International Journal of Medical Sciences And Clinical Research (ISSN – 2771-2265)
VOLUME 04 ISSUE 04 PAGES: 33-42
SJIF IMPACT FACTOR (2022: 5. 893) (2023: 6. 184) (2024: 7.544)
OCLC – 1121105677
Publisher: Oscar Publishing Services

Journal Website: https://theusajournals.com/index.php/ijmscr

Research Article

FUNCTIONAL ASYMMETRY AS ONE OF THE MECHANISMS OF FUNCTIONING OF THE NERVOUS SYSTEM IN NORMAL AND PATHOLOGICAL CONDITIONS

Submission Date: April 18, 2024, Accepted Date: April 23, 2024,
Published Date: April 28, 2024
Crossref doi: https://doi.org/10.37547/ijmscr/Volume04Issue04-05

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ABSTRACT

In recent years, research into functional interhemispheric asymmetry has been intensively carried out in our country and abroad. An analysis of publications related to this topic shows that the problem of interhemispheric asymmetry is associated with some fundamental properties of living matter and is present at almost all stages of the evolutionary ladder. In the 30-40s of the 20th century, the study of functional asymmetry in healthy people began. The identified asymmetries were divided into three main types: mental, motor and sensory.

KEYWORDS

"Reduced criticism", "denial" "impaired awareness", "non-recognition of the disease", "defective insight", Motor asymmetry, interhemispheric asymmetry.

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INTRODUCTION

Motor asymmetry - asymmetry in the functioning of the legs, arms, and facial muscles, for example, in right-handed people, the left hand is more resilient than the right to static force; the muscles on the left side of the face are stronger than the right, as a result the left side of the face appears more masculine. Previously it was assumed that the basis of motor asymmetry is the anatomical asymmetry of the motor areas of the cerebral cortex, but at present this statement is refuted [5]. The development of motor asymmetry is determined by the activity of the periphery in the early periods of ontogenesis, which leads to microstructural rearrangements at the level of the cerebral cortex, that is, anatomical asymmetry is a consequence of the activity of the periphery [46]. Motor asymmetry appears and increases in childhood, reaches its maximum development in adulthood, and is leveled out in late age. If you begin to retrain a left-handed person in early childhood, then he will be left with a characteristic sensory and mental asymmetry that is different from that of a right-handed person [2]. Motor asymmetry is unstable and can change during the adaptation period [4]. The right hemisphere is responsible for stereoscopic vision, rotation in space, spatial representations and orientation, perception of both the left and right parts of external space [11]. According to some authors, the right hemisphere type of processing is characterized by a general assessment of the situation in context, distinguishing movement patterns based on their global characteristics [11].

Sensory asymmetry is an asymmetry in the functioning of the senses. Sensory asymmetry is a clearer and more constant characteristic of the activity of central systems. This type of asymmetry persists and becomes stronger throughout life [10]. There are asymmetries in the organs of vision, hearing, taste, smell and touch. Information perceived by sensory systems enters the right and left hemispheres, and its processing and storage occurs in the hemisphere, adapted to this type of information. In experiments studying the asymmetry of touch, it was found that the pain threshold is higher on the dominant hand, and temperature sensitivity is higher on the non-dominant hand [2]. The most pronounced asymmetry in the functioning of the organs of vision and hearing. It is known that the dominant eye is the first to catch an object, so its accommodation occurs faster. The object is perceived by the dominant eye as larger and more contrasting. A predominance of the right side of the visual field and the left hemisphere in the perception of verbal stimuli and in the analysis of verbal information was revealed, which is more pronounced in right-handed people [4]. The aiming ability and localization of the object in space are different [17]. In this case, a change in interhemispheric asymmetry leads to a change in ocular dominance, which is manifested by a

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change in visual fields and subjective localization of objects [20]. Auditory asymmetry is considered a more stable type of sensory asymmetry, since visual asymmetry is leveled out after 30 - 35 years, and auditory asymmetry - after 40 - 50 years of life [16]. The presence of interhemispheric connections ensures the transfer of information to the other hemisphere, with verbal information arriving in the left hemisphere, and non-verbal information in the right hemisphere. Low-frequency sounds are better distinguished by the left ear, and high-frequency sounds are better distinguished by the right ear [2]. At this point in time, there is no convincing data proving the existence of functional asymmetry of the organ of taste and smell.

The Main Findings and Results

The distribution of higher nervous functions between the hemispheres (thinking, consciousness, emotions, perception of space and time, speech) is defined as mental asymmetry. Relationships: in this case, they are built on the principle of "specialization" and not "dominance" [2]. It is advisable to analyze the "brain-psyche" relationships with a separate characteristic of each link. The brain is a paired material organ. In the implementation of right-handedness and left-handedness of the hemispheres in a living brain, such a fundamental factor is important, acting only in a living brain, as time [10]. The psyche is impossible without the brain, but it differs fundamentally from it in its intangibility. In most people, the left hemisphere is dominant in speech and verbal thinking and memory based on it, motor functions (the psychomotor sphere of the holistic psyche), and the right hemisphere is dominant in the perception, experience of the world and oneself in this world (the psychosensory sphere of the holistic psyche). A left-hander is different from a right-hander to the extent that the asymmetry of his brain is different. Asymmetries of the brain and psyche are mediated by spatiotemporal factors [24]. These asymmetries apparently mean the opposite of the spatio-temporal organization of the paired work of the hemispheres of the brain and the two main spheres of the integral psyche. An assumption arises about the special role of space and time in the implementation of asymmetries of the human brain and psyche [22]. It is currently assumed that changes in mood are associated with changes in the activity of the structures of the left hemisphere with simultaneous inhibition or disinhibition of the structures of the right hemisphere [28].

