Review Article

AI: Unique Opportunities and Global Challenges – A Hybrid Approach to Modeling Reality and Its Perception

Valeriy Mygal[1], Galyna Mygal[2], Stanislav Mygal[3]

1. National Aerospace University Kharkov Aviation Institute, Ukraine; 2. Lviv Polytechnic National University, Ukraine; 3. Independent researcher

To solve the problems and challenges induced by digitalization and the use of specialized GenAI, a hybrid approach to modeling three-dimensional physical and digital reality is being developed. Based on a new philosophy of modeling, which includes second-order metascience, cybersemiotics, and cognitive metaphor, a structural-functional methodology for studying a hybrid environment is being developed, within which spatio-temporal connections of opposite phases of dynamic processes of various natures appear.

It is shown that the synergy of the use of semiotics, cybersemiotics, and cognitive metaphor contributes to the formation of integrative metathinking and the choice of strategies for creative activity. At the same time, the development of the methodology itself (metathinking) through extreme principles, relationships, and structures, as well as the proposed hybrid universals, contributes to the formation of an individual's learning cycle and style. The cognitive aspects of the manifestation of the phenomenon of the human factor in education and science, which limit the creative capabilities of the individual and give rise to systemic contradictions between physical and digital reality, are considered. In this case, obvious and hidden cognitive distortions arise, which give rise to new problems of safety (functional, informational, and physical), mental health, and diagnostics.

Within the framework of the structural-integrative methodology, the foundations of an integrative meta-theory of natural structuring (transformation) of information flows (time series) of various natures into cognitive graphic images are created, which display the conjugate opposite phases of the functioning of the elements of complex dynamic systems, including the human body. To study transient functional states of a person and their quantitative assessment, original tools are proposed. They are based on the heuristic value of ancient signs – Ouroboros, Star of David, tetractys,

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Scandinavian runes, the use of which within the framework of a hybrid approach contributed to the study of parallels between the perception of physical reality and the mysticism of Eastern philosophy. In particular, the extreme principles of modern natural science have made it possible to establish a connection between the Star of David, the Merkabah (tree of life), and the Qabalah.

Global challenges to mental health, safety, and professional activity are associated with the manifestation of cognitive and metacognitive distortions, which are induced by digitalization and depend on the psychophysiological state of a person (pilot, dispatcher, driver, etc.). They are studied by cognitive science and neuroscience, as well as ergonomics/human factors, engineering psychology, and human factors engineering. To reduce the risks of man-made disasters, the idea of complementarity of ergonomics, engineering psychology, and human factors engineering is being developed within the framework of metaergonomics of a hybrid environment. The cognitive metamodel of the metaergonomics structure takes into account the physical reality of consciousness and the virtual reality of the subconscious, the connection of which contributes to successful professional activity.

New tools for modeling a neural network within the framework of natural computer science are proposed, which are based on the integrative metatheory of digital modeling of a hybrid subject environment. The new paradigm and principles of the natural knowledge base based on the structural-functional methodology and integrative meta-theory of modeling create unique opportunities for solving pressing problems through GenAI. The relevance and possibility of forming balanced creative-critical metathinking in the process of interaction in the digital world are discussed.

Correspondence: papers@team.qeios.com — Qeios will forward to the authors

Structure of the Article

The information structured in the article reflects the evolution of the interdisciplinary exchange of ideas, methods, and technologies in the process of successful activities of a materials physicist, an ergonomist-engineering psychologist, and an architect-designer. Therefore, to perceive a hybrid approach to AI, as well as hybrid methods for processing, displaying, and analyzing information flows of various natures, the article is structured as follows.

Section 1 "**INTRODUCTION**" examines the origins of the problems and risks induced by digitalization and identifies new systemic contradictions generated by specialized GenAI. They create challenges and

risks associated with the use of AI in CDS management. It is shown that a hybrid approach to modeling reality within the framework of the concept of a hybrid subject environment, which includes higher order functions - cognition, sensory perception, language, abstract thinking, imagination, is universal.

Section 2 "**FORMATION OF HEURISTIC THINKING – A HYBRID APPROACH IN EDUCATION**" examines the origins of new problems induced by digitalization, as well as new ideas for overcoming them within the framework of natural computer science. A critical analysis of the synergy of STEM education has updated the connection between an individual's thinking and worldview, perception of the harmony of nature, and successful experience. The heuristic value of generalizing observations through triads and dynamic symmetry is shown. This is, in fact, the development of the ideas of the astronomer, mathematician, and philosopher Kepler (manuscript "Harmony of the World", 1646), poet, writer, and philosopher Goethe (manuscript "The Doctrine of Color", 1889), and physicist experimental theorist J. Maxwell, who created color photography using a triad of colors on black and white film.

The heuristic value of the ancient Ouroboros sign and the structure-sign in the form of a hexagon (Star of David) promotes the transition from interdisciplinarity to transdisciplinarity and the study of the harmony of fractal nature through conjugate triads and establishes the cognitive value of the convergence of sciences and technologies. The heuristic value of the spatio-temporal ordering of information flows is considered using the example of the transition from NBIC technology to NBICS technology, associated with emotional intelligence, which inspires and stimulates the development of creative thinking. The relevance of spatio-temporal structuring of information for the formation of heuristic thinking in science, technology, and art has actualized the study of interrelated cognitive problems induced by digitalization, as well as the implementation of the idea of cognitive visualization through GenAI.

Section 3 **"HYBRID APPROACH TO MODELING PHYSICAL REALITY"** examines the physical reality of a fractal nature and the neural network digital reality of a hybrid approach to interaction in the digital world. A neural network is one of the ways to implement artificial intelligence, which imitates the functioning of the human nervous system. Therefore, the rapid development of specialized AI based on interdisciplinary cross-fertilization is driving significant progress in the fields of cognitive science and neuroscience. At the same time, cognitive visualization of dynamic processes in the space of dynamic events made it possible to generate the idea of the universality of distortions of information flows of various natures, which are sources of information about physical and digital reality. Based on the awareness of this idea, complementary paradigms for the knowledge of reality are proposed. It is shown

that the superposition of universal sources of information in a hybrid subject environment leads to synergy, which is the basis for the synthesis of complementary heuristic metamodels of complex dynamic systems (CDS).

The fourth section, **"HYBRID UNIVERSALS – FORMATION OF INTEGRATIVE METATHINKING AND LEARNING STYLE,"** examines the cognitive aspects of the human factor phenomenon in education and science, which is associated with the subconscious (intuition, successful experience, and synchronicity-coherence of information flows). They shape the integrative metathinking as well as the learning style of the individual. Based on experience-oriented learning (Kolb cycle) and its learning styles, the principles of experience-oriented learning of an individual are formulated, through which the individual constructs his "reality" in the hybrid brain.

Therefore, the foundations of the integrative modeling methodology in a hybrid environment are semiotics, structural ontology, and second-order metasciences, the integration of which is based on complementary principles, paradigms, and universals.

Spatiotemporal distortions and fluctuations of the hybrid environment are hidden universals. The general concepts (universals) of information flows of various natures are structure, inversion, and harmony, on the basis of which the idea of hidden connections between consciousness and the subconscious is developed. Therefore, we see the prospects for the development of heuristic metamodeling through the prism of the fractal paradigm, which allows the use of mathematical tools of fractal structures and holography, the topological and holographic structures of which are similar, as well as the natural structuring of information flows. On this basis, an integrative meta-theory of computer modeling of reality is being developed.

The fifth section, **"INTELLECTUAL ACTIVITY IN EXTREME CONDITIONS,"** emphasizes the importance of further developing the idea of identifying the individuality of creative activity, which reflects the peculiarities of the relationship between the structures of consciousness and the subconscious. They are associated with the functional asymmetry of the brain hemispheres, which determines the characteristics of thinking in science, art, and design. With the help of neuroscience (neuroergonomics, neuropsychology, etc.), it has been established that the peculiarities of the perception of digital reality create cognitive problems. They, influencing the transitional psychophysiological state of the individual, are the main reason for the manifestation of the phenomenon of the human factor during the creation and functioning of the CDS. In turn, the universality of the tools of creative activity is associated with a triad of features - thinking, worldview, and aesthetic perception of nature by the individual, which limits

interaction with GenAI. Analysis of the evolution of the synergetic system made it possible to optimize individual creative activity in extreme conditions (ecological, man-made, and social)[1][2][3].

The complementarity of heuristic CDS metamodels of various natures simplifies risk management and system design of transformations in a hybrid subject environment. In particular, the complementarity of ergonomics/human factors – engineering psychology and human factors engineering has allowed us to develop a convergent approach to the study of current problems of human factors, ergonomics, and engineering psychology, the complementarity of which is metaergonomics. A key role in it is played by the integrative metatheory of digital modeling of a hybrid environment, which is based on the methodology of integrating semiotics, structural ontology, and metasciences.

In the "Conclusions and Proposals" section, it is emphasized that the structural-integrative methodology for studying a hybrid subject environment and new ideas of symbiosis of explicit and hidden universals make it possible to identify the characteristics of an individual's mental activity in the process of his interaction with Gen AI, which opens up new opportunities for creative activity. As part of the methodology for researching a hybrid subject environment, new tools for creating a neurocognitive network have been proposed, which make it possible to develop principles for the formation of a hybrid knowledge base for the intellectual support of decisions made by an individual using Gen AI.

1. Introduction

The article actualizes new problems and risks generated by digitalization, the complexity and multidimensionality of which follow from the UNESCO document "Artificial Intelligence Technologies in Education: Prospects and Consequences." In our opinion, among the many problems and challenges, cognitive problems of online education, safety, and mental health are of particular interest. In particular, the new EU law imposes clear obligations on high-risk artificial intelligence systems due to their significant potential harm to health, safety, fundamental rights, the environment, democracy, and the rule of law.

The origins of problems and risks induced by digitalization. As shown in the work[4][5], the peculiarities 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, form heuristic thinking and cognitive flexibility.

With the help of neuroscience (neuroergonomics, neuropsychology, etc.), it has been established that the manifestation of cognitive problems depends on the psychophysiological state of a person. The problems

are a consequence of:

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

All this has led to cognitive overload, which has created problems with the mental health of the younger generation and new risks for the functioning of the CDS in unpredictable conditions. At the same time, the decrease in the importance and "weight" of fundamental, academic, and humanitarian disciplines is a consequence of non-compliance with the recommendations of the UN and UNESCO on the transdisciplinarity of education. At the same time, the increase in the number of man-made disasters, epidemics, financial and other crises, as well as many conflicts, wars, and epidemics, is associated with the manifestation of the phenomenon of the human factor. Automation of CDS control, ergonomics, and human factors engineering has not solved the problem of the viability of CDS elements in extreme conditions[6].

On the one hand, large language models (LLMs) have revolutionized AI, demonstrating in 2023 a colossal leap in the capabilities of artificial intelligent systems. On the other hand, LLMs have not made it clear how these abilities can arise in machines and in people. The creation of specialized generative AI has not only opened up unique possibilities for cognitive computing but also demonstrated the importance of cognitive aspects in transport. Thus, cognitive distortions reduce the safety of the functioning of the CDS, create problems in technical and medical diagnostics, which has updated the importance of the human factor in education and science[7][8][9][10][6][11][12][13].

In the above UNESCO document and the EU law of 2024, key problems are indicated. We identified three problems in the document, namely:

- understanding AI technologies in education: new practices and assessing benefits and risks;
- using AI for teaching and assessing performance, as well as improving the quality of education;
- application of AI technologies to stimulate innovation.

At the same time, the rapid development of AI, IT, and ICT technologies is inevitably accompanied by numerous risks and difficulties, the significance of which for education, science, and mental health, as well as biological, functional, and information security, is not yet realized.

GenAI – new systemic contradictions. The increasing complexity of interaction in the digital world has given rise to systemic contradictions, as well as many problems. They are studied by computer science, neuroscience, and cognitive science[10][6].

This allowed us to establish that:

- computer models of real processes have become more complex than reality itself;
- transition states are inherent in information sources and elements of complex dynamic systems (CDS);
- cognitive aspects of digitalization give rise to unconscious actions and errors.

Their consequence is the manifestation of the human factor during active interaction with the artificial digital environment, when immersed in which cognitive problems manifest themselves:

- duality of perception of physical reality;
- distortions of reality that generate cognitive dissonance;
- irrelevant selection of information in extreme operating conditions.

The inconsistency of existing standards and security methods reduces the physical, biological, and information security of elements of complex dynamic systems (CDS).

Risks of CDS management associated with the use of AI. Human creative activity in real and/or virtual space is influenced by cognitive problems that are caused by a hybrid subject environment[14][13].

In a hybrid natural environment, the structural community of biological, organic, and inorganic substances, on the one hand, blurs the boundaries between them, and on the other, creates new opportunities. A fundamental characteristic of physical reality is its structure as a set of stable connections that ensure the integrity and identity of objects to themselves, as well as the preservation of their basic properties during internal and external changes. In a transdisciplinary approach, the exchange of information flows that circulate from one branch of knowledge to another allows unity to emerge in diversity and diversity through unity. To reveal the nature, characteristics, and structure of the flow of information, as well as to search for new approaches, it became necessary to combine methodological and conceptual tools within the framework of metasciences[4]. The nanometric scale of information interaction has led to the study of cognitive aspects that are significant for education, science, and the further development of modeling technologies[4][5]. As a consequence, the complementarity of mathematics and physics, as well as the connection with their metasciences, has

opened up new opportunities for modeling physical reality. In particular, the search for new ideas and approaches to solving many pressing problems (creating unique nanomaterials, optimizing activities, and increasing safety) is facilitated by the development of nature-like technologies based on NBIT[15][13]. The archetypal shape of our three-dimensional reality is the triangle, which balances opposites into a harmonious unity through structural ontology. Its main concepts are space, time, and motion. In this article, we demonstrate a hybrid approach to the perception of physical and digital reality. It is based on a triad – the evolution of structure, the evolution of functionality, and the evolution of thinking. In the study of the cognitive aspects of digitalization, we also use a triadic approach and triadic analysis, triadic logic, and triadic principles[7][8][9][10][6][11][12][13]. The synergy of these triads is due to the manifestation of the principles of universality, interconnectedness, and complementarity.

Advantage of a hybrid approach. The neocortex (new brain) is responsible for higher-order functions such as cognition, sensory perception, language, abstract thinking, imagination, and consciousness. Therefore, we also include an artificial neural network, which encompasses communication channels, the human brain, and information sources of various natures (detectors, sensors, etc.), as universal hybrid environments. Their dynamics are subject to general principles and criteria and are described by the same equations, parameters, and criteria. Obviously, therefore, the increasing complexity of cognitive computing has increased interest in neural networks, which are:

- one of the ways to implement artificial intelligence;
- a computer model that simulates the functioning of the human nervous system;
- a type of AI that is used to process complex data sets.

Artificial intelligence systems use various approaches (logical, structural, evolutionary, and simulation), the boundaries between which are blurred. Very often, there are mixed systems where part of the work is performed according to one type, and part – according to another. In our opinion, the unique knowledge base is the topology of an evolving fractal nature, which opens up new opportunities for predictive analytics with GenAI.

In a hybrid environment, the emergent properties of CDS elements appear, which depend on the balance:

- system-forming and system-destroying factors[10];
- symmetry and asymmetry of feedbacks[1];
- opposites induced by influence[8].

In unforeseen conditions, the complementarity of the emergent properties (vitality, survivability, and stability) of the CDS elements creates a synergy that increases instability and uncertainty, the non-linear relationship of which increases the risks of CDS management. Transitional psychophysiological states of the human body have become relevant[16].

Having overcome interdisciplinary barriers, we offer universal sources of information, which are fluctuations, jumps, and noise of information flows of various natures, the emergent properties of which can be the key to:

- restoration of mental health through generative AI, which helps to unlock the creative potential of the individual,
- optimizing the strategy of educational and creative activities, revealing the innovative potential of human communication with GenAI,
- creation of valid methods and systems of medical and technical self-diagnosis, which contribute to the creation of a personal e-doctor with GenAI.

The complementarity of the areas of creative activity and perception of the harmony of physical reality allowed the authors to set interrelated relevant goals of the work:

1. Integrate semiotics, structural ontology, and second-order metasciences into a structural-integrative methodology for studying relationships in hybrid natural environments.
2. By using new ideas of symbiosis of explicit and hidden universals, identify the features of the spatio-temporal mental activity of the individual.
3. Create the foundations of an integrative meta-theory of computer modeling of reality, based on the natural structuring (transformation) of information flows of various natures into cognitive graphic images.

2. Formation of Heuristic Thinking – A Hybrid Approach to Education

2.1. STEM education

2.1.1. Complementarity of mathematical and heuristic thinking

Search for new ideas and connections. On the one hand, heuristics are based on methods used in the discovery of new concepts, ideas, and relationships between objects and sets of objects. On the other hand, "mathematics," translated from Greek, means a triad – cognition, knowledge, and study. As we see, the very nature of mathematical knowledge promotes freedom of thought and judgment. Therefore, the virtual incompatibility of mathematics and the humanities is visible. In particular, promoting STEM education, which covers natural sciences (Science), technology (Technology), technical creativity (Engineering), and mathematics (Mathematics). This model, combining natural sciences and engineering subjects into a single one, has been developing in recent years and has become quite popular because it responds to the challenges of the time. Students choose those Science, Technology, Engineering, and Mathematics (STEM) courses that emphasize the external over the internal. The consequence of this transformation of modern education is:

- a flat view of reality;
- routinization of thinking at the sociocultural level (mechanization of life);
- dominance of practical training, which is valued above fundamental training.

