Neuro-Logocentric Representation of Brain Activity as a Conceptual Basis for Artificial Neural Networks: a Critical Analysis

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Abstract

The aim of this article is a critical analysis of the logocentric representation of brain as a conceptual basis for artificial neural networks (ANNs). Neuro-logocentrism turns possible mostly because of some similarities of brain activity to logical reasoning. They are discrete mode of action, semblance of realization of logical connectives and inferences, presence of two “values” (“all-or-none” principle). It is demonstrated that they are only loose analogies. The idea that neurons are net nodes that realize logical and computational operations as quite simple automata is based on the concept of connectionism that appears a new special type of hylemorphism. On the contrary, brain activity demonstrates the primacy of the whole and its irreducibility to the aggregative sum of elements and parts. It appears continual totality, where everything is reciprocally interconnected, so that it is impossible to establish any unified formalism for it. Brain essentially is a part of the living, not “bio-logic” but fully biological reality, which has an emergent mode of existence with its unique properties. Such processes as neuroplasticity and synaptic pruning are responsible for adaptive and teleonomic re-shaping of the brain. Usual conventional logic is suitable for computing machines and their nets, but it is incapable of reproducing such autopoietic phenomena. As a result, there is a fatal ontological gap between natural networks of neurons and ANNs. The second ones are not able to implement complex cognitive functions as they are product of the logocentric hypertrophy of algorithms which is fully devoid of flexibility of the living brain.

Keywords

Artificial Neural Networks; Brain; Logic; Logocentrism; Neuro-Logocentrism; Connectionism; Algorithm; Computation; Digitality; Autopoiesis

Нейро-логоцентрическая репрезентация активности мозга как концептуальная основа искусственных нейронных сетей: критический анализ

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Аннотация

Целью статьи является критический анализ логоцентрической репрезентации мозга как концептуальной основы искусственных нейронных сетей (ИНС). Нейрологоцентризм становится возможным главным образом из-за некоторых сходств активности мозга с логическим рассуждением. К ним можно отнести дискретный характер действия, видимость реализации логических связок и выводимостей, наличие двух «значений» («принцип «все или ничего»). Показано, что это всего лишь нестрогие аналогии. Идея, что нейроны являются «узлами» сети, каждый из которых как довольно простой автомат реализует логические и вычислительные операции, основана на концепте коннекционизма, который представляет собой новый особый тип гилеморфизма. Напротив, реальная деятельность мозга демонстрирует главенство целого и его несводимость к агрегированной сумме своих элементов и частей. Оно предстает континуальной целостностью, где все реципрокно взаимосвязано, так что для него невозможно установить единый формализм. Онтологически мозг является принципиальной частью живого, не «био-логической», а в полном смысле биологической реальности, имеющей эмерджентный способ существования со своими уникальными свойствами. Такие процессы, как нейропластичность и синаптический прунинг, отвечают за адаптивную и телеономическую перестройку мозга. Обычная конвенциональная логика подходит для вычислительных машин и их сетей, но не способна воспроизводить такие нелинейные аутопоэтические явления. В результате имеет место фатальный онтологический разрыв между естественными сетями нейронов мозга и ИНС. Вторые не способны реализовать сложные интеллектуальные функции, поскольку являются продуктами логоцентрической гипертрофии алгоритмов, полностью лишенными аутопоэтической гибкости живого мозга.

Ключевые слова

искусственный нейронные сети; мозг; логика; логоцентризм; нейрологоцентризм; коннективизм; алгоритм; вычисление; дигитальность; аутопоэзис

Introduction

Modern humanities experience a strong determinative influence from life sciences and, more particularly, from neuro- and brain sciences. Almost all major problems connected with mind, consciousness and intelligence are under this impact. And, wider, the disclosure of the principles which will turn out to be a missing part of a "puzzle" for solving fundamental world-view problems is more often considered to be at responsibility of neurobiology (Bennett, Dennett, Hacker & Searle, 2007). Nevertheless, modern neuroscience also turns into an object of a feedback influence from humanities. The impact of such discipline as logic on neuroscience and its technological applications is analyzed in this article. Particularly, the talk is about the idea that brain activity is essentially similar to logical reasoning. This narrative we will call neuro-logocentrism. Artificial neural networks (ANNs) seems to stand far from this speculative view, but indeed they were inspired by similar ideas about how neural tissue works. Interpretation of the latter influences the understanding of the ontological status of this technology. Nowadays mainstream explanation of the neural networks' success consists in the approach called connectionism:

> "Connectionist models of cognitive processes take the form of artificial neural networks, which are virtual systems run on a digital computer. An artificial neural network is composed of layers of many simple neuron-like units that are linked together by numerically weighted connections. The connection strengths change according to various learning rules and the system's history of activity" (Thompson, 2010, p. 9).

