Conscious Artificial Intelligence:
Can Current Artificial Intelligence Achieve Consciousness?

Feyzullah Temurtaş[1,2]
[1]EE Eng, Bandırma Onyedi Eylul University, Balıkesir, Turkey, ftemurtas@bandirma.edu.tr, ORCID: 0000-0002-3158-4032
[2] AINTELIA Artificial Intelligence Technologies Company, Bursa, Turkey, temurtas@gmail.com, Scopus ID:6603197371

Consciousness is said to be associated with neuronal activity in the brain, but how this relationship works is still unknown. There are different theories and opinions on whether consciousness is a biological phenomenon or a physical process. The question of whether consciousness can be created in artificial intelligence systems has also been raised. In this article, current artificial neural network models that attempt to mimic the workings of the brain have been discussed and evaluated for their adequacy in addressing the issue of consciousness.

Keywords: *Artificial Intelligence, Consciousness, Artificial Neural Networks, Neuroscience.*

1. Introduction

Consciousness is subjective experience. Examples of conscious experiences are perceiving a scene, suffering, having a thought, or reflecting on the experience itself. Conscious experiences are unique to the person and can only be accessed from within [1]. It is known that consciousness is associated with neuronal activity in the brain [2]. However, how this relationship is still at the level of discussion.

Consciousness and intelligence are a feature that is necessary to exhibit appropriate behaviors to the environment for survival and adaptation. Some researchers claim that this feature can also be observed in living things that do not have a nervous system or have a simple one, and even in plants [3].

Artificial intelligence has started to be used very widely today. The issue of consciousness is still not fully understood and agreed upon. Discussions continue on whether artificial conscious intelligence is possible or not. There are different conceptual approaches that try to explain consciousness as a phenomenon, such as Neurobiological Naturalism (NN) [4] and Integrated Information Theory (IIT) [1,5]. NN argues that it is a biological phenomenon and depends on certain neurobiological features, while IIT claims that consciousness is a fundamental reality feature and that consciousness is a physical process and this process is determined by the physical properties and interactions of neurons. It is evaluated that NN and IIT are fundamentally different and difficult to integrate. NN argues that artificial consciousness is not possible, while IIT argues that it is possible [6].

Scientific studies that question whether brain activity such as activation functions are the cause of consciousness are also being done. However, the causal relationship between consciousness and action potentials has not yet been clearly revealed [7].

Architectural suggestions are presented to create consciousness in a virtual reality environment, but these architectures are still far from creating a real consciousness [8]. He argues that human consciousness and understanding are not algorithmic, that is, they cannot be imitated by computers [9]

The neurochemistry of consciousness is also related to various neurotransmitters. These include glutamate, acetylcholine, GABA, norepinephrine, dopamine and histamine. Brain phenomena related to self-awareness also constitute an aspect of consciousness. Some brain regions such as anterior cingulate, frontoinsular cortex, prefrontal cortex are associated with self-awareness. There are studies that associate consciousness with brain regions and

associate brain neurochemistry and neurotransmitters with consciousness, but no complete explanation has been put forward yet [10]

There are also electromagnetic consciousness theories that suggest that consciousness can be understood as an electromagnetic (EM) phenomenon produced in the brain [11]. It has been suggested that the inclusion of communication via EM field in brain function models could reshape the discussions on consciousness [12].
It is thought that consciousness cannot be fully explained by classical physics and that the brain has partially quantum mechanical processes [13]. Among scientists, there are also those who argue that consciousness is produced by quantum processes. However, this theory has not yet been tested experimentally. There are also studies suggesting that consciousness may be related to quantum computations and that quantum computations in microtubules in brain neurons lead to consciousness [14].

Although ethical issues are discussed on this subject, there are also studies on the use of three-dimensional biological entities grown in the laboratory called human brain organoids (HBO). Some HBOs are evaluated to be able to experience simple emotional states such as pain and pleasure or even a consciousness about themselves. HBOs are entities that are genetically human and can interact with the environment. Some HBOs can create biological-cognitive hybrid systems by connecting to electronic devices or transplanting into animal brains [15].

