Research Article

Semblions of Words — The Language of Natural and Artificial Neural Networks

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The hierarchical structure of metaphors, as linguistic concepts and other mind tools embodied in Lakoff's cognitive linguistics terms, requires an indication of the mental representations in human minds and the corresponding biophysical representations. The author claims that the searched biophysical representations, which are the basis of mental representations, may be hierarchically related neurons called semblions. According to the connectionist concept, the hierarchical structure of a neural network emerges during the learning process and concurrently constitutes a memory. Semblions of objects, concepts, ideas, and models can be associated on a neurological level with neural representations of phonemes heard simultaneously while perceiving objects and creating their representations. This way, new higher-order semblions are made, corresponding to the words. The work shows how stimulating semblions can cause recall, association, thinking, and other higher mental functions necessary for using natural language. In this way, the reconstruction of mental states takes place based on the propagation of neuronal excitations. The author also indicates why semblions representing mathematical concepts adequately describe many physical world phenomena. At the same time, their polymodal counterparts can be used for a metaphorical description of qualia. The complementarity of the associative memory model proposed by Horzyk with the model of the architecture of self-conscious systems proposed by Galus, which can be used to build artificial self-conscious systems that reasonably use both natural and formal languages, was pointed out.

The further development of recursive models of consciousness leading to the presentation of the Motivated Emotional Mind (MEM) model has confirmed that in the process of bottom-up information transfer responsible for creating semblions, rules of similarity are utilized from engrams representing knowledge in the mind to patterns of neural excitations transmitted from the lower sensory layers of semblions. The functioning of the multilayered architecture of brain fields based on the principles of searching for similarity patterns aligns with the hypothesis of using metaphors in subsequent processes of generalization and association, forming the basis for higher mental functions, and creating the semantics and syntax of the language.

1. Introduction

The study aims to show that recently discovered extensive neural structures, which are neural representations of perceived objects, can be a biophysical basis for remembering sensations of varying degrees of generality, from simple stimuli, through subjective sensory impressions (so-called qualia) to complex images of a scene and general concepts, ideas, and models of reality. These remembered concepts and impressions can be associated with sets of sound or picture signs, creating a language of communication. This hypothesis makes it possible to consider whether the recently proposed self-learning structures for parallel processing of memory contents allow the design of artificial cognitive systems to create language and use it intelligently in the environment of other autonomous systems, not excluding people.

Natural, developed language of communication is one of the skills that distinguishes humans from all other living creatures. This also applies, and even more so, to formal languages, including mathematics. With the help of language, we can describe the most subtle emotional states, extraordinary subjective impressions, complicated logical relationships, highly complex structures, material and mental structures, and precise, strict relationships of mathematical structures. The amazing flexibility of language allows us to transfer our feelings and ideas to other people who share the same language. The compliance of the mathematical structures created in our minds describing the models of phenomena with the experimentally confirmed laws of nature and the actual course of these phenomena is even more interesting. Progress in understanding the principles of our mind's functioning allows us to consider hypotheses about what brain processes are responsible for producing such a rich and effective language and how we obtain the ability to describe the world around us adequately. The starting point for these considerations will be the perspective of cognitive linguistics. We will not, however, deal with the hypothesis of the language of thought of Fodor and Polyshyn, computationization, or the vision of formal language, most fully developed by the school of Noam Chomski and his followers, distinguishing syntax as the basis of language structures and setting a framework for semantics (Chomsky, linguistic theory 1982).

In light of the achievements of modern cognitive science, the postulates of the existence of a so-called linguistic module, or an innate, universal grammar modified by local forms of natural languages, have limited usefulness for explaining how the mind produces language. Mathematical linguistics relating to regular languages does little to explain how the mind creates abstract concepts of natural language. Most animals communicate effectively in the language of gestures, facial expressions, smells, and inarticulate sounds that cannot be analyzed logically, and their grammar is certainly not formal. On the other hand, it is possible to search inside the human brain for structures that play the role of a "language module" postulated by Chomski, which we will do in the following chapters. Interestingly, simple prematematic concepts can be formulated in a natural language, far from formalism. However, creating a regular formal language requires language processing at a high degree of generalization according to the principles of logic accessible only to human minds. Chapter 5 will consider the possibility of using an information model to build an artificial system that consciously uses natural language.

2. Tools of the Embodied Mind

A constructive approach to creating the concepts of language and its grammatical structures should be identified with the concept of the embodied mind and the role of metaphors. The structure of linguistic concepts and relationships reflects the motor experiences and spatial relationships we experience through contact with the environment. Basic, subjective sense impressions, the so-called qualia, are the basis of terms that describe elementary sensations and perceptions of specific objects. The higher cognitive functions, abstraction, categorization, generalization, associations, and further idealization carried out on their basis shape abstract concepts, complex models, and the corresponding linguistic constructs. This process is described in detail in the works of Galus (Galus 2015 a, b, c). Even complex mathematical concepts reflect our familiar sensations of moving the body in space or directly observing objects. This applies to the notions of a class or sets abstracted from everyday experiences of operating sets of objects collected in a limited space, the concept of a derivative of a function derived from the observation of real, dynamically changing body movements, as well as a gradual approach to the boundary of the area or the finish line ending the movement. The concept of recursion also derives from the experience of repetitive events and deliberately organized activities (Lakoff, Nunez 2000).

According to Lakoff and the followers of the cognitive tradition, the tools of the embodied mind in shaping language are image schemas, the aspect system, and conceptual metaphors. Imaginary schemas combine cognitive, perceptual, and conceptual functions, i.e., language and reasoning with perception. The authors refer to commonly used schemas: up-down, part-whole, background plan, and container diagram. In the linguistic description, the structure of events is defined by the "aspect". Considering that all motor processes have a general structure reflected in the descriptive language, we can consider it as an aspect system. (Lakoff, Johnson 1999).

Cognitive linguistics, justifying the idea of the embodied mind, attaches great importance to the role that mirror neurons play in human brains. Vittorio Gallese and Alvin Goldman believe those mirror neurons are the basis of the important mechanism of "embodied simulation" (Gallese, Goldman, 1998). Gallese describes brain simulations as "... an automatic, unconscious, pre-reflective functional mechanism leading to the modeling of objects, people, and events. It takes part in creating mental representations, so it is the basis for learning about reality. " (Gallese, 2009, p. 196). Simulation, in this sense, is not only an imitation of observed motor behavior but is a mental process where the stimulation of mirror neurons generates thought processes similar to those occurring in the mind of the observed subject. This allows you to guess intentions and understand partners' intentions in social relationships. It is the basis of empathy, i.e., the ability to imagine pain and joy and all other mental states, to understand the causes of these states that are dear to us. This may result from the willingness to exchange information about these states, which is conducive to language formation. According to Frans de Waal, the capacity for empathy, combined with the maternal instinct, leads to altruism, the broader the view of the world and the greater the awareness of one's role in this world. This leads to collaboration and learning as a socialized process, which also fosters language development (de'Waal 2014). According to Vilayanur Subramanian Ramachandran, the structures that contain mirror neurons play an essential role in creating abstract representations. Due to their polymodal nature, they can play a fundamental role in creating metaphors (Ramachandran 2012).

Both Lakoff himself and his followers have pointed out that the act of understanding language usually means finding in mind a known counterpart to an object or process described in words. This can be interpreted as finding a metaphor that corresponds to these objects. We must have become acquainted with these counterparts of objects or processes during our life experiences. So, we understand statements by finding metaphors that correspond to them in our memory, just as we recognize objects and processes by comparing them with patterns embedded in our minds. George Lakoff and Mark Johnson argue that: "... the entire conceptual system within which we think and act is inherently metaphorical" (Lakoff, Johnson 2010). Metaphors can be characterized as understanding and experiencing a thing in terms of another thing or generally transforming objects of one realm into objects of another realm. This definition covers both the level of bodily experience and the level of linguistic expression. What is less important here is the similarity of sets of objects and more the similarity of the structure of relations between them. Transferring ready-made structures to new fields of cognition allows for raising the level of abstraction in the cognition process. The highest levels of abstraction relate to issues of mathematics and formal logic.

To explain how the theory of metaphors can create the language of mathematics, cognitive science introduces the concept of embodied mathematics alongside the embodied mind. The embodiment of mathematical abilities means that they arise from our animal, primitive numerical competencies, such as estimation, subitation, rudimentary counting, addition, and subtraction, but also from everyday experiences, including the perception of spatial, static, and dynamic relationships and the orientation of our own body towards neighboring objects, operations of grouping objects in a space bounded by a "container," using a symbolic notation, persistent repetition of actions "endlessly," etc. However, real mathematics requires harnessing subtle metaphors, the hierarchies of which are introduced by Lakoff and Nunez (2000). It is difficult to imagine mutual communication without understanding the intentions of the interlocutor, thanks to simulation and without the use of metaphors. Especially the description of direct, raw sensory impressions, the so-called qualia, is not possible without the language of metaphors and even the language of poetry. It is impossible to describe the taste of wine, the smell of a rose, or the sound of a flute without referring to polymodal metaphors. Therefore, the fundamental role of the embodied mind's tools in understanding the world and in formulating the language of social communication should be recognized. More complex objects usually have more well-defined features and therefore are subject to logical analysis and much more accurate description, which we will discuss later.