In this article we try to demonstrate that connectionism contains neuro-logocentrism as its conceptual basis, show its theoretical background and reveal its principal limitations.

Theoretical background of the logocentric representation of brain

Why could the idea of the logical nature of neural activity even appear? Logic *prima facie* embraces a completely different ontological realm: it is conventionally understood as a science about phenomena tightly connected with human conscious reasoning, whereas brain appears a natural system. In answer it is possible to turn to the legacy of pioneers of the logocentric view on the brain, McCulloch and Pitts. They reply at the very beginning of their famous article "A logical calculus of the ideas immanent in nervous activity":

> "Because of the 'all-or-none' character of nervous activity, neural events and the relations among them can be treated by means of propositional logic. The 'all-or-none' law of nervous activity is sufficient to insure that the activity of any neuron may be represented as a proposition" (McCulloch & Pitts, 1990, p. 99-100).

The "all-or-none" law means that every neuron principally has only two alternative options for its reaction: 1) if the level of stimuli is insufficient, the neuron won't fire; 2) if the level of stimuli is sufficient, the neuron will fire. Although different limitations of its mechanism have been found later, this principle remains to be one of the basic ideas about how neuron operates with information. The parallel with logic is quite obvious: it corresponds to the bivalence, a basic principle of classical logic, according to which every proposition can get one of two logical values, truth or falsity.

Secondly, McCulloch and Pitts claim that there is also a parallel in the mode of structural organization: synaptic relations between neurons somehow correspond to logical connectives. For instance, conjunction suits to be an expression of the summation of stimuli from other neurons, whereas disjuction is able to reflect the processing of alternative streams of stimuli; negation then manages to reveal neuron's activity which inhibits a signal. In this light, a single neuron is interpreted as a neuro-logical unit, which makes simple (atomic) "propositions", while neural circuit makes complex (molecular) ones. The idea of the importance of collectivity causes theoretical simplification of individual neurons. As a result, many theorists separate the "real" (biological) neuron and the "concept" (artificial) one:

> "The artificial neuron remains an insubstantial shadow of a real neuron. These simplified neural models can be considered concept neurons, explicitly designed based on a concept of how neural processing takes place. The concept neurons are attempts to get to the essence of neural processing by ignoring irrelevant detail and focusing only on what is needed to do a computational task. The complexities of the neuron must be aggressively pared in order to cut through the biological subtleties and really understand what is going on" (Lytton, 2007, p. 88).

In other words, artificial neuron is understood as a node of network. Premiss that set of bounds is more important than set of elements themselves has laid to the approach called connectionism, which is now actively used in ANNs:

> "Connectionist networks are composed of a (typically large) number of simple processing units (nodes) which operate in parallel rather than serially. Content in connectionist networks is not local and addressable, but distributed across numerous nodes and encoded as a pattern of connections. The basic elements of an artificial neural network are simple processing units which are designed to emulate the operations of individual neurons" (Carter, 2007, pp. 187-188).

Due to theoretical simplification, artificial neuron can be represented by software program, which in its turn represents some functional dependency. The transisition from inputs to output is implemented by a set of algorithmic rules, which seem to be quite similar to logical conditional inferences, although they may be incomprehensible to an external observer, remaining a black box (Zednik, 2021). Ideas of reductive logocentrism and network architecture both turn out to be core for the connectionist model:

> "Two key elements of the McCulloch – Pitts work – that of a logical description of activity and a functionally connected network of idealized neurons – are central

> to cognitive modelling and to modern conceptions of cognition, neural activity, and the logical organization of the brain" (Abraham, 2002, p. 4). ANNs is a product of both these trends transferred from fundamental theory to applied technology. Moreover, connectionism "assumes that artificial neural networks are mirroring systems of our biological neural networks. Therefore, by studying the first, we can uncover a lot about the second" (Vassallo, 2024, p. 41).

