

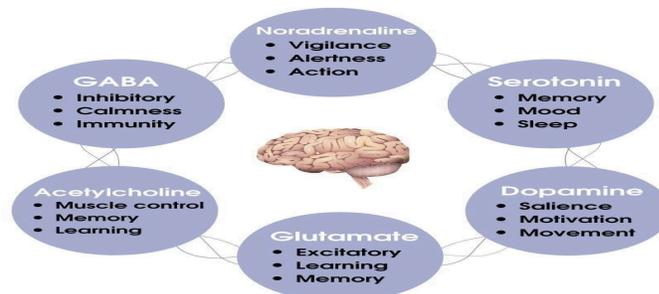
Memory
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Lecture - 7
Neuropsychology of Memory - I

Hello, I welcome you all again in this lecture series of Memory, lecture number 7. Today, we are going to extend our understanding about the nervous system. So what we are going to study today is the neural transmission. How neurons communicate with each other, how the neuronal signal moves from one end to another end. So as you can see on your screen, there are two neurons connected with each other.

Now, one thing we have to understand that the two neurons do not connect or interact with each other jointly. There is always some space or cleft is always there. This cleft which we are talking about it, is varies from 30 millimeter. Now, the two, when the one neuron is there, then the other neuron network connectivity there and this spacing is 30 millimeter. So what we are talking about here is that, there is a presynaptic connection and the postsynaptic connection.

And this is the synaptic connection between the two. And this space is something which we from literature we know is 30 millimeter. Okay. So neurons generate their own chemicals and which we call it as neurotransmitters. And these neurotransmitters are more than 100 in numbers.



Source: [Hyman, S. E. \(2005\)](#)

In psychological studies we consider 30 and out of 30, 9 are of primary importance for us to study when neuron fires these neurotransmitters are pushed back through the axons so the neurotransmitters push back through the axon and it reaches to the down level and then they come to the synaptic vessel where you can see here is the or the cleft, the exchange is happening at the synaptic cleft here the exchange of the neuron neurotransmitter happens. When neurotransmitters are released, they float into a synapse between the neuron and the other cell. And this space, which we are calling it, where they float, is 30 nm approximately. Okay. Neurotransmitters flow in this gap and find the receptor site.

Now, as we discussed in the earlier lecture, not all receptors find the receptor site. And not all receptor sites also find the neurotransmitters but whichever neurotransmitters find it they just go and bind it together the remaining neurotransmitters are reabsorbed by the original neuron in a process called reuptake. So the excess of the neurotransmitter do not go wasted they again go back into the neuron itself so reuptake is happening. So, there is less and less, you know, the wastage of the neurotransmitter is there. Because after every release, there will be some amount of neurotransmitters will be left out. It is important for us to note that pseudo-unipolar thing also happens, which means when the one axon is there, this axonal part can be done, can go down to another side of the neuron also.

So, two unipolar, pseudo unipolar is there. So, one pole is there and they have been divided into two separate parts. Minus 50 to minus 80 millivolt current is required. Now, why this variation is there? Because this neuron may be different.

This neuron may be different. And these two different neurons may fire potential at different potential. So that is why this ranges from minus 50 to minus 80. Sodium potassium pump is always there, the uptake of sodium and down regulation of the potassium ion. This sodium potassium pump plays a major role in the action potential.

The neurotransmitters as I was telling you, more than 100 types of neurotransmitters are there and out of which 30 neurotransmitters are used in the psychological functioning. Out of these, 9 we study. And the most common neurotransmitters which we see,

gamma-aminobutyric acid, acetylcholine, glutamate, dopamine, serotonin, and noradrenaline. Now, if you see closely these neurotransmitters, one thing what we understand is that gamma-aminobutyric acid plays a role in the inhibitory process. Any information which you want to inhibit.

We can't learn everything. We can't form memory about everything. So, we are selective. We do the categorization. We know there is a fruit category.

