

Modeling Language Learning in the Brain - Neural Networks - and Artificial Intelligence

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Abstract

Neuro-network language learning is linked to the ability to activate the brain and the mind, meaning the activation of nerve cells responsible for transmitting information and stimulating important areas in the learner's brain. The emergence of neuro-network learning in the brain has been associated with modern technological developments in the field of informatics and the advancement of research in neuroscience, particularly in the area of neurophysiology. Today, modern cognitive educational pedagogy seeks to leverage artificial intelligence, especially neural algorithms and their learning, whether supervised or unsupervised. From this, the following questions come to the reader's mind: What is neuro-network learning in the brain? What are its cognitive extensions in artificial intelligence? And how does this contribute to building cognitive linguistic achievement in the modern learner?

Keywords: Brain maps, neuro-network language learning in the brain, neurophysiology, neural networks, artificial intelligence...

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Introduction:

Language learning in the modern era is considered one of the challenging educational activities due to the special nature of this process, which varies according to educational stages and the cognitive abilities of learners. For this reason, various linguistic theories have sought to find an ideal explanation for the process of language acquisition and to develop learning theories that help in understanding the nature of language and how to teach it to achieve high linguistic competence with minimal effort and time. Chomsky's theory was one of the most prominent contributions in this field, followed by Ronald Langacker's theory, which deepened our understanding of the nature of language and the process of linguistic acquisition. These theories contributed to the development of computational linguistics by using information networks to describe language, providing a model that can be modeled within the fields of linguistics and computer science.

Neuro-network education is considered a model inspired by the conceptual structure of human neural networks in the theory of information knowledge or computer science. This model developed with the advancement of neuroscience and artificial intelligence; where neuroscience revealed how the brain works in processing, receiving, analyzing, and retrieving information. This field, known as neurophysiology, is concerned with analyzing the process of information flow within the nervous system, while artificial intelligence deals with processing information in a pictorial and physical manner. Therefore, this research aims to explore neuro-network learning and its relationship with artificial intelligence as part of the analysis performed by the brain.

First: Learning and Neural Network Education:

1. Learning:

All humans have the ability to acquire knowledge, and learning can occur in the context of an organized educational institution and through a specific curriculum, making the learning process directed and studied with designed inputs, while the outcomes are expected or nearly expected. In contrast, learning can be unintended through the experiences and encounters a person faces in their daily life.

The concept of learning has been addressed with multiple definitions, seeking to understand this complex process at the brain level. Some have treated this process as part of the behavior or daily activity that a person practices in their life. Others have tried to give it a scientific character based on various brain activities related to understanding and perception. From this standpoint, proponents of the cognitive theory defined learning as "the process through which an individual receives sensory information, processes it, and encodes it within the neural structures of the brain to retain it for later use."

Here, the concept of learning goes beyond merely receiving information from the external world through the five known senses: hearing, sight, smell, taste, and touch. It includes how this information is transferred to the brain, where it is encoded, analyzed, interpreted, and stored in

memory for retrieval and use when needed. Learning is considered "an internal mental process inferred by observing changes in an individual's performance as a result of practicing a certain task." Thus, learning occurs through stimulating mental processes such as concentration, creativity, and imagination, utilizing all external mental processes to receive information to achieve the desired performance, despite differences in abilities and skills among learners. The more these mental processes are stimulated, the more successful the learning becomes.

2. Neural Network Learning:

It is a complex symbolic mental interaction that requires the interconnection of a group of nerve cells that allow directing this educational and learning process. The term "network" was taken from neuroscience, which has proven that the brain's operation in executing various commands is done through the interconnection and interaction of a group of elements within the nerve cell. This interconnection in cognitive linguistics is known as conceptual blending or mental space, as stated by Fauconnier, who says: "Indeed, achieving blending as the basic imaginative faculty underlying all thought and behavior would not have been practically possible if its theoretical requirements had not been the regularity of semantic information in the human mind within spatial conceptual groupings." Thus, mental activity is considered an essential component in the conceptual process and the organization of information and concepts, and in every intellectual or behavioral act performed by individuals. The process of conceptual blending activates billions of cells in the learning and communication process.

