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RESEARCH ARTICLE

Mind–brain identity theory confirmed?

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Abstract

Presented here is a novel graphical, structural, and functional model of the embodied mind. Despite strictly adhering to a physicalistic and reductionist approach, this model successfully resolves the apparent contradiction between the thesis regarding the causal closure of the physical realm and the widely held common-sense belief that the mental realm can influence physical behavior. Furthermore, it substantiates the theory of mind-brain identity while shedding light on its neural foundation. Consciousness, viewed as an epiphenomenon in certain respects, simultaneously possesses causal potency. These two aspects operate concurrently through distinct brain processes. Within the paper, particular emphasis is placed on the significance of qualia and emotions, accompanied by an explanation of their phenomenal nature grounded in the perceptual theory of emotions. The proposed model elucidates how autonomous agents can deliberate on various action scenarios and consciously select the most optimal ones for themselves, considering their knowledge of the world, motivations, preferences, and emotions.

Keywords Reductive model of consciousness · Phenomenal awareness · Stream of thoughts · Motivated, emotional mind · Mind-brain identity theory · Perceptual theory of emotions

Introduction

The concept of causal closure has severe implications for understanding the essence of our consciousness. The assumption that the causal chain of physical processes in the material universe cannot be broken anywhere is a thesis stronger than the assumption of materialism/physicalism. As Justin Tiehen showed, the belief about the causal closure of the physical world is independent of the general materialistic attitude and reductionism (2014). To adopt a materialistic attitude is equal to believing that if we establish all physical facts, we will establish this way all existing facts. But if no change is possible without corresponding physical change, then it is reasonable to think that the mind must bring about physical changes if it is to cause any changes at all (Crane and Árnadóttir 2013).

The theorem about the causal closure of the physical sphere is strongly justified by the observed regularity of the world and the logically necessary symmetries that apply to it (Weyl 2016). Symmetry is a primal property of nature that determines the possible dynamic laws of nature and from it, follows the laws of conservation of observables in line with Noether's postulates (Hanc et al. 2004). Any interference with the laws of physics would violate the symmetry and, therefore, both the logic and coherence of the world, which would undermine the possibility of its existence (Spurrett 1999). If this is the case, the thoughts of humans and conscious animals cannot interfere with this physical realm. The belief that thought cannot do this turns out to be a major obstacle in explaining the influence of the psychic realm on the physical domain, mind–body, or mind–brain relationships.

So, where does our completely opposite belief that our thoughts are causal and can affect the material world come from? What is thought, and how does it interact with matter? These questions require a clear answer. Sect. "Causal closure and the mind" will consider the consequences of adopting the causal closure principle for solving the mind–body problem. Failure to adequately solve this problem leads us to undermine physicalism and recognize dualism, at least in the form of property dualism. We can remain on the ground of physicalism and reductionism if

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we bring forward a new interpretation of consciousness that removes the powerlessness of existing models.

The reductionistic approach is considered strongly suspicious and even trivial. However, Alexander's position (1920) seems right that if the object is considered really exist in nature, it must have causal power. But what about mental phenomena? Don't they exist in reality? This is the essence of the mind–body problem, focused on a question of mental causation. If we consider the causal cohesion of a physical domain and assume that mental properties are not reduced to the physical domain, how may mental properties have causal power for a physical domain? Some philosophers answer that the question of mental causation is a false problem based on unjustified metaphysical background and is entirely unnecessary. Others claim that the issue of mental causation can be solved through identity theory or eliminativism. These simplified solutions are called by Kim (1998) "Free lunch" solutions because they neglect or ignore the problem. No such approach is satisfactory for modern cognitive science.

The new model of the mind should cover the issues of perception, conscious decision-making, accompanying feelings, and phenomenal awareness. I accept and develop the reductive model of the conscious mind of Galus and Starzyk and the constructions of Lamme and Galus as the basis for the task formulated at the beginning. (Galus and Starzyk 2020; Galus 2023, Lamme & Roelfsema 2000, Lamme 2004). The Motivated Emotional Mind Model (MEM) developed there, depicts how the mind can demonstrate both access and phenomenal awareness. By proposing a simplified graphical form of the model in Sect. "Model of the Phenomenal Awareness", I explain how organisms can become aware of what they are doing and thinking and why the subjective awareness of the result is delayed in relation to the activity performed.

Sect. "Perception. Qualia" will discuss the essence of perceptions and giving meaning to percepts, and the connection between the ways of manipulating the environment and the body with the effects of these manipulations. The evaluation of perceptions to give them meaning and thus selective power is dominated by affective states of mind. As part of the perceptual theory of emotion, we will analyze in Sect. "The role of phenomenal experience in decision-making", how we experience feelings and emotions (Brady 2013; Salmela 2011) and how emotional states affect the reactions of organisms. In Sect. "Memories, imaginations", I describe how the mind learns about what is happening to it and its environment, that is, how the reporting consciousness evokes memories, dreams, and images of phenomena, objects, and their subjectively felt features. With a refined model, we can identify the biological processes that define the mind-brain interaction. These include the process of transmitting information in direct perception that directs spontaneous, reflexive, instinctive reactions without the participation of consciousness (Sect. "Mind–body interaction"). The independent process of retrograde up-down transmission of information and stimulation of the lower sensory brain fields results in the awareness of the effects of action. This moment of getting conscious has no direct impact on the behavior of the system/organism. In Sect. "How does the system act?", I will describe how, despite the epiphenomenal nature of reporting consciousness, a conscious agent can plan long-term actions and implement them successfully. When planning long-term action, it is necessary to consider various scenarios and choose the most favorable one from the point of view of the long-term good of a conscious agent, organism, or artificial system. I will state in this section what biological or computer process can accomplish this type of conscious deliberation.

The final conclusions and further expectations for the model are presented in Sect. "Conclusion". It summarizes the relationship between the three aspects of consciousness: perceptual, executive, and reporting consciousness.

Causal closure and the mind

At the core of the concept of the causal closure of material reality is a deep conviction about the deterministic nature of physical phenomena (considering the stochastic nature of some phenomena, particularly their quantum nature and the probabilistic interpretation of the wave function). The methodology of scientific research takes as a fundamental assumption the thesis that the exact causes lead to the same effects. The lack of repeatability of the measurement results is interpreted as a random measurement error possible to be estimated with the use of statistical methods; as a methodological error resulting from insufficient control of all measurement conditions; or as the detection of the influence of an unknown factor, sometimes leading to the discovery of new physical phenomena.

Observations of the world around us are accumulated by civilization and create common knowledge about the world. They are the basis of the development of science. Thanks to the progress of science, an increasing part of humanity shares the view that the world we live in is rational, regular, and locally stable. Jaegwon Kim emphasized the power and completeness of physics as follows: "… physics is causally and explanatorily self-sufficient: there is no need to go outside the physical domain to find a cause, or a causal explanation, of a physical event" (Kim 2005). If we accept this view, then there is no room in nature for any mental causality to occur as well. Not, at least, if mental causes are distinct from physical causes (*Irreducibility*).

By accepting the thesis about the causal closure of the physical world, we join the discussion that has been going on for many decades about its contradiction with the common belief that the mental realm has a causation effect on the physical realm (Kim 2005, 2009; Papineau 2009; Crane and Árnadóttir 2013). The contradiction is that the appearance of additional mental causes affecting the causally closed physical domain is, in essence, a violation of the laws of nature. The explanation for this contradiction prompts philosophers of the mind to adopt various positions. Especially if we reject this kind of over-determination, the inference may be the epiphenomenal nature of mental phenomena.

Another conclusion from this apparent contradiction is the rejection of all forms of irreducible physicalism. An example of this is the frequent in past stance that property dualism is true and physicalism is false (see Cleeveley 2015). Or we must somehow weaken the assumption about the causal closure of the physical world, for example, by a "difference-making" account (Kment 2010), or to claim that an event can have multiple causes (Kroedel 2015: 367–368, Crane and Arnadottir, 2013: 255).

None of the presented options has been universally accepted by the scientific world. Nothing indicates the necessity or even the need for such extreme assumptions. In this article, we will search for the explanation of contradictions by giving the concepts under consideration a slightly different meaning. As the authors mentioned above, Crane and Árnadóttir, I will defend the thesis that reductionism is possible. Moreover, I will argue that consciousness is, in some respects, an epiphenomenon, although this is not clear from the theses presented above. A proper model of the mind-forming brain can eliminate their apparent contradiction. The models listed at the outset can be furthered, more precisely formulated, and supplemented with convincing evidence of functioning. This work's main goal is to present a functional and graphical model of the conscious brain and the interdependence of brain processes leading to manifestations of consciousness recognized by psychology.

Model of the phenomenal awareness

The reduction of the mental states of natural brains to biophysical processes requires proposing a model of the brain whose architecture, structure, and functional features enable experiencing phenomenal sensations. Of course, the same structure should perform cognitive functions, thanks to which the brain can recognize the environment and learn appropriate behavioral responses. The criterion of adequacy is the achievement of one's own goals (intrinsic intentionality obtained in the course of evolution) or those imposed by the creator/constructor (induced intentionality).

Numerous models offer effective solutions to the problem of perceiving the environment, recognizing objects, planning, making decisions and actions that effectively implement the planned goals. Many of them were the basis for constructing artificial brains that effectively control robots capable of learning and intelligent actions (Del Pin et al. 2021). In specialized intelligent activities, models using deep learning (LeCun et al. 2015), reinforcement learning (Wang et al. 2020), or motivated learning (Starzyk 2011) often achieved results exceeding human capabilities. Philosophers classified problems related to decision-making processes in the brain as "easy problem" of consciousness, as opposed to the "hard problem" related to experiencing first-person mental impressions and phenomenal consciousness.

A consistently physicalistic model of brain processes was presented by Lamme, studying the neural processes involved in the decision-making processes that govern the responses of organisms. He distinguished the feedforward process of passing neural stimulations through the cortical network, which may mediate automatic, reflex-like, yet intelligent and complex cognitive behavior. And backward cortico-cortical interactions, mediated by feedback and horizontal connections (Lamme and Roelfsema 2000; Lamme 2006, 2012). A similar hypothesis was formulated by Galus and Starzyk, who also presented a simplified model of network organization capable of implementing these processes (2020). Both models assume a hierarchical structure of the neural network, corresponding to the hierarchical structure of knowledge fixed in the brain, which these structures represent. This hierarchy comprises successive layers of brain fields that process signals from the lower layers, starting with sensory cells.