We know there is an apple category. We know there is a profession category. And to know about each of these category, we have to also apply the inhibition. So, inhibitory control is there. The another side to it is the calmness.

Gamma amino butyric acid plays in the role in calmness. If dysregulation of GABA is there, the person may be highly anxious, may not be feeling calm and relaxed. As a result, when these individuals go for the psychiatric treatment, the clinical psychologist or psychiatric doctor give them a GABA releasing drug which can bring the person into calm state then also when the GABA regulation is dysfunctional or getting impaired then the immunity is being compromised as well so what we understand is that the role of GABA is multiple but if we relate this GABA process with memory then its important role is in the inhibition. So, in memory inhibition, GABA aminobutyric acid plays a major role.

If we talk about the acetylcholine, then you will see its role directly is there in the memory. How the memory formation is there, consolidation is there and how it is influencing the learning. If acetylcholine is not there, then the learning and memory process is going to be compromised. Learning and memory will be dampened. In an healthy individual, acetylcholine seems to be aiding an individual to do a new learning and to form a memory for a long period of time.

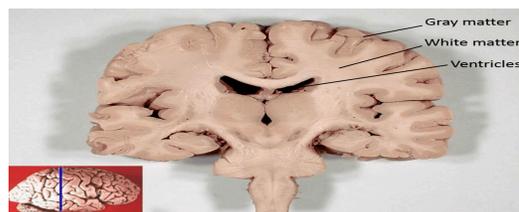
Similarly, we also know its role in emotional control. When we talk about the glutamate, we see glutamate is also playing an important role in learning and memory. Now we see that the two distinct neurotransmitters both these neurotransmitters are contributing in the learning and memory processes with this at least we get an understanding, clear understanding that more than one neurotransmitter is responsible for memory formation

consolidation, reconsolidation and their up regulation and down regulation may vary, may impair the learning and memory processes. We also know excitatory effect is because of the glutamate. The brain requires these neurotransmitters for proper functioning and we see that for the healthy functioning of the human being, healthy functioning of the central nervous system, the role of these neurotransmitters is very crucial. Then another dopamine, the up regulation and down regulation of dopamine seems to have direct role in the motivation.

An individual which is not motivated at all, they have been given dopamine. Self-motivation, dopamine releases more. Healthy diet, Healthy daily routine releases dopamine. Then if we talk about the serotonin, memory, mood and sleep. If you are having insomnia, then serotonin dysregulation will be observed.

If your mood is swinging, serotonin dysregulation will be observed. Serotonin deficiency will be observed. Similarly, noradrenaline, another neurotransmitter, seems to play a role in alertness. A person who is aware, conscious, thalamus, play a major role in alertness and awareness. So, noradrenaline uptake in the thalamus may be important.

And not only that, but its role in the action and vigilance is quite robust. So, these neurotransmitters, these six neurotransmitters are playing major role in the learning and memory processes. Now, moving further down the line, being a researcher of memory, it is very important for us to have a basic understanding about the anatomy of the brain. And when we talk about the anatomy of the brain, then we have to see what are the important components of the brain. And the important components of the brain are grey matter.



Source:

<https://organismalbio.biosci.gatech.edu/chemical-and-electrical-signals/nervous-systems/>

Brain is composed of grey matter and white matter. This area, grey matter, this area, all these areas are white matter. And the empty area are the ventricles. So the brain is a part of central nervous system. Earlier we studied central nervous system, medulla oblongata and then the peripheral nervous system like we discussed earlier.

So this is central nervous system comprised of brain, and stem and this part peripheral nervous system is the another some type of central nervous system central nervous system when we are talking about it, it is organized into gray matter which is unmyelinated axons are there, the axons are not having myelination, myelination help in the conduction of electrical impulse so when the electrical current is moving From one neuron to the another neuron, it should move smoothly. Myelination is required. Myelination provide conduction. As a result, the current moves from one neuron to the other without any loss, without any electrical loss.