Neural network learning refers to the ability to stimulate the dynamics of learning by activating the learner's brain to transform language information into pictorial meanings through the overlap and interaction between the structure of information in the neural form and reality. Information moves from lower processes to higher processes by activating neural and mental mechanisms. The pictorial meaning results in the formation of concepts in a network form known as the neural network diagram. The first to present this conceptual model regarding the nature of information in the neural network was Rumelhart and McClelland in 1986, who dedicated this topic to two groups called the Sharks and the Jets, explaining how information spreads and is retrieved within the neural network, so that each individual within the two groups has specific characteristics that help us reach the specific individual within this network.

The importance of the neural network lies in its performance of several roles and tasks within the brain in the form of integrated templates, each with a primary task, whether in analyzing, encoding, decoding, or retrieving information. It is "suitable for many

It is "suitable for a great many types of presentation tasks such as recall memory, disambiguation of words, understanding dialogue, sensory perception, compound names, creative procedures, and others. This type has strongly qualified the network to be a formal image (Formalism) of coherent and interactive models in communication. There are purely formal benefits." Therefore,

this network is considered necessary for the learning process, as it is a main component that activates long-term memory due to the ease of information retrieval. It also helps in understanding utterances and dialogue, activates the processes of attention and perception, and stores meanings and names in conceptual and structural networks. It contributes to problem-solving and the processes of creativity and innovation necessary for learning.

Secondly, Network Learning and Language Teaching: Language is considered a vital element in the communication process. According to modern linguistic research theories, especially those presented by Chomsky and proponents of the mental or cognitive approach, language represents an innate ability or mental faculty with which an individual is born. This faculty helps him later in acquiring language, which enhances the transmission and comprehension of information, whether auditory or written. The process includes receiving information from the environment, encoding it, processing it, and analyzing it within the brain using mental processes. Therefore, language according to this approach is considered one of the mental organs responsible for the various activities carried out by the brain. It plays a major role in communication through understanding the world, direct interaction with reality and its analysis, and develops the learner's thinking, creativity, and problem-solving abilities.

Based on this, a modern branch in the science of linguistics has been established that focuses on how this organ functions during the processes of understanding and perception and even language production. This branch is now known as cognitive linguistics, which explains mental activity in the context of studies that examine mental processes, relying on language as a central mental ability related to perception, symbols, expression, and thought.

This approach contributed to the development of new concepts of learning based on the study of the mind and the neural activity of the learner while receiving information. The schema theory or neural network theory was used to explain brain activities, where these projects are considered socially driven and characterized by cooperation.

Terms such as schema or neural network include the conceptual processes carried out by the mind during language comprehension and production. This process includes the re-presentation or retrieval of information and concepts from various linguistic corpora. Cognitive studies aim to understand the processes that work during language use and how it is stored in memory, as well as the methods of encoding and analysis practiced by individuals, in addition to studying how grammar and semantics work in the brain.

The neural network learning process depends on three basic elements whose roles differ according to their function in activating the mind and stimulating nerve cells, which are:

1. The teacher: whose function is to stimulate mental neural activity;
2. The learner: who performs brain neural activity so that language is formed in a system of coding and analyzes this encoding into conceptual data according to his comprehension abilities;

3.The content: a collection of information that can be encoded and transformed, according to cognitive standards, into a knowledge repository for the learner.

Third – Neural Network Learning and Neuroscience: The development of neuroscience, as well as modern detection devices such as the EMG (electromyogram), the IMFR (electromagnetic scan), and the IRM (cell scanner), played a prominent role in revealing the nature of the neurons in the brain and in understanding the components of this sensitive organ in the human body. These devices facilitated the process of observation and tracking the path of information within the neuron, or the activity of the neural impulse and the movement of hormones and the way information flows, after “showing the great role the brain plays in controlling the linguistic process and its interactive pathways, and the integrative linkage between the different language-responsible centers in the brain in order to regulate the linguistic communicative act.” The results revealed by these devices showed that the brain performs a significant activity in the process of receiving and analyzing language. They also disclosed the presence of specialized language centers in the brain, such as Broca’s area and Wernicke’s area, and the arcuate fasciculus which connects the two areas. Brodmann identified a group of areas in the brain according to their function, including the visual areas 17 and 18, the auditory areas 22, 41, and 42, the tactile and parietal areas 1, 2, and 3, or the motor areas 4 in humans. There are areas called association areas, which are the frontal areas 8, 9, 10, 11, 44, and 47.