On the one hand, scientific and technological literacy provides some of the skills needed for employment, but on the other, technical savvy and quantitative STEM undervalue imagination, which:

- separates perception from cognition;
- narrows intuitive awareness by encouraging universal and unrealistic taxonomies, the rules of which are the theoretical basis of classification;
- confirms the dominance of nature and does not take into account Bloom's taxometry.

Existing ISO safety standards (ISO 45001 (Health & Safety), ISO 31000 (Risk management), IEC 60300) take into account only natural, man-made, anthropogenic, and environmental hazards. This has created a

global challenge to problems – security, the mental health of the individual, as well as the negative impact of generative AI.

STEM education and AI. Today, technical savvy is more valued than broad-mindedness. However, such education underestimates imagination and encourages universal generalizations and unrealistic taxonomies. For example, ChatGPT often offers answers that only an employee with knowledge and experience can distinguish from the truth.

In general, STEM, by reinforcing logic and calculation, favors the external over the internal, which:

- projects (projects) a flat view of physical reality;
- shows how the tool of the mind narrows and routinizes thinking;
- limits the sociocultural level (mechanization of life activities).

With this restriction of cognitive freedom, most people are focused on obtaining the material that is necessary to exist and survive in society. Therefore, they consider teaching art and literature unnecessary. Thus, STEM knowledge itself leads to a narrow view of knowledge and life as entirely rational. It leads to:

- imbalance in academic education;
- damage to human integrity;
- formation of only the creative thinking of a person.

Therefore, the analytical STEM disciplines of higher education, with their codified procedures, have contributed to the diversity of specialized AI, the interaction of which can lead to “glitches” and, as a result, to new risks.

Heuristic value of generalization. For the formation of heuristic thinking in science, technology, and art, self-structured information, which is operated by natural computer science, is relevant. We have updated the study of interrelated cognitive problems induced by digitalization and drew attention to the heuristic value of generalizing observations, the idea of which was revealed by the astronomer, mathematician, and philosopher Kepler in the manuscript “The Harmony of the World.” The harmony of triads was used by the poet, writer, philosopher, and creator of the theory of color I.W. Goethe, and physicist J. Maxwell (theorist and experimenter) used three colors to obtain color photographs in 1868.

The universal structure of the metamodel in the form of a hexagon (Star of David) made it possible to carry out effective interdisciplinary interaction and simplify the study of structures of fractal nature[5][13],

as well as establish the heuristic value of the ancient Ouroboros sign.

Cognition of the harmony of physical reality and perception of the complexity of digital reality depends on the functional asymmetry of the brain, which determines the characteristics of an individual's creative activity. The transition from NBIC convergence to NBICS convergence demonstrates the heuristic value of cognitive imaging, the effectiveness of which depends on the psychophysiological state of the person. This indicates the heuristic value of generalization, which inspires and stimulates creativity.

2.2. Heuristic metathinking in science, technology, and art

2.2.1. Generating useful ideas

The connection between worldview and consciousness and subconsciousness. Modeling of objects and design is based on the principle of similarity, isomorphism, and universality of the laws of the structure and development of the world. Bionics is based on this principle, which applies the principles of organization, properties, functions, and structures of living nature in technical systems. The work[4] examines the connection between an individual's worldview and the perception of the harmony of nature and shows that purposeful interaction with nature, culture, and the digital world at various levels of knowledge, in parallel with binary analysis, develops intuition and intelligence. Basic mental operations (analysis-synthesis-comparison) make it possible to find common features and properties in information flows of various natures and predict the functioning of objects in extreme conditions[6].

On the one hand, language is an instrument of science, culture, and evolution, and on the other, the cognitive capabilities of an individual are determined by intuition, experience, and emotional intelligence. At the same time, theorists continue to invent new names for old concepts and confuse them more and more. Creativity, as the ability to generate new and useful ideas, is closely related to memory, encoding, storing, and retrieving information[17].

At the same time, consciousness connects the subconscious, forming a contradictory unity of knowledge, beliefs, and doubts. Whereas behind everything rational there is a forgotten history of the development of an idea (method, technology, etc.), the creative development of which requires a search for fresh ideas and universal tools. Therefore, GenAI cannot generate new ideas, but its integration with the individual opens up new opportunities for creative activity, influencing complex systems thinking, which is associated with consciousness and subconsciousness.

Consciousness, subconsciousness, and semiotic information. The semantic aspect of information, reflecting the relationship between the form of a message and its semantic content, is semiotic information. This is due to the fact that in the process of digitalization of science and education, the logical basis for the extraction of knowledge is increasingly moving away from reality. On the one hand, the relationships between many events form something immeasurable and unimaginable. On the other hand, the increasing complexity of the problems being solved limits the unique capabilities of digital modeling. Therefore, researchers see many events that are not measured or modeled but are expressed by signs, symbols, and images. The thinking process is a process of pattern recognition[18], the analysis of which forms a system of principles, values, and ideals. Therefore, metathinking has a complex structure, the study of which is extremely necessary for fruitful creative intellectual and emotional activity.

The work[4] shows that for the development of heuristic metathinking, semiotics is important, which uses signs (symbols and images) to store, transmit information, and identify it. At the same time, the flexibility of cognitive perception is important, which contributes to the organization of images (impressions) so that from them one can:

- extract general ideas;
- gain new knowledge;
- find universal sources of information (universals).

The pragmatic understanding of semiotic information, communication, and language is associated with second-order cybernetics, the essence of which is that information is the difference that creates difference. Recursion of consciousness is a barrier to the development of creative thinking, and for programmers, recursion is self-evident. Therefore, with the help of AI, it is possible to overcome the recursion of consciousness in various fields of education, science, and technology. Cognitive distortions induced by digitalization especially affect decisions made in extreme conditions, being the main reason for the manifestation of the human factor in science and education.

2.3. Harmony of nature and heuristic metathinking

2.3.1. Complementarity of principles and structures

The principle of self-similarity. Constructions of fractals are used in physics, in such sections as hydrodynamics, plasma physics, electrodynamics, and radio electronics. Bionics, the science of applying

the principles of organization, properties, functions, and structures of living nature[19] in technical systems, is based on fractal principles. In our opinion, the key principles of natural science are:

- Fermat's minimum time principle;
- the principle of superposition of secondary Huygens-Fresnel waves;
- the principle of self-organization of the system to counteract the effects of Le Chatelier-Brown.

On the one hand, the heuristic value of these principles manifested itself in the revolutionary ideas of M. Planck, N. Bohr, L. De Broglie, E. Schrödinger, E. Heisenberg, P. Dirac, M. Born, R. Feynman, and others. On the other hand, extremal principles play an important role in biology, in information theory, and in optimal control problems, in which these principles are not associated either with mechanical motion or with geometry, or with the concept of "action". This is a consequence of the mutual deducibility of equations, as well as many analogies (geometric, mathematical, optical-mechanical, etc.), the general dimension of the functionals of which corresponds to the "action" (time x energy).

All rational activity takes place in a world created by creative activity. Therefore, in heuristic modeling, we proceed from the paradoxes of the technological world, extreme principles, and the harmony of nature. Their complementarity and interconnection are manifested in cognitive aspects that are induced by digitalization. In particular, cognitive distortions limit the development of IT and ICT[8][7][20][9][6][21][12][13] and the expansion of the natural science worldview. Therefore, STEM education does not contribute to the perception of culture (art) by researchers, technologists, and designers who do not study the golden ratio (Platonic solids, Fibonacci numbers, etc.).

Harmony of nature and development of metathinking. Heuristic thinking is closely related to bionics, which displays the harmony of nature[19]. I. Kepler* in the book "The Harmony of the World (1619) discusses the harmony and correspondence of geometric forms, physical phenomena, including music, and the structure of the universe. By summarizing his observations and linking the mathematical doctrine of harmony with the basic laws of planetary motion, Johannes Kepler* made an enormous contribution to optics, mathematics, and music theory. They act as a "method of harmony" for the knowledge and substantiation of new mathematical and physical laws (Kepler's laws). Kepler's introduction of the concept of formative force makes it possible to formulate laws of development in nature of an anti-entropic nature (based on the mechanism of the "divine (golden) section"). The "method of harmony" makes it possible to explain the action of Kepler's "shape-forming" force, based on

the principles of the development of physical processes over time. Unfortunately, the foundations of the idea of the "golden ratio," Fibonacci numbers[12], and others are not a required subject in universities.

Triadic heuristic structures. The work[4] shows that the degree of information distortion under external and internal influences depends on the psychophysiological state of a person, which psychologists determine using Luscher color tests. It is important that the primary colors in I. Goethe's circle are in the form of a triangle, and the first-order colors in the form of an inverted triangle are spatially balanced and form a hexagram that looks like a Star of David. In 1861, J. Clerk Maxwell created the three-part theory of color and produced the first color photograph on black and white photographic emulsion. After 100 years, the reverse transition from binary to trinity was realized in different methods of holography, the variety of types of which (dynamic, color, acoustic, etc.) confirms the connection of the holographic nature of memory not only with thinking but also with intuition and emotional intelligence. Consequently, the direct and reverse transition from binary to trinity, which is used in art, science, and psychology, is associated with the harmony of fractal nature, which is harmonious, adaptive, and sustainable[22]. This is a manifestation of the universal thermodynamic principle of Le Chatelier-Brown, which reflects the resistance of CDS to any external influences.

AI and the cognitive value of heuristic models. In computer structural-functional models in the field of natural sciences, as well as computer topological 3D models, two types of model structures dominate - hexagon and pentagon. Cognitive models of discrete (digital) control of CDS through self-connected cycles of action and reaction use the principle of detailed equilibrium. It is based on A. Einstein's ideas about forced transitions, the geometrization of which made it possible to create a universal cognitive model of self-balanced control of associated processes of different nature[15][23].

When synthesizing the cognitive model, we used:

- key principles of metaphysics[13];
- extreme principles of natural science;
- emergence of universal sources of information.

The synergy and complementarity of these principles, as well as the phenomenon of self-organized criticality[24], made it possible to display the harmony of self-organized nature and its fractality in the form of two feedback loops (see Fig. 1). The cognitive model is shown in Figure 1 (models a., b., and c.).

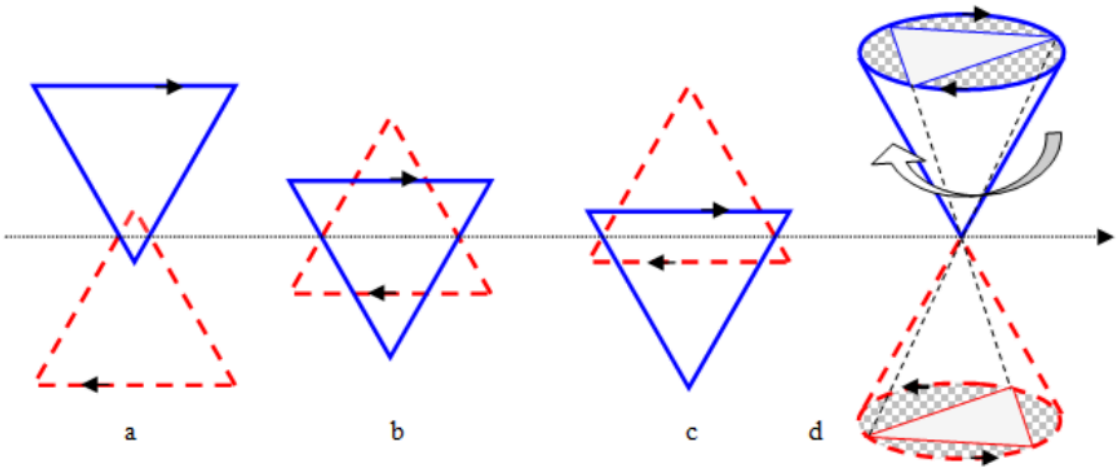

Fig. 1. Generalized cognitive model of dynamic balance of conjugate cycles.

In the figure, the action cycle is highlighted in blue and directed clockwise. The induced counter-cycle is indicated by a red dotted line and is directed counterclockwise. Cognitive models a., b., and s. reflect the establishment of dynamic balance through self-organized criticality[24]. The model (d.) displays the state of the object up to the bifurcation point. With local dynamic balance, the structure of the model has the form of a hexagon (Star of David). These cognitive models are a further development of the fruitful ideas of convergence of sciences[13].

Models (a) and (c) reflect the dynamically unstable phases of the cycle, and the stable structure is reflected by model (b). The dynamic equilibrium phase of connected cycles has the shape of a Star of David. The cognitive 3D model of ideal management is presented in the form (d). The work[23] shows that model (d) can be synthesized by superposition of two Sierpinski fractals or a Koch snowflake fractal and an antifractal.

Universal code of cognition. The hexagon (Star of David) is a universal code for understanding evolutionary changes in nature and assessing the viability of the CDS[21][23]. The hidden connection between knowledge, thinking, and intuition is due to the holographic nature of memory, which is also based on the theory of signs - semiotics. Their complementarity allows us to create, anticipate, and survive in extreme conditions. These assumptions are confirmed by the heuristic nature of the ancient sign ouroboros[3], which looks like a snake biting its own tail. This sign reflects the principle of dualism, which is indispensable in psychology. According to the theory of archetypes by Carl Jung (Carl Gustav Jung, Lorenz Jung.), the ouroboros is a symbol suggesting darkness and self-destruction at the same time

as fertility and creative potency. Its connection with the subconscious is confirmed by discoveries in which the connection between the content of dreams and intuition is obvious (Mendeleev, N. Bohr, A. Einstein, Rene Descartes, etc.). A heightened perception of reality in extreme conditions (ecological, man-made) promotes the interdisciplinary exchange of ideas, methods, and successful experiences within the framework of metaergonomics (see 5.4).

2.4. Universal structures and interdisciplinary interaction

2.4.1. Conjugate triads

Physical and mental reality. The individual characteristics of the authors' creative thinking are discussed in the work "Current problems of creative activity, new opportunities and new problems"[4], where it is shown that the hexagon is most often found in nature, technology, and art. Therefore, the identification of conjugate triads of the structure of thinking allowed the authors to establish the complementarity of their worldviews. Thus, the core of the thinking of physics and metaphysics includes - (principles, analogies, and symmetry), which reflect physical reality. The kernels of thinking of an ergonomist and an engineering psychologist include (optimality, balance, harmony), which is reflected by the mental world. While the core of thinking of an architect and designer includes (knowledge, composition, and practice), which reflects 3D physical reality, his mental world is reflected by the associated triad (emotions, reflection, and intuition). Thus, the cores of the authors' individual thought structures cover the physical world and the mental world, and their coherence covers the fractal nature. This complementarity facilitated the exchange of ideas and methods, the evolution of which in the process of successful activity expanded the worldview of each author of this work. At the same time, the further development of universal structures, as well as their philosophical understanding, allowed:

- carrying out further development of the generalized cognitive metamodel of thinking;
- considering triads of conjugate opposites of the physical world and the mental world as a relationship between consciousness and subconsciousness;
- establishing that the overlap of thinking structures has great innovative potential.

Their complementarity made it possible to create metamodel structures in the form of a hexagon, a pentagon, and their superposition, the innovative value of which is discussed in section 5.6.

Cognitive performance in a natural hybrid environment. On the one hand, models of the structure of thinking in the form of a hexagon differ in their "nuclei" and are similar in structure[4], and on the other

hand, coloring the conjugate triads with natural colors (yellow, red, and blue) contributes to the perception of the harmony of physical reality, while the use of first-order colors (orange, purple, and green) contributes to the perception of harmony and disharmony of mental reality. Therefore, the transfer of Kepler's method of harmonies to the study of natural hybrid environments contributes to:

- interaction of the physical and mental worlds;
- mutual enrichment of methods, approaches, and ideas;
- development of creative thinking.

At the same time, the principles of metaphysics are used in bioinformatics, and the principles of biomimetics in computer science and design. Therefore, interdisciplinary study of current problems of vitality, safety, and mental health has turned out to be quite fruitful[3][25][7][9][1]. In particular, the formation of metaphysical thinking based on the complementarity of natural sciences and their metasciences contributed to both the further development of research methods and the birth of "fresh" ideas within the framework of a transdisciplinary approach[9][21][15]. Indeed, the aesthetic perception of natural colors in metamodels contributes to the manifestation of intuition, because geometrization has always been a generator of "revolutionary" ideas in physics[26]. Therefore, the combination of harmonious colors located nearby in the cognitive metamodel strengthens them, and the combination of less harmonious colors leads to disharmony. Emotional intelligence and intuition are associated with successful experience in solving real problems. And so, physical reality is associated with the formation of consciousness, and digital reality is associated with the formation of the subconscious. The consciousness of this allowed us to establish the complementarity of extreme principles of natural science and biomimetics. The high heuristic value of the balance of opposites, their interconnection, and the harmony of perception of physical reality in a single cognitive space of dynamic events[2] allowed us to develop an integrative meta-theory for modeling CDS, which is discussed in section 4.3.4.

