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# From Neuromemory to Metamemory

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## I. Introduction

It is lucid marvelously that neuronal activity in the brain permits human language to travel via air from a speaker who produces it towards a hearer in order to perceive it. Notwithstanding, the neurons have activated speech organs inside the brain. After the revolution of imaging brain devices, neurons are seen active in the brain according to the following approaches: either at a given moment in a time (synchronically) or at a long time (diachronically).

Universal forces in the brain: memory, language, and neurons are definitely governed humanity which must be mentioned to urge nations from their various cultures to scrutinize, delve and investigate them rigorously.

Memory in the brain is pervasive all over convolution which gets enlarger every time the brain`s functionality works on memorizing. Avicenna is known as Ibn Sina (980-1037): after he delineated the mind and body, he came across the memory that owns intentions and wrote about weak memory. In the same context, Abu Hamid ALghazali (1058-1111) construed memory as the storage that receives impressions through ours senses and located in the hinder lobe. Arabs extend their contributions to the limit that Abu Zaid Albalkhi (850-934) provided the differences between neuroses and psychoses. He also pointed out that health is brought at the balance between mind and body level; or otherwise causes illness. Ibn Arabi (1164- 1240) Muhiy Adeen Muhammad puts the neurological activity in the brain into account to get precise measurements of the body (Haque, 2004).

Pulvermüller (1999) dissects associative memory covers all cortex. Our senses are stimulated by the external world and start processing them to their actual lobes. The most complicated sense is eyes which are responsible for sight in particular and does several visual accesses in the brain. Amazingly, eyes process external world perspicaciously via an optic nerve just directly from the eyes to the occipital lobe at the end of the brain where the visual items get processed, analyzed and connected to other ones to be memorized or undergone in the process of decay.

For about three decades, psychologists have postulated the existence of human memory systems. Many speculations concerning memory have come up since Hebb (1949), Miller (1956), and Broadbent (1958). Between the 1950s and the 1960s. Investigating memory has become very popular globally, especially in neuroscience, psycholinguistic, cognitive, and neurolinguistic domains; nevertheless, neuromemory will be coined in this book as a neologism.

Many of us have a memory concern, how to enhance it, how to have a great memory and how to raise our children with the ability of memorization. Memory is everyone's concern. Therefore, parents boost their kids to memorize verses, numbers, words, songs, and so many objects around them, and those parents keep revising the input, day by day hitherto, they become satisfactorily able to start remembering various things.

I usually do these games with my trainees to trigger their memory and crystalize it. Once I was training a group of students, I suggested a quick competition even before starting the program. I told them I would have an assistant during the course but I would approve the only victorious one in the competition. Then, to be an assistant, you have to remember what I will exactly say. After that, I listed my amalgam of inventory words and numbers randomly; I found three extraordinary trainees who had had that expansion sharp memory and memorized them in the same arrangement I presented them; interestingly, others had shown some great attempts varied from one trainee to another.

In this book, I would provide erudite readers with a comprehensive view of memory in the brain and an introduction to the neologism term "*Neuromemoery*".

### 1.7 Definition of terms

- *Memory*: defined as "the knowledge of an event or fact of which in the meantime we have not been thinking with the additional consciousness that we have thought or experienced it before" (James, 1950).

- *Neuromemory*: a term that I call scientific fields to use to study memory as a neuron phenomenon beyond physiology, psycholinguistics and it should be underlied neuroscience as a branch of it.
- *Psycholinguistics*: is "an interdisciplinary field of study in which the goals are to understand how people acquire language, how people use language to speak and understand one another, and how language is represented and processed in the brain." (Fernandez and Cairns, 2011).
- *Cognition*: refers to the nature of memories at the highest level of analysis and the psychological level (Eichenbaum, 2002).

**Key words:** Memory, Neuromemory, Psycholinguistics, Neurolinguistics, and Cognition.

# I. The brain Edifice

## 1. Brain Structure

Anthropology claims that both homo-erectus and homo-habilis had no language but homo-sapian sapian had eventually the language and the metioned reason was gradual growth of the human brain (kebbe, 1995). It is quit interesting part of the origin of language that reconnoiter the language and mankind irrespective to the existence of those former types before homo sapian sapian.

In Greece, Hippocrates 400 BC described a loss of memory and a language disorder for the one side (Fromkin et al., 2014) paralyzed (Hemiparesis) whereas Plato in the 4th century BC purported that brain is the center of all senses; comparing to Aristotle who dissected brain as the cooler in contrary to heart which is seen as the Centre (Ahlsen, 2006).

It is nominated the flesh part inside the skull in particular in the cranium. Brain is the most unknown part among many levels on top of them is language and how it comes in the middle between thoughts and feelings (language and brain). The resourceful brain is the essential part for language, memory (Alameer, 2016) and is the part that concocts the muscles (brain and language) and many other systems.

The human brain has approximately over 100 billion neurons interconnected with a billion fibers. The cortex occupies the surface of the brain, often called gray matter. Moreover, cortex, contains about 30 billion neurons which each makes and interaction with not less than 1000 cells (Kemmer, 2014). Therefore, the brain is able to (1) send and receive messages from all sensory organs, (2) control all voluntary and involuntary movements, and finally (3) represent memories.

Thereafter, Ali Ibn Abbas died (982) was a proponent scholar who coupled mental health to the physiology, besides his full discussion about mental disorders such as: memory loss, sleeping disturbance, epilepsy, vertigo, hemiplegia, hemiplegia and many others. Furthermore, Alzahrawi ( 930-1013) is considered the father of the Skelton after his masterpiece book entitled " The Fracture of the Skull" which he categorized the fractures and the treatment for each type.

If we delve deep, brain over history can be seen as unnecessary as heart in the ancient Egyptians era; Pharaohs removed brain before mummification and kept heart for other purposes after death. During the Greek era, the brain had a considerable matter as the quintessential centre for soul and mind; later on, it wasn't that significant anymore. Arabic Muslims contributed significantly to field of neuroscience. Razes dissected the brain as the top of honorable organs in the human body and, he delineated the connection between spinal cords and brain. Avicenna in his valuable book introduced the brain in a full chapter poiting that brain physiologically designated into two hemispheres. Moreover, Alkarki who died 1037 presented neurons and spinal nerves in full description precisely. Ahmad Albalkhi (850-934) grounded the following terms mental and psychiatric health and argued them in thorough. He interestingly studied the psychosomatic diseases confirming assertively the brain interaction.

The external surface of the brain where amazing wrinkles can be seen is called cortex. It is covered about 1 meter square. It is interesting to mention that brain has more than 100 billion neurons that meet with more than a billion of fibers (Love & Web, 1992). Consequently, this gigantic network in the brain is able to: send and receive messages all over the nervous system 2) run all voluntary and involuntary movements and 3) function memory (Fromkin et al., 2014) and (4) I would vehemently consider to tackle the dichotomy of language perception and production.

The largest mass in the brain is the cerebrum which consists of three parts: a) cerebral hemispheres b) basal ganglia and c) rhinencephelon. All foregoing parts have been explained by (Love & Web, 1992) as follows:

a- the brain has two identical cerebral hemispheres which are not entirely coherent whereas the adjacent halves are meeting at the point where it is called the middle commissures where the corpus callosum is the connected point.
b- Basal ganglia are consisted of gray matter at the location of beneath the cerebral cortex.
c- Rhinencephelon refers to the smell or olfaction for the old brain of species.

Not to mention the inseparable correlation between language and brain, the latter (brain) amazingly equipped with a marvelous capacity in order to generate enormous bulk of sentences and ideas at both broad levels: processing and creating (Kebbe, 1995). Brain consists of complex electrical activation where it happens reciprocally between neurons based on internal or external stimulation to act and interact.

The nerves transmit both sensory and motor fibers. Dissections of our brains have been conducted by Ibn AlNafees who rectified the fallacy theories of Galen and Avicenna (Oataya, 1982).

Brain, in general, was the most blurred organ in the human body for many years; however, recent robust studies of brain and the revolution of technology reveal spectacular discoveries about it. Brain is conclusively a device that holds many wonders inside the skeleton in its edifice and functions, which expose a fabulous structure biologically, physically, physiologically and more strange millions of processes every moments. Emergence of brain science goes beyond its edifice and delves more into two incomparable aspects: memory and language. Metaphorically, the brain works heavily comparing to a giant serial computer, of course, after

accounting the difference between them which absolutely adds flavors to the former: the brain.

Aftermath, it turns out that neurons are quintessentially covered all over the brain adjacent to the memory that apparently intertwine with neurons to function more and implement all types of memory.

Brain and mind are quite different; the brain shows the physical tangible part whereas the mind represents the mental intangible one. In addition, the brain is made of nerves and neurons which can be seen and touched but the mind is abstract, unseen and untouchable. Moreover, mind controls and manages mental functions and acts as a system. In other words, the former, mental functions are the bundle of the following: language, perception, memory, and on top of them thinking and reasoning. The latter, it's a system that represents the world. Hence, the first definition is germane to cognition in terms of mental processes whilst the second tackles the operation in it that undergoes the representations. In conclusion, the mental processes can be studies in cognitive psychology field.

In 1854, Gratiolet, a French anatomist, concluded that anterior lobes were honored to be pillars of human`s intellectual faculties, but sensation, inclination and passion were assigned in parietal and occipital lobes. However, brain in vertebrates may consist of two parts: Paleo which means "old" and the neopallium which means "more recent."

Nevertheless, the brain knowledge intensively and extensively from neurological perspective has been widely proven, and they thoroughly succeeded. In their marvelous book entitled "Neurology for the Speech-Language Pathologist," Love and Webb dissect the brain in depth. The brain's color is gray similar to an oval melon with soft touch. The brain weighs 1,350 grams in average, approximately three pounds. It is naturally placed in the bony skull part; in particular, it is called the cranium. The encephalon is brain's synonym, and the Cerebrum is an identification of the enormous mass in brain.

The human cerebrum includes three parts: the cerebral hemispheres, the basal ganglia and the rhinencephalon; therefore, they will be mentioned in detail, respectively. The cerebral hemispheres constitute the two halves of the brain. Critically, they are discriminated against and readily discernible. The corpus callosum connects the identical halves. The corpus callosum is a C shape consisting of bulky fibers, nearly 200 million nerve fibers that vehemently show a pivotal network. It connects the two cerebral hemispheres and constitutes a massive collection of white matter. It is dissected in the brain as the largest "set of the commissural fibers" (Love and Webb, 1992).

A group of subcortical nuclei taking into account the responsibilities of primary control, motor learning, executive functions and emotions are the basal ganglia (Lanciego, J., Luquin, N., & Obeso, J., 2012). It is directly below the cerebral cortex. The basal ganglia consist of the corpus striatum associated with motor functions. The rhinencephalon is a part of the old brain which the prefix rhino terminology refers to the nose. Accordingly, the term is easy to see that old species' brain functions deal primarily with olfaction or smell. Hence, the brain structure is oval-shaped with a tail-like appendage termed spinal cord hanging from the base.

However, the brainstem is a hidden part internally that cannot be viewed unless the cerebral hemispheres are cut away. It is intertwined with spinal cords, thrust upward into the brain between the cerebral hemispheres. Hence, the brainstem fits the cranium proportionately because the upper structures are crowded.

**1.2 Neurons**

Intriguingly, the second half of the 20th, as a result of bulky studies and researchers manifests that the brain operates synergistically. However, many of neuroscientists in this era consented that the brain is a network vehemently. It's the spectacular place where creativity, innovation and talent reside permanently before and after unleashing them. At first sight of the brain, it might show a solid organ but plunge into it endeavor robustly to unraveling sundry of things such as functions, cognition, physiology, and many others; however, the intricacy of the brain is not absent. It is significant to observe and study small units that constitute the brain which is neurons.

Neurons are the rudimentary component of the nervous system in terms of anatomical and functional units, which also are subordinate to all neural conduct and demeanor; speech and language are inclusively on top of them juxtaposed with the hearing system. It is worth noting that membranes of protein and lipid layers surround the neurons. Moreover, they are about billions in the central nervous system but they relatively small despite neurons varying in size.

Histologists, such as Cajaland Golgi and a plethora of successors (Purves et al., 2019) agreed that there are two prominent categories of the cells in the nervous system: first) neurons or what they are sometimes called nerve cells, and second) neuroglia which is glial cells.

Moreover, Love and Webb (1992) state that " each neuron contains a cell nucleus and a series of one to a dozen of projections." The projections that transport impulses from the cell to the body parts are tilted axons whereas the ones that carry impulses to the neural stimuli are called dendrites. It is differently clear that thousands of connections will be made basically by axons towards other brain cells.

