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Cognitive and Heuristic Modeling of Reality, Developing Innovative Thinking: A Semiotic Approach to Training an Individual

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Abstract

The article is devoted to the development of ideas and methods for individualization of training based on the complementarity and interrelation of the structures of cognitive and heuristic metamodels of hybrid reality, including the human brain. Digitalization of science, education, and technology has increased the complexity of spatio-temporal relationships, the virtuality of which has created new challenges to the quality of education, mental health, and technogenic safety. Based on the evolution of ideas, paradigms, and methods for studying physical and virtual reality, the structural-functional approach to the transformation of experiential learning cycles according to D. Kolb is developing. Based on the semiotic paradigm of cognition, integrative methodology for studying complex dynamic systems, and criteria for assessing creative activity, the structural-functional approach to metamodeling of a hybrid subject environment is developing. The author's cognitive 3M-metamodel (metathinking, metacognition, and metaphor) and the author's heuristic 3S-metamodel (self-knowledge, self-regulation, and self-reflection) are presented. Interrelation and complementarity of 3M and 3S metamodels contribute to synergy, emergence, and harmony, which are aimed at the formation of an individual's metathinking in the process of learning from experience using GenAI.

Keywords

Consciousness and subconsciousness; creative and critical thinking; integrative informatics; extreme principles of natural science; semiotics of the subject environment; second-order metasciences

1. Introduction

1.1 The relevance of developing creative potential

The solution to the problems generated by digitalization and specialized AI is possible within the framework of the universal concept of a hybrid environment. In it, one can learn to study and to realize consciousness allows semiotic tools and bionic principles that contribute to the cognitive visualization of hybrid reality. At the same time, cognitive metamodeling of explicit and hidden relationships in a hybrid dynamic system, including the human brain, opens up unique opportunities. This work is a further evolution of ideas and methods for studying the individuality of objects of animate and inanimate nature, as well as the idea of the complementarity of cognitive and heuristic metamodels. In particular, the

work (Mygal V. et al., 2024) show that:

- digitalization of education is not only new opportunities, technologies, and methods, but also new challenges that can be overcome through metamodeling within the concept of hybrid reality;
- the growth of complexity (statistical, dynamic, structural, algorithmic, and informational) forms complex-systemic thinking, for which not only cognitive distortions (systematic errors) are relevant, but also inherited cognitive distortions;
- new challenges and risks associated with the use of AI in the management of complex dynamic systems (CDS) are due to the hybrid subject environment in which higher-order brain functions (cognition, sensory perception, abstract thinking, and imagination) are manifested.

Obviously, the reaction to external and internal stress factors induces new relationships that affect the perception of the dynamic complexity of the functioning of CDS elements and the static complexity of the spatial distribution of many sources of information of different natures.

Features of semiotic modeling of individual thinking. On the one hand, cognitive visualization allows us to identify the features of the structure of explicit and hidden relationships that determine the individual's way of thinking (synthetic, analytical and pragmatic). At the same time, graphic language simplifies the study of consciousness and subconsciousness, the connection of which determines the worldview and perception of the world. On the other hand, the versatility of semiotic tools facilitates cognitive visualization and heuristic metamodeling of a hybrid dynamic system, including the human brain. This made it possible to synthesize a generalized cognitive model of AI functioning in the form of two conjugated triads. Their relationship and complementarity allow us to systematically analyze the dynamic and static complexity of the hybrid environment. This contributes to the development of intuition and emotional intelligence.

Problems of learning associated with GenAI. The rapid development of GenAI and its wide application in various subject areas has revealed a number of new problems (ethical, legal, creative, etc.), which are considered in our works (Mygal V., Mygal G., & Mygal S., 2023; Mygal V., Mygal G., & Mygal S., 2024). They draw attention to the features of interaction in a hybrid subject environment, the individual nature of which gives rise to new contradictions. This creates global challenges to mental health, safety, and self-learning. Thus, the use of GenAI, on the one hand, protects the student from information overload, and on the other hand, limits the effectiveness of cyclical learning according to D. Kolb (Kolb, 1984; Kolb A. Y. & Kolb D. A., 2013). At the same time, deterioration of mental health (loss of empathy, flash perception of information) limits the unique possibilities of self-learning with the help of specialized AI and also increases the complexity of self-reflection. Therefore, the scientific and pedagogical activity requires the formation of qualitatively new thinking (meta-thinking), which takes into account:

- Features of cognitive perception;
- The difference between physical and digital reality (Mygal V., Mygal G., & Mygal S., 2024);
- Cognitive aspects of interaction in the digital world.

The main objectives of the work: (1) Based on the study of an individual's thinking in extreme conditions, to establish the cognitive features of the perception of physical and digital reality. (2) Within the framework of general semiotics, to develop new universals based on Signs-indexes, Signs-icons, and Signs-symbols. (3) To propose a hybrid toolkit for the development of an individual's meta-thinking in the process of learning from experience.

The complementarity and interconnection of these goals open up new opportunities in the study of the connection between consciousness and the subconscious, taking into account which allows for increasing the creative potential of an individual. On this basis, the possibility of solving new challenges generated by digitalization and the use of GenAI in education is discussed.

2. Features of the perception of reality that influence an individual's thinking

2.1 Individuality of functioning of a hybrid dynamic system

In extreme habitats, even small impacts generate individuality in the functioning of living and nonliving objects. It manifests itself in the form of nonlinearity, uncertainty, and instability of spatiotemporal time series. In turn, this triad is associated with the universal concept of self-organized criticality (Bak, Tang & Wiesenfeld, 1988). Indeed, different phenomena (landscape formation, evolutionary processes, growth of crystalline compounds, activity of the nervous system, economic behavior, etc.) have a number of common properties (Roco & Bainbridge, 2021). Thus, new phenomena have been identified in crystalline compounds that are technologically inherited and associated with residual stresses of the first kind. They are characteristic of individual macroblocks of crystalline ingots, the growth of which under extreme conditions is accompanied by a decrease in symmetry. At the same time, in individual blocks, residual stresses of the

second kind generate a layered structure and abnormally high parameters, which indicate the manifestation of morphic effects of the second order (Nye, 1957).

