Comments on the Article "Dialogical Structure of the Brain and the Ternary System of the Mind: The Neurosemiotics of Yuri Lotman"

Комментарий к статье «Диалогическая структура мозга и троичная система психики: нейросемиотика Юрия Лотмана»

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Commentary

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Marco Sanna, the author of the article, "Dialogical Structure of the Brain and the Ternary System of the Mind: The Neurosemiotics of Yuri Lotman", written in the format of a popular science essay, reflects on the complex structure of the human mind's information systems as they manifest in everyday life, the origins of "semiotic creativity", and the mechanisms involved in creating abstract symbols and meanings [1]. The author alerts us to the importance of synchronizing semiotics with the neurosciences and to the usefulness of the Yuri Mikhailovich Lotman model. He invites further discussion amongst experts involved in integrative neuroscience, including psychiatrists, medical psychologists, neurolinguists, evolutionary psychologists, anthropologists, and cultural scientists. The essay can be considered an introduction to the problem. The correct structuring of the context of the article allowed us to highlight a number of promising ideas from Yu. Lotman and to consider the expediency of applying some provisions of his theory in modern research. With this comment, I would like to support the initiative to revive interest in the research of this world-renowned scholar and to consider the idea of a semiotic space and the methods of Lotman in the context of the development of interdisciplinary neurocognitive research.

The author focuses on the ambient underestimation of the theoretical work of semiologist and culturologist Yuri Lotman, which was conducted in the second half of the 20th century. Yet his contributions remain highly relevant if we want to take neurosemiotics to the next level of integrative science and post-non-classical philosophy [2]. This idea forms the core of the article and justifies its title. Works on neurolinguistics and semantics of that period in science evolution were influenced by the ideas of the famous psychophysiologist Alexander Romanovich Luria; about secondary systemic speech disorders that go beyond the understanding of local topical distribution of primary functions [3]. Based on the above-mentioned achievements of that time, Lotman developed a theory of a semiotic space ("semiosphere") with its internal and external boundaries, which extended beyond the scope of natural sciences and philology. One cannot but agree with the author that the specialization and translation of information through both the dialogue of an individual with the external world and the internal "dialogue of the two hemispheres", which is based on functional asymmetry, can be considered Lotman's significant contribution [4, 5]. The author's view constitutes the quintessence of the article and justifies the choice of its title. According to Lotman's explanation, the idea of a semiotic space resulted from the development of mathematical and natural sciences: "The success of non-Euclidean geometry and the emergence of the theory of relativity put forward the ideas of the relativity of space, the

multiplicity of spaces, their asymmetry, and symmetrical complementarity" [6]. Relying on his approach, Yu. Lotman was able to identify significant differences between natural language and actual speech and texts: the unexpressed versus the expressed, the ideal versus the structural and materialized, respectively, which is important for understanding the specifics of neurolinguistic and cultural studies. In the late 20th century, Lotman's ideas about the semantic network of lexical and syntactic units, his concept of cognitive processes and a neurosemiotic model, were innovative, widely discussed at conferences, published in academic literature, and highly regarded in the Russian researchers community. Yet, these ideas are now rarely mentioned in the development of contemporary cognitive theories or in applied research on an international scale. The possible reasons for such a state include the difficulties involved in interpreting the key concepts put forth by Yu. Lotman and the lack of vigorous efforts to integrate of interdisciplinary principles into the study of deep brain processes at the interface with Lotman's semiotics.

It becomes clear that Lotman's ideas today align with modern scientific perspectives on connectomics, functional plasticity, and the cognitive elasticity of the human brain. They also resonate, to some extent, with the concept of the cognitome of Konstantin Vladimirovich Anokhin, which describes mental functions and consciousness as the activity of a neural hypernetwork. A comparison of Lotman's structural-functional approach to complex mental functions with Anokhin's latest ideas on the principles upon which the brain functions reveals that both address problems of a similar character [7, 8]. K.V. Anokhin, developing the concept of a high-order hypernetwork model of the brain, noted a serious overall shortcoming affecting modern studies into higher mental functions and consciousness processes [7]. That shortcoming is the lack of a fluid neurobiological theory that explains information systems devices and consciousness; in other words, a theory of how rich subjective experience is gained through brain activity [9, 10]. Konstantin Anokhin insists on a radical restructuring of ideas about the brain from the position of functional systems theory to overcome the "gap" between conventional neurophysiology and psychology. He offers a bridge in the form of an alternative "mind-brain" theory with holistic functional systems. At the same time, the scale of the functional unit can vary depending on the required set of processes. This perspective introduces a new fundamental dimension in neurobiological systems that "elevates them to the category of cognitive systems" [7]. According to the theory of functional systems, the activity of a cognitive organism and its adaptation are shaped by the accumulation of subjective experience and the development of the ability for "anticipatory reflection of future interactions with the environment" [7]. In Vyacheslav Borisovich Shvyrkov's research, which builds on this theory, it is demonstrated that neurons are specialized in relation to holistic elements of subjective experience rather than isolated physiological or psychological functions [11].