It is worth emphasizing that the former, axon, is different from dendrite in length which shows a longer

single fiber than to the lateral, dendrite; which is shorter. Axon`s mediocre length starts from micrometers up to 2 metres whereas dendrites of the neurons are not more than millimeters. Those projections have dichotomy tasks: 1) receive stimuli and 2) conduct neural impulses. Furthermore, dendrites have the tree-like in terms of shape in contrary to the axons that are akin to wires that we have at home equipped with myelin. By the same token, axons are literally unbranched, if we are relatively speaking, while the dendrites are ramified. Love and Webb (1992) dissect axons and dendrites as the unbranched process of a nerve cell and short branched process of a nerve cell, respectively. Purves et al. (2019) view that "Dendrites are the primary targets for synaptic input from the axon terminals of other neurons and are distinguished by their high content of ribosomes, as well as by specific cytoskeletal proteins."

Dendrites with the incremental ramifications are significant in institutionalizing (information processing capacity of individual neurons).

Myelin is a substance that keeps electrical signals and continues flow, establishing connections in all directions; with new neurons.

Furthermore, neural impulses from the neurons to others were conducted and provided in the cerebrum adding a neural density. The complex neural activity is receiving infinite capacity that has been established from high density (Love & Webb, 1992). Put differently, neurons at this level have two extremities: one end for receiving signals, and the other for transmitting the signals. (Goldstein, 2008).

Amazingly, neurons are varied in the brain which are dedicated to processing information from the external words as those for the five senses. Consequently, neurons are among rudimentary factors that construe and understand how the brain unleashes the cognitions. Edgar Adrian, in the 1920s, contributed noticeably to the field by recording electrical signals from sensory neurons. This work later received the Nobel Prize in the early 1930s; it also coincides with other scientists` views that a neurotransmitter gets released after the synapses get the signals (at the end of the axon). This chemical message surges are transmitted by axon which is linked to the dendrites of other neurons (Goldstein, 2008). Not to mention, there is a little gap between (the end of the axon and the dendrites of another neuron) which has been purported by Cajal. It is called a synapse.

The firing of neurons is a term that occurs between neurons as communication between them through electrical impulses and neurotransmitters. To get a better understanding, the main parts of a neuron are dendrites, axons and soma. The first two formers have been aforementioned and the latter; soma, which is the body cell that is attributed as the main part of the neurons and sustained: in other words, maintain function for itself and a significant function for the neurons and the nervous system. Moreover, soma is the factory where 1-nucleus stays, 2-DNA exists, and 3- proteins are prepared and moved via axon and dendrites.

Neuroscientists should tackle a tremendous detail about these three fundamental pillars of neurons. Therefore, they are excluded.

It seems that neurons are fortified by enormous accounts of other neurons commensurately adjacent to dendritic branches which all together work for the integration of information. In other way, nerve cells (neurons) are the essential components of both the brain and nervous system that play a crucial role in receiving inputs from sensors that are coming from the ambient world externally and sending motor orders to muscles; however, between the two trips of receiving and sending, a phase that electrical signals are activated all the time.

Intriguingly, the engram is a physical chemical that changes in the neurons to manifest the memory persistence used to trace memory, can be a shred of extraordinary evidence that affirms and fortifies the term **neuromemory** vehemently.

One significant example of the power of neurons and sensors in the brain is the retina. It is a region in the central nervous system that highly catalyzes light reception; retina sensors detect these red, blue, and green colors. In other words, other colors do exist; on the contrary, the brain makes mixed amounts of colors to have the color collection. It mainly transmits the encoded visual items to the brain. The retina is a structural layer with a finite number of cellular classes. Thus, investigations recently confirm that the transmitter is released twice alternatively: in the dark and in the existence of light. A photoreceptor cell works functionally with a subdivision of discrete morphological compartments, and consequently, it consists of outer and inner segments. Therefore, the outer part encompasses light absorbing visual pigment, the lateral inner part rich in mitochondria, a nucleus located in soma cell, a Greek word that means the body of a neuron with a bulbous shape.

There are about 130 million cells; generally, they are categorized into 1- rods and 2-cones; consequently, they process 100 million bits of information from the external senses. Retinal processes work to transform the pictorial representations to an appropriate format that will enable the optic nerve to transmit the data to the central brain structure, specifically, the occipital lobe.

**1.3 Primary various lobes**

Lewin's concern in the organization of the brain was a breakthrough, specifically the various portions of lobes (Marshal and Magoun, 1998). The human brain has three predominant lobes, and the fourth is relatively tiny. They are as follows: frontal, temporal, parietal and occipital lobes, respectively. These different four lobes are localized on the brain surface.

However, significant marks, particularly gyri and sulci, should be used to recognize the four lobes. Sulcus, the latter, refers to a depressed groovelike fold on the brain surface that splits the gyri. Conversely, the former (gyri) refers to an elevation process on the brain's surface that happens in terms of the convolutions of the cortex.

The cortex in the brain is divided into four divergent regions. They are:

1- temporal lobe which may have the primary auditory areas and is involved in the recognition of objects
2- the frontal lobe which could be divided into the motor cortex
3- prefrontal lobe which is quite vital in planning and problem solving and finally, 4- the occipital lobe.

**1.3.1 Frontal Lobe**

The frontal lobe occupies a third of the hemispheres` surface. The frontal lobe is easily accessible from the top of the skull just behind the forehead. It is "separated from the parietal lobe by the central sulcus which divides the precentral gyrus from postcentral gyrus" (Ingram, 2007). Long gyri could be immediately placed from the anterior to the central sulcus. Subsequently, the gyrus could be called the precentral gyrus which makes up the majority of the primary motor cortex. The voluntary control of the skeleton and muscles is contralateral that undergoes the cells' responsibilities.

The frontal lobe looks like a throne of an abstract intelligence of the human brain. By the same token, a new secret lurks behind the frontal lobe, which is the organ of an intellect. It contributes to guide and integrate the characteristics of personality. The value of the brain is assigned in the frontal lobe resides upon other lobes. However, not everyone may agree that the frontal lobe is essential but on the contrary, I significantly do.

Antonio Caetano Moniz (1875- 1955), a neuropsychiatrist at the University of Lisbon, Portugal, was an outstanding pioneer in the domain. Twenty patients had been severely reported tentative operation under his supervising. Frontal lobes parts could be replaced mutually, and damaged bilateral did not disrupt psychic life (Marshal and Magoun, 1998).

Review to avoid repetition

Frontal lobe serves the abstract intelligence and contributes greatly to uphold and excel the personality features in the brain. In contrary to many who disagree that frontal lobe is necessary (Alameer, 2016) greatly does agree for many reasons: a) it is the residence of abstract intelligence b) it helps to guide personality c) a place for word generation and d) it could be the location of long-term memory which is not crucially against any necessity of remove it because there was an evidence of 20 patients whom had received tentative operation by Antonio Caetano Moniz in the frontal lobe without any harm because frontal lobes could be surrogated each other mutually (Marshal & Magoun, 1998). It seems frontal lobe is the best appropriate lobe that tackles intelligence. It is the reception the signals that come from senses and it is taking the accountability of higher functions of cognitions one of which solve problems. In terms of memory, working memory is one priority of the frontal lobe. Any damage to this area might cause attention problems. Hence, any stroke that might cause damage to the frontal lobe will affect the blood supply in this area which is called Broca`s area.

Frontal lobes take place behind the ears which their roles are clear in processing emotions, language and visual perception such as faces. Left side dominant of it is tackling language perception, learning and retaining verbal information comparing to the right side dominant which is taking care of learning and remembering information such as visua-spatial things and music.

Pierre Paul Broca (1824-1888), a French surgeon, neurologist, and anthropologist, argued that language must be located in the left hemisphere for most of the population, mainly right-handed. He investigated the brain of two patients who suffered from language loss and motor speech disorder. Accordingly, he localized the center of the human speech area irrevocably. In other words, he claims that the faculty of language articulation in the posterior part of the third frontal convolution occurs in the left hemisphere, and it crucially involves speech.

Broca viewed language as a faculty with a constant relation between ideas and signs. The cerebral hemispheres could be dedicated for speech vastly. Therefore, Broca's area is located in the posterior region of the left frontal lobe where the speech articulation is situated. Broca asserted that a fifth lobe called the limbic lobe has existed, and later on, some anatomists believe it is dedicated to the olfactory system.

**1.3.2 Parietal Lobe**

On the top of the brain is the parietal lobe location; the right hemisphere controls sensory attention and body image whereas the left one gets the advantage of controlling significant movement and interestingly controlling some aspects of language. The parietal lobe is an associational area**.** However, anteriorly, it is confined by the central sulcus but inferiorly, it is restricted by the posterior end of the lateral sulcus. Besides, it is bounded posteriorly by an imaginary frontiers line. The somatosensory cortex mediates accurate information anteriorly. Conversely, the processed information could be used in the posterior for somatic sensory posteriorly. Intriguingly, the sensation of somesthesia such as temperature, pain, anger should be sent to the sensory cortex from the opposite side of the body.

**1.3.3 Temporal Lobe**

It is the seat of the auditory processing system in the brain. The primary auditory cortex is located in the inferior wall of the lateral fissure. The posterior part of the superior temporal gyrus could be the auditory association area, precisely very popular as Wernicke's area. Carl Wernicke was a German doctor who, in the 1870s, reported that this area leads to the ability of speech understanding specifically. In his excellent book "The Future of Mind," Kaku states that the temporal lobe helps to recognize faces visually and sentimental feelings; Moreover, any damage to this area causes two awful problems: 1- loss of speech, which is technically called aphasia 2- disability of faces recognition.

Conversely, any harm or damage to it may cause severe problems: 1- disability of faces recognition 2- identify objects 3- memorizing new information 4- problems in long-term memory and 5- aphasia which will be addressed later in the course. For example, prosopagnosia which is loss the ability to recognize faces might happen if there is a damage on the lower- right side of the brain. The people still identify the face as a face but they are unable to identify whose face this is no matter they are siblings or friends. Intriguingly, it has been reported that people with prosopagnosia look in to mirror whilst they asking about the stranger who is looking back at them (Burton et al., 1991; Hecaen and Angelegues, 1962; PArkin, 1996) from cognitive psychology. The area in particular is called fusinform face area (Kanwisher et al., 1997) consists of bulky neurons.

**1.3.4 Occipital Lobe**

The occipital lobe occupies a small area at the brain's back exactly behind the parietal lobe. It is characterized by imaginary lines. Visual centers lie at the rear area of the brain in the occipital lobe; thus, vision is the occipital lobe's concern and injury or damage to it may cause blindness and visual deficiency. The occipital lobe in the brain is always working for the visionary. However, Any damage to the occipital lobe may cause hemianopia but the bilateral lesion may cause blindness (Hermann Munk, 1881).

The most complicated sense is eyes which are responsible for sight in particular and does several visual accesses in the brain. Amazingly, eyes process external world perspicaciously via an optic nerve just directly from the eyes to the occipital lobe at the end of the brain where the visual items get processed, analyzed and connected to other ones to be memorized or undergone in the process of decay.

The optics of image formation heterogeneously was mysterious in vertebrates hitherto the seventeenth century. However, scientists were trapped with the notion of the upside-down image in the eyes known as camera obscura since Ibn Al-Haitham`s contribution. It refers to a tiny dark space provided with a pinhole aperture that allows light and creates an inverted image; intriguingly, the scene is full of light. Thus, this inversion of the image caused a nuisance for philosophers such as Leonardo Di Vinci (in the sixteenth century). Kepler (1604) proposed the Vivo of the image theoretically by eyes, and it has been affirmed experimentally by Scheinder (1619 and 1652; cited in Glickstein, 2004). Subsequently, the inversion image assumption has been approved after precedent demonstrations above. The optic nerve transmits the images in the occipital lobe inversely.

The image of entities is inverted in the visual domain and reversed from left to right; consequently, it is crucial to present the visual rules on the cortex:

1- the upper half is represented below the calcarine.
2- the left visual field could be in the right hemisphere and vice versa.
3- the lower half is shown above the calcarine sulcus (Love & Web, 1992).

Anatomists affirm early that the optic nerve prominently exists at the back of each eye, directed to the brain. The genesis of the optic nerve is in the brain, and it is extended out to the eye heading the occipital lobe. Dr. Ismaeil (2013) is a neurologist I met and interviewed, explained that fibers from each eye appear united, and then they get crossed, constituting X-shaped optic chiasm. The visual shape memory task activates the temporal cortex which is responsibility for object recognition. The eyes unite and the optic nerves converge before they come into the brain, making an X-shape.

Visual orientation could be recognized by neurons that kept busy in detecting a given sensory. The dichotomous photoreceptors are rods and cones. The former "rod" is concerned with dim light and vision cases

in the peripheral of sight. The second ones are used for bright lights and they are responsible for the vision center and works as a color detective. The left hemisphere receives data from the right visual part and moves them via the optic nerve to the back of the brain.