2.2 Explicit and latent cognitive biases induced by learning and emotions

Explicit cognitive biases are systematic errors that are associated with learning and are easy to identify. Whereas, to identify latent cognitive biases, various approaches are used (logical, structural, evolutionary, and imitation), the boundaries between which are blurred. Extreme conditions allow neurons to recover both anatomically and functionally, as well as create new synaptic connections. However, only half of the individuals exhibit neuroplasticity, which allows neurons to recover both anatomically and functionally, as well as create new synaptic connections (Haken, 1995; Haken, 1996; Leventhal, 1984; Parasuraman & Mehta, 2013; Fedota & Parasuraman, 2009). Therefore, the individual brain is able to:

- create hidden intrahemispheric connections;
- activate new pathways and establish hidden interhemispheric connections;
- move from one psychophysiological state to another.

Therefore, the individuality of learning, based on successful experience, is so relevant. Indeed, experience is an important component of the development of an individual's emotional intelligence, since they are associated with strong feelings, remain especially deeply in the memory of a creative person. The development model is proposed in the works (Leventhal, 1974; Leventhal, 1984), which suggests that Human emotions can be based on three functional levels: sensorimotor, schematic, and conceptual. The relationship between these levels is accompanied by the evolution of thinking.

2.3 Peculiarities of individual thinking as a consequence of interaction on the network

On the one hand, it is quite natural for a young person to strive for the fastest possible processing of information, and on the other hand, the constantly increasing information load entails changes in the psyche, logic, and memory. As a result, predominantly digital (network) thinking is formed, which determines a change in behavior patterns. Conventionally, the properties of a person's network thinking are divided into positive and negative:

(1) ***Positive properties:*** The value of the information received is determined by codes and keywords and not by content. Therefore, an individual can freely move from one network to another and is also able to combine several images that are not related to each other. At the same time, each time, he changes his behavior and principles.

(2) ***Negative properties:*** a) the thinking of a network person is clip-based, that is, based on the operational superficial perception of a mass of disparate fragments of information. At the same time, the individual does not notice the emerging contradictions; b) network thinking is stereotypical, template-based and easily programmable, and is also incapable of independent thinking due to the lack of long-term memory.

Thus, the fragmentation of the information consumed collides with the biological need of the brain to create a holistic image of the world, which is formed on the basis of the readings of all human senses. Network thinking is characterized by one-dimensionality, in which an individual independently completes the missing fragments from individual fragments of information. At the same time, the individual uses the simplest possible decision-making patterns, which leads to many contradictions and conflicts in the "student-information environment-teacher" system. As a consequence, the manifestation of the phenomenon of the human factor in education, limits the optimization of the learning structure and the construction of an individual learning trajectory.

3. Metamodeling of thinking—metalanguage of hybrid reality

3.1 Cognitive complexity and heuristic value of symmetry/asymmetry of a hybrid environment

In the process of development and learning, individual experience and the construction of an emotional pattern of information processing are formed, which are automatically included. Corresponding to spontaneous emotions, they form the emotional intelligence of the individual. As shown in our work, thinking from simplicity to complexity is structure-forming, and in the opposite direction, it is structure-destroying, which is a consequence of the functional asymmetry of the brain. The left hemisphere of the brain analyzes the topology of physical reality, and the right hemisphere of the brain analyzes the static complexity of the distribution of multiple sources of information (defects, inhomogeneities). Within the framework of such a cognitive metamodel, the perception of dynamic and static complexity was studied (Mygal V., Mygal G., & Mygal S., 2024). Natural language includes nested and ordered metalanguages, each of which has a more specialized vocabulary and simpler syntax. Therefore, the use of a metalanguage in which mathematics and logic communicate to integrate and generalize the results of psychological and electrophysiological studies allows systematic errors to be identified.

3.2 Heuristic metamodel of the structure of triadic creative thinking

Metamodeling has a logical, mathematical, and general philosophical basis and represents a new principle of data organization. The structure of the heuristic metamodel of creative thinking consists of two conjugate triads that display dynamic and static complexity. On the one hand, the relationship of these complexities generates the static nature of the distribution of heterogeneities in the environment of information transmission, and on the other hand, the dynamic exchange of information in the hybrid brain occurs (see Fig. 1).

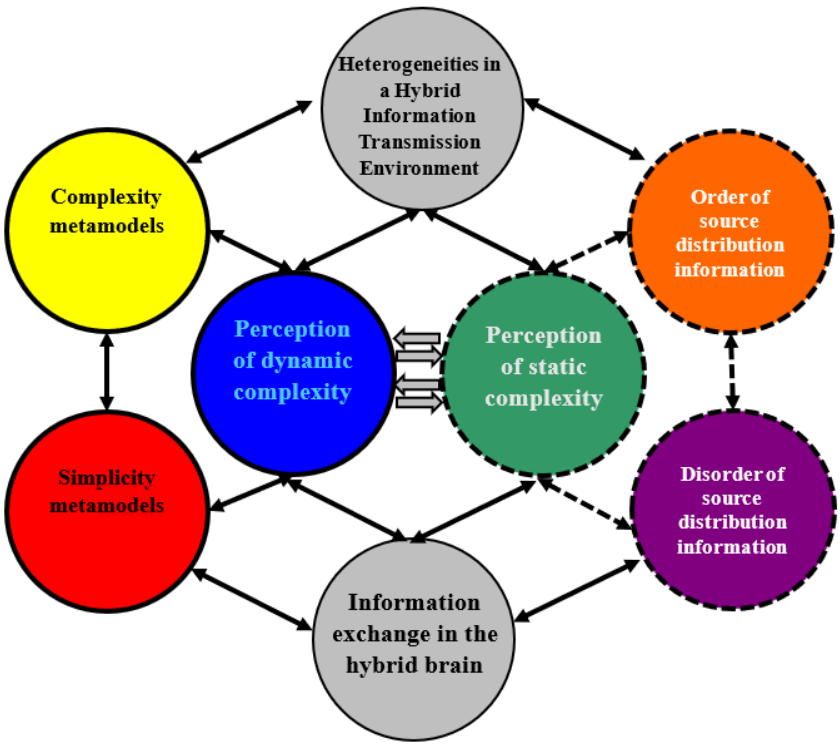

Figure 1. Heuristic metamodel of the structure of triadic creative thinking.