The existence of functional asymmetry of the telencephalon hemispheres in relation to speech functions has been established. However, the left hemisphere dominates linguistic operations, including speech, syntactic analysis and phonetic representation. However, the results of many years of work have shown that although the left hemisphere plays a decisive role in speech operations, its speech activity is modulated by the right hemisphere [5]. A

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manifestation of speech asymmetry is the anatomical asymmetry of certain paired areas of the brain. The magnitude of some fields predominates in the left hemisphere, others - in the right. In the frontal and temporal areas, the coefficient of asymmetry of the fields that are part of the motor and sensory speech zones is greater than in other fields of the same areas [5]. It has been established that the connection between the cortical part of the brain and the brainstem is different. In right-handed people, the right hemisphere is more closely connected with the diencephalic region, responsible for autonomic, humoral, and endocrine regulation [1]. Paired brain structures are in close interaction, which determines the heterogeneity of functional asymmetry in individuals. Most authors recognize that in the integrative activity of the brain, which provides the adaptive capabilities of the body, the decisive role belongs to the processes of dynamic interaction of the hemispheres [2]. These processes are carried out according to three types: reciprocal interaction, interaction according to the type of complementarity (each hemisphere makes its own complementary contribution to the implementation of a particular function) and the most complex type of interaction - according to the type of superposition (damping), or correction of distortions [2]. It is believed that functional asymmetry is based on differences in the biochemical activity of cells originating from the same embryonic rudiment [22], and, accordingly, an asymmetric distribution of receptors: if there are more ligands for certain receptors in any of the structures, then there should be more receptors themselves in this same structure than in the contralateral formation.

Thus, at the moment, the existence of a functional asymmetry of the central nervous system has been established, the basis for the formation of which is biochemical asymmetry. The long and varied history of studying functional asymmetry has established, first of all, its extreme mobility and variability in various situations, including pathology.

The study of functional asymmetry of the cerebral hemispheres began in the mid-19th century in patients with focal brain lesions caused by hemorrhages and traumatic brain injuries. It was found that damage to the left hemisphere cortex leads to speech impairment in 85% of cases, which was first established by Broca [10]. Subsequently, results were obtained on speech representation in the right and left hemispheres. In right-handed people with damage to the right hemisphere, olfactory hallucinations, disturbances in imaginative thinking, and topographic memory were detected. When the left hemisphere was damaged, disturbances in speech, consciousness, and verbal memory were observed. In left-handed people, the clinical picture did not depend on the side of the brain injury. However, there are syndromes that appear only in left-handed people due to brain damage [2]. An example is the state of twilight consciousness,

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Crossref doi Google Scholar WorldCat MENDELEY
Publisher: Oscar Publishing Services

specularity, skin-optical sense, sleep disturbance, with the subsequent development of endogenous depression, which is especially pronounced in patients with epilepsy with concomitant mental disorders. Violation of spatio-temporal characteristics in a cerebral catastrophe is manifested by left-sided spatial agnosia and Korsakov's syndrome, which arise, as a rule, with focal damage to the right hemisphere of the brain, often combined with left-sided "hemi": hemihypesthesia, hemianopsia, hemiparesis. It has been noted that memories are also based on the mechanisms of temporary interaction between the two hemispheres and that disruption of this leads to mnestic disorders [12].

Stroke is one of the most common forms of focal brain damage. Functional asymmetries underlie the formation of certain clinical manifestations of the disease. A large number of studies on brain damage have shown that a motor defect in the limb ipsilateral to unilateral hemispheric damage is more characteristic of left- rather than right-hemisphere damage [14]. Limb apraxia is the best clinical example of this asymmetry [30]. Neuroimaging experiments and studies using transcranial magnetic stimulation have also shown that the left hemisphere is specialized in controlling a variety of motor skills, and some studies have also identified a role for the right hemisphere [4]. The relative importance of each hemisphere has been examined and is likely to vary depending on the demands of a given movement [3]. This is illustrated by a study of goal-directed movements and grasping, which showed greater performance deficits when more planning was required after left hemisphere damage, and when tracking or not tracking a target in brain-damaged patients depending on the behavioral task at hand[25].

