

PSYCHOLOGICAL IMAGE AS AN ACTIVE DISTRIBUTED SYSTEM

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Abstract

In the article, the core component of the integrated behavioral unit - the ideal image of the goal (IG) – is looked at as an electrodynamic structure circulating in a ring of interneurons and generated by the neural networks that owe their activity to homeostatic imbalance.

The afferent information flow; the ideal image of the goal, synthesized and retained until the results of the goal-directed behavior are achieved; the motivational gradient including efferent mechanisms are integrated into the electrodynamic structure of the image of the goal. Being an active one-dimensional distributed system, the electrodynamic structure (EDS), with the help of the motivational gradient, spontaneously, by using the information incorporated in IG, forms spatially heterogeneous structures, which are responsible for adaptive behavior. The article outlines mathematical methods of description of the integrated behavioral unit and of the ideal image of goal.

Key words: *subjective time, psychological image, goal-directed behavior, image of the goal, topology space, integrated behavioral unit, artificial intelligence*

PURPOSE OF THE WORK

Modern theories in psychology and neurobiology, principles and methods of experimental simulation and mathematical modelling of goal-directed behavior and instruction lack completeness of perception and description of “ideal” in the structure of goal-directed behavior. It is the structure of mentality that forms the sequence of adaptive behavior, defines vectors and duration of behavior directed at achieving the goal.

Although we cannot furnish the IG mathematical models we are working on now in this publication, we want to introduce you to some of the mathematical methods that can help to create an adaptive model of the ideal part of BU (a metamer of behavioral continuum): the ideal image of the goal.

DISCUSSION

According to Anokhin P.K. (1), the integrated behavioral unit (BU) in the theory of functional systems of the 2nd type, which support homeostasis due to a change of behavior, is responsible for creating, retaining and subsequent removing of the ideal image of the goal (IG), which is a space-time structure of activated neural circuits of the brain.

We think that the afferent part of BU is triggered by a significant imbalance of the parameter/parameters of the metabolic, psychological and social spectrum, i.e. departure from the boundaries of the “normal zone”. For metabolism: departure from the upper/lower boundaries of the “normal zone” to the level of suprathreshold sensitivity of receptors; for structures of the psychological and social spectrum to the level: “cognized - non-cognized”; “acceptable - unacceptable” (6). The distinguishing characteristic of “living beings” is their responsiveness to disturbance of the homeostatic balance, to imbalance, i.e. selective response to the object of an actual need. The need, being the most significant disposition of the motive, constitutes “an impelling force, a cause of behavior” (9), initiates BU activation.

The “normal zone” is assumed as the aggregate of steady performance parameters, which is formed by the confidence interval boundaries, where the probability of occurrence of another parameter value is > 95%. The actual data on average values, boundaries of the confidence interval and relationships of the basic parameters of metabolism in healthy people, which were obtained by using the probing method for arterial and venous blood, were reported in our previous publications (4).

The currently available methods can be applied only to assumed equivalents of BU: electrical, electrochemical, gas-hemodynamic, metabolic, behavioral, etc. It is assumed that at the physiological level the BU core mechanism, the forming of an acceptor of action results, i.e. IG creation and retention, is represented by excitation circulating in a ring of interneurons (11).

We assume that the afferent information flow initiated by the homeostatic imbalance; the ideal image of the goal, which is synthesized and retained until the results are achieved; the motivational gradient (including effector mechanisms) are a closed circular electrodynamic structure (EDS) generated by activated neural networks. When seen as a diagram, the EDS structure includes the peripheral nervous system (paths of afference / efference), neural networks of the cerebral cortex (neural columns), and neural formations of the spinal cord. Being a temporary formation, the existence of which depends on how soon the final result is achieved (parametric equalization), EDS is a one-dimensional active distributed system (that may have cellular topology), which combines hundreds of thousands (millions) of elements (neurons) of the circulating energy flow. In other words, we define EDS as an energy structure with psychophysical, behavioral, metabolic and other derivatives, implying a morphological (anatomic) substrate – neural networks as the EDS generator (6).

In the system of goal-directed behavior, EDS derivative, the psychological image has dualistic nature, acting both as the ideal image of the future and the prerequisite initiating goal-directed behavior. The synthesized and retained image of the goal includes basic forms of anticipatory reflection: prediction and goal-setting. Despite the differences: prediction – anticipatory reflection of the sequence of objective nature; goal-setting – getting an individual involved in the goal-directed activity, interfering of these forms of anticipatory reflection define the selection of the available parametric information, the selection of the control signal and, consequently, the choice and changes in the tactics and strategy of adaptive behavior.