Fractal structures of a hybrid environment. TThe idea of the holographic nature of memory makes it possible to present psychological phenomena in more generalized fractal forms because the mathematical apparatus of fractal structures and holography is similar. The mathematical apparatus of fractal structures will correspond to the Fibonacci sequence, golden ratio, mathematical progression, and non-Markov random processes. Accordingly, holography is self-similar in the representation of symbolic information (Thue-Morse sequence, Fibonacci sequence, Pribram transform). To summarize, the similarity of mathematical features contributes to the understanding and explanation of the mental

nature and consciousness, which opens up great scope for further research into various mental phenomena and the nature of human consciousness. Topological (fractal geometry) and physical (holography) approaches are most suitable for studying cognitive activity. Further development of the idea of complementarity of concepts and their cognitive value is given in subsection 5.4.

Relationship between dual and tripartite structure. Increasing complexity has created challenges in cognitive computing, necessitating a shift from interdisciplinarity to transdisciplinarity. The transition is based on the connection between triad and concentric duality, which can be represented as a system of binary opposite ideas. Therefore, duality and triadic properties are inextricably linked, for duality never arises as such, but always as the limit of triplicity. Concentric dualism itself is a mediator between diametric dualism and the triple system, and the transition from one form to another occurs precisely through it[27]. At the same time, the diametrical form of duality is static, since its transformation does not give rise to anything other than duality. However, concentric duality is dynamic because it carries within itself a hidden triplicity. In other words, any attempt to move from asymmetrical triplicity to symmetrical duality presupposes a concentric duality, which is dual like the latter and asymmetrical like the first[27]. Consequently, the dual structure determines the classes, and the triple structure determines the relationships between them. The dual structure can be designated as a model or static, and the triple structure as dynamic[27]. Our view of the problem, which is primary in the history of human thinking, religion, and art, is the recognition in a hybrid environment of the complementarity of two opposite principles and the idea of the whole.

2.5. Cognitive sciences and neurosciences – new problems

2.5.1. Psychophysiological state of a person

Duality of perception of nature, individuality of thinking. Neurosciences (neuroergonomics, neurophysics, neurodesign, and neuropsychology, etc.) have established that cognitive problems depend on the psychophysiological state of a person. Therefore, the study of activities in the digital world is limited by many cognitive problems. The key problems are:

- presentation and analysis of weakly formalized information;
- studying the characteristics of an individual's thinking and identifying cognitive distortions;
- studying multiple sources of information, the synergy of which creates new problems.

They reflect the contradictions between the style of thinking and the methods of processing, displaying, and analyzing information. They are due to the complexity of discrete thinking, which is based on intuition and successful experience. Therefore, when implementing individual scenarios of adaptation to external influences, a person intuitively uses the flexible logic of antonyms. Obviously, cognitive dualism is associated with an intuitive search for a spatiotemporal balance between extremes. The duality of perception of nature, individuality of thinking, and functional asymmetry of the brain hemispheres determines the characteristics of cognitive activity[18]. Therefore, effective interaction with GenAI is possible only through universals that are characteristic of a hybrid subject environment.

Reality transformation tools. New cognitive tools are mental operations that form models and technologies for transforming reality. The composition of cognitive tools includes the underlying operations in consciousness (semantic operations) and the reflection of these operations in the sign environment. The process of cognition is closely related to the perception of the harmony of the hybrid space-time environment and is inevitably subject to cognitive distortions (systematic errors). Therefore, the perception of the harmony of digital models is facilitated by the use of universality:

- natural colors (yellow, blue, and red), which are the basis for obtaining all other colors, as well as associated secondary colors (orange, purple, and green), which are obtained by combining two natural colors. With the help of such a palette, it is possible to achieve both contrast and harmony at the same time;
- inversion, which has cognitive value in physics, biology, logic, geometry, computer science, psychology, and other sciences. Inversion allows you to study and understand harmony as the agreement of opposites in human activity (design, art, programming);
- the principle of detailed equilibrium, which reflects the equality of probabilities of direct and reverse processes (cycles) of different natures. These processes can be quantum transitions, cycles of functioning, or reactions between an object and a subject.

Perception of the harmony of nature and knowledge of digital reality. True beauty lies in the harmony and balance of opposites, which is most manifested in the hexagonal structure of the relationships between the key sciences (physics, mathematics, and natural philosophy) and their metasciences [3]. Obviously, therefore, the complementarity of opposites is most manifested in those heuristic metamodels that have the form of a hexagon (Star of David)[4]. Thus, the complementarity of color harmony, inversion, and the principle of detailed balance allows us to consider the structure of functioning as a spatio-temporal

process that reflects the harmony of interaction with digital and fractal nature[2]. At the same time, the configuration of the operating cycle of the CDS element reflects the structure of the dynamic process, and the covered area reflects the structural energy, the change of which is the driving factor of its evolution. In particular, the shape of the 3D structure of metamodels of physical reality reflects the harmony of fractal nature[2].

The intellectual activity of an individual is determined by the functional asymmetry of the cerebral hemispheres, which connects design, art, and aesthetics, namely:

- the ability to find similarities between things that are different;
- searching for differences between things that are similar;
- the creation of a possible "whole" from impossible "parts."

Their complementarity allows the individual to generate ideas, and their interconnection allows the individual to visualize them. However, the intellectual activity of an individual, when implementing ideas, is limited by the difficulties of choosing strategies for solving real problems in computer science and technology, which are caused by the functional asymmetry of the hemispheres of the brain, which is also a hybrid subject environment. Thus, the right hemisphere is aimed at processing complex and unfamiliar information, and the left hemisphere processes information that is familiar to us in more detail and structure. Thus, the functional asymmetry of the brain determines psychophysiological and mental (phylo- and ontogenetic) aspects. The brain, working as a paired organ, implements any mental function and determines the choice of learning strategy.

2.6. Convergence of sciences, knowledge, and technologies

2.6.1. Relationships between spatial and temporal properties

Convergence of Sciences. General methods, the relationship of structure to function, and extreme principles of physics, biology, and chemistry contribute to their convergence[23]. The mutual enrichment of natural disciplines is facilitated by the exchange of research methods, which has made it possible to go beyond their limits and gain new knowledge. The extreme principles of natural science, the geometric interpretation of which reflects the dualism of nature, allow us to simplify the study of interdisciplinary connections. Therefore, the generator of revolutionary ideas in physics, biology, and chemistry has always been geometrization, which made it possible to streamline the world of structures[26].

Convergence is based on the principles of natural sciences and the commonality of their models and structures. This has updated the study of the relationship between the spatial and temporal properties of nanostructures. However, the increasing spatial complexity of structures is accompanied by increasing temporal uncertainty. This has created new difficulties and problems, most clearly manifested in the nanoworld. Thus, the interdisciplinarity of principles, structures, and dynamics (functions) is the basis of convergence.

Convergence of knowledge. The convergence of knowledge is facilitated by the interdisciplinary ideas of N. Wiener[28]. He introduced the most general form of signal organization (its structure) as its spatio-temporal ordering (its linear invariant). He proposed new fundamental concepts, namely the topological and projective invariants of space-time structure. This allowed N. Wiener to show that new concepts make it possible to reveal different forms of signal organization in relation to images. In essence, this is a qualitative–quantitative approach to information analysis that allows:

- to unify the processing of information flows;
- to visualize the spatiotemporal structure of the signal;
- to use the general principle of isomorphism.

This made it possible to develop indicators and criteria based on the general laws of the functioning of objects and to take into account individual characteristics of functioning.

Convergence of technologies. The transition from NBIC-convergence to NBICS-convergence has opened up a huge field of activity for humanitarian knowledge, but, unfortunately, increasing complexity has become a source of systemic contradictions. Therefore, complexity, on the one hand, accelerates (stimulates, creates), and on the other hand, it slows down (restricts, interferes). The complexity of heterogeneous information is twofold:

- accelerates the process of formalizing relationships, the diversity of which hinders their modeling;
- stimulates the need for mathematical models, the nonlinearity of which creates systemic problems (safety, stability, etc.);
- creates neural networks that interfere with the selection of relevant information.

This duality leads to paradoxes and erroneous decisions if they are not based on successful experience. As a consequence, there are many non-systemic solutions that predetermine the emergence of spatio-temporal problems of security, mental health, and CDS management.

The relevance of studying the evolution of the fractal world is supported by the integration of various methodologies, methods, and technologies that are based on universal principles and many fruitful ideas. We have identified three key ideas: 1) A. Einstein on forced transitions in a non-equilibrium environment; 2) G. Haken on the principles of brain function; 3) I. Goethe on the transformation of the duality of contrasting colors in time into the spatial harmony of the triad of natural colors. Based on the complementarity of these ideas, we created a cognitive model of self-balanced process control based on three key principles of metaphysics. To study the functioning of self-organizing objects under extreme conditions, three key principles are most important, namely:

- the principle of connection between binary and trinity, transforming metaphysics into a unified system of paradigms;
- the principle of fractality (self-similarity), reflecting the unity of the whole and the particular;
- the principle of double cyclicity, reflecting the spatiotemporal order.

Their complementarity is manifested in natural fractals and multifractals, which, on the one hand, exhibit statistical self-similarity, that is, self-affinity. On the other hand, the orderliness of the space-time structure is characteristic of dynamic natural fractals and multifractals[10].

AI and cognitive space. The articles [2][9][6][5] discuss the cognitive aspects of hybrid visualization of analog and digital information, which made it possible to create a hybrid cognitive space on a transdisciplinary basis. In general, cognitive space, hybrid technologies, and extreme principles of natural science make it possible to increase intellectual capital by:

- combination of elements of different teaching methods (transformational, machine learning, etc.);
- creation of a hybrid environment (platform) for dialogue between students and teachers;
- innovations based on augmented reality and digital twins.

Augmented reality and digital twins in the cognitive space create qualitatively new possibilities for design, furniture interior, bionics, and an integrated approach to the formation of coloristics of the subject environment, as given in the work[19]. Digital twins in three-dimensional cognitive space contribute to the development of critical and creative thinking, the balance of which contributes to the development of heuristic thinking[29]. At the same time, the convergent approach promotes the exchange of ideas, methods, and technologies between teachers and scientists of different specialties.

Cognitive value of visualization and convergence. Creativity and innovation are often the result of a fertile union of imagination and consciousness. Whether we turn to art or science, it is clear that broad knowledge relies on the relationships between individual clusters of multisensory images in the mind. The best artists and scientists integrate intuition and unconscious processes with mental abilities, including:

- observation accuracy;
- spatial and kinesthetic thinking;
- identifying key parts of a complex whole.

Their complementarity allows one to identify patterns, invent, and construct, which is inspiring and has heuristic value. Indeed, the human mind has three keys: a number, a letter (shape), and a note, which reveal the harmony of the real world, and the complementarity of these keys allows us to know, think, and dream. At the same time, the connection between knowledge, thought, and dream allows us to create, invent, and envision, which stimulates innovation[30].

The works[12][23][4][5] propose a convergence of complexity, which is based on the transformation of fractal signals of various natures into cycles of functioning and adaptation, which has heuristic value. The geometric simplicity of the proposed models allows us to take into account the duality of the features of dynamic processes occurring at different spatial and temporal scale levels. The evolution of the topological model reflects the universal law of unity and struggle of opposites. Our successful experience with cognitive imaging and the evolving hybrid approach encourages other scientists, educators, and designers to seek new opportunities to overcome interdisciplinary barriers by harmonizing interactions within a hybrid modeling approach using the hexagon structure. Consequently, the hexagon (Star of David) is a universal code for understanding evolutionary changes in nature, and assessing the viability of the CDS of self-balanced control of processes of different nature is shown in Fig. 1.

Heuristic value of triadic harmony. The main goal of creative activity is to achieve harmony between the abstract source of logic in the mind and the graphic manifestation of the imagination. For the true beauty of nature lies in the harmony of triads of conjugate opposites associated with emotional intelligence, which inspires and stimulates.

Orderliness in mathematics, physics, and biology is considered in[15], which shows its heuristic significance in education, which is related to the goals set in:

- mathematics – order for the sake of results;

- physics – order for the sake of unity of action;
- biology – order for the sake of homeostasis (balance of opposites).

They reveal the connection between structure and function, which is the basis of aesthetics, harmony, and imagination.

The relationship between cognition and imagination is based on the relationship between form and essence. Indeed, form, as an abstract concept, imposes its conditions on essence, but tangible essence has form. Harmony is achieved when the essence expresses its form extremely accurately and beautifully, which is the formula of any art and aesthetics.

Harmony of thought manifests itself in a variety of forms, such as:

- the artist, giving free rein to his imagination, strives for harmony of composition and color;
- the architect strives for the unity of theme and creative search - balance and aesthetic connection;
- the designer strives for complete harmony between abstract form and tangible essence.

The outer world corresponds to the inner world, and since the outer world has a clear structure, the mind also has a structure. It is this structure of the mind, reflecting the structure of the physical world, that allows us to think logically and consistently. The future is interpreted not as a noosphere, but as a harmonosphere – a sphere of harmony of mind and feeling, man and nature. Therefore, information flows can be divided into three flows based on knowledge or data, as well as their superposition. Each stream in the triad has its own benefits. Incorporating knowledge into deep neural networks (DNNs), which are purely data-driven, can potentially improve overall system performance.

3. Hybrid Approach to Simulating Physical Reality

3.1. Integrative Paradigm of the Hybrid Approach

3.1.1. Conceptual Foundations of the Hybrid Approach

Cognitive Visualization of Dynamic Processes. Vision always precedes implementation, and the laying down of thoughts creates the surrounding reality, the affirmation of which forms consciousness (physical reality). Modern processing of signals of various natures through the geometrization of their dynamics, within which the triangle is the archetypal form of our three-dimensional physical reality and network digital reality. Therefore, the basis of the hybrid approach is:

- variational principles of mechanics (principle of least action, etc.), which lie at the origins of the theory of optimal control and cybernetics;
- interdisciplinary unity and mutual enrichment – cybernetics, synergetics, nonlinear dynamics, semiotics, cognitive graphics, theory of dimensions and dynamic similarity, the development of which was facilitated by geometrization;
- principles of system dynamics, the manifestation of which is hidden in the natural structure of electrophysiological signals, as well as in the responses of sensors and smart materials (nanostructures, functional materials, etc.) to extreme influences.

In our opinion, their consequence is significant progress in the fields of cognitive sciences (cognitive psychology, cognitive graphics, cognitive linguistics, etc.) and neurosciences (neurobiology, neuropsychology, neuroergonomics, neuroeconomics)[21]. In this case, geometrization and cognitive visualization of dynamic processes of various natures played a key role, which contributed to interdisciplinary mutual enrichment and the development of AI. The purpose of visualization is twofold; on the one hand, it helps to understand the structure of the relationships between the elements of the CDS, and also to analyze it through the association/relationship between them. On the other hand, our subconscious, using intuition and successful experience, generates new ideas that allow us to integrate various methods, approaches, and criteria[5]. Therefore, specialized GenAI opens up new opportunities for a radical solution to the problems of intellectual support for solving current security issues (informational, biological, and functional), as well as mental health and creative activity.

Consciousness and the essence of physical reality. We study the essence of reality through the amazing discoveries that have been made in science over the past twenty years. They help to better understand how the brain creates its own reality and how it differs from the virtuality that GenAI creates. The book (The Tao of Physics by Fritjof Capra), based on parallels between modern physics and Eastern philosophy, shows that for the brain, visualization or mental representation is not just unnecessary daydreaming, but a creative process that:

- helps a person control and direct energy flows;
- is able to create cognitive images through the transformation of scalar information flows of various natures;
- generates new ideas and new models.

Having realized the essence of the parallels between modern physics and Eastern philosophy, we came to understand that inspiration, prayer, and intuition are not something supernatural, but are subordinate to second-order metasciences and are associated with the subconscious. Whereas consciousness carries out visualization (mental representation), imagination, and positive affirmation, which creates reality. At the same time, the relationship between reality and the subconscious forms metathinking (thinking about one's thinking), which determines a person's competence. Therefore, there is a problem of determining the boundaries of human competence, which is associated with the objectivity and accuracy of cognitive judgments, as well as with consciousness and subconsciousness. Features of the perception of physical reality are most manifested in the following cognitive phenomena[13]:

- sense of knowledge – error in the accuracy of knowledge actualization;
- illusion of knowledge – exaggeration of the degree of understanding of the material;
- Dunning-Kruger effect – people with low cognitive abilities tend to overestimate their self-esteem, and people with high abilities tend to underestimate it[9].

It is important to emphasize that every person's judgment is subject to the Dunning-Kruger effect to one degree or another in those areas where they cannot objectively assess the limits of their competence. Therefore, the main methodological problem in the study of cognitive problems is induced cognitive distortions, which are caused by the heterogeneity of the hybrid environment for processing and transmitting information.