There is a rather attractive hypothesis in the literature about the control of goal-directed movements, according to which the left hemisphere is more specialized for ballistic movements, more dependent on the planning and implementation of a motor program and to a lesser extent on direct sensory feedback [25]. This hypothesis associates the right hemisphere with the control of non-ballistic movements, which are more dependent on sensory feedback and less dependent on motor programs [22]. However, this difference was not confirmed unequivocally. It should be noted that the described effects were demonstrated either separately in the group with right or left hemisphere damage, but not in both. The use of kinematic analysis makes it possible to distinguish in the initial component of the movement an acceleration phase and a deceleration phase, which ensures the approach of the hand to the target and is associated with the open loop process.

A fairly in-depth development of the problem of interhemispheric asymmetry in the theory of goal-directed movements has shown that the influence of

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the functional specialization of the hemispheres on changes in posture in patients who have suffered an ischemic stroke remains poorly understood.

Acute cerebrovascular accidents are one of the main causes of disability in the population, which determines the medical and social significance of effective rehabilitation of this category of patients [27, 9].

The difficulties of neurorehabilitation of patients with stroke are largely related to the variety and severity of the neurological and cognitive disorders they have, which significantly limit their life activities and make it difficult to restore daily activities [11, 24, 19, 2]. Along with other cognitive functions, stroke often affects the patient's awareness of the severity of his disease and its consequences [96, 79]. To denote the patient's decreased awareness of the manifestations of his illness and the functional limitations caused by it, terms such as "anosognosia", "reduced criticism", "denial" of the disease, "impaired awareness", "non-recognition of the disease", "defective insight", etc. are used.

For a long time, many authors understood the term "anosognosia" only as a patient's non-recognition of hemiplegia due to organic cerebral damage, and by "denial" - one of the forms of psychological defense in patients without structural changes in the brain [47]. Over the years, the interpretation of the term "anosognosia" has expanded, and currently it refers to a heterogeneous group of inappropriate reactions of the patient to his illness, including complete or partial denial of the symptoms of the disease; incorrect perception of a part of the body, a joking attitude towards one's disabling defect, ignoring other people's questions about the disease, etc [110].

It is emphasized that underestimation may relate to both motor and cognitive impairments [53]. The most recognized point of view is G.P. Prigatano (2005) and T. Hart et al. (2009), who understand anosognosia as a pathologically expressed overestimation by a patient of his functional capabilities in the motor, sensory or cognitive spheres, the cause of which is primarily associated with organic brain damage [94, 74].

We used the expressions "anosognosia of motor (cognitive) dysfunction" and "pathological overestimation of motor (cognitive) capabilities" as equivalent in meaning.

Pathologically expressed underestimation by patients with ischemic stroke of their deficits and functional capabilities in the motor or cognitive spheres is associated with a decrease in the patient's motivation for treatment, a decrease in his active participation in the process of restoring lost skills and, thus, with a deterioration in the results of neurorehabilitation [94, 104, 45, 60]. However, in practice, neurologists often underestimate the clinical manifestations of illness

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awareness disorders, have difficulty diagnosing them, and downplay their impact on the limitations of patients' daily activities [75]. In this regard, it is important to clarify the issue of the frequency of occurrence of anosognosia in acute ischemic brain damage. Meanwhile, this kind of information is scarce and contradictory, which is partly due to the use of different diagnostic criteria for this disorder and the conduct of studies at different times after a stroke [49]. Although it is emphasized that anosognosia is discrete and heterogeneous in its manifestations, the prevalence of its variants has not yet been studied [87, 41], Meanwhile, doctors' awareness of the frequency of occurrence of different variants of anosognosia in the acute period is important for its timely diagnosis and appropriate correction of rehabilitation measures.

Data on the morphological basis of anosognosia in paralysis and cognitive disorders are also contradictory. If at the end of the 20th century, a decrease in patients' awareness of their neurological defect was associated mainly with damage to the parietal or parieto-temporal regions, then later evidence appeared of the significance of the pathology of the frontal lobes, as well as the fronto-parietal or fronto-parieto-temporal regions of the cortex, especially the right hemisphere of the brain brain [51, 86]. In general, the anatomical basis for decreased awareness of motor or other symptoms of the disease remains unspecified [84].

Clarification of this issue may help to increase the alertness of doctors and improve the timely diagnosis of this disorder.

In recent years, data have emerged indicating the relationship of anosognosia in patients with ischemic stroke with deterioration of other cognitive functions, although in general the place of anosognosia in the structure of neuropsychological and neurological syndromes remains not entirely clear. The impact that patients' underestimation of their motor and cognitive deficits has on the results of neurorehabilitation remains insufficiently studied [45, 60].

Thus, data on the incidence of anosognosia, its neuroanatomical correlates, connections with other neuropsychological disorders, and the impact on the effectiveness of rehabilitation treatment for patients in the acute period of ischemic stroke require clarification. This kind of information can help improve the clinical diagnosis of anosognosia, more fully understand the causes of functional limitations in specific stroke patients, and optimize their individual neurorehabilitation programs. All of the above determined the purpose and objectives of our work.

We have not found a single study characterizing the influence of structural asymmetries in humans on the formation of a motor defect after a stroke.

All this aims at finding reserves aimed at optimizing the provision of medical care to patients with vascular

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diseases of the brain, differentiated rehabilitation in patients with hemispheric ischemic stroke, taking into account the localization of the lesion.

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