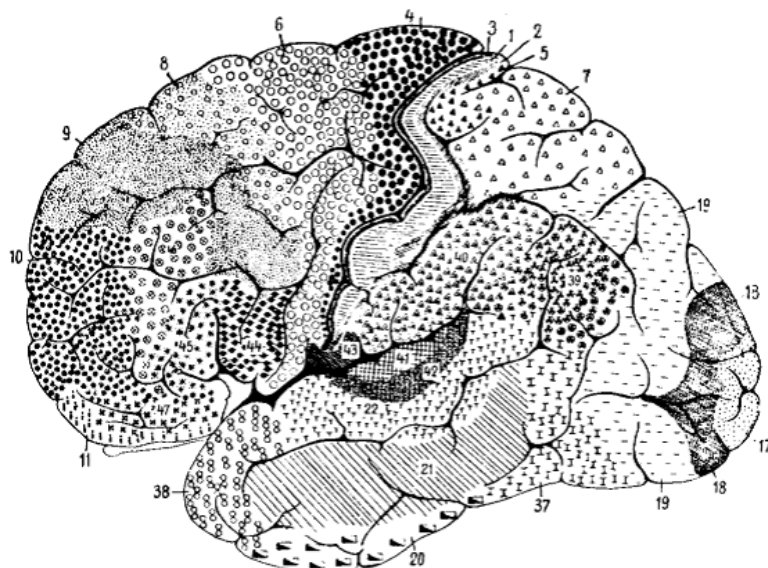


Figure 1: Brodmann's Map of Brain Areas

Language is first formed through these neurons in the form of mental images that reflect the representation of objects, events, and situations encountered by the individual during the perception process. The individual usually possesses the ability to recall visual images of things, which are

typically translated into mental images that help in identifying and controlling them with a high degree of accuracy. These mental images reflect the external reality in a tangible or sensory form in templates that share common features. These templates are called mental spaces, which, according to Fauconnier, are “small conceptual packages constructed as we think and talk for purposes of immediate understanding and behavior.” These mental images help the language user to understand reality and communicate about it by converting these images into words. “When the first part of the word is heard, the listener activates all the words that begin with this part at once” in a process akin to both collection and sorting at the same time. Sternberg assumed that in this process, it is easier for the individual to represent images than to represent words and symbols, considering that these mental images “are described as physical and clear, and are easy to control, manipulate, and recall. They rely on external sources based on the environment and usually occur as a result of interaction with elements of the external environment,” which makes the recall of information instant and immediate. In this sense, it is similar to how a computer works, where algorithms help it recognize and analyze information faster, often exceeding the capabilities of the human mind. The process of mental imagery is based on the following foundations:

1. Mental Rotation: At this stage, the mind performs the rotation of various mental images it knows or stores in the brain, in the form of a retrieval process of images of these entities. This mental rotation process is accompanied by gradual transitions of neural impulses that perform symbolic conversion of primary stimuli to the cells, which in turn perform symbolic conversion of transformed stimuli.

2. Image Scanning: The mind retrieves information through the actual scanning process of perceived or imagined representations and events in a process similar to the scanning of photographic images, in which the retrieval of sensory or abstract information occurs, either wholly or partially.

3. Visual Comparison of Quantities: This process is carried out by comparing sensory or abstract images that usually share one or more features. This process occurs faster in the brain when the size difference between these objects decreases and the similarity increases, which helps the brain accelerate the immediate retrieval of information related to these mental images.