Artificial neural networks usually take place in the form of software modeling. Although there are hardware studies [16,17], they are not much beyond numerical modeling logically. In this study, it is aimed to make an evaluation on the issue of consciousness especially in current artificial neural network structures.

2. Examples of studies done with biological neural structures

Gidon et al. question the causal link between action potentials and consciousness in their study. The study assumes that it is possible to record the neural activity (in the form of action potentials) from all the neurons in a participant's brain and then play it back to the same neurons later, and discusses whether this artificial repetition would create a conscious experience. However, the article states that the findings question the causal link between consciousness and action potentials, and that this link is not fully understood [7].

Sechzer et al. investigated the effects of pure lithium isotopes (Li-6 and Li-7) on maternal behavior and offspring development in their study. Lithium isotopes caused different maternal behaviors in mother rats. Mothers given Li-6 showed excessive interest in their offspring, while mothers given Li-7 neglected their offspring [18]. Fisher emphasized that this study points to the possibility of quantum processing in the brain, and that it would be very important to reproduce this striking experiment [19].

Dent et al. suggest in their study that microtubules play a role not only in shaping neurons and organelle transport as structural elements, but also in intracellular signaling, and have a function of carrying information [21]. Grass et al. claim that light plays a role in intercellular communication, and that we should see our brain as an "optosybermetic system" or a "holographic computer" thanks to light guidance in microtubules [22]. According to this view, light signals in our brain shape our conscious experiences.

Quantum biology field is developing due to the aspects of biology that cannot be explained by classical physics laws of biology such as theoretical chemistry in biological activities like neural activities [23]. They have examined the quantum optical properties of microtubules and their possible effects on brain function in the literature. They claim that microtubules, which are an important part of the cytoskeleton structure of brain cells, can show quantum optical phenomena as a result of interaction between water molecules and quantized electromagnetic field, and that quantum optical properties of microtubules can help explain the physical basis of conscious experiences [14, 24-27].

Kagan et al. developed a system called DishBrain, which integrates human or rodent-derived neuron cultures into high-density multi-electrode arrays (HD-MEA), and places them into a simulated game world that mimics a classic arcade game called "Pong" through electrical stimulation and recording. The authors claim that neuron cultures show a phenomenon they call synthetic biological intelligence, and suggest that the study can provide new insights into the cellular basis of biological intelligence, and pave the way for silicon-biological computing platforms [28].

In their study, Stanford Medicine researchers report that they have succeeded in creating hybrid working circuits by connecting human nerve cells or neurons and supportive brain cells with rat brain tissue. This method makes it possible to study healthy brain development and brain disorders that arise during development without removing tissue from the human brain. The researchers perform these experiments by creating brain tissue-like structures called organoids in laboratory dishes and transplanting them into a rat's brain. Thus, they can observe the effects on the animal's behavior. This study offers a new platform to investigate healthy development of human brain and developmental brain disorders. It also provides testing opportunities for new drugs and gene therapies [29]

3. Artificial neuron and artificial neural networks

Artificial neural networks are a model consisting of multi-input signal processing elements that are inspired by biological nerve cells. These elements are called artificial neurons and they are connected in a hierarchical way to form different layers. As seen in Figure 1, an artificial neuron is a simple mathematical modeling of a real nerve.