Therefore, meta-analysis of changes in the cycles of information exchange between conjugated triads allows us to study the features of thinking that are associated with the functional asymmetry of the individual's brain. In particular, in creative thinking, the perception of the transition from simplicity to complexity and from order to disorder does not depend on the sequence of consideration of the cycle—clockwise or counterclockwise. Consequently, creative thinking is based on independent cycles of perception of dynamic and static complexity, which allows hybrid online and offline learning to be implemented through:

- transformation of experiential learning according to D. Kolb;
- use of hybrid methods of information processing;
- borrowing new ideas from nature, the beauty and harmony of which are interconnected.

In real time, all relationships between dynamics and statics are manifested. Consequently, the structure of explicit and hidden relationships reflects the features of information perception that the triadic creative thinking of an individual reflects. Indeed:

- Intuition forms a composition (image, work);
- Knowledge contributes to reflection;
- The successful experience of an individual forms intuition (subconscious).

The new methodology of heuristic metamodeling is based on the complementarity of paradigms (synergetic, triadic and semiotic). Their relationship, as well as taking into account the structural and functional asymmetry of the brain, unites physical and social ontology, which contributes to the formation of creative thinking in the learning process. In our opinion, the individuality of creative thinking is determined by the dominance of intuition (subconscious), which allows different styles of thinking to be combined during collective brainstorming.

3.3 Cognitive metamodel of constructive thinking

Engineering use of concepts and metaphors as constructive forms of thinking is relevant for training architects, programmers and psychologists, for whom the analysis of the balance of external and internal information is important (see Fig. 2).

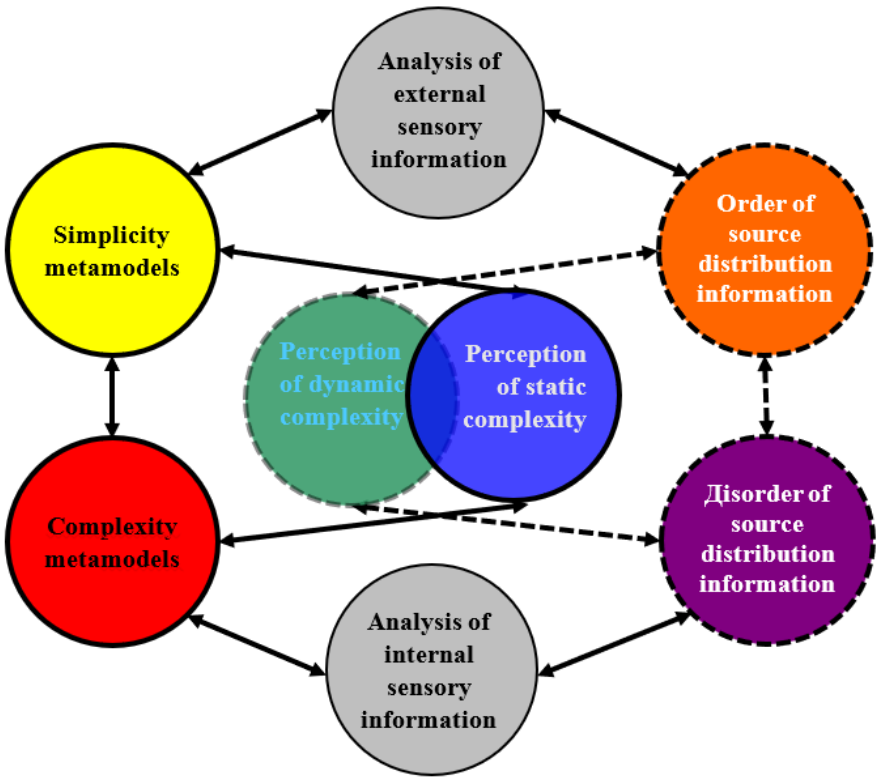

Figure 2. Cognitive metamodel of triadic constructive thinking.

As we can see, the peculiarity of constructive thinking of an individual is:

- search for balance of conjugated triads of opposites;
- establishment of harmony of triads of opposites;
- inversion of the structure of triads of opposites.

Their complementarity reflects the dominance of knowledge (consciousness). Indeed, the laws of conservation (balance), symmetry (harmony) and inversion of structure in physics, biology and computer science contribute to the search for new patterns.

3.4 Perception of the evolution of harmony and differences in hybrid reality

The relationship between the consciousness and the subconscious of an individual shapes activity in a natural hybrid environment. At the same time, any idea or innovative solution cannot arise without many explicit and hidden relationships between consciousness and the subconscious. Therefore, the emotional experience of an individual determines the emergence and development of an idea, which is based on:

- emotions of previous successful decisions;
- results of observation of a fractal nature;
- dynamic similarity of structures, methods and technologies.

At the same time, the balance of static and dynamic connections is achieved through the inversion of the structure and harmony of perception of conjugated triads of opposites. The induced complementarity of spatio-temporal relations is manifested in intuition, which is associated with consciousness and determines emotional intelligence. Cognitive perception of the evolution of physical reality is a dynamic process that is induced by stress factors of the environment and

activity. Therefore, for the expansion of the worldview, it is important to understand the evolution of self-organized dynamic systems in both living and non-living nature studies (Mygal V. P., Mygal G. V., & Mygal S. P., 2024).