Anatomists viewed a nerve existing behind each eye directed toward the brain. Emphatically, optic flow always influxes to pathways and moves to the three-dimensional layout of the atmosphere of vision. Internally, both eyes fight for functional possession of the binocular cortical neurons. The optic nerve plays a significant role in memorizing things such as concrete objects over abstract ones. The occipital lobe receives these data and deals with them to easily store concrete objects in the cerebral cortex.

In the early nineteenth century, Flourens (1824) found a decorticated hen to be blind and assigned vision to the cerebral cortex. In the human brain history, the occipital lobe obtained a prominent position in anatomy and physiology because "it is the primary cortical projection of the most extensively studies" (Marshal and Magoun, 1998, p. 101).

From Germany, Karl Burdach determined that the thalamus has a structure to serve the vision. In other words, the dorsal thalamus is the main threshold which visual data reach the cerebral cortex in the vision system from the eyes passing by the optic nerve where eventually the vision factory resides in the occipital lobe (Usery and Alitto, 2015).

Panizza (1785-1867) explored strong evidence in this regard, and he provides a way of how the visual impressions move from the eyes to the brain (Marshal and Magoun, 1998). In the Lombardy Institution Journal, Panizza wrote about the optic nerve and his dissection about the determined convergence of optic fibers at the chiasma (Latin term means crossing or convergence). Lesion on one side of the brain will affect the eye of the opposite side. Panizza experimentally explored that the occipital lobe is strictly essential for vision.

The 1960s and 1970s were characterized by different advanced studies of concepts about the brain neurologically. The outstanding pioneer, Noam Chomsky, confirms the innate mechanism in the brain and emphasizes the universality features among the population reflected in language. Eric Lenneberg, linguist and psychologist, highlights the biological aspect of language (love & Webb, 1992). The language particularly should be placed in the context of neurology.

The spilt-brain's claim was explored and reported by Roger Sperry and his colleagues in (1969). Anatomical differences in right and left centers are distinguished in the brain, importantly language. The more prominent areas in the left temporal lobe in the fetus, infant and adult have been explored to suggest that cerebral dominance for language anatomically is in the brain, contrary to the view of speech centers, which is progressive lateralization center (love & Webb, 1992).

Hermann Munk (1881) is the most influential figure (contributor) for the visual function of the occipital lobe. He (1881) reports that if the occipital lobe were destroyed, the subject would be afflicted by hemianopia (half-blindness of the visual field) and the bilateral lesion may cause blindness entirely. Ironically, mental images activate in the left parietal lobe, which is also be generated, whereas the occipital lobe attributes to different visual tasks.

However, the occipital lobe is the vision dedication. The occipital lobe demonstrates remarkably a loyal activation and correspondence to the visual imagery in various experimental studies. It is significant in the perception of visible objects, and it has been involved tremendously in visual short-term memory tasks.

## II. **Memory**

**2. Memory**

From the simplicity of memory meaning, it is the ability to retain and remember the previous experience from one hand and acquired skills and knowledge from the other one. It is considerably a kernel factor and a biological principle in learning. Therefore, if the memory is not active or not recalling, getting experience out of it would not be easy. Moreover, the obtained joyful side of life, will be lost if the retain is weak or inactive.

The experts are aware of the memory processing and retaining. The new memories are formed by new interacting among neurons which executes physical changing in their morphs. All these changings are occurring in the cortex, temporal lobe; specifically in a small complicated part called hippocampus. It conspicuously plays essential role which is organizing most of main functions inside the brain before problem solving and learning languages.

Studying memory has a long history in psychology. Memory is an intrinsic and cognitive process that may be advocated to acquire new knowledge and remember information (Bartlett, 1932). Systematic studies of memory were applied in the late nineteenth century. Memory refers to a mechanism that allows humans to retain and retrieve information constantly.

The brain intrinsically and extrinsically is intricate to the level that some proponents' function; I.E. memory, language, perceptions, and others are still a considerable challenge to neuroscience. Thus, Johann Gesner a German physician who claimed that no speech disorder happens without memory disorder based on six cases whom were mentioned on his book "Speech Amnesia". (Ahlsen, 2006). Moreover, damage to the brain tissue might cause cognitive dysfunction which refers to the deficiency that occurs for the group of cognitive tasks such as attention, learning either verbal or nonverbal, short-term memory, problem solving, motor functioning and processing visual or auditory objects which is entitled dementia.

In the brain, chemical signals in the communication of individual nerve and glial cells occur from neural "differentiation" to memory.

Memory has been a subject of research since the early time. In the ancient civilization of Egypt, although they had accomplished excellent knowledge of engineering, science and art, the brain was considered a functionless organ. Aristotle indicated that the soul existed in the heart whereas the mind was viewed as a blank slate.

However, the theories mentioned above were not proven due to the lack of objective evidence. The biology of the brain emerged 400 years ago when telescope invention revolutionized solid evidence about many aspects of human beings atmosphere such as the universe, neurology, brain, memory, and so forth. Many spectacular inventions have revolutionized our scientific horizon of life such as MRI, FMRI (Functional magnetic resonance imaging), EEG scan, PET (Positron Emission Tomography), TES and MEG. These inventions strongly reveal the brain's functions from metabolism to the blood flow, consumed oxygen and motion of convolutions among different lobes.

Contemporary studies of memory underpin the dichotomy of short and long-term memories, which Bartless calls primary and secondary. However, recent memory studies began in the late 1950s. In addition, the domains of memory study and language have catalyzed a synergistic effect on each other since early views. Human memory was postulated by Atkinson and Shiffrin who proposed broadly three sets of memory systems: sensory, short-term and long-term; many scholars (1) differentiate between explicit and implicit memories, (2) explicit memory expresses intentional or conscious recall of facts and events and finally (3) implicit memory reflects any change in the performance that belongs to information or skills (Zhang et al., 1997).

An English psychologist Sir Frederick Bartlett (1886, 1969) carried out many investigations about remembering during the first half of the twentieth century. Bartlett viewed that retaining information relies on the information on the person`s memory. His distinctive view confirmed that people use their previous knowledge (schema), which he purported that remembering is a reconstructive process. Furthermore, Bartlett theorized that people, by remembering, build up a memory and its occurrence.

Remembering is experienced when a mental incident is attributed to the memory. Fuster (1999 p.12) distinguishes memory systems according to many attributes: "1- the content that systems store 2- principles of operation of storage and retrieval 3- storage capacity 4- duration 5- putative neural structure and finally 6- mechanism involved in their operations".

Recent studies of implicit memory have shown that visual words and objects' repetition-priming effects bear many similarities. For instance, word repetition effects have shown independent semantic priming effects. Repetition priming of visible objects can be observed for novel information with no pre-existing memory representation. The prominent role of visual perception is to extract the environmental features from the sensory receptors, mainly vision (Olshausen, 2004). Vision has a powerful clue in memory and a marvelous existence in the brain which I often encounter.

Do you eager to have examples of harp extraordinary memory? Absolutely yes because memory

existence drives us curiously to see uncanny models; accordingly, two prodigious examples of people who have incredible memories are: Chao Lu from china who had memorized 67,890 digits and, another incomparable example of a savant with a prodigious visual memory, Steven Wiltshire who drew a picture of London when he was 11 years old. Computer science presents a powerful explanation of cognitive memory (O'Nuallain, 2002 p.70) elucidates:

When viewing memory as a store, a computational metaphor is extremely useful. In computing, we make a distinction between storage media which are potentially removable from the machine like floppy disks, RAM (random access memory) which is the primary workspace of the computer and ROM (read only memory) which contains a few commands without which operation of the computer is impossible (COPY, DIR, etc). Similarly we make a distinction in human memory between long-term memory, conceived as back up storage, and short-term memory which is a workplace. In the meantime, certain ROM commands remain, continually present (e.g. don't fall off heights; nothing can be in two places at the same time).

However, memory is a mentalistic term rather than a psychological notion in the brain; mentalistic concepts such as thinking are fruitful. Hence, memory systems also involve the brain system in which diffusion areas of the cortex feed into different subcortical areas.

**2.1 Human Memory**

In ancient times, philosophers and researchers have been interested in studying the human brain and improving its mysterious functions. Many of philosophers such as Plato, Socrates, Aristotle, and many others were concerned with memory and the nature of thought. Consequently, their interest enthralled them to keep observing human minds.

Since James (1890-1983), the father of primary and secondary memory, memory studies have been revolutionized; human rudimentary knowledge about memory could be found in Arabic-Latin revival and Western civilizations. Thus, Dutch scientists introduced a new optical magnification by the seventeenth century, which greatly facilitated anatomical studies. Brain function emerges as integrative or holistic aspects. The brain is now admittedly the most complex organ of the human body.

According to Ashcraft (1994), three kernel aspects of human memory are included: (1) initial acquisition of information, (2) subsequent retention of information, and (3) recall of information.

Memory is a concern of many psycholinguistic studies, and it has been studied rigorously for a long time. It refers to a group of networks of neocortical neurons and connections that link them together. Memory is broadly defined as the capacity to retain information in the brain (Fuster, 1999 p.9). Definite evidence suggests that human memory capacity depends vastly on memory systems and subserves non-linguistic functions.

Psychologists categorize memory into three phases: 1) sensory memory which enables humanity to absorb information vis senses such as after have a look to a tree, it will go via eyes to this type of memory and will vanish very swiftly unless it moves to short-term memory.

2) short-term memory which becomes so active if the information is rehearsed and find repetition. In 20 seconds this information might be lost if it does not meet any efficient rehearsed. The capacity of it is finite.

and 3) long- term memory which enables humanity to retain information for long time; some of which might last forever (Arabic Encyclopedia, 1997). To retain received information, they need intensive repetition and excessive feelings (emotion) towards these information which as Stanley Schachter stated that emotions have two essential components: psychological arousal and cognitive label. Hence, the both components mainly are so paramount but the former one seemingly has its significance in this issue.

Nevertheless, the loss of memory might attribute to certain reasons such as a disease, a stroke, trauma, an extreme shock or psychological incident; some of which might get recovered but others might not be. In case of a stroke, memory could be a bit hard to recover particularly the past memories. By the same token, retrograde amnesia which mostly popular among boxer players may cause loss memory for seconds after receiving hard punch (strike). Car accidents also can cause loss of memory for some time which might extend either to months or years. Alternatively, frontal amnesia that happens as a result of physical brain stroke leads to loss the present memory besides both types might befall because of emotional shocks.

People consistently access some information visually where they reside in both hemispheres of the brain. Several studies investigated memory. Put differently, I would instead shed light on memory and language; besides, draw attention to the pivotal role of vision in processing linguistic concepts in short-term memory analytically, as an example of the correlation between language and linguistic notions. Not to mention the introduction of the Neuromemory term that should stand alone field separately.

Driscoll (2001) states that pattern recognition is "the process whereby environmental stimuli are recognized as exemplars of concepts and principles that are already in memory" (cited in Lutz & Huitt, 2003).

Indeed, memory reflects the quantities of a lifetime experience. The nature of memory has been investigated in various fields such as biology, physiology, neurology and psychology. However, with the rise of modern neuroscience and cognitive science paved the way of understanding memory. The recent mechanisms

insights of memory have been emerged to comprehend the mind and other brain`s functionality.

The structure of memory, memorizing and recalling require interconnected areas in the brain (system). By principle, memory is assumed to be retained and stored in cortical areas while organ that facilitates all these operations is the hippocampus. Despite the crucial role that the hippocampus sustains, rudimentary lines must be added: 1) it seemingly advocates a pivotal role in sensory information for the reason of consolidating memory (Ullman, 2008) of facts and events 2) conducted studies on rodents show that spatial memory of the location of items is a hippocampus responsibility that supports this type of memory and 3) although the time duration is controversial, the hippocampus might bear more duration time (Bear, 2001). Neuroimaging technologies such as Pet and fMRI have shed light on the former which has an increase of metabolism in the hippocampus which is a result of subjects who studied information to recall, and the latter activation of the hippocampus and parahippocampal gurys resulted from a conducted study for subjects who studies a list of items (Purves, et al., 2019).

Hippocampal neurons might opt for people or items based on familiarity we have. Its cells constitute "associations" (Bear et al., 2001) between sensory stimuli for the information either about space or not. Moreover, integration of sensory experience with any events resulted from receiving bulky inputs which might assist in building new memories. Furthermore, the hippocampus has a kernel role for constructing and innervating memories to link the latest information from the sensory with the knowledge that existed previously.

Memory is a multi- network of neocortical neurons and cells (Fuster, 1999). Experiences of these networks depend on the diverse aspects of inner and outer environment of the brain. A network may vary in size and it is modifiable widely by further experience. Thus, it is subject to growth. Memory is working in an association between stimuli and reinforcement in order to constitute the complex of memory system.