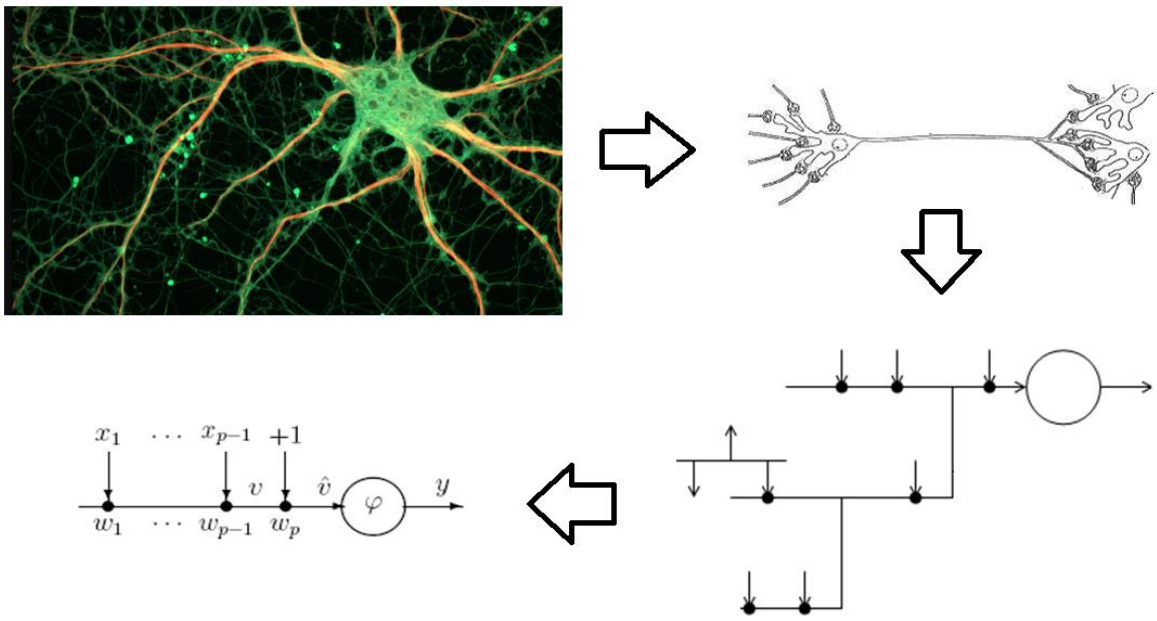

Figure 1. *Artificial neural node modeled by inspiration from biological nerve*

Artificial neural networks can be used to solve various problems using different layers and activation functions. For example, there are common models such as Multilayer feed forward neural network, Convolutional Neural Network, Radial Basis Functional Neural Network, Recurrent Neural Network, Long Short-Term Memory, Probabilictic Neural network. However, artificial neural networks do not fully reflect the complexity of biological nerve systems. There are thousands of types of nerve cells [30], thousands of synapses in each nerve cell, neurotransmitters, receptors, active ion gates, microtubules, magnetic and quantum effects in the real brain. Artificial neural models remain quite simple compared to a real nerve. This can be compared to the stickman picture representing the human (Figure 2). Deep or shallow artificial neural network models are powerful tools for solving many current problems by mimicking the computational power of the brain that is understood to some extent, but they are not at a level that can be compared with brain complexity.