Lame describes their operation using the visual domain example: "The cortical sheet contains tens of cortical areas, each with their own anatomical and functional characteristics. Cortico-cortical fibers connect these areas, so information can flow from sensory to other sensory areas, motor areas, and vice-versa. These connections define a hierarchy among these areas. Primary visual cortex (V1, also striate cortex or area 17), where visual information enters the cortex, is the lowest area in the visual sensorimotor hierarchy. From V1, information is distributed to the extra-striate areas (like V2, V3, V4, MT), and from there to areas in the parietal and temporal cortex, constituting the 'dorsal' (parietal), and 'ventral' (temporal) visual streams (Felleman & Van Essen 1991). The dorsal stream is mainly translating sensory input into motor behavior, while the ventral stream plays a central role in object recognition" (Lamme 2012).

This bottom-up process is called the Fast Feedforward Sweep (FFS) in his work. It reaches the executive centers in the motor cortex. In the process of learning and life experiences, processes of this type are recorded in the astrocyte-neural network, creating neural representations of the knowledge. In the work of Galus and Starzyk, these representations were called "semblions" following the works of Kunjumon Vadakkan, who first proposed such an organization and mechanisms for associating memory traces, engrams, into multi-layered semblions representing complex objects, a scene surrounding an organism or a conscious agent, or a model of the environment (Galus and Starzyk 2020; Vadakkan 2010, 2016). A sketch of the semblion is shown in Fig. 1 (with permission of the author: Galus 2023).

The figure shows only a fragment of the neural network representing the recognized object. The network is also a processor, transmitting signals from the lower sensory layers to the motor fields in the FFS process, and at the same time, it changes the strength of connections, consolidating the perceptual experience and thus facilitating the recognition of repetitive sets of stimuli generated by the environment or inside the organism.

An essential feature of such network organization, justifying giving it the distinctive name "semblion," is the ability to associate events occurring simultaneously in different brain regions, including different modalities. The criterion of associative coupling is the simultaneous occurrence of stimuli. The criterion for transferring the stimulation configurations composed in this way to higher layers is their number, extent, and strength of connections and similarity to previously fixed patterns. This type of architecture is, in fact, an associative memory, capable of learning to recognize objects and events in the environment. As we have shown in the book "Reductive Model of the Conscious Mind", this type of organization of the astrocyte-neural network allows for the implementation of the processes of categorization and generalization of perceived objects, which, combined with intermodal associations between neural fields, columns, and microcolumns, enables inductive and deductive reasoning (Galus and Starzyk 2020).

By supplementing the network fragment in Fig. 1 with the missing elements of the receptors of external and internal senses, executive devices—effectors, and the body connecting these elements together, we will obtain a model of a conscious organism presented in Fig. 2.

The model symbolizes the transmission paths of perception, interoception, and proprioception signals to the upper fields of working memory, which have direct communication with the executive fields and effectors. This main stream of transmission, symbolized by blue arrows pointing to the right, is the FFS process during which categorization and generalization of objects and phenomena in the perceived environment occur. They are recognized, and thanks to massive associations, a model of the environment is constructed. Thanks to this, the body can adequately respond to what it perceives. Reactions can be innate reflexes or learned and fixed in procedural memory. As I wrote above, the cognition process of FFS is entirely unconscious, and labeling the purple rectangle with the name "executive awareness" is a concession to the established tradition that the processes that control our actions are some forms of "consciousness" (Galus 2023).

The second channel of information circulation in the embodied, conscious brain is the body's response to proprioception and interoception signals and feedback about the state of homeostasis, the internal state of the body, employing an expanded network of interoceptors and proprioceptors. We will discuss the body's reactions in Sect. "Model of the Phenomenal Awareness". What is most important at present is the fact that internal sense perception is associated with cognition processes. Thanks to this, our knowledge recorded in engrams is emotionally marked (Galus 2023). Associated sensations influence the competition between signal configurations in the FFS process. In this way, organisms can select behaviors that are most beneficial from the point of view of the organism's well-being. Decisions are made taking into account all the body's consolidated knowledge about the effects of previous actions, the relationships between objects, the relationships between their components, and the model of the entire recognized environment. This knowledge is acquired in the course of learning or is passed on genetically (phylogenesis) and is recorded in semblions constituting the permanent, declarative memory of the organism, which, if it does not affect the behavior of the organism at a given moment, is subconscious. If it determines reactions, it is working memory or "executive consciousness," as it is called in the work of Galus (2023). Cognitive science calls it the "easy problem of consciousness" because there are many concepts of how decision-making processes can be implemented and how to build artificial functional models with such properties.

Our goal is to explain the essence and model phenomenal consciousness, i.e., first-person impressions, feelings, and mental experiences that constantly accompany cognitive processes and are used to optimize intelligent behaviors for survival. These kinds of feelings, emotions, and mental phenomena occur in two domains of brain functioning:

The first domain is experiencing impressions provided by the senses. It includes:

1. First-person sensory experiences during perception, the so-called qualia, i.e., the subjective perception of

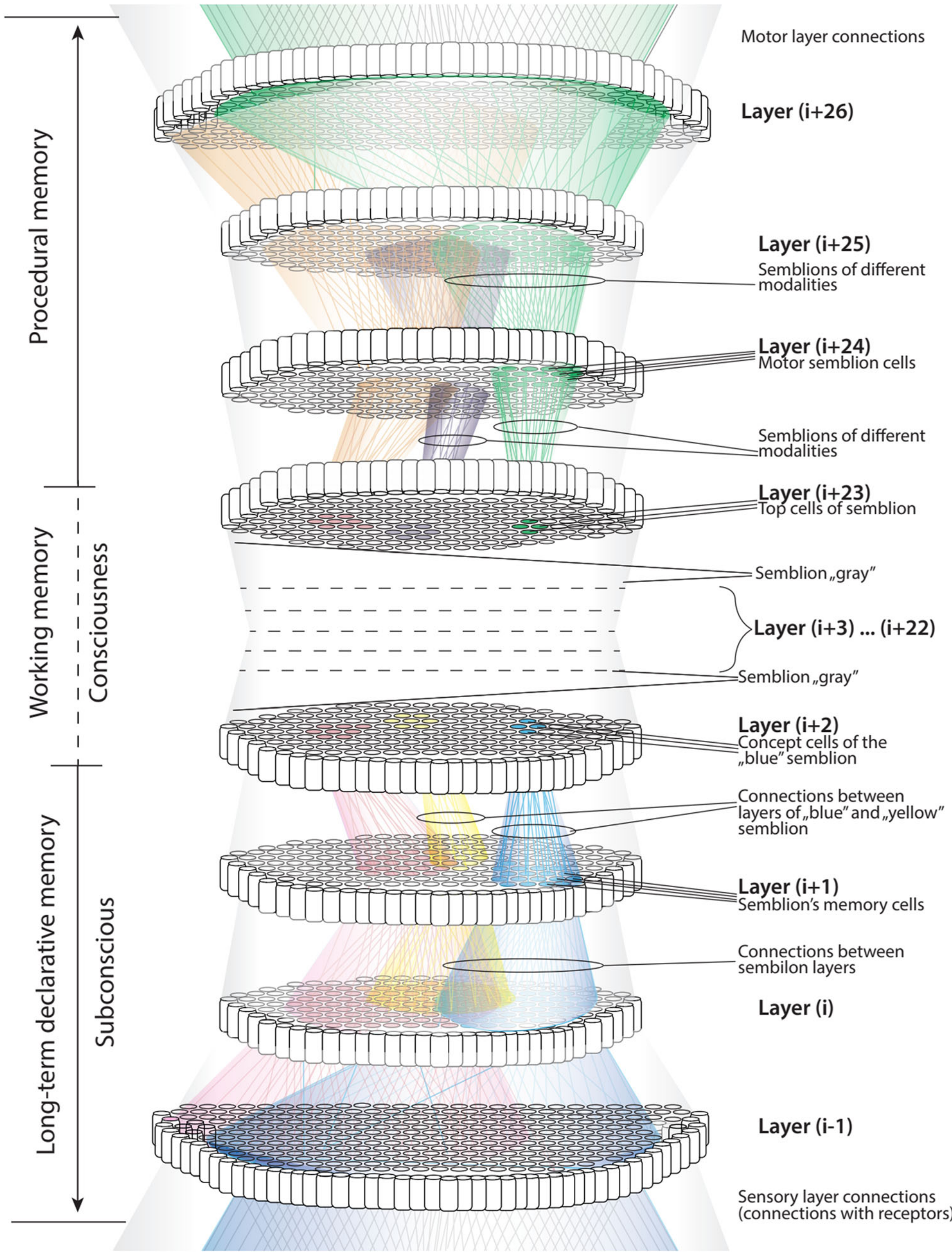

Fig. 1 The hierarchical structure of the memory. Only a few examples of connections are shown. The structure of semblions and subsemblions may be observed. Couplings between semblions aren't shown. Groups of memory cells in certain layers that are connected in a way that allows the transfer of stimulations between them are marked with the same color. Only existing tracks of stimulations leading from lower to higher layers are marked on the picture. Feedback stimulations and couplings between cells on the same level (layer) have been omitted. The figure shows that one cell of a higher level may be stimulated with signals coming from many lower-layer cells. The group of cells marked with the same color in particular layers symbolizes complexes corresponding to specific features of objects. We call them memory fields. Small memory cell groups (or single cells) representing memory field groups of many lower layers are called concept cells (cells marked with pink, yellow, and blue in layer i + 2). Above the apical neural fields, the cognitive semblions connect to the brain's motor fields' layers. In these layers, learned motor reactions are remembered, constituting the system's procedural memory after training (consolidation). The stimulations to act come from the top cognitive fields, dominated by the most forceful conscious arousal. The layers of semblions that activate the stimulation are called working memory

colors, characteristic tastes and smells, tactile sensations, slipperiness, roughness, etc.