The subconscious is the complementarity of symbol, sign, and image. The Greek word "symbolon" means "sign," "signal," "omen." At the same time, the Greek verb "symballo," being a word with the same root as the previous word, has the meaning "connect," "collide," "compare." Etymologically, these Greek words indicate the coincidence of two planes of reality, that is, the fact that a symbol has meaning not in itself, but as the intersection of constructs of consciousness with one or another possible object of this consciousness.

The urgent task of today is the need to analyze the relationships (symbol, sign, and image), the complementarity of which contributes to the perception of the harmony of physical reality. The relationship between these concepts gives an idea of the form and method of symbolic expression because symbolism and imagery are the most common ways of representing and replacing phenomena, properties, and relationships of both the material and spiritual worlds.

The process of cognition is inevitably subject to cognitive distortions (systematic errors), which are associated with the individual's perception of the harmony of the objective environment. Therefore, the universal structures discussed in 2.4. are expanded through the complementarity of means of perceiving the harmony of physical reality, among which the most effective use is:

- natural colors (yellow, blue, and red), which are the basis for obtaining all other colors, as well as associated secondary colors (orange, purple, and green), which are obtained by combining two natural colors. With the help of such a palette, it is possible to achieve both contrast and harmony at the same time;
- inversions, the universality of which has manifested itself in physics, biology, logic, geometry, computer science, psychology, and other sciences. Indeed, inversion allows us to experience harmony as the agreement of opposites in human activity (design, art, programming);
- the principle of detailed equilibrium, which reflects the equality of probabilities of direct and reverse processes (cycles) of different nature. These processes can be quantum transitions, cycles of functioning, reactions between an object and a subject.

The complementarity of inversion, the principle of detailed balance, and harmony of perception contribute to the harmony of perception of digital metamodels. In particular, the configuration of the structure of models of physical reality reflects the beauty of living and inanimate nature. This allows us to consider a change in the configuration of the functioning cycle of an element of the CDS as a dynamic process and a change in structural energy as a driving factor in the evolution of nature[5].

Hexagonal structure of relationships. Therefore, the true beauty of metamodels lies in the harmony and balance of opposites, which is most manifested in the hexagonal structure of the relationships between key sciences and metasciences[4][5]. Obviously, therefore, the complementarity of opposites is most manifested in those heuristic meta-models that look like the Star of David[23][13][4][5]. The essence of the Star of David as a symbol:

- unity of opposites;
- variability and constancy;
- form and content.

Their complementarity reflects the unity and connection of opposites, namely mobility and peace, concrete and abstract, finite and infinite. This connection is due to the direct transition from duality to triadity and the reverse transition from triadity to duality.

Subsection 2.1 discusses the complementarity of mathematics and heuristics, from which the heuristic complementarity of cognitive paradigms follows.

Paradigms of cognition of physical reality. Real environments for processing and transmitting information are nonlinear, heterogeneous, and unstable, which gives rise to the divergent development of sciences and ICT[13]. The model of nonlinear communication by T. Newcomb, which has the form of an equilateral triangle, is widely used[31]. The following paradigms are important for the development of a hybrid approach:

- Triadic paradigm of harmony. It allows for the unification of creative development through the harmonization of related triads in science, art, and design. In particular, an analysis of the methods and properties of key sciences and their metasciences (mathematics - metamathematics, physics - metaphysics, philosophy - metaphilosophy, etc.) is given in[5]. Such an analysis reduces uncertainty and most fully reflects reality[13][5]. This paradigm is also the basis of the theory of solving inventive problems[5]:
- Synergetic paradigm. It extends not only to the structures of the macro- and microworld but also to the relationships that develop between matter, energy, and information within the framework of self-developing open nonlinear systems[18]. This is the key paradigm for modeling physical reality within the hybrid approach.
- Semiotic paradigm. In the main directions of semiotics (activity-theoretical and socio-psychological), the complementarity of key types of signs (sign-image, sign-indicator, sign-symbol) is used. Therefore, in the semiotic space, each sign act has reality[32].

The complementarity of these paradigms unites physical and social ontology, which gave rise to a new idea of the universality of a hybrid subject environment based on semiotic space. It uses universal means to transfer emotional and intellectual content between objects and subjects of the digital world.

3.2. Semiotics, cybersemiotics, and cognitive metaphor

3.2.1. Complementarity of heuristic metamodels

Hexagon is the main sign-symbol of semiotics. The spatiotemporal structure of coupled cyclic processes is considered in[6][12][15]. They show that the local dynamic equilibrium model can be synthesized by different methods. In particular, through the superposition of two Sierpinski fractals, the Koch

Snowflake fractal, and the antifractal, as well as conjugate fractal triangles[33]. It is important that it looks like the Star of David, new interpretations of which were proposed at the end of the 20th and beginning of the 21st centuries. These are: a) a fully connected graph, b) Goethe's color circle, c) magic numbers, d) a mathematical theorem, e) magic nodes, f) the Da Vinci code, etc. Therefore, every nation, surviving in an environment with certain energy and information resources, interprets the Star of David in its own way. It can be assumed that the Star of David is a unique genetic algorithm for studying the processes of emergence (self-organization) of a new phase (structure), its survival (stability), and development (adaptation) under certain energy and information resources. The use of such an algorithm turns the complementarity of heuristic meta-models in the form of hexagrams into a cognitive value that promotes creative activity. Thus, the use of natural colors, reduction, and inversion in eristic meta-models in the form of the Star of David increased their cognitive value. This made it possible to propose another interpretation of it - a person learns the harmony of physical reality (nature) through the perception of conjugate triads and adapts to digital reality through the dualism of thinking and mentality.

The essence of the Star of David as a symbol:

- unity of opposites;
- variability and constancy;
- form and content.

Their complementarity reflects the unity and connection of opposites, namely, mobility and peace, concrete and abstract, finite and infinite. This connection is due to the direct transition from duality to triadity and the reverse transition from triadity to duality.

Composition of signs (symbols) and cognitive distortions. The composition of signs or symbols is a universal means of transmitting information to:

- physics (symbolic dynamics, spiral dynamics);
- ergonomics and engineering psychology;
- different types of design (ethnodesign, biodesign, object environment design).

This approach simplifies interdisciplinary collaboration in the digital world. In essence, semiotics is associated with a wide range of humanities and natural sciences. As a research methodology, semiotics allows one to analyze the main types of cognitive activity (everyday, scientific, philosophical), stimulating the unification of the humanities and natural sciences.

To solve current problems of science, education, and mental health, it is important to take into account the variety of systematic errors that are common to everyone under extreme conditions.

The dependence of activity errors on the functional state (stress, fatigue, etc.) of a person is considered in the works[3][12][6]. These works focus on genetically inherited cognitive biases, the individuality of which is actively studied by neuroscience and cognitive science[34][35]. Genetically inherited cognitive distortions are one of the main reasons for the manifestation of the human factor phenomenon in science, education, and technology. Therefore, generative AI is necessary for the search for new ideas and solutions to current problems, among which the key ones are:

- security (physical, functional, and informational);
- maintaining mental health;
- reward and recognition of creative activity.

Therefore, for fruitful creative and innovative activity, a sign-symbol in the form of a hexagon, in which the dualism of the contrast of opposites and the harmony of conjugate triads have cognitive and heuristic value[4], is essential.

Harmonization of creative activity. Harmony links design, art, and aesthetics, in which an individual's intellectual abilities are determined by successful experience and emotional intelligence[4][5]. These abilities are manifested in:

- the ability to find similarities between things that are different;
- an intuitive search for differences between things that are similar;
- creating a possible “whole” from impossible “parts”.

Their complementarity inspires learning, design, art, and programming. It is achieved only when the essence most accurately and beautifully expresses its form[4]. The functional asymmetry of the cerebral hemispheres determines the psychophysiological and mental (phylo- and ontogenetic) aspects. The brain, working as a paired organ, implements any mental function and determines the choice of strategy for studying a hybrid subject environment. This allows the individual to generate ideas and their relationships, to visualize them. Thus, the right hemisphere of the brain is aimed at processing complex and unfamiliar information, and the left hemisphere processes information that is familiar to us in more detail and structure. The intellectual activity of an individual when implementing fresh ideas limits the complexity of choosing strategies for solving real problems in computer science and technology.

3.3. Choosing a strategy for creative activity

3.3.1. Generalized cognitive metamodel of activity (cognition) strategy

Basic metascientific categories. The philosophy of modeling a hybrid subject environment includes a triad of relationships: space and time, matter and energy, information and entropy, which are basic metascientific categories[36][37][4][5]. Therefore, psychologists, engineers, and philosophers used the principle of structural-functional analogy: the similarity of the functions of a computer and a "human cognizer." This allowed us to talk about the similarity of 3D structures that implement these functions. The information metaphor, using terms from the theory and practice of programming, is more open to interpretation than the computer metaphor. Psychologists consider a person as a self-organized system that reflects the spatio-temporal and energetic characteristics of physical reality in sensations, images of perception, ideas, etc. A generalized cognitive metamodel of the structure of explicit and hidden triads, which reflect the internal unity of the opposites of the hybrid subject environment, is shown in Fig. 2. The synthesis of a metamodel in the form of a hexagon made it possible to achieve complete harmony between the abstract form and the tangible essence, between the abstract source of logic in the mind and the graphic manifestation of the balance of relationships between conjugate opposites.

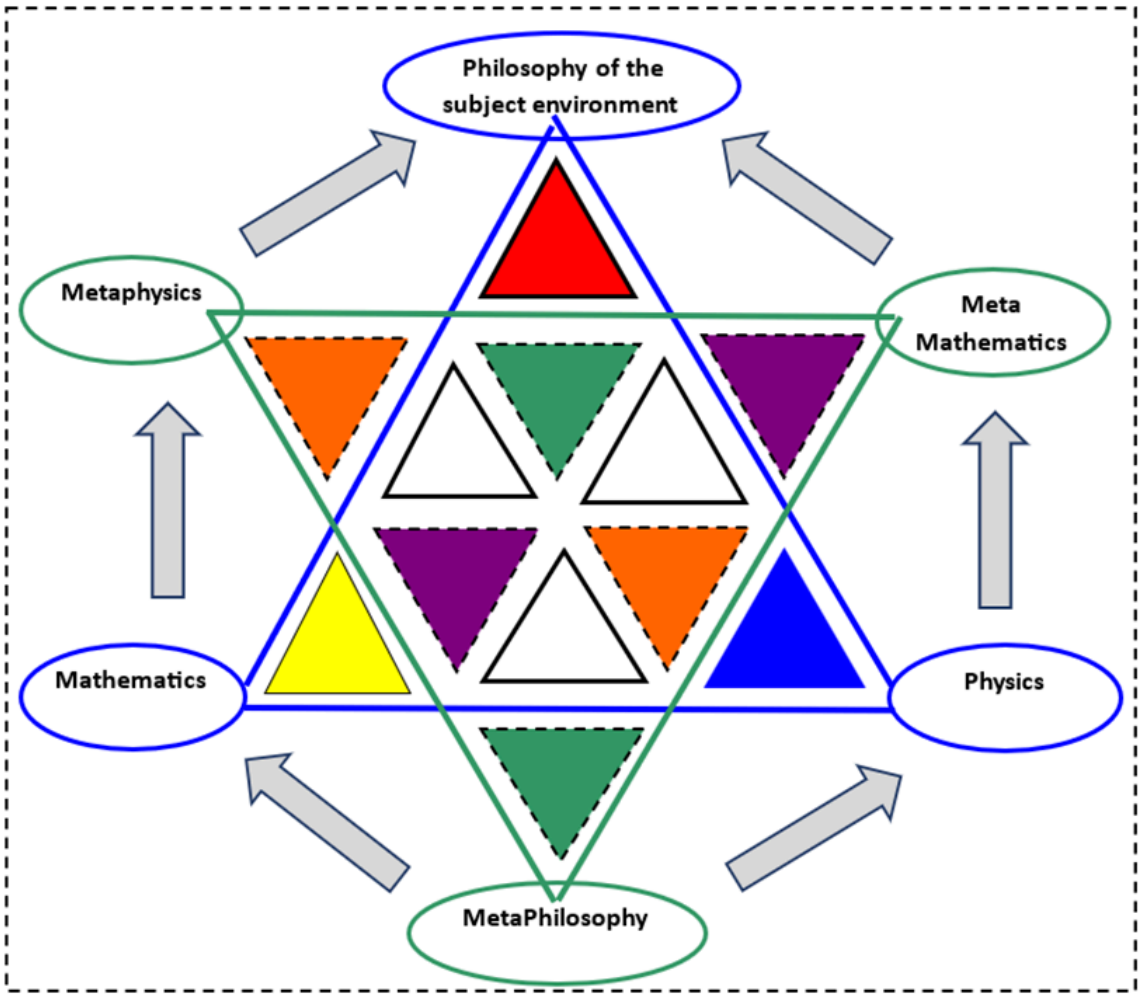

Fig. 2. Generalized cognitive metamodel of activity metastrategy.

(In the figure, conjugate triads are highlighted with lines and dotted lines).

It is symbolic that this is the only possible choice of 6 natural colors in the picture. From a systematic analysis of the structure of the metamodel, it follows that there is a harmony of relationships between the key sciences (physics, mathematics, and philosophy) and their metasciences. Importantly, that:

- the triangle of key sciences has a triad of associated metasciences;
- the triangle of metasciences (metaphysics, metamathematics, and metaphilosophy) has one state, the uncertainty of which is manifested in the balance of gray rather than white;
- the choice of conjugate triangles (triads of colors) is individual and depends on heredity, education, design of the subject environment, as well as on psychophysiological factors (fatigue, stress, influence of natural factors).

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Asymmetry of choice - metacognitive strategies[4] activities. The hybrid subject environment takes into account the asymmetry of the generalized cognitive metamodel, as well as the features of the computational neurobiology of the brain. From Fig.2, it follows that the dominance of the left hemisphere of the brain determines the first strategy, which includes the triad of sciences - mathematics, philosophy of the subject environment, and physics. Their obvious clockwise connection is highlighted in natural colors (yellow, red, and blue). When the right hemisphere of the brain dominates, the second strategy for studying the subject environment is implemented, which includes the triad of metasciences (metamathematics, metaphilosophy, and metaphysics). The balance of these strategies is achieved through a cognitive metamodel, in which the vertices of the triangles (triads of sciences and their metasciences) are directed in opposite directions. Therefore, the generalized cognitive metamodel reflects:

- internal unity and balance of opposites;
- cognitive value of the relationship between key sciences and their metasciences;
- the desire for reunification, balance, and harmony of conjugate triads of opposites.

As we see, two approaches to the strategy of studying a hybrid subject environment reflect the internal unity of its opposites. Obviously, therefore, the complementarity and interconnection of key sciences and their metasciences allowed the authors to overcome interdisciplinary barriers and synthesize heuristic metamodels of complex dynamic systems of various natures, which have the form of a hexagon and reflect the internal unity of the opposites of a hybrid subject environment[4][38].

Balanced metathinking. The complementarity of the two strategies allows for the formation of balanced metathinking in the process of an individual's activities. Therefore, our heuristic metamodels of complex dynamic systems (cyberphysical, information flows of various natures) also have the form of the Star of David[29][6][15]. This is a consequence of the fact that such a structure of a subject-specific hybrid environment takes into account the features of the computational neurobiology of the brain, namely:

- decomposition of information into three types - synergetic, intuitive (individual), and redundant;
- the dynamics of calculations carried out by the brain includes the color harmony of triads of opposites;
- continuous search for a balance between opposites - order-disorder, harmony-disharmony, truth and falsehood.

The interconnection of neuro-cognitive sciences and key meta-sciences increasingly contributes to creativity. On the one hand, the triad of key sciences/metasciences forms a broad worldview based on the perception of the harmony of nature. On the other hand, the triad of neuro-cognitive sciences (neurophysics, neural networks, and neurodesign) develops a person's ability to work with sources of information, the dynamic complexity of which forms metathinking[4][4].

Cycles of perception of simplicity/complexity and orderliness/disorderliness. A comparative analysis of the functioning of a topological 3D model, the complexity and simplicity of which do not depend on the direction of rotation, as well as a model of an information transmission line, the ordering and disorder of which also do not depend on the direction of rotation. The human brain, as a hybrid environment, perceives both dynamic and static complexity simultaneously and perceives statistical order and disorder in the process of evolution. In Fig. 3, the conjugate triads of these relationships are highlighted in natural colors according to J. Goethe, which made it possible to identify two conjugate triads (in the figure, they are highlighted with lines and dotted lines).