3.5 Heuristic value of understanding hybrid reality through semiotics

The hybrid neocortex (new brain), which also controls analytical and mathematical thinking, is responsible for higher-order cognitive functions (sensory perception, language, abstract thinking, imagination, and consciousness). Therefore, we also include the following in the universal hybrid environments:

- The human brain;
- An artificial neural network that includes communication channels;
- Information sources of various natures (detectors, smart sensors, etc.).

On the one hand, the dynamics of processing complex data sets is subject to general principles, criteria, and is described by the same equations, parameters, and criteria. On the other hand, the functional asymmetry of the cerebral hemispheres determines the individuality of cognitive capabilities and neuroplasticity, which is the basis for the development of emotional intelligence, as well as innovative thinking and NLP (Mygal V. P., Mygal G. V., & Myhal A. B., 2023). The most common nonlinear communication model by Theodore Newcomb has the form of an equilateral triangle, the vertices of which are the communicant, the communicate, and the social situation. The interaction of the communicant with the communicator is carried out both taking into account the social situation and without taking it into account, which simplifies the understanding of hybrid reality (Newcomb, 1953).

3.6 Cognitive value of emotions that stimulate imagination and insight

Positive and negative emotions of an individual transform black-and-white duality into a triadic color perception of the harmony of physical reality. At the same time, coloring the conjugated triads with natural colors simplifies the system analysis of the structure of induced relationships. Considering emotions and thinking as unconscious and conscious aspects of the mental process, we can characterize emotional intelligence by a certain attitude of the subconscious to consciousness. At the same time, if the thinking process itself is unconscious with the awareness of other aspects of thinking, then we can talk about sudden insight; and if the thinking process is conscious, we can talk about imagination. Consequently, imagination is the result of thinking in the process of cognition of a hybrid reality, which is carried out with the help of emotions and the perception of the harmony of a fractal nature. Therefore, emotions are extremely important in the cognitive process for thinking about and visualizing ideas.

4. Hybrid learning—unique opportunities with GenAI and new risks

4.1 New risks associated with digital thinking

The use of AI is growing rapidly in the education sector, which is due to its ability to transform many aspects of the teaching and learning processes. Thus, AI can create:

- immersive virtual learning environments (Course Hero, MathGPTPro, Cognii, Knowji);
- "Intelligent content" (Century Tech, Socrat);
- individual plans for learning for each student (Gradescope, Socrat, Carnegie Learning).

At the same time, the above specialized platforms create new risks that are associated with:

- the development of network thinking and, as a consequence, fragmentation of knowledge, clip perception;
- contradictions in the "student-information environment-teacher" system;
- development of predominantly creative learning.

To reduce these risks and obtain positive results from the use of AI in education, new tools (methods and technologies) are needed that allow the balance and harmony of opposites to be established in a hybrid environment, as well as a systemic analysis of the evolution of thinking to be carried out.

4.2 New functions of GenAI—unique opportunities for an individual

Using a fractal triangle, designers model the topology of physical reality, the heterogeneities of which are universal sources of information. Therefore, the fractal triangle not only connects computer science, semiotics and cognitive sciences, but also creates unique opportunities for using specialized AI to individualize learning. What is relevant for education is that GenAI uses a combination of three key skills:

- Learning—collecting information and processing it for further use;

- Reasoning—choosing the optimal algorithm to achieve a result;
- Self-regulation—continuous improvement of skills to achieve goals and results.

Their combination allows using GenAI in education to implement new functions, namely:

- personalization of educational programs that best match the interests, needs, and knowledge of an individual;
- hybrid learning, which significantly simplifies the learning process;
- automation of processes (checking tests and assignments online.

All this reduces conflict, improves the quality of learning, and promotes the development of meta-thinking.

4.3 Mental, ethical, and legal issues of using GenAI

They are provided in the EU law, UN resolutions, etc. (Mygal V. P., Mygal G. V., & Mygal S. P., 2024). In particular, in 2024, WHO drew attention to the fact that every 10th European teenager has a digital addiction, which is put on par with nicotine. The negative impact of games, video information, and social networks on mental health is recognized and requires attention and correction.

The triad of key problems of using GenAI includes:

- formation of digital thinking (see 2.3.);
- deterioration of mental health;
- decreased security (information, functional and environmental).

They limit the development of critical thinking in the learning process and also lead to an increase in the manifestation of the human factor phenomenon in the technosphere. In addition, due to the total spread of neural networks, students experience a dominant development of only network thinking.

4.4 Semiotic connections between sciences and their metasciences

Physics creates idealized models, and semiotics constructs these models using one or another sign system. In them, the creative idea and imagination are a single process:

- formation of a holistic subject-project environment;
- transversion of things into signs and signs into things;
- studying the objectivity of subjectivity and vice versa, the subjectivity of objectivity.

It is important that semiotic systems include different modes of communication (visual, verbal, non-verbal and musical), as well as various "multimodal" ensembles of any of these systems (Kress & Van Leeuwen, 2001). Our works show the heuristic value of metamodels based on the fractal triangle and the Star of David. In particular, the value of metamodels in the form of the Star of David is due to the fact that its configuration:

- contains the Hebrew alphabet;
- is in the Tree of Life diagram, which is used in Kabbalah and astrology;
- is used in esoteric teachings (Gnosticism, Kabbalah, theosophy, and anthroposophy).

Therefore, in the work (Mygal V. P., Mygal G. V., & Mygal S. P., 2024) attention is drawn to the parallels between physics-metaphysics and Eastern philosophy. The fruitful use of the Star of David form in heuristic modeling contributed to the authors' overcoming interdisciplinary barriers in the process of joint activity and the formation of their metathinking (Mygal V. P., Mygal G. V., & Mygal S. P., 2024).