2. Feelings of internal states related to homeostasis, kinesis, and behavioral reactions reported by the body's inner senses.

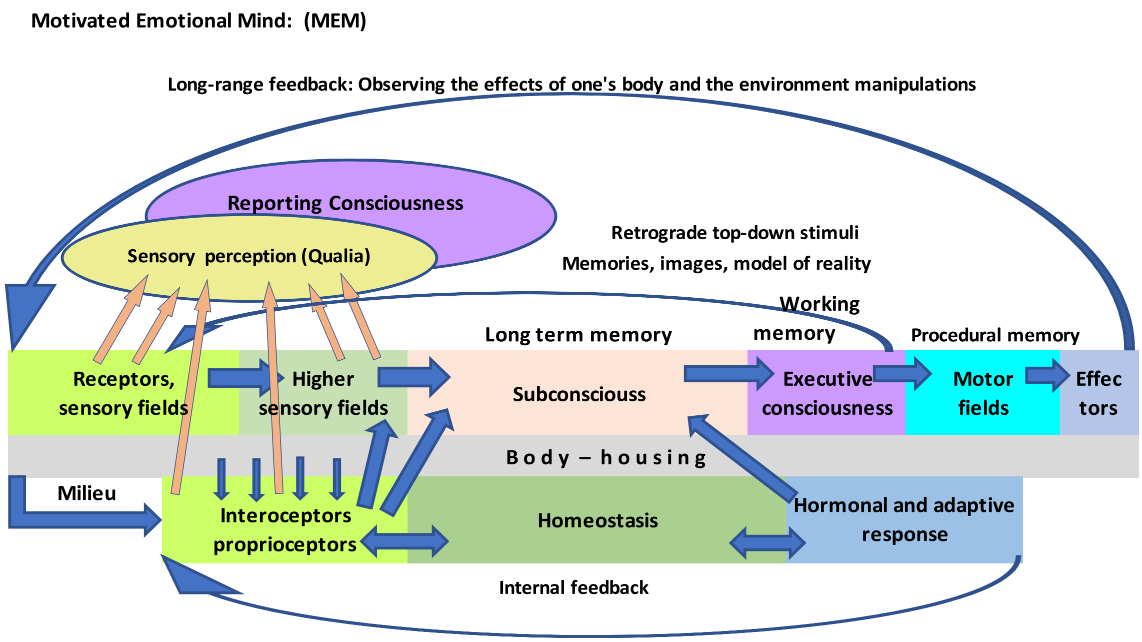

Fig. 2 The top bar symbolizes the processes in the cortical fields of the brain. It covers the perception of signals delivered by receptors, remembering in persistent memory, processing information in working memory, and controlling reactions through effectors. The broad blue arrows show the order in which the information is transmitted. The narrower gray central stripe symbolizes the body of the system. It is closely related to subcortical fields or peripheral centers symbolized by the bottom bar that controls system homeostasis. The interoceptor provides data for homeostasis. The adaptive homeostasis processes are realized mainly thanks to secreted hormones and neuromodulators. The elliptical fields represent the mental states of the system, with the yellow field corresponding to sensory perception in the primary, direct perception of objects and phenomena, the violet field corresponding to secondary visual images caused by memories and mental images, which we subjectively perceive as consciousness reporting the state of the system and its relationship with the environment. The long-arched arrows represent feedback: upper—through relations with the environment; middle—through the axons of the up-down neural network and the process of back activation; lower through the physical and biochemical effects of the body interior on interoceptors. Orange arrows indicate the sources of impressions and mental feelings

3. The second domain includes mental states not directly related to perception, among which the following can be distinguished:
4. Our dreams, images, and memories appearing in the imagination.
5. Emotions accompanying unsatisfied needs (intentional emotions in Brentano nomenclature).
6. Moods, unintentional mindframe such as anxiety, depression, relief, dejection (not related to a specific cause)

Our model should explain all these phenomenal sensations and answer the question of what mental states are and what their relationship is to the brain processes. I consistently reject dualism, remaining within the framework of physicalism following the postulate of Sect. "Causal closure and the mind". Disregarding eliminativism and various forms of panpsychism, it should be noted that also other trends, including behaviorism (sensations are syndromes of behavior and dispositions to behave) and functionalism (sensations are biological computational or otherwise "functional" processes), do not give a satisfactory answer to the nature of the relationship between the brain and the mind.

The natural solution to the problem for physicalists is to adopt the mind–brain identity theory, according to which mental states are only processes accompanying neuronal processes, in essence being nothing else than the states of the brain that generates these mental states (Smart 1959, 1961, Place 1956). However, Max Black's objections formulated by Ned Block (2006), and broad criticism of opponents, cast doubt on the legitimacy of such a position (Kripke 1980; Chalmers 1996). As Polger points out: "Identity theories claim that sensations are brain processes, but they do not take any stand on the nature of brain processes. … The identity theorist identifies sensations with brain processes, not with molecular or subatomic processes that occur inside brains" (2011).

However, to circumvent the contradiction and remove the explanatory gap, it is necessary to delve into the nature of biological processes. The presented model supports the Theory of Identity in a more profound and subtle formulation.

Perception. Qualia

Let's start by explaining what perception is and how impressions, or experiencing reality, arise.

The transmission of excitations from the receptors to the upper layers described in Sect. "Model of the Phenomenal Awareness" leads to the creation of mental images recreating the observed scene, supplemented by other modalities, sounds, smells, tastes, and tactile sensations. These mental images mainly arise in the cortex, including the entorhinal cortex and in the hippocampus. But also in the nuclei of the lateral geniculate body in the telencephalon, above the brain stem kernel, but in its close vicinity, thanks to which the semblion is co-created in the affective part (Damasio 2018). The merging of images of different modalities occurs mainly in the cortex but also in the thalamus with its cortical, subcortical, and cerebellar connections. When talking about images, we must remember that no structures are formed in the brain that resembles actual images. There is no music playing, no smells spread. Visual retinotopic stimulation arises only in the lowest. Primary visual fields V1 … V3, MT. The image maps disappear in the following fields. The categorization process selects the essential, salient features of the scene and recognizes what we are looking at from their set. From the fragmentary information, the higher fields of the visual cortex construct a coherent picture of the world. (Galus and Starzyk 2020). The brain recognizes them by comparing them with patterns, where their similarity is sufficient because one cannot count on the same stimulation of billions of synapses in millions of neurons. Many researchers compare perceptions to controlled hallucination—we predict what will be seen and adjust the percept to what is expected. In fact, this kind of anticipation does not occur. Representations of percepts are compared in the brain to patterns existing in the subconscious mind (Nave 2021; Galus 2023).

The aforementioned selection of the bottom-up configuration of stimuli and their dynamic adjustment through association with other analyzed stimuli according to the similarity to the remembered patterns is the equivalent of their recognition. The entire hierarchy of brain fields stimulated in this way constitutes a semblion representing a perceived object or phenomenon. They are the base of direct, primary, perceptual consciousness. So, the essence of primary, direct perception[1] is to recognize perceived objects to respond adequately.

How does phenomenal experience appear in direct perception? To create this type of feeling, it is necessary to embody the organism and create the feedback loop marked in Fig. 2 by the long arc of the arrow labeled "Long-range feedback: Observing the effects of one's body and the environment manipulations." According to the description, this coupling allows an organism with external senses to observe the effects of manipulating the environment and its own body. For the purposes of our reasoning, we consider teleceptive and exteroceptive sensing together. On the other hand, decision-making takes place thanks to the competition of bottom-up stimuli thanks to the spontaneous process of fast feedforward sweep (Lamme FFS) without the participation of conscious awareness.

Let the feeling of slippery be an example of a developing sensory impression. This kind of feeling cannot be described in symbolic language. The best efforts require poetic language: metaphors, similes, and hyperboles. On the other hand, we may experience a slippery feeling when gripping a wet piece of soap or a jellyfish. Trying to tighten our fingers on soap or catch a jellyfish, we can perform many trials and manipulations. Each time we see the results of our efforts. But most importantly, our senses, the proprioceptors of the skin of the fingers, provide us with direct sensory impressions. We associate our movements, feelings, and effects. We discover the similarities and subtle differences in gripping and catching soap, jellyfish, and slippery fish and the accompanying sensations. We remember these feelings just like other objects and events. It is these subjective, direct sensory experiences that we call qualia. Semblion of quale, associating with cognitive representation, becomes a subsemblion that adds phenomenal character to the accumulated knowledge. Thanks to this, abstract concepts are embedded in the associated sensory impressions. Thinking about soap, we can present not only propositional characteristics but also recall its slimy nature. We recall what our sensory cells sensed at the time. The lower brain sensory fields reproduce similar arousal and evoke similar impressions. The vast majority of notions are hybrid. They combine cognitive content and a phenomenal element. It appears as a result of sensory experiences.

Galus and Starzyk describe the meaning of qualia as follows: "… such a creature, animal or human, having the ability to recognize the elementary features of objects by feeling the direct sensory impressions they cause, will be

[1] Here, the term "direct perception" is used in a different sense than the commonly understood meaning according to Gibson's Theory of Direct Perception. Gibson's theory does not satisfy many researchers, and especially the "ecological optics" introduced by him raise doubts as to its explanatory power. The term "direct perception" I propose refers to the complex process of comparing patterns of signals

Footnote 1 continued
transmitted from receptors with patterns previously fixed in memory. This is a departure from Gibson's assumptions (1950). I introduce this notion to distinguish this kind of primary, direct perception from the secondary perception of impressions generated by lower sensory fields stimulated by backward signals from the upper brain layers, as will be explained in the following sections.

able to comprehend their meaning—for example, their suitability for planned activities. Man, feeling the hardness of the nail, will be able to assess whether it can be hammered into a slightly softer wooden board. Walking along the icy path, he will expect to slip, but given the roughness of the soles of his shoes, he will feel the stability of the steps, preventing a fall. By the brightness of a fruit's colors, he will be able to assess its ripeness, and by the smell of meat he intends to eat, he can assess its freshness" (2020: 38). The examples given show how important qualia can be for effective functioning in any environment.