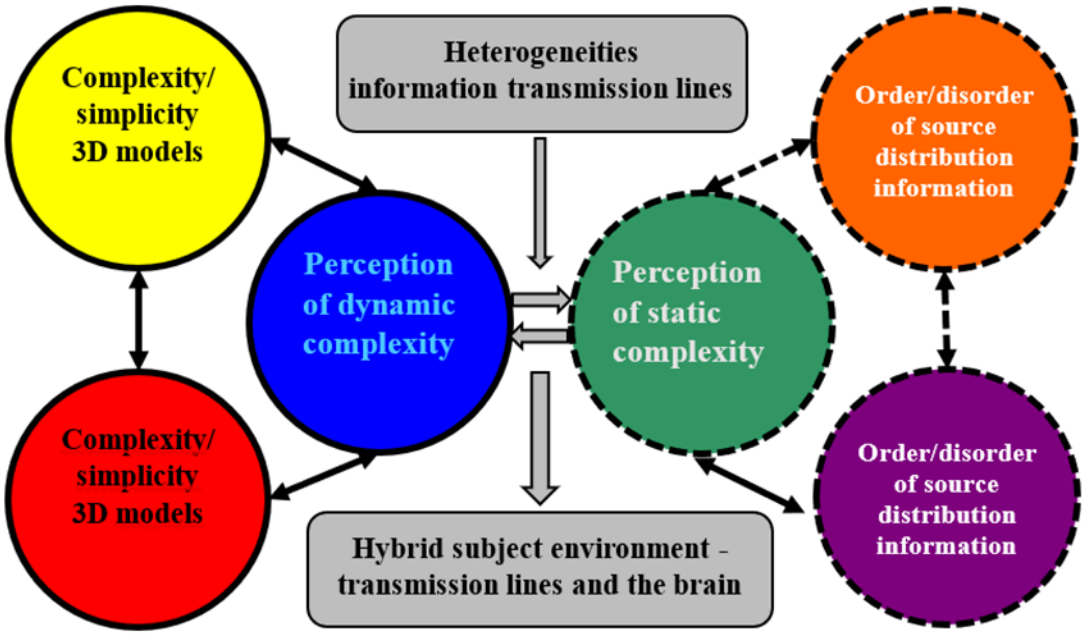

Fig. 3. Metamodel of independent cycles of analysis of the dynamic complexity/simplicity of a 3D model of the environment and the perception of order/disorder of the static complexity of the distribution of heterogeneities (defects) in the environment.

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The figure shows the independence of the direction of rotation of the cycles of perception of dynamic and static complexity in two models - 1) an information transmission line, 2) a hybrid environment containing many sources of information. In real time, there are hidden connections between the dynamic and static complexity of models, which in extreme conditions create new systemic problems (forecasting, knowledge extraction, etc.). To solve such problems, the idea of inversion is suitable, which is widely used in physics, biology, computer science, psychology, and other sciences, as well as the color harmony of conjugated triads. Note that the degree of distortion of information under external and internal influences depends on the psychophysiological state of a person, which psychologists determine using tests by Luscher and others. It follows from this that universal tools (inversion, harmonization of perception, etc.) are promising for solving problems of safety, reliability, and stability. The metamodel of cycles of dynamic and static complexity, in which perception depends on the direction of rotation (counterclockwise or clockwise), is shown in Fig. 4. This model takes into account the individuality of the holistic perception of the topology of physical reality, which designers model through a variety of triangular elements.

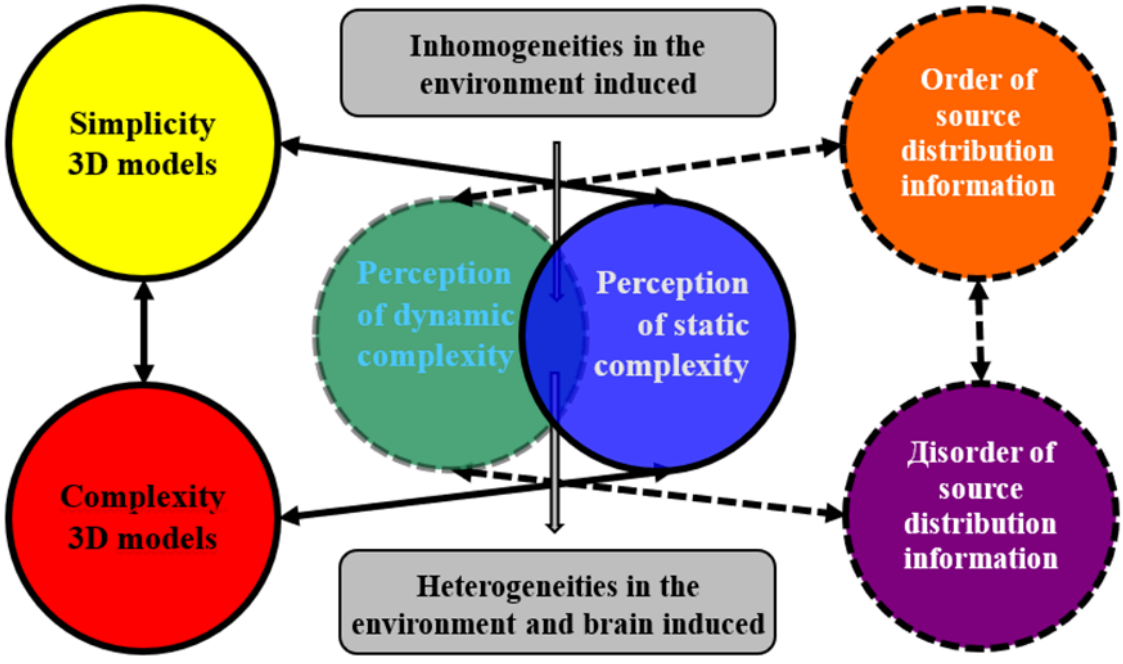

Fig. 4. Metamodel of the structure of analysis of dynamic complexity of dependent cycles of perception of dynamic and static complexity.

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Presented in Figs. 3 and 4, the meta-models complement the cognitive meta-model for choosing an activity meta-strategy, shown in Fig. 2. It is obvious that external and internal stress factors induce complementarity in the perception of complexity/simplicity, as well as order/disorder, which allows us to identify new universals in which the relationship between harmony and inversion is manifested. At the same time, hidden transitional psychophysiological states of a person determine the distortion of information under external and internal influences. Therefore, the induced complementarity of space-time relations manifests itself in the dominance of intellectual intuition, which is based on the holographic nature of memory. All this confirms the connection between spatiotemporal structure and function in a hybrid environment. In particular, the inversion of space-time relationships was first identified in sensors and radiation detectors based on zinc chalcogenides[39], as well as the transformation of the spectrum under external influence[39][40]. Thus, metamodeling allows us to introduce new universals, which are:

- inversion of space-time relations in real time;
- complementarity of dynamic and statistical descriptions of the functioning of the CDS;
- hidden spatio-temporal relationships, the individuality of which is most evident in the hybrid space of dynamic events in real time[2].

Within the framework of this metamodel, independent cyclic processes are studied that proceed clockwise and are structure-forming, as well as counterclockwise processes that are structure-destroying. In general, inversion and harmonization, this model allows us to study the complementarity of the dynamic and statistical descriptions of the functioning of the CDS, which is most manifested in a hybrid subject environment[13][5]. The complementarity of the metamodels shown in Figs. 3 and 4 is due to the fact that, on the one hand, the dynamic complexity of the model is combined with its spatial simplicity of analysis, and on the other hand, the static complexity of many sources of information is combined with the spatiotemporal orderliness of their distribution, and the nature of the disordered distribution of these sources, which is induced by exposure to stress factors, does not affect the holistic perception in real time.

Symbols as universals. From the harmony of Kepler's spheres, it follows that in fractal nature there are:

- natural universals that are multifractals;
- universal sources of information (fluctuations, noise, etc.);

- natural hybrid structures, hexagon with pentagon, the interaction of which creates uncertainty, instability, and ambiguity.

Their complementarity limits forecasting capabilities, and their interconnection opens up new possibilities for GenAI.

The hybrid approach to metamodeling of three-dimensional reality is also based on triadic symbols:

- Fractal triangle,
- Pascal's triangle,
- Sierpinski triangle.

Consequently, the triangle, as an archetype of three-dimensional reality, is one of the unique ancient signs and symbols, the use of which in ergonomics simplifies interaction, and in mathematics and physics stimulates the creative activity of the individual.

The connection between the ancient symbols (Star of David, Kabbalah, and Merkabah) follows from the triad - the golden ratio, the Fibonacci number, and the Platonic solid. It is noteworthy that all 22 letters of Hebrew are embedded in the design of the Star of David. The Merkabah is intended for healing and balance, being one of the most powerful symbols, promoting spiritual growth and connection with the higher self.

Cognitive metaphor serves as a way of knowing, structuring, and explaining the digital reality around us, in which we speak with analogies, explaining reality with mathematical deductive and axiomatic reasoning. Therefore, physical reality is built on general physical and mathematical knowledge, and the method of developing this reality is mathematical. Therefore, new “opportunities and limitations” arise, determined by the chosen “reality” viewed from a scientific point of view.

4. Hybrid Approach to Forming Metahindings

4.1. Metacognition, metadistortions, and metathinking

4.1.1. Metacognition

Three levels of experience. The study of “knowing about knowing,” “thinking about thinking,” “awareness of awareness,” etc., goes back to the works of Aristotle. In 1976, the concept was introduced by John

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Flavell[41], who identified four components of metacognition: metacognitive knowledge, metacognitive experience, goals, and strategies.

In another work[42], they define metacognition as the process of using reflection to consciously study one's thinking and become aware of one's own strategies of mental activity. They include planning, choosing activity strategies, and monitoring cognitive activity[43].

Many authors subscribe to the idea that metacognition is not limited to conscious control. Exploring the problem of the structure of the intellectual sphere (mental experience), they distinguish three levels of experience[44]:

- cognitive experience – mental structures that provide storage, ordering, and transformation of available and incoming information;
- metacognitive experience – mental structures that allow for involuntary and voluntary regulation of intellectual activity, and also include involuntary intellectual control, voluntary intellectual control, metacognitive awareness, and an open cognitive position;
- intentional experience – mental structures that underlie individual intellectual inclinations that form subjective criteria for choice regarding a particular subject area.

The direction of searching for a solution, sources of information, and methods of processing it, etc., is determined by cognitive abilities (perception, learning, remembering, thinking, understanding, reasoning) that are manifested in solving problems and making decisions.[45] concluded in their meta-analysis that "educating people about the nature of creativity and creative thinking strategies is an effective and perhaps necessary component of creativity."

Complex systems thinking and metathinking. With the introduction of the concept of complex systems thinking, Mainzer[46] built a bridge between natural science and humanities cultures. The works[1][21][6][13][15][5] show that cognitive visualization of dynamic event cycles allows the application of new ideas and technologies for analyzing the statics and dynamics of fractal information flows of any nature in a transdisciplinary cognitive space. The graphic display of the structure of technological processes in time, as well as the distribution of many different sources of information in a single cognitive space, opens up new opportunities for creative activity in the digital world. Thus, the possibility of transforming statics into dynamics is confirmed by modeling the evolution of solar activity in the cognitive space of dynamic events, which made it possible to establish that this dynamic structure is multifractal[11].

The structure of relationships between heuristic and cognitive metamodels of thinking is transformed into conjugate triads, the perception of harmony of which simplifies their systemic analysis through:

- establishing a balance of conjugate triads, coloring them with natural colors, which simplifies cognitive perception;
- inversion of conjugate triads, the effectiveness of which has been demonstrated in physics, mathematics, software algorithms, etc.;
- synthesis of complementary dynamic, static, and statistical metamodels.

Their spatiotemporal configurations showed that the perception of harmony depends on psychophysiological factors (fatigue, stress, etc.). The important role of external and internal factors is due to the manifestation of Le Chatelier's principle[22].

Determining the causes of key problems in the functioning of objects of various natures in extreme conditions allows us to predict the consequences of problems and find possible ways to solve them. Thus, the heuristic model of a cyber-physical system showed the importance of the triad - nonlinearity, uncertainty, and instability[6].

On the one hand, the secure operation of cyber-sociotechnical systems (CSTS) requires specific integration with human and social factors[47]. On the other hand, technological progress requires the expansion of human capabilities (functional, physical, and cognitive). Therefore, heuristic metamodeling is an effective method for solving new problems[6][23][5].

Metathinking and cognitive distortions. Cognitive aspects induced by digitalization are considered in works[13][3], where the idea of effective hybrid offline and online learning in a single cognitive space is developed. This is a further development of the idea of geometrization of spatio-temporal relationships in a single cognitive space of dynamic events[2]. Since in this space the induced spatial uncertainty distorts the structure of the information flow in time, the spatiotemporal connections between them have cognitive significance. In particular, one-dimensional time series (fractal electrophysiological human signals) are transformed into topological 3D models of adaptation cycles. The restructuring of their configuration and change in the area covered reflects the influence of external and internal stress factors on adaptation processes. Spatiotemporal relationships between opposite phases of functioning reflect the psychophysiological state of a person[12]. On the one hand, the differentiation of special sciences and their divergent development affect the safety, viability of CDS, and mental health. On the other hand, the convergence of the natural sciences was accompanied by their interdisciplinary mutual

enrichment and the development of new ideas[15][5]. Therefore, significant progress in the field of cognitive sciences (cognitive psychology, cognitive graphics, cognitive linguistics, etc.) and neurosciences (neurobiology, neuropsychology, neuroergonomics, neuroeconomics) has made it possible to propose new ideas for the convergence of the life sciences[13].

At the heart of modern research – nanotechnology, deterministic chaos, artificial intelligence, neuroscience, humanitarian technologies – is an internal unity that is associated with the use of the theory of self-organization and synergetics. This allows us to embrace deep and important scientific ideas, including artificial life, cellular neural networks, cognitive computing, and cognitive visualization. Thus, the basis of cognitive metadistortions is the individuality of the subconscious (intuition, successful experience, and emotional intelligence), the interconnection of which forms the consciousness. Therefore, the decisions made are influenced by the past, which manifests itself in the explicit and hidden relationships between sleep and intuition. Like everything known to man in the Universe, the individuality of the brain is manifested in activities, some features of which can be studied and duplicated by generative AI. This opens up new opportunities for realizing the creative potential of self-learning using GenAI (e-teacher).

Motivation and creativity. They influence creativity, the creativity of which depends not only on individual abilities but also on the environment in which a person creates[48]. Creativity is a cyclical process fueled by small victories. While intrinsic motivation promotes creativity, extrinsic motivation usually, but not always, has a detrimental effect. So, Amabile notes that creativity can be negatively affected by:

- expected reward;
- expected score;
- observation and limited choice.

All of these factors potentially influence creativity, which is dependent on motivation. The opposite is also true: a favorable environment can stimulate the development of creative abilities[48]. Neuroscience helps us understand ourselves, that is, analyze and change our own way of thinking. After all, there is nothing more intuitive and at the same time more complex than the concepts of space and time, which form complex systems of thinking and are a kind of bridge between science, culture, and art[46]. So far, neither the instruments nor the brain sense space and time. At the same time, the individuality of functioning can be studied as a sequence of dynamic events without resorting to the concepts of space and time[2]. This is very important for:

- experience-oriented learning;
- problem-based learning;
- hybrid offline and online learning.

4.2. Experience-based learning

4.2.1. Kolb's Neuroscience and Learning Styles

Kolb's learning cycle and its stages. In the process of transforming experience through a cycle of trial and error, four stages are important:

- specific experience;
- reflective observation;
- abstract conceptualization;
- active experimentation.

This is the famous Kolb cycle, in which effective learning ensures that the student passes through all stages of the cycle. At the same time, the four-phase cycle forms a learning style - a person, depending on the characteristics of internal cognitive processes, previously formed learning habits, and preferences, gravitates towards more familiar ways of learning new things and transforming experience. The idea is that it is easier for a person to learn by building one or another strategy. Kolb classified learning styles and suggested that they influence a student′s movement through the phases of the learning cycle. There are only four stages in the Kolb cycle, of which two stages are responsible for gaining experience:

- concrete, that is, direct experience (Concrete Experience, CE);
- abstract conceptualization (AC).

While the other two are responsible for the transformation of experience:

- reflective observation (RO);
- active experimentation (AE).

The student, forming his own knowledge, alternates the steps of gaining experience and transforming this experience. Gaining experience refers to the information that the student perceives, and under transformation (learning style) is how exactly the student assimilates, interprets, and uses this

information. Kolb considered cultural, historical, and social aspects in teaching as an integral part of the student's internal experience, which also affects the effectiveness of the learning process.

Basic principles of experience-oriented learning. Kolb also formulated principles of learning, among which the most important principles are about:

- a continuous process of knowledge formation;
- the process of human resolution of conflicts between different points of view on the world;
- the process of adaptation to the complex and contradictory surrounding reality.

Thus, with the help of neuroscience, Kolb explained the work of the human brain in the process of cognition and how the structure of an individual's knowledge is organized, which is very important for its effective interaction with generative AI. In Kolb's book "Experimental Learning"[49], there are chapters about the place of experience-oriented learning in higher education, the professional and personal development of a person, and the concept of lifelong learning (lifelong learning).

4.3. Hybrid approach to metamodeling methodology

4.3.1. Complementarity, similarity, and analogy as hybrid universals

Complementarity as a hybrid universal. The foundations of the integrative methodology of metamodeling are semiotics[32], structural ontology[33], and second-order metascience[50], the integration of which is based on complementary principles, paradigms, and universals. In understanding the hybrid physical and digital reality, the keys are:

- principles – complementarity, interconnection, and balance of opposites of synergetics;
- paradigms - triadic, synergetic, and semiotic;
- hybrid universals, in which the complementarity of tools (color, inversion, and reduction) actualizes the systemic analysis of physical reality.

