. Asymmetric connections between the inferior parietal cortex and the motor cortex of the human brain apparently related to hand activity *(Cheng et al., 2021; Neubauer et al., 2020; Wan, 2022).*

All manifestations of functional asymmetry of the cerebral hemispheres are divided into three groups: motor, sensory and mental. Motor asymmetry is related to the peculiarities of the motor activity of the right and left parts of the body and is a set of signs of inequality in the functions of the muscles of the arms, legs, halves of the body and face in the formation of general motor behavior. Many studies are devoted to motor asymmetry, namely manual asymmetry. According to the leading hand, people are divided into right-handed (with dominance of the left hemisphere), left-handed (with dominance of the right hemisphere) and ambidextrous (with equally developed hemispheres). The study of manual asymmetry is important from many aspects, in particular, it is useful for improving (optimizing) professional training and work organization of people in those specialties that require significant motor activity of the upper limbs.

Sensory asymmetry (sight, hearing, taste, smell, and touch) consists in the fact that the central parts of the analyzers in the right and left hemispheres of the brain perceive the information coming to them from the senses differently. Attention to the study of sensory asymmetry, primarily auditory and visual, is constantly growing, which is due to rapid changes in modern society, which is becoming more and more information-saturated, and therefore a person in his daily educational or professional activities has to quickly and qualitatively process significant amounts of information.

Mental asymmetry is manifested in the unevenness of the functions of the large hemispheres of the brain in the process of mental activity, which includes emotional manifestations, perception, thinking, consciousness, speech, etc. *(Behosh et al., 2021).*

In 95% of men and 80% of women, the left hemisphere of the brain is usually dominant *(Arslan, 2016: 75)*. It provides analytical activity, comprehension of oral and written language *(Ries et al., 2016)*, expression of thoughts in words, implementation of mathematical calculations and fine motor skills. So, the left hemisphere specializes in verbal-symbolic functions, while the right hemisphere is responsible for the spatial-synthetic functions of the brain: perception of space, gestures accompanying speech, recognition of familiar objects.

The functional activity of the cerebral hemispheres studied by specialists in various fields of biology and medicine: anatomists, physiologists, neurologists, psychiatrists, narcologists, sports medicine doctors and rehabilitation specialists, as well as specialists in humanitarian field's – psychologists, linguists, teachers, etc.

2. Organization of investigation

In the work, 92 students aged 17–20 studying at the biology and philosophy faculties of the Ivan Franko National University of Lviv were examined, among them 80 women and 12 men (uneven gender distribution is due to the predominance of girls in these specialties).

All research participants had no health complaints. Functional asymmetry of the cerebral hemispheres was assessed by determining the coefficient of functional asymmetry of the brain *(Nevedomska, 2010)*. To do this, each participant of the experiment performed a series of 12 tests aimed at assessing motor and sensory asymmetry, and marked the result of each test with the letter L or R in the case of left or right half of the body, respectively. In the absence of predominance, the test result was marked with the letter B (both).

The calculation of the asymmetry coefficient (CA) was carried out according to the formula:

CA = [(ER – EL) / (ER + EL + EB)] x 100%, where: ER is the number of tests in which the right half of the body predominates in performing the task; EL – the number of tests in which the left half of the body prevails; EB – no advantage. According to the coefficient of asymmetry, the following groups were distinguished: ambidextrous – 0 – 9%; low CA – 10 – 55%; high CA – 56 – 100%. Negative values of the asymmetry coefficient indicate the dominance of the right hemisphere of the brain.

3. Prevalence of brain hemisphere dominance among students

The aim of the work was to provide methodological approaches for teaching the discipline "Physiology of the central nervous system and higher nervous activity" to students of the Faculty of Biology majoring in "Biology" and "Secondary Education (Biology and Human Health)" and to students of the Philosophy Faculty majoring in "Psychology" of the Ivan Franko National University of Lviv, depending on type of dominant hemisphere of the brain.

As the result of the research conducted, the majority of students (75.1%) of both sexes, regardless of the chosen profile (natural or humanitarian), revealed the dominance of the left hemisphere, which is fully consistent with generally known data, as well as the fact that the average level of functional asymmetry prevails *(Susanti, 2018)*. As can be seen from Table 1, the average level of functional asymmetry with the dominance of the left hemisphere was 65.2% of students. Dominance of the right hemisphere was found in only 2.2% of students. Quite unexpected was the fact that almost 21% of students were ambidextrous according to the test (Table 1).

Table 1

Distribution of natural and humanities students according to the coefficient of hemispheric asymmetry

n=92	LH Dominance			Ambidextrous	RH Dominance
	Low	Medium	High		
Asymmetry coefficient (M±m)	16,6±0,20	42,29±1,84	76,36±1,36	2,37±0,84	-6,08±5,92
%	6,5	65,2	5,4	20,7	2,2
N	6	60	5	19	2

During a detailed analysis of the functional asymmetry of the hemispheres, depending on the chosen profile, it was found that among students of both natural and humanities education, the same tendency towards the predominance of an average level of functional asymmetry with the dominance of the left hemisphere (tables 2; 3), however, with some predominance of such students among natural scientists (79% among biology students versus 62% among psychology

students). At that time, ambidextrous and individuals with right-hemisphere dominance were more common among psychology students. In particular, 25% of students who chose psychology had equihemispheric dominance, while only 5% of biologists were equihemispheric (Tables 2, 3).