Of course, this kind of cognitive program is not appreciated by Neoplatonists. They argue that the language of metaphors cannot be precise enough in formulating logical analyses or complex mathematical models relating to physical reality or abstract. They point out that the theory of metaphors is speculative and full of inaccuracies unacceptable to mathematical minds. Another objection concerns the sources of the stability of the accumulated knowledge and its cumulative nature in the ontogenetic and cultural sense, which is difficult to explain with the "metaphorical" method of acquiring knowledge.

Andrzej Pawelec, for example, points out that understanding the meaning of a perceived object or a recognized sign cannot be the result of recalling its metaphorical form. He criticizes Lakoff's model, in which we have two layers: the basic structures of meaning that seem to emerge in "direct experience" physical and derivative meanings resulting from transfers and integration of elementary systems. The layer of direct meanings is supposed to be the result of "gestalt perception, motor projects, and detailed mental images" (Lakoff 1987: 267); Pawelec claims that it cannot be assumed that in communing with the world an automatically stable representation of this world "emerges." Take mental pictures, for example. Referring to Piaget, Pawelec writes: "... the image is neither an element of thinking itself, nor a direct continuation of perception: it is a symbol of an object, and one that is not yet manifested at the level of sensory-motor intelligence.. Stable representation of an object in mind results from a symbolic imitation of that object, e.g., distinguishing it from other objects, showing it with a gesture, or drawing it. An object's "essential" structure can only emerge in mind through symbolic actions... " (Pawelec 2005). This thesis clearly contradicts the following model of building a hierarchical structure of mental representations and the corresponding biophysical representations of the perceived reality. From the qualia to the level of the world model in which the embodied mind operates.

Lakoff and Johnson (2010) retort that metaphorical representations work systematically and can achieve the necessary precision, covering all events, scenarios, and relationships between objects of many domains. The above accusations are also successfully refuted by Bartosz Brożek and Mateusz Hohol, pointing out that linguistic and psychological data indicate the effectiveness of the metaphor theory. The theory of metaphors fits into linguistic phenomena such as polysemy and the change of meaning of concepts and, at the same time, explains them. In psychological, behavioral research using priming, it has been shown that metaphors still dominate the conceptual structure, determining images and decisions despite strong priming. In developmental studies on the formation of metaphorical ability in young children, it has been shown that metaphorically appears in the second stage, when the child gradually learns to project a conceptual structure from one domain to another.

Similar effects have been demonstrated in psychological studies on gestures and their comparison with the accompanying verbal explanation (Brożek, Hohol, 2014). Brożek and Hohol supplement the tools of the embodied mind with the use of symbols, "imitation," and social interactions that create culture. They are all closely related to each other because symbols are the foundation of human culture. Without them, culture and science could not exist. Imitation is a unique cognitive ability of the mind that man has mastered most perfectly. Perhaps it results from neotenia in humans, as many animals learn through imitation during their infancy and early development. Human infants, too, are real machines for imitating their parents' behavior. But the ability to imitate is also the basis of cultural development. As the authors write: "... imitation plays a fundamental role in the emergence and evolution of culture." And further: "... the cumulative cultural evolution along with the evolution of mathematics... is made possible by a specific cognitive ability formed by natural selection: I M I T A T I O N. Imitation creates a "cultural trap" effect when the accumulation of cultural development effects makes it impossible to go back to earlier stages. "We can modify inherited cultural products and add new inventions to them, which in turn, by imitation, are learned from us by subsequent generations." The authors strongly support the concepts of mind, embodied mathematics, and Lakoff's theory of metaphors. They write: "... Lakoff's concept (metaphors) best explains the genesis of many cognitive abilities. At the same time, it seems to be the only existing scientific theory that systematically explains the genesis of mathematical cognition".

3. Genesis of cognition

Note that when talking about simulations, metaphors, imagery schemas, and other tools of embodied mind and embodied mathematics, it is essential to point to the neural mechanisms that could perform these functions. The theories of Lakoff and his epigones do not point to the neuronal background and specific biophysical processes responsible for the ability to use language. They also do not indicate a method of computational modeling that would allow, even in the distant future, to transfer the natural language to the artificial intellect so that it could be understood by other living or artificial people. Progress in the study of the biophysical processes underlying neural processes makes it possible to outline the process of language formation,

Searching for the biological basis of our linguistic abilities requires referring to the architecture of consciousness of natural minds because without awareness, it is impossible to know and understand, and without them, communication using language cannot exist. The model of architecture capable of understanding natural language includes a specific semi-hierarchical structure of neural modeling fields postulated by Perlovsky (2001, 2007), in which processes of creating neural representations of perceived objects take place. At the biological level, these neural modeling fields correspond to clusters of synaptic islets that act as spatially extended charge probes capable of responding to the distribution of electric charges carried by excitatory signals in accordance with the principles of Neuro-Electro-Dynamics of Dorian Aur and Mandar Jog. (Aur, Jog 2010, 2007). The interactions of space-time "directional pulses" (in terms of Neuro-Electro-Dynamics) generated by the electric fields of signals and coupled neurotransmitter complexes are accompanied by deformations of the structure of the protein chains that make up the synaptic channels and charge flow paths in the dendrites, axons, and perikaryon of the neuron. Changes in the structure of proteins require the complementarity of spatio-temporal distributions of directional pulses with the local topology of electromagnetic microfields of protein molecules. This complementarity is the basis for finding the similarities of newly incoming sensory stimuli with the molecular structure of synaptic and neuronal elements formed in the course of learning, constituting short-, medium- and long-term memory. On the other hand, deformations of this structure due to intense or repeated excitatory impulses are the basis of memory plasticity, enabling learning.

A model that considers these interactions is presented in the essay "Architecture of Consciousness" (Galus, 2015a, 2015b, 2015c). According to this model, neural modeling fields form a multi-layer semi-hierarchical structure in which the stimulation of patterns recognized due to their similarity to patterns embedded in memory is transferred to higher layers (bottom-up signals). Since the stimulation of several dozen to several thousand synaptic fields is needed to stimulate the neuron of the higher layer, this information transport involves a huge compression of information, and the hierarchy of stimulations creates the so-called semblions or excitation trees turned with the "crown" down. The term "semi-hierarchical" is related to the fact that the structures thus created have an inverse hierarchy of reverse and parallel top-down stimulation. The name "semblion", corresponding to the name "semblion" introduced by Kunjumon Vadakkan (Vadakkan 2011, 2012a, 2012b), denotes the neural structures that form the biological basis for the representation of elementary mental perceptions at the sensory level, up to the concepts, concepts, ideas, and models on increasing levels of symbolically defined conceptual structures. Thus, semblions, as neural representations of what we perceive or remember from previous experiences, are specific configurations of hierarchically organized structures of "neural modeling fields" according to the Perlovski nomenclature. They are organized by consolidating the pathways of neuronal excitations sent to the synaptic fields of neurons through synaptic channels, dendrites, and axons, as well as neurons traveling through the soma. We are dealing here with the strict equivalence of the semblion in the biophysical sphere with its mental representation in the psychic sphere. Stimulating a semblion means arousing in our mind a corresponding thought.

A more detailed description of the role of semblions in cognitive processes and the biophysical processes that constitute them can be found in the works cited above (Galus, 2015a, 2015b, 2015c) and the literature cited therein. The essence of the conscious architecture model is the ephaptic, transverse couplings between the semblions through adjacent synaptic fields. This allows not only the recognition of similarities in the configuration of synaptic stimuli but also the associations of semblion groups and the illusions of sensory stimulation while actually stimulating a semblion related

 doi.org/10.32388/1ATS9M.2

to a different modality. Low-level semblions correspond to memorized simple sensory semblions, and higher levels create more elaborate structures and represent complex abstract objects. It is only at this higher level of the hierarchy of generalizations that we can speak of the modality of mental representations. Large, associated networks of semblions can create models of scenes or complex processes. The procedure of transposing a sequence of temporal events into a spatial structure allows for storing episodes in episodic memory and also for their playback. The cited work shows that the postulated structure of the neural network is capable of motivated self-learning. The main motivations for the activity of individuals equipped with the brain with the postulated architecture were indicated. The motivated learning procedure, where an autonomously acting individual is able to independently formulate action goals, plan, and make decisions was presented by Janusz Starzyk and colleagues. He proposed a mechanism for creating a "hierarchy of pain", ranging from primitive sensory pains to "psychological pain" of an abstract nature (avoiding pain is considered a strong motivation to act). They must be matched by the complementary structure of semblions at various levels of abstraction, from the sensory level to the level of the most abstract feelings (Starzyk 2011, 2012, Graham 2015). At the sensory level and low levels of the hierarchical structure of the semblions, they correspond to direct sensations, perceptions of the simplest features of objects, percepts of individual objects, and at higher levels of gradual generalization, ideas, complex concepts, models, and finally a general model of the perceived world, called a worldview. The process of creating semblions is described in detail in part 4 of this work.