4.5 Conscious subconscious—a heuristic metamodel of second-order thinking

Awareness of one's knowledge determines the effectiveness of learning. At the same time, the individual's subconscious determines the nature of interaction in the digital world, the increasing complexity of which creates new cognitive problems and global challenges. Consciousness, subconsciousness and critical thinking are linked by emotional experience, which determines the nature of interaction in the digital world. The heuristic metamodel of hidden relationships, displaying second-order metathinking, is also synthesized in the form of the Star of David (Fig. 3).

This model demonstrates conjugate triads that reflect the awareness of the evolution of the authors' thinking during the transition from physics to metaphysics, from ergonomics to meta-ergonomics, from design to meta-design. At the same time, the evolution of the subconscious through self-training, self-knowledge and self-reflection contributes to the development of second-order meta-thinking, which is based on the perception of harmony and balance in information flows of various natures.

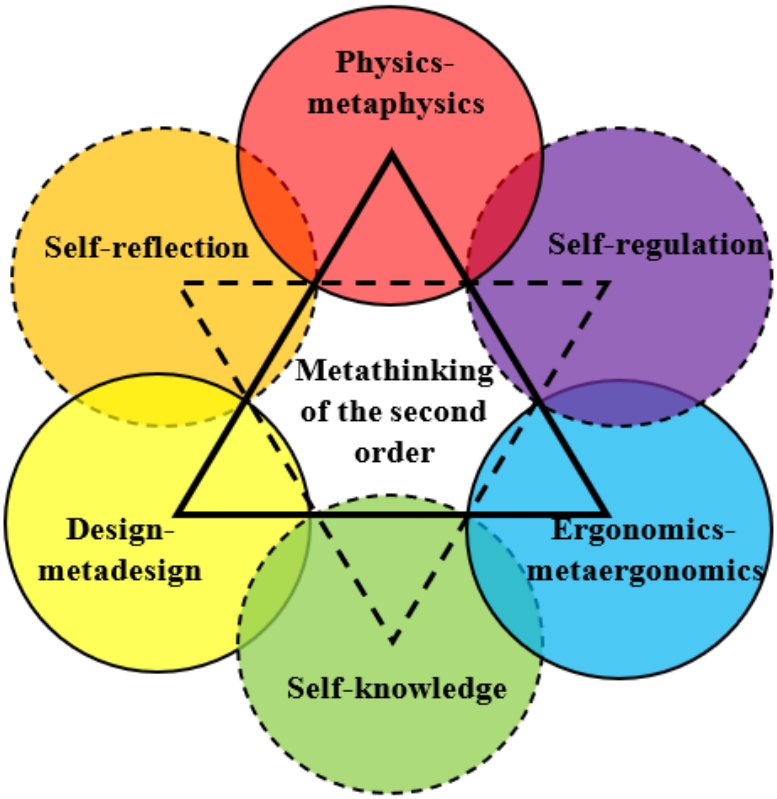

Figure 3. Heuristic metamodel of hidden relationships and second-order thinking.

4.6 Semiotic triangle—the value of the Star of David as a universe

The structure of the sign is reflected in the semiotic triangle, in which the unity of the form, representing, replacing some object, and information about it is manifested. This allowed us to overcome interdisciplinary barriers and synthesize metamodels of the functioning of fractal nature in the form of the Star of David, as well as their semiotic analysis in a single cognitive space of dynamic events to implement. This contributed to fruitful joint activities. In particular, to expand the scope of application of Niels Bohr's complementarity principle for interconnected cognitive and heuristic metamodels of synthesizing thinking (Mygal V. P., Mygal G. V., & Mygal S. P., 2023; Mygal V. P., Mygal G. V., & Mygal S. P., 2024). Supplementing this process with new ideas, meanings and know-how.

From numerous interpretations of the Star of David, it follows that it surprisingly combines the idea and the paradigm, as well as the connection of the structure of the sign-symbol-code with the functionality. Indeed, the hexagonal form of the Star of David displays:

- conjugated triads of opposites, which are the basis for the complementarity of metamodeling methods for physical and digital reality;
- structural balance, which is widely used in the natural sciences, computer science, art and psychology (life sciences);
- inversion, which is widely used in the natural sciences, computer science, culture and life sciences.

Therefore, the hexagonal shape of the Star of David is a universe that made it possible to implement a structural-functional approach to different types of creative activity within a single cognitive space of dynamic events. It should be noted that the space of dynamic events is synthesized on the basis of interconnected extreme principles of natural science, dimensional theory and the Gauss method. The consequence of their complementarity is the relationship of cognitive and heuristic metamodels, which are based on the similarity of natural information processing processes in nature, the brain and human society. Therefore, the use of a semiotic structure—a universe in the form of the Star of David opens up new opportunities for survival, cognition and increasing the creative potential of an individual.

4.7 Heuristic value of the evolution of ideas, paradigms and semiotic universals

Overcoming interdisciplinary barriers between a physicist-materials scientist, an ergonomist-engineering psychologist and a designer-architect contributed to the formation of meta-thinking, which led to the evolution of ideas. The most relevant are the evolution of the following triad of ideas:

- a single cognitive space on a transdisciplinary basis, which was transformed into a search for hidden connections between consciousness and the subconscious;
- integrative thinking, which was transformed into the development of second-order thinking on a semiotic basis;
- dividing the methodology of teaching individuals into two, which are characterized by different strategies and methods for solving creative problems.

At the core of their relationship is a semiotic universal, the coloring of which in natural colors helps to achieve harmony, in which the inversion of conjugated triads simplifies the search for a balance of conjugated opposites, and semiotic analysis helps to find new ideas and develop creative potential.