Conversely, Fuster (1999) affirms radically that association must be attributed to all memories, at the root of their genesis and their evocation. Memories are diffusely distributed in the brain. Gallistel (2006) persists that the "essential function of memory is the carrying of information forward in time. It is the repository where information resides when it is not used". Wierzbicka (2007) states a definition for memory scientifically as the three main components involved: personal experiences, knowledge coming out of the external experience and thinking ability about the processed knowledge.

**2.2 Nervous system**

Significant concepts of the nervous system originate in the second half of the nineteenth century as the result of studies of anatomy and physiology. It orchestrates and stimulates all body parts besides it permits adoption of amendments that might happen. There are three essential parts in the nervous system: central nervous system, peripheral nervous system and autonomic nervous system. Hence, it is the primary concern of the neuroscience field from diverse angles as the cellular, functions, behaviors, computation, molecular and medical aspects.

The central nervous system consists of the brain and spinal cord. Senses send all collected data to undergo an analysis process which as a result effectively decides how the body corresponds to them. It also releases more instructions to the required interactions.

The peripheral system consists of two different nerves: 1) the sensory nerve which carries information from receptors to the central nervous system and 2) the motor nerve which sends commands to the body parts from the central nervous system. The autonomic nervous system gets the orders from the unconscious side of the brain to the inner parts. It functions tasks such as heartbeats, digestions and many involuntarily processes in the body.

However, many scholars began to understand human memory from the neural basis of memory which revolutionized the field decisively. Human memory is comprised of a nervous system that miraculously possesses about 10 billion neurons exchanging information.

Cajal, a Spanish eminent neurohistologist scientist, published his classic monograph on retina in 1892. He argued that the retina, brain and spinal cord are made up of elements individually, later called by Waldeyer "neurons". Neurons could be close to each other and work in a synergetic way and, in other words, they never be integrated or fused. However, billions of neurons greatly vary in size and most of them are small in the central nervous system.

The fundamental source of all communication in humankind is the nervous system. Understanding the human communicative nervous system requires to understanding the nervous system thoroughly as a segregate system from other body structures. Consequently, I would rigorously suggest the term neuromemory, in order to make this combination of neurons and memory a distinguishable field that the following papers uncover about it in detail.

**2.3 Cortex**

In 1664, English physician Thomas Willis published a description of the anatomy of the human brain.

Willis suggested that different areas of the brain manage many operations. The brain could be divided into cortical and subcortical areas. Thus, the histogenesis of the cerebral cortex is completed in the human brain since prenatal (Balazs et al., 1977).

Franz Gall views that the notion of the cerebral cortex is dramatically distinct processing regions and the throne of complex cognition. Apparently, memory is a two coins sides: one shows the necessity side and the other affirms the mandatory side of the activities that are ongoing processing in the areas of the cerebral cortex.

Cortical memory is a generic term for the inclusion of the cerebral and neocortex in all kinds of memory. Interestingly, the root structure of the neocortex is akin to the same surface and it is characterized by the striking of the regulations of vertical and horizontal regularities of its cells and fibers. Put differently, any new achieved information, knowledge or experience from the external world may trigger new memory; however, to be consolidated, it must be relied on the impermanent cortical network.

Schafer (1900), in his book "Textbook of Physiology," explains the cerebral cortex superbly. The cerebral cortex looks like a sheet about one meter square; to suit the human brain in the skull, it is folded amazingly which may distinguish the human brain. In addition, multiple memory systems in the brain including the cerebral cortex may diverge in pathways leading from the cortex to structures beneath, called subcortical structures and these pathways may form different kinds of memory systems.

Controversially, Gall and Spurzheim (1810-1819) and Flourens (1824), the cranioscopists and phrenologists assert that the cerebral cortex comprises of a number of separate areas. Each area is accompanied by a specific personal characteristic. For instance, memory in the cortex could be enlarged if a person has a good memory.

On the contrary, the experiments of Gall and Flourens failed in spite of their belief in the cerebral cortex responsibilities. Later on, evidence began to appear for the sake of functional localization in the cerebral cortex. Broca and many other experts provide decisive evidence about cerebral cortex areas dedicated to different functions. The most conspicuous experiment that explored the motor and sensory functions in the cortex was first proposed by Fritsch and Hittzig. The outstanding proponent scholar of cortical memory networks is neither a scientist nor a neuroscientist but a Viennese economist: Friedrich Von Hayek (1988-1922).

The brain surface is called the cortex that is distinctively wrinkled and the cortex is increased in size through life experience. O'Leary and Rakic argue that control of cortical development intrinsically and extrinsically has been epitomized in protomap and protocortex assumptions. According to these assumptions, it is increasingly conspicuous that normal development of the cortex encompasses a synthesis of both intrinsic and extrinsic control.

**2.4 Visual Cortex**

Recently, a theoretical framework has emerge for how pattern analysis is done by the visual cortex. The ideas of the visual cortex theoretically were proposed more than forty years ago by Attneave and Barlow. Therefore, the theory of visual cortex has become more concrete nowadays through tremendous efforts in neuroscience.

The notion of the visual cortex has a probabilistic model of pictures and neurons that actively represent these pictures. Visual cortex structure in the mammalian consists of numerous areas. Visual functions may be associated with the occipital lobe region, and it is arranged in columns of cells with similar properties. The brain is rich in structure; however, there are at least fifty- four processing areas in the visual cortex. Thus, the visual cortex exhibits sustained action in the absence of a visual stimulus.

The primary visual cortex could be shown to contain a retinotopic map of the external visual world; in particular, each item would be represented by neurons with a specific receptive domain that encodes and accesses the visual features. The projection of vision primarily may form 2% to 3% of the gross of cortical areas in the human brain.

Neurons in the visual cortex may correspond depending on the depth of stimuli factors such as color, shape and motion. Schall (2004) claims that the differences between items start from neural signals that distinguish the features of visual objects. These Signals are available when the neurons in primary and extrastriate visual, which are next to the primary visual cortex, produce a few spikes. The consciousness perception of the visual world is entirely the responsibility of the visual cortex.

The visual cortex in the nervous system has been a model for plasticity since the pioneering work of Hubel and Wiesel (1968). Plasticity is a brain ability that works on changing the neural representation "either qualitatively or quantitatively" which is also called neuroplasticity. Moving function from a damaged area to an intact one compared to the ability of the brain to use learning to apply more processes are two main dichotomies of neuroplasticity which are respectively called; Functional and structural plasticity. In addition, neurons show responses selectively to various objects features.

Within the visual cortex, lateral inhibitory connections that contribute to orientation selectivity and orientation selectivity shows a popular side of the cortical neurons. Orientation selectivity is "a dynamic

property which increases and then decreases with time after the presentation of a stimulus, suggesting that recurrent excitatory connections within cortex also contribute (Pei et al., 1994; Ringach et al., 1997)". Vision tasks are associated with different areas among the visual cortex sense's occipital, temporal, and parietal regions.

Psychology concludes that visual short-term memory represents components of visual memory in the early visual cortex. Physiological evidence shows that a neural correlate of short-term memory involves representation in early visual cortex. Intriguingly, the coined term **"neuromemory**" manifests the necessity of getting a separable and stand-alone domain

A hypothesis argues strongly that visual short-term memory and attention have a correlation in terms of neural mechanisms. Psychophysiology views that visual short-term memory involves relatively visual representations. Fuster in his spectacular book "Memory in the Cerebral in the Cortex" (1999) mentions that two- third of the neocortex is allocated to vision which I speculate that the vision is the king of senses.

**2.5 Cerebral Cortex**

The outstanding neurologists and physiologists dissect the cerebral cortex into a substantial set of sensory and motor processing areas, not to mention the anterior cortex. Pavlov succeeds in finding that "a very simple kind of memory could be reduced to the association between an arbitrary stimulus and a similarly arbitrary response" (Eichenbaum, 2002 p.171). Thus, a predominant view confirms that the sensory and motor are representatively associated with the cortex.

However, the cerebral cortex and brain have been intrinsic components of the visual system for over a century. Cerebral hemispheres look like identical twins although the operations more or less differ on the left and right sides of the brain f the localization proponents are still tackling the brain a localized. Nevertheless, the holism school admittedly views the brain as a synergic network.

The cerebral cortex has many "anatomically circumscribed" (Eichenbaum, 2002. P.4) each makes a considerable contribution to memory function. The connection besides cognition, compartment and consolidation are the four Cs that Eichenbaum construes brain function pertinent to memory in his book. Connection is one of the brain functions that have a close relation to memory, and it dissects the basic electrical process of the brain that tackles information and how they interact, with each other, to assist memory. Moreover, it is clear from the connection that memory is encoded within the dynamics of connection between nerve cells.

Cognition tackles the memory analytically at the psychological level which either shows that memory is an association of stimulus response and stimulus reinforcer, which is the result of behaviorism school; which always explains the human beings as a group of behaviors, or networks that have cognitive operations. Consequently, results show that some mechanisms guide the form of 1- behavior 2- cognitive form which is in memory and distinguished in psychological mechanisms and anatomical pathways. The third C is compartmentalization which investigates memory localization. The debates about localized memory in certain brain areas have been raised from one side whereas the others argue that memory is everywhere in the brain. Subsequently, it has also seen that memory is compartmentalised. It is enthralling that the relationship between memory and cognitive processes is proven. However, if particular areas might show memory is localized, it is clear that memory is pervasive in the brain, and compartmentalization needs further explanation in the light of modern studies and holism theory.

The last C is consolidation which seeks "when and how" to have permanent memories by applying two ways of consolidation which one is devised and named by Eichenbaum "fixation" and the other one is reorganization. The former takes into account "the cascade of molecular and cellular events during which the changes in connections between cells become permanent" (Eichenbaum, 2002. P.5). The latter, reorganization, receives new information after the brain structure interaction; this recent information will be added to each person's previous knowledge as integrated information.

The cerebrum is involved with different sensory and motor functions. Cortical data are received from restricted areas in cortex including sensory and motor ones via the brain stem. Learning and motor skills are the most important skills involved. The cerebellum has a thalamic output lane to the cerebral cortex. Eichenbaum (2002) mentions in his book, "The Cognitive Neuroscience of Memory" that the cortex could be sharply divided into posterior and anterior fields which are involved in perceptual processing and are involved in motor processing, consecutively.

Conversely, the cerebellum means little brain and obviously much smaller than the cerebrum. The cerebellum is a discriminated structure of the regularities of its internal circuitry, and it weighs about one-eighth and locates at the rear of the brain just below the cerebrum base.

**2.6 Phyletic and Individual Memory**

Intrinsically, information undergoes the basic forms and brain connections at birth. Two genres will be added, phyletic and individual memories. Phyletic memory comprises the primary sensory and motor neocortical systems. More specifically, phyletic memory can be expressed simply as the memory of species. In other words, it looks like an inherited endowment that, by innate, this memory responds and recalls the rudimentary feature of sensation and movement. However, it is immensely adaptive. I would rather call it the memory of nation in addition to sensation and movement; more specifically, it goes from one generation to another but genetically it is hard to localize it and extremely difficult to speculate the codes of cells that hold this sort of memorable features.

Put differently, I surmise that the phyletic memory has two sides: 1) it is developed from one generation to another, and 2- it eminently include cultural factors such as language, social factors, customs, traditions and many others. In other words, this genre of memory determines the traditions, customs, and heritage aspects from parents' everyday dialogues.

Alternatively, individual memory is localized but not mostly in the association cortex and it is firmly a genetic structure foundation of the cortex. However, memory could be expanded throughout individual experiences. In addition, it is constructed from a synaptic connection between neurons that represent the sensory and the internal or external world (Fuster, 1999). Also, memory has various systems rather than a simple unitary or dual phenomenon. Therefore, individual memory corresponds to the experiences from the external world. James (1950) states that there are more methods to store information in the memory. This belief constitutes the basis for a multi-store model of memory which later on was proposed by Atkinson and Shiffrin (1968). Consequently, this theory proposes that memory has three separate structures: 1- sensory store, 2- short-term memory, and 3- long-term memory. These stores are presumably permanent and consistent like computer hardware and every memory has distinctive properties concerning its capacity, duration and code.

The former, phyletic memory, is the most kind of memory that needs to be proven and established in contrast to, the latter, individual memory could be quickly established in our perception, behaviors, processing of the external world around us, and the most noticeable consequence is language.

**2.7 Sensory Memory**

Cognitive psychologists have not attracted the concept of sensory memory whereas some other students of human behavior are interested in learning more than in sensory memory. It refers to the short-lived memory for sensory details out of five senses: vision, auditory, olfactory, touch and taste. These sensory stores preserve information directly from our senses mainly.

Alternatively, sensory memory operates differently from other memories, such as mental images, in terms of using the five senses. Research on attention reveals that the last few words could often be recalled. Though, understanding the sensory memory leads to understanding the performance of memory. It is a substantial aspect of experiencing the outside world consciously (Byrne & Menzel, 2008).

