The Brain as a Constructor: What Does the Visual Perception Has in Common With Language?

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The report presents the arguments justifying drawing analogies between visual perception and speech language as the particular 'brain languages', having fundamentally common features. The structural (letters, syllables, sentences, punctuation marks) and functional (spelling, grammar, syntax) organization of the 'speech language' will be used as a ground for such kind of non-trivial analogies. The theoretical and experimental data, obtained at the E. Sokolov school in human and animal research for more than 40 years, will be employed as some reasons for the allocation of such a general concept as 'brain languages.'

The report presents numerous results of psychophysical (multidimensional scaling, factor analysis) and electrophysiological (EEG, ERPs) experiments with humans, behavioral (instrumental learning) and neurophysiological (registration of neurons responses) experiments on animals (mollusk, fish, frog, rabbit, monkey), obtained by E. Sokolov and co-workers at the approach "Human-Model-Neuron". The color vision, perception of the shape elements of object, motion perception, and semantics (perception of words denoting colors and emotions) were under interdisciplinary research. We prove that the most appropriate method of modeling in the "Human-Neuron-Model" approach is the construction of a geometrical model of "subjective space," where the stimuli are represented by the points, and interpoint distances correspond the subjective differentiation between stimuli. The spherical coordinates of the points are interpreted as subjective characteristics, and the Cartesian coordinates are considered as a reflection of the activity of the neuronal mechanisms. The analysis of the spaces for different signals reveals the general structure of these spaces, which is a combination of a different number of two-dimensional geometrical modules. We refer these data to the principle of alphabetic language construction, and to propose that the basic elements (dual-channel modules) of the visual system are combined into multi-channel networks analogous to the combination of letters into syllables, morphemes, and words. In speech the combination of letters into syllables or morphemes into words is determined by the meaning rather than by physical characteristics or configurational characteristics of word elements. Similarly in visual perception the combination of dual-channel modules into a multi-channel network for complex stimulus detection is determined by the subject meaning of the stimulus, but not by the physical characteristics of the light pattern. The brain language hypothesis is being discussed in connection with the idea of 'the Brain as Constructor'.

Our studies set to further progress in understanding the nature of perception that requires including into the research the categorical characteristics.

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Diversity of Neurons, People and Cultures as an Evolutionary Basis for Systemic Complementarity

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The significance of diversity of system components in the processes of phylo- and ontogenetic development, which unfold at sub-organismic, individual and inter-individual levels of interaction, will be discussed. We consider a system as an organization of elements (neurons and somatic cells) mutually cooperating to achieve an adaptive result of behavior. Our view can be considered as a modification of the well-known principle developed by E.N. Sokolov: "Neuron — Model — Human". We studied genetic and impulse neuronal activity in freely behaving animals as well as brain activity (EEG, fMRI) and heart rate variability (sample entropy as an indicator of complexity of activated experience) in people solving different cognitive and social (e.g., moral dilemmas) tasks. Effective mutual cooperation of elements comprising a system is largely ensured by differences in their degrees of freedom. We found that these differences are manifested in heterogeneity of neurons that belong to the same system (intra-system diversity). Our results showed an increase in complexity and differentiation of experience during individual development, which was associated with a rising variety of neuronal and somatic cell specializations involved in sequential episodes of learning (inter-systems diversity). This increase passes through a stage of regression – a reversible decrease in the diversity of activated cells, – observed under stress, raised emotionality and learning. The processes of regression assist in accelerated formation of new "simplified" adaptations, which at later stages become more and more complex. We found differences in brain activity and efficiency of behavioral performance between individuals with analytic and holistic types of mentality during solving a range of cognitive and social tasks individually and collectively (competition/cooperation). Based on these results and theoretical considerations, the principle of systemic complementarity is proposed: mutual cooperation of different individuals and cultures is evolutionary essential for achieving collective results. The diversity of cells, neurons, humans and cultures provides an effective complementarity in achieving adaptive outcomes for individuals and their communities. Diversity is usually considered as an important preparation for future changes in the environment: the survival of communities is ensured by individuals who are more prepared. Diversity as the basis of complementarity is no less evolutionarily important for both current existence and future development of individuals and their communities. Acknowledgements. The study is supported by the Ministry of Science and Higher Education of Russia (No. 0138-2021-0002) and the Foundation for New Forms of Development of Education (FNFRO), agreement with the Institute of Psychology RAS, #RUOM1019.

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Endogenous Cell Activity in Evolution

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The study of endogenous pacemaker activity was one of the main areas of neurophysiological work of E.N. Sokolov. These works were continued on living beings of different taxonomic position and evolutionary age - prokaryotes of cyanobacteria Oscillatoria terebriformis, amoeba proteus amoeba, single-cell eukaryotes yeast Saccharomyces cerevisiae, social amoeba Myxomycetae and Dictyostelium discoideum, infusoria Paramecium caudatum, multicellular eukaryotes leech Hirudo medicinalis and snail Helix lucorum.

Microelectrodes for detecting intracellular electrical activity and macroelectrodes for detecting field potentials were used in the experiments. The rhythmic activity of living beings that differ in the complexity of the structure and have different evolutionary history is very similar in frequency characteristics. Frequency spectra of rhythmic