In the above-mentioned work, "The Architecture of Consciousness", the view was presented that avoiding pain and striving for pleasant experiences motivates intelligent behavior. On the other hand, for conscious and awareness-raising behaviors, it is necessary to show an "understanding instinct" based on curiosity identical to exploratory behavior. In Part III of the above-mentioned work in Chapter 11, "Curiosity," and in Chapter 12. The Comprehensive Model of the Conscious Mind; the subsection "Understanding the Process of Understanding" hypothesized that the basis of this instinct is the natural properties of neural modeling fields. This hypothesis is based on the known psychological effect of feeling emotional satisfaction when the mind learns something new. These can be new semblions close to the immediate sense, new objects at a higher level of generalization, or new ideas or aesthetic impressions at the highest level of our worldview or artistic tastes. This feeling of enjoyment in learning and understanding new is the basis of learning, research, technical experimentation, art creation, and cultural development. The ancients noticed this, which was reflected in the Stoic interpretation of eudaimonia or even in the description of its role in Aristotle's writings. Getting to know the new and incorporating it into the structure of knowledge about the world and the collection of previous experiences was called the process of understanding there. And the fact of striving to explore the environment and available sources of knowledge was called the instinct of understanding.

A similar instinct of curiosity and the search for understanding is found, for example, by Heller in his book Philosophy of Science (Heller 2016). This drive is driven by felt emotional satisfaction, the pleasure of the pure act of knowing. The sense of isolating this instinct may be questioned because cognitive science takes it for granted that the strongest motivation behind the operation of natural and artificial intelligent systems is to avoid pain and seek pleasure. However, eudaimonia is very different from common hedonia, which is the direct pleasure of our senses. While direct sense enjoyment is available to nearly all sensed intelligent creatures, the enjoyment of new knowledge is available to higher-level minds capable of constructing a complex model of their environment by learning and remembering past experiences. Feeling this kind of pleasure is not related to irritating any of the senses. This feeling is generated inside the brain as a result of neural processes occurring in the course of cognitive processes. One can anticipate, and it is part of the hypothesis presented above, that natural neural networks tend to complement the states of neuronal excitations and patterns embedded in memory in proteins. And also that achieving complementarity is biochemically signaled as the pleasure that drives this pursuit. This would be the biophysical basis of the "understanding" instinct.

Neural Modeling Fields (NMF) achieve the above-mentioned goal of state complementarity by directing and associating the appropriate excitatory signals with the corresponding synaptic fields, and through continuous associations to maximize the pattern match signal. The success of these associations unleashes a reward mechanism, possibly a hormonal one, which is registered in the brain's pleasure centers as feeling pleasure from novelty and as a pleasant sense of "understanding". Objects for observation or mental considerations, mapped in semblions, are selected by selecting the most intense stimulations, and then directed by the path of excitatory associations, either effectively (transversely) or descending, backward, to working memory, where they are made aware. As described in the essay "Architecture of Consciousness", the intensity of excitations results from changes in the intensity of synaptic field excitations related to movement and novelty elements in the signals supplied to NMF. The mechanism of selecting the contents of working memory described there, and thus our consciousness was called the "attention" mechanism. According to Starzyk, wandering thoughts and jumping from one topic to another take place thanks to mental saccades similar to visual saccades, directing our eyes to the important objects of the scene in front of our eyes (Starzyk & Graham 2015). Motivated learning processes are possible only in the case of an autonomous agent operating in a dynamically changing environment and are closed in the circle of (sensory) perception - information processing in order to plan activities in the environment (in the conscious mind) - execution of planned activities (thanks to effectors) - re-observation of the effects actions. We call such a system, learning by manipulating the environment, "embodied intelligence". In the presented cyclical process, a model of the environment is built, the world in which the intelligent system moves, which is tantamount to obtaining a higher degree of awareness. No longer purely perceptual awareness, but time-space awareness, distinguishing one's own person in it, i.e. gaining self-awareness. Lakoff's original idea of cognition is significantly expanded thanks to simple perceptual schemas.

The model of mind based on the heuristics of neural modeling fields capable of creating and collective interaction of semblions does not contradict previous concepts of creating language and the thinking process using symbolic language (as opposed to neural processes at the level of reflexes, simple feelings and responses to sensory arousal) by the embodied mind, from the famous K-Lines by Marvin Minsky (Minsky 1980) to the "embodied meaning" in the neural theory of language by Jerome Feldman and Srinivas Narayan (Feldman J. & Narayanan S. 2004). Let us use the last example to demonstrate the strength of the presented model. The authors indicate that the pre-motor cortex (Brodmann field 6) and parietal cortex in hominids are coupled not only for coordinated motor control (damage to field 6 causes incoherent movements - ataxia) but also create mental representations of motor activity, which allows for its planning. The authors hypothesize that this set of brain centers serves as a neural substrate for meaning attached to words describing planned or performed actions. They refer to the work of Pulvermueller (2001) where he cites evidence of sensory / motor circuits serving this purpose, that is, grounding the bodily meaning of words (embodied meaning).

However, it should be shown how particular meanings of words corresponding to specific actions can be combined with concepts embodied in these brain structures that refer to these actions. A theory is needed of how expressions are associated with their meanings. Feldman and Narayanan describe a simple experiment of associating coincidentally spoken as single word labels (names) with the corresponding movement and interpreting the results in terms of Construction Grammar. The method of interpreting the results used, which is limited to the indication of large-scale brain structures, contributes little to the understanding of the method of creating meaning and verbal-motor associations. However, these results can be wonderfully used to justify the mechanism of creating semblions. These results indicate that the semblions can involve motor structures and prove that multimodal associations of the semblions do occur. It is possible to explain the obtained results in depth, reaching the level of biophysical processes in neural modulating fields. As we will show later, this allows us to seriously think about building an artificial autonomous agent capable of verbally reporting on intended activities and describing activities already performed.

Is Semblion Architecture able to discover a structure with a complexity greater than the simple Markov process? This is difficult because it would have to be shown why this hypothesis is not automatically refuted by the pumping lemma. The answer to this question requires reference to the process of memorizing and processing sequences of events in episodic memory. At the same time, the time sequences of neuronal excitations are converted into spatial distributions of changes in the conformation of proteins that preserve these excitations in synaptic fields. In this way, dynamic semblions are created that represent sequences of events, which can also be phonemes and words of language. The way of creating such semblions is discussed in more detail in the work of Galus (Galus 2015b, p. 255). Recognition of the structure of successively incoming signals transposed into a spatial form in episodic memory takes place by comparing them and detecting their similarity to the patterns existing in the brain, and thus also in the mind, which arise during language learning. This recognition is therefore identical to the pattern recognition of spatial objects. The operation of detecting similarity, rather than the exact structure of a sequence of words, limits the formal regularity of the language. All the experimental achievements of researchers, which are referred to by Feldman and Narayanan in the work discussed above, are a strong argument for the existence of the postulated mechanisms and organization of memory in natural brains. On the other hand, embedding the semblions in the biophysical processes of neuro-electro-dynamics provides a much deeper basis for the analysis of the possibilities and limitations of their mutual interactions. Consequently, it creates an opportunity for further research on the heuristics of neural modeling fields, leading to a possible falsification of the postulated theory of the conscious mind.

The works of Rizzolatti and colleagues, quoted by Feldman and Narayanan in the article cited above, can be taken as confirmation of the actual occurrence of semblions in the human brain. (Rizzolatti et al. 1996 et al.; Galus 2022). The advantage of the semblion's hypothesis over the previous fragmentary theories is its explanation and justification by fundamental biophysical, neurological, and psychological processes at every level of the analysis of the functioning of the brain and the mind generated by the brain.