5. Metamodeling of hybrid reality that develops integral thinking

5.1 Contradictions generated by natural informatics

On the one hand, it is based on mathematical modeling, the capabilities of which are limited by Gödel's theorem (meta-mathematics). Therefore, natural informatics does not allow:

- to overcome interdisciplinary barriers in solving urgent problems of the technosphere;
- to implement the convergence of special disciplines as it is implemented in the natural sciences (physics, chemistry and biology);
- to develop universal indicators, criteria and functional features of physical reality.

In our opinion, natural dynamic and static information should be obtained online using semiotic tools, the complementarity of which contributes to the systemic perception of physical reality and the development of integral thinking. Indeed, the most effective algorithms are "inspired by nature", and these are cellular automata, evolutionary computations, swarm intelligence and others. There are also many developments of computing systems that are based on the key principles of biomimicry (bionics). Many designers, architects and researchers believe that we do not copy nature, but are inspired by it (Benyus, 2002). Therefore, metamodeling of nature (physical reality) makes it possible to change the ways of growing crystals or breeding organisms, storing information, self-healing or self-learning.

5.2 Integral perception of physical and digital reality

Features of thinking in science, art and design, as well as the connection of an individual's worldview with the perception of the harmony of nature, heuristic thinking and cognitive flexibility form (Mygal S., Mygal V., & Mygal G., 2023). With the help of neurosciences (neuroergonomics, neuropsychology, etc.), it has been established that the manifestation of cognitive problems depends on the psychophysiological state of a person (Parasuraman, 2013; Mygal V. P., Mygal G. V., & Myhal A. V., 2023). These problems are a consequence of:

- accelerated digitalization of science, education and technology;
- the complexity of modeling nonlinear physical reality;
- hyperspecialization, which has led to side effects (fragmentation of knowledge, clip thinking and the illusion of knowledge).

Within the framework of the structural-functional approach to the designer's thinking, attention is drawn to the heuristic significance of:

- structure-forming and structure-destroying factors;
- the unification of physical and social ontology;
- taking into account the integral features of the individual's brain activity.

5.3 Integral thinking in science, art and design

The key principles of integral thinking are holism (the world is a single whole), contextuality (perception of the world depends on the subject environment) and systematicity (considering the problem as a complex system that cannot be solved by adding up parts). Therefore, the interrelation and complementarity of cognitive and heuristic metamodels allows us to take into account the peculiarities of an individual’s brain activity and to further develop the structural-functional

approach to the perception of physical and digital reality (Haken, 1995; Haken, 1996; French, 2014). The research methodology is based on the post-neoclassical paradigm of scientific knowledge, a dialectically developing subject-object system of relationships in a hybrid innovative educational environment. The methodology also includes new methods of interdisciplinary research and metamodeling of reality, which combine physical and social ontology. Their complementarity contributes to the harmonization of the data (information) structure, which is widely used in the natural sciences, computer science, art and life sciences.

5.4 A semiotic approach to the development of innovative integral thinking

The formation of innovative metathinking is facilitated by the unification of physical and social ontology, which makes it possible to take into account the peculiarities of an individual's brain activity through the further development of a structural-functional approach to the perception of physical and digital reality (Haken, 1995). The methodology for the formation of innovative metathinking is based on the post-non-classical paradigm of scientific knowledge, a dialectically developing subject-object system of relationships in a hybrid educational environment, as well as the interconnected principles of biomimicry. The formation of metathinking includes new methods of interdisciplinary research (neuroscience, cognitive science), as well as metamodeling of reality, which combines physical and social ontology.

6. Semiotic universes—integration of models and technologies

6.1 Emotions and heredity

Today, cognitive distortions influence and sometimes determine the cognitive essence of a student (teacher, operator, designer, and risk manager). Therefore, the search for new ideas for solving the problems of cognitive distortions acquired in the process of activity and inherent in each individual, as well as genetically inherited hidden cognitive distortions (Leventhal, 1974; Leventhal, 1984) is very relevant.

In cognitive visualization of physical and digital reality, the connection between emotional experience (subconscious) and awareness of one's knowledge (consciousness) is manifested (Gilbert, 2006). At the same time, modeling the dynamics and distribution of natural sources of information serves, on the one hand, to study them and better understand them, and on the other hand, it produces ideas for the implementation of new computing systems (artificial life, self-reproduction models, etc.). Thus, in our work (Mygal V., Mygal G., & Mygal S., 2024), a new idea is developed about the complementarity of explicit and hidden relationships in a hybrid environment, which is based on:

- balance of triads of conjugate opposites;
- harmony of perception of hidden relationships;
- transitions from triad to duality and back from duality to triad.

The consequence of this is the complementarity of cognitive and heuristic metamodels (Mygal V., Mygal G., & Mygal S., 2023; Mygal V., Mygal G., & Mygal S., 2024), which is achieved through the use of the Star of David as a universe.

6.2 3M-metamodel of individual cognition of reality as a static universe

The structure of relations of dynamic equilibrium of opposites in the generalized metamodel is achieved due to: inversion of conjugated triads of opposites, use of natural color circle according to Goethe when coloring the graphic model, as well as spatial perception of the structure of relations in a hybrid environment (see Fig. 4a). In the center of Fig. 4a the first M-metamodel of cognition is shown in the form of colored circles (B, 1, 1), displaying the topology of the physical world (red), as well as the harmony of equilibrium of the inner world (green). The second metamodel of cognition of reality is displayed by the upper hexagon, in which two conjugated triads form a static configuration of the Star of David. At the same time, two pentagons built into it rotate in opposite directions, ensuring the stability of structure-forming processes. The third metamodel of cognition of reality is formed by means of inversion, as a result of which the static configuration of the Star of David is provided by the display of two conjugate triads (lower Star of David). At the same time, the inversion of two pentagons provides stability of structure-destroying processes. The complementarity of the triad of M-metamodels as a static universal has heuristic value.

