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Progressive Evolution of the Animal and Human Brain

Section 1. Interdisciplinary element-systemic model of the progressive evolution of the animal brain as carrier and transducer of regulatory cell signals.

Progressive evolution of the animal brain is interpreted as an open circuit of regulatory cell signals referred to as the reflex arc. A hierarchical sequence of the overbuilt spatial 0-3 dimensional reflex arcs acting as transducers of the elementary signals is developed during the progressive evolution. Each arc is made up of five transducers. Receptors generate input signals upon exposure to the habitat. Sensory centers convert receptor signals into nerve sensory signals. Associative centers convert sensory signals into motor signals. Motor centers convert motor signals into nerve motor signals. Effectors execute output motor signals in the habitat. The resulting signal system - the reflex arc – takes the form of a transformational circuit (cycle) open to the habitat. Effector signals transit reversibly into receptor signals through the mediation of the habitat, thus closing the circuit.

The transformation of signal systems, i.e. reflex arcs, is effected as the superstructure to the hierarchy: the original arc of 0-dimensional point-like cell signals is the basis for the superstructure of the arc of 1-dimensional linear-spreading signals, next, the arc of 2-dimensional fields - image signals - is superstructured, and, finally, the arc of 3-dimensional associative signals builds over. In general, the progressive evolution of signals may be interpreted as a quaternary sequence of binominal signal systems that unfold into the elements – system-elementogeneses, and reversibly fold into the systems – element-systemogeneses.

It should be noted that the formation of the reflex arcs is the result of the phase transition of final multicellular plant individuals with strictly fixed cell functions into the original multicellular animal organisms of excitable cells – carriers of reversible functions regulated by 0-3-dimensional cell signals.

1. Colonial multicellular animals. The reflex arc of 0-dimensional point-like regulatory cell signals - mediators. Evolution of the multicellular plant individual results in the phase transition – elementogenesis of animal cells that are characterized by a reversible state of excitation and inhibition during the performance of cell functions. Signal regulation starts with the receptors - sensory input, and complete with motor output through the effectors. This is not a complete circuit.

2. Lower animals (invertebrate). The reflex arc of 1-dimensional linear impulse nerve signals that flows along cross-striped muscles. Their systemogenesis leads to the formation of differentiated channels of the central nervous system. The reflex arc becomes the unit determining the order of signal flow: habitat – receptors – ascending sensory nerves – transformative nerve centers – descending motor nerves – executive motor and secretory effectors – habitat. Effector signals transit reversibly into receptor signals through the mediation of the habitat, thus closing their common circuit of the regulation. An animal organism is formed with innate multiple forms of behavior directly representing the relations with the environment.

3. Higher animals (vertebrate). The reflex arc of 2-dimensional regulatory cell image streams. Elementogenesis of impulse signal system leads to the formation of 2-dimensional projection signal fields - images. Their systemogenesis forms: receptor- and effector-based image fields, ascending and descending projection tracts and respective cortical fields. The sequencing of signal flow: habitat – modal receptor images – signal streams via ascending nerve projection tracts – the respective images of projection sensory fields of the cortex – transformative associative fields, images of projection motor cortical areas – signal streams via descending projection tracts – the respective image effector fields – habitat. Effector signals transit reversibly into receptor signals through the mediation of the habitat, thus forming their common circuit of regulation. Animals with trainable behavior are born representing probabilistic relations with the environment by trial and error.

4. Higher primates, hominidae. The reflex arc of 3-dimensional regulatory cell network memory. Elementogenesis of the system of image fields of the brain results in the formation of secondary associative fields of 3-dimensional spatial memory and image recognition. Their systemogenesis forms sensory motor associative memory fields in the cerebral hemispheres. The sequencing of association flow: primary modal projection sensory fields of the cortex – secondary fields of sensory associative memory – common sphere of sensory associative memory of the occipital lobes of cerebral hemispheres – transformative associative network of three-dimensional memory (each sensory image can be associated with each motor image – “internal Internet”) – common sphere of motor associative memory of the frontal lobes – secondary associative motor fields – primary projection motor fields. Through the mediation of the performers and the environment motor associations transit reversibly into sensory associations, thus forming their circuit. The behavior of the anthropoids enables to represent the causal relations of the environment and becomes plannable.

Section 2. Interdisciplinary element-systemic model of the progressive evolution of the human brain as carrier and transducer of the determining cognitive signs.

Human brain is modeled as the primary open circuit of regulatory cell signals incorporating the secondary circuit of the determining cognitive signs that forms consciousness.

