Research Journal of Educational Sciences ISSN 2321-0508
Vol. **3(10),** 17-21, December **(2015)** *Res. J. Educational Sci.*

Review Paper

Cognitive Neuroscience and Education: Understanding the Teaching Learning Strategies, Learning Disabilities and Neuromyths

Bhattacharya Jonaki and Pal Prasenjit
Rabindra Bharati University, Kolkata, INDIA

Available online at: www.isca.in, www.isca.me
Received 28th October 2015, revised 13th November 2015, accepted 29th November 2015

Abstract

The present review paper provides an overview of the learning process and the impact of neuroscience to this. Cognitive neuroscience advances our knowledge on learning and has potential application to education. Previous research suggests that cognition is a fundamental learning process which adopts brain based strategies in learning. In this regard we briefly sketched the basic idea of brain and neurons. After that we have tried to explore how human organism learns in a neuro scientific way? The conducive learning environment and appropriate teaching- learning strategies also have been brought under the scanner. Finally we have tried to understand whether these strategies can solve the learning disabilities like Dyslexia, Dyscalculia and ADHD or not?

Keywords: Cognitive neuroscience, brain, neurons, learning, memory, learning disabilities, dyslexia, dyscalculia, ADHD.

Introduction

A life is born and then there begins the never ending learning, life long learning until the end of life. When a human child first encounters with the concept of "cat" then he is in a situation of learning. It is more of a biological phenomenon. A child's perception of a cat –four legs, one tail, white colour, creating "mew " sound etc. involves different areas of our brain encoding for shape, colour, smell, sound etc. It takes thousand of neurons to be connected in a neural network for encoding the concept of cat. The electrical signals send by axon of a neuron releases neuro chemicals at terminal ends into synapse. The space between two neurons is known as synapse. If the receiving neurons' dendrites have the appropriate chemical receptors then electrical signals will be passed from one neuron to another. In this manner brain develops networks which encodes and stores learning experiences. Every time we see the cat the connected neural network creates the representation of cat.

Our perception changes over time. For example we may experience black cat. This new information about the colour of a cat adds or changes the neural network which we already have. The creation of these connections through restructuring the neural network and their ever-changing nature is called neuro plasticity. It happens as we perceive our world differently from time to time and we proceed along the path of life long learning until the end of life. This is the basic idea of how we learn according to neuro scientist.

The 1990's is termed as the "decade of brain". The advancement in technology of measuring brain activity contributed to the development of neuro science at a rapid pace. The integration and application of the knowledge of neuro science in the field of education has given birth of a young field of research known as neuro education or educational neuroscience. The new brain imaging techniques has made it possible to watch the brain as it learns. With these observations of "learning brain" neuro education helps us to understand learning, learning disabilities and to develop suitable teaching learning strategies by ignoring the neuro myths.

Neuro science perspective of learning

All human learning will ultimately have a brain basis[1]. This is the neuro science idea which gained much of attraction in last one and half decades. In order to understand this we need to know some basic anatomical knowledge on brain and neuron.

Brain: Fore brain, mid brain and hind brain are the three parts of human brain as shown in part-1. Fore brain, the largest part of the brain is divided into left hemisphere and right hemisphere. The mid brain is responsible to relay sensory information and to respond. Bodily functions are regulated by hind brain. Our complex social network is regulated by cortex which is shown in part-2.

The cortex distributed in frontal, parietal, occipital and temporal lobes by the corpus callosum are shown in part 3. The frontal lobe is for reasoning while the temporal lobe is responsible for auditory skills as well as memory. In order to integrate information and mathematical skill we need the parietal lobe while the occipital lobe is for visual processing. Our neural network[2] across different part of the brain is meant for cognitive process.

The subcortical structure i.e. under the cortex structure of brain is shown in part 4. In fore brain cerebrum is associated with vision, smell, test etc. In mid brain structures like thalamus and hypothalamus and in hind brain the cerebellum are associated with learning.

Journeying deeper inside each of the lobes we will find that medulla and striatum also contributes to the human learning.

Neurons: In the following figure we can see the diagram of neuron which is composed of three part mainly axon, dendrite and cell body. The neurones can transmit information from one to another.