6.3 3S-metamodel of the structure of self-regulation of learning

The metamodel of the structure of relationships of information exchange is shown in Fig. 4b. As we can see, its structure is also represented by conjugated triads, the number of relationships between which is 9, which coincides with the number of styles of experiential learning in the cycle of David Kolb (Kolb, 2013). Indeed, the acquisition of experience and its

transformation in the process of self-regulation includes self-development, self-knowledge and self-reflection. These processes are studied by second-order metathinking, which, as one of the emergent properties of an individual, is associated with the ability to:

- change in a positive direction your inner spiritual world and effectively adapt to the learning environment;
- self-realization, through personal efforts and creative work;
- resolution of internal contradictions not only with the natural subject environment, but also the social one, including spiritual life (art, poetry, etc.).

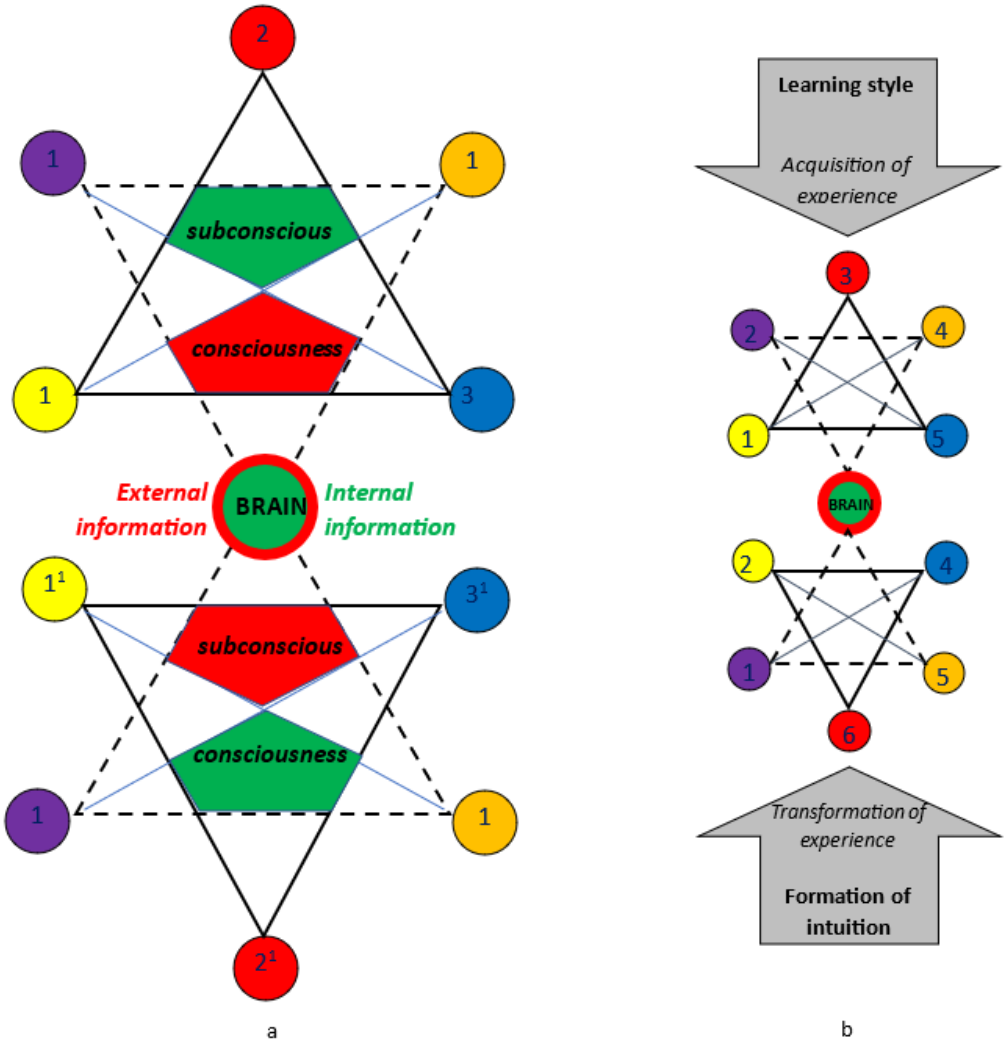

Figure 4. Cognitive 3M-metamodel of spatial perception of relationships in a hybrid environment (a) and Heuristic 3S-metamodel of the structure of self-regulation in the process of acquiring experience and transforming it (b).

Depending on the direction of the worldview, its self-development can be realized in the unity and interaction of three levels: social adaptation, social self-regulation and self-organization. In essence, the 3S metamodel of the structure of relationships is a temporal universe, the use of which contributes to the development of the skills of creative activity of the individual.

6.4 Optimization of learning activity cycles

The key role of the human factor in education, as well as its development in the context of modern challenges, requires the search for new tools for integrating humans and technologies. According to Kolb's theory, knowledge and skills are acquired during a cycle consisting of four phases—specific experience, reflection and observation, abstract thinking,

active experiments. These learning cycles form 9 learning styles (see Fig. 4c), in 4 of which consciousness and creative thinking dominate, and in the other 4—the subconscious and critical thinking. At the same time, the inversion of the structure of relationships does not change the functionality of the metamodels. Consequently, the complementarity of the 3S and 3M metamodels of self-regulation and cognition of reality allows the learning activity of students to be optimized. In particular, offline training of designers-designers is optimal for teamwork, for whom the complementarity of the following styles is important – imagining, initiating, acting, feeling and balancing. Therefore, online training is optimal for students who achieve results by weighing opposing arguments ("pros" and "cons"), which contributes to the complementarity of learning styles, namely: reflecting, analyzing, reflecting, solving and balancing. At all stages of the learning cycle, it is important to have a creative vision of problem solving, which requires the development of a balancing style by all students, which allows maintaining balance by weighing all the pros and cons. It is important to emphasize that the learning style is a certain state at each stage of life, the evolution of which reflects a change in the relationship of consciousness to the subconscious. At the same time, a huge number of images, metaphors, as well as other art tools simplifies work with the subconscious.