The phenomenal character of qualia is the foundation of perception, leading to the creation of mental states representing the perceived reality. What transforms the direct reaction of sensory receptors fixed in the memory into conscious perception in the simplest case of direct perception? The perception process consists of: (A) Recognition of perceived objects by comparing their representations with patterns already stored in memory. (B) Associating the perceptions with the accompanying qualia and emotions. (C) Embedding such representations, emotionally charged, and through the semblions association, integrated with phenomenal experiences, into the model of the environment and the worldview created by the system.

Artificial intelligence algorithms are currently deprived of such capabilities. On the other hand, we are starting to equip robot bodies/housings with tele- and proprioceptive sensors. Therefore, we can expect the manifestation of qualia in robots if only we let them learn to feel them.

As seen from the above considerations, the perception process is strictly subjective. Although registering sensory signals can be described from a third-person perspective, the accompanying qualia and emotions are purely personal. They are generated by the body and senses reactions to the signals coming from the environment. The sensations that accompany experiencing these kinds of interactions are specific to the life history of each individual. This phenomenal layer, becoming a component of the representation of the model of the world, creates the psyche. It includes not only the material structure of the brain but also the past and present experience of the conscious individual's relationship with the environment.

Are we aware of this? Seemingly yes because such enriched percepts constitute perceptual awareness. Is it possible, then, that we can make decisions thanks to perceptual awareness? It seems not, because when the stimuli travel to the higher fields for approx. 200 ms, we are entirely unaware of it. (Frigato 2021). Comparing the triggering configuration with the patterns, through the association and interaction with the top–down signals and from other modalities, takes another 100–150 ms. Only then can we speak of awareness. However, stimuli spontaneously and autonomously reach the executive fields during this time. There is no place or time for deliberation and choice of response. We can see what our body is doing, but we have no conscious influence on these actions.

For many neuroscientists and philosophers, this is a critical moment on the path to understanding phenomenal experiences and subjective sensations. In the last decades, theoretical attempts have focused on the search for neural representations of percepts in the upper layers of the cortex responsible for cognition. It has been wondered how they can miraculously transform into mental representations. The activated neural network cell tree in the layers of the visual pathway creates hierarchical neural representations, semblions. It seems natural that the arousal of receptor cells in lower sense fields of the semblions is similar to seeing an image and images perceived in this way we call mental representations. Thanks to them, we perceive the world and the state of our bodies. The upper layers of the brain, by associating top semblion cells, representing more and more abstract features of perceived objects (concept cells), only recognize these sensory representations. They can perceive the general picture or select individual objects according to known patterns previously learned. This is done by focusing or switching attention and by mental saccades (Galus and Starzyk 2020).

From my experience, I know how difficult it is to accept such a thesis. After all, the retina in the eye resembles the matrix of pixels in a television camera. Does the camera "see" images? If not, what is the difference between the camera lens and our eye? Well, the camera is not connected to a computer/brain that recognizes the main structures and components of the image and does not build a model of the scene on this basis. It does not learn to compare and remember patterns of objects perceived. In the natural brain the lower visual fields, together with the retinal receptors, create an image. The upper visual fields recognize all spots, lines, textures, and objects and build the overall appearance of the scene from these elements. I tried to recall various objects and images, wondering what cells I was activating then. These must be neurons in one of the fields of the visual tract. Presumably, in the case of memories and images, these are not the cones and rods of the retina because the picture is not as clear as the images viewed directly. What's more, they are disturbed by the images coming from the eye. To recall familiar landscapes, we close our eyes to shut out these interferences. Everyone can check how difficult it is to imagine anything while staring at the light of a strobe lamp. (Unless we have the exceptional ability to focus, or after a long time of staring, the eyesight will become habituated). Ultimately, I was convinced of the presented mechanism through incredibly realistic visions during lucid dreaming. Waking up, on several occasions, I have literally seen my dream images disintegrate into tiny pixels under the intrusion of visual stimuli provided by my opening eyes.

To understand the role of sensory receptors, let's cite the simple psychological experience. Let's bring the outspread palms together and touch with the fingertips the same fingers of the other hand. Now we can freely switch our attention, focusing on any pair of fingers. If we concentrate enough, we will feel the contact between successively selected pads. Our brain understands which fingers are touching, but it is the finger proprioceptors that sense pressure. There is nothing else. The brain "understands" that there are many fingers and how they are located. But it is the proprioceptors that are aroused, and the signal of this stimulation is transmitted to the brain. Stimulation does not create a reflection of finger pressure in the brain. The complex geometric configurations of both hands create symbolic, propositional knowledge because we can define it in words, which is an attribute of access consciousness. What we cannot describe is the elusive feeling of pressure resulting from the activation of the tactile receptor. It is impossible to describe this impression because it contains no salient, distinguishing features. We could eventually describe more complex perceptual experiences, for example, changes in pressure, displacement, etc.

Similarly, other senses receptors "touch" the surrounding reality or bodily states of homeostasis. In this way, they create qualia. Qualia are mainly produced by receptors and sensory fields. Qualia of internal states, equivalent to affective states, are also produced by intero- and proprioceptors. There are no other mental representations. Each time we feel anything, the widely understood receptors of external signals from the environment, and internal signals, from the inside of our body, are active. The brain analyzes the images created by the senses, understands them by comparing them with the stored patterns, and incorporates them into the broadly understood model of the world. It isn't easy to indicate an alternative way of direct perception, so let's use this hypothesis in further discussion.

The role of phenomenal experience in decision-making

Phenomenal awareness of qualia improves the ability of organisms to recognize the situation in the environment and respond adequately. Let us recall that decision-making takes place thanks to the competition of bottom-up stimuli thanks to the unprompted process of fast feedforward sweep (Lamme FFS) without the participation of consciousness (Galus 2023: 10).[2] So where is the place for a phenomenal experience, emotions, feelings, and the influence of the psyche on our behavior?

As I wrote in Sect. "Model of the Phenomenal Awareness", it is the emotional markedness of the knowledge represented by the semblions that guides the processes of selecting the signals that control the most favorable reactions of the organism. The cognitive structure of semblions is supplemented by feelings accompanying current information processing and decision-making processes, and they can appear independently of the perception process. Mental states representing feelings and emotions become subsemblions of semblions of the organism's reaction and behavior patterns. As in the case of creating representations of perceived objects, the criterion of association is time coincidence and possibly the frequency of co-occurrence. Thanks to this, our knowledge recorded in engrams is emotionally marked (Galus 2023:15). Associated sensations influence the process of competition between signal configurations in the FFS process. In this way, organisms can select behaviors that are most beneficial from the point of view of the organism's well-being. Panksepp proves that the essence of becoming aware of sensory perceptions and transforming them into impressions that can influence behavior is to associate them with feelings and emotions (1988, 2004, 2005), which in psychology is called the "Indispensability Claim," according to which emotions are indispensable in acquiring knowledge of some essential values (Deonna and Teroni 2022; D'Arms and Jacobson 2010).

So, what exactly are these emotional states and feelings?

I am inclined to acknowledge the fundamental thesis of the Perceptual Theory of Emotion which generally assumes that emotions are forms of perception along the lines of sensory perception (Brady 2013; Salmela 2011, Printz 2004). The motivated, emotional mind system (MEM) provides humans and other living entities, for which this structure has evolved, intrinsic and evaluative information about their success in the quest for survival. Positive emotions indicate the experience of situations that are positively correlated with survival; negative emotions may be outcomes of evaluating situations that negatively correlate with survival. These raw emotions are ancestral memories that have been phylogenetically important for survival and, as such, have been genetically coded to be inborn capacities (Panksepp and Biven 2012).

Feelings represent the body's internal state, signaled by interoceptors located throughout the body in all internal organs. They represent the quality of their functioning—the

[2] Dreams testify to the automatism of cognitive processes. The action in the dream takes place automatically. We have practically no influence on it. Even strong feelings of fear or excitement do not allow us to avoid unwanted situations or continue with wanted ones. The activations of the semblions spontaneously form a chain of events. However, sometimes we remember them, and then we can use dream memories like other life experiences.

state of homeostasis. Signals from the interoceptor are transmitted to the brain mainly via the vagus nerve. This applies especially to sensors from the throat, heart, lungs, and abdomen and information from the digestive tract, respiration, and heart rate functioning.

In addition to interoceptor signals, information is transmitted to all body cells in the form of hormones, neuromodulators, and neurotransmitters released into the bloodstream, many of which have been identified and studied in detail. For example, a pleasant feeling of satisfaction is associated with releasing endogenous endorphins (Kringelbach, Berridge 2015). Stress, on the other hand, activates the hypothalamic-pituitary system and, through corticoliberin, releases dynorphin responsible for unpleasant feelings (Benjamin 2008). Others, such as cortisol, serotonin, dopamine, oxytocin, adrenaline, and many others, regulate the contraction and relaxation of smooth muscles, bronchial and tracheal constriction, the work of the intestines, stomach, etc. Adrenaline and norepinephrine, i.e., stress hormones, mainly affect the cardiovascular system, thus improving blood circulation, strengthening muscle tone, and increasing the heart rate. The released adrenaline increases the body's need for oxygen, increases body temperature, and the stress hormone—cortisol additionally increases blood glucose levels to provide the body with the energy it needs. All signals transmitted by streams of ions and chemicals reach from the body area and subcortical systems, i.e., the evolutionarily older areas, to the neocortex phylogenetically recent neopallium and its behavioral and awareness systems functions, processing information coming from the senses informing about the outside world.

Feeling inner sensations is possible thanks to the stimulation of these deep structures, which is why Solms equates the feeling of affective states with the stimulation flowing from the brain stem and subcortical layers. According to Panksepp (1998) and Solms (2021), the informational link of the body's homeostatic functions with the cortical centers of the brain is the periaqueductal gray (PAG) structure, which is the final common path to the affective output. As suggested by Merker (2007) and Panksepp (1998), perception is integrated in the superior colliculus (nucleus adjacent to the PAG), which represents the sensory-motor map of the environment. PAG, on the other hand, represents the needs of the organism. Together with the midbrain locomotor region, they form the decision triangle ensemble. This affective/sensory/motor interface gives value to associated representations of perceptions and the accompanying emotions, prioritizing individual streams of stimulation, i.e., the stimulation of individual semblions. Selecting the semblions dominating working memory, i.e., executive awareness, according to the priority of needs, ensures making the most favorable decisions about reactions to changes in the environment, taking into account the state of homeostasis (Solms 2021). Damasio and Carvalho (2013) also proposed this functional arrangement for what they called the "proto-self," emerging at an early stage of evolution. It may be an evolutionary precursor of the integrative functions performed by the intracerebral decision triangle.