There are three major ramifications for sensory fibers: one is the ophthalmic nerve, the second is the maxillary nerve and the third is the mandibular nerve; accordingly, those ramifications are dedicated to the eyes, the upper part of the mouth and lower part of the mouth, respectively.

Examining sensory memory is necessary to investigate working memory. The sensory memory transfers information in an array to working memory (a new model from STM addresses cognition). Distinctively, its structure is formed away from attention. After complicated experimental procedures, sensory memory could work, foremost, for both modalities: vision and auditory. Modeling could be a distinctive feature among the human species because it advocates breakthrough, enhances, improves, and triggers civilization with future.

Temporary memory has two phases for stimulus qualities: firstly, a continuation of the stimulus for about a quarter of a second, and secondly, a vivid recollection for many other seconds. In addition, the integration of sensory memory features requires attention, which could result in a non-sensory type of memory. A process of information theory could be related to short-term and long-term memory. However, several studies have proved that sensory modulation is related to short-term memory.

Another approach in this regard is Piaget's Cognitive Development Theory. Jean Piaget views four different stages regarding information processes: sensorimotor, preoperational, concrete operational and formal operational period. The sensory memory`s duration becomes longer for less intense stimuli and the sensory of stimulus may reflect conscious access to the neural processes included in perception. In other words, the sensory memory has two subsystems: 1- the shorter sensory storage is about 100–200 ms in duration and 2- the longer sensory storage lasts approximately 10–20s and it is perceived as a vivid memory of the stimulus. Hence, it is considered the first level of incoming perception of information processed in the brain.

**2.8 Visual Memory**

Ibn Al-Haithem, an eleventh- century Arab scholar, established the principle of image formation and provided a lucid description of camera obscura designed more or less as same as eyes system. He purported that any gained experience has got an impact on what we see and how we see. His book The book of Optics unfolds the puzzle of the vision and gently discusses Euclid scholars and Aristotle who claimed that the eyes didn't perceive items by sending a bunch of lights; items came into eyes via giving off forms; respectively. However, he delineated that beams of light penetrate the eyes at the back. After that, the optic nerve takes what they have reached to the eyes directly to the occipital lobe in the brain. At the theoretical level, Kepler reveals the true nature of image formation in eyes, and Scheiner confirms it experimentally. Subsequently, Des Cartels (1677) illustrated the principle of image formation in the human eye inevitably. A visual system could be a highly passive system. The pathway of vision begins with receptors in the retina and ends in the visual cortex. Sight among higher mammalian is widely corticalized in the brain.

Santa (1977) conducted an experimental study and concluded that visual information is stored in a picture-like memory. Basically, visual information is transferred to a memory of vision. Visual information refers to "the visual features or details of an object that are encoded and stored in memory" (Shannon, 1948).

Young people use visual storage formation in order to create visible entities. A visual item is considerably well remembered. Pictorial information seems inevitable and, besides, it provides subjects with a meaningful explanation of the picture. Apparently, subjects show high recognition memory for any circumstances once they use images. Accordingly, subjects remember a meaningful interpretation of the picture more than the physical details of the picture. I believe that recalling events accompanied by pictures is more accessible than ones without pictures. The visual memory of interactive images develops memory. By the same token, bizarre images may assist subjects in showing a better memory, too.

The trip of visual stimulus entity moves via receptors in the retina (at the back of the eye). Then, the message passes on to ganglion cells (as the optic nerve). Visual sensory memory refers to the brief representation of visionary stimulus that may persist following the disappearance of that object. Visual memory is akin to memory.

Ironically, the visual sensory memory could be seen as iconic memory. Paivio (1986) defines iconic as a picture-like representation. The storage capacity of iconic memory substantially exceeds the capacity of short-term memory, it may store a dozen or so of letters, and it works on a short time scale orderly 200-500 ms at most 1500 ms. The estimation time of iconic memory lasts not exceed 100 ms. In other words, the subject discovers that the fadedness of the iconic memory has begun.

On the contrary, iconic memory may be more robust than short-term memory experimentally. Therefore, various items are represented in the iconic memory such as color, shape, direction, motion, and finally flicker; accordingly, iconic memory is not visible persistence decisively.

Further differences between iconic and visual short-term memory (VSTM) will be addressed as follows:

First: iconic memory could be disrupted severely by subsequent visual events in the same retinal location.

Second, stored data in the iconic memory could not be compared to patterns presented in various parts of the visual field.

Finally, VSTM represents object and viewer-centered coordinates patterns while iconic memory represents them in retina-centered coordinates. Visual short-term memory: allows storing visual items or information for a while (Sperling, 1960).

Conversely, iconic memory is shorter than short-term memory, in which the capacity to retain a sensory image goes up to one second after the presentation and it matches entirely the sensory image that has elicited it. Put differently, immediate memory could last a few seconds longer and it coincides with what we commonly call short-term memory.

The vision cortex needs heavily visual experience and focuses since/from early life. The identification of visual areas exhaustively depends on reliability in features related to 1- connectivity 2- architecture 3- functional characteristics, and 4- visual topography. The visual exclusively or predominantly occupies about half 52% of the cortical surface of the cortex. Koch and Crick (2004) argue that: "to be aware of an object or event the brain has to construct a multilevel, explicit and symbolic interpretation of part of the visual scene". In terms of neurology, it broadly means the various stages in the visual hierarchy. Vision is considerably defined as "a sequence of processes, each of which is a mapping from one representation to another" (Heydt, 2004).

**2.9 Mental Images**

Aristotle views the mental image as a decisive process in both cognition and thinking and his theory is considered the cornerstone of the modern analogical imagery view which maintains the correlation between perception and imagery. Imagery refers to "the ability in forming internal mental representations of visual patterns and in using such representations in solving spatial problems." (Carrol, 2008).

A mental image refers to the personal experiences within a sensory modality. It could be the result of the

interaction between visual representation and a subject`s knowledge. Similarly, mental images are mentally intricate products; inner formation could be described and transformed. It is a complex phenomenal experience but an internal representation in which information about the visual form of objects can be manipulated. Interestingly, visual mental images correspond to short-term memory. The ability of the visual system can distinguish differences that could be improved. Pictorial material has a high imagery value.

Numerous studies demonstrate that mental imagery in human cognition has three significant principles: 1- reasoning, 2- creativity, and 3- comprehension. However, the mental image is akin to a perceptual experience and it happens in the absence of external stimuli.

From a neuroscience perspective, investigations have shown that mental imagery generates neural activity in sensory and motor networks of the exact forms. Arguably, a neural mechanism commonly underlies imagery and perception.

**2.10 Visual Short-Term Memory**

The capacity of VSTM hovers around four to five entities and the representation of those items in VSTM may occur with the lack of details retention. So, VSTM is a finite memory dramatically and has a limited capacity. Subsequently, subjects retain sixteen features related to the objects including color, size and others. Eventually, neurons that encode various features of the object are fired in synchrony. Relational information between items must be encoded in VSTM. It may allow visual information for temporary storage in order to differ them from iconic memory.

Other scholars such as Mewhort and his colleagues argue that the decay leads to poorer information because the location of test letters is forgotten. Therefore, it reveals that the relationship between location of information and identity was not in the literature at the time of Sperlings' (1960) investigations. Thus, the identity and location must be integrated, and independent channels must be processed in the visual system. People could perform with five locations perfectly. Hence, a number of early experimental studies explore that short-term visual memory is finite and limited in number. Visual imagery would be invoked by generating concrete ideas.

However, an important view may arise concerning VSTM by Lee and Chun: "What are the units of VSTM?" To answer this question, they confirm that the visual world comprises meaningful objects and each object consists of multiple characteristics. Chunking is defined as the units of VSTM that include an aggregation of features that form specific objects.

**2.13 Taxonomies of Memory**

Memory is a network of the cortex, connective links of an array constituted by experience between neocortex and neurons. It tremendously involves complex networks that can be discovered only by cognitive processes. Therefore, memory has a cognitive form distinguished in the dichotomy of its psychological mechanisms and anatomical pathways from the other types of memory. Thus, it is emphasized that all inputs and outputs are pervasive in the neocortex which meets recent bulky views. The function of cortical neurons in memory is exclusively part of those networks. Finally, Eichenbaum (2002) confirms how and when memories could be permanently stored and substantiates the threshold of the recent neuroscience domain since the second half of the 1800s.

Human memory encompasses short and long-term memory separately after the temporal memory that lasts just for seconds and decays swiftly. Memory is identified in terms of retention, acquisition and retrieval mechanisms.

James (1950) distinguished between primary memory, which he viewed as awareness of what has happened, and secondary memory, which he viewed as our knowledge and experiences of events that move from consciousness part to the part of the psychological past.

More than fifty years later, dissociation between the notion of short-term and long-term memory has been supported by Hebb. The only distinction between dichotomies of memory has an absolute neuropsychological perspective. There are two separable systems: the former depends on reverberating electrical activity temporarily and the second depends on neural growth to represent a more long-term memory.

An important question arises: how do we process information in the STM and LTM? The answer simply tells that information comes to a sensory organ before it is recoded into short-term memory storage. Then, if information were rehearsed intensively and adequately, it would be sucked in the long-term memory for last; otherwise, they would be lost or at least hard to remember. This dichotomy view predominated vastly in the late 19650s.

Conversely, in the early 1960s, the previous assumption of memory was unnecessary and not parsimonious. In the mid of 60s, a bustle of gigantic activity concerned memory has occurred, but vital decisions divided memory into long-term and short-term memory.

Nevertheless, instead of treating long-term and short-term memory as discrete systems, it could be

more valuable to elucidate the durability differences of memory as a significant result of coding. The ramification view of memory depends on a primary system of memory.

Pioneers such as Atkinson and Shiffrin (1968) have conducted various studies on memory with a conclusion of the nature of human memory. There are two types of memory from human psychological memory: short-term and long-term. Short-term memory is similar to a temporary storage with a finite bulk of information.

**2.13.1 Short Term Memory (STM)**

Short-term memory is viewed as the conscious contents particularly the internal thoughts and fleeting accesses. Its contents may endure entities and last until we lose our attention. Short-term memory mediates external information from the outside world to long-term memory via sensory organs to the brain. George Miller (1965) affirms that the number of entities that human brain can hold in brain is between 5 up to 9 or $7 \pm 2$ Miller`s law which is known as the magic number. Hence, memory span is about five words, six letters and seven digits.

STM is eminently an active brain content and conceived as a perceptual process. The temporary hold of information happens in the brain for a short time, from seconds to minutes. The capacity of short-term memory is entirely limited. It allows retaining finite information for a limited time. To be more specific, an adult's memory is approximately between 5 and 9 irrelevant items. The concept of short-term memory is akin to heightened activation. Short-term memory capacity usually increases until it reaches a maximum in young adulthood and starts decreases in old age. Ebbinghaus (1885/1913) conducted a study concerning the short-term memory capacity and he concluded that seven unrelated pictures or words were remembered. Short-term storage may be vital for many activities such as memorization, observation, onset for long-term memory, learning, pedagogy and analysis. The necessity of STM for the brain is high on the ground that it is needed to have some purposive capability mechanisms of doing tasks. Any absence of rehearing causes the decay with time unless refreshed or repeated. Many studies address short-term memory in terms of auditory, capacity, emotion, spelling, and span.

A single letter or a word shows virtually no loss in short-term memory. Nonetheless, it is substantiated that when the subjects could not show rehearsed memory, the short-term memory decay. Short-term memory is a system that enables people to reflect many features of the information-processing metaphor of memory temporally (Thorn and Page, 2008).

However, cognitive research reveals that short-term memory has a structure, not just a formless reservoir. Short-term memory might be maintained and manipulated information. The processes of short-term memory could be addressed in the light of neural processing. To be epitomized, short-term memory advocates the retention temporally although a finite amount of information on processing; any mental manipulation is formed by STM. STM has been identified strongly in terms of attention.

Though external information comes to the short-term memory from the environment via various perceptual processes such as vision, short-term memory preserves these data until either transfers them to the long-term memory or decay. In other words, the repetition of the information process is called rehearsal. Once the information gets rehearsed, it will be transferred to the long-term memory for permanent storage; otherwise, it will be decayed. Thus, increasing rehearsing of information contributes to consolidating long-term memory retention.

Essentially, short-term memory is the access key to retained information. Many studies indicate how short-term memory works; short-term memory accesses information from sensory organs. Then, it can keep data from seconds up to minutes which helps to remember information. Accordingly, information will be transferred to long-term memory for permanent retention (Anderson, 1995).

