Memory

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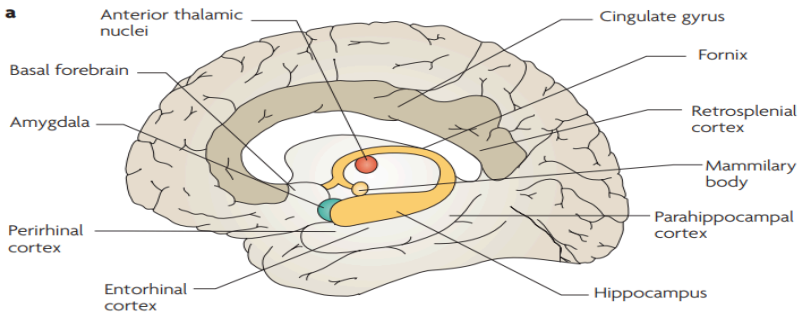
Lecture - 8
Neuropsychology of Memory - II

Hello, I welcome you all in the memory series lecture number 08. Here in this topic, we are going to talk about the neuropsychology of memory. As yesterday we were discussing about the aspects, the measurement, the assessment about the memory research, we discussed about the brain regions responsible in the memory processes. We even discussed about the different types of the lobes which the brain has been divided into and the central nervous system, peripheral nervous system. We discussed that there are four major types of lobe where the human brain is divided and the two hemispheres left side and right side of the brain.

And these two hemispheres are being connected together with the corpus callosum. Now, today we are going to discuