

# Mathematical Modelling of Human Cognitive and Neurophysiological Systems for Biomedical Applications

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**Submitted:** 2024, Dec 18; **Accepted:** 2025, Jan 20; **Published:** 2025, Jan 27

**Citation:** Kondratenko, V., Slovianov, L. (2025). Mathematical Modelling of Human Cognitive and Neurophysiological Systems for Biomedical Applications. *Biomed Sci Clin Res*, 4(1), 01-10.

## Abstract

The complexity of the human psyche remains a central topic in neuroscience, psychology, and biomedical science. This paper introduces a novel approach to understanding the human psyche by integrating cognitive and neurophysiological systems into a unified mathematical framework. The study proposes a formalized model based on logical predicates to explore the interplay between physiological and cognitive processes, shedding light on the mechanisms behind human thoughts, behaviours, and interactions.

The human psyche operates through two primary systems: the first signalling system, rooted in physiological responses, and the second signalling system, which enables cognitive functions like language, reasoning, and abstract thinking. Despite their interconnectedness, a lack of robust feedback mechanisms between these systems often leads to errors in perception, reasoning, and decision-making. This paper examines these gaps and their implications for mental health and behaviour.

The research builds on 14 foundational concepts, ranging from the physical basis of matter to the architecture of the nervous system, to establish a comprehensive theoretical foundation. Key highlights include

- The description of neural networks as the biological substrate for the psyche, emphasizing their adaptability and complexity.
- The identification of "harmful functions" in the psyche, such as selfishness, deceit, and aggression, which arise from evolutionary and genetic constraints.
- The development of a logical model that allows for the prediction and analysis of the psyche's normative functioning.

The mathematical framework formalizes the relationships between various elements of the psyche and its interactions with the environment. By applying logic and predicate theory, the study demonstrates how these relationships can be expressed in a structured and testable manner. This approach offers a method to evaluate mental processes, identify potential dysfunctions, and propose corrective strategies.

The findings have significant implications for biomedical science. The model provides a foundation for understanding the root causes of mental health disorders, bridging the gap between theoretical research and clinical practice. It also opens avenues for the development of diagnostic tools and therapies aimed at enhancing the feedback mechanisms between physiological and cognitive systems.

In conclusion, this paper presents a ground-breaking step toward the formalization of the human psyche's functioning. By integrating concepts from neuroscience, psychology, and logic, it offers a new perspective on the challenges and opportunities in understanding mental processes. The proposed model is not only a theoretical construct but also a practical tool for advancing research and improving clinical interventions in mental health.

**Keywords:** Human Psyche, Cognitive Systems, Neurophysiology, Mathematical Modelling, Mental Health

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## 1. Introduction

The study of the human psyche lies at the intersection of neuroscience, psychology, and biomedical science, representing a critical area for understanding cognitive and physiological processes. Despite significant progress in these fields, the intricate mechanisms that govern the integration of physiological signals and cognitive systems remain insufficiently explored [1]. This gap often leads to challenges in diagnosing and treating mental health disorders effectively [2].

A fundamental issue is the lack of robust and flexible feedback mechanisms between the first signalling system (physiological responses) and the second signalling system (cognitive and linguistic functions). This disconnect can result in errors in perception, reasoning, and adaptive behaviour, highlighting the need for a more cohesive framework to study these interactions [3].

Existing literature provides extensive insights into the physiological and cognitive components of the psyche. For example, the role of neural networks in mediating mental processes has been explored in neuroscience while psychology has focused on the behavioural manifestations of cognitive functions [4,5]. However, few studies have attempted to bridge these domains systematically using mathematical models [6].

This paper addresses this gap by proposing an integrated approach to understanding the human psyche. The model builds on established scientific concepts, such as the architecture of neural networks and the principles of signalling systems, to develop a structured framework. By employing logical predicates and formalized reasoning, the study seeks to establish a predictive and analytical tool for exploring the psyche's normative functioning and its deviations [7].

The significance of this research extends beyond theoretical exploration. By providing a mathematical and logical foundation for the psyche's operations, the study opens pathways for clinical applications, including improved diagnostic methods and targeted interventions for mental health disorders [8]. This integration of cognitive and physiological systems represents a critical step toward a more comprehensive understanding of human behaviour and its underlying mechanisms.

## 2. Methods

### Necessary Encyclopaedic and Widely Recognised Concepts in Biological Sciences for the Topic Concept 1: The Concept of Modern Natural Science Types of Matter

The cornerstone of natural science is the concept of matter, encompassing the world around us and everything that exists. Modern natural science categorises matter into the following types [9].

- Substance.
- Physical field.
- Physical vacuum.

Substance is the primary form of matter, possessing rest mass [10].

Physical field is a special type of matter that facilitates physical interactions between material objects and their systems [11].

Physical vacuum represents the lowest energy state of a quantum field [12].

## 3. Each Type of Matter is Examined in Detail

Substance, as the foundational type of matter with rest mass, consists of particles. For instance, visible objects are composed of molecules, which themselves are made of atoms. Atoms are comprised of nuclei and electrons, while atomic nuclei consist of nucleons, and nucleons are composed of quarks. Research into matter continues to evolve.

The physical field is a unique type of matter ensuring the cohesion of material particles and the transmission of influence from one particle to another. Metaphorically, a physical field can be likened to a “force web” binding particles together into unified systems, while allowing material bodies to pass through without damaging the web. Historically, classical physics strictly contrasted substance (discrete structure) and physical fields (continuous). However, quantum physics has revealed the dual wave-particle nature of micro-objects, showing that substance and fields complement each other.

The discovery of the close interrelation between substance and field has deepened our understanding of matter's structure. Modern natural science asserts that all physical fields and natural interactions are manifestations of four fundamental forces [13].

- Strong interaction,
- Electromagnetic interaction,
- Weak interaction,
- Gravitational interaction.

Efforts are ongoing to discover additional types of interactions in both the microcosm and cosmos, but none have yet been verified.

## 4. Strong Interaction

Strong interaction binds quarks into hadrons and holds nucleons within atomic nuclei, acting over distances of approximately 10-13 cm. Its theoretical basis is quantum chromodynamics, which explains how particles involved in strong interaction, known as hadrons, are composed of quarks. Examples of hadrons include nucleons such as neutrons and protons. Quarks interact via strong forces, which weaken as the distance between quarks decreases. Two key regions are considered.

- When the interaction radius exceeds nucleon size, the strong force manifests in nucleon interactions.
- When the radius is smaller than nucleon size, the interaction appears between quarks themselves.

Strong interaction ensures the stability of atomic nuclei. Despite the repulsion between positively charged protons within a nucleus

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due to electromagnetic forces, the strong interaction prevails, preventing the protons from scattering.

## 5. Electromagnetic Interaction

Electromagnetic interaction acts between particles with electric charge and is responsible for electromagnetic phenomena. This interaction underpins forces that allow matter to exist cohesively at atomic and molecular levels. For example, electromagnetic interactions

- Prevent atoms from disintegrating.
- Govern chemical and biological bonds between molecules.

The electromagnetic spectrum includes:

- Radio waves.
- Infrared radiation.
- Visible light.
- Ultraviolet light.
- X-rays.
- Gamma rays.

These interactions are essential at the macroscopic level, facilitating the stability of matter and enabling various natural and technological processes.

## 6. Weak Interaction

Weak interaction underlies many processes, such as particle decay and neutrino interactions with matter, acting at distances of approximately 10<sup>-16</sup> cm. Weakly interacting particles include leptons, such as electrons and neutrinos. Observed during beta decay of atomic nuclei, weak interaction plays a critical role in thermonuclear reactions within stars. Key characteristics

- It is far more intense than gravitational interaction,
- It is short-ranged, confined to distances smaller than an atomic nucleus.

## 7. Gravitational Interaction

Gravitational interaction manifests as the mutual attraction of objects with mass. Though negligible at microscopic scales due to small masses, it becomes significant at macroscopic and cosmic levels due to the immense masses involved. Characteristics of gravity include.

- Universal nature—affecting all objects with mass,
- Governing planetary orbits and star evolution,
- Playing a central role in the dynamics and evolution of the universe

For instance, gravitational interaction explains

- Earth's attraction exerted on objects,
- The orbital motion of planets around stars,
- The large-scale structure and progression of the cosmos.

## 8. Quantum Field Theory and Interaction Carriers

According to quantum field theory, interactions between substance particles are mediated by specific particles called interaction carriers. These carriers include [14]:

- 8 gluons for strong interaction,
- 3 massive gauge bosons (W<sup>+</sup>, W<sup>-</sup>, Z<sup>0</sup>) for weak interaction,
- 1 photon for electromagnetic interaction,
- 1 graviton (theoretically predicted but not yet observed) for gravitational interaction.

For instance, electromagnetic interaction between two electrons occurs via the exchange of photons. Many theoretical physicists hypothesise that all natural forces stem from a single interaction, manifesting in four different forms. The ultimate goal of fundamental physics is to develop a "grand unified theory" of these interactions. To date, only the electroweak theory has successfully unified weak and electromagnetic interactions.

It is hypothesised that during the Big Bang, a single unified interaction existed, which separated into four fundamental interactions as the universe evolved.

## 9. Physical Vacuum

Physical vacuum is not an absolute void. It represents the lowest energy state of a quantum field. Quantum field theory suggests that the vacuum continuously generates and annihilates virtual particles, which can transform into real particles under certain conditions. For example, in some experiments, particle-antiparticle pairs are created from the vacuum as energy converts into mass. The vacuum may exist in different states with varying energy levels, as confirmed by certain experimental predictions. However, science has yet to provide a comprehensive description of the structure and properties of the vacuum.

## 10. Levels of Matter Organisation

Modern natural science identifies the following structural levels of matter organisation [15]:

- **Microworld:** Consisting of particles such as molecules, atoms, and quarks
- **Macroworld:** Including entities comparable in size to humans, such as mountains, grains of sand, bacteria, and everyday objects.
- **Mega world:** Encompassing cosmic-scale bodies such as galaxies, stars, planets, and the universe as a whole.

## Concept 2: The Multicellular and Multi-Level Architecture of the Human Body

The multicellular and multi-level architecture of the human body is well understood [16]. However, significant challenges remain regarding information exchange between the components of this architecture [17].

At the boundary where continuous substance transitions into discrete matter, all fundamental interactions and physical laws originate, along with physical and cosmological constants [18].

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This stage, facilitated by the information accompanying every field and substance, demands close attention from scientists.

To this day, science has not identified either the generator of the meaning behind this information or its material transporter, equipped with a comprehensive set of properties and characteristics [19]. Furthermore, the mechanisms for exchanging information between the components of the complex, multi-level architecture of living matter remain unknown [20].

While the informational functions of the central, autonomic, and peripheral nervous systems are partially understood [21], the existence of communication channels between components of the human body's architecture beyond the nervous system is entirely uncertain (this is a hypothesis that requires further research).

### **Concept 3: The Human Nervous System**

The human nervous system is composed of neural networks of extraordinary complexity, permeating every one of the 248 known organs in the human body [20]. However, whether the intricate network of neuronal connections directly encompasses all 1014 cells, many of which are non-neuronal, is not established. A single interneuron (intermediary neuron) can have up to 150,000 synaptic inputs [22], resulting in an enormous number of intercellular connections. For example, the human brain, with its 1011 neurons, is estimated to have approximately 1014 connections [23].

If it were confirmed that neural networks encompass all cells of the human body, it would resolve questions about direct information exchange between cells of the same organ and those of different organs.

### **Concept 4: Sensory Organs and the First Signalling System**

The sensory organs of the human body are equipped with specialized electrical components called sensors [21]. These sensors measure specific parameters of the human body and transmit this data as current impulses through neural networks to a designated receptor in an automatic regulator, which maintains the parameter within an acceptable range [24]. This regulatory system is referred to as a closed-loop automatic regulation system (CAR) of direct action [25].

Simultaneously, this system reflects the parameter in the human consciousness in the form of a sensory stereotype associated with the respective organ. For instance, the visual image perceived by the eye. The CAR system is created by the nervous system based on a blueprint encoded in the human genome [26]. The information transmitted via neural networks is not encoded; the carrier of this information is the current value transmitted from the sensor to the regulator.

The CAR system is also known as the first signalling system of the human body, alternatively termed the reflex arc. The total number of reflex arcs in the human body is still unknown. While the number of simple reflex arcs can be estimated, the integration of sensory information with higher-level cognitive functions involves vast and complex neural networks, the full extent of which remains

to be elucidated [20,27,28]. Each thought, whether elementary or structured, can only be realized through a neural network arc.

### **Concept 5: The Second Signalling System**

With the emergence of speech in human communication, the second signalling system developed, serving as a tool of the human psyche to encode physical information (as described in Axiom 4) into words or their combinations in human language [29]. However, the second signalling system functions exclusively on the foundation of the first signalling system, without which it cannot operate correctly [30].

The presence of the second signalling system in the human body became a foundation for processing elementary thoughts, as each reflection formed by this system constitutes an elementary thought.

### **Concept 6: Thinking and the Logic of Material Existence**

The operation of thoughts is referred to as thinking, which is always aimed at identifying cause-and-effect relationships between elementary thoughts [31]. These relationships inherently reflect the causal connections between forces that drive matter. This is because the movement of matter is the sole reliable indicator of its activity [32].

The cause-and-effect relationships between the forces that drive matter can be referred to as the logic of material existence. In the process of studying matter, only the logic of its activity is revealed. This logic, in science, has been recognised as the natural laws governing the activity of both inanimate and living matter [33].

### **Concept 7: Experimental Discovery of Material Logic**

The logic of material existence can only be understood through direct experimentation with the specific matter of the universe [34]. Without such experimentation, it is impossible to obtain the necessary information about the properties of this matter, its interactions with the environment, and, more importantly, its cause-and-effect relationships with the components of this environment [35].

### **Concept 8: Consequences of Ignorance of Material Logic**

Ignorance of the logic underlying the activity of any studied phenomenon in the universe inevitably leads to the collapse of any cognitive endeavour [36]. Hypothetical theories cannot resolve this deadlock, as they stem from the imperfections of the human psyche, explained by its relative immaturity compared to the age of the animal world [34,35,37-39]. This imperfection lies in the psyche's current ability to operate with thoughts that are not supported by the first signalling system.

### **Concept 9: The Psyche in Organised Living Matter**

Living matter, including complexly organised animals with nervous systems, exists in a state of constant and eternal motion. This state not only led to the emergence of the psyche within such matter but also enabled the creation of diverse mental images based on it.

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Mental images serve as reflections within the consciousness of interacting pairs of organisms with nervous systems [40]. The psyche is defined as a property of highly organised matter, allowing an individual to reflect the objective reality of the universe and, based on the mental image of this reality, manage their activities and behaviour on operational, current, and long-term levels [41].

Reflection fixes the formed mental image of environmental influences in the memory of the subject's consciousness, necessarily aligning this image with the subject's worldview.

The highest level of reflection in living matter takes the form of the most complex and sophisticated type of reflection—mental reflection.

The consciousness of a particular individual integrates the diverse phenomena of human reality, transforming them into a truly holistic way of life for that person.

Consciousness represents a cohesive system of higher mental functions (HMFs), where there are no fundamental or secondary functions [30]. This system comprises equally important functions, numbering approximately 40 to 60, responsible for the highest level of human psyche operation. Psychologists classify these functions as artificial, instrumental, and voluntarily controlled by individuals, with a foundation in social development. However, neuroscientists, neuropsychologists, and biochemists assert that HMFs are implemented either through [42]:

- The genetic basis of stereotypical architectures within neural network fragments designed for specific purposes, or
- The genetic neural structure of the human brain, endowed with the capabilities of a Universal Biological Architect. This architect creates neural network architectures tailored to implement each HMF by differentiating neural stem cells within its population.

These two hypotheses remain to be confirmed by researchers in the near future.

The activity of consciousness and HMFs ceases upon an individual's death [43]. For new-borns, the development of consciousness and HMFs begins from birth [20,27,29-30].

### 11. Higher Mental Functions Include

- Mental reflection,
- Perception,
- Representation,
- Voluntary attention,
- Voluntary memory,
- Reasoning (extrapolation reflex),
- Speech,
- Writing,
- Logical thinking,
- Imagination,
- Consciousness,
- Nine gnostic functions (fundamental to the cognition of natural phenomena),

- 20 to 40 intellectual functions.

The human psyche, with all its HMFs, from the perspective of a neurophysiologist, combines the roles of two theatrical masters:

- A *scriptwriter*, describing the physiological phenomenon being studied in the language of reflections, where the key figures are physical variables engaged in the dynamics of the phenomenon;
- A *director*, repeatedly staging performances based on the existing script of the studied phenomenon, classifying the performance as a fragment of their own intellect on the topic of the fully researched physiological phenomenon. The director necessarily considers the impacts of the environment, interactions with the surroundings, and the mental simulation of the interaction of “self” with their own psyche.
- The psyche addresses the following life-support tasks for humans [44-47]:
  - Active but simultaneously subjective reflection of the real universe by the individual,
  - Adaptive regulation of the individual's physiological states in accordance with current environmental impacts and interactions,
  - Adaptive operational management of behaviour and reactions in line with current environmental influences and interactions,
  - The ability to mentally simulate the interaction of “self” with one's own psyche.

### Concept 10: Immaturity of the Psyche and Harmful Functions

The immaturity of the human psyche, as noted in Concept 8, is the root cause of the presence of more than 70 harmful functions within it [48]. These functions contradict moral behaviour even among members of the same species. Examples of harmful functions include [49]:

- Egoism, exploitation of humans by humans, falsification, authoritarianism, greed, aggression;
- Double standards, avarice, inflated self-esteem, envy, abuse of trust;
- Slander, deceit, laziness, fraud, deception, criminality, treachery;
- Robbery, pursuit of easy gain;
- Clan-based principles in ideological, political, scientific, and social activities;
- And many other vices.

These vices of the psyche are undoubtedly determined by the low quality of the human genome's design in the area responsible for the organisation of the psyche. It is certain that the progressive evolution of humanity will eventually eliminate these behavioural vices, just as the human species once emerged in the animal world [50]. However, this evolutionary process likely requires no less than a billion years. In the meantime, these vices have already led to the self-destruction of up to eleven previous human civilisations over just a few millennia. There remains a possibility of the self-destruction of our 12th civilisation. However, all of this occurs in the name of the progressive development of civilisations and must be accepted as a natural law of the progressive evolution of our universe.

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### Concept 11: Strategies for the Scientific Community

In the current situation, where understanding the mysteries of progressive evolution of the human organism [51], particularly its psyche, is paramount, two strategies are possible for the international scientific community [52]:

#### Option 1

- Avoid interfering with the natural secrets of improving the human psyche through progressive evolution of its genome;
- Maintain the existing paradigm of scientific activity within the international scientific community;
- Wait, potentially for a couple of billion years;
- Then, assess the newly evolved human psyche;
- Accept it as a satisfactory level of perfection for the scientific community in the realm of the psyche and create a new model of organisational management for this new societal community to ensure its prosperous existence;
- Alternatively, wait until the self-destruction of the current civilisation or accept the inevitable disappointment.

#### Option 2

Act without delay, here and now, within a specific state, by prioritising fundamental science and critically re-evaluating established dogmas. It may require abandoning certain research areas in favour of fundamental studies, focusing on understanding the logic of phenomena across the entire spectrum of foundational sciences and involving the global scientific community in this approach. No socio-economic system can fully provide the financial and material resources needed for such large-scale research. However, uniting scientific efforts, preserving previously acquired knowledge, and leveraging methodological possibilities can solve such an immense challenge.