If the neurons are longer in length, huge amount of current is required because huge amount of current will be getting loss also. But because we know there is a limited amount of current is there generated by the neuron and it has to move from the top to the bottom, then myelination helps. Gray matter does not have myelination and it plays role in formation processing centers of the brain. White matter, networking between these processing. How the networking is there.

And then the ventricles, fluid filled cavities in the center. Cerebro-spinal fluid. So when we see this structure of the brain, the two hemispheres like a walnut are connected together. So this connection when the two hemispheres are connected together, they are connected through a mesh like network. This mesh like network is nothing but it's a corpus callosum. And left hemisphere and right hemisphere are Separately connected.

The bottom end of the brain. Which is back side. Here. A small brain. Which you call. Dense with neurons, is the cerebellum. So one is the cerebellum.

Cerebellum. Cerebellum which you see here. And then. The corpus callosum is there. Which connects the two hemisphere. Then the brain stem.

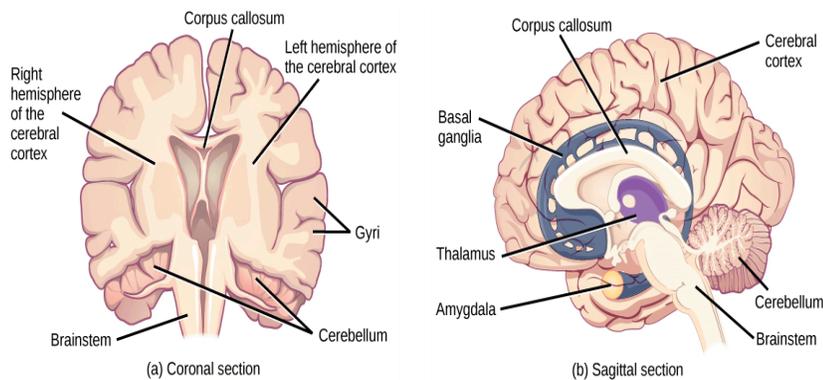
which is the medulla oblongata, we call it. And in this, you will find, this is the amygdala, which we saw in the previous slide, red color. And this amygdala is residing on the structure, which is the hippocampus. This is the ambassadolateral amygdala and cerebral cortex is there. So, cerebral cortex, cerebellum,

These structures, thalamus, amygdala are the primitive structures of the brain which has evolved over period of time. So, the two type of sections, when you cut the brain from the center like this, then you see this sagittal section. Two hemispheres are separated like this. Brain is there, you cut it from between the two. If the brain is like this and you cut the brain like this,

Then you see the left side and right side. This is the coronal section. And if you cut the brain like this, if you cut the brain like this, then it is the sagittal section. So the cortex comprises of two hemispheres, right and left, and four lobes. Four lobes.

What are these four lobes? Frontal lobe, temporal lobe, parietal lobe, And occipital lobe. Four lobes. And frontal lobe.

We earlier discussed about it. There is also lateral prefrontal cortex. Ventromedial prefrontal cortex. Medial prefrontal cortex is there. Which is somewhere this region.



Source: [OpenStax Biology](https://openstax.org)

Parietal is this region. Occipital is this region. Temporal is this region. Now. The two hemispheres are joined together by thick fiber bundle, corpus callosum, machine-like network.

The diencephalon comprising of thalamus and hypothalamus. What do you see here? And then the cerebellum controls the balance and motor coordination, which is the small brain here. This part balances your bodily motion. Like now, when I am standing, it is coordinating, it is balancing the body.

and then the brain is some connects the rest of the brain with the spinal cord so this brain is same which is coming down is connected to the brain okay so this cartoon actually gives a clear picture to us the four different types of brain as we discussed about the occipital lobe which is important for the vision this occipital lobe is further divided into five layers V1, V2, V3, V4, V5. When we are doing a very crude visual information, not detailed information, crude, then V3, V4, V5 is used. But when detailed, precision, specific visual information is required, then V1 and V2 is being used. Similarly, we see the motor area here, motor cortex, somatosensory motor cortex. But,

The parietal lobe is a separate entity and body here. This parietal lobe is also responsible for the what pathway? What is this object? What is knife? What is spoon?