Transferring information between humoral processes related to the release of hormones, neuromodulators, specific proteins, and even the concentration of simple substances or ions of certain elements to nerve cells, where they could be involved in the process of semblion formation, requires overcoming the blood–brain barrier. As Damasio points out, there are many opportunities for this, as many structures serve as terminals for such communication (2018). Chemical signals traveling in the capillaries douche these structures, thanks to which they can directly inform selected brain regions about the current state of homeostasis. (Craig 2009; Louveau et al. 2015). These include the farthest field in the brainstem, periventricular organs in the endbrain (telencephalon), and root ganglia, whose neurons have long axons distributed throughout many internal organs (McKinley et al. 2003; Devor 1999). We are dealing with the simultaneous transmission of information about all processes and states inside the body, both through the peripheral nervous system and the humoral path. Interestingly, Damasio suggests that perhaps peripheral system axons devoid of myelin sheaths may be directly responsive to humoral factors (Tang et al. 2007; Damasio 2018). For example, glutamate plays an essential role in the sensation of pain sensory perception by affecting the myelin-free C neurons and poorly isolated A-fibers, which also play a crucial role in forming feelings (Fernández-Montoya, Avendaño, Negredo 2017).

If we have a series of hypotheses about the mechanism of feelings, the question arises, what actually experiencing them? Where do they appear? The essence of feeling is triggering bodily reactions through all factors mentioned. We are dealing here with a complex, mutual relation: (a) perception of internal states; (b) physiological changes in the organism as a result of disturbances in homeostasis; (c) behavioral reactions; (d) the cognitive response of the organism. All these factors interact and create feedback loops that result in or seek to restore: homeostasis and evaluation of the effect achieved. Disturbances in homeostasis or external stimuli generate interoceptor signals (b) perceived by the system (a) and result in both physiological (b) and behavioral (c) feedback responses. Their secondary replication of the sensory perception enables access awareness and cognitive responses (d). In this way, they acquire epistemic significance (Brady 2013). Interaction in feedback loops can lead to an avalanche-like amplification of these signals, leading to panic or euphoria, depending on the source of the primary stimulation.

The thesis that emotions are manifested through bodily reactions was formulated by William James as early as 1890. According to this thesis, the body of animals and humans not only senses changes in the external environment with the help of receptors but also similarly senses the internal states of the organism with the help of interoceptors. We can feel the level of chemicals in the blood, blood pressure, temperature, body position, muscle tension, and the mutual arrangement of bones and body parts. This set of information allows us to create an image of our bodies. It is not about a geometric image but about understanding the proper state of homeostasis or its disorders. It is about all disturbances, sensations, signals, and circumstances that trigger bodily, somatic, or behavioral reactions, including mimic ones. Emotions are complex psychophysical states, including, among others, physiological processes, brain events (triggering cognitive-evaluating activities), feelings (subjective experience component), and behavioral phenomena.

Consistently reasoning, affective states should be identical to these responses.[3] Behaviorists, neurologists, and psychologists from Freud (1915) to Panksepp (1998, 2005) or Solms (2021) agree that affective states must be conscious. By definition, we cannot feel anything without awareness. Thus, the essence of phenomenal awareness is the above-mentioned reactions of the organism. Moreover, these responses lend a phenomenal character to the cognitive experiences of observing the environment.

Let us take a well-known example of feeling hungry.

The uncomfortable sensation of the desire to eat, or hunger pangs, is caused by the stomach's muscular contractions when it's empty. After a meal, our gastrointestinal tracts slowly empty by pushing food through the stomach and the small and large intestines. Specialized contractions called the migrating motor complex (MMC) sweep away undigested food. The final phase of the MMC is regulated by a hormone called motilin. Motilin-controlled contractions cause rumbling in our stomachs and coincide with hunger pangs in humans. Another hormone implicated in hunger control is ghrelin. In mice, ghrelin activates neurons called agouti-related peptide (AgRP)-expression neurons in the hypothalamus region of the brain, which tells us that we are hungry. This bunch of neurons is the control center for hunger. (Amin, Mercer, 2016). But it's not the activation of these neurons that causes hunger. Their excitation is a neural representation of hunger. Feeling hungry is a specific feeling of our stomach contracting. Thanks to the above-described processes and hormonal signaling, we experience it, recognize it, and can respond adequately. The theories of identity seem confirmed in this respect.

Internal communication must ensure that physiological signals, mainly chemical, generated as a result of metabolism and homeostatic phenomena detected by interoceptors reach the appropriate brain centers—the neural centers regulating the body's behavioral reactions. How does the organism "know" where to direct hormones and neuromodulators to the appropriate center? How can ghrelin be directed to the correct hypothalamus region? The organism does not know this. These substances are distributed through the circulatory system throughout the body. Simply put, in the appropriate "centers" of each feeling, neurons are equipped with specialized receptors capable of capturing substances addressed to them. If they appear, this center reacts to them in a specific way.

Similarly, other feelings can be recognized and associated with the body's corresponding homeostatic/bodily, somatic, and behavioral responses. Bodily reactions represent the organism's internal states and are closely related to the internal organs. We can mention here a plethora of examples: contraction and relaxation of smooth muscles, constriction of the bronchi, trachea, larynx, pharynx, obstruction of the airways, contractile gasping for air; behavioral reactions: emotions are expressed in facial expressions, body posture, the diaphragm tightens, which causes shallow breathing. Under stress, pressurized people tighten the anus and buttocks, and the weight of the body shifts from the metatarsus to the heels—that's why people move and stand differently. The kneecaps are pulled up; the thighs are stiffened; the muscles along the spine are also strained; the hair stands out; the eyes blink; the heart rhythm changes; palpitations. Next, let us mention somatic reactions: sleep disturbances, headaches of various natures, pain in the spine and joints, lack of energy, hunger, thirst, heartburn, itching, burning, numbness, colic, tingling, redness, pain in various parts of the body, sweating. And on the part of the digestive system: spasms of the intestines, stomach, flatulence, belching, vomiting, nausea, indigestion, constipation, irritable bowel syndrome, etc. And other psychogenic factors such as teeth grinding, dizziness, euphoria, etc.

Not only psychologists but also everyone from their own experience can roughly assign these symptoms to specific emotional states. Psychology has a great deal of literature on this subject. Each of these symptoms can be assigned physiological, endocrine states that interact with each of these states. The peripheral nervous systems and brain centers feel all these reactions, especially hormonal imbalances. Each of them transmits a correlated signal to

[3] Rodrigo Díaz (2021) conducted experimental testing of the subtraction argument to investigate whether emotions require bodily reactions. Research has shown that, subjectively, in the assessment of the tested persons, bodily reactions are not inseparable from the experienced feelings. However, the arguments of Panksepp and Solms remain more convincing given the subjective nature of these studies.

the peripheral or central nervous system and finds a neural representation there. Independent sensory and interoceptive tracks collect information about these states and link them with cognitive states, giving epistemic meaning to the experienced affective states. The idea that emotions are reactions to matters of apparent importance or significance, and grounded in our cares and concerns, suggests that emotions involve or motivate a behavioral response to such things. This is in line with our experience of emotion that a practical response engaged in an emotional reaction can be plausibly viewed as the mobilization of behavioral resources, which prepares the subject for action in response to the object or event, and which often or perhaps typically results in behavior. Emotional feelings do not generally resemble nonintentional bodily sensations, such as relaxation or agitation. Still, we learn about them via bodily feelings experienced in some part of one's body, such as headaches or "butterflies in the stomach." This again allows us to connect feelings with cognition and give them epistemic value (Leventhal 1982), which corresponds to the aforementioned Indispensability Claim (Deonna and Teroni 2022).

So, to the question formulated by Prinz: "Is emotions a form of perception?" (2006), the unequivocal answer is "yes." Seems, this is more precisely justified by Salmela (2011). According to him, emotions include somatosensory perceptions of physiological changes that are felt as either bodily or psychic feelings, and they resemble sense perceptions in their immediacy, qualitative richness, perspectival character, more or less impoverished inferential structure, stronger or weaker modularity, intentional aboutness, as well as in their liability to epistemic standards of the warrant. Nevertheless, as Salmela says, these similarities do not fully justify a generalizing interpretation of emotion as a kind of perception.

Brady exposes doubts about the epistemological claims of the Perceptual Model; however, his criticism is conducted from completely different positions (2013). It is assumed that there are significant differences between emotional and perceptual experiences at the epistemic level. In particular, emotional experiences, in contrast to perceptual experiences, do not seem to be reasons or evidence for the relevant judgments. According to him, a simple perceptual model is insufficient because emotions nevertheless have epistemic value, because by attracting attention, they facilitate and accelerate the evaluation of perceptual experiences. According to his arguments, perception itself, unlike emotions, does not make us look for the causes of reactions, beliefs, and judgments that our empirical experience of the world brings. So, it doesn't make it any easier to understand what we perceive.

None of the arguments above dispute that emotions can or do contribute to our understanding of value by attracting and absorbing attention. I am opposed only to blurring what is essential for emotions with what accompanies emotions empirically in the mental life of complex, rational entities.

The presented development of the MEM model illustrated in Figs. 1 and 2 enables a much deeper justification of the theses of the perceptual theory of emotions and dispels Brady's doubts. For this purpose, let us realize that the signals from the interoceptors consolidate their connections with the lower sensor fields of the semblions, as indicated in Fig. 2, with thick, oblique blue arrows pointing to the field of permanent memory and the higher sensory fields. There, they merge with the impressions created by other modalities with visual images, sounds, smells, and tactile sensations. Merging occurs in the subcortical superior colliculi and in the cortex, and the hippocampus plays the primary role at the highest level of integration. Still, the lower layers also have the possibility of association in the nuclei of the geniculate body in the cerebrum, above the nuclei of the brainstem, and thus co-form the affective part of the semblion. The coupling of stimuli signaling internal bodily and physiological states creates an effective evaluation system of the general state of the organism and the environment. From this level, they are treated the same way as signals from the sensory receptors controlling the environment. They impact beliefs, thoughts, judgments, perceptions, and decisions. Moreover, internal feedback loops can evoke memories of emotions and their re-sensing, just as feedback-stimulated visual fields generate recreated images, imagined visions, and memories of images.