Today, it is more evident than ever that a particular area of knowledge has become the bottleneck of the capacity filled to the brim with fundamental ignorance about our universe.

This area is the study of matter as a continuous substance and the ontological foundation of the universe with its discrete manifestations: secondary (substance) and tertiary (field) forms.

For centuries, the scientific community has faced the challenge of uncovering the relationship between continuous and discrete entities as specific physical realities of the universe and the mechanisms of their transitions, if such transitions exist. Unfortunately, answers to the most crucial questions about the world around us are still lacking.

As noted in Concept 1, matter has no structure and exists as a continuous substance—a homogeneous medium lacking discrete components or measurable physical quantities. Consequently, matter cannot be perceived by the known sensory organs of humans, even with the necessary amplifiers for each sensory organ. Sensory organs, with appropriate amplification, can perceive forms of matter such as substance and field. However, the mechanisms of matter formation and the laws governing them remain unknown

to the international community. Nonetheless, natural scientists do not doubt the genetic connection between the concepts of matter, substance, and field.

According to the author, all human, financial, and material resources of fundamental science should be directed towards understanding the concept of matter, its properties and characteristics, and the algorithms for the formation of different forms of matter [53]. This is a matter of the effectiveness of scientific research.

All other research problems related to various technological issues of microeconomics can be transferred to applied and commercial science or any scientific structures supporting such a priority hierarchy.

### Concept 12: Physical Vacuum in the Framework of General Relativity

According to the general theory of relativity, space is inconceivable without the physical vacuum. Indeed, in such a space, not only would the propagation of light be impossible, but scales for space and time could not exist, and there would be no physical spatial-temporal distances in any meaningful sense.

Experimentally, the physical vacuum has been established as a material medium represented by a quantum field. In this field, fluctuations occur, elementary particles are generated (excited states of the quantum field), electromagnetic waves propagate, and displacement currents flow through the field.

The physical vacuum is a form of matter, representing the state of a quantum field with the lowest energy [53].

To a first approximation, the quantum field can be imagined as space filled with charge quanta. That is, all energy levels of the physical vacuum are filled with quanta of the same sign (as described by Dirac's hole theory) [54]. Charge quanta are always in motion (since there is no matter without motion), and this flow of charge quanta is associated with a flow of magnetic quanta, known as the magnetic field. Thus, a quantum of the field is a continuously moving electromagnetic quantum, which is known to propagate solely in the manner of an electromagnetic wave.

### Concept 13: Scales of Space and Time

Space is a form of the existence of matter, characterised by its extension, structure, coexistence, and interaction of elements within all material systems [55]. Space expresses the coexistence, extension, and structurality of any interacting objects.

Time characterises the sequence of changes in states and the duration of existence of any objects and processes, as well as the internal connection between changing and persisting states.

A scale is the ratio of the size of an image to the size of the object being depicted.

The concept of “elementary particles,” firmly established in

modern science with geometric dimensions on the scale of 10<sup>-19</sup>, is inherently dual:

- They can exist as substances or as quanta of fields, depending on the parameters of the state of the medium in which they function [56].

This duality indicates that understanding the laws of matter's functioning using human sensory organs without amplifiers—for instance, amplifying vision by 10<sup>19</sup> times and slowing the rate of state changes in the observed natural phenomena by the same factor—is fundamentally impossible [57].

#### Concept 14: Advancing Instrumentation for Research

Currently, desktop film equipment with a resolution capability of 10<sup>15</sup> for amplifying and slowing the mentioned parameters exists. Initial research into living matter can begin using this existing equipment [58]. However, the parallel development of film equipment with resolutions reaching 10<sup>-19</sup> for these parameters would undoubtedly significantly enhance the efficiency of exploration [59,60].

It is certain that the necessary instruments for such research will soon be created. However, the organisation of scientific activities is crucial as it determines the effectiveness of science. The bottleneck of unexamined matter prevents any useful knowledge from escaping the sphere, which is already filled to capacity with fundamental ignorance about our universe.