Attention should be paid to the strict convergence of the presented model of the conscious mind with the theory of cognitive linguistics metaphors. The postulate of the embodied mind is deeply justified by the idea of embodied intelligence, introduced by researchers of classical artificial intelligence. These concepts are not identical, yet the presented model shows how embodied intelligence, by accumulating experience in memory through manipulation of the environment, can create neural correlates of the effects of these experiences, creating an embodied mind. On the other hand, linguistic metaphors are found in semblion structures, which are coupled through neural modeling fields leading to extensive associations corresponding to complex models, ideas, and other abstract linguistic constructs expressed in symbolic language. The mechanism of creating metaphors corresponds to finding similarities between similarly structured semblions. As we can see, there is a close causal link between the comprehensive model of conscious mind architecture and the theory of metaphors. Experimental confirmation using a tetrode probe (Aur & Jog 2010, Jog & Aur 2006, Jog et al. 2007) of creating protein structures that are the biophysical basis of hierarchical memory, identical with neural representations of perceptions and operating by searching for similarity (not identity) of the received arousal configurations in the synaptic fields, is significant support for Lakoff and Johnson's intuition. Their linguistic-mental metaphors have a biophysical mapping of similarities in the topology of electrical charges in the synaptic fields (NMF) to the distribution of charges in sensory impulses.

Nothing limits the breadth, detail, and precision of mapping reality through associated sets of semblions, which allows you to create the most sophisticated mathematical models. Modern methods of imaging the work of the brain confirm that during mental processes related to complex structures, almost all regions of the cerebral cortex are stimulated. Most often, the mind of average ability is not able to grasp the entire structure and the complete model with which it is familiar. On the other hand, thanks to the ability to associate and the mechanism of switching attention described in "The Architecture of Consciousness", it is possible to "wander" through various aspects of the modeled problem. So, we have here both the imaginary schemas and the aspect system. To "see" the whole problem, it is sometimes necessary to review the entire diagram several times. The symbolic notation helps a lot in this, as it divides the scheme as a whole and its mental representation in the form of an associated set of semblions into parts corresponding to sub-semblions and marked with unambiguous symbols - words or mathematical symbols. Thanks to this, the most important relationships and patterns of processes taking place between partial, well-defined concepts are abstracted. It results in a colossal compression of information that allows operating with very complex schemes.

Fortunately, our minds have the ability to associate mental patterns enchanted in semblions with sound, graphic, or gestural symbols. Thus they form a spoken and written language. This is done by associating perceived objects with the incoming signals of other modalities. The primary mating criterion is simultaneity (coincidence). We learn a language by demonstrating a thing and at the same time saying or hearing its name, pointing to an appropriate inscription or gesture (e.g. in the case of sign language). When an object is abstract, then it is enough to describe its features to recall an appropriate mental scheme and present a symbol corresponding to it. Due to the existence of dynamic semblions (variable in time but spatially recorded in the structure of neural modeling fields, as described in the cited work "Architecture of Consciousness"), we can have mental patterns of processes recorded in episodic memory. This allows common operations to be associated and applied to new fields. We are then dealing not so much with metaphors as with analogies. Moreover, the similarity search function of neural arousal configuration can handle both perceived metaphors and discovered analogies. Thanks to this, Lakoff and Nunez's observation that "... a conceptual metaphor is a neuronally embodied, fundamental cognitive mechanism that allows the use of the inferential structure of one domain to infer another domain" has a strict neurobiological justification. Therefore, their intuition is also correct that the concepts and ideas that arise in the process of metaphorization are not only mathematical objects but can also be the basis for a mathematical inference system. Imaginary diagrams of processes, using Lakoff's terminology, can also derive names - symbols that we can use metaphorically or create more complex constructs used in similar ways in many fields. From the point of view of the role of semblions, one could say that the basis of cognition is rather the process of searching for analogies and similarities, and this is how I propose to broaden the understanding of Lakoff's metaphors.

One should also emphasize that the hierarchical model of metaphors complies with the hierarchical structure of semblions. Both the fixed simple, directly sensual semblions, and metaphorical concepts at the level of qualia, as well as the corresponding semblions, are nested in the lowest layers of neural fields directly coupled with our senses. This results in a deep embedding of the abstract concepts formed on higher levels in these immediate, subjective sense impressions (symbol grounding). This enables a proportionally deep, multi-faceted understanding of the abstracted concepts. Artificial intelligent systems, even equipped with powerful relational databases, in fact, do not understand the concepts they operate according to the rules imposed by programmers, because they do not build these concepts into the wider model of the world and do not relate these concepts to the elementary sense impressions that contact with symbolized objects by these concepts he evokes. They don't have our qualia, they don't have a worldview. So, we deny them awareness, we deny them purposeful action, and we know that even if we understand the language they speak to us, they do not understand their language themselves. Where in the presented model is the place for mirror neurons and for the role of imitations so important for observing the cumulative nature of creating a culture in social interactions? The model of self-aware cognitive architecture resulting from the specific structuring of neural modeling fields strongly supports the hypothesis of concept cells (grandmother cells). It can be assumed, in some simplification, that the so-called mirror neurons are conceptual neurons that, when sensed, induce sensations and reactions similar to those experienced by the observed neighbor. This does not prove the existence of mirror neurons in the sense of enthusiastic reports from the early 1990's made by the team of Giacomo Rizzolatti from Parma (Di Pellegrino, Fadig, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, Rizzolatti, 1996; Rizzolatti, et al., 1996). It does not dispute the objections raised by Hickok, Pascolo and Dinstein (Hickok 2009; Pascolo, Ragogna, Rossi, 2009; Dinstein, Thomas, Behrmann, Heeger, 2008). The existence of specific mirror neurons with specialized functions has not been proven. However, no one has disputed the results of behavioral studies conducted in Rizzolatti's syndrome for over 20 years. Only their interpretation may raise doubts (Galus 2022).

The presented alternative explanation of the observed behavior of first macaques, and then of humans through the occurrence of hierarchical structures called semblions, seems to be much better justified. The groups of cells at the top of the semblion hierarchy can be called conceptual neurons, and the reactions of entire semblions externally stimulated by sensory experience can be identified with the reactions of "mirror neurons", which in this case will no longer be individual specific neurons, but complex but typical structures of our neural network. Being aware of the ongoing controversy surrounding the concept of conceptual neurons, we cannot ignore the experimental confirmations of the presence of this type of structure in human brains presented e.g. by Quiroga and colleagues (Quiroga, Fried, and Koch, 2013; Quiroga, Reddy, Kreiman, Koch, Fried, 2005). The existence of semblions is confirmed by the detection of hierarchical structures in the entire area of the cortex. The visual cortex has such a structure, in which we distinguish layers from V1, V2 through V4... V7, where we can also distinguish retinotopic maps, up to more than 20 successive layers stimulated by visual stimuli. The same applies to other modalities, including the sense of hearing, from the layers of the primary cortex with a tonotopic structure, through the secondary and tertiary auditory cortex, to the F4 regions of the prefrontal and frontal cortex, acoustically stimulated but at the same time associating stimuli of other modalities.

In the already cited work "The Architecture of Consciousness" one can find a justification why intelligent individuals learning in a similar environment will have similar qualia, especially if they have similar senses. Similarly, with a similar level of awareness and experience (as a result of learning procedures), one can argue that they will have a similar conceptual system. Perhaps their motor reactions will be different. However, the perception patterns, understanding the reaction, and anticipating the next action should be adequate to the experienced physical and social environment. The corresponding mental representations in the form of semblions should also have a similar structure, and for this reason, by analogy to mirror neurons, they can be called mirror semblions.

The ability to imitate does not result directly from the cited model of consciousness. It is worth noting that social learning through imitation contributes to a lesser extent to the development of the language and more to its dissemination. Even so, the enormous importance of the ability to imitate should not be questioned; this ability is widely used in the animal kingdom. Its evolutionary significance is undisputed, and so is its origin. It can be associated with the instinct of curiosity and exploration. As shown in the mentioned work, the exploration instinct is restrained by the fear of discomfort, pain, and death. Imitating other individuals can greatly increase the courage to take new actions. The risk taken will often pay off because it favors exploring new areas and new resources. Therefore, the ability to imitate creates an evolutionary advantage and should be subject to positive selection. Mirror semblions can be very helpful for this. Brożek and Hohol's assessment is accurate in that the mastery of people in imitating the behavior of their own and other species is one of the foundations of our culture's success. Another is the ability to cumulatively develop culture thanks to the created and then preserved symbols (Brożek & Hohol 2014). It is the semblions that consolidate the concepts and rules of language that can be regarded as the "language module" sought by Chomski.

The remarkable similarity of the neural network in the animal world raises the question: why don't other animals create symbolic communication languages? After all, we belong to the same biological world. After all, a lot of research on the behavior of neurons is carried out on snail neurons. Mammalian brains show remarkable morphological similarity, not to mention the brains of macaques and apes. One can assume that their brains develop complex semblions representing qualia similar to ours. Their seeds of a communication system indicate the ability to create concept-symbols with a certain degree of abstraction. What is the difference causing such dramatic effects?