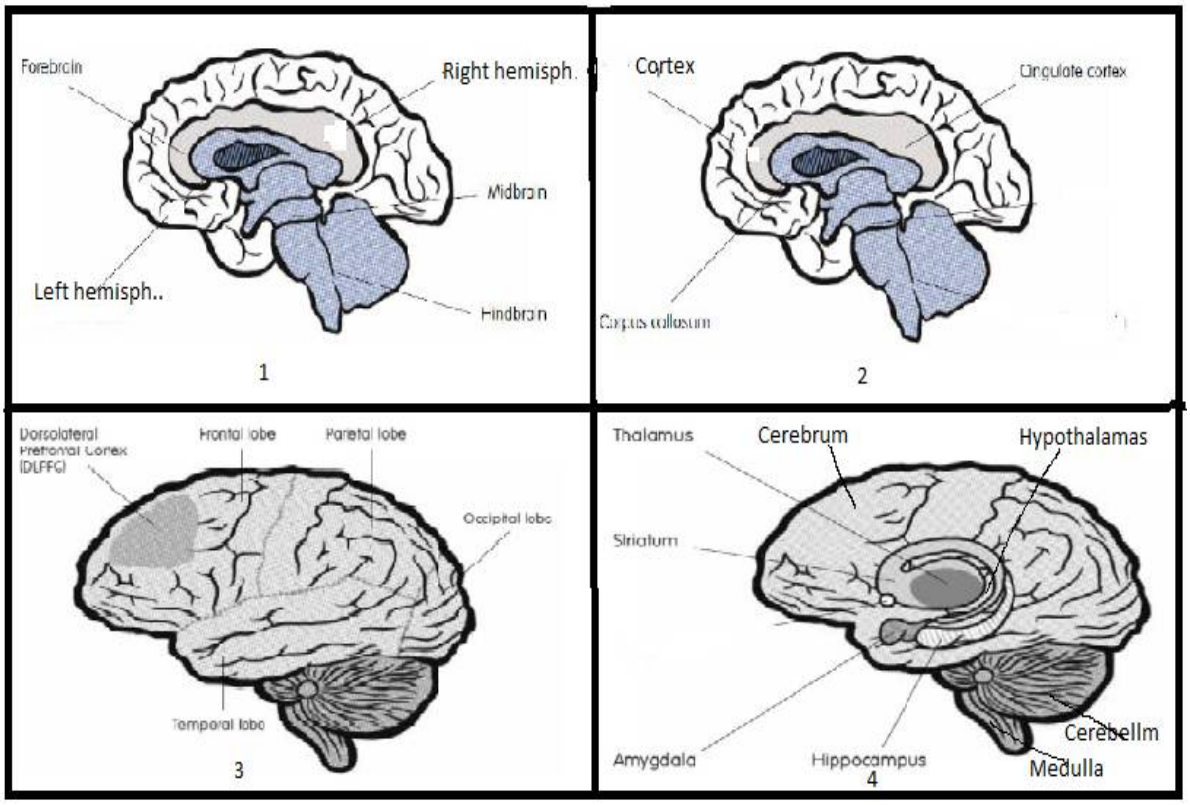

Figure-1
Cross section of human brain

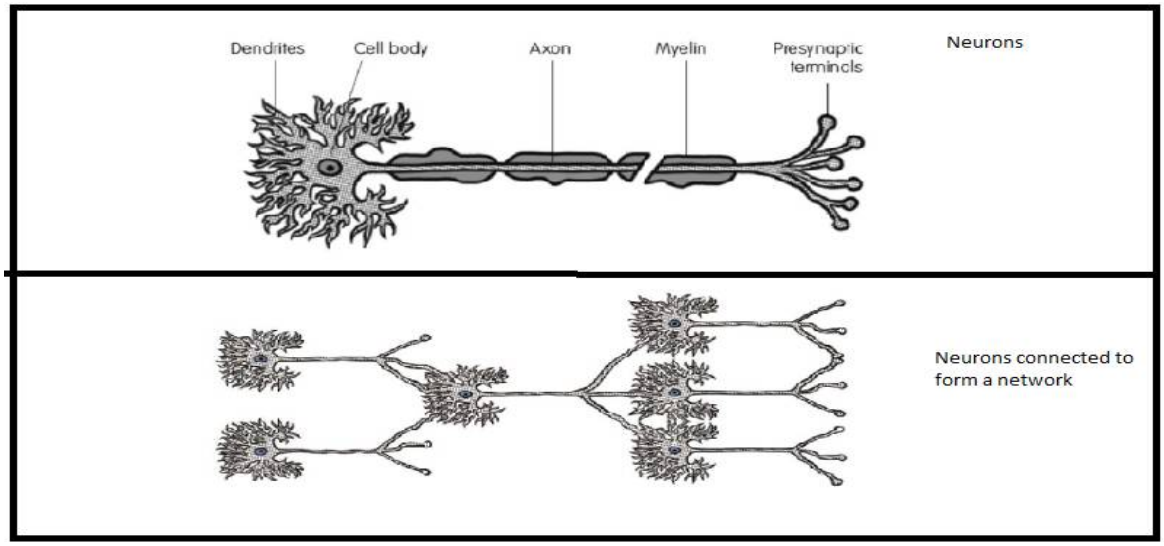

Figure-2
Microscopic Image of Neurons and Its Connectivity

Learning

Learning refers to change in observable behaviour. There exists a common acceptance in the neuroscience that learning occurs with the formation of memory. Sensory events are stimulated by the specific areas of brain and the learning causes a change in neural circuitry known as neuro plasticity. This change in connectivity between neurons undergoes massive restructuring with the development of brain from childhood to adulthood. This birth of new neurons is known as neurogenesis and formation of neural circuit is called synaptogenesis[3]. So that sensory events come to stimulate areas other than those which they originally stimulated is the cortical destruction. As the cortical destruction goes up destruction of learning and retention also goes up.

Art of learning and memory disruption is a function of amount of cortical area destroyed. The location of ablation is unimportant.

Attention and Memory

As our attention seeks different neurons are stimulated then. For example as we look at a pen we shift our attention from the point to the eraser to the wooden shaft. When all neurons are stimulated by different aspects of the pen the result is our perception and identification of the pen. Underlined psychological mechanisms are responsible for different kind of memory. Without memory there is no learning[4].

Short term or working memory: Physical and structural changes between neurons are the transient or short term memory that is responsible for assemblies of cells and phase sequence. Short term memory is relatively transient neural activity that is triggered by sensory stimulation but remains continuous for some time after the sensory event is transmitted[5].

Long term memory: Declarative memory: Long term memory is thought to depend upon consolidation of short term memory. Anything that disrupts the former should also disrupt later. Long term memory can be divided broadly as declarative and non declarative memory.