The concepts presented above reflect knowledge about the world around us that, at certain stages of science, were not doubted within the scientific community. Over time, however, even these ideas have been questioned by individual thinkers. Today, each of these concepts contains contentious elements for various individuals. Nevertheless, they represent scientific conclusions.

For researchers, the formula “I know that I know nothing” may make sense as a piece of everyday wisdom, but it is absolutely unproductive in practice. A foundation is necessary for building the edifice of science.

The scientific thought process relies on reasoning as a method of reaching goals [34]. Such reasoning and the information it utilises must not be excessive to ensure the efficiency of goal attainment—meaning the shortest path in terms of time and energy expenditure. Wandering down false routes does not contribute to efficiency and introduces the temptation of adopting erroneous conclusions. The physiological aspects of the efficiency of human psyche functioning have been addressed by the author in previous works. This article demonstrates a mathematical model of the ideal psyche as the result of formalisation.

To analytically solve functional problems related to the normative activity of the ideal psyche in the human body at various scales of its reflection, we can present, for instance, the task of forecasting the sustainability of this activity in the format of a target theorem.

Supported by the 14 previously outlined concepts, the theorem carries the following semantic load:

**Concept 15:** "By strictly adhering to the knowledge outlined in the preceding 14 concepts, their logical conjunction guarantees the exclusively normative functioning of the human psyche [40]."

The semantic content of the theorem's conclusion is identified as Concept 15.

The entire problem statement must then be expressed in the language of first-order predicate logic to align with the methodology of automated theorem proving. To achieve this, the knowledge concepts should be identified with the term "axiom" assigned the number corresponding to the relevant concept.

To represent the target theorem in a formulaic manner, each of the axioms presented above in the article's context should be formulated as a first-order predicate logic formula.

## 12. Results

### 12.1 Mathematical Model of the Ideal Psyche's Functioning in the Human Body

To analytically solve functional problems related to the normative activity of the ideal psyche in the human body at various scales of its reflection, we can present, for instance, the task of forecasting the sustainability of this activity in the format of a target theorem. Supported by the 14 previously outlined concepts, the theorem carries the following semantic load:

**Axiom 1:** p<sub>1</sub>(X), where p<sub>1</sub> conveys the logical content of the context of this axiom, and the variable X identifies the organism of an abstract human.

**Axiom 2:** p<sub>2</sub>(X), where p<sub>2</sub> conveys the logical content of the context of this axiom, and the variable X identifies the organism of an abstract human....

**Axiom 14:** p<sub>14</sub>(X), where p<sub>14</sub> conveys the logical content of the context of this axiom, and the variable X identifies the organism of an abstract human.

**Axiom 15:** p<sub>15</sub>(X), where p<sub>15</sub> conveys the logical content of the context of this axiom, and the variable X identifies the organism of an abstract human.

**Target Theorem:** Based on the logical formulas of Axioms 1–15, the formula for the target theorem will be:

$$\begin{aligned} & (\forall X)((p_1(X) \wedge p_2(X) \wedge p_3(X) \wedge p_4(X) \wedge p_5(X) \wedge \dots \wedge p_{14}(X)) \\ & \Rightarrow p_{15}(X)) \\ & \Rightarrow (\exists X)((p_1(X) \wedge p_2(X) \wedge p_3(X) \wedge p_4(X) \wedge p_5(X) \wedge \dots \wedge p_{14}(X)) \\ & \Rightarrow p_{15}(X)) \quad (1) \end{aligned}$$

In order to significantly reduce the number of formal symbols in formula (1), we denote the formula by identifier F1:

$$(p_1(X) \wedge p_2(X) \wedge p_3(X) \wedge p_4(X) \wedge p_5(X) \wedge \dots \wedge p_{14}(X))$$

Then formula (1) will take a new form:

$$[(\forall X)(IF1 \vee p_{15}(X))] \Rightarrow [(\exists X)(IF1 \vee p_{15}(X))] \quad (2)$$