In my opinion, we can assume that the difference lies in the number of levels at which the structure of the semblions is integrated and in the extent of associations that can take place between them. The premises presented in the cited work by Gallus (Galus 2015a) indicate that the neural network requires not two or three levels of processing but several dozen. Perhaps even up to 20 - 40 levels. Each additional level of linkage enormously increases the number of combinations and permutations of the ways of linking the neural modeling fields that make up the semblion structures. Perhaps in the evolutionary process, even a small mutation that enlarged the surfaces of the cerebral cortex, at the same time made it possible to direct neuronal stimulations to subsequent layers and modeling fields, resulting in the emergence of even more abstract concepts - concepts - models. The ability to associate concepts is no less important than thinking abstractly and using language. These properties depend on the effectiveness of ephaptic couplings at the level of synaptic fields, on the range of axon and dendritic connections between the cooperating layers of the cortex and neural fields, on the availability of specific protein molecules in synaptic channels, dendrites, and axons, and the subtlety of functioning, and especially on the levels of sensitivity established by the "attention" mechanism, i.e. the discrimination threshold of synaptic field stimulations. These factors determine the individual's ability to associate, associate, and remember knowledge and may change with growth, development, experience, aging, and under the influence of pathological changes, diet, and stimulants. Most of these factors are known to function from a neurological point of view.

There is little we can say about the differentiation and the desired structure of the proteins that make up the synaptic-neuronal structure, except that people's ability to remember differs significantly. The course of the powerful axon bundles connecting individual neural fields and directing neural stimuli to specialized brain structures has also been studied to a small extent. Some of these bundles feedback signals from the high to the lower fields, and not always within the same modality. We can conclude about their scope based on images provided by modern methods of imaging brain activity. They are also characterized by high individual variability. However, the interspecies differences have not been explained to the extent that we can draw general conclusions. We can conclude that particular individuals differ significantly in their abilities. Due to its complexity and the surface of the cortex, the human brain seems to be a perfect foundation for multi-level semblion structures that create a complex conceptual system.

4. Models of Reality

Neural representations of our perceptions, experiences, observed processes, rules governing fragments of the observed reality, abstract constructions in the form of mathematics, logic, and all other concepts cumulatively created by human culture and learned in the course of broadly understood learning and self-learning through experiencing the environment, created and saved in semblions, are models of some part of the experienced reality. By their very nature, these models must be incredibly simplified. To avoid Bonini's paradox, it is necessary to radically compress the information contained in the models we use (Bonini 1963). This takes place in the process of idealization of objects perceived sensually or considered in the imagination. In this process, the characteristic, salient features of objects detected directly by our senses create configurations of stimulations directed to the neurons of the neural modeling field of the higher layer. The "modeling" field NMF is related to its role in creating a model of the object or its features. If a specific configuration of stimulations, i.e. directional impulses in terms of neuro-electro-dynamics, corresponds to previously remembered configurations, then the stimulation is recognized as a representation of some important feature of the object and is the basis for the categorization of these features, and at higher levels, symbolizing objects having a set of specific features. In this way, increasingly condensed representations of increasingly complex objects are created in subsequent layers, where the peak neuron can be considered a symbol of an object (concept, model) and associated with a sign generated by the neural network in any modality, and the entire tree consolidating the path of subsequent idealizations creates a semblion corresponding to the neuronal representation of the object.

One can pose the question of how adequately these spontaneously and automatically generated representations reflect perceived objects and phenomena. The presented mechanism of semblion formation strongly supports the associative theory of thinking and can equally lead to accurate associations representing the perceived environment following objective reality, as well as lead to associations solidifying a false, subjective image of reality.

Of course, the stimulation of a top, spike neuron, called a concept cell, causes, through feedback, the stimulation of the entire semblion down to the level of sensory cells, which results in "seeing" an object or an imaginary object. Such spreading stimulation may also induce stimulation of semblions related through functional, ephaptic (lateral) synaptic coupling, creating rich associations and an intentionally directed course of thinking, problem consideration, etc. The result of such a hierarchical organization of semblions is the nature of the accumulated knowledge. The abstract objects remembered are very general and therefore blurry and fuzzy. The idea of, for example, a "ball" does not tell us much about what a ball really looks like. Only after feedback stimuli reach the level of the lower visual fields (V1...V4) of the semblion corresponding to a specific ball, we can, on the one hand, recognize and classify the object as a ball, and on the other hand, we can "see" its details, specific size, color, texture (Galus, Starzyk 2021). And even a specific ball recalled does not match the richness of details of the ball when viewed directly. Apparently, not all synaptic pathways are stimulated in the same retrograde way in this recalling process. However, the advantage of this system is the fact that even a ball noticed in poor lighting conditions and flashing in front of our eyes for a short moment can be recognized thanks to even a residual similarity to the ball pattern represented by the corresponding engram/semblion. Moreover, its image can be completed by stimulating the remaining parts of the appropriate semblion. This is done thanks to feedback top-down from the top layers of the brain that encode concepts and ideas. Thanks to this, we can tell more about it than our senses can perceive. At even higher levels of idealization, we can similarly recognize complex objects and the scene

doi.org/10.32388/1ATS9M.2

unfolding before our senses. Semblions create abstract models that reside in our minds. They do not site in memory. They themselves are our memory.

Comparing the processes observed in nature with the intention of generalizing them, results in the rejection of less significant disturbances and irregularities, which reveals the main rules according to which these processes operate. This leads to the disclosure of the laws governing processes repeated in nature, which we tend to treat as the laws of nature. An attempt to precisely, symbolically write down these laws, i.e. their mathematization, is another step of generalization, but usually an even greater approximation due to the need for their further idealization by introducing an axiomatic system. The great success of the models created by science, these simplest, conceptual only and on the other hand, the very complex axiomatic systems, is their usefulness in various areas of application. This allows not only to interpret new phenomena observed in nature and the results of planned experiments, but also to predict their course, putting forward hypotheses with a high chance that the already known process models will fit their actual course well. Of course, we are still learning about phenomena for which we are unable to create such effective models. However, the power of models explaining the behavior of matter allows us to create technologies that we could not even dream of until recently.

All these explanations regarding the creation of languages to describe reality do not answer the question that torments many scientists, especially mathematicians, physicists, and philosophers. Why do we observe such great compliance of our primitive models with reality and their universality?

Many mathematicians and physicists, realizing the universality of the laws of nature "discovered" by them, attribute to the mathematical models describing these "laws" an extraordinary power to order the world. They suspect that their abstract mathematical models are primitive in nature and that the material world adheres to them for some reason, hence their mathematical nature. An amusing example of extreme Platonism was presented by Max Tegmark in his popular book "Our Mathematical Universe" (Tegmark 2015). By searching for isomorphism of the alleged mathematical equations of the "General Theory of Everything" with the matter that these equations can describe, he proves that the entire Universe with all its history and even the necessary Multiverse, of which our world is a tiny part, is in fact a mathematical structure. He argues, the existence of the Multiverse results from the existence of mathematical structures that do not exist in our world. Since such structures were discovered by mathematicians, there must be other material worlds that correspond to them. Of course, such an exotic view is a provocation of the mathematical mind, which is aware that at most the solutions of the equations of the General Theory of Everything with the material reality described by them can be characterized by isomorphism, and not these equations themselves. And the set of their solutions is a description of what exists in the world in all its complexity, which could justify Bonini's fears that the model may be as complex as the reality that the model is supposed to describe. It would also be an extremely deterministic model, and therefore a tasty morsel for Laplace's demon. Less extreme views are expressed by a significant group of Neoplatonists, including many mathematicians fascinated by the effectiveness of mathematics in describing material structures and processes. They believe that the mathematical nature of the world lies in its compliance with stable mathematical structures. These are independent of the material world and especially of human minds. It is not people who create them, they discover them.

All these views are not fully justified. On the one hand, it should be remembered that a deeper understanding of the laws of physics almost always leads to a deeper entry into the world of mathematics. Our more complex models require building increasingly sophisticated and complex abstractions described strictly using mathematical symbols. This gives us the impression that the laws of mathematics are superior to the laws governing the behavior of real matter. However, this is only an illusion of the power of our reasoning. An illusion intensified by the ease of manipulating symbolic structures, where by changing the axiomatic system we can create new geometries, new worlds characterized by the extraordinary beauty of mathematical simplicity and at the same time the richness of the forms in which they manifest themselves. The impression is spoiled by the awareness that all true sentences derived from a formalized theory, based on a complete axiomatic system, have the nature of a tautology. In fact, we do not know of any phenomenon that would be in perfect agreement with any law of physics, chemistry or other natural sciences, not to mention the so-called laws of social or economic sciences. These laws are subject to ideal mental structures abstracted from observations of the real world. They are the basis for a special intuitive sense and belief that certain mathematical constructions are true. The impressions corresponding to the most basic concepts of set theory, which Gödel included the axiom of extensionality or the axiom of pair, are formed based on elementary observations of reality that two sets of the same elements are identical, or that the combination of two sets also constitutes a set, and one that is the sum of their elements.