Consequently, ANNs pretend to be not only a result of inspiration by brain but also an explanatory tool for their natural prototype. In a philosophical sense, connectionism appears a modern special version of hylemorphism, arguing that network structure is primary and more significant than the content, whereas the quality of content is reduced to the quantity of connections and their weights.

The concept of logic's objectification and its consequences

Nevertheless, the logocentric approach to the brain should be inscribed in a larger context, which is connected with the genesis of logic itself. While Kant believed that logic had been fully completed by Aristoteles, it then entered the new stage of rapid progress caused by its symbolic mathematization:

> "Logic, in its most general sense, is the theoretical study of the structure of reasoning, the analysis of the language of propositions, and their logical relations. The late nineteenth century saw the mathematization of logic: the rules of language, reasoning, deduction, and inference – operations of the mind – were mathematized with the development of mathematical logic, an 'algebra of logic'. The logic of propositions can be symbolized, with variables or symbols representing propositions or sentences, resulting in what we now call Boolean algebra" (Abraham, 2002, p. 19).

Finally, a new discipline called theory of algorithms and computations appeared, and it is recognized that logic played the major role in its genesis (Loveland, Hodel & Sterrett, 2014). But in some sense logic became a "servant" of mathematics as a larger formation. Therefore, it was transformed into a rigid formal language. In fact, mathematical logic is not logic in the full sense of the word: it is its own artificial model. Its central benefit is the explication of formal reasoning rules and their transformation into automatic processes of accurate calculation, whereas the main disadvantage is mechanization and alienation of logical reasoning from its human prototype:

> "This is an automatic process that does not require any explicit knowledge of the rule. Logicians have formulated some processes of this sort into explicit rules, but this does not mean that the rules are present as explicit sentences in the minds of people who are not logicians" (Goldblum, 2001, p. 73).

Another significant trend in the development of logic is a *prima facie* bizarre intention to represent it as something objective. The most famous illustration of this idea was provided by Hegel's system, but it was made from the point of speculative idealism. It is obvious *a posteriori* that Hegel's system didn't become logic's mainstream. But, paradoxically, symbolic logic also started to search for own ontological groundings. Probably one of the brightest examples is Wittgenstein's approach:

> "Logic pervades the world: the limits of the world are also its limits. The propositions of logic describe the scaffolding of the world, or rather they present it… Logic is not a body of doctrine, but a mirror-image of the world. Logic is transcendental" (Wittgenstein, 2002, pp. 68, 76, 78).

Wittgenstein put emphasis on the normative character of logic and, therefore, its independence from subjective dimensions. That's why he understood logic as an invariant "structure" not only of human language but of the world itself. In addition, mathematization of logic also made a significant contribution to the idea of its objective existence, since there is an ancient tradition of interpreting mathematics as an ontological phenomenon. Logic and mathematics are quite similar in this context, they both express the structure of the world in the most general way but still differently: "The logic of the world, which is shown in tautologies by the propositions of logic, is shown in equations by mathematics" (Wittgenstein, 2002, p. 82). Within the tendency of logic's mathematization McCulloch and Pitts only changed one kind of mathematics to another (discrete one):

> "In pursuit of McCulloch's dream of a theory of knowledge based on logic, McCulloch and Pitts could now replace the continuous mathematics of the physicists – with the discrete mathematics of the logicians as the appropriate tool for modelling the brain and studying its functions" (Piccinini, 2002, p. 192).

If these ideas only conceptually prepared the objectification of logic, its practical beginning was associated with construction of the first computing devices that reproduce logical operations. One of such pioneer works was made by C. E. Shannon. He showed that logical calculus can be represented by work of electromechanical systems built from such simple elements as relays and switches. In his work, the following statements which are similar to the ideas of McCulloh and Pitts are present: 1) importance of bivalence expressed in the mechanism's ability to take one of only two states: "We shall limit our treatment to circuits containing only relay contacts and switches, and therefore at any given time the circuit between any two terminals must be either open (infinite impedance) or closed (zero impedance)" (Shannon, 1937, p. 4); 2) importance of logical connectives, when their formal meaning is independent from mechanism's substrate:

> "There are many special types of relays and switches for particular purposes, such as the stepping switches and selector switches of various sorts, multi-winding relays, cross-bar switches, etc. The operation of all these types may be described with the words 'or', 'and', 'if', 'operated', and 'not operated'" (Shannon, 1937, p. 29).