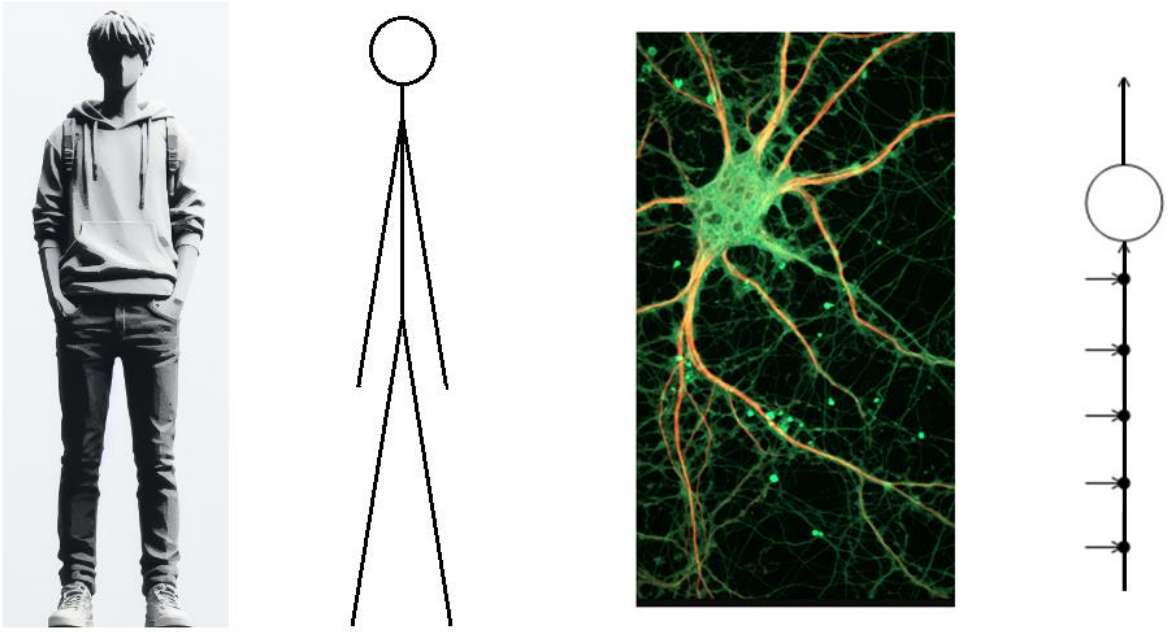

Figure 2. *Comparison of stickman picture representing human with an artificial neuron representing biological nerve*

4. Results and discussion

This article discusses the issue of consciousness in the context of artificial intelligence. It addresses whether consciousness is a biological phenomenon or a physical process, the relationship between consciousness and factors such as neuronal activity, neurotransmitters, electromagnetic fields, quantum mechanics, microtubules, architectural proposals for creating conscious artificial intelligence, and ethical issues. Consciousness is a subjective experience and is associated with neuronal activity in the brain. However, how this relationship works is still unknown and there is no complete explanation or consensus on this issue.

Studies with biological nerve cells reveal different factors such as quantum processes, electromagnetic phenomena, light guidance, microtubules in the brain. These factors are thought to play a role in the formation of consciousness. The use of biological entities produced in laboratory environments such as human brain organoids provides a new platform for studying conscious experiences. However, this method also brings ethical problems along with it. Sample studies with biological nerve structures show different approaches and methods for creating conscious artificial intelligence.

Current artificial neural network models are quite simple compared to the complexity and diversity of real nerve cells. Since the functioning of nerves and quantum effects have not been fully understood yet, artificial neural models are far from representing real nerves. The models used in artificial neural networks are simple computational models, whether software or hardware. The distributed parameters corresponding to synapses in these models are coded numerical or analog information. It is not realistic to expect the formation of consciousness, which we do not yet know what it is physically, from the combination of these well-known distributed parameters. Therefore, it is evaluated that the current artificial neural networks and artificial intelligence models are insufficient on the issue of consciousness. Artificial intelligence, although currently far from creating consciousness, is clear that it will develop and become more widespread day by day.

REFERENCES

[1] G. Tononi, M. Boly, M. Massimini, C. Koch, “Integrated information theory: from consciousness to its physical substrate”, Nature Reviews Neuroscience, 17(7), 450-461, 2016.
[2] M. M. Andelman-Gur, I. Fried, "Consciousness: a neurosurgical perspective", Acta Neurochirurgica, 165:2729–2735, 2023.