What is earth? All these things, visual area, sense signal, the parietal and then gives the answer back. And where? comes back to the temporal area this is the temporal area which is having a small area as olfactory smell good bad foul smell this cerebellum area is at the bottom of these four lobes and this is very dense and as we studied earlier it is for the balancing part The information from the central nervous system relays back through the spinal cord to the peripheral nervous system.

And from peripheral nervous system, it comes back again through this spinal cord to the brain. This spinal cord we also called as medulla oblongata. Now, the frontal side is this area, orange area, which is a very big area. So prefrontal cortex, frontal lobe of the cerebral cortex is storage of short term memory. Storage of short term memory or as Baddeley and his proposed is to oversight for the working memory.

Decision maker, problem solving, mental reasoning, logical problem, everything is frontal cortex. Also known as central executive system. The area which is the hippocampus is in the temporal lobe. Hippocampus is right here. Consolidation of short term memory into a long term memory.

Now the projection from this hippocampus to the frontal cortex is very very dense. These projections ensures that the information should be stored for a long period of time. so for the initial memory formation for the initial memory formation hippocampus is registering when an individual has registered this information and is in deep sleep slow wave spindle slow wave ripples are generated which activates a network from hippocampus to the frontal cortex. It starts to happen.

And this back and forth projection helps in the consolidation. So, for the initial formation of the memory, initial formation of the memory, these areas, these structures are required. Organization of memories in the brain, if you see the famous case study, Henry Mollison. where the hippocampal and adjacent area of the parahippocampal was being removed because of blackout and seizures the individual was having. And once it was removed, what we saw is that androgate amnesia emerged.

After the surgery, the individual was not able to form the new memories. So how we analyze memory impairment here? Which provides an understanding about the memory organization in the brain. In terms of the damaged brain regions. As we can see here.

What we see. The person the individual. Was. More than 50% correct. For the public event.

And for the famous faces also. So AMN indicates the amnesia. NCUN means control. Not amnesia. No brain impairment.

No brain injury. What we see. individuals performed correctly the public event happened in 1980 there was a clear distinction the public event happened 70s distinction 60s more distinction 50s no distinction what does this mean the henry mollison in 1950 was struggling with blackouts and seizures his surgery happened in 1953 so which means any public event till 1950 he was able to remember or recall but the event which happened

after 1950 he was not able to remember or recall this clearly indicate that the dependency on hippocampus was there peep the for the formation of new memory hippocampus is required after 50s he didn't had hippocampus as a result his performance was very bad so impaired for 1970 to 80 but was that normal at the level of 50 and 60.

At the year of 60, you can ask me a question. At the 60, we do not see that discrimination. The reason being his disease was progressing. His storage may be dependent initially on some adjacent areas. But as the year passed by, total dysfunctioning, disconnection, no projection was there.

So, T7 is no connection at all. Now for the famous faces also, what we see? For 40 and 50, it was so-so. But after 50, there was a clear distinction. So critical structures of the brain may be initially required for the formation and retrieval of memory.

Formation and retrieval of memory. Which means that hippocampus is required to form and to retrieve. Memory may become independent of these structures over period of time. As the information get old, then it becomes independent of structure. So, this finding suggests that the brain regions cannot be, damaged brain regions cannot be the site of permanent loss.

So, permanent representation. So, for an initial formation of memory, hippocampus is required. But once the memory becomes old, then we do not need hippocampus. And this is what we saw from Henry Mollison case. HM has been kind enough and he did lot and lot of studies, helped the researchers to unravel the underlying processing of memory.

What we see here is the role of prefrontal cortex in memory. What we understand is that the frontal cortex as we saw from the previous figure, this region, one has to understand that this is the left side and this is the right side. left prefrontal cortex and right prefrontal cortex. And this left prefrontal cortex is further divided into three parts. That is DLPFC, VMPFC, ventromedial prefrontal cortex and medial prefrontal cortex.