The theoretical approaches to information processing by the mind-brain proposed by Yuri Lotman and Konstantin Anokhin offer prospects for identifying the fundamental underpinnings of human cognitive and mental functions. Notably, Lotman's approach aligns with contemporary views on the technological sophistication of cognitive studies, including "thinking machine" technologies. Optogenetics methods have brought about a revolution in neurobiological research. These technologies have the potential to help clarify the most controversial points in Lotman's theory and the views of the author of this article. With their help, it would be possible to test the biological aspect of the phenomena of cerebral bilingualism and continuous interaction of the two hemispheres during resting state or specific tasks, as referenced in the manuscript. In Lotman's era, such possibilities remained in the realm of imagination. Moreover, it is now evident that artificial intelligence and machine learning are no longer just research tools. Modern AI technologies already contribute to the modeling of cognitive processes that diverge from the analog modes of perception and thinking most familiar to us. However, fully understanding these processes requires the development of appropriate neurocognitive theories.

Over time, the trends in neurolinguistic research have changed under the influence of neuroscience discoveries. Today, the semantic structures of language are well-studied, with consideration given to the distribution and association of language functions in the brain's cortical hemispheres and the relationship between speech and thought. In recent years, research into the interaction between cortical speech areas and the non-speech sensorimotor regions of the brain has identified neural networks that involve deep subcortical structures. This has clarified the operational and regulatory roles of particular areas. The brain functions in a highly integrated fashion, with interhemispheric connections playing a crucial role in sensory, motor, and cognitive processes. These points of contact involve transitions

between hemispheres through both "mirror" and "non-mirror" tracts, the latter including functional loops such as those between Broca's and Wernicke's areas. The corpus callosum, consisting of approximately 100 million fibers, enables both hemispheres to process the same task within an extremely short interval [11]. To explore how the hemispheres communicate, different functional speech networks, including semantic networks, are being studied. One hypothesis suggests a strong interaction between left-hemispheric processing of syntax and right-hemispheric processing of prosodic information via the corpus callosum, allowing these two types of linguistic information routes to influence each other [13, 14]. Generalized data from more than 100 brain imaging investigations (fMRI and PET) have shown that physical speech signals exist in the brain as multiple distinct choice points within both the information input and output systems. Around 730 areas of increased activity have been identified in the left hemisphere, which are responsible for phonology, semantics, and sentence or text processing, with a significant overlap between them [15].

When analyzing neurobiological data related to semantics, it is important to consider their potential mobility over short periods of time, particularly as a language's working vocabulary expands and its syntax becomes more simplified. These processes are characteristic of many modern languages. All of this suggests a distributed network of speech production which is similar to the World Wide Web.

For these studies, Lotman's concepts of information flow and schematic models could prove valuable. One can nod to the author's formal logic in correlating Lotman's theoretical predictions with the accumulated empirical neurobiological data and the modern frameworks that reflect them, including those addressing the role of human subjective experience, reflection, and the relationship between personality and culture.