The spatiotemporal integration of semiotics, structural ontology, and metasciences is facilitated by the balance of opposites, which is achieved through signs in the form of a pentagon (pentagram) and a hexagon (hexagram). These signs are closely connected in our world and most reflect reality. The relationship of hexagrams and pentagrams is not only present in the very core of our DNA, but also in other structures of our body.

Analogies and dynamic similarity as hybrid universals. In various physical analogies (electromechanical, hydrodynamic, optical-mechanical, etc.), the connection between statics and dynamics, as well as the complementarity of symmetry and conservation laws (the theorem of
E. Noether), is manifested. On the one hand, dynamic similarity reflects spatial order (symmetry, cycle, shape, and sign), and on the other hand, it determines the cause-and-effect relationship of dynamic events in time. Displaying the harmony of space-time communication means such a relationship between elements (signs) when they repeat and balance each other. This does the following:

- physical principle of detailed equilibrium – mutual compensation of any two oppositely directed processes;
- the law of structural harmony of systems, which indicates new possibilities for studying self-organized phenomena of Nature[32];
- Le Chatalier-Brown thermodynamic principle.

Cognitive distortions as hybrid universals. Spatiotemporal distortions and fluctuations of a hybrid environment are hybrid universals. General concepts (universals) of information flows of various natures are structure, inversion, and harmony. Their interrelation and complementarity determine the functionality of the information source. Therefore, cognitive distortions create difficulties, problems, and contradictions that are associated with an increase in induced dynamic and static complexity. In particular, the difficulties of selecting relevant sources of information in a nonlinear hybrid environment, the presence of switchable potential, and dissipative forces lead to self-organization in nonequilibrium systems[51]. Dissipative structures tend to order through fluctuations, which is accompanied by an increase in their complexity and uncertainty. It can be assumed that the connection between dynamic and static complexity at the nanoscale leads to hidden cognitive biases.

The connection between statics and symmetry is based on similarity, meaning such a relationship between elements (figures) when they repeat and balance each other. Thus, the excitation of natural oscillations (Chladni figures[5]) in an optically isotropic polycrystalline medium revealed the manifestation of dynamic symmetry, characteristic of both inorganic objects (symmetry axes of 1,2,3,4, and 6 orders) and living nature objects (symmetry axis of 5-th order)[46]. Therefore, the complementarity of dynamic and static complexity is a hidden hybrid universal, to identify which an integrative structural-functional methodology of digital metamodeling of a fractal nature is being developed.

The work[5] develops the idea of hidden connections between consciousness and the subconscious, which is based on the development of fractal and systemic thinking in the learning process. Therefore, we see the prospects for the development of heuristic metamodeling through the prism of the fractal paradigm. For this purpose, mathematical tools of fractal structures and holography are used. Topological structures (fractal geometry) and holographic structures are similar. There is a connection between synergetics and holography, which manifests itself in more general forms, as well as in the holographic nature of memory. It can be assumed that fractal holographic structures make it possible to present psychological phenomena in more generalized forms. Therefore, fractal thinking involves flexibility, creativity, intuition, and a systematic approach to problem-solving. New opportunities for the development of fractal thinking are opened up by digital twins, augmented reality, and mixed reality, which are important for:

- the development of human emotional intelligence;
- the individualization of training;
- metamodeling and metadesign.

4.3.2. The structure of the connection between sciences and their neurosciences is a cognitive metamodel

Second-order metasciences and neuroscience research. The work[5][4] shows that thinking about one's thinking (metathinking) opens up new opportunities for creative activity, the universal tools of which are recursion, balance, and inversion. They contribute to overcoming interdisciplinary barriers and fostering creative connections. The representation of the structure of connections between physics and neurophysics, ergonomics and neuroergonomics, design and neurodesign in the form of a hexagon (Star of David) made it possible to identify the structure of conjugate functional connections in a generalized metacognitive metamodel (see Fig. 5).

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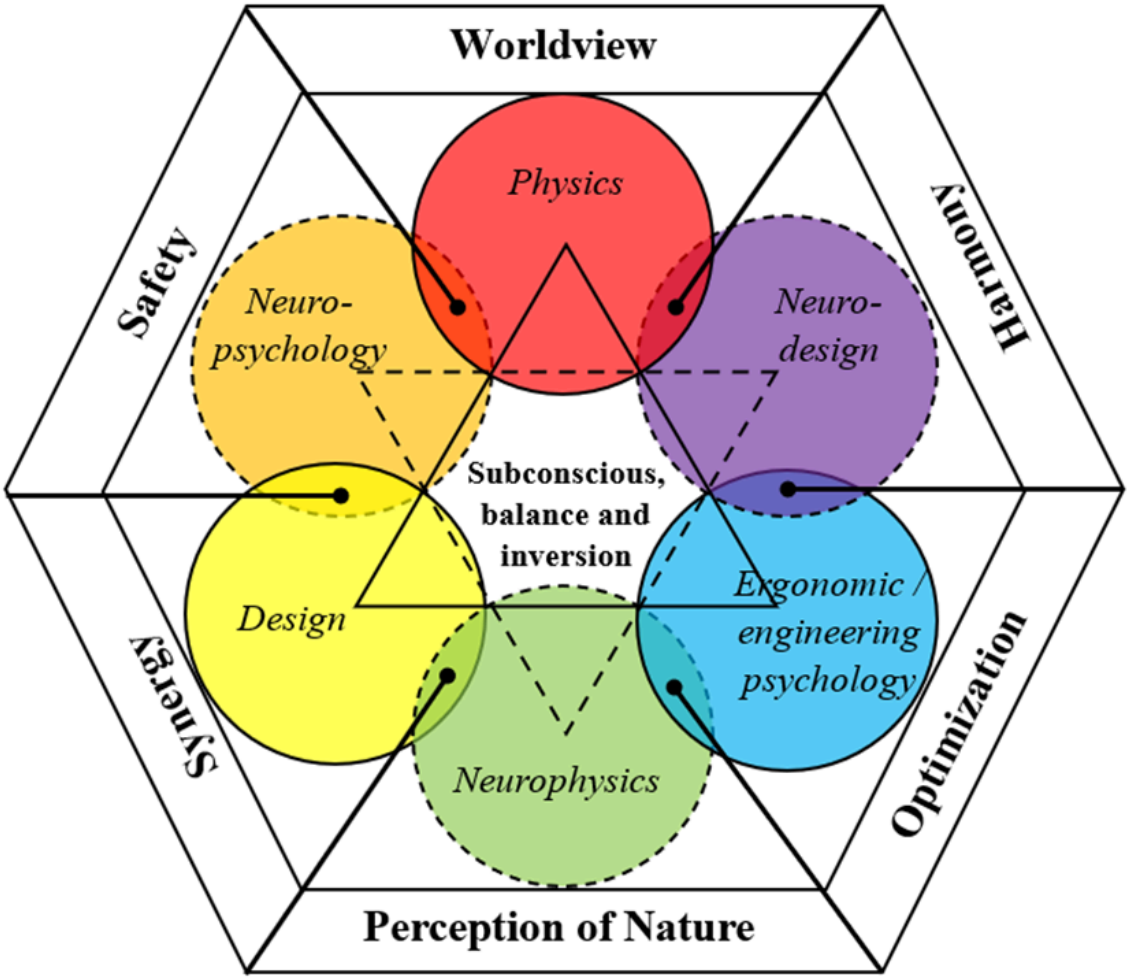

Fig. 5. Generalized cognitive metamodel of the dyadic-triad structure of conjugate relationships that form cycles of transformation and adaptation in ergonomics and engineering psychology.

In the figure, using the natural circle of colors by I. Goethe, the connections between:

- physics, ergonomics, and design, which are painted in natural colors;
- neurophysics, neuroergonomics, and neurodesign, which are colored with 1st order colors;
- conjugate opposites, which are painted in contrasting colors.

As a result, a cognitive metamodel of the structure of conjugate triads was synthesized, the use of which contributes to the formation of metathinking. It is based on a person's ability to cognize, analyze, and change their own way of thinking, which opens up new opportunities. At the same time, the methodological significance of using recursion, balance, and inversion contributes to the humanization of scientific and technological development and fruitful creative activity.

The basis of consciousness and harmonious activity is recursion, balance, and inversion, which are determined by the duality of hidden second-order relationships between the triad of disciplines (physics, ergonomics, and design) and their associated triad of neurosciences (neurophysics, neuroergonomics, and neurodesign). The cognitive metamodel contains hidden triads that reflect the internal unity of opposites. This also confirms the cognitive value of hybrid universals, which simplified the analysis of the relationships between key sciences and metasciences[38][4].

4.3.2. Structural-functional modeling мetamethodology

Metathinking. Thinking about your thinking is extremely necessary for fruitful intellectual and creative activity[46]. The basic ideas of second-order cybernetics are developed in the works[50] on the basis of neurophysiological and neurocognitive sciences. They show that:

- knowledge is a biological phenomenon;
- each individual constructs his own “reality”;
- knowledge is “coordinated” with the world of sensory experience, but not “identical” to it.

Therefore, the relevance of second-order cybernetics emerged in the study of social and biological systems, both autonomous and closed. The study of CDS cycles, consisting of interacting elements, is based on the structure of a graph in the form of a pentagon. This approach opens up prospects for modeling the dynamics and analyzing the viability of CDS elements, including the human body, which is characterized by a set of electrophysiological signals[29][6].

The increasing complexity of technology and the digital world creates new problems in shaping the worldview in the learning process. This prevents overcoming interdisciplinary barriers in the digitized world and adapting to extreme environmental conditions (pandemic, war, environmental, and man-made disasters). Therefore, to develop thinking about your thinking, you need:

- humanization of technology and scientific and technological development;
- understanding of actions, cycles, and phenomena of reality;
- knowledge of extreme principles of natural science and their methodological significance.

Bacon believed that “the sciences that study thinking are certainly the key to all others. And just as the hand is an instrument of instruments, and the soul is a form of forms.” V. Vernadsky considered art to be another way through which it is possible to gain a deeper understanding of nature, man, and the cosmos.

He is the creator of the theory of the birth and evolution of the Universe based on the biosphere and noosphere.

Complementarity of hidden relationships. The work[4] examines dyadic and triad technologies, the effectiveness of which has been demonstrated in psychology, art, metaphysics, logic, critical thinking, and metamodeling. Further development of these technologies is carried out through a convergent approach to solving real problems and side effects in education[13]. This approach showed that uncertainty, nonlinearity, and instability are characteristic of nonlinear dynamic systems and information processes of various natures. Their spatiotemporal configurations represent trajectories-cycles of functioning, reflecting adaptive and transformational processes. This made it possible to establish the nature of induced and inherited cognitive distortions that interfere with the development of metathinking and limit it.

Metaheuristic metamodels of cyberphysical systems in cognitive computing and artificial intelligence have the form of the Star of David[13][15]. Harmonization of relationships and inversion of harmoniously related opposites made it possible to improve hybrid complex-systemic thinking through conjugate triads of systemic and fractal thinking. Thus, harmonization, balance, and inversion make it possible to systematically develop the designer's spatio-temporal imagination and establish his codes of cognitive perception[29]. Harmonization of relationships and inversion of harmoniously related opposites). It is shown how the cognitive metamodel of the structure of conjugate triads of hidden relationships between physical reality and virtual psi-reality contributes to the formation of metathinking.

The work[4] presents a new cognitive metamodel of the structure of conjugate triads of relationships between the metasciences of physical reality and digital (virtual) psi-reality, the systemic analysis of which contributes to the deconstruction of disciplinary knowledge through the convergence of special sciences and technologies. Their manifestation in the universal cognitive space when visualizing the corresponding information flows allows one to choose methods for studying the environment and to form hybrid complex-systemic metathinking in the process of successful creative activity.

Metathinking and the structure of hidden connections. The growth of chaos in the information world and its increasing complexity is accompanied by increased cognitive dissonance[15][4]. This can only be overcome by returning to the origins of world harmony through the geometrization of thinking with its visual representation of the three-dimensional structure of the space of our existence. The representation of the structure of connections between physics and neurophysics, ergonomics and neuroergonomics,

design and neurodesign in the form of a hexagon (Star of David) made it possible to identify the structure of conjugate functional connections in a generalized metacognitive metamodel (see Fig. 6). From the system analysis of intersections in Fig. 6 follows a triad of hidden connections, namely:

- metaphysics shapes a worldview that promotes optimization and synergy;
- metaergonomics optimizes activities that are determined by the perception of nature and its harmony;
- metadesign creates safe objects based on the perception of the harmony of nature (biomimicry).

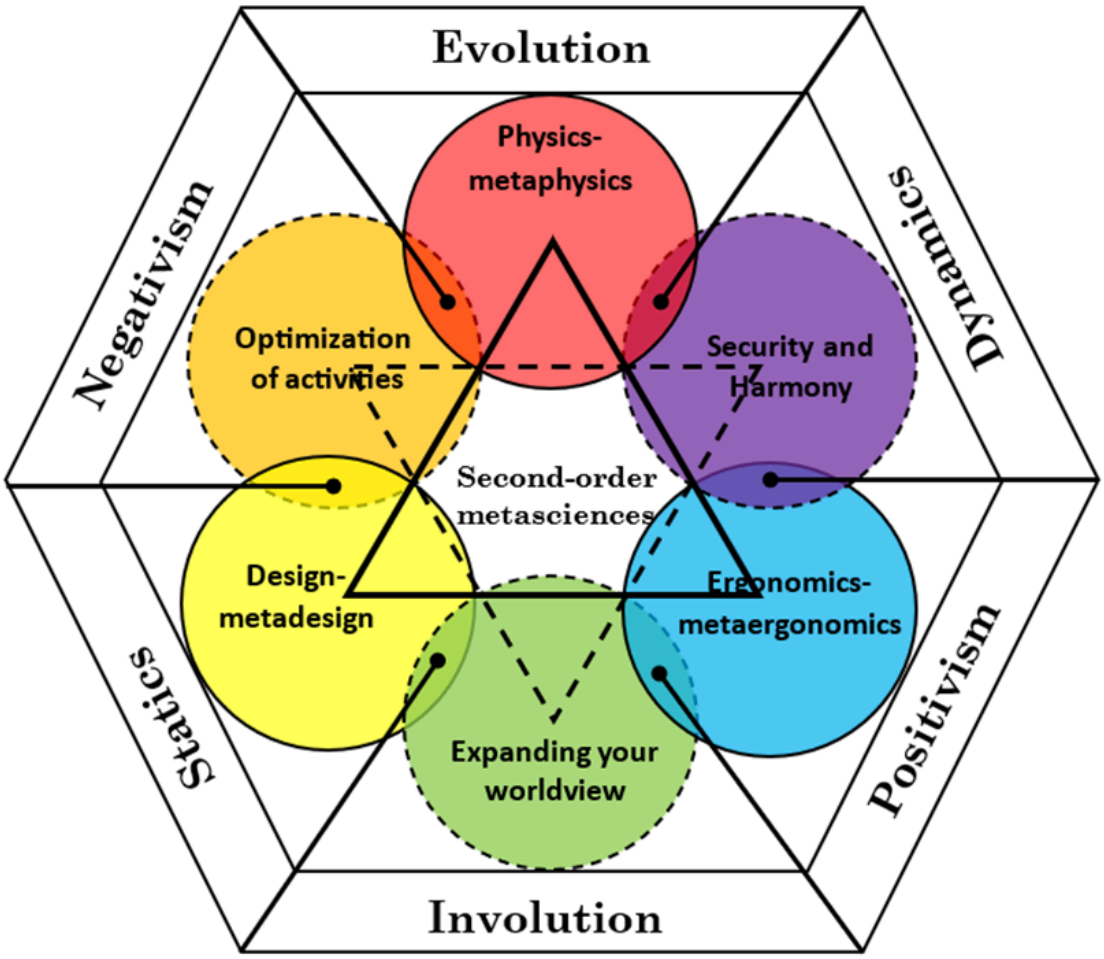

Fig. 6. A generalized metacognitive metamodel of the structure of conjugate functional connections, the systemic analysis of which forms metathinking through second-order sciences.

Solving current problems (safety, mental health, and viability of the CDS) requires the harmonization of spatio-temporal relationships between ergonomics/engineering psychology and human factors

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engineering, the complementarity of which is the basis of metaergonomics. Therefore, the idea of using hybrid universals in metaergonomics contributes to the formation of metathinking, which is based on the transition from the duality (contrast) of antonyms to the trinity (harmony) of conjugate opposites. They reflect the relationship of an individual's consciousness to his subconscious, the hidden connections of which are studied by second-order metasciences. Thus, from the generalized cognitive metamodel of the structure of conjugate triads of metamodels, it follows that second-order cybernetics takes into account explicit (social) and hidden (cognitive) connections.