This suggests that bodily responses not only accompany affective states but are the very essence of emotions. Of course, in the structure of the semblion, it would not be easy to distinguish the cognitive part—knowledge about the phenomenon, and the emotional part. The proportions between these components will be different in the case of individualized emotions than in the case of impersonal, pure emotional states. If we love "someone" or fear or hate "someone," we can usually supplement the storm of emotional feelings with a propositional rationale for why we love or hate him. We do this by associating neural representations from sensory fields stimulated by interoceptors with neural areas of declarative memory, containing knowledge about the objects of these emotions. The participation of associations with these memory fields will be much smaller in the case of such emotions as satisfaction, anxiety, or fear, where it is often difficult to identify the cause that brings us into these states. The semblions that represent them, in the lower layers, at their base, may have mainly interoceptors informing about the state of homeostasis. They are the equivalent of qualia produced by the senses that monitor the environment. Because emotions strongly influence the body's reactions, one should expect to associate the effects of acting under the influence of emotions with the feelings that accompany it. This is how semblions are created, representations of these specific qualia of emotional states.

The most significant difficulty is the primary, innate emotions that arise in the neonatal or infant stage when no associations with the higher brain fields can occur due to the lack of life experiences. It can be assumed that the feeling of pain and accompanying emotions is associated with innate pathways of transmitting stimuli and triggering bodily reactions. Such inborn semblions responsible for unconditional reflexes and instincts can be found in the brain structures in fMRI studies at the earliest stages of development.

Does it sound plausible that we recognize our feelings through bodily reactions?

Let's perform the inverse operation of the subtraction procedure on the example of a well-known phenomenon. If we have fallen in love with someone without even thinking about the object of love, we can feel general excitement, butterflies in the abdomen, redness, tightness in the breast, throat, and sexual arousal. Interoceptors inform about the absence of homeostasis disorders; we feel the stimulation of the brain's pleasure center located in the ventral tegmental nuclei area (the limbic nucleus of the midbrain, sending dopaminergic fibers to all structures of the limbic system), we feel an increased level of endogenous opiates, including a whole cocktail of fluctuating levels of endorphins, serotonin, oxytocin, dopamine, adrenaline, testosterone, etc., etc. Oh, and still intrusively recurring images of a loved one, favorite poses and behaviors, images of their voice, smell, and tactile sensations, but this is a complement generated by the external senses. Of course, our belief in hot love can be supplemented with knowledge about the abilities of the chosen one, her professional and family position, and her wealth. All this information complements each other, creating a passionate desire to be with the chosen one and remain with him for life. However, the neural representation of this relationship would be considered dry and cynical if it were not supplemented at the very base with the bodily sensations mentioned at the beginning. All these aspects of affection to a loved one can be handled by neural structures—semblions, postulated by the MEM model. What else could we add to this love relationship? If anything, why shouldn't this "something" has a neural representation that associates itself with a complete picture of this commonly known phenomenon? If, on the other hand, such a neural representation is possible, then it must be concluded that the MEM model well describes complex mental states with a high emotional charge and answers the question of "how we can feel a state of consciousness from a first-person perspective?" asked at the beginning.

The critique of the perceptual theory of emotions is concerned with the doubts of whether perception itself exhausts the depth of feelings known to psychologists and poets. Diaz's experiments testing the subtraction argument (2021) also questioned the extent to which the perception of bodily reactions could exhaust the richness of the emotional world. However, a century of psychological research in-depth by physiological investigations, and techniques for visualizing the work of the brain brings knowledge of such a multitude of these reactions that they can boldly aspire to describe the most subtle affective states. As illustrated, for example, in the case of the well-known feeling of love, in other affective states, the mechanism of emotion is similar. However, signals may come from other internal organs, another cocktail of hormones, neurotransmitters, and neuromodulators may bubble in the veins and brain, other brain centers may be stimulated, and different bodily reactions may occur. All this is reflected in new semblion configurations, generating immeasurable emotional wealth.

The argument that the perceptual model underestimates concentration or absorption of attention seems to be inaccurate as well because it is clear that strong sensory stimuli, whether they come from external sensory receptors or from interoceptors, will have the greatest stimulating power and according to the "Attention" mechanism described in the MEM model of Galus & Starzyk, will dominate the path of neuronal, mental and behavioral reactions. On the other hand, the epistemic meaning of emotions should be assessed very heedfully, bearing in mind that interoceptors' signals are not processed in multilayered neural structures capable of categorization and generalization and, therefore, cannot create abstract meanings, as is the case with sensory stimuli. These signals are often transmitted to the brain centers through the long nerve fibers, where they are consolidated with other modalities. Only such associated structures represent epistemic value used to evaluate perceived objects, events, and bodily states. Of course, in the initial processing stages, the strength, extensiveness, and location of the emotional stimulus can be assessed, which carries some conceptual value. Still, it is limited to the level appropriate to the qualia of the external senses.

For this reason, the sensations of the inner senses can be further treated as subjective sensory impressions as the raw material and the basis for creating knowledge about the environment and creating a model of the environment. This knowledge enchanted in semblions, dynamically tracking changes in the environment and the body, is used to plan an action, imagine, evaluate the effects of an action, and activate motor responses to the observed changes. In this way, emotions are woven into the unconscious "executive awareness" (Galus 2023). This paradox raises the question of when we really become aware of these emotions. Having the MEM model, we can conclude that in the case of direct perception, we feel them simultaneously with the perception of the surrounding reality. We will discuss the issue of emotions accompanying our actions in the next section.

Memories, imaginations

Signals of the proprioception responsible for emotions guide the selection of behavior scenarios, but this process is unconscious. So, when do we become aware of the emotions accompanying what is happening around us and in what we participate?

The answer requires a reminder that information in the neural network is transmitted not only up forward but also top–down, from the higher fields of the frontal cortex to the cerebral sense fields, as symbolized by the smaller internal feedback loop in Fig. 2. The retrograde, feedback stimulation of excitatory signal transmission paths causes the reconstruction in the lower sensory fields of the same neural states that occurred during the perception process. This process is called back activation (Meyer and Damasio 2009). If this feedback arousal is due to recalling, then our sense fields reproduce the sensations we had while remembering. The recollected image comes before the mind's eye, supplemented with sounds, smells, and other sensory impressions. If they were accompanied by emotional states permanently associated with this image, we might also experience a similar emotional state. In the quoted articles by Galus and Starzyk (2020, 2023), the authors suggest that it is precisely these recreated images, this restored mental imagery, that we perceive as becoming aware of what we are thinking about. What comes in front of our eyes and what our senses register afresh is similar to direct sense perception. These images, this movie that, thanks to re-stimulation, constantly scroll before our senses, we can recognize, register, and associate with new or old patterns in our memory. By subjecting them to categorization, generalization, and further associations, we can create new concepts, new ideas, and more complete models of reality supplemented with our emotional attitude, which becomes a significant criterion for evaluating the created knowledge. We become aware of our thoughts. If these recreated images are formed as a result of the activities carried out, our senses constantly generate a report of what is happening. That is why we call the consciousness shaped by this separate process "the reporting consciousness" (Galus 2023). The idea that consciousness plays a reporting role in the system's functioning has already been presented before, for example, in the work of Oakley and Halligan (2017). They attributed to consciousness the ability to report on mental states (which themselves remained unconscious). Now, however, this reporting role has been explained by a neural process taking place in natural brains.

Mental images themselves are a subjective phenomenal experience because dreams, hallucinations, images, and memories have a strictly personal, individual nature. No configuration of signals that mimic semblion arousal in one individual will produce similar sensory experiences in another. Each of us has different patterns of objects and phenomena fixed in memory, shaped by life experiences (group 3 of sensations in the second domain, listed in Sect. "Model of the Phenomenal Awareness"). Of course, memories or imaginations can be accompanied by other phenomenal constructs from different domains. These can be qualia (memories of sports adventures are usually accompanied by tactile, temperature, and sometimes colored sensations) and emotions (we can feel sadness, joy, fear, etc.). The hypothesis that restored mental imagery or illusory images is related to the stimulation of primary sensory areas has already been presented in the 'Imagery Debate' by many theoreticians and experimenters (Lee and Nguyen 2001; Cermeño-Aínsa 2021; Pan et al. 2012). However, the model MEM shows the neurological justification for such a location of perceptual processes and their relation to cognition (compare: Kosslyn 1980; Tye 1991). Experimental confirmation of the presented hypothesis is the work of Slotnick, Thompson and Kosslyn (2005), who demonstrated by fMRI imaging that visual mental imagery induces retinotopically organized activation of early visual areas.[4]

An interesting question is whether during lucid dreams when we experience the emotions associated with dreams, there is a retrograde back-activation of interoceptors and the endocrine system replicating the endocrine state associated with experiencing similar waking events. The chemical microclimate of the brain during sleep is determined mainly by neurons in the brainstem, which send their axons widely to the forebrain, spinal cord, and cerebellum. Among the chemicals released by these cells are dopamine, noradrenaline, serotonin, histamine, and acetylcholine (Pace-Schott and Hobson 2002). Ongoing findings support the cholinergic facilitation of REM sleep (Leonard and Linas 1994; Vasquez Baghdoyan 2001). The neurotransmitter of the cholinergic system is acetylcholine. Its level increases significantly during the thought process, especially in its initial stage, which requires increased attention, and also at the stage of memory consolidation (Kopf et al. 2001; Power et al. 2008). Since the REM sleep phase is associated with the quasi-conscious perceptual

[4] This changes our understanding of phenomenal sensations. Pennartz, for example, continues to claim (2022) that phenomenal experience is created at the highest level of representation. However, the opposite is true. This experience comes about through the lower sensory layers.

experience of dream visions, it can be presumed that the mentioned neurotransmitters and hormones accompany emotional experiences during dreams. Reporting awareness plays a dominant role during vivid dreams.