Those ideas opened a possibility to create logical gates, which were then used in processors of computer devices. Further progress showed that logical gates can be realized with a wide variety of different material (mostly physical) phenomena. Despite this diversity, the most optimal of their versions remains to be electrical:

> "Basic gates were initially constructed mechanically using levers, often operated by cog wheels. Later they were made from electronic relays followed by vacuum tubes. These days basic gates are fabricated using transistors, as these are reliable, very small and cheap to produce" (Groote et al., 2021, p. 5).

Although transistors continue to be widely used in digital technologies, modern science is focused on the construction of more efficient and powerful forms of logical gates. One of the popular trends here is the bio-inspired approach, which seeks to create gates based on the principles taken from the living. Brain is no exception: the neuromorphic paradigm supposes that simulation of the cerebral information processing patterns is a key to the next generation of computers (Kamsma T. M. et al., 2024). All in all, the fact is that logic appears objectificated (at least in some alienated form) within the framework of emerging computing technologies.

Brain activity as computation: from the logical to the digital?

After the work of McCulloch and Pitts probably one of the most influential works on this topic was J. Von Neumann's "The Computer and the Brain". He was interested in the comparison of brain not with "pure" logic but right away with its applied forms in computer machine. The central concept here is computation, so that the question is transformed into the next one: is brain a kind of computing machine? Neumann takes into account even narrower question: is its functioning digital? The "digital" is traditionally understood as discrete in opposition to the "analogue". It also literally means something connected with numbers and computing in numbers.

Neumann's answer is generally positive: "The most immediate observation regarding the nervous system is that its functioning is prima facie digital" (Von Neumann, 2012, p. 40). Digital system is interpreted by him as a complex consisting of two subsystems – the logical and the arithmetic. Indeed, logic being a general doctrine of reasoning as such is quite autonomous from maths; there is no privilege for numbers in it: "Logical forms are without number. Hence there are no pre-eminent numbers in logic" (Wittgenstein, 2002, p. 35-36). As a result, digital can not be purely logical by definition, so that neural activity (as well as functioning of the conventional computer) turns hybrid. Nevertheless, if we consider computations in a special binary system, the substitution of the concept can occur: the appearance of logicity can be simulated in this case as Truth easily turns in "1" and Fallacy – in "0".

Logical "dimension" of the brain is explained by Neumann with the same arguments which have been already found in the works of McCulloch/Pitts and Shannon:

1. Neuron's functioning according to the "all-or-none" rule:

> "The nervous pulses can clearly be viewed as (two-valued) markers, in the sense discussed previously: the absence of a pulse then represents one value (say, the binary digit 0), and the presence of one represents the other (say, the binary digit 1)" (Von Neumann, 2012, p. 43).

2. The possibility of formalizing the work of neural net with logical connectives:

> "If a neuron is contacted (by way of its synapses) by the axons of two other neurons, and if its minimum stimulation requirement is that of two (simultaneous) incoming pulses, then this neuron is in fact an 'and' organ: it performs the logical operation of conjunction (verbalized by 'and'), since it responds only when both its stimulators are (simultaneously) active. If, on the other hand, the minimum requirement is merely the arrival (at least) of one pulse, the neuron is an 'or' organ – i.e. it performs the logical operation of disjunction (verbalized by 'or'), since it responds when either of its two stimulators is active... Neurons appear, when thus viewed, as the basic logical organs – and hence also as the basic digital organs" (Von Neumann, 2012, p. 53-54).

Therefore, the idea of the brain's digitality doesn't contradict the broader logocentrism but, on the contrary, turns out its successor.

Irreducibility of brain activity to logical operations

Activity of neurons can be formally analyzed from the logical point of view, but it has powerful limitations. First, the two-valued approach to neural impulse appears to be approximative simplification. Nervous tissue realizes two fundamental processes (excitation and inhibition), so that there should be at least three-valued logic ("1" for excitatory signal, "0" for no signal and "−1" for inhibitory signal), which becomes even more complex because of the smooth character of the signal: "We can use any number between −1 and +1 to describe inhibitory as well as excitatory synapses of various strength" (Splitzer, 1999, p. 23). But, indeed, "weights" of neuron-like units in the neural net also appear continuous:

> "In just the same way that neurons can fire at different rates, each unit in a connectionist model has a variable activity level: a measure of how 'excited' it is at any given time. Strictly, this activity level is a continuous variable between zero and one, but in practice, most connectionist networks are constructed so that the unit counts as 'on' if its activity level is above a certain threshold, and as 'off' if the level is below that threshold" (Walmsley, 2016, p. 92).