**2.13.2 Working Memory**

Cognitive psychologists have developed short-term memory mechanisms in order to clarify how it helps us interact with the external world and achieve our goals. Working memory exploration goes back to the 1880s when Ebbinghaus presented the experiments in controlled studies. In spite of enormous studies regarding working memory, researchers have no consensus on one definition. Instead, most researchers such as Baddeley and Hitch (1974) agree that working memory may look like stores of task-relevant information. Its importance is necessary for the comprehension of language and self-monitoring production; accordingly, language is still the miraculous phenomenon in the brain that working memory subserves language proficiency.

The working memory is considered the main system of cognition. It occurs in the human cognitive processes, which are responsible for manipulating external incoming information and storing it for a finite time within the operations of cognitive tasks Unlike the STM mentioned earlier, it lasts not more than seconds, which sharply manifests limitation in capacity, which affirms that rehearsal is needed. Interestingly, the STM study was decreasing strongly in the 1970s. Baddeley and Hitch (1974) have developed a concept of working memory

at a theoretical level. The concept of working memory is connected primarily with the correlation between memory and cognitive performance.

The contemporary conceptualization of short-term memory is considerably working memory. Miller, Galanter and Pribram consented to call short-term memory "working memory (WM)" which emphatically serves as an advocate system for doing cognitive work, such as listening, reasoning or making decisions. Working memory is a sort of temporary system that preserves images and their representation; essentially, in order to perform tasks cognitively".

Working memory is a confined capacity system that helps to store and modify information. Therefore, it holds about seven units of information or it might hold 12 digit numbers if they are somehow categorized into groups. Working memory has undergone substantial amendments and refreshments in the past two decades, but it has sundry incarnations, which yield fruitfully. However, three components characterize the model: central executive, visuospatial sketchpad and the phonological loop. Baddeley (2002) explains those components:

1- the central executive effectively excels the control upon various activities which determines what the following component should do at any given time. It is limited in numbers, but people could do it simultaneously. For instance, people can watch TV and have a drink at the same time. However, the executive is a bit vague, but some functions have not been explored.

2- the visuospatial sketchpad deals with the information of the visuospatial one. It is essentially the system that endows the human brain to form visual images, convert words into images and manipulate them.

3- the phonological loop expresses the auditory rehearsal system, and auditory storage holds phonological representation shortly. Consequently, working memory assumes that phonological representation could store both visual and auditory material such as letters, which may convert into a phonological store (Carroll, 2008).

Historically, it was easy for psychologists to find limitations of short-term memory. Thus, STM is a subcomponent of WM. STM is a subset of WM (I.E. WM = STM + attention); performance on STM tasks should be related to performance on WM tasks (Kail & Hall, 2001).

The literature of short-term memory remains a controversial term. Researchers maintain that there could be a pure recovery; at least of the elements maintained at the conscious awareness attention. Working memory is a kind of short-term memory that people rely on when they rehearse to memorize and information could be forgotten as soon as it is no longer relevant. Amazingly, this is why it is called working memory.

Working memory has been viewed as a functional component of cognition that permits humans to comprehend, retain and support learning. I would rather donate actionable cornerstone of WM explanation which I purport that working memory must be the essence of thoughts, cognition, retention, and acquiring knowledge. Try to close your eyes and then go to check an item or pick a pen from your desk that you know by remembering its place; this ability to locate that item is an excellent example of spatial working memory, a form of short-term memory. WM can be retained in long-term memory or decayed if no longer rehearsed or used. From a brain perspective, working memory is a neocortical ability in various lobes in the brain. A plethora of conducted research on humans and animals view that the prefrontal cortex keeps information in working memory, and it also joins the working memory for problem solving and behavior planning (Bear et al., 2001).

By the same token, neurons still stand out in the prefrontal cortex showing responses in working memory in the high primate. Put differently, imaging the brain for human beings delineates that many areas in the prefrontal cortex are involved in WM (Bear et al., 2001). Hence, it is vehemently clear that neurons and memory should be adjacent as I proposed earlier "neuromemory".

**2.13.3 Long Term Memory (LTM)**

Long-term memory is defined as a structural memory that preserves knowledge permanently. Its entailment includes retaining information for days, weeks or more. Therefore, this type of memory bears and stores information that can be recalled for years. James (1950) denoted in his dazzling book, "The Principles of Psychology" that there is a distinction between two types of memory: primary and secondary memory. Therefore, secondary memory is the gargantuan amount of information from the past that can be called up on various occasions. In other words, long-term memory has an infinite capacity. Long-term memory is defined as the systems of memory that are responsible for storing information permanently; I.E. word generating processes could be a tendency for the left frontal lobe areas. Nevertheless, the scope of the frontal lobes could be excited for long-term memory, specifically episodic memories (Martensson, 2008).

Moreover, long-term memory has two distinctive aspects, episodic and semantic. Long-term memory may greatly expand short-term memory and it requires the ability to consolidate activities. Furthermore, the representation of knowledge in long-term memory may posit two types: explicit and implicit memories. Since the explicit memory may involve conscious potential, the recall implicit memory sticks with learning motor skills such as riding a bike, more importantly unconsciously. A dichotomy of explicit memory arises as follows: episodic and semantic memories.

Episodic memory deals with personal facts and experiences, which take place or pertain to an occurrence of events periodically. However, the differentiation between memory in the broad sense and memory in the narrow sense is similar to semantic and episodic memories, respectively. In fact, various authors explore the distinction between knowledge and experience such as Piaget, Inhelder, and Nielsen. People have two kinds of memories: one is the memory of personal experiences and the other is acquiring knowledge by study (Carroll, 2008).

Concisely, it is greatly expressed, retrieving information, from a person`s perspective rather than long-term memory. Thus, scenarios of our daily life that happen every day are considerable experiences; to remember those events such as in a class, lecture, party and the like, it must be the significant responsibility of episodic retrieving memory.

Semantic memory deals with general facts of life and it refers to the organization of acquaintance of words, symbols, concepts and objects. In other words, classes of information (motor skills), spatial knowledge, general knowledge and social skills are included. I have to remind you again that language is the unique conspicuous aspect among human beings. Consequently, remembering objects, abstract words, actions and many others are taking place in semantic memory which has a splendid role in cognitive aspects in which naming and word-picture match are examples and parts of language representations. Nevertheless, studies based on MRI and PET show that patients of Alzheimer's dementia meet semantic memory difficulty which corroborates the neural side that manifests the relationship between memory and neurons in different areas such as the temporal and frontal association cortex.

A series of studies view that semantic memory enhancement involves the prefrontal cortex. For example, experts recall chess pieces more than novices. Experts show high technicality using memory by repetition, connecting items, linking information, intruding sensors intensively, forming memorable scenarios in their brains, manipulating all of these vast data, transferring codes into meaningful thoughts and interpreting them into accurate language.

Constantly, experts store items in the long-term memory, targeting their future to enhance their own lives by crystalizing their memory skills. Other scholars affirm that experts may group or chunk various pieces into larger nodes in working memory when they have meaning to foam their skills and enrich both their competence and performance because I confirm that memory is an extremely pillar of both competence and performance.

Put differently, trauma or electroconvulsive therapy (Bear, F. et al., 2001) might corroborate negatively by erasing short-term memory. However, the same trauma might not affect long-term memory that has been retained permanently.

At this phase, I would delve further and elaborate another dichotomy of memory that relied on the consensus of cognitive scientists and neuropsychologists:

The first dichotomy is called declarative (explicit) memory and the second one is nondeclarative memory which is the counterpart of declarative memory and is often called implicit.

Nevertheless, Ullman (2008) views both dichotomies of memory systems as "refer to the entire neurocognitive systems involved in the learning, representation, retention and use of the relevant knowledge and skills" p.190. Brain structure network functionally helps declarative memory which shows a complementary role.

Declarative memory refers to the memory that one`s has personally; scenarios, experiences, and events are involved. It is the storage that exists in the consciousness and interestingly language is the essential way to declare and express it, e.g. words of a poet. Fuster (1994) views declarative memory as the knowledge of what. In other words, a group of memories can be declared, assessed, and reported verbally (Tulving, 1983, 2002). Therefore, remembering a capital city and a marriage invitation, respectively facts and events, is declarative memory. It is noted that it is akin to encoding events of one's life experiences as one writes an autobiography. Interestingly, it is an episodic memory. A close relationship has been mentioned to the ventral stream (Ullman, 2008) that rigorously takes the representations of vision and auditory into the long-term memory. Hence, declarative memory came out of attention, focus and was expressed by language such as events, images, or even sounds. Our awareness efforts are explicit memory. Put differently, it is viable that declarative and procedural memories might analogously have roles across language and non-language domains. It underlies one stipulation which is: "if the functions they subserve in non language domains share characteristics with language"(Ullamn, 2008) P.190. Some observations manifest that women have higher declarative memory abilities than men whereas men have more procedural memory in language and other domains. Interestingly, girls retain intricate forms better than boys.

The second one is the knowledge of facts that have no correlation with any certain incident, but the facts we have got and facts we obtain daily. It is the matter of classifying events without recalling scenarios; when or where they have been apprehended. It is absolutely the semantic memory. Episodic memory retains autobiographical events from our memories. However, the difference between episodic and semantic memory

has a biological perspective.

Conversely, Procedural (implicit) memory involves a constellation of cognitive skills, habits and mental functions I.E. learning how to lace up shoes or putting a belt on. Therefore, procedural memory is characterized as non-declarative type, or implicit memory. Non-declarative memory is absent in the consciousness to a large extent and its concern is acquired skills at the unconscious level. Accordingly, procedural memory (non-declarative memory) befalls when we do things with the absence of focus like driving a car or riding a bike. Hence, motor skills, cognitive skills and any acquired and retrieved information not by conscience are non-declarative memory.

Moreover, this implicit memory was intensified because of the exploration of mnemonic ability. If it is retained and consolidated, then a brilliant breakthrough about Alzheimer's patients might thrive and prosper one day, hopefully. Hence, the two dichotomies of memory start as declarative and procedural memories until the incremental touch of pioneers (ZolaMorgan and Squire, 1993) and their proponents who exerted efforts and a bit later renounced and bounced: the procedural memory is the first and the non-declarative memory is the bounced (Fuster, 1994). Moreover, the non-declarative has been used instead of procedural memory that the lateral has been included.

To unravel the interferences and convergence between declarative vs. non-declarative memories, distinctions are listed as 1) declarative memory has episodic and semantic, which can be seen as facts and events that use knowledge about facts events, respectively. Dealing with what we memorize using our conscious, I would rather use attention which is another attribute that characterizes declarative dichotomy. It bears explicit memory. The memory span in this dichotomy is relatively fast and fragile in terms of memorizing and forgetting.

2) non-declarative memory is the memory of skills, habits and outcomes behaviors. It is dedicated to learning rules and sequences. Contrary to the former dichotomy, both obtained learning and emotions are all happened way far from attention (consciousness); I avoid the word because it might lead to puzzle and perplex who has an interest away from experimental and solid sciences. It is implicit memory. To form this dichotomy, rehearsing and practicing are significant to increase span of time that memory retains and stays longer but unforgettable. Learning needs repetition in order to exposure to stimuli or practice with either a skill or a habit.

Historically, mnemonics has been a result of the non-declarative interest among pioneers and their proponents. It is broadly used in pedagogy and it has been emphasized by Ancient Greeks and Romans in order to improve learning processes. The mnemonic term is generally agreed on and is a reliable enhancement of memory; consequently, mnemonics is a learning tool that motivates learners to remember facts by coding the knowledge such as color, rhyme, song, acronym, or acronym a phrase. For example, to remember the four directions: North, East, South and West; they will be encrypted in the following order: Never Eat Shredded Wheat; by using letters initially, we codify the four directions into a mnemonic way.

Imagery mnemonics creates interactive images to facilitate memory processes and consolidate information. Mnemonics allows learners to utilize the organization of information to be remembered and retrieved. For mnemonists, it is challenging to retain an enormous number of digits that have been reached to memorize over 67,000 decimal places according to world records using various methods (Purves et al., 2019).

Fuster (1994) believes that procedural memory looks like the knowledge of how. It comprises data that cannot be easily expressed or conveyed verbally. Therefore, it consists of procedural knowledge. In other words, the memories of motor skills or activities that we perform without consciousness are considerably assigned as non-declarative memories. Alternatively, in the study of long-term memory, the nature of retrieving information has been taken for granted.

A plethora of domains have studied language from different points of view; for instance, psychology was concerned with language acquisition, usage, memory but I insist in contrast to mention in this regard that memory has been investigated as a human aspect as a result of memorization whereas memory is preferably addressed in terms of neurolinguistic phenomena. Another view of language comes from severe accidental damages such as aphasia (loss of speech), amnesia (loss of memory) and other horrible damages in certain areas in the brain which concerned the neurology and neurolinguistics; as will be mentioned below, domains.