The structure of formula (2) includes two separate formulas connected by the implication operation:

- $F2(X) \equiv [(\forall X)(IF1 \vee p15(X))]$
- $F3(X) \equiv [(\exists X)(IF1 \vee p15(X))]$

In the theory of automated theorem proving [61-63], 27 formal rules of equivalent transformations of first-order predicate logic formulas have been defined and proven in order to reduce logical formulas to a canonical format containing only axioms and three logical operations (conjunctions, disjunctions, and negations). Two of them look like this:

$$(F2(X) \Rightarrow F3(X)) \equiv (IF2(X) \vee F3(X))$$
$$(F2(X) \Rightarrow F3(X)) \equiv (F2(X) \wedge \neg F3(X))$$

One of the rules states  
 $\neg \exists \equiv \forall$

One of the rules prescribes to free the formula from all universal quantifiers if there are no other quantifiers in the formula.

If we use these last four rules, then the formula (2) will take the following form:  
 $[IF1 \vee p15(X)] \wedge [\neg(IF1 \vee p15(X))]$  (3)

Formula (3) is a conjunction of only two contradictory components. This indicates its inconsistency, but also indicates the truth of the theorem as a whole, since the methodology of automatic theorem proving is based on the derivation of the inconsistency of the theorem formula as a whole.

Therefore, the theorem is successfully proven.

### 13. Discussion

What does a formal proven theorem, Concept 15 or Axiom 15 essentially establish? It establishes a connection between the known laws of the surrounding world and the normative functioning of the human psyche. It is the ability to connect this wide range of knowledge for the purposes of understanding, for example, mental functions or analysing statements as results of mental activity that is in itself the subject of the article's novelty. The former model also provides a number of advantages for effectively solving practical problematic tasks. Namely: the ability to accurately solve, simplicity and ease of use, efficiency and a way to combat information redundancy. By substituting specific values of X, for example, the name of a specific person, the model provides the ability to move from the general global model to considering statements concerning specific people or the results of their intellectual activity. The model is quite universal. It can be supplemented with any true statements that have confirmation in real life, and not in the world of abstractions.

### 14. Conclusion

The findings presented in this article offer a structured framework for exploring the functioning of the human psyche within the scope of biomedical science. By framing foundational concepts as

axioms and employing predicate logic, the model serves as a tool for understanding the normative activity of the psyche.

### Significance for Biomedicine

1. **Improved Diagnostics:** The proposed axiomatic model provides a basis for assessing deviations in mental and physiological processes. This framework may assist in identifying dysfunctions and developing targeted interventions.
2. **Interdisciplinary Collaboration:** The integration of neuroscience, psychology, and computational sciences fosters a broader perspective in studying the psyche. This interdisciplinary approach may contribute to a deeper understanding of mental health and its relationship with physical health.
3. **Potential Therapeutic Applications:** The logical structure of the model could inspire algorithms for mental health support systems. These systems might simulate normative scenarios, offering insights into therapeutic pathways.
4. **Ethical Perspectives:** By identifying the origins of harmful functions of the psyche, the model encourages discussions on ethical and evolutionary considerations in addressing mental health challenges.

### Practical Implications

1. **Standardisation in Research:** The formalisation of concepts ensures that studies on mental processes adhere to a unified framework, promoting consistency.
2. **Advancements in Bioinformatics:** Predicate logic aligns well with bioinformatics methodologies, enabling systematic analysis of data on mental and physiological health.
3. **Educational Impact:** The model's integration into medical education may enhance understanding of the interplay between cognitive and physiological systems.

### Challenges and Future Directions

While the theoretical model is promising, its application requires further exploration:

1. Translating the logic into practical guidelines for clinical use.
2. Developing technologies to simulate the psyche's ideal functioning.
3. Extending research to diverse populations and conditions to verify the model's applicability.

This basic mathematical model describes the normative functioning of the human psyche. Its potential for diagnostics, therapy, and education underscores its relevance to biomedical science. Ongoing efforts to refine and validate the model through interdisciplinary research are critical to realizing its full potential.

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