Therefore, the idea of predominantly analog nature of neural activity alone can not be the main argument against neuro-logocentrism due to capacitites of multi-valued, fuzzy and temporal logics, which are able together to formalize complex, nonlinear and continuous phenomena. This is the reason why J. Vegh and A.J. Berki claim that neuro-logical approach can overcome the dichotomy of the digital and the analog in the case of the brain: "The neural information transfer is neither digital nor analog and the neuro-logical (resembled mixed analog/digital) mode can be more efficient, so it can probably provide higher limiting bandwidth" (Végh & Berk, 2023, p. 12398).

We believe that the main counterarguments lies in the field of ontology. Continual character is an external manifestation of the brain's essence as a special kind of reality. Every neural spike is not a single "point" event as it occurs within the ontological scenery of the living process. For insctance, it can be modulated by numerous bioagents (neurotransmitters, proteins, hormones, ions). The environment of a neuron is not only its "input" and "output" neighbours but also other types of cells (e.g., glial cells) and complex physico-chemical surroundings. If "nodes" of ANNs are fundamentally the same in their essence, such uniformity can not be found among neurons as they demonstrate evolutionary-designed structural and functional diversity: "The brain has hundreds of different neuron types, and individual synapses contain hundreds of different proteins. Duplication and divergence shape brain evolution, just as they do in biology more generally" (Marcus, Marblestone & Dean, 2014, p. 551). The differentiation in quantity is central in the case of artificial neurons; the qualitative diversity is ultimate for the real nerve cells. Altogether, real neural activity can (and should) be inscribed in the ontological domain, particularly in a special kind of ontology, namely, bio-ontology.

Important limit to the logical connectives' application lies also in that they formalize some sustainable operations. On the contrary, real actors in the brain are flexible, constantly changing nets, which are brilliant example of the ancient maxim that "the whole is bigger than sum of its parts". It is proved by life itself: neurons permanently become damaged and dead, but their place is taken by others due to compensatory processes. Moreover, this holism appears fractal as every neuron is not a "material point": it consists of multi-level subsystems and elements, so that it also represents an integrity. As such, neuron has its autonomy, being determined not only from the outside but also from the inside:

> "The structural and functional repertoire of a cell is more than a simple addition of the myriad of protein structures and their functions. Instead, cellular architecture is highly modular. Organelles are the largest units in the cell and are themselves composed of discrete subunits with different functions. At the smallest level, these subunits are assemblies of proteins composed of domains with individual functions. At each level of this modular hierarchy, cellular functions emerge from structures that come together as domains, proteins, protein complexes and assemblies of complexes… In neurons, cellular modules exist at all hierarchical levels" (Arendt, 2020, p. R603).

In other words, we shouldn't forget that a real neuron is a living cellular system with its genetic and biochemical background. Real neuron conducts all general vital functions for its own survival besides its informational functions in the neural net:

> "A neuron is a cell, too. Before it can do any seeing or signaling or thinking, a neuron has to take care of itself. This means it has the same enormous machinery for energy metabolism, protection against toxins, and communication both intracellular and extracellular as other cells in the body with more prosaic job descriptions" (Lytton, 2007, p. 182).

Sure it is possible to continue applying the predicate "logical" to the vitality of a neuron, but it readily turns into an elusive metaphor.

Irreducibility of brain activity to computations

Nevertheless, the term "computation" can be interpreted much wider than the term "logical operation". Nowadays it has become a synonym of almost everything which somehow exhibits algorithmic functioning. For example, P. Churchland et al. consider the brain to be a computational system as they understand computations just as ordered operations under states which represent something:

> "We can consider a physical system as a computational system when its physical states can be seen as representing states of some other systems, where transitions between its states can be explained as operations on the representations... Nervous systems are also physical devices with causal interactions that constitute state transitions. Through slow evolution, rather than miraculous chance or intelligent design, they are configured so that their states represent – the external world, the body they inhabit, and in some instances, parts of the nervous system itself – and their physical state transitions execute computations" (Churchland & Sejnowski, 2017, p. 62, 67).