The greatest difficulty is the part of the article in which the author offers an interpretation of Lotman's notion of the "semiotic boundary" (a necessary entity to ensure interhemispheric translation and dialogue in perceptual and thinking systems) as an independent structure functionally connected to the hemispheres. The article's discussion of the controversial and multifaceted phenomenon of the "semiotic boundary" as a functional brain unit and semiotic space is positioned as the core of the work, advocating for the relevance of Lotman's ideas. To support this argument, the author includes several examples from modern neurobiology but does not explore the limitations of these findings. In particular, the concept of the boundary, as interpreted here, requires analysis grounded in a broader body of scientific evidence. This is especially important given that the phenomenon of the border, as stressed by both Yu. Lotman and the author, suggests not only changes in its extent — such as becoming wider — but also shifts in the degree of involvement of specific structures. Modern neuroscience sheds light on the variability of the brain in the context of neuroplasticity, which, as part of humanity's genetic heritage, reshapes the brain under sociocultural influences throughout cultural development. With each new stage of cultural evolution, individuals acquire skills that drive significant neural changes. For instance, studies have documented more extensive interhemispheric connections in musicians who began training at an early age. It is interesting that Lotman's predictions about entirely new forms of information, described as the metaphorization of untranslatable information during interhemispheric interaction, have gained validation in neuroscience. According to Yu. Lotman, this phenomenon arises from the differing specializations of the hemispheres. Such a phenomenon of total information (not just added), when the interplay of brain regions amongst each other leads to a qualitative transformation when a new whole is not the result of a simple addition of separate elements, fits the description of emergentism. It is to be expected that the study of the semiological boundary in neurobiological studies will be difficult given the myriad changes involved in synaptic activity, the receptor density, and the brain cells and that occur for a variety of reasons. Additionally, the author provides only a cursory discussion of the cerebellum's role, despite the emerging research that underscores its relevance in this context. A more in-depth exploration of its functions could further enrich the discussion.

Some of the important topics raised by the author include the influence on the brain biology of factors related to the cultural space, as well as possible biological and psychosocial mechanisms and the links between them. Given that the evolutionary history of the human species is linked to the development of language in the pursuit of personal and sociocultural goals, the consideration of culture in Lotman's neurosemantic model is an important issue that requires a separate study. The work builds on Lotman's pivotal article, which presents culture as collective intelligence, proposing an epistemology of isomorphism between the individual and collective minds. In the context of two-way

directionality, we now consider the reciprocal influence of cultural learning and brain activity (a type of counter-movement), in which cultural experience rearranges neural connections, reprograms circuitry, and modulates functional relationships between brain regions. This has been shown in numerous studies to the point that performing certain cultural tasks can lead to the formation of specific brain modules. Cross-cultural analysis shows that it is important to take into account the established differences between the thinking of people belonging to the "Western" culture as opposed to those of the "Eastern" culture.

Lotman's understanding of the influence of cultural factors is important in studying the mental activity of a "reflective", "creatively thinking", "creative" person — a position detailed by the famous philosopher Merab Konstantinovich Mamardashvili in terms of cultural-dialogical reflection [16–18]. The link between the individual and the collective mind through the dialogue of people with cultural forms in Lotman's theory is manifestation of the principle proposed by Russian philosophers and psychologists. M.K. Mamardashvili likens the relationship between man and culture to a kind of influence of "cultural forms" (art, science, philosophy, others) as "man-forming machines"; i.e., building in man what "could not be otherwise" done [16]. Lev Semyonovich Vygotsky's publications trace the idea that culture, particularly art, performs psychotechnical work and can transform human thinking [19]. In search of a link between culture and man, L.S. Vygotsky uses the concept of the word, while M.K. Mamardashvili, building his ideas on the basis of ancient and postmodernism/post-non-classical philosophy, uses the concepts of logos and topos. The significance of language units, speech systems, and the role of reflection in the works of L. Vygotsky, Yu. Lotman and M. Mamardashvili are considered from different vantage points, but the essence of their ideas is rooted in the same space of a reflection on the content and mechanisms of formation of cultural forms. Yuri Lotman and Merab Mamardashvili sought to grasp the nature of the mechanism that undergirds the process of transformation of a person in their contact with cultural forms and the emergence of redundant properties in human biology — rhythms and intonations of the soul. In the framework of this approach, the emergence of redundancy requires a dialog between a person's self and his/her reflective position, which is designated as the Other. It is the formed redundancy in the course of reflection that allows one to transform known perceptions and become a source of new knowledge about the studied reality, its development, and regulation. Thus, a reflective person emerges not simply due to the mastering of a word-concept, but due to cultural forms, logos, and topos. It is in dialogue with these elements that the individual shapes and creates their own identity.

The manner in which Yu. Lotman approaches his ideas for interdisciplinary research in medicine is based on the biopsychosocial model of mental and neurological disorders. However, data on the biological effects of numerous factors related to everyday experiences and cultural influences remain insufficient. The latest version of the ICD-11 international classification of mental disorders emphasizes this issue. The concept of "dialogue between hemispheres" raised by the author is quite relevant when discussing difficult cases with speech and other cognitive impairments, especially in the context of ontogenetic development. There are known cases of cognitive brain mobility — recovery of speech, or semantic functions in severe lesions of the dominant hemisphere in early childhood. Potential models for studying the role of hemispheres can be variants of the progressive neurodegenerative diseases caused by old age, which often begin as localized disorders of synaptic activity, focal brain atrophy, and isolated symptoms. Neuroplasticity and compensatory mechanisms often contribute to cognitive impairment developing gradually and subtly at first, becoming clearly manifested as both hemispheres and paired brain regions become involved. According to neuroscientists, most cognitive functions in humans are duplicated in the left and right hemispheres in cortical areas (prefrontal, motor, sensorimotor cortex, secondary associative cortical centers) and basal nuclei (hippocampus, amygdala, striatum, others), and they are functionally identical. Interhemispheric communication allows for the development of a compensatory mechanism and the maintenance of a normal functional asymmetry.