Interrelation and complementarity of principles, relationships, and structure. It allows for balanced self-renewal in different types of creative activity. Thus, the complementarity of principles is manifested in natural dynamic fractals and multifractals[33][4], as well as in structural functionalism (experimental psychology). Therefore, it is necessary to expand the researcher's worldview based on the relationship of modern metaphysics with metaphilosophy and metamathematics[46][5]. For modern metaphysics, the connection of cognitive aspects with different types of complexity, which is discussed in[15][5], is important. They show that cognitive biases result from individual perceptions and representations of complexity, instability, and nonlinearity. Therefore, the principles of structure formation are relevant for heuristic metamodeling, namely:

- principles of duality and trinity, the hierarchy of which turns metaphysics into a unified system of paradigms;
- the principle of fractality (self-similarity), reflecting the unity of the whole and the particular;
- the principle of double cyclicity, manifested in the orderliness of the spatio-temporal structure of information flows of various natures.

Complementarity of worldview, metathinking, and semiotics. Worldview, as a system of principles, values, and ideals, has a complex structure that includes a contradictory unity of knowledge and values, intellectual and emotional elements, beliefs, and doubts. However, in the process of digitalization of science and education, the logical basis of knowledge production is increasingly moving away from reality. Researchers see many events that are not measured or modeled. Therefore, such events are expressed by signs, the relationships of which form something immeasurable and unimaginable. The pragmatic understanding of information, communication, and language is associated with second-order cybernetics, the essence of which is that information is the difference that creates difference. The

foundations of semiotic theory were developed by Charles Pierce, a mathematician with experience as a surveyor.

Interrelation of structures as a hybrid universal. The differentiation of sciences has led to the emergence of specific languages, as a result of which scientists of different specialties, speaking about the same essence, do not understand each other. Philosophers, scientists, and designers are aware of the emergence of interdisciplinary barriers, resulting in second-order sciences and neurocognitive sciences (psychology, machine learning, artificial intelligence and robotics, neuroscience, anthropology, linguistics, design, and philosophy). They widely use triadic structures (fractal triangle, pentagon, hexagon, and other triune systems). Their use allowed the authors of the article to overcome interdisciplinary barriers and create an integrative metatheory of digital modeling of a hybrid subject environment. It turned out that triadic structures make it possible to model objects that have a different ontology and a different nature of development. Therefore, the interconnection of structures is a hidden universal, the use of which in a hybrid environment contributes to the development of metathinking. In section 5.4, the idea of using hybrid universals and cognitive visualization is being developed to expand the worldview during the digital transformation of ergonomics and engineering psychology into metaergonomics.

4.3.3. Natural modeling of emergent properties of CDS

New possibilities for computer modeling of reality. The problems of predicting the functioning of information sources in extreme conditions are associated with changes in their structure. They lead to genetically inherited cognitive biases that give rise to systematic errors. The works[2][7][6][10] show that local distortions in the structure of information flows of various natures in real time are new sources of information about:

- dynamic and static complexity;
- unstable transition state of the hybrid environment;
- the nature of the distribution of information sources in a heterogeneous hybrid environment.

Therefore, the natural structuring of information sources, in extreme conditions, does not allow the predictive analyst to carry out the individual functioning of information sources of various natures.

Structural ontology has wide application in various fields of science, including philosophy, biology, physics, sociology, and others. Therefore, the metatheory is based on the integration of semiotics,

structural ontology, and metasciences, which allows:

- to study a complex system and take into account the variety of interrelations of its elements;
- to analyze the structure of objects and their properties;
- to explain complex processes and reconcile them with your sensory experience.

At the same time, universal tools have been created using conjugate fractal triangles. They include interconnected semiotic signs – a pentagon (pentagram) and a hexagon (hexagram) – which reflect the natural harmony of nature. It is based on the Golden Ratio, which helps to understand and explain the functioning of the CDS in extreme conditions.

Natural decomposition of information sources and emergent properties. The modeling is based on the transformation of the time series V(t) into a triad of cognitive graphic images, the order of which is reflected by the evolution of the Boltzmann entropy H (t), as well as the rate of entropy production dH/dt. In this case, the evolution of second-order entropy F (t), as well as the rate of entropy production d F /d t, can be represented in the space of dynamic events in the form of H-signatures and F-signatures, which, in essence, are structural and functional characteristics of the evolution of the state of the source information, namely:

- H (t) and dH/d t in the form of H-signatures (H (t) - dH/dt);
- F (t) and d F /d t in the form of F -signatures (F (t) - dF /dt);
- The degree of interconnection of these signatures can be assessed using a matrix of indicators that reflect the degree of balance of anti-phase components.

Therefore, the complementarity of pentagrams and hexagrams in topological 3D models and their interconnection makes it possible to study the emergent properties of information sources of various natures, as well as elements of the SDS, including the human body.

4.3.4. OpenAI - creativity motivation, limitations, and new problems

OpenAI - new opportunities. From the perception of the harmony of nature, it follows that the development of metathinking opens up new opportunities for optimizing an individual's activity in difficult conditions within the framework of the structural and functional methodology of digital modeling.

OpenAI has become an integral part of the creative process in many related industries (science and education, design and architecture, music and poetry, film and animation). On the one hand, the main

advantage of solving creative problems with the help of AI is new opportunities:

- to generate new ideas for solving current problems;
- to analyze large data sets and identify new ideas, principles, and patterns;
- to develop creative products to enhance the individual's metathinking.

On the other hand, GenAI allows us to develop innovative products and services that meet the individual needs of people. These capabilities to create real content at the scale of many processes and technologies are impressive. However, the main motivator of creativity is the objective recognition of the fruitfulness of new ideas. Since the lion's share of scientists' time is spent working with literature, which in modern conditions is greatly complicated by the huge number of scientific publications, the problem of developing tools that will help save time and not miss anything important is extremely urgent. Search engines based on OpenAI work with complex search queries, use synonyms, generate summaries, and can be a navigator in promising ideas, directions, methods, and technologies. In addition, the use of OpenAI contributes to the development of heuristic and cognitive thinking, which increases the creative potential of the individual,

New problems. Like any digital technology, OpenAI can create deceptively real content, which also brings its own challenges - from deepfakes to disinformation, privacy concerns, and bias - there are many unanswered questions. What's missing from AI problem-solving is:

- the empathy and intuition needed to create truly unique works of art, design, and music;
- knowledge of the subtle nuances of the creative process, i.e., the ability to understand the context;
- balanced thinking and human intuition, which are based on successful experience in solving real problems.

Problems are solved by people who have creative potential, which makes it possible to create and find new things. In particular, high-quality creative products are created by a person with creative intuition, empathy, and a track record of success.

OpenAI's dependence on training data raises legal, ethical, and bioethical issues. When using OpenAI in automated transport dynamic systems, legal issues related to authorship and liability arise. Copyright law must balance the benefits for creators, users of generative AI tools, and society at large, rather than relying on judicial interpretation. In particular, collecting third-party data to teach or imitate an artist's style violates copyright. Therefore, it is necessary to stimulate research into the nature of ethical issues so as not to limit innovation.

AI and the development of creative thinking. GPT-based search engines work with complex search queries, use synonyms, generate summaries, and can be a navigator in promising ideas, directions, methods, and technologies.

Digitalization is influencing the creative processes through which designers, researchers, and psychological engineers formulate ideas and bring them to life. Such processes form the characteristics of the creative activity of an individual who has three keys (number, letter (shape), and note) in order to:

- explore nature, think, and dream;
- discover the harmony of the real world;
- create by borrowing ideas from nature, i.e., use biomimetics.

Their complementarity inspires and defines a positive thinking style that promotes the development of creative thinking.

In our opinion, with the help of OpenAI, you can solve creative problems through logical, creative, and analytical thinking. Their complementarity allows:

- justifying the criteria for objective assessment using meta-analysis;
- identifying the influence of cognitive distortions;
- evaluating new ideas, methods, and technologies.

Using OpenAI, you can evaluate different approaches to conducting meta-analysis of the survival of complex dynamic systems (Bayesian meta-analysis, cumulative meta-analysis, multivariate meta-analysis), which promotes metathinking.

5. Intellectual Activity in Extreme Conditions

5.1. Artificial Intelligence for Scientists

5.1.1. Merging Artificial Intelligence Technologies with Scientific Research

Categorization of the Physical World. OpenAI helps you save time and ensure you don't miss anything important. Covering approximately 30,000 peer-reviewed journals, its GenAI-based search engines handle complex search queries, use synonyms, generate abstracts, and can be a navigator to promising ideas, trends, methods, and technologies.

Scopus AI creates an atmosphere in which the rush to merge artificial intelligence technologies with scientific research seems not only inevitable but also desirable. However, the desire to quantify and categorize the physical world leaves little room for unusual nonlinear phenomena that:

- cannot be easily explained;
- challenge existing knowledge structures;
- stimulate real innovation.

While AI offers the appeal of objectivity, quality, reliability, and speed, it prioritizes data and simplified answers over problematic questions and deep understanding. Therefore, a new paradigm is needed to search for fresh ideas, methods, and technologies.

Problems of Integration of Scientists and OpenAI. Integrative indicators and universal criteria for creative activity are discussed in the article[4], which shows that the key to the integration of interdisciplinary research is the criteria for evaluation and reward, namely:

- number of views and number of downloads and their dynamics;
- the ratio of the number of views to the number of downloads and its dynamics;
- number of citations and Hirsch index.

Taken together, these criteria make it possible to evaluate new ideas, technologies, programs, and models, serving as an objective "compass" for creative activity. In our opinion, their analysis through OpenAI provides new opportunities for realizing creative potential. In particular, statistical analysis of the dynamics of changes in relationships between various quality criteria using OpenAI is very informative.

5.2. The Evolution of Ideas as a Source of New Ideas, Methods, and Technologies

5.2.1. Connection of Consciousness, Subconscious, and Eastern Philosophy

The connection between modern physics and Eastern mysticism. C. Jung attaches equal importance to consciousness and the subconscious, which he calls parallel paths of development of modern physics and Eastern mysticism. We see hidden connections between them in the parallels between modern physics and Eastern philosophy. Indeed, on the one hand, consciousness determines knowledge, the triadic structure of which includes principles, methods, and technologies (method + subject = result). On the other hand, the subconscious determines cognitive experience (sensation, perception, idea), the dyadic

structure of which acquires rational meaning. Therefore, their relationship is applicable to the specifics of mystical experience and mystical thinking and corresponds to G. Bateson's network paradigm, in which the concepts of analog and digital language appear. The combination of approaches allows us to adequately identify the rational foundations of Eastern mysticism.

Modern physics has confirmed one of the main provisions of Eastern mysticism: all the concepts we use to describe nature are limited; these are not facts, but products of our thinking - parts of a drawn map, not of the real terrain. The truly revolutionary content of Einstein's theory is that the space-time coordinate system exists in the form of objective reality as a physical whole. On Earth, gravity has little effect on space and time, but in astrophysics, the curvature of space-time is very important.

Both the modern physicist and the Eastern mystic come to the conclusion that all phenomena in this world of change and transformation are dynamically interconnected.

Ancient signs are tools for entering another reality. The more we study the religious and philosophical treatises of Hindus, Buddhists, and Taoists, the more obvious it becomes that they all describe the world in terms of movement, fluidity, and variability[52]. In particular, tetraxis * is an important element of sacred geometry. The mystics were engaged in science and, being one with the Universe, tried to get to the bottom of its very depths. It is necessary to note that there are hundreds of examples of great mystics. For example, the astronomer Kepler, the famous physicists A. Einstein, Niels Bohr, Pauli, and many others. Physicists John Wheeler and Richard Feynman had a rather unconventional view of the structure of reality. At the same time, their brains used ancient signs (images) as tools for entering another reality. In particular, the ancient teaching about the signs of the zodiac logically complements the picture of the world created by modern scientists. The statements of Albert Einstein and the famous astrophysicist John Wheeler are adjacent to quotes from the Torah and Zohar. The insight of the sages of Kabbalah paradoxically goes back to the discoveries of astronomers, throwing a bridge between deep antiquity and the distant future, mysticism and science, astrology and astrophysics.

5.3. Thinking in extreme conditions

5.3.1. Problems and risks

Heightened perception of reality. Our work[4] shows that extreme conditions sharpen the perception of reality. In particular, the exchange of methodology and experience among the authors contributed to:

- the development of a convergent approach to learning[13];

- discussing new ideas for harmonizing interaction in the digital world;
- the transfer of technologies from one field of knowledge (optical range) to another (nanowave range) – space-time inversion to determine the strategy of activity.

Their relationship is the basis of the idea of cognitive visualization of evolution, which contributed to the development of methods, universal indicators, and criteria for studying the viability of complex dynamic systems. All this was most manifested in a hybrid space-time environment[21][15], in which a connection was established between physics, mathematics, and natural philosophy and their metasciences[38]. Also, based on the key principles of bionics, metaphysical principles of a convergent approach to heuristic metamodeling of physical reality have been developed. The convergent approach to reality metamodeling is based on the triad:

- complementarity of new universals;
- the relationship between consciousness and subconscious;
- the harmony of fractal nature.

The use of their structures for training AI opens up qualitatively new opportunities for innovative and scientific activities based on the natural knowledge base.

However, environmental stress factors cause spatial and temporal distortions of information flows, which are associated with local inhomogeneities in information sources of various natures (sensors, detectors, etc.), as well as with local inhomogeneities in transmission channels[12]. All this, when exchanging information, significantly affects the network topology (physical, logical, and informational). In particular, within the framework of the transdisciplinary approach, sources of information distortion are universal sources of information, from which, based on the measured time series (scalar signal), it is possible to reconstruct a topological 3D model[21].

5.3.2. Latent problems of safety, reliability, and stability of CDS

Viability of CDS. Digital transformation has created systemic latent problems of safety, reliability, and sustainability of the CDS, the interconnection of which determines the complexity of solving the problem of viability in extreme conditions. Transformation of a one-dimensional time series into a topological 3D model of the functioning of a dynamic system allowed:

- overcoming the increasing information complexity when modeling the functioning of the CDS;

- identifying the latent structure of induced connections, which determines the individuality of functioning;
- evaluating modeling results visually in real time, which is important for choosing a risk management strategy.

Local distortions of the multifractal signal increase dynamic and structural complexity. However, transforming these distortions into a configuration of ordered opposing components simplifies the cognitive perception of the complexity of 3D models.

It should be noted that the analysis of the topological 3D model of functioning stimulates the active work of both hemispheres of the brain[21], which simplifies cognitive perception and the stability of the elements of the CDS. The representation of information flows of different natures in a hybrid space of dynamic events allows for data mining that is not yet accessible to humans and computers separately. It expands the capabilities of control, machine learning[6][53], as well as intelligent support systems[6][7].

Human-computer interaction – new risks. The connection between ergonomic and cognitive aspects is considered in the work[9], which shows the difficulties of creating safe, reliable, and resistant to difficult conditions CDS, including computer systems, due to the lack of awareness among students (developers) of the ergonomic and cognitive aspects of human-computer (machine) interactions. The versatility of the human factor issue necessitates the actualization of interdisciplinary connections, the identification of which is facilitated by the development of the idea of complementarity:

- universal extreme principles of dynamics;
- dynamic parameters of state, speed, and acceleration, the relationship of which is characteristic of all fractal signals;
- integrative indicators of orderliness and spatio-temporal balance.

On their basis, entropy criteria for ordering the structure of information flows of various natures have been proposed, with the help of which the influence of complex conditions, environmental stress factors, and activities on the effectiveness of human-computer interaction has been established.

Further development of the idea, the use of structural patterns of information sources, and the convergent methodology proposed in the work[7][54][53] make it possible to erase the interdisciplinary boundaries between scientific and technological knowledge. However, the lack of effective criteria for

selecting relevant information makes it difficult to assess the risk of a dynamic system operating under unpredictable conditions.

5.4. Cognitive ergonomics, human factors, and human factors engineering

5.4.1. Cognitive ergonomics

Human factors: external and internal stress factors. The works[6][5][4] show that stress factors distort information flows of various natures and create systemic problems of security, mental health, and risks of VTS management. To make responsible decisions in real time, you need to develop metathinking. This requires the unification of tools for processing, visualization, and analysis of information flows of different natures. In particular, cognitive modeling of information sources of various natures is proposed, based on visualization of their spatio-temporal structure. Transformation of the fractal signal into a topological 3D model of functioning and its spatiotemporal signatures allows complexity to be assessed using probabilistic and deterministic research methods based on the degree of order, as well as the degree of energy balance.

In general, the development of metathinking opens up qualitatively new opportunities for:

- formation of balanced creative-critical positive thinking in the process of cognitive activity;
- identifying the characteristics of an individual's thinking and optimizing his learning trajectory;
- forecasting risks/consequences of overcoming complexity thresholds that lead to disasters.

At all stages of the life cycle of complex systems, it is necessary to optimize the workspace and coordinate the designs and functionality of equipment with the psychophysical characteristics of workers, which has turned out to be a complex, multifaceted, and interdisciplinary problem.

Complementarity of the concepts of ergonomics and engineering psychology. In the field of safety (ergonomics, human factors, risk, and viability theories), these are discussed and actively developed through differentiation, theorization, mathematization, and systematization[35]. At the same time, the cause of more than 75% of man-made disasters is still the human factor, and the "price" of human activity is growing[55]. Therefore, the safety problems of complex dynamic systems and their elements, including humans, have necessitated the search for new ideas and approaches in practical ergonomics to solve current problems caused by digitalization and extreme operating conditions of CDS elements, including the human body.