Again, the theory of computation was tightly connected with logic from the very beginning, so that if the brain is a computing machine, it is also a logical machine in a broad sense (like Turing machine). H. Putnam supposes that Turing machine as an abstraction can be represented by different ontological systems, including biological ones:

> "In particular, the 'logical description' of a Turing machine does not include any specification of the physical nature of these 'states' – or indeed, of the physical nature of the whole machine. In other words, a given 'Turing machine' is an abstract machine which may be physically realized in an almost infinite number of different ways... A Turing Machine might very well be a biological organism" (Putnam, 1975, p. 371, 412).

This overextended approach has its limits too. For instance, the strong version of the Turing-Church principle demands to take into account the specifics of the real Turing machine's substrate, because squarely this substrate maintains an ability to compute different ontological processes by emulating them on ontological processes within such machine (Deutsch, Ekert & Lupacchini, 2000). The substrate of a real machine may provide benefits as well as limits for its computing capacities, while certain substrates appear fundamentally inconsistent with their computational use.

Abstract understanding of the terms "logical" and "computational" is very fragile because they lose their conventionally-recognized identity and become a fuzzy metaphors. For example, etymology of the term "computation" literally means reasonable operations with numbers, so that this process assumes the presence of mind. E. Thompson claims that real computation is exclusively human, being not purely intelligent but immersed in psychological and sociocultural context:

> "The original model of a computational system was a person – a mathematician or logician – manipulating symbols with hands and eyes, and pen and paper... The problem with this myth is that real human computation-the original source domain for conceptualizing computation in the abstract-was never simply an internal psychological process; it was a sociocultural activity as well. Computation, in other words, never reflected simply the cognitive properties of the individual, but instead

those of the sociocultural system in which the individual is embedded" (Thompson, 2010, p. 7-8).

Within such approach, even computers and their nets don't compute but only artificially simulate this process.

Logocentric connectionism of ANNs versus autopoietic totality of brain

Nowadays computer machines and ANNs launched on them remain to be physical systems. Ordinary mathematical logic and algorithms can be reproduced by them. Living systems are ontologically quite distant from pure physical ones, having their unique properties. They are often described in terms like self-preservation, adaptation, evolution, teleonomy. G. M. Edelman claims that central concepts of computer science are insufficient for the living (and particularly for the brain) as they don't reflect the adaptive way of biological existence: "Programs, software, and learned routines are for logic machines. Suppose it turns out that despite the possession of logic in circuitry is not sufficient for an animal to deal adaptively in its initial interactions with the things of this world" (Edelman, 1987, p. 24). It is well-known that if we begin to explain the complex from the point of view of more simple, we lose the ability to understand emergent qualities of the first. However, the reductionist approach to life is still widespread. For instance, M. Minsky proposed the following strategy for explaining the brain:

> "First, we will have to understand how brain cells work. This will be difficult because there are hundreds of different types of brain cells. Then we'll have to understand how the cells of each type interact with the other types of cells to which they connect. There could be thousands of these different kinds of interactions. Then, finally, comes the hardest part: we'll also have to understand how our billions of brain cells are organized into societies" (Minsky, 1988, p. 25).

In such bottom-up approach, which moves from the elements, through their connections, to the whole, brain appears a connectionist "society" of neurons, where each of them is described not as a specific individual but as a simple automaton.

On the contrary, real essence of biological parts can be fully understood only in the context of its place and role in the synergistic whole, so that the primary type of explanation for them is top-down. A. Damasio claims that, in the end, brain itself is only a part of an organism; therefore, it serves the biological needs of the organic integrity:

> "The cells that constitute multicellular organisms live within highly diverse, complex societies... in complicated creatures with many cells, neurons assist the multicellular body proper with the management of life. That is the purpose of neurons and the purpose of the brains they constitute" (Damasio, 2010 p. 35, 38).

Consequently, an explanation of the brain's work is possible only by fitting it into a broader evolutionary and adaptive context. G. M. Edelman argues that natural selection patterns occur in the brain, calling this concept “Neural Darwinism”:

> “Instead of assuming that the brain works in an algorithmic mode, it puts the emphasis upon the epigenetic development of variation and individuality in the anatomical repertoires that constitute any given brain region and upon the subsequent selection of groups of variant neurons whose activity corresponds to a given signal” (Edelman, 1987, p. 44).