4. Visual Imagery: This process involves linking actual perception and visual imagery of things, places, and entities within the brain regions responsible for this function located in the hippocampus and the facial memory area. The parietal regions support the spatial component of mental imagery, while the temporal lobe supports visual aspects. Mental rotation is considered a spatial task that tends to generate activity in the parietal cortex, where the temporal structures are activated when a person imagines the visual properties of objects.

5. Cognitive Maps: Cognitive maps help in remembering and identifying the spatial structure of the environment. The imaginative representations of the world are often referred to as cognitive

maps. The relationship between imagination and action appears particularly in these maps. We usually imagine the environment in which we live when we plan how to move from one place to another. In children, the process of cognitive map processing develops from linear tracking to map scanning. In adults, the same tracking process appears when learning new places, but they first follow the routes in the form of mental maps and then quickly transition to scanned maps. There is brain activity during the map scanning process that is very similar to visual imagery. There is also activity in the inner motor cortex and hippocampal cells.

6. Translation from Words to Images: In this process, spoken words are translated into mental images due to the mind's ability to convert verbal descriptions into rich mental maps of the surrounding environment. For example, when listening to a football match on the radio while driving, one can imagine the players' positions on the field and recall stereotypical images of their faces and bodies previously seen.

Fourth – Neural Network Learning and Artificial Intelligence: Artificial Intelligence (AI) in the modern era is considered one of the most vital fields due to its contributions to the development of media and modern communication, such as computer science, robotics, and other areas. Artificial intelligence primarily relies on simulating human intelligence in dealing with life in general, including language, which is considered the basis of thought for this being. Based on this, most research in the field of artificial intelligence focused specifically on this aspect due to its role in developing this field, such as translation, computing, and learning. It quickly moved into the field of reading and writing. Thus, several studies emerged that paved the way for the development of this vital field in the life of modern humans, through which the computer was able to simulate the human brain in the simplest operations related to language processing, and in some cases, in more complex operations such as automatic speech recognition and natural language processing (NLP), and even visual processing of images and information, known as computer vision, in which the computer simulates the human brain in retrieving, modifying, and transforming these images—what is known as image processing.

Since the human brain interacts with its environment in a smooth and flexible manner through this type of intelligence, scientists have worked on creating a robot that simulates this activity, which is known in the modern era as the field of robotics. It has achieved remarkable development through pattern recognition and the service of grouping similar items, which facilitates machine learning. Despite the complexity of the human mind due to the abundance of neurons that enable humans to understand, speak, learn, and remember, artificial intelligence scientists have tried to imitate this type of intelligence to achieve highly accurate results in computer processing of various information through what is called the neural network. Due to the interconnection and interaction between these neurons in analyzing things, another vital branch in this rich science has emerged, known as deep learning.

Fifth – Leading Models of Artificial Intelligence in Neural Network Learning: Learning in general, and network-based learning in particular, are among the most important fields in which artificial intelligence has been invested, due to its role in developing this activity that humans continuously need to enhance their cognitive and scientific abilities. Nevertheless, several models have emerged aiming to explain the learning process in the brain and attempt to utilize it in the field of artificial learning, including the model of Collins and Quillian, Smith's model, and the model of Collins and Loftus. The Collins and Quillian (Collins et Quillian) model is considered one of the pioneering works in this field. They developed a visual model that represents information in long-term memory and how it is retrieved as it happens in the mind. This model is known as the *Teachable Language Comprehender (TLC)* model, introduced in 1970, after they posed a fundamental question about the representation of information in memory: How is information represented in memory and how is the meaning of a concept determined?

According to this model, understanding language requires identifying the features and properties of concepts and working to understand how these concepts are retrieved from long-term memory. This model is based on two main assumptions: Representation of Concepts and Information Retrieval, and two key principles: Hierarchical Organization Principle and Cognitive Economy.

The task of the first assumption, Representation of Concepts, is to create a stereotypical image of all forms and entities that share a property or a set of properties within a specific genus or category, which is referred to by Collins and Quillian as Semantic Nodes. The second assumption's task is the retrieval of information through what is known as long-term memory, in which the memory is in a state of dormancy or inactivity and is quickly activated upon seeing or hearing any of these concepts or meanings related to a specific subject through distributed activation across all the cells that contain these concepts.