Typically, normal and pathological ageing processes begin in the non-dominant (usually right) hemisphere responsible for speech function and semantic functional networks. Often, the compensatory mechanism becomes exhausted only at late stages of neurodegenerative diseases, with a gross deficit of higher mental functions. For example, in a typical form of Alzheimer's disease, cognitive disorders manifest themselves in amnestic syndrome, which involves both the left and right hippocampus (a strategically important structure for the memory processes). At the same time, the preservation of speech in patients plays

a compensatory role and helps them remain socially active for a relatively long time, until pronounced bilateral brain atrophy begins to set in, leading to impaired semantic interpretation and encoding of information. In the later stages, the patient first experiences difficulty recalling the right name of a familiar object, and then they lose the name altogether, not understanding what it is and what it serves, and they also lose the rules of verbal communication. But in a human neurodegenerative pathology, there also exists a localized lesion of the dominant brain hemisphere at the onset of the disease. The clinical picture is dominated by the syndrome of isolated primary progressive aphasia, with pronounced limitations as relates to daily life. These cases, with unilateral lesions (including neuroimaging data), come with a low chance of rehabilitation. It is probably a lesion in a strategically important area responsible for speech, but unpaired in a functional sense. In psychiatric and neurological practice, there are cases where patients experience a loss of categorical understanding of the world, along with speech disorders, such as impoverished vocabulary and the erosion of syntactic grasp. It is often challenging to determine whether these impairments stem from deficits in working memory, attention, slower information processing speeds, or other related issues. The causes and mechanisms behind these speech disorders, particularly in the context of neurodegenerative diseases, remain a topic of debate, because of mounting evidence indicating that speech semantic functions are not limited to the dominant hemisphere. For example, the right hemisphere plays a crucial role in the processing of complex aspects of perception and expression, such as metaphor, humor, and contextual meaning, while the left hemisphere is primarily responsible for literal and rational interpretation [20]. The development of neurosemantic methods for diagnosis and neurorehabilitation is crucial.

In conclusion, to summarize my thoughts on the article "Dialogical Structure of the Brain and the Ternary System of the Mind: The Neurosemiotics of Yuri Lotman", I believe it is important to highlight the potential value in integrating Lotman's approach in the shaping of the objectives and the means to achieving them in contemporary cognitive neuroscience, psychiatry, and neurology. His theory provides a framework for studying highly organized constructs linked to intellectual perception and behavior, the predictive role of brain processes, and their influence on the development of complex cultural forms. Another strength of Lotman's concept is its epistemological foundation, centered on the isomorphism between the information systems of the individual and collective mind. When developing Lotman's ideas, it would be beneficial to integrate the principles of post-non-classical philosophy, particularly interdisciplinarity. At the same time, it is also important to highlight the limitations of Lotman's approach, especially the real challenges in interpreting key concepts, such as the "semiotic boundary" between the two hemispheres, the underdevelopment of interdisciplinary integration, and the dearth of reliable experimental data. Still, these ideas merit to be explored further, for example, through a narrative review approach, which could help define the potential scientific applications and limitations of Lotman's concept in research. It should be noted that the article is somewhat overloaded with the ideas of both Yu. Lotman and the author, and that some topics and concepts are presented in a speculative way, without sufficient scientific validation. The most controversial part of the article is on the "hard problem" of consciousness, which, outside of medicine and neuroscience, is often treated as a private, philosophical category. The author discusses the unity of consciousness in the context of interhemispheric dialogue, referring to Yuri Lotman, but not referencing modern research or the views of leading figures in neuroscience. This is a critical field, and incorporating contemporary perspectives is essential when dealing with one of the most ambiguous aspects of our understanding of living organisms. Anokhin's cognitome theory could also be valuable in this context [2]. The author is encouraged to address these limitations by presenting contemporary views and substantiating Lotman's theories with reliable empirical evidence. I wish the author success as he continues to explore this topic.

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