1. The primitive man. Circuits of 0-dimensional determining cognitive signs. Dominant hemisphere is built over the preceding interhemispheric system of memory associations and becomes the carrier of abstract sensory sign projections that ascend from interhemispheric sensory fields, and the carrier of abstract motor sign projections that descend to the hemispheres. The interaction of abstract cognitive signs forms human consciousness. The initial pattern of the abstract sign representation of the object spread over the whole space of consciousness, and then it differentiated: next generations acquire schematic images of objects as partial abstraction, and, finally, projecting point-like signs-notions as final abstract form of consciousness. Such consciousness has sensory input, i.e. sign representation ascending from sensory memory associations, and motor output, i.e. projection descending from motor sign representation of consciousness to motor memory associations. Primarily, sensory and motor notions are not interconnected

in consciousness, and it can be regarded as tabula rasa. Connections are effected through underlying subcortical associations located in the cortex. Next, the secondary internal conscious-subconscious ideal circuit of cognitive transformations is sequentially formed including: sensory and motor notions and sensory and motor memory associations. By trial and error, its correspondence with the real natural object-object relations is established, meaning that the process of self-cognition is effected. Since that great moment, the evolution of ideal objects of the consciousness will carry on the progressive evolution of real natural objects.

2. Speech community. Circuits of 1-dimensional determining social cognitive signs. Primary elementogenesis of the preceding system of body activity and perceptions of persons develops 1-dimensional linear interpersonal speech channels of communication for the sender and the recipient. Their systemogenesis evolves as follows: by trial and error, the circuit of social consciousness is established as a uniform understanding of speech actions and perceptions thereof by the sender and the recipient. Next, the secondary circuit is built over these direct relations of the sender and the recipient. Conventional indirect understanding of words of a given speech community is formed, and each person as its member gets an opportunity to determine social relations.

3. Civilized society. Circuits of 2-dimensional determining social cognitive signs. Primary elementogenesis of the preceding system of verbal relations leads to the formation of 2-dimensional group logical statements (propositions) about objects and attributes. Their systemogenesis is formed as follows: by trial and error, the circuit of objective consciousness is established including ideal logical relations of objects and attributes and their real causal relations. Next, the secondary system of objective consciousness builds over. It is formed based on the direct relations of objects and attributes in the entirety of their socially-mediated relations. Objective consciousness of the civilized society determines its knowledge, skills, various types of artistic and technological creativity, etc.

4. Informational society. Circuits of 3-dimensional determining large-scale world-related cognitive signs. Primary elementogenesis of the preceding system of binominal object relations leads to the formation of 3-dimensional quadrinomial inferences (di-counterpropositions) about the progressive evolution of the brain. This complex form of transdisciplinary informational consciousness enables to determine the relations of the brain to the world as a whole.