Declarative memory or explicit memory is again categorized into semantic memory that is memory of an events and episodic memory. Autobiographical memory is a kind of episodic memory.

Non declarative memory: Non declarative memory like motor skills, habits, abilities etc. are stored and retrieved from long term memory. Non declarative memory depends on the changes in striatum, amygdala, cerebellum etc.

Individual with right hemisphere damaged will likely to display difficulties in attention and perception while failure to see is characterized by damage in left hemisphere.

The greater is the consolidation of our memory greater will be the chance of recall it in a future time. Dopamine works as a chemical reward during the learning process[6]. This dopamine reward mechanism serves to strengthen the neural circuitry connections. This is the biological process of learning[7].

Learning environment: Human brain not only learns by encoding information into memory but from total environment where the information is situated. So learning is a function of total environment. In general learning environment means where a learner belongs with all his or her surroundings i.e. all kind of things from which the learner is entitled to learn. The information presents in the environment is encoded by human brain into memory and by which learner learns.

Physical environment: Physical environment may include school, family where the learner learns related to what they learns from their parents, books, toys, television, peers etc. Many experiences of learning of a person has in a short period of time are related to one another. Good health condition, enough food, drink and sleep is necessary for formation of memory and facilitate learning[8].

Cognitive environment: There are limits to our information capacity and thus for memory or learning. Capacity of prefrontal cortex, level of stress, content of learning, motivation and incentive towards learning, social interaction and support etc. determines the cognitive capacity and plays critical role in enhancing the limits of learning. We have numbers of things to learn. We have to choose among them for limitation of our cognitive capacity. Self-directed learning may help in this connection.