It is logically evident that this type of awareness cannot influence the events it reports, so the thesis presented in my works cited above that it is a local epiphenomenon (local in the spatio-temporal sense) finds justification. This thesis is supported by experiments showing that this report appears significantly delayed. Our brain and we ourselves first plan an action, make decisions, and perform planned actions, and only hundreds of milliseconds later do we realize what happened. The reason for this delay is evident when we will look at Figs. 1 and 2. We can see that retrograde top-down arousal must travel through many layers of the neural network before the executive awareness signals reach the sensory fields triggering reporting consciousness. The stimulation of the neuron in each next layer takes from one to a couple of milliseconds. Considering the estimated number of semblion layers, the total reaction delay can reach several hundred milliseconds, which is consistent with Libet's experiments (1982, 1985, 2003, Libet et al. 1983). Therefore, our reporting awareness cannot keep up with the "executive awareness." At the same time, it becomes a strong argument for the locally epiphenomenal nature of this type of consciousness.

To accept the thesis about even a locally epiphenomenal nature of consciousness is deeply inconsistent with most people's beliefs. After all, it seems to us that our thoughts guide our actions. Also, many philosophers, neurologists, and psychologists reject this view and claim that the conclusion about the epiphenomenal nature of consciousness is evidence of a flaw in the model. Let's try to get around this apparent paradox by using our model and the above explanations. First, as we wrote in chapters 3 and 4, qualia generated by perceptual awareness affect cognitive processes because they are an integral part of neural representations, semblions of cognitive knowledge. On the other hand, the processes that arouse feelings and emotions, although unconscious at this stage, influence decision-making processes; therefore, they clearly have causal power. The apparent explanatory gap concerns only the reporting consciousness when we become aware of our actions and their effects on the environment and the feelings and emotions accompanying them.

Mind–body interaction

Having a model of the conscious mind MEM, let's try to propose a solution to the problem formulated in Sects. "Causal closure and the mind" and "Memories, imaginations", and answer how the epiphenomenal, reporting consciousness, which corresponds to the phenomenal awareness, can affect the body's reactions in any way.

In the beginning, one must ask if it must influence at all. The answer is obvious. Reporting consciousness is the essence of our thinking and our general awareness. Travestying Nagel's saying, it is thanks to it that we experience "what it is like to be" aware. It is from the course of our thoughts that we expect a manifestation of the will to do what awareness suggests or imposes on us. But in section four, we saw that executive consciousness automatically determines our responses through the motor apparatus. Is it possible to break the dominance of executive automatism? Due to the constant competition of semblions for access to the executive channel, at the highest level of the hierarchy of neural representations of ideas and models of beliefs and views, there may be rivalry with well-established patterns of behavior radically contradictory to the patterns of immediate reactions. If their supervisory potential is sufficient, they can stop the automatic sequence of reflex or instinctive associations (Galus 2023).

This is not the end of the perception process and developing optimal responses. Although the automatic reactions are stopped, feedback signals are sent from the upper layers to the sensory fields. Sensualization, visualization, and thus awareness of one's own thoughts occur. The secondary images generated in this way are perceived by the senses in the same way as sensory signals in direct perception. One can call it the "secondary perception". There is competition between sensory perceptions from the environment, stimuli from within the body system, and visualized thoughts. The ability to perceive visualized thoughts, i.e., memories, dreams, and imaginations, results in the possibility of launching the executive awareness trail again and exploring the imaginary effects of new choices made at this stage. It results in the modification of the selection of action scenarios. This corresponds to planning an action without executing it. "Reporting Awareness" can re-visualize the effects of this planning. By associating the effects with our aims resulting from motivation (emerging mainly from unsatisfied needs), we can assess the effects of the planned action and choose the scenario that suits us best. This "choice" is equivalent to pre-activating the semblions representing that scenario. There is a kind of priming that determines brain processes in the ascending phase until the effectors are activated, and the planned action is carried out.

We can identify the whole process with the phase of reflection and consideration before making the best decision. When planning our action, we can imagine its effects and subject the entire plan to critical logical analysis in semantic terms and using "image schemas" fixed in memory according to the concept of Lakoff and Johnson

(2010). Using abstract concepts, we can then express a plan of action in the language of logic, mathematics, or another symbolic language (Galus 2018).

When evaluating planned actions, it is beneficial to imagine the qualia we expect to experience. For instance, if we already know the quale of soap's slipperiness (as described in Sect. "Perception. Qualia"), we now can imagine the touch of a bar of soap. We then can literally feel the slippery touch in our hand, sometimes aiding that feeling by moving our fingers as if we were grasping them. These impressions seem blurry and paler than in the case of direct perception. However, they are recognizable and allow for more effective planning of the action of grabbing the soap in the bathtub. The resulting mental correlation of the quale of slipperiness can be supplemented by association with an emotional attitude. Suppose the unsuccessful grabbing of the soap was accompanied by anger caused by impatience. In that case, the very memory of an unpleasant event can trigger the release of neurotransmitters, recreating the original mental state. This is done through the backward activation of the brain's associative fields along the paths down the semblion hierarchy, marked with the symbolically arched blue internal feedback arrow in Fig. 2. In this way, the semblions representing objects and phenomena gain firm valuation, allowing them to predict their actions' effects accurately. So, they, associated with a sequence of beneficial sensations, have a chance to dominate working memory and gain access to motor fields and effectors, as indicated by the thick blue arrows running from left to right on the colored bar simulating the brain in Fig. 2.

How does the system act?

How does executive consciousness steer responses? It is simply in the course of learning and life experiences that we develop connections between working memory and executive effectors fields. Suppose the selected configuration of arousal in this memory wins the competition with other stimuli. In that case, the most potent stimulation of the semblion corresponding to this configuration is transferred to these fields and further to the effectors. The scheduled action will be performed. The procedural memory that activates the necessary accompanying reactions is also helpful here (Fig. 1). The completed task is consistent with the entire system of knowledge, beliefs, and experiences supported by an emotional relationship to objects and performed activities. It complies with the will of the system. Our thoughts at the working memory and executive consciousness level have guided our actions. But it is a minor surprise that we receive a report of what we just did a fraction of a second later when we receive feedback signals to the sensory fields that will construct a picture of what happened, including the emotions that accompanied it. This delay does not matter when we plan an action and visualize the imaginary action before taking it. If we act immediately afterward, we may even have the illusion that our movement is simultaneous with our awareness of it. We can only be a bit surprised that the actual events sometimes proceeded differently than planned.

Does the hypothetical MEM model describe the implementation of long-term plans of people and animals or conscious, autonomous robots?

Sometimes we plan our actions in advance, hoping to achieve the intended result. However, the usually unpredictable dynamics of events disturb our plans of action. We act then spontaneously, often ineffectively. Tasks are only partially implemented, and reactions must constantly adapt to the dynamic situation. The correction seems obvious because we know that thanks to awareness, we can observe the impact of our actions on the achieved results. However, as we have indicated above, the perceptual consciousness does not keep up with the flow of events realized by the executive consciousness. We observe the effects too late to make adjustments to the plans.[5]

Now, we try to use the hypothesis of the MEM model to improve the selection of adequate system responses (deliberate decision).

Let us distinguish two cases. The first (A), when the action is taken under the influence of phenomenal consciousness ("hard problem" of consciousness). Its contents are emotions accompanying perception, feelings, affective states, moods, but also memories of objects and their features (qualia) and imaginations associated with the perceived reality. The second (B), when the decision to act requires overcoming logical and cognitive problems defined in abstract terms ("easy problem" of consciousness). This is the typical content of access consciousness, which we can formulate propositionally.

(A) Let's start with the first case. As we described in Sect. "How does the system act?", as part of the reporting awareness, we have a feedback mechanism that informs the system about the current course of action and visualizes planned actions. Thanks to this, the system can imagine the planned moves and thus predict their far-reaching effects.

[5] This analysis of planning and decision-making methods requires distinguishing between automatic, drive, reflexive or instinctive action and conscious action, which results from deliberation and planning. We deal with the drive or instinctive actions in situations when logical analysis is impossible due to the necessity to make immediate decisions or when our knowledge is insufficient to make rational decisions. This situation applies to almost the entire animal world, the behavior of which is determined by direct perception and executive consciousness.

As I have indicated above, the unprompted operation of executive consciousness can be temporarily suspended and delayed. This can be done under the pressure of motivation by triggering a top-down, learned pattern of "delayed action," such as the "image schema" (Galus 2018; Lakoff and Johnson 2010). During this time, the feedback of the stimulation of the reporting consciousness generates a multimodal visualization of the planned course of events. This requires the functioning of the so-called "dynamic semblions" that can record representations of events in episodic memory (Galus 2015). The new states of the sensory fields and the entire hierarchy of modified semblions are stored. The subconscious has changed. Now another round of analysis of the planned actions can take place, but with the awareness of the expected effects and with a new state of consciousness. Information circulates in a cycle:

1. delay of immediate response—>
2. realizing the current state thanks to the reporting consciousness (retrograde activation process)—>
3. perception of the visualized current situation—>
4. transferring information to the upper cognitive fields (FFS)—>
5. selection of the dominant scenario—>
6. and so forth …

Repeating this sequence many times allows you to optimize the system's response and implement your own medium- and long-term plans. Of course, the information is transmitted continuously. In the upper layers, it includes small fields of semblions representing the model of behavior (Galus 2022). Downward transmission excites millions of cells of receptive fields, reproducing the scene of planned action. Thanks to these processes, higher animals and people, who can suppress immediate, spontaneous reactions typical of reflexes and instinctive action, are capable of deliberation, long-term consideration, and planning. Thanks to this, their planning and thoughts are accompanied by an imaginary movie presenting what they are about to do.

(B) The second case seems more complex than the first. The obstacle is that abstract concepts cannot be presented to our senses, so we do not have sensory representations of these concepts.