Conclusion

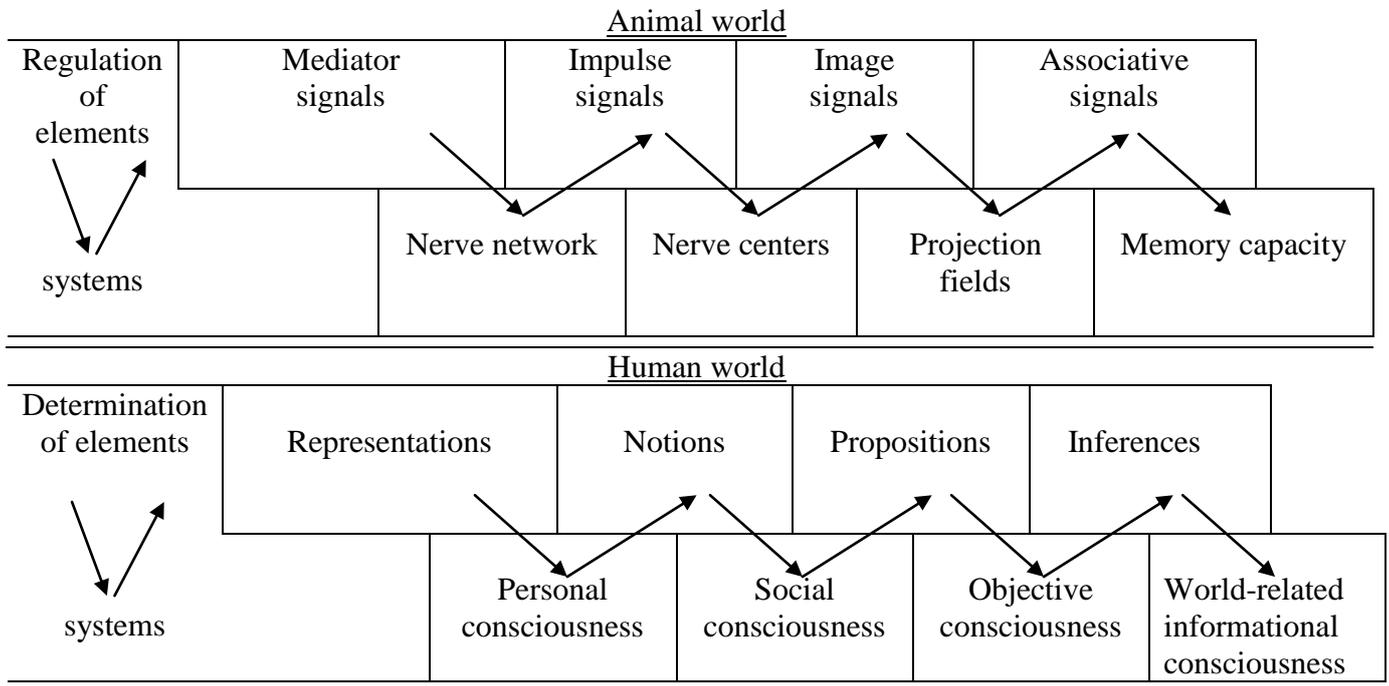
We proposed an interdisciplinary element-systemic model of the progressive evolution of the animal brain as an environmentally open circuit of cell signals' transformations referred to as the reflex arc. 0-3 dimensional reflex arcs are formed during evolution. The model of the progressive evolution of the human brain is interpreted as the primary open circuit of regulatory cell signals incorporating the secondary circuit of the determining cognitive signs that forms consciousness. 0-3 dimensional hierarchy of circuits is formed during evolution. The form of progressive evolutionary development is the sequence of binominal quaternary series of objects.

P.S. Natural progressive evolution of the brain as a prototype of the artificial intelligence.

To the author's view, the animal world is a 0-3-dimensional spatial hierarchy of cerebral signals regulating the organism's behavior (mediator – nerve impulse – projection image field – associations of three-dimensional memory). The sequencing of increasingly sophisticated signals of higher animals in the circuit (cycle) is as follows: habitat → primary projection sensory fields of the cortex → secondary recognizing associative fields of sensory memory → associative network of general memory (internal Internet) capable to associate each sensory image with each motor image → secondary associative motor fields → primary projection motor fields → habitat (addendum 1). No models of the artificial intelligence can achieve the level of cerebral complexity of hominids as the carrier of natural intelligence.

The progressive evolution of the human, to the author's mind, can be interpreted as a hierarchy of discrete sign forms of cognition (representation – notion – proposition – inference). One of the cerebral hemispheres, the higher regulating organ of the organism, becomes dominant in humans. Its representative fields activate local patterns of excitation as abstract signs corresponding to images of the downstream sensory and motor memory. Sensory and motor signs-representations become units of conscious thinking of each individual. The human brain activity is brought to a higher level of development, having taken up the torch from nature and opening up the possibility to cognize the relations of natural objects. In the course of the progressive evolution of Man, his personal intellectual circuit of notions mediates through the following stages: 1) through the circuits of verbal comprehension in the consciousness of the speech community; 2) through the circuits of logical objects and their attributes in the consciousness of the civilized society; 3) through the circuits of particular worlds and the world as a whole in the consciousness of the informational society. In the end, the network organization (Internet) of the ideal world enters into correspondence with the network organization of the real world, thus completing the progressive evolution.

The model of evolution: alternation of forward element-systemogeneses and reverse system-elementogeneses of the evolutionary objects



Steps of progress of evolutionary elements and systems

The animal world of signal regulation of cell structures		
Colonial animals	A ⁰ Mediator signals	A ⁰ Nerve network
Lower animals	A ¹ Impulse signals	A ⁻¹ Nerve centers
Higher animals	A ² Image signals	A ⁻² Projection fields
Higher primates	A ³ Associative signals	A ⁻³ Memory capacity
The human world – sign determination of thinking consciousness		
Primitive community	A ⁰ Abstractions	A ⁰ Personal consciousness
Speech community	A ¹ Verbal notions	A ⁻¹ Social consciousness
Civilized society	A ² Logical propositions	A ⁻² Objective consciousness
Informational society	A ³ Categorical inferences	A ⁻³ World-related consciousness

Steps of the progressive evolution of the nervous system Superstructures of nerve reflex arcs and cognitive circuits