Table 2

Distribution of biology students depending on the type of functional hemispheres asymmetry

n=19	LH Dominance			Ambidextrous
	Low	Medium	High	
Asymmetry coefficient (M±m)	16±0	35,36±3,45	75±0	9±0
%	10,5	79	5,25	5,25
N	2	15	1	1

As for the dominance of the right hemisphere, in our study this type of functional hemispheric asymmetry was observed in only 2 psychology students, which is 2.2% of all studied students and 2.7% of the total number of psychology students.

Table 3

Distribution of psychology students by the type of the hemispheres functional asymmetry

n=12	LH Dominance	Ambidextrous
	Medium	
Asymmetry coefficient (M±m)	47±4,33	0
%	83,8	16,2
N	10	2

It is known that the left hemisphere is better suited for verbal and analytical processing of information and the right hemisphere is better suited for processing information in a visual-spatial-holistic way. Verbal functions of the left hemisphere underlie analytical thinking. Visual-spatial functions of the right hemisphere provide imaginary thinking processes (figurative thinking).

The left hemisphere, which is mainly involved in analytical processes, operates with discrete concepts and a sequence of individual symbols, and therefore it can be called logical. On the contrary, the right hemisphere works with whole constructions, with sensory images that provide a whole analogous description of the world.

The unity of such two main aspects as the functional asymmetry (or specialization) of the cerebral hemispheres and their interaction ensures the mental activity of a person. Interhemispheric organization of mental processes is the most important psychophysiological characteristic of brain activity. The ability to correctly diagnose the dominance of a student's hemisphere and to choose a strategy of educational and cognitive activity corresponding to these features will contribute to the most efficient organization of the educational process.

4. The influence of cerebral hemisphere dominance on learning

What information can a teacher get, knowing about the individual profiles of the functional asymmetry of the student's brain hemispheres?

Individuals with the dominance of the left hemisphere of the brain (with a left-hemisphere type of thinking) have a tendency to abstraction and generalization, linguistic and logical character of cognitive processes, high concentration, concentration of attention, deep and accurate reproduction of factual material, however, they may have difficulties when necessary to independently complete tasks, feel discomfort, if you need to show ingenuity, creativity *(Kuchmenko, 2009)*. For the successful educational activity of such students, the teacher must provide clear, specific, preferably written instructions, analyze the details during the explanation, repeat new material for better assimilation, arrange individual tasks to test knowledge.

Students with a right-hemisphere type of thinking are prone to creativity and the concrete-figurative nature of cognitive processes, and therefore experiments, practical activities, especially in groups, and emotionally colored presentation of material are effective during learning.

Students with an equihemispheric type of thinking, in which the right and left hemispheres work synchronously, quickly assess the situation and make decisions, and therefore have the opportunity to be successful in various organizational scenarios.

Individual features of the functional asymmetry profile of the cerebral hemispheres determine the adaptive capabilities and psychovegetative reactions of students in different periods of educational activity.

Such data allow teachers to apply an individual approach to students during their studies at the university in order to form a complex of knowledge in their specialty and preserve the health of students.

"Physiology of the central nervous system and higher nervous activity" is one of the basic discipline for students majoring in "Biology", "Psychology" and "Secondary education (biology and human health)", as it reflects the relationship between the biological and mental components of the body's functioning, characterizes the physiological the basics of mental processes, innate and acquired forms of behavior and integrating functions of the nervous system in the processes of adaptation to changing environmental conditions, including anthropogenic and social factors.

5. Examples of the methodological approaches

Both secondary education and academic education with its high degree of complexity and specialization are mainly aimed at the development of the left hemisphere, to some extent neglecting the development of the right hemisphere of pupils and students.

Discreteness of perception (in parts), rationality, prognostication, consistency, analyticity, audisticity (the leading role of auditory analyzer), dominance of abstract-logical thinking and orientation towards symbolic verbal-digital and formula coding of information are characteristic of left-hemisphere individuals. This type of perception and processing of information causes high indicators of the development of verbal intelligence and a tendency to theoretical and analytical activities. Left-hemisphere students have a large memory capacity, actively use arbitrary memory, and require repeated repetition and memorization to memorize.

Right-hemisphere people are characterized by such features of the processes of perception and processing of information as syntheticity (integrity), deductiveness, complexity, nonlinearity, spontaneity, visualism (the leading role of the visual analyzer), the dominance

of visual-figurative and visual-action thinking. The consequence of this is high indicators of the development of non-verbal intelligence, ease of spatial orientation, inclination to practical activities. The right hemisphere ensures an even distribution of attention, not its focusing and concentration, and the process of memorization mainly occurs during practical human activities.