There is no need to look for some pre-mathematical intuition here. These semblions arise spontaneously in the course of observing the real world, and further reasoning is only the result of neural processes of association and searching for similarities and analogies. The further idealization of these concepts that takes place thanks to these processes transforms specific observations, through general intuitions, into strict abstract formulations expressed in a formal symbolic language. Many idealizations leading to simple laws are possible due to the approximate nature of our observations. Real planets and suns do not orbit in ellipses. The actual values of the precession of the motion of planets and moons differ from those calculated even with relativistic corrections taken into account. The more precisely we measure the course of phenomena, the more different corrections and the more various factors we have to take into account. In our scientific activities, we select phenomena that we can examine and easily describe. It is for these phenomena that we have constructed the most perfect models. Processes involving complex nonlinear interactions leading to highly chaotic solutions are difficult to describe mathematically and precisely model them.

Does a full description of matter have to take into account all the paths through which it moves? Or are there simple laws that give rise to this complex behavior of matter? This would mean the mathematization of the world.

We don't know this fully.

We know some common properties of matter that have never been affected since we observed them. Nay. We have grounds to assume that if these properties, these laws of matter, were violated, perhaps matter could not exist, and the universe would certainly not be mathematical. Yet Universe is at least a little mathematical. At least locally, we are happy with its regularity and stability.

These fundamental properties of matter include symmetries occurring at the most basic levels of its structure. As Emma Noether (Grech 1995) showed, symmetry gives rise to conservation laws, and fundamental translational and rotational symmetries give rise to conservation laws for momentum and angular momentum. The SUc(3) xSUL(2) xUY(1) symmetry is the gauge symmetry of the standard model of quantum field theory. We are looking for supersymmetry (SUSY), which will allow us to write the equations of quantum gravity. Under certain conditions, symmetry can be broken, and this creates an infinite variety of matter behaviors. Are there any higher-level laws that "tell" matter that it should exhibit these symmetries? It seems not. There is no indication of this. The matter is as it already is. And these symmetries result in the repeatability of phenomena, which manifests itself as their cause-and-effect nature. We believe that everything has a cause and that the same causes will produce the same effects. Are these symmetries of matter and the space it creates sufficient to explain such an extraordinary correspondence between the course of material phenomena and their predictions based on relatively simple models and theories that we have managed to create so far? This will be shown by further research and attempts to cover phenomena that we have not yet been able to explain with these models. In any case, the search for the mathematical nature of the world in its symmetry undermines the Platonic belief in the independent existence of mathematical structures. We will discover nothing else in our approximate equations (apart from even more general symmetry groups and detailed parameters of the material components of objects). This is a very high level of generality in the description of phenomena in the universe, and we can be proud that we can describe the symmetries of the world in mathematical language. However, it is not this language, nor symbols denoting the symmetries of matter that create this matter. Our experience of observing the world allows us to assume that it is arranged in such a way that phenomena proceed similarly, regardless of the place where the phenomenon occurs and regardless of the viewing angle from which we observe it. This doesn't actually have to be true. There may be no two identical places and viewing directions in the entire universe. This is our next approximation, assumption, hypothesis, and this is how we briefly write down it symbolically, in the form of symmetry.

The most complete understanding of the world around us, as well as the understanding of the Universe at the highest level of generality, depends on the precision of the symbolic language in which we describe its models. Therefore, we need a new mathematical Platonism, showing that these models exist objectively in the material world. They exist only as semblions - mental representations of symbols, ideas, and models created in our minds. By communicating, exchanging concepts, and learning from each other, the semblions of mathematical models have a similar structure in many individuals of our species. Dynamic semblions, reflecting the relations between semantic semblions, create a grammar of mathematical transformations enabling their strictly formal composition. In this case, we are not talking about association, because it occurs in the few who can create a metaphorical image of these mathematical structures that create simplified models of the real world, but are specific enough to allow intuitive prediction of the course and effects of the modeled processes. The language of mathematics is a powerful tool because it allows us to operate models according to formal rules, going beyond our imagination, and only imagine the formally calculated effects of the functioning of these models.

5. The language of artificial neural networks

Is it possible for artificial, intelligent systems to master a natural, complex symbolic language? Could it be through self-learning or even through an imitation of our human language? Could they use it with understanding? Will they then have self-awareness? The artificial recognition and speech synthesis systems built so far do not meet these conditions. Highly specialized algorithms of well-known chatbots allow for the recognition of many words in a specific language, and other algorithms select answers, and often questions imitating a conversation in a natural language. Expert systems integrated with the chatbot even allow you to obtain useful information as a result of such a conversation. However, we realize that this is only an imitation of a conversation because the chatbot we are conversing with does not understand its own statements. He does not collect knowledge outside the designated field. He does not have the creativity to provide answers beyond the deterministically programmed repertoire of reactions to the questions put to him. Often, chatbot anthropomorphization is understood as introducing random or chaotic controlled random elements to mask the algorithmically determined nature of its response. The difficulties faced by designers of chatbot systems significantly exceed the technical challenges related to the speed of information processing, the capacity of the required memory, access to knowledge resources, or the ability to process huge data sets. The main difficulty is that understanding a language requires grounding the concepts that are necessary to formulate an answer in the broad, multi-layered context of general knowledge, and this requires awareness. It is essential to have a model of the surrounding reality and sometimes a model of the whole world. What is needed is the ability to learn and, as a result of learning, the ability to constantly expand and deepen this model. The ability to continually develop the model arises also thanks to acquiring new knowledge during the conversation. So far, there have been no ideas about how an algorithm could be created to give the system awareness and the ability to talk intelligently. It is not necessary to recreate all the connections and structures of the human brain to achieve this, just as it is not necessary to recreate membranous or feather-covered wings to mimic bird or insect flying. However, it is advisable to understand the neural network's architecture capable of generating consciousness. There are many indications that the hierarchical structure of semblions can most effectively arise in multilayer neural networks. We need the architecture of neural modulating fields and the knowledge of heuristics, according to which excitations from the lowest sensory layers are transferred to the higher layers, where concepts, concepts, and models are created, as described in the above-cited work "Architecture of Consciousness" (Galus 2015a, b, c).

An increasing number of cognitive scientists' question whether the effective association and comparison of multi-layer processing and storage structures interacting in parallel, analog and non-linearly, can be emulated or simulated by serial processing of discrete, and even more so binary, signals in sequence computers. In any case, the digitization of numerous, simultaneously processed signals, with excellent dynamics and fast-changing time characteristics, invariably confronts designers with the problem of combinatorial power complexity of their recognition and processing (Perlovsky 1998). Hence, it is easy to justify past failures while simultaneously hopes are created that new generations of petaflop performance supercomputers will solve this problem.

Fortunately, there are concepts of basing artificial systems on a hierarchical, multi-layer connectionist structure, designed for parallel processing, where we only deal with linear combinatorial complexity, which can be overcome with the help of currently available technologies. Such an idea was presented by Adrian Horzyk in the form of a hierarchical structure of a neural network formed by specific neurons, the interactions of which were modeled with graphs that enabled easy programming of an IT structure corresponding to the adopted concept of the functioning of such a network (Horzyk 2013). As the author writes: "Various combinations of associatively related neurons make it possible to define simple and complex objects and the relationships between them." Relationships between objects of the nature of associative similarity, sequence, context, definition, and suppression were distinguished. Combinations of these properties characterizing relations between neurons create associatively related structures representing objects. The author calls these structures "semassels" - semantic-associative units. The ability to create and store them stably results from the properties of the neuron, the biologically inspired model of which is presented in the discussed work, as well as from the properties of the associative system itself. An essential feature of the model of a neuron capable of functioning according to the described association system are the variable time characteristics of its sensitivity to stimuli. This enables competitive stimulations to create new semassels competing for attention. It is difficult not to notice the convergence of the features of the associative intelligence modeled in this way with the postulated architecture capable of generating consciousness and self-awareness. Neurons with their presynaptic fields, dendritic outputs, and axons correspond to neural modeling fields. Their primary task is to detect similarity, which corresponds to similarity relations. Associative relations correspond to the heuristics of the neural modeling field regulating the transmission of stimuli both to the higher layers, in accordance with the defining relations, and to the neighboring ones, in which contextual relations are established. The semassels created in this way are strictly equivalent to the semblions with their conceptual neurons at the top of the hierarchy (defining concepts-objects). The consciousness architecture model predicts both associative sequence relationships, through the episodic memory structure, and effective suppression relationships, to maintain the dynamics of the system without losing its stability. The presented concept of IT feasibility modeling does not aspire to create a system that consciously uses natural language. However, this model has shown practical effectiveness in implementing simple sort functions and classifiers. It was shown how knowledge graphs used for automatic categorization and generalization can be formed. These processes are the basis of the associative AI that the author has been striving for.