Feedback links do not extend to the areas of the visual, auditory, tactile, or olfactory cortices. Retrograde visualization/sensualization of these concepts and ideas is impossible. Decisions are made based on a logical analysis for which memorized, innate, or learned logic schemes are used. These schemas are represented by the aforementioned "image schemas" proposed by Lakoff and Johnson (2010). They include elementary concepts of embodied linguistics and mathematics, such as top–bottom, part–whole, plan–background, greater–lesser, container scheme, recursion, and subitation (Galus 2018). The localization of representations of these schemes, in the form of semblions, can be expected in the frontal cortex, where decisions are made.[6] Problems are solved by associating them, likening, and matching them to known schemes. The process is most often led to the state of "understanding," which corresponds to modifying the problem representation to a form consistent with the current model of reality. Then, the model agreed on this way, dominates working memory, and has access to execution fields and effectors. Decisions made become effective.

Of course, because the usually considered objects, phenomena, and scenarios are of a hybrid nature, combining the phenomenal layer with the propositional layer, both aspects are analyzed in parallel, simultaneously. The behavioral model which is selected is the resultant of stimulation generated by both streams of information (if it is physically possible).

The brain operating according to the MEM model with associative memory architecture, covering both cases (A) and (B), is possible in robots and artificial systems. In that case, they can plan their actions rationally and consciously, like higher animals and humans. In systems where this procedure is less efficient, it is still possible to act intelligently in response to the current situation. Most animals and machines live only in the present time, using perceptual and executive awareness. The interaction of reporting and executive consciousness allows humans and higher-order animals to rise to a level of understanding not only of the current situation but also planning for their future. It also allows them to influence it in a planned way.

Conclusion

The presented model can be used to verify previous speculations about mental causation. An example is an interesting attempt by David Papineau (2013), who uses an incomplete understanding of the laws of thermodynamics to save the causal role of the psyche.[7] Papineau notes that: fundamental laws are reversible (time symmetrical), and macroscopic laws are irreversible (time asymmetric). This is an apparent incoherence between the micro and macro worlds. Therefore, as he claims, it is possible that mental

[6] Particularly, concepts are encoded in the human Medial Temporal Lobe by an assembly of neurons, called "concept cells," that respond to stimuli representing a specific object, phenomenon, or location. (Quiroga 2019; Galus 2022a; Quiroga et al. 2005; Waydo et al. 2006).

[7] Papineau infers from the so-called laws of physics. However, he forgets that they are only models of reality. We have no evidence that there are any time-reversible processes in nature. The existence of such phenomena would violate the fundamental CPT symmetry.

states affect complex, macroscopic objects and have mental causal power without violating the fundamental laws of the microworld. Assuming that the neuronal (physical) states P are the realizers of the mental states of M, he posits the following thesis (page 5): "Considering the evolution of the system from states P to P*, it can be assumed that it is not the neuronal states of P that are the cause of P*, but the mental states M. However, the M state can also be realized by a slightly different P' state if its similarity to the P state is sufficient. So, it is M that is the real cause, not P or P'." So it is mental states that cause physical states, which contradicts the causal closure of the physical realm.

The presented model allows for resolving this apparent contradiction. According to our model, the M state is also an effect of P or P' because it is a mental state generated by feedback excitation (back activation) flowing from higher-level semblion layers into the sensory fields, creating reporting consciousness. Therefore, it is an effect that accompanies the neural states of the executive consciousness, which has an intrinsic, self-existent causative power. It is clear (the underlying assumption of the MEM model) that if there is sufficient similarity between the P or P' states, they will be able to excite the higher layers of semblions in the motor cortex and cause similar responses. The mental state of reporting consciousness M is an effect of the P or P' state to the same extent as the P* reaction, and it cannot, therefore, have any causal power. Thus, it was possible to reconcile the deterministic functions of executive consciousness with the subjective feeling of the impotent stream of reporting consciousness. The risk of recognizing and accepting the dualism of property as formulated in Sect. "Causal closure and the mind" has thus been definitely removed.

We can therefore confirm the Mind–Brain Identity Theory without compromising the way of feeling qualia, feelings, and emotions and visualizing memories, dreams and imaginations, and all phenomenal sensations. Our executive consciousness is responsible for our reactions to the surrounding environment, and our reporting consciousness generates the accompanying psychic world. But as we have shown here, the psyche also arises through material biophysical processes. We must confirm that the thinking and acting of conscious agents are entirely material. At the same time, lovers of classification divisions can maintain the belief in the dualistic nature of the world, pointing out that phenomenal phenomena are caused by other neural processes than access consciousness, which is equivalent to executive consciousness. We can clearly see that our conscious experiences can be epiphenomenal in a way, and at the same time, our thinking keeps causative power.

The MEM model can also solve other philosophical dilemmas due to its grounding in a hypothetical biological structure. Its effectiveness in this respect is difficult to predict, but it seems that it contains innovative elements that break the explanatory impotence of the existing models. The explanation of many philosophical dilemmas so far seems insufficient, the most important of which are:

1. Feeling of qualia and perceptual consciousness.
2. Subjective feelings of emotions.
3. Mental causation. Mind-brain relationship.
4. Understanding the surrounding reality and one's role in the environment.
5. Free will.

Significant innovations in the MEM model to re-attack these problems are:

a. Distinguishing two aspects of consciousness served by two independent neural processes.
b. Postulate of backward activation in the sensory and emotional domain, resulting in the reporting consciousness.
c. Modification of object patterns, reaction patterns, and knowledge structure by perceiving mental imagery created by reporting consciousness.

Thanks to these innovations and the new approach, I proposed a deeper understanding of problem 1., and a preliminary explanation of problems 2. and 3. I believe that soon, the even stronger explanatory power of the MEM model will be revealed in the interpretation of many studies aimed at understanding natural brains and the minds they create. Moreover, this model may be a clue for attempts to build an artificial, conscious, emotional brain.

Structure of consciousness

Attempts to define the phenomenon of consciousness have encountered difficulties. They seemed insurmountable because they strived to explain a multifaceted phenomenon, realized by completely different neural, biophysical, and behavioral phenomena, using one definition, one process or property of matter. The basic structure of consciousness includes three main aspects: Perceptual Consciousness, Executive Consciousness, and Reporting Consciousness. Their mutual relationship and cooperation in creating a sense of consciousness symbolize Fig. 3.

The perceptual consciousness (red circle) that generates the phenomenal consciousness is individual and strictly personal because it is shaped by the characteristics of one's own body, the specificity of the environment, and one's own experiences in this environment. The processes of categorization and generalization abstract salient features from the percepts, and thus they can be symbolically

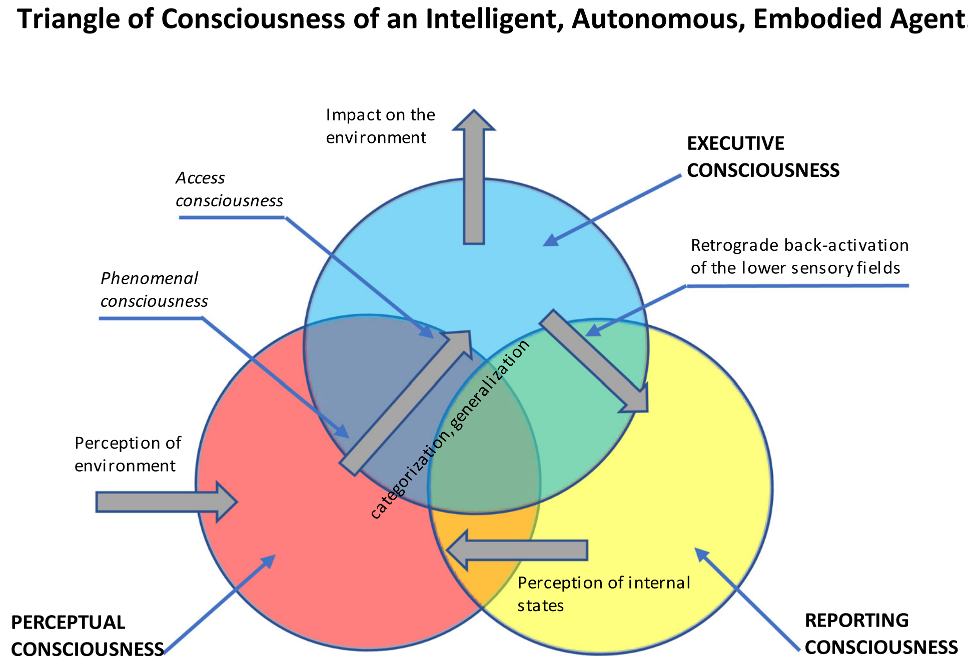

Fig. 3 Triangle of consciousness. The colored circles symbolize the main aspects of consciousness: perceptual, executive, and reporting consciousness. Gray arrows symbolize the flow of information between areas of the neural network in which the processes responsible for particular aspects of consciousness are located

described. In this way, such consciousness is transformed into propositional, access consciousness. Associative processes allow constructing of the environment model, supplemented with emotionally marked objects and phenomena, creating executive consciousness (blue circle). Here symbolically formulated knowledge can be logically processed. The direct interaction of executive consciousness with effector fields results in the performance of selected actions. Retrograde stimulation of the lower sensory fields evokes memories, mental images, and engrams of performed, imagined, or planned actions. They report the actions of the agent/system and its thoughts, considerations, and intentions. This is the essence of reporting consciousness (yellow circle in Fig. 3).

In this way, the identity theory found confirmation in biological and information processes. As we have shown, this does not contradict the fact that these processes produce phenomenal consciousness. It is clear now how the interplay of biological, mechanical, or computer processes creates phenomena that conscious beings perceive as mental or affective states.

Secondary perception of the internal states of neurons provides information that is re-categorized and re-generalized by modifying the hierarchical structure of knowledge, which reflects the hierarchical organization of the brain's neural fields. Observation of the effects of one's own actions and manipulation of the surrounding environment, as well as the registration of internal nervous states carrying information about emotions and feelings, allows for the assessment of knowledge. It is used to select the sequence of stimulation leading to the most beneficial behavior from the point of view of the agent/system. This makes an autonomous, embodied entity that exhibits this kind of complex consciousness capable of intelligent behavior according to its own set of motivations. His mind, acting in line with the MEM model, becomes an intentional being. Our sense of consciousness involves experiencing all aspects of it simultaneously and coherently.

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