A plethora of studies have been conducted and the results have deeply dissected enormous cases and acquainted brain to the humanity. The Scottish surgeon Charles Bell (1774-1842) was famous for his operation that he had done on brain and nervous system which had been him the first one who underpinned that neurons have certain functions. Intriguingly, he had paved the differences ways, in the spinal cord, between sensory nerve and motor nerves. He has been distinguished by the description of paralysis in the face, that happens because of the lack control of the facial muscles on the affected side, that attached to his name as Bell`s Palsy which . The prominent figure in the field was Franz Joseph Gall (1758-1828) a neuroanatomist who navigated the brain with the conclusion of: mental faculties are localized. It is very interesting to tell that Gall decided to draw a map illustrates the brain`s functions. By the same token, Gall viewed the cortex of the brain consisting of a layer and uniform. It is very exciting to know that “organology” has been defined by Gall which sometime

later came to be Phrenology which means study of determining the traits of personality, capacities and the bumps that happen to the skull (Fromkin et al., 2014). Gall (1825) also dissected the poor understanding children, their use of speech and compared them to those who have intellectual disability (Rhea Paul, 2012).

Conversely, bulks of debates predominated at that time after Gall; some savants were antagonist but some were protagonist. Pierre Flourence conducted many studies on birds to check if there was any harm or dysfunction to the brain occur when the large parts of cortex removed and the conclusion was no deficit would be harmed or functions of the brain would be intact. Moreover, others have upheld him intriguingly such as Luigi Rolando and Louis-Pierre Gratiolet (Ahlsen, 2006) after conducting enormous studies on cortex.

Interestingly, the round went back to the Gall`s view because of his student Jean-Baptiste Bouillaud (1825) who upheld and supported the view and in addition he figures it out. Accordingly, Bouillaud was against Flourens and affirmed that partial paralysis could happen because of limited cortical lesions (Ahlsen, 2006). Boulliaud contributed greatly to the speech disorders when he explored the damage in brain among many cases and found two types of disorders: 1- word memory and 2- speech movements which consented to Gall`s view.

Extra exploration had taken place to the brain, Ernest Auburtin had reached to a person who shot his skull bone in the frontal lobes; yet the frontal lobes were intact where Ernest decided that any pressing against the frontal lobes with spatula, the patient will stop talking which is to him a great proof that speech is localized in this lobe. What is enthralling here is that Ernest Auburtin was Bouillaud`s son-law

This era has been through many discoveries and disputes concurrently due to the rapid proceeding in the investigation and revolution of science.

Tremendous fortune for the sake of cognition addresses the mental set of processes all in terms of acquiring knowledge; those processes are memory, thinking, judgment, attention, reasoning, perception, learning, and many others.

Amazingly, the physics perspective has been involved in studying sounds of a language that move in the atmosphere from the speaker to the hearer whilst this sort of phonological production of sound can be investigated separately. Every tiny chap of sound is accessible to study in detail and compared to other sounds; however, this physical aspect of language may contribute strongly to imitate and produce an infinite number of sounds.

**2.14 Amnesia**

Memory can be seen from another extremity: the disorder of memory known as amnesia. Ali Ibn Abbad Almajusi has been discussed loss of memory as a mental disorder before 995 (Haque, 2004).

Horrible damages in certain areas, diseases, injuries, concussion, chronic alcoholism, tumor, inflammation of the brain as in encephalitis, and any incident such as stroke will affect memory. Bear et al., (2001) purport that if amnesia is apart from any cognitive deficit, it is named dissociative one. In other words, a correlation between memory deficits and brain injury has been viewed clearly in terms of dissociated amnesia.

Truman is a fundamental factor that causes amnesia in two ways:

1-memory loss occurs before the trauma towards what was known, simply the previous memory loss. It is called retrograde amnesia which in traumatic cases severely turns into complete amnesia for learned information, and 2- incapability of constituting new memories or learning it about facts, events, and words after the trauma which is called anterograde (Bear, et al., 2001 & Purves, et al., 2019). A bilateral lesion occurs in the medial temporal lobe structures that inhibit learning information. Accordingly, after any damage, phonology and semantics knowledge will not be acquainted nor obtained which follows the assumption that the structures might underlie the ability of learning morphology and semantics; word formation and word meaning, respectively.

It has consequences in cases: severe ones preclude the person from remembering and learning new things whereas mild ones show weak learning and the demand for repetition is indispensable. To crystalize the scene, someone is sitting in a chair that stays at the office on a pile floor, a scream from the kids' room heard. She stands quickly to move but because of the slippery floor, she falls and her head comes across the edge of the desk. If she has got retrograde amnesia, he will not remember a thing that lasts two days (the scream too) whereas in severe cases, she might not remember many things that year. However, if she diagnosed anterograde amnesia, you might remember anything before the hit, the shout from the kids' room; however, you might not recall any of the events such as visiting a gallery after the occurred trauma.

Not to mention Alzheimer`s that might occur among women more than men. It hurts the medial and neocortical temporal lobe structure whereas the basal ganglia, Broca`s areas in the frontal lobe and motor regions are healthy. The onset of Alzheimer starts with memory disorders. The first phase shows the loss of attention and fixation of new memory while the later phase also manifests that long-term memory gets affected as a result of autopsy, severe lesions of " the cholinergic nuclear aggregates of the basal diencephalon" (Fuster, 1999. P.41). Its patients show poor acquiring and processing motors, and cognitive skills and also show the same at expressive and receptive syntax. It seems that the hippocampus and entorhinal cortex have received

some changes which is bound to the patients who have suffered problems in forming memory. Hence, it has been delineated the memory disorder of Alzheimer patients to the cholinergic neurotransmitter system, the hippocampus and the cortical link to the associative cortex (Fuster, 1999).

## III. **Neuromemory**

**3. Neuromemory**

The essential goal of the book is to navigate neuromemory, memory and its taxonomies till metamemory.

Neuromemory as I coined both memory and neurons which are inspirable dichotomy which constitutes a quintessential factor in the brain between human beings, particularly when they adjacent to language, logic, met thinking, and other tasks in the brain. They have been studied from almost all scientific domains which sustain all means of making memory and neurons stand alone as a separate domain. In other words, neuromemory, I believe, has all fundamental underpinnings that establish neuromemory as a separate domain. Various Domains that studied memory and neurons have concluded that memory and neurons are inevitably proven in the brain; they are inspirable and they are woven with many tasks, I.E. language, processing external world, thinking and many others. It has been manifested that all types of memory reside in cells and cells are the storage of memory which demonstrates that the term "neuromemory" needs to stand alone and be studied under the neuroscience domain. The domain of neuromemory should encompass cortex, cells, neurons, memory taxonomy, memory disorder such as amnesia, short-term memory loss, Alzheimer`s, artificial memory and the future of neuro-techno memory.

Therefore, the bulky bilingual studies have manifested that humans remember pictures better than words; one of which is my study. Brown, Neath, and Chaters' (2007) view that retrieving memory is distinctive in terms of location, temporal position, ordinal position and others. The role of the sensor lies greatly in memory; any sensor carries data to memory, it will be either stored or decayed. In addition, sensors have a remarkable correlation with the cerebral cortex in terms of storage, comprehension, learning, analysis, and most mental processes are in the brain.

Memory is a vital process in the brain particularly in the cerebral cortex. This view accordingly corresponds to the forms of visual storage among young people. Obviously, people forget insignificant things that are neither used nor rehearsed which devastate these memories over time.

Neurolinguistics is amazingly revealed throughout the contrast experiments of various studies. Harry Whitaker introduced the Neurolinguistics term technically into the academic field in 1971. Whittaker (1971) stated "a proper and adequate understanding of language depends upon correlating information from a variety of fields concerned with the structure and function of both language and brain, minimally neurology and linguistics". The neurolinguistic term bears the correlation between language functions and brain (Ingram, 2007). Neurolinguistics concerns the threshold of the explanatory that apprehends the brain's nature and the linguistic pattern from an internal perspective. Therefore, neurolinguistics is able to explain linguistic deficits such as amnesia as well as linguistic phenomena in terms of construction and acquisition.

Neural experts view that any representation of memory in all its forms is decisively clear that data must land in a cell somewhere in pervasive memory all over the brain which must be called neuromemory.

I feel compelled to argue that neuromemory from a neurological perspective is full fledge in terms of learning, retaining, and neural based. It will catalyze the educationist to design language curriculums compatible with the learners' abilities and needs. Also, it stimulates memory generally no matter what taxonomy of memory is to work, trigger and launch appropriately in order to get more knowledge. Intriguingly, neurolinguistics, as I see, consents that neuromemory should be inextricable and tackled inseparably.

I would hasten neuroscience to reconsider the view of memory studies among intact and patient people by not overlooking the segregation of memory and memory disorders from neuroscience which might help scientists to focus more on the field. However, the domain would not prosper until bulky studies will be conducted on humans compared to the plethora of studies that conduct on animals i.e., rats. As a matter of fact, no one is against these experiments because they affirm negative or positive assumptions before applying them to humans. Nevertheless, the separate domain "Neuromemory" will be helpful for the scientists and specialists to conduct enormous experiments which support humanity entirely.

I would also hasten to manifest that the correlation between sensor and representation of the external world in the brain is inevitable for many reasons:

1- the five senses mediate the external world to the brain since childhood.
2- the subjects memorized concepts based on their vision or their sounds by whispering.
3- vision visually stores the external world, whereas the auditory system holds sounds.

Psycholinguists address the external behavioral patterns of memory whereas neurolinguists address the memory internally, in the brain. I suggest that STM should be placed in the neurolinguistics and not in the psycholinguistics domain as a result of a study I conducted regarding STM. Psycholinguistics views that memory and learning are intertwined and they cannot be separated. Therefore, the only way they studied and referred to memory was through learning. They are brilliant pioneers in the succession of addressing memory as a human phenomenon but their results interpreted the behavior of memory. However, psycholinguistics should be set free from short-term memory issues, I believe. Hence, much evidence throughout neuroimaging and

neurolinguistics fortified my actionable call; moving STM away from psycholinguistics.

Linguists such as Naom Chomsky argue for accomplishing the feat of the native language by some neural machinery designed for this task (Ingram, 2007).

Enormous studies about brain contribute broadly to memory, metacognition, cognition, metamemory, and now to neuromemory. Exposure to visualization effectively improves cognitive skills in many areas on interpersonal and intrapersonal levels.

Moreover, the cognitive process reflects the mental ability to process information for many purposes and one of which is retention. It moves smoothly from the conscious (short-term memory) to the unconscious (long-term memory) process (Sommer and Wurtz, 2004).

Cognitive perspective was effectively proved. Since the images were visually absent, the subjects memorized the concrete nouns and remembered them more easily than abstract nouns. This cognitive process proves that cognition plays a significant role in process concrete nouns efficiently.

However, Ingram (2007) affirms that language must be a cognitive rather than physical artifact. Thus, human sensory-motor and cognitive systems effectively compose linguistic phenomena which Chomsky formed in the Minimalist Program terminology in 1995.

Put differently, I argue that since neuromemory is represented in the brain for many reasons:

1- neurons are the only place where memories will be retained.

2- brain`s functions such as memorizing, thinking, reasoning, and retrieving, are all in the brain, need memory which defines the necessity of coining the neuromemory terms.

3- neurons receive the data that results from sensors.

Furthermore, the metacognitive term refers to metamemory, the language use and processes affiliated with learning. So cognitive processes manipulate and store information. The certainty of being aware of knowing what we know, understanding our personal needs, heading towards acquiring knowledge and lack of skills is inevitably metacognition. In other words, it's a matter of accomplishing tasks in our daily life.

The physiological study provides understanding observations that underlie the mechanisms of cognitive processes in STM which is conscious memory (Echenbaum, 2002).

## IV. **Language in Memory**

### **4. Neurolinguistics**

Neurolinguistics as a major targeted immensely the way that cognitive capacity functions language after the broad dissection from biology field towards brain and its tissue (Kemmerer, 2014).

Neurolinguistics has prospered last decade vastly and obtained many tangible findings such as: 1- the brain active pattern 2- left temporal activation in meaning comprehension (Tucker et al., 1998 neuroscience of language book).

Besides, neurolinguistics unraveled some basics in terms of language such as the dominance of the left hemisphere and the perception and production of the speech in specific areas; as will be explained in the course in the temporal and frontal lobes. The aforementioned discoveries have been made in the era between mid 19$^{th}$ century and early 20$^{th}$ one.

Neurolinguistics has got a golden gate after Broca`s conclusions. Consensus is apparently declared, though. In the beginning of the 20$^{th}$ century, it seems these findings inspire neurolinguists and endeavor greatly to assist them to get acquainted to the symptoms or to exert more examination of the cortex of the brain for more prognosis. In the 2$^{nd}$ half of 20$^{th}$ century, neurolinguists commenced to draw more test to assess the aphasics.

Neurolinguists in terms of Broca`s aphasia, invigorate and corroborate the area by research, investigation and they broaden the area. Their impact on the field is essentially clear to fathom and digest the area.