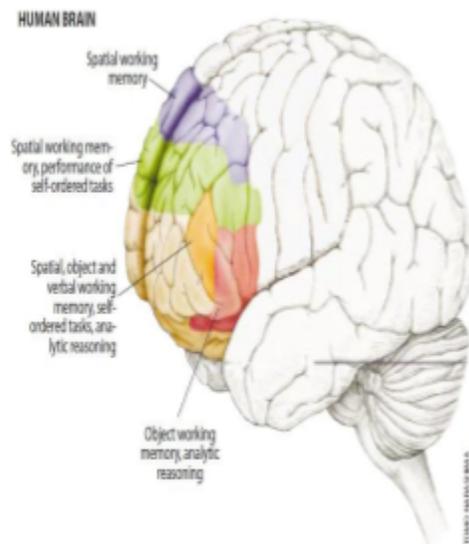
So, this is right and left. This is right and left. This is right and left. Now, the areas if you see here, spatial working memory performance of self-order task. Spatial objects, verbal working memory, self-order task, analyzing and reasoning.

Analytical thinking and reasoning, left side of the brain. Emotional task, right side of the brain. So, active maintenance, verbal, spatial and object formation. Frontal cortex is constantly doing that. Updating, constantly updating the information.

Memory update, memory maintenance, both is being done by the frontal cortex. Hippocampus provide new and new information. Frontal cortex adds, decides, reasons. Schematic processing and complex fact processing. Meaningful information and ambiguous information.

Both are being processed by frontal cortex. Frontal cortex has to decide if it is meaningful or not. If it is non-meaningful, frontal cortex says no. Save time. It is trying to optimize the system.

Sometime central executive system, frontal cortex is also seen as an attentional system. Attentional system where you pay attention, where you shift attention, where you divide attention, where you sustain attention, where you select attention. Damage to prefrontal cortex may result in confabulation, misinformation, misinterpretation. Damage to this area can lead into this misinterpretation, misinformation. The prefrontal lobes are also associated with metamemory and self-regulation.



Source: [Shinozaki \(2013\)](#)

An individual whose frontal cortex is intact, we see they can self-regulate their emotion. They have cognition of cognition. They have memory of memory. However, those individuals whose frontal cortex is impaired, they face challenges. Let us summarize what we have studied in this section.

So, in this section what we have studied is the neurotransmitter. There are more than 100 types of neurotransmitters. Out of 30 are important in the psychological functioning. And out of these 30, 9 is important. Out of which we discussed the 6 types.

Gamma-aminobutyric, acetylcholine, serotonin, adrenaline, and etc. We also studied the anatomy of the brain. The grey matter, white matter, ventricles. We studied the structure of the brain. which has been divided into four lobes.

Frontal, parietal, occipital, temporal. How their projections, how their connectivity is there. How the central nervous system is sending information to the peripheral nervous system. And how the information is traveling back from peripheral nervous system to the central nervous system. We discussed about the cerebellum.

Furthermore, we also studied about the organization of memory in the brain. How the memory is organized in the brain. To understand this, we used the case study of Henry Mollison where we discussed that Henry Mollison was able to remember the event that happened in the year of 50s and 60s. And also, not only the public event, But the famous personality in that period.

He was organizing the memory. Because he was having the frontal cortex. Sorry hippocampus. But once the hippocampus is compromised. Once the hippocampus was not present.

In the system. Then to organize the memory. Was a challenging task. And he performed poor. Compared to the control.

Once the memory is consolidated and hippocampus is there, then it is okay. But once the memory becomes old, then it becomes independent of a structure. And finally, we also

studied the role of prefrontal cortex in the memory. Now, prefrontal cortex is having two sides, left and right. Prefrontal cortex is subdivided into three parts.

And their role in the decision making, analytical thinking, problem solving, Because we know further cortex is seen as a central executive system. We stop here and in next class we will take this thing further down the line and we will study the nervous system little bit in more detail. Thank you.