[3] Anthony J. Trewavas, František Baluška, “The ubiquity of consciousness, cognition and intelligence in life”, European Molecular Biology Organızation EMBO reports, 12(12) 1221-1225, 2011.
[4] T. Feinberg, J. Mallatt, “The nature of primary consciousness. A new synthesis”, Consciousness and Cognition, 43, 113-127, 2016
[5] G. Tononi, M. Boly, M. Massimini, C. Koch, "Integrated information theory: from consciousness to its physical substrate", Nature Reviews Neuroscience volume 17, pages450–461 (2016)
[6] F. Ellia, R. Chis-Ciure,"Consciousness and complexity: Neurobiological naturalism and integrated information theory", Consciousness and Cognition, volume 100, April 2022, 103281
[7] A. Gidon, J. Aru, M.E. Larkum, “Does brain activity cause consciousness? A thought experiment”, PLoS Biol, 20(6): e3001651, 2022.
[8] A. Kadin, “Conscious Machines for Autonomous Agents and Cybersecurity”, TechRxiv. Preprint., https://doi.org/10.36227/techrxiv.17308406.v1, 2021
[9] R. Herce, "Penrose’s new argument and the non-locality of consciousness", PENSAMIENTO, 78(298), 337-350, 2022.
[10] N. C. Paredes, “Models of neural processing of consciousness: insights from cognitive and systems neuroscience", Revista Mexicana de Neurociencia, 23(6), 214-222, 2022.
[11] A. Liboff, “Magnetic correlates in electromagnetic consciousness”, Electromag. Biol. Med., 35(3), 228–236, 2016.
[12] J. McFadden, “Consciousness: Matter or EMF?”, Front. Hum. Neurosci, 16:1024934, 2023.
[13] S. A. Kauffman, A. Roli, "What is consciousness? Artificial intelligence, real intelligence, quantum mind and qualia ", Biological Journal of the Linnean Society, 139 (4), 530–538, 2023.
[14] S. Hameroff, “‘Orch OR’ is the most complete, and most easily falsifiable theory of consciousness”, Cognitive Neuroscience, 12(2), 74-76, 2021.
[15] A. Lavazza, M. Reichlin, "Human Brain Organoids: Why There Can Be Moral Concerns If They Grow Up in the Lab and Are Transplanted or Destroyed", Cambridge Quarterly of Healthcare Ethics, 32(4), 582–596, 2023.
[16] 0. Cetin, "Implementation of artificial neural networks on adaptive hardwares", Ph.D. thesis, EE Eng., Sakarya University, Sakarya, Turkey, 2006.
[17] Z. Xu, F. Li, C. Wu, et al., "Ultrathin electronic synapse having high temporal/spatial uniformity and an Al2O3/graphene quantum dots/Al2O3 sandwich structure for neuromorphic computing", NPG Asia Materials, 11(18), 2019.
[18] J. A. Sechzer, K. W. Lieberman, G. J. Alexander, D. Weidman, P. E. Stokes, "Aberrant Parenting and Delayed Offspring Development in Rats Exposed to Lithium", Biol Psychiatry, 21, 1258-1266, 1986.
[19] M. P.A. Fisher, "Quantum cognition: The possibility of processing with nuclear spins in the brain", Annals of Physics, 362, 593-602, 2015.
[20] E. W. Dent, P. W. Baas, "Microtubules in neurons as information carriers", Journal of Neurochemistry, 129, 235–239, 2014.
[21] F. Grass, H. Klimab, S. Kasper, "Biophotons, microtubules and CNS, is our brain a “Holographic computer”?", Medical Hypotheses, 62, 169–172, 2004.
[22] I. Khmelinskii, V. I. Makarov, "Analysis of quantum coherence in biology", Chemical Physics, 532, 110671, 2020.
[23] M. Jibu, S. Hagan, S. R. Hamerof, K. H. Pribrame, K. Yasue, " Quantum optical coherence in cytoskeletal microtubules: implications for brain function", BioSystems ,32, 195-209,1994.
[24] P.C.W. Davies, "Does quantum mechanics play a non-trivial role in life?", BioSystems, 78, 69-79, 2004.
[25] N.E. Mavromatos, D.V. Nanopoulos, "Quantum mechanics in cell microtubules: Wild imagination or realistic possibility", Advances in Structural Biology, 5, 283-318, 1999.
[26] D. Nanopoulos, "Theory of Brain Function, Quantum Mechanics and Superstrings", Report number: CERN-TH/95-128, 1995.
[27] B. J. Kagan, A. C. Kitchen, N. T. Tran, et al., "In vitro neurons learn and exhibit sentience when embodied in a simulated game-world", Neuron, 110 (23),3952-3969, 2022.
[28] O. Revah, F. Gore, K. W. Kelley, et al., “Maturation and circuit integration of transplanted human cortical organoids”, Nature, 610, 319–326 (2022).
[29] K. Siletti, R. Hodge, A. M. Albiach, et al., "Transcriptomic diversity of cell types across the adult human brain", Science, 382(6667), 2023.