6.5 Individualization of learning—unique opportunities GenAI

The work (Mygal V. P., Mygal G. V., & Mygal S. P., 2024) shows that specialized AI platforms not only provide unique opportunities but also create new problems in education. The rapid growth of AI in the education sector is due to its ability to transform many aspects of the teaching and learning processes. Today, AI can create:

- immersive virtual learning environments;
- intelligent content;
- plans for each student.

In particular, many innovative companies are creating specialized AI to achieve these results. Summarizing all the benefits that neural networks can bring to the field of education, it is necessary to mention the following main points:

- Personalization—with the help of AI, individual educational programs are already being created today that best match the interests, needs and knowledge of a particular student;
- Distance learning—artificial intelligence significantly simplifies the process of distance learning, improving the quality of education obtained in this way;
- Automation of processes—AI is given the task of performing routine tasks, such as checking tests and other assignments, and teachers have time for more important, creative aspects of teaching.

To effectively use the unique capabilities of AI in education, an individual needs to develop integral thinking in the process of learning from successful experiences.

6.6 Health preserving approach to learning with the help of personal GenAI

The problems of interaction in the "student-information environment-teacher" system are considered by us in our works for 2016-2023 years, and also developed in the work. The business orientation of specialized AI has created new problems and global challenges to the mental health and safety of the new generation. The development of network thinking leads to the loss of mental health and empathy, and also causes digital dependence. A decrease in the quality of education necessitates the development of a hybrid approach to digital interaction, within which the adaptation of GenAI contributes to an increase in cognitive flexibility. This increases the effectiveness of learning due to:

- awareness of new opportunities, which stimulates motivation;
- individualization of tasks, which contributes to successful learning from experience;
- using art coaching techniques, because natural beauty and aesthetics contribute to creativity.

Therefore, taking into account the features of cognitive activity by adaptive AI in the process of activity will increase the creative potential of the individual.

The universality and complementarity of hybrid methods: modeling reality, information processing and learning technologies, the search for hybrid universals (methods, technologies and signs) allows the GenAI-transformer to be created. On its basis, innovative thinking can be developed taking into account the individual cognitive characteristics of the individual, which opens up qualitatively new opportunities for individualization of the trajectory (strategy) of learning with the help of GenAI.

Overcoming interdisciplinary barriers between the authors contributed to the evolution of thinking and the development of meta-thinking, which was manifested in fruitful joint work. Our innovative activity is reflected in patents and Know-how, among which the following Know-how are of particular interest to education:

- a method for determining the individual characteristics of thinking;
- method for determining the stressful psychophysiological state of an individual;
- method for predicting the transitional psychophysiological state of an individual.

On the one hand, the greening of education is important for sustainable development, for which the innovative focus of training is important. On the other hand, it is necessary to take into account the cognitive characteristics of an individual, the evolution of which contributes to the search for new ideas. Therefore, innovations (patents and know-how) for the development of integral thinking of an individual are relevant, which can be implemented with the help of a personal GenAI-transformer.

6.7 Static-temporal 3S-3M universe—innovation for a safe future

The idea of self-organization made it possible to understand the development of the complex from the simple and the emergence of order from chaos. Therefore, emergence explains complex phenomena in various fields (thermodynamics, biology, digital technologies, etc.). The use of the cognitive mind metamodel (3M metamodel) in the form of a double Star of David in the process of creative activity demonstrates:

- optimization of balance when moving from one Star of David to another through inversion, which reflects the harmony of physical reality and the fractality of nature;
- instability of the relationship between consciousness and the subconscious, the inversion of which reflects the transition from one pentagon to another;
- the influence of the asymmetry of the cerebral hemispheres on the formation of meta-thinking, which indicates the stability of oppositely oriented hexagons and pentagons.

Obviously, the 3S-metamodel displays a double cycle of the pentagon in the hexagon, which makes their superposition an effective means of cognition, management and evaluation using GenAI.

Thus, the complementarity of the 3S- and 3M-metamodels is associated with the inversion of the structure and the balance of conjugated triads, as well as the harmony and balance of opposites. Their synergy allows innovative thinking to be formed in the learning process based on emotional experience.

7. Conclusions

The problems of digitalization of education are connected with the manifestation of individuality, which in extreme conditions of the relationship between consciousness (cognitive visualization) and the subconscious (hidden and inherited cognitive distortions) change. From the analysis of the evolution of problems over the past 5 years it follows that:

- The problems have become more acute due to new contradictions, cognitive distortions, loss of empathy, digital thinking;
- Cognitive overload and conservative structure of education;
- Increasing conflict in digital interaction due to the use of AI.

These problems can be solved by reducing the interaction time in the system (student-information environment-teacher" by transferring some of the teacher's certain functions (preparing and checking tests and tasks, taking exams) to AI-based platforms.

To solve new problems and challenges (side effects and phenomena) generated by the use of GenAI in education, the following has been done:

(1) Cognitive features of perception of physical and digital reality in extreme conditions have been established.
(2) Within the framework of general semiotics, new universals based on Signs-indexes, Signs-icons and Signs-symbols have been developed.
(3) A hybrid toolkit for studying individual thinking has been proposed.

To identify and take into account obvious and hidden cognitive distortions:

(1) A generalized semiotic approach to hybrid methods of studying reality, integrative methods of information processing and hybrid teaching technologies using GenAI has been applied.
(2) Hybrid tools (information sources, universals, metamodeling methods and cognitive visualization methods), as well as second-order metasciences are applied.
(3) Personalized GenAI-transformer and 3S-3M universe allows to identify all cognitive distortions.

The complementarity and interrelation of these hybrid tools opens up new possibilities in studying the connection between consciousness and the subconscious, taking into account which allows increasing the creative potential of an individual.

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