An example of how these two assumptions work: when a person hears the word *eagle*, the mind immediately retrieves the concept of *animal* as a category or semantic node, and long-term memory is quickly activated to reach the true concept of this animal through distributed activation across all the cells containing the meanings of (bird – feathers – wings – claws – flies – predatory... etc.), which helps the mind recall all types of animals that fall under this pattern or semantic node.

Regarding the two principles that these assumptions operate under:

- Hierarchical Organization Principle: Its function is to hierarchically organize information or semantic features in a regular order in which long-term memory moves from general to specific, helping the mind in the retrieval process, such as classifying the concept of an eagle within birds, a shark within fish, and a horse within land animals. Reversing the hierarchy, all fall under one pattern, which is *animal*. If we talk about a specific type under these animals, there is another order

that these concepts follow, moving from part to general, such as the concept of *cat*, where it is classified from *animal* to *land – carnivore – four-legged – domestic*, and so on.

- Cognitive Economy Principle: Its main function is always storing information at a higher level without duplicating it each time with any of these concepts.

Conclusion:

This article addressed the topic of neural language learning and its relationship to artificial intelligence in the form of a study that targets the most prominent leading models in this field through defining neural network learning and artificial intelligence as one of the most vital fields in this era. Among the findings reached on this particular topic are the following:

- Neural network learning is one of the most important fields on which artificial intelligence has relied in creating models specific to e-learning and language computing.
- Neural network learning primarily depends on mental imagery and the neural network in representing information in long-term memory.
- Artificial intelligence primarily depends on neural network learning as it is a group of neurons that can be observed, interpreted, and simulated.
- The Quillian and Collins model is considered the most important pioneering model in the field of neural network learning and artificial intelligence, as it presented an integrated model of the nature of the processes of understanding and perception for both tangible and abstract meanings, based on the assumptions of concept representation and information retrieval from long-term memory (distributed activation), and the principles of hierarchical organization and cognitive economy.

References

- Ghoneim, A. (2019). *Al-Mazj al-Tasawuri: al-Nazariyya wa tatbiqatuha fi al-'Arabiyya* [Conceptual Blending: Theory and Applications in Arabic] (1st ed.). Tunis: Miskiliani for Publishing and Distribution.
- Anderson, J. (2016). *'Ilm al-nafs al-ma'rifi wa tatbiqatuhu* [Cognitive Psychology and its Applications] (M. H. Hawashin et al., Trans.). Jordan: Dar Al-Fikr.
- Beaugrande, R. de. (1998). *Al-Nass wa al-khitab wa al-ijra'* [Text, Discourse, and Action] (T. Hassan, Trans.) (1st ed.). Cairo: Alam Al-Kutub.
- Koling, Y. (1999). *Al-Mawsu'a al-lughawiyya* [Linguistic Encyclopedia] (M. Al-Hamidi & A. Al-Humaidan, Trans., Vol. 2). Riyadh: King Saud University Press.
- Tuma, A. M. (2016). *Biolojia al-lisaniyyat: Madkhal li-l-usus al-biyujiniyya li-l-tawassul al-lisani min manzur al-lisaniyyat al-'asabiyya* [Biolinguistics: An Introduction to the Biogenetic Foun-

dations of Linguistic Communication from a Neurolinguistic Perspective]. *Majallat al-Mumarasat al-Lughawiyya*, (37), University of Mouloud Mammeri, Tizi Ouzou, Algeria.

• Aliouane, M. (2018). Ru'ya jadida li-l-ta'allum: tanawul 'asabiyy ma'rifi [A New Vision for Learning: A Neuro-Cognitive Approach]. *Markaz Jil lil-Bahth al-'Ilmi*, (43).

• French Sources:

• Changeux, J.-P. (1983). *L'homme neuronal*. Paris: Librairie Arthème Fayard.

• Lemaire, P. (2005). *Psychologie cognitive* (1st ed.). Paris: De Boeck Universitaire.

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