The convergence of this concept with the architecture of the natural brain makes it possible to build an artificial system capable of conscious action, and its graph structure adapted to the parallel processing of information raises hope for the possibility of a quick technical implementation of such an undertaking. The more so because the technology provides components perfectly suitable for the role of electronic substrate for the functions defined in the Horzyk model (Benjamin et al. 2014, Merolla et al. 2014). The proposed neural network model has sufficient flexibility to supplement it with functions necessary for such a task. The necessary supplementation concerns introducing motivation to act, learning, and planning actions according to one's own system of values. It seems an appropriate solution would be the use of learning algorithms motivated by the ability to feel discomfort (pain in cognitive terminology) and pleasure when the needs of the system are met. One should also consider introducing motivation in the form of the ability to feel positive emotions (perhaps pleasure), in the case of achieving high values of the detected similarities in extensive synaptic fields and semblions, which will correspond to satisfaction with understanding the new stimuli.

An important element of the conscious system is the grounding of symbolic knowledge in direct, subjective sense impressions, which requires the creation of semblions, the hierarchy of which begins with simple sensory stimulations. Suppose we choose a set of sensors with human-like characteristics. In that case, there will be chances of forming human-like impressions, which will greatly facilitate future communication with self-aware machines. Certainly, the time characteristics of changes in sensitivity to stimuli will have to be determined experimentally depending on the dynamics of amplitude and time changes of signals appearing in the environment in which the system is to operate. The characteristics of these changes may have several time constants corresponding to changes in the size of the perikaryon and habituation and sensitization of the neuron, in the case of periodic appearance of very strong or very weak signals. Experimental selection will also require the range of associative connections and grouping of connections according to the sparse coding rule. The system must be able to learn in a complex environment by directly manipulating objects in this environment and checking its effects. This will allow for the development of appropriate procedural memory semblions enabling effective operation. It is doubtful whether the fulfillment of these assumptions will force the use of supercomputers with even greater powers than the classic AI. It seems that there is no such danger. In the proposed architecture, one neuron can participate in the creation of many semblions. Under the conditions of rare connections, a relatively small number of neurons is enough to represent complex objects. Nowhere is it said that the qualia of an artificial system must be Hi-Fi and HD. It is the visual, auditory, and tactile fields that occupy a large part of the cerebral cortex, and these can be minimized. More important is the number and range of connections as well as the number of hierarchy layers creating semblions. Even more critical will be the learning procedures during which the basic qualia, the appropriate quantum of knowledge, the model of reality, and finally the worldview must be formed. If people who use speech for communication are part of this reality, and the artificial system has effectors in the form of a speech synthesizer, the conscious artificial intelligence will have a chance to learn to speak. Her communicative ability will depend on the wealth of the created semblions reflecting her knowledge about the world and her skill in using language as a specific tool for manipulating those objects of the environment that are capable of communication. A rich language for reporting and exchanging information about your intentions, emotional states, and needs will help us recognize that the system does have awareness.

The newly built system will not be ready for use. It will have to acquire appropriate knowledge for a long time and practice using it, in using his own body and mind. He must have time to learn to speak. Must have time to create a new language for mathematics. Hopefully, it will take less time than it will be for humans. Can an artificial self-awareness system achieve a level of intelligence and awareness like humans? Does the proposed model of natural and artificial mind architecture add anything to the speculations so far? The most significant benefit of the models presented here is recognizing that the conscious use of language requires a relatively high degree of awareness. People have very different consciousnesses, and there will probably be a period when the intelligence of artificial minds will approach the average level we see in humans. However, it is implausible that it will stop at this level. The presented model does not contain any restrictions on enlarging memory areas of neural modulating fields or increasing the number of processing levels. The speed and reliability of electronic systems will ensure greater efficiency of artificial systems. Efficient homeostatic systems will ensure efficient work without fatigue and the related breaks for some type of sleep. However, no miracle is to be expected to dramatically surpass human intellectual capacity. Even the most abstract concepts need to be embedded in qualia, and these, as mentioned above, will be similar to ours if artificial systems are in a similar environment.

Of course, if we equip them with better senses, x-ray vision, the ability to sense a magnetic field, or anything else, their richness, and variety of sensations will increase. This may result in the emergence of new concepts, new words that are difficult to understand. Today, however, we too can extend our sense experiences through the use of tools. Therefore, machines' new perceptions of the world will not come as a shock to us. At the highest levels of abstraction describing the models of our world, one cannot expect a sudden detachment of their level of complexity from the models we use. Any generalization towards a higher-level model must be data-driven. We realize that in the world of micro- and macro-world physics, it will be more and more difficult for us to obtain such data. Of course, efficient, intelligent systems may allow us to plan new experiments and see regularities in colossal data sets inaccessible to our minds. However, it will not be an abrupt process. For a long time to come, human minds will follow the interpretations of more agile minds, just as a student follows his teacher. Unfortunately, the biological evolution of the brain is too slow, and someday, its adaptive capacity will prove insufficient. The only thing left for us to do then is to integrate our brain with the artificial support system. Even later, a biological addition to a super-efficient machine will prove to be completely unnecessary.

6. Summary and Conclusions

The need to recapitulate the presented argumentation resulted from several reasons: 1. The suspension of the Polish magazine Rocznik Kognitywistyczny in 2018 (where the primary version of this article was published in Polish), which limited access to the original publication; 2. The need to translate the original text into English to increase its accessibility; 3. A need to update the argumentation due to the constant progress in the field of neuropsychology and philosophy of mind.

It should be noted that the passage of time has not made the postulates of the presented theory of creating neural representations of symbols, concepts, ideas, and models of the environment in the form of semblions obsolete. However, today, six years after its formulation, there is more empirical and theoretical confirmation to justify it. In 2021, together with Janusz Starzyk, we presented a reduction model of the conscious mind that takes into account the fundamental impact of emotions on the creation of semblions of symbolic concepts and abstract ideas that are elements of access consciousness. We also pointed out the importance of emotions in creating representations of affective states and first-person sensory impressions, which are an element of phenomenal consciousness. Taking into account the emergence of motivation to act as a result of emotions resulting from unmet needs of the system/organism, we call the functional model Motivated Emotional Mind (MEM) (Galus, Starzyk 2021).

The MEM model is an extension of the recurrent model of consciousness proposed by Lamme. Recurrent Processing Theory (RPT) suggests that the essence of conscious processing of perceptions is the cyclic transmission of stimulations in spatially and temporally distributed, dynamically variable connection loops between lower and higher brain areas. The FeedForward Sweep (FFS) process transmits bottom-up signals from receptor cells to higher cortical layers, where objects are recognized, and understood and appropriate responses are developed. This process takes place unconsciously. The awareness of perceptions occurs as a result of retrograde stimulation with signals transmitted back, top-down. Activation of feedback in subsequent cycles may cause modification of memory engrams (Lamme & Roelfsema 2000; Lamme 2006; 2012). The MEM model clarified the functions of backward stimulation, clearly indicating that the FFS process is responsible for creating semblions, and the Backward Recurrent Process is responsible for recalling memories, images or dreams (Galus 2023a; 2023b). The cited works present this model in a simplified graphical form, as well as empirical evidence for the roles of both processes. They justify the role of dynamic semblions and procedural memory in speech generation. Speech and verbal responses can be treated as one of the behavioral reactions to perception and to the train of thoughts that permanently accompany each natural being during the mental activity. The associative processes of semblions described in this work can lead to the construction of a stream of statements (and/or inner speech) with thematic continuity and logical structure equivalent to statements generated by modern large linguistic models LLM, such as Chat GPT. The success of the MEM model in explaining speech generation indicates directions for further neuropsychological research, especially those using imaging of the functions of all brain areas. LLMs have proven to be an effective path for emulating propositional awareness in artificial brains, while the MEM model shows a path for emulating affective states and phenomenal awareness in robots equipped with such intelligent artificial brains.