By this view, natural neural nets which represent adaptive patterns of cognition and behavior get selected and “survive”, while maladaptive ones get “eliminated”. The latter is happening due to such mechanisms as different kinds of apoptosis (programmed cell death of a neuron) and synaptic pruning (removal of neural contacts). In general, this processes are aimed at the maintaining homeostasis and, moreover, ensuring sustainable development of the brain as key adaptive system. Nothing like this is possible for today’s ANNs.

The brain permanently adjusts itself to complex environment, to the body, and, finally, to the mental realm, which is generated by its own activity. M. Splitzer supposes that traditional computer distinction between hardware and software doesn’t make sense in the case of brain as its structure adapts itself to functions and processes “launching” on it:

> “In contrast to a conventional computer, our brain ‘hardware’ cares a great deal about what ‘software’ is running on it, because ‘bio-hardware’ constantly adjust itself to the software… In neuronal systems, there is neither a distinction between data and programs nor a central processing unit” (Splitzer, 1999, p. 11, 14).

Mechanistic division into processor, memory, programs etc. is meaningless because the brain is a fractal totality, a “melting pot”, where parts work all-together as a dialectical continuum of elements and systems, structures and functions, causes and effects:

> “From this capacity of the nervous system to interact discriminately with its own states in a continuous process of self-transformation, regardless of how these states are generated, behaviour emerges as a continuum of self-referred functional transformation… every one of its states can be its input and can modify it as an interacting unit… every internal interaction changes us because it modifies our internal state, changing our posture or perspective (as a functional state) from which we enter into a new interaction. As a result new relations are necessarily created in each interaction and, embodied in new states of activity, we interact with them in a process that repeats itself as a historical and unlimited transformation” (Maturana & Varela, 1991, p. 38-39).

Brain activity is a continuous process, so that not only spatial parameters (right topology of neurons and their connections) are needful for its functioning but also temporal ones. L. E. Kay supposes that namely time appears a new key element when we move from logical formalism to its “embodiment” in the brain:

> “An essential new element in this theory was an introduction of time. If neurons were to compose a computer of propositional calculus, then one should take into account

that, if the spikes arriving on the axon of two neurons represent truth values of some two propositions, then the neuron computing the logical operation of this two input propositions can give its answer only a cycle-time later than the time of input production" (Kay, 2001).

But time can be understood in completely different ways. The bright example is a N. Wiener's distinction between the Newtonian time and the Bergsonian time (Wiener, 2019): the first one is determined, one-dimensional and reversible, whereas the second one is flexible, multidimensional and irreversible. It is well-known that temporal logic has already been created but it remains "Newtonian", since time is formalized as sequence(s) of discrete steps in it. It is obvious that such mechanistic model doesn't have anything in common with organic time in the brain. The latter is generated by complex activity connected not only with information transfer but with life itself: biorhythms and processes of organic self-organization create synergistically the continual whole that is not identical to itself at each new moment.

Using popular concept of autopoiesis, we can say that the brain is the most autopoietic biosystem as it constantly re-shapes itself in absolutely different, unique ways, avoiding mechanistic following some fixed rigorous rules. Usual logic of computations and algorithms can not catch and formalize the very core of this specificity. We certainly may say that the brain realizes its own neuro-logic as Maturana and Varela try to put it:

"The nervous system in turn has evolved as a system structurally and functionally subservient to the basic circularity of the living organization, and hence, embodies an inescapable logic: that logic which allows for a match between the organization of the living system and the interactions into which it can enter without losing its identity" (Maturana & Varela, 1991, p. 39).

But, indeed, logic loses here its identity; it becomes an elusive metaphor. C. Malabou, being inspired by the discovery of autopoietic process of neuroplasticity, writes about the destruction of the "Machine Brain" concept:

"The analogy between the cybernetic domain and the cerebral domain rests on the idea that thinking amounts to calculating, and calculating to programming... The discovery of the plasticity of brain functioning has rendered such a comparison moot. Plasticity invalidates not the analytical or explicative value of the mechanical paradigm in itself – a paradigm that is, to a certain extent, indispensable for thinking about brain function – but rather the central function habitually associated with the computer and its programs. Opposed to the rigidity, the fixity, the anonymity of the control centre is the model of a suppleness that implies a certain margin of improvisation, of creation, of the aleatory" (Malabou, 2009, p. 35).