For the purpose of the system analysis of the dynamics of adaptive self-regulation, we see it feasible to use an integrating term covering the IG “creation – retention” stage and the entire effector structure of BU: the motivational gradient (MG), where $t_{IG} = t_{MG}$.

We think that MG can be defined as an active distributed system (ADS) capable of spontaneous creating, due to information contained in IG, static and spatially heterogeneous structures facilitating adaptive behavior (for example, morphogenesis in a fertilized egg). The ADS behavior types are described by non-linear differential equations (7).

As MG has model characteristics of a future result and acts as the determinant of behavior, it forms the mechanism and the vector of the self-regulation process resulting from goal-directed behavior producing parametric equalization, need satisfaction and motive removal. We offer an equivalent MG, hemodynamic, scalar gradient (having morphophysiological characteristics) as an MG biophysical “marker”: venous-liquor pressure in the exchange field of actualized neural circuits (4).

Seeing MG as a route of the fastest change in scalar values that are changing from one to another space points, we define the “zero” (starting) point of subjective time (ST) required in the IG structure for the expected action result (EAR), which in psychological time can be assumed as an abstract point, while “the present is always a certain interval” (8). The expected action result (EAR) is a constructive outcome of the ideal image of the goal. The action result (AR) is the final stage of goal-directed behavior that is brought into effect through the motivational gradient discontinuing the BU afference at the point of parametric equalization. The occurrence of the expected action result (EAR) is the starting point of building an assessment scale of the time required to achieve the result (ST). During the goal achieving process, the linear motion from MG to the action result (AR) means ST decreasing motion (to the “0” point in EAR). In other words, the decreasing time flow has the vector opposite to the vectors of the effector part of MG and increasing values of (physical, biological) time, reaching the “zero” value at the point of parametric equalization (6). Therefore, the ST flow can exist only if in the inward world of an individual there are events, the nature of which is immaterial (perceptive, motor, cognitive). Thus, being a one-dimensional structure, having a duration value ($t_{ST} = t_{IG} = t_{MG}$) and the vector, ST can also act as a vector “marker” of IG (MG).

Goal formation (voluntary/involuntary, actualized/latent, strategic/interim) can be described as “behavioral continuum of alternately changing components” (9): BUs “flowing” from the “previous” into the “next” (there can be different sequence options including transformation, “overlapping”, interference, etc.). The intervals between BU actualizations depend on variations of homeostasis parameters (imbalance of the system) prior to the suprathreshold level and initiation of the subsequent (latent) IG.

We think that goal formation determined by the imbalanced system is continuous representation from one space – objective reality – to other space – mental structures of representation (with different dimensional, time, space, etc. categories) and the subsequent projection of mental structures (IG) into the external world through goal-

directed behavior. Thus, the correlation between the sets is established, where near points of evaluation develop into near points of values. In information interaction of two systems (either real or ideal), either of them can be seen as the model of the other system inasmuch as it represents it (10). As the nature of IG that is a one-dimensional time-extended structure allows omitting the distance (measurement) concept in the mental image structure, we think that further computations in this field can be made by using mathematical tools of topological spaces, which make it possible to assess the proximity of points, while ignoring the concept of distance (2). We believe that this approach offers good opportunities for description, studying and modeling of “modal relationships between spatial patterns, coherence laws....., regardless of relationships between measures and values” (Listing, 1847- 3)

Integrated behavioral units are structurally identical regular sequences, which, regardless of the IG content and the end result achieved by means of MG have characteristics of bijection where each element of one set correlates with an element of another set. Due to the bijection that retains the object as an information matrix in representation of the coded structure, these structures can be seen as isomorphic (12).

During BU actualization, there is an equivalent, time symmetrical, having morpho-physiological parameters, BU derivative structure of the biophysical (liquor-venous pressure–7), scalar gradient; it is continuous representation of this gradient, a biophysical equivalent of each structurally identical regular sequence (BU), a marker of the relationship that we define as translation symmetry. Therefore, we think that the integrated behavioral unit, including the biophysical equivalent, can be defined as a psychophysiological metamer in behavioral continuum both for tactical and strategic (sums of interval-slotted interim and continuously sequenced goals) purposes.