Jakobson (1963) for instance, examined the studies in order to manifest the factor between damage in the brain and ability of language within the same case or different one. Whitaker (1971) is one neurolinguists who reviewed, researched and scrutinized the approaches the written by scholars. He stated that language in the brain is well connected that different parts, sub mechanisms and systems greatly interact in synergy.

Aftermath, conducting comparative studies between normalcy of people and affected people came to the surface to identify mental problems, language deficit and cons and prons. Some of which these studies firmly elevate the value results that neurolinguists reached out in the problems of language deficit and in particular Broca`s aphasia.

However, Neurolinguistics has witnessed great prosper drastically because of linguistics, technology, cognitive psychology and brain experimental studies. Adjacent of medical devices some of which MRI, FMRI and MEG are significantly assist the field to grow vehemently. Research after the glamour background either empirically or theoretically corroborate in synergy.

Neurolinguistic research has three fundamental objectives as they have seen by Chris Westbury (neuroscience of language book,1998), they are: a- studying language disorders systems b- categorize the

linguistic components and c- map our discern of the language processing and turn it into intelligible and comprehensible form. Moreover, I would vehemently insist to consider normal people to the aforementioned goals in order abut them to investigate further intercepts phenomenon among them in order to reveal more use and function of language in the brain.

Neurology and linguistics look different in certain aspects but they may meet at certain points (Kebbe, 2008). These interconnected domains investigate the bridge between language from one extremity and the brain aspects of functioning language from the other extremity. Neurolinguistics attempts to reveal how the brain perceives and produces language at many levels. Neurolinguistics can be defined as Yule (1999) viewed "the study of the relationship between language and brain".

Alameer (2016) views that neurolinguistics has been technically fetch to the academic field by Harry Whittaker in 1971 after the influence that has been boosted in 1960s by Noam Chomsky (Ahlsen, 2006). The terms "NL" tackles any binding between language and brain functions (Ingram, 2007) besides manifests the brain nature and linguistic data connection. Neurolinguistics is a domain which can uncover about language deficits and disorders such as: aphasia, amnesia, agrammatism and so forth at construction and acquisition levels (Alameer, 2016).

It is worth mentioning that neurology succumbs to diagnostic concerns and aims to study the nervous system which is contrary to linguistics which study the language which show no point to converge (Kebbe, 2008). Nevertheless, these two broad domains become interdisciplinary enterprise in terms of, as Kebbe (2008) corroborates "the neurological aspects of language pathology include abstract linguistic analysis" and in terms of the referring the dichotomy speech of language production and perception to the brain inclusively and particularly to nervous system. Put differently, neurologists address memory and language which glaringly corroborate that language and memory and their functions take place in the brain internally first (Alameer, 2006).

However, language is inevitably in the brain (Alameer, 2016) based on enormous of studies and investigations. The figure of linguistics, Noam Chomsky portrays that native language is acquired by some neural machine planned for this task (Ingram, 2007). Language is marvelously a universal force (Alameer, 2016) to determine humanity, interpret science and phenomena and inaugurate civilization. It has been envisaged in terms of its origin as the most mysterious factor among humanity (Kebbe, 2008) equally to coded encrypted cells that creatures have because of the lack of authentications and documentation.

**4.1 The strategy of memorizing nouns**

Languages consist of three dimensions: 1- sound 2- structure and 3- meaning. Therefore, language definitely is embarked by sounds that constitute words that build sentences that deliberate meaning. Moreover, sounds are studied by phonetics and phonology study those pattern. The words formation is tackled in morphology whereas the structure and sentences are undergone syntax and finally the meaning is the main issue for semantics. It is worth mentioning that the following: Phonetics, phonology, morphology, syntax, semantics and pragmatics which studies the speakers' intentions, are the pivot concern of linguistics.

Consequently, language intrinsically and extrinsically is the scene of extensive studies. Noticeably, many aspects of languages have been studies in particular phonology and syntax as production. To delve more, many studies tackled articles, active and passive sentences, pronouns, verbs and structure (word order) in languages Swedish, Arabic, Dutch- German, Italian, Dutch, Spanish, Dutch and German, respectively.

By using imaging devices, bulky of studies have been done to observe activities in order to canvass syntactic process, WH- questions, the inverse patterns in languages: Dutch, Persian, Dutch and Dutch, respectively. Phonetics and phonology problems are another concern for researchers such as hard articulatory issues in Chinese language.

Accordingly, the problem might haunting the syntactic processing is the result of the verb "be" production which is in particular hard to the Broca`s aphasics.

Spectrums of information in linguistics are perceptive (in the brain) or expressive which at the first sight tell that language is a means of communication which is a limited alleged because language should go further to develop life, enhance human beings behaviors, find solutions, hone skills, interpret thoughts and fortify civilization.

Kebbe (2008) has full-fledged ~~that~~ neurolinguistics that paves the road of language based on assumption that language has s dichotomy of production and perception.

Bulky of results paved the way for the neurolinguists to delve deep into brain. They keep unraveling things one of which is the Broca`s aphasia and how the language practices in this area night assist linguistic competence for any new language (Musso et al., 2003). The chins of neurons are making such an interaction and connection in order to permit this ability.

Neurolinguistics among some people is nothing but debatable and controversial. We do concur that hypothesis are falsified and nullified. Nevertheless, brain and functionality in it is arduous and complex but this

domain is not moving rapidly but it prospers slowly based in enormous studies and investigations due the pioneers who keen to pursuit the fact that come out of experiments. Despite of some who view that nothing is certain for neurolinguists but the left hemisphere which is the area of language, I consider this claim is true because they prefer not to implement hypothesis but only bona fides.

A full-fledged strategy of memorizing linguistic concepts fortifies 1st language learners, 2nd language learners, pedagogists, parents, trainers, instructors, and many other interested people, with vital memorization ability. Piaget views language as a cognitive process rather than processing information (Piattelli-Palmarini, 1980). Hence, these obvious views support the claim that language is not a behavioral phenomenon. Not to mention, all aforementioned domains prospered and well contributed to memory. For instance, we are all enthralled by the children's acts when they insist on grasping the concepts` meanings around them. A child pays attention to objects around him and scrutinizes them; overtimes, he recognizes the object; its shape, color and other features. Then, he listens to people around him pronouncing the concept "name" of the object. Afterward, the child pronounces while the parents rectify that pronunciation and consolidate entities in memory.

Relying on concrete nouns consolidates our memory which has been manifested that concrete nouns are the most powerful words to be remembered (Schwanenflugel et al., 1992).

Repetition, attention, and time will rehearse and consolidate the retention of the concept in memory. Using short words might help having expanded memory because the capacity of short-term memory is better for short words (Martensson, 2008).

Conversely, if a language learner meets complex concepts to acquire and grasp the meaning, then the intangible (abstract) concepts lack the solidity, shape, color, and other materialistic features are the critical reasons. It is clear that we cannot retain abstract notions unless we build them on concrete ones. Hence, the hindrance of difficulty of abstract ones precludes from remaining in memory; however, the solution is clear now, use the intangible notions in the context of concrete ones to memorize, increase, enhance and develop your language aspect.

Hence, the hindrance of difficulty of abstract nouns prevents them from remaining in memory; however, the solution is now clear, build intangible concepts on tangible ones to increase, enhance and develop your memorization of abstract nouns. All of the above was part of an experimental study that I have conducted.

In general, memory is a universal aspect of humanity. Psycholinguists widely succeeded in their interpretations of memory and its divisions, as external behavioral. However, neurolinguists address memory in the brain internally which determines that memory, language, and its functions in the brain.

Conversely, the memory and language in the brain are holistic phenomena from external and internal perspectives and both intertwined homogenously in the neurolinguistics domain.

Processing specific information concrete and abstract concepts coincide with mental skills such as memorizing, thinking, and recalling from a cognitive perspective.

Consequently, throughout the memory domain and its ramifications from the internal perspective of the brain, I would strongly use the Neuromemory; technically, in terms of the future study of memory because humankind reaches a new era of realizing various aspects of life; particularly the brain, language and now I declare memory too.

So, I would decisively suggest that memory and neurons must be addressed as Neuromemory; moreover, it has the sense of investigation internally and externally which opens the gate to experiment, study, enhance and develop. Furthermore, addressing neuromemory separately becomes necessary since we have a solid structure (brain), storage (memory), neurons where the data reside, and unique items. Finally, a pretty quiet understanding of language functions in the brain will advocate robustly get neurology and memory coined because language is an inevitable function that determines sturdy aspects and functions in the brain; on top of them is memory. Finally, as I believe, neuromemory is a separable field that must stand alone and tackle all memory taxonomies neurologically.

## V. **Metamemory**

It is renowned that cognitive psychology inspires pioneers to search and pursue domains such as metacognition, which includes attention, memory, awareness, and perception in each metamemory, which is the book`s concern. It seems memory and metamemory are linked well inextricably to the level that understanding the former might be essential or at least adequate for perceiving the latter and vice versa. In other words, they influence each other, and they both, in synergy way, tackle learning, retrieval and long-term retention. Ironically, perceiving any form of memory is not necessarily required to perceive metamemory; nevertheless, metamemory probably will benefit from memory knowledge (Dunlosky & Bjork, 2013).

Intriguingly, Jean Piaget, the pioneer, and founder of cognitive development, concluded, after many observations upon children, that children have the ability to think about thinking, the definition of metacognition, which might later inspires Flavell to coin the metamemory term aftermath.

The history of metamemory was dated back to Josef Hart`s work in 1965 whereas the term was coined and introduced by John Flavell in 1970. Bulky empirical studies, interviews, questionnaires, and theories have been conducted on both adults and children since 1965; not to mention many discussions have been placed since Aristotle. They have been conducted in terms of knowing their memory, evaluating and stimulating learning strategies to motivate subjects. Moreover, Flavell coined the term; Ann Brown attached attention to it, linked it to education, and contributed to the term by a framework that consecutively unified the field.

Therefore, metacognition can introduce the knowledge that anyone has about the processes of cognition. Put differently, metamemory as a domain stands on its own whereas metamemory research "was itself fragmented" ((Dunlosky & Bjork, 2013 p. 15).

Metamemory was introduced to the field by Flavell in 1971 in which he described metamemory as the knowledge of storage, processes, retrieval and operations. Simply, it means knowledge about memory that they are retained (Borkowski, Ryan, Kurtz, & Reid, 1983). Moreover, it delineates the outline knowledge about processing memory that everyone has which describes the metamemory knowledge compared to metamemory awareness that coincides with the monitoring and edifice of memory (Perfect & Schwartz, 2002).

It also indicates the knowledge of one`s memory. In other words, it refers to the person who has a memory, and he knows totally that his memory has the knowledge and is entirely aware of this knowledge. Miller (1997) defines metamemory as the knowledge of memory. It also has two critical elements: monitoring and control of memory which both are controversial from one side and quite significant in everyday life situations (Do et al., 2012). However, research on metamemory purports that people might get control of their memory willingly; yet, there is a lack of metamemory at the neural level. Hence, two fundamental factors are included: the knowledge of memory processes and awareness. By the same token, a plethora of definitions hovers within the knowledge of memory that we have such as the one`s knowledge of memory via his awareness. Metamemory has been seen as the knowledge of memory abilities besides understanding correlations between those abilities and memory.

Metamemory from 1965 until 1979 goes and covers various fields and subfields. It is better to mention the history timeline and scholar contributions' to it as follows: in 1965, Hart came up with FOK which feeling of knowing. A year later, 1966 Tip of the Tongue by Brown and Mcneill was determined. Zacks in 1969 presented self-paced study besides Arbuckle and Cuddy who drew Judgment of Learning. Tversky and Kahneman (1974) purported Judgment and Decision Making. Hindsight Bias has been based by Fischhoff in 1975. Fischhoff, Slovic, and Lichtenstein (1977) studied confidence two years later. Markman delineated Education and metamemory in 1977. Development in Children was investigated by Wellman in 1978, and Source Monitoring was researched in 1979 by Johnson, Raye, Wang, and Taylor ( Dunlosky & Tauber, 2016).

The domain of Metamemory attracted experts and scholars to carry on their investigations. The time between 1980s to 1995 has witnessed significant studies such as: Neuroscience of Metamemory (1986) by Shumamura & Squire, Metamemory Methods in 1990 by Nelson & Narens ( Dunlosky & Tauber, 2016).

To delve further, metamemory has been conducted on learning process starting from the threshold of 1- initiation of learning, the judgment of learning/ forgetting to retrieval 2- the feeling of knowing judgments and to post learning, and 3- retrospective judgments. Metamemory and other areas such as: remember- know judgments and déjà vu are bridged all. Hence, it is prospered significantly in terms of research and study. Finally, neuroscience dissects metamemory, somewhere, in the prefrontal lobe.

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