Erroneous ontological identification of mind with nervous activity can also lead to some arguments in favor of neuro-logocentrism. For example, N. Wiener recognizes human abstract reason as a cradle of logic, but at the same time he mixes it up with nervous system as its material substrate: "Logic which means anything to us can contain nothing which the human mind – and Hence the human nervous system – is unable to encompass" (Wiener, 2019, p. 172). Of course, mind and brain should be strictly distinguished. Brain is a biological organ and, therefore, a part of natural reality. It is only a "lower" basis for human mind as more complex ("higher") sociocultural system. Brain is extremely sophisticated but ultimately natural system. It was shaped by objective biological forces: genetic variability, heredity and natural selection. For this reason, G. M. Edelman and G. Tononi claims that logic, being a product of human mind, is not able to explain mind's own natural background, while evolutionary forces are able to do it:

> "Logic is, for example, a human activity of great power and subtlety. If the evolutionary assumption is correct, however, we can conclude that the workings of logic are not necessary for consciousness. Logic is not necessary for the emergence of animal bodies and brains, as it obviously is to the construction and operation of a computer. The emergence of higher brain functions depended instead on natural selection and other evolutionary mechanisms" (Edelman & Tononi, 2008, p. 16).

On the contrary, logic in a broad sense (pre-established orderliness of programs and algorithms) is primary for every computer technology, including ANN.

Consequently, the ontology of biological brain is radically different from the connectionist ontology of ANN. Several theorists support an ambitious project that ANNs, being inspired by brain, should be "returned" to it. The talk is about some hybrid symbiosis when ANNs can be integrated in human nervous system: "Artificial intelligence has entered an era in which systems directly inspired by the brain dominate practical applications. The time has come to bring this brain-inspired technology back to the brain" (Kriegeskorte, 2015, p. 420). But the described ontological gap between them makes this project elusive too.

Conclusion

To conclude, the very possibility of neuro-logocentrism is connected not only with some real similarities ("all-or-none" law, analogy of neuron's actions to some logical connectives) but also with the theoretical widening of the logic's meaning itself. ANNs are logocentric namely in this broad sense as their work is based on formalized algorithms and programs that are at least partially the result of the objectification of logic. Connectivism is inherent in ANNs because they "act" and "learn" in a distributed manner by changing the weights of the synaptic connections between their nodes.

On the contrary, there are strong arguments against the brain's logocentric and connectivist view. The brain is, in its essence, part of biological reality. The living is unique in the way of its existence: it presumes self-preservation, adaptation, and autopoiesis. The brain seems to be the most autopoietic biosystem due to constant adaptation to both natural and sociocultural environment. Therefore, every neuron is not a "node" of net that reproduces a quite simple and compact repertoire of tasks. Such autopoietic processes as neuroplasticity, neurogenesis, sophisticated balance between excitation and inhibition are principally non-algorithmic as they avoid routine following some rigorous rules and re-shape brain every time in the unique way. The brain is a continual totality where everything is reciprocally interconnected, so that it can not be reduced to any united formalism. If connectionist paradigm is based on bottom-up approach, viewing the whole as a sum of parts, the brain clearly demonstrates the predominance of top-down approach, when the whole is primary and local phenomena should be inscribed in its context, considering their individual properties and accumulated life experience. Autopoiesis of the living brain seems to be a "missing part of a puzzle" which prevents ANNs from providing a "key" to the essence of human intelligence.

An attempt to fit brain activity to machine learning of ANNs is inadequate as in this case the prototype appears a model of its own model through the vicious circle. The situation of inconsistency between substrate and function (attribute) takes place: logical reasoning can not be fully embodied in ANNs as it is an attribute of human mind. But brain is also not reason itself: it is an organic system which works according not to any logic but to immanent natural laws. In the end, neuro-logocentrism is an irrelevant ontological construct. Probably it can become an epistemological construct when logicians try to built formal systems, describing brain activity. Nevertheless, conducted analysis shows that it is also extremely unlikely. Brain is not neuro-logical or even bio-logical but biological organ in the full meaning of the word. With all its autopoietic vitality, brain resists any attempts of its formalization and simplification.

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