The cited differences in the perception and processing of information by individuals with left- or right-hemisphere dominance indicate that it is important for left-hemisphere students to apply a discrete approach to learning, that is, the inductive method "from part to whole". In working with right-hemisphere students, on the contrary, it is necessary to use the deductive method of learning "from the general to the specific".

The use of the inductive method when studying a topic is especially useful when the material is mainly factual or related to the formation of concepts, the content of which can become clear only during inductive reasoning. For left-hemisphere students, it is advisable to offer calculation and situational problems that are solved by the inductive method, especially when the teacher considers it necessary to independently lead students to learn more generalized concepts, mechanisms, laws, etc.

The dominance of the right hemisphere determines the propensity for creativity, concrete-figurative nature of cognitive processes, divergent (aimed at developing as many options as possible for solving a problem) thinking. Right-hemisphere students benefit from formulating tasks that require the identification of consequences from some more general propositions. To control the quality of the knowledge of such students, it is advisable to use closed-type tasks with the choice of one correct answer from among four or five proposed options, tasks to establish correspondence (or to search for logical pairs) between the proposed elements, filling in tables, supplementing diagrams, etc.

So, for example, when studying the topic "Physiology of the visual sensory system" in working with students with a left-hemisphere type of thinking, the teacher can use tasks, namely:

Task 1. For a hyperopic patient in 2.3D, the distance to the point of near vision (punctum proximum) is 52.3 cm. Calculate the width of accommodation. Round the result to the nearest tenth and specify the units of measurement.

Task 2. Calculate the size of the projection of an object on the retina of the eye, which is 4.1 cm high and located at a distance of 38.2 cm. The distance from the nodal point to the retina is 17 mm. Round the result to the nearest tenth and specify the units of measurement.

In advance, the teacher provides an algorithm for performing actions, explains the necessary basic concepts.

When working with right-hemisphere-dominant students, you can use closed-ended test questions to choose the correct answer from a set of proposed answers, for example:

Test 1. What is the adaptation of the eye to a clear vision of objects at different distances called?

1) hypermetropia;
2) refraction;
3) myopia;
4) accommodation;
5) anomaly.

Test 2. Rays reflected from an object are focused in front of the retina. What is this type of eye refraction anomaly called?

1) Emmetropia;
2) Myopia;
3) Hypermetropia;

4) Amblyopia;
5) Astigmatism

Since there are students with dominance of one or another hemisphere or lack of dominance in the classroom at the same time, it is advisable to select different types of tasks for consolidating the studied material and quality control of knowledge to enable all students to realize their abilities in accordance with individual psychophysiological characteristics.

As for the relationship between the type of hemispheric asymmetry and task performance, there are some contradictions. According to Everts et al. *(Everts et al., 2009)*, greater language lateralization as determined by functional magnetic resonance imaging (fMRI) correlated with higher verbal IQ. Chiarello et al. *(Chiarello et al., 2009)* used visual hemifield paradigms to assess language lateralization and found a positive correlation between the degree of lateralization in these tasks and reading skills. On the other hand, according to the data of other researchers, task performance deteriorates with increasing asymmetry. For example, individuals with less lateralization perform better on a face discrimination task than more lateralized individuals *(Ladavas & Umilta, 1983)*. Similar results were observed when subjects simultaneously performed two cognitive tasks (face recognition and lexical decision) *(Hirnstein et al., 2008)*.

Among the students who participated in our study, the clear majority are left-hemisphere dominant, and the level of dominance corresponds to the average. Such students are inclined to perceive facts, examples and make generalizations based on them, as well as to move from theory to using knowledge in a laboratory class during experiments, solving problems, solving open-ended problems, orally answering detailed questions.

Of course, developed intelligence involves the coordinated interaction of the left and right hemispheres, and therefore interest in educational activities, a specific topic, discussion of different points of view, establishing differences in processes (properties, signs, etc.), which are compared with each other, activates the work of the right hemispheres, which will only contribute to the achievement of learning goals, regardless of which type of hemisphere dominance the student belongs to. Based on the data we received, we should talk about the use of inductive or deductive teaching methods, about deductive and problem-based explanation of the topic, about reproductive or search-based practical work, which stems from the didactic goal that the teacher sets for himself at a certain stage of the lesson. Although there are far fewer right-hemisphere students than left-hemisphere students, the teacher should also use teaching methods and techniques to mobilize the capabilities of the right hemisphere. During the explanation of the material, it is, for example, a consideration of the process in its development, dynamics with a detailed visualization of all stages, and not just their enumeration with a short definition, but for independent processing of the material by students – the use of project technologies.

6. Conclusion

So, despite the fact that most students are dominated by the left brain hemisphere, organizing of the educational process needs to use methods of educational activities aimed at the development and activation both (left and right) brain hemispheres.

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