Emotional environment: Learners' feelings are a vital function in the process of learning. An environment must be created to the learner where they can freely express their emotion. If the emotions are released safely from the learner then in the process of learning it can be consolidated as necessary to achieve the optimum learning. The proportionate emotional adherence to the information is decided by the amygdala of the brain.

Teaching learning strategies: Keeping in mind the neuroscience idea about when, how and in what kind of environment learning occurs the pragmatic guidelines for appropriate teaching learning practice were designed by the researchers. One important name is Lila Davachi, Associate Professor of Psychology at New York University. According to her "**AGES"** is necessary for effective learning[9].
A = Attention, G = Generation, E = Emotion, S = Spacing

Attention: In an environment there are numerous factors which may attract the learners' attention. But the learner should focus his or her attention at a particular time towards specific stimulus out of many stimuli. It is essential condition of learning. Instead of Multi tasking, Uni tasking is essential for learning.

Generation: Children learn everything in an uncensored way but adult chooses the learning experiences of their own interest and learns in a self directed way. The brain also learns in a self directed way. So the teacher should adopt the teaching learning strategy accordingly. He /she can generate some problem before the students and encourage them to learn in a self directed way by solving the problem. Problem –cantered rather than a subject-cantered approach can facilitates learning.

Emotion: Emotions consolidate memory. Emotional cue ignites more neuronal activity and strengthens the memory collection and retrieval. Positive emotion is conducive for effective memory formation and learning. Introduction of game in teaching learning strategy will be helpful for learning.

Spacing: Our cognitive capacity is limited. Time gap is required for effective learning. Due to our limited cognitive capacity learning will be minimum when it occurs at a stress. Learning material should be placed in front of a learner after a period of gapping in time.

Learning disabilities

Neuroscientist view of learning presented above describes the biological process of learning. Educational neuroscience explores the interaction between cognitive neuroscience and education[10]. There are some mostly common learning disabilities as they relates to education[11].

Dyslexia: To attain achievement the learner must have the ability to read, understand and represent the matter wherever necessary. Mapping phonetic sounds or sound elements of language to orthographic symbols or letter, word and sentence is the essence of reading and writing languages. Reduced activation of left hemisphere and posterior superior cortex causes dyslexia[12]. According to research findings the language learning competencies is inversely proportional to age. Language learning starts from the beginning of the life. The neuroscience investigates and tries to differentiate the role of human brain in the process of learning language with the age. This realization is necessary to make educational policies while dealing with dyslexia problem with respect to foreign language learners.

Dyscalculia: Lack of simple mathematical computational skill causes dyslexia. One of the main causes of dyslexia is the inherent learners' disability to calculate and to handle different types of mathematical operation on a set of data used in mathematical problem. Sense of magnitude and its visual and verbal representation is a function of complex neural network. Cerebral cortex region are meant for different mathematical operation.

ADHD: Attention Deficit Hyperactivity Disorder (ADHD) is mostly common problems found in the school learners. These learners are unable to attain their definite learning objectives due to their inattentive, impulsive and over reactive nature of behaviour.

The behaviour of these children may be characterised as inattentive, overactive and impulsive. They present a particular challenge to the teacher and to themselves. Neural differences in anterior cingulate and prefrontal cortex may give rise ADHD. For research it may be said that it is not wholly a medical problem. Influence of school environment particularly informed strategies followed by any school teacher may gives beneficial result in this regard.

Conclusion

The field of educational neuroscience as a connective link between cognitive neuroscience and education is complex[13]. There are few instances where neuroscience findings really contributed to the educational policy and practice. Specialized research has contributed different findings in the neuroscience and applied neuroscience in the process of learning. Though the disciplines are closely linked it is difficult to translate different findings of neuroscience in education. One of the hurdles between neuroscience and education are the neuro myths. We would like to point out the followings: i. As a switch board brain does not work. Destruction of brain tissue from the frontal lobe is disruptive. ii. Child experiences are more important in learning language then adult experiences[14]. iii. One with wide varieties of sensory-motor experiences causes normal functioning. iv. The function of normal brain can be explained as an interrelated whole. Educational experiences can not be arranged exclusively for one hemisphere. Both hemispheres have to be educated equally. v. Both the cerebral hemisphere is asymmetrical in function. Attention and perception difficulties are related to right hemisphere while left hemisphere's disfunctioning causes difficulties in speech perception which is essentials for learning.

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