References

- Aur D., Jog M.S., (2010) "Neuroelectrodynamics - Understanding The Brain Language", IOS Press,1–235,
- Aur D., Jog M.S., (2007) "Neuronal spatial learning", Neural Processing Letters, Vol 25, no 1, pp 31-47.
- Aur D., Jog, MS, (2006), "Building Spike Representation in Tetrodes", Journal of Neuroscience Methods Volume 157, Issue 2, 30 October, 364-373
- Benjamin B.V., Gao P., McQuinn E., Choudhary S., Chandrasekaran A.R., Jean-Marie Bussat JM, Alvarez-Icaza R., Arthur J.V., Merolla P.A., Boahen K., (2014) "Neurogrid: A Mixed-Analog-Digital Multichip System for Large-Scale Neural Simulations", Proceedings of the IEEE Vol. 102, No. 5, May.
- Bonini C.P., (1963) „Simulation of information and decision systems in the firm", Englewood Cliffs, N. J.: Prentice-Hall
- Brożek B.,, M. Hohol M., (2014), „Umysł Matematyczny", Copernicus Center Press, Kraków
- Chomsky N., (1982) Zagadnienia teorii składni, Ossolineum, Wrocław

- Dinstein I, Thomas C, Behrmann M, Heeger DJ (2008). "A mirror up to nature". Curr Biol 18 (1): R13–8
- Di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V., & Rizzolatti, G (1992). „Understanding motor events: a neurophysiological study". Experimental Brain Research, 91, 176-180.
- Gallese, V.; Fadiga, L.; Fogassi, L.; Rizzolatti, Giacomo (1996). "Action recognition in the premotor cortex". Brain 119 (2): 593–609.
- Feldman, J., & Narayanan, S. (2004). "Embodied meaning in a neural theory of language". Brain and language, 89(2), 385-392.
- Gallese V. Goldman A., (1998) „Mirror Neurons and the Simulation Theory of Mind-Reading" Trends in Cognitive Sciences. 2,12
- Gallese V., (2009) „Ucieleśniona symulacja: Od neuronów, po doświadczenie fenomenologiczne"; Formy aktywności umysłu. Ujęcie kognitywistyczne, t.2: Ewolucja i złożone struktury poznawcze. Wydawnictwo Naukowe PWN, Warszawa s.196
- Galus W.L., (2015 a) „Architektura Świadomości. Część I: Logika i morfologia sieci neuronowej", Roczniki Filozoficzne T. 63 nr 1 p. 139-171.
- DOI: http://dx.doi.org/10.18290/rf.2015.63.1-9
- Galus W.L., (2015 b) „Architektura Świadomości. Część II: Struktura molekularna i biofizyka pamięci", Roczniki Filozoficzne T. 63 nr 2 p. 237-261. DOI:10.18290/rf.2015.63.2-14
- Galus W.L., (2015 c) „Architektura Świadomości. Część III: Wola i sens istnienia", Roczniki Filozoficzne T. 63 nr 3. p.129-168. DOI:10.18290/rf.2015.63.4-5
- Galus W.L., (2022) Whether Mirror and Conceptual Neurons are Myths? Sparse vs. Distributed Neuronal Representations, Network: Computation in Neural Systems, Jan, 2022; DOI: 10.1080/0954898X.2022.2029967
- Galus, W.L. (2023a) Different Aspects of Consciousness Explained by Distinct Biophysical Processes. Journal of Theoretical and Philosophical Psychology., Aug. 2023. https://doi.org/10.1037/teo0000236
- Galus, W.L. (2023b) Mind–brain identity theory confirmed?, Cognitive Neurodynamics vol.17:1–21. https://doi.org/10.1007/s11571-023-09992-6
- Galus, W., Starzyk J. (2021) Reductive Model of the Conscious Mind, IGI Global 2021. ISBN13: 9781799856535
- Graham J., Starzyk J.A., Jachyra D., (2015) "Opportunistic Behavior in Motivated Learning Agents", IEEE Trans. on Neural Networks and Learning Systems, Aug; 26(8):1735-46.
- Heller M. (2016) „Filozofia Nauki", wyd. III Petrus, str.21, Kraków 2016.
- Hickok G (2009) "Eight problems for the mirror neuron theory of action understanding in monkeys and humans". J Cogn Neurosci 21 (7): 1229–1243
- Horzyk A., (2013) „Sztuczne systemy skojarzeniowe i asocjacyjna sztuczna inteligencja", Akademicka Oficyna Wydawnicza EXIT, Warszawa.
- Jog MS, Aur, D., Connolly CI, (2007) "Is there a Tipping Point in Neuronal Ensembles during Learning?" Neuroscience Letters Vol. 412, Issue1,22, January 2007, Pages 39-44;
- Lamme, V.A.F. (2006). Towards a true neural stance on consciousness. Trends in Cognitive Sciences, 10(11), 494-501.
- Lamme V.A.F. (2012) Can neuroscience reveal the true nature of consciousness? CiteSeerx: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwikmKullfP4AhUW6CoKHUKNA58QFnoECAgQAw&url=https://www.nyu.edu/gsas%2Fdept%2Fphilo%2Fcourses%2Fconsciousness05%2FLammeNeuroscience.pdf&usg=AOvVaw3WdApL1VCE8i67Y9HX-Iw9
- Lamme V.A.F., Roelfsema P.R. (2000) The distinct modes of vision offered by feedforward and recurrent processing, Trends in Neurosci. Vol. 23,11; 571–579, 2000
- Lakoff G., Johnson M., (1999) „Philosophy in the Flesh. The Embodied Mind and It's Challenge to Western Thought", Basic Book, New York
- Lakoff G., Johnson M., (2010) „Metafory w naszym życiu", Altheia, Warszawa
- Lakoff G., Nunez R.E., (2000)„Where Mathematics Comes From. How the Embodied Brain Brings Mathematics into Being", Basic Books, New York
- Merolla P., Arthur, J., Alvarez, R., Bussat, J.-M., Boahen, K. (2014), „A Multicast Tree Router For Multichip Neuromorphic Systems", IEEE Transactions on Circuits and Systems I: Regular Papers, Vol. 61,3.
- Minsky Marvin (1980), K-Lines: A Theory of Memory, Cognitive Science 4, 117-l 33
- Pascolo PB, Ragogna R, Rossi R, (2009). "The Mirror-Neuron System Paradigm and its consistency". Gait Posture 30 (Suppl. 1): 65
- Pawelec A. (2005) „Znaczenie ucieleśnione. Propozycje kręgu Lakoffa". Kraków 2005.
- Perlovsky L.I., (1998) "Conundrum of Combinatorial Complexity", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol 20, No.6, June
- Perlovsky L.I., (2001) „Neural Networks and Intellect: using model based concepts", New York: Oxford University Press

- Perlovsky L.I., (2007) „The Knowledge Instinct”, New York, Neurodynamics of Cognition and Consciousness. Understanding Complex Systems, pp 73-108.
- Pulvermueller F. (2001) „Brain reflection of words and their meaning”, Trends in Cognitive Sciences, 5.12
- Quiroga, R.Q., Reddy, L., Kreiman, G., Koch, C., Fried, I. (2005) „Invariant visual representation by single neurons in the human brain”, Nature 435 (7045), pp. 1102-1107.
- Quiroga Rodrigo Quian, Fried Itzhak, and Koch Christof, (2013)„Brain Cells for Grandmother”, Scientific American.com 31, February 2013.
- Ramachandran V.S., (2012) „Neuronauka o podstawach człowieczeństwa. O czym mówi mózg?”, Wydawnictwo Uniwersytetu Warszawskiego, Warszawa
- Rizzolatti G. et al. (1996) „Premotor cortex and the recognition of motor actions”, Cognitive Brain Research 3. 131-141
- Starzyk J.A. (2011)„Motivated learning for computational intelligence", Computational Modeling and Simulation of Intellect: Current State and Future Perspectives, ed. B. Igelnik (IGI Publishing, Hershey, PA);
- Starzyk J.A., & Graham J. (2015) "MLECOG – Motivated Learning Embodied Cognitive Architecture", IEEE Systems Journal, July 2015, online 10.1109/JSYST.2015.2442995.
- Starzyk J. A., Graham J. T., Raif, P. and Tan A-H., (2012) “Motivated Learning for Autonomous Robots Development”, Cognitive Science Research, v.14, no.1, p.10(16) pp. 10-25;
- Vadakkan K.I. (2011), “Processing semblances induced through inter-postsynaptic functional LINKs, presumed biological parallels of K-lines proposed for building artificial intelligence”, Frontiers in Neuroengineering.
- Vadakkan K.I., (2012a) “Framework of consciousness from semblance of activity at functionally LINKed postsynaptic membranes”. Frontiers in Psychology (Consciousness Research) 10;
- Vadakkan K.I. (2012b), „The nature of "internal sensations" of higher brain functions may be derived from the design rules for artificial machines that can produce them”, Journal of Biological Engineering 6-21,
- de'Waal F., (2014) „Bonobo i ateista. W poszukiwaniu humanizmu wśród naczelnych”, Copernicus Center Press, Kraków

Declarations

Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.