Human activity has shifted significantly towards cognitive load in the context of the rapid integration of information and industrial technologies[34], while cognitive distortions have increased the cost of errors. Thus, the influence of cognitive aspects on the effectiveness of interaction in the digitized world was paid attention to in the works[54][13]. Today, information interaction is determined not only by the peculiarities of the development of thinking in the family, school, and university, but also by the era of digital technology, which is mediated by the screen. In the 21st century, the new generation is dominated by:

- the exciting quality of instant contact;
- an unlimited flow of information;
- virtual games and the virtualization of personal life.

Accordingly, the cognitive essence of a person changes – a schoolchild, a student, an employee, an operator, a designer, a manager. Therefore, the search for new ideas to solve the problems of cognitive distortions that are acquired in the process of activity and are inherent in each individual, as well as hidden genetically inherited ones, has become very relevant[23][21].

5.4.2. The new paradigm of metaergonomics

Dynamic balance through the inversion of opposites. The metamodel of the balance of relationships in the form of two conjugate Stars of David is shown in Fig.7.a) and c), obtained through inversion.

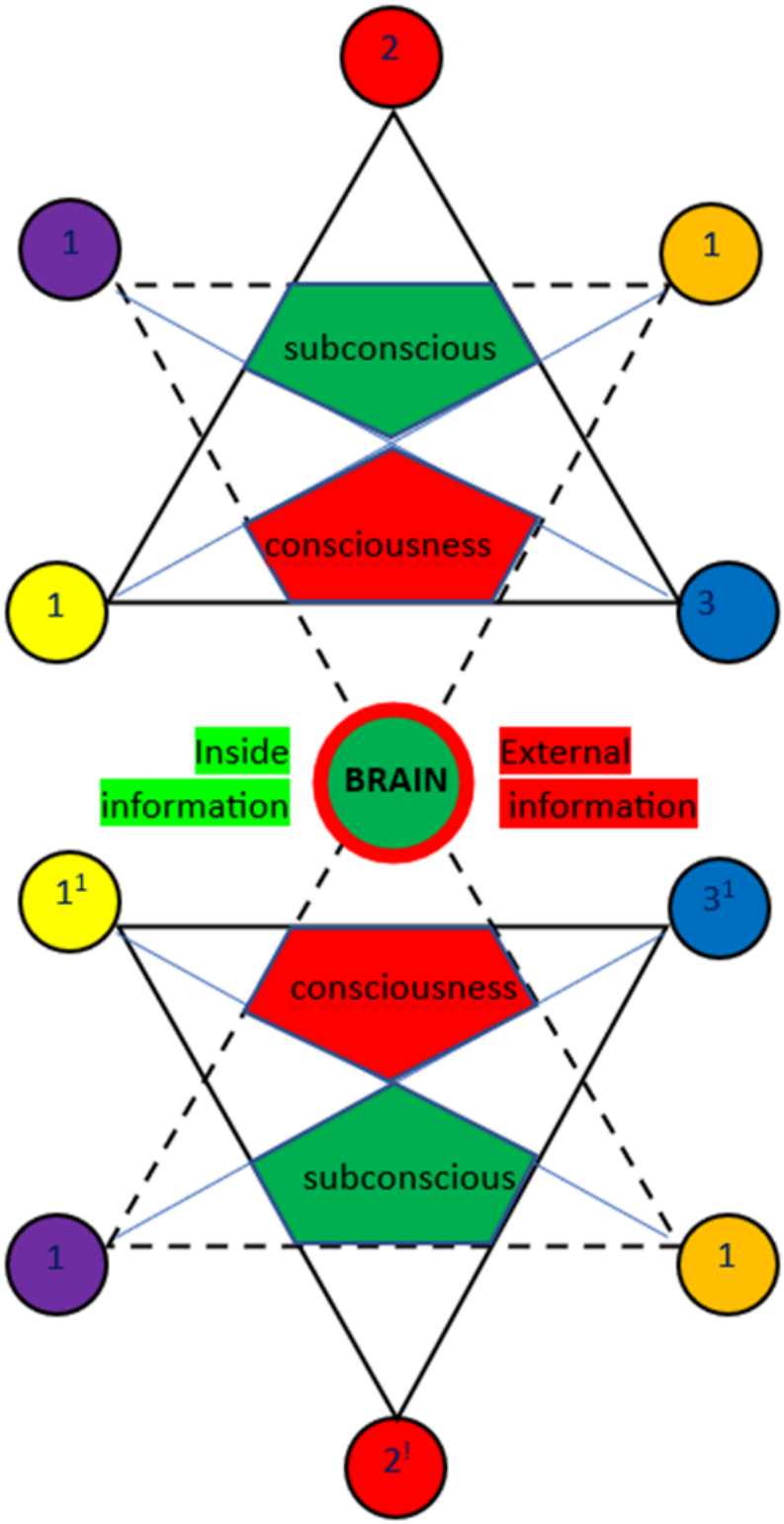

Fig. 7. The author's generalized metamodel of knowledge, survival, and wisdom in the form of a double Star of David (hexagon and its mirror image), which is self-consistent

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with the double pentagon (five-pointed star – pentacle[6] and its mirror image) as a universal sign-symbol-code.

In Fig. 7, the mirror conjugate Star of David (solid - 1,2,3) reflects the physical reality of consciousness, which is painted in natural colors – yellow, red, and blue, and the mirror conjugate (dotted 11 brown) reflects the digital reality of the subconscious, in which consciousness (red) and subconscious (green). When they are inverted, the colors change places, which contributes to the formation of metathinking.

In essence, this is a metamodel of metathinking, in which the connection of worldview with consciousness and subconsciousness contributes to:

- interdisciplinary exchange of ideas, methods, and successful experiences within the framework of metaergonomics;
- creative activity based on the perception of harmony and achieving the unattainable;
- the formation of a hybrid approach to understanding the harmony of the physical world and the harmonization of mental health.

It is important to emphasize that the meta-model of meta-ergonomics in the form of a double Star of David includes:

- transition from one Star of David to another through inversion;
- transition from one pentagon to another through inversion;
- two oppositely oriented hexagons and two pentagons.

Therefore, it can be assumed that the pentagon in the hexagon performs a double cycle, which makes their superposition an effective means of cognition, management, and control. Thus, the complementarity of engineering psychology and ergonomics created the basis for the transition of the design of human-machine systems from technocentric to anthropocentric.

They laid the foundation for understanding the role of human individuality in ensuring the safe functioning of complex systems. At the same time, the creation of the Japanese “economic miracle” was based on the principle of creating and developing a certain mindset among all participants in the production process. Human factors engineering has shown the effectiveness of applying system principles, cognitive ergonomics, and neuroergonomics to optimize interaction in a human-machine

system and increase its safety at the design stage[6]. The dynamic model of metaergonomics shows the relationship between the hexagon and the pentagon in the form of the Merkabah tree of life, see Fig. 7.

Since “mathematics” in Greek means the triad (cognition, knowledge, and study), the very nature of mathematical knowledge promotes freedom of thought, judgment, and creativity. Only prejudices force us to see the virtual incompatibility of two cultures - mathematics and humanities. In the three-dimensional Merkabah, the two Stars of David rotate in opposite directions, which is the basis of Ouroboros.

Digital ergonomics, safety, and metaergonomics. Automation of the management of transport systems is accompanied by an increase in the number of information sources, which generates a variety of information flows, a variety of methods for their processing, display, and analysis. As a consequence, there are unsolved problems – the choice of a method for processing and displaying information flows, as well as interrelated analysis tools (parameters, indicators, and criteria), the deficiency of which makes it difficult to identify and take into account their individuality when modeling functioning in extreme conditions.

Digitalization of the CDS has created the basis for the transition of the design of human-machine systems from technocentric to anthropocentric, and for understanding the role of the individuality of human metathinking in ensuring the safe operation of complex systems. This is indicated by the Japanese “economic miracle,” which was based on the principle of creating and developing a certain mindset among all participants in the production process. Human factors engineering has shown the effectiveness of applying system-forming principles, cognitive ergonomics, and neuroergonomics to optimize interaction in a human-machine system at the design stage[6].

At all stages of the life cycle of complex systems, it is necessary to optimize the workspace and coordinate the designs and functionality of equipment with the psychophysical characteristics of workers, which turned out to be complex and multifaceted tasks. To solve them, anthropometry, biomechanics, technical aesthetics, engineering psychology, etc., are used. Today, ergonomics/human factors are under the attention of psychologists, physiologists, and many other specialists. Comfortable activities are in demand in the modern business environment, where such activities contribute to the integration of IT and ICT in Industry 4.0. Therefore, comfortable activities are in demand in the modern business environment, where such activities contribute to the integration of IT and ICT in Industry 4.0.

Human factor management in extreme conditions is, first of all, taking into account:

- human cognitive capabilities;
- behavior patterns;
- psychophysiological characteristics.

In our opinion, the main goal of metaergonomics is to optimize the intellectual activity of an individual in a hybrid subject environment to ensure safety, reliability, and comfort. The basis for ensuring the development of an individual is the presence of a broad worldview, convergent thinking, and empathy (high consciousness), as well as a human-centric view of the researcher, designer, and technologist.

5.5. Cognitive value of interrelated concepts, nature-like algorithms, and natural technologies

5.5.1. Cognitive imaging and digital modeling

Convergent modeling approach. The application of a convergent approach and the means for its implementation to information sources of different natures (EMR, radiation, and acoustic radiation sensors), as well as to human electrophysiological signals (EEG, EOG, rheogram, etc.), demonstrates advantages. At the same time, new opportunities for identifying hidden spatio-temporal relationships determine the safety of the functioning of dynamic systems in difficult conditions. An atlas of such models will simplify the intellectual selection of an effective solution. The innovative potential of the approach, tools, and atlas is enormous. Cognitive visualization and modeling will simplify human-computer interaction in training, designing, and testing new dynamic systems. This will increase the safety of the functioning of complex dynamic systems, including the functioning of the human body, and also opens up new opportunities for interaction with GenAI.

The AI gene, digital ergonomics, and engineering psychology continue to develop[29]. Therefore, there is a growing need for universal means of interaction (universals, criteria, and characteristic features), which are the key to:

- unlocking the innovative potential of human collaboration with AI;
- ensuring that AI systems contribute to education and mental health;
- the creation of valid methods and systems of medical and technical diagnostics.

Revealing hidden spatiotemporal relationships. Creating natural interactions between humans and AI systems is accomplished through the spatiotemporal integration of semiotics, structural ontology, and

second-order metasciences. Their relationship is the basis of the proposed structural-integrative methodology for studying a hybrid subject environment, which, within the framework of natural computer science, made it possible to propose new ideas for the symbiosis of explicit and hidden universals of interaction.

The innovative potential of the approach, tools, and atlas is enormous. Cognitive visualization and modeling will simplify human-computer interaction in training, designing, and testing new dynamic systems. This will increase the safety of the functioning of complex dynamic systems, including the functioning of the human body.

The concept of complementarity as a universal. The increase in chaos in the information world is accompanied by increased cognitive dissonance in the cognitive process[13][5]. This can only be overcome by returning to the origins of world harmony through the geometrization of thinking with its visual representation of the three-dimensional structure of the space of our existence. An example of such a structure is social communication networks. The generalized concept of complementarity, proposed by Niels Bohr, covers not only physics but also biology, psychology, cultural studies, and the humanities[56]. In particular, the generalized principle of spatiotemporal complementarity, on the one hand, has methodological value for the convergence of sciences and technologies, and on the other hand, increases the heuristic value of the integrative metatheory of metamodeling of physical and digital reality. The complementarity of metamodels makes it possible to solve current problems and challenges that are generated by the digitalization of the economy, science, and education, and these include the mental health of the new generation and the loss of empathy, the safety of the functioning of the CDS in extreme conditions, as well as predicting the evolution of the CDS in the conditions of environmental and man-made disasters.

6. Conclusions and suggestions

6.1. Main conclusions

To solve the problems and challenges induced by digitalization and the use of specialized GenAI, a new idea of a hybrid approach to modeling three-dimensional physical and digital reality is being developed, which is based on:

- second-order metasciences (metamethodologies, cybersemiotics, and cognitive metaphor);
- new tools of structural-functional methodology for studying a hybrid environment;

- spatio-temporal connections of opposite phases of dynamic processes of various natures.

At the same time, the complementarity of the elements of semiotics, cybersemiotics, and cognitive metaphor contributes to:

- the formation of Kolb's learning cycle and style;
- the development of integrative metathinking;
- choosing the optimal strategy for creative activity.

In turn, their complementarity contributes to the development of the methodology itself (metathinking) through extreme principles, relationships, and structures. While the cognitive aspects of digitalization and specialized GenAI give rise to systemic contradictions and side effects, which are the basis of new problems of security, mental health, medical and technical diagnostics, they also limit the development of education, science, and technology.

Attention is drawn to the heuristic value of ancient signs (Ouroboros, Star of David, tetractys, Scandinavian runes), which contributed to the study of parallels between the perception of physical reality and the mysticism of Eastern philosophy. The interconnection of metaheuristic metamodels made it possible to substantiate the connection between the Star of David, the Merkabah (tree of life), and the Kabbalah.

The difficulties of identifying the individual characteristics of human thinking are studied by neuroscience and cognitive science, and ergonomists and engineering psychologists optimize human activity in a hybrid subject environment. To reduce risks and man-made disasters, the idea of complementarity of ergonomics, engineering psychology, and human factors engineering is being developed within the framework of metaergonomics. However, digitalization and the use of GenAI also increase the risks of environmental and man-made disasters. A metacognitive metamodel of the structure of metaergonomics is proposed, which takes into account the physical reality of consciousness and the digital reality of the subconscious. It is shown that their hidden connections in the process of successful activity contribute to the formation of balanced creative and critical metathinking, and also form a learning style (creative activity) and patterns of behavior in extreme conditions.

6.2. Key offers

1. New hybrid universals (spatio-temporal connections, inversion and reduction, dynamic symmetry, and spatial ordering), which are the basis of the integrative meta-theory of digital modeling of a

hybrid subject environment.

2. New tools for interaction with GenAI, which are based on a natural intellectual knowledge base, allowing the individual's thinking characteristics and his creative potential to be revealed through:
   - universals that stimulate creativity;
   - universal integrative indicators of the effectiveness of scientific activity;
   - objective criteria for evaluating ideas, methods, and technologies.
3. New tools for the development of personal metathinking, which, with the help of GenAI, take into account the influence of systematic errors (cognitive distortions) when solving key problems of creative activity.

6.3. The future of GenAI

Complementarity: new universals, integrative indicators, and objective evaluation criteria open up qualitatively new opportunities for the formation of balanced creative-critical thinking in the process of creative activity. To do this, using the proposed structural-functional methodology, it is possible to create a natural generative AI database, which will allow you to create:

- a kind of "market" of ideas, technologies, and innovations;
- integrative criteria for evaluating new ideas, methods, and technologies;
- incentives for creative activity in science, education, and engineering.

Today, GenAI can both promote the growth of creativity and become a fundamental driving force of the economy, and limit its development. At the same time, decent remuneration will contribute to the realization of the creative potential of both an individual and many individuals. The country, by investing in education, science, and culture, increases human capital, the development of which stimulates the accumulation of productive capital.

Footnotes

[1] Johannes Kepler *German mathematician, astronomer, mechanic, optician, discoverer of the laws of motion of the planets of the solar system, creator of the discreteness of the scale of both the major scale and the minor scale. They use a third, which contains three sounds and two tones.

[2] Fibonacci* is the great mathematician of medieval Europe, Leonardo of Pisa, who is best known by the nickname Fibonacci. A researcher of a number sequence in which each subsequent number is equal to the

sum of the two previous numbers. The ratio of neighboring Fibonacci numbers tends to the golden ratio as they move away from the beginning of the sequence.

[3] Ouroboros*, the interpretation of the Ouroboros symbol describes it as a representation of eternity and infinity, in particular the cyclical nature of life: alternation of creation and destruction, life and death, constant rebirth and death.

[4] Metacognitive Strategies * Metacognitive strategies are learning (teaching) techniques that encourage students (teachers) to think about their thinking when learning new topics and concepts.

[5] Chladni figures Relatively large particles collect in nodal lines, where the vibration amplitude is zero or relatively small (this phenomenon was observed by Chladni). In this case, resonance allows us to selectively excite one normal vibration we need, rocking the body with the help of an external force with a frequency equal to the natural frequency of the normal vibration. Quantum chaos. Integrated and chaotic systems.

[6] Pentacle * The five-pointed star is the oldest symbol of safety and security, and also symbolizes mastery, progress, and self-confidence.

Ethics Statement

This article is a review and theoretical work. It did not involve new studies with human participants or animals performed by any of the authors. Any discussion of human cognition, psychophysiology, or behavior relies on previously published and cited research.

Data Availability Statement

No new data were created or analyzed in this study. Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study. Information synthesis is based on publicly available cited sources.

Author Contributions

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