Significant parameter fluctuations exceeding the “normal zone” boundaries – the homeostasis “pattern” initiating MG and characterized by totality of its own values and vectors of all components of the space-time configuration: excited receptors, neural circuits, mental structures, metabolic systems, and efferent mechanisms. In the MG dynamics, parameters of homeostatic metabolism are actual numbers (representing continuous values), which in the homeostatic continuum constitutes the predetermined nature of the dynamic scalar filed in four-dimensional space, where u (the number) = $u(x, y, z, t)$. Therefore, we think that it is possible to create a structural pattern corresponding to the scalar differential equation and to make subsequent mathematical computation of “fragments” of the psychophysiological metamer: BU having modal characteristics and existing in the dynamic scalar field. We believe that the above suggestions can open new opportunities of computation of artificial intelligence models.

By describing IG and MG, we also describe dynamics and interaction between one-dimensional, time-extended structures, neuron firing mechanisms, generation and transmission of electric signals, associated metabolic changes, which are formed by dynamic changes in concentrations, charges, relationship mix, etc. of physical particles and their combinations constituting metabolism substances. The primary interaction of the entire spectrum of these substances (having their relationship constants) takes place in the following conditions: sizes – 10^{-9} m. (Na-0.42 μ m, K-133 μ m, H₂O-0.276 μ m, etc.); weight – 10^{-27} kg. (Na-22.99; K-39.09; H₂O-29.9, etc.)

CONCLUSIONS

Having no other size parameters, except for the time parameter, IG (EDS) includes all possible and representable types of space and measurements, which allows making an assumption about their existence (possible building) in mental formations of a human being where they occur in the compactified (potential) condition and can be decoded (built) by operating systems of the brain (thinking, imagination, etc.), as for IG elements (“inward”) it acts as a space-time structure with the unlimited (unknown to us) number of levels of freedom.

The existence of translation symmetry of metabolic dynamics of homeostasis and psychophysiological structures of the brain (IG, MG) makes it possible to extrapolate mathematical computations of markers: the scalar (hemodynamic equivalent of MG) and the vector (subjective time) markers to the core component of the metamer of the integrated behavioral unit – the ideal image of the goal.

Taking into account the one-dimensional nature of the ideal image of the goal, which has the unlimited number of levels of freedom and sets basic characteristics for the structure, vector, temporal duration etc. of the behavioral metamer, we think that elements of the “string theory” (M-theory) mathematical apparatus used for computation of one-dimensional extended structures setting characteristics of weight, charge, etc. (including the dual transformation providing switchover between different scale systems) can be used for mathematical description of the integrated behavioral unit, motivational gradient and the ideal image of the goal. Due to the mathematical apparatus of the basic components of the integrated behavioral unit, we will be able to find mathematical equivalents of the interaction mediator and relationship constant of the ideal image of the goal,

having biophysical and time “markers”. When put into effect, our suggestions (or part of them) will help to solve the problem of adequacy in modeling of complex systems, to complement the existing methods of research and modeling of human psychics and artificial intelligence by using computational conclusive methods, including a mathematical analysis of the ideal mental structures

REFERENCES

- Anochin PK. Philosophical aspects of the theory of the functional systems. Moscow: Science;1978.
- Engelking R. General Topology. Moscow: Mir; 1986.
- Kolmogorov AN.,Yushkevich AP. Mathematics of the 19-th century. Theory of analytical functions. Moscow : Science;1981(2):98-99.
- Kruglov AG., Gebel GY.,Vasilyev AY. Intracranial venous pressure as a possible determinant of mental regulation. IJBM 2011; 1(4):245-248.
- Kruglov AG.,Gebel GY.,Vasilyev AY. Impact of Intra-Extracranial Hemodynamics on Cerebral Ischemia by Arterial Hypertension ;IJBM 2012;2(2):89-95.
- Kruglov AG.,Vasilyev AY. Mathematical Approaches in Studying the Ideal Image of the Goal. IJBM 2014;4(1):46-48.
- Rubin AB. Kinetics of biological processes. Soros Educational Journal.1998;10:84-91.
- Rubistein SL. Fundamentals of general psychology. St.Petersburg; 2003.
- Shvyrkov VB. Introduction to objective psychology.Neuronal basics of psychics . Moscow, Psychology Institute of RAS(Russian Academy of Sciences);1995.
- Simankov VS.,Lutsenko YV. Adaptive management of complex systems by using the image recognition theory. Krasnodar Technological University ; 1999.
- Sudakov KV. Fuctional systems.Moscow: RAMS (Russian Academy of Medical Sciences) Publishing House;2011.
- Vereshchagin NK., Shen A. Fundamentals of the set theory. Lectures on mathematical logic and algorithm theory. Part 1.2-nd ed.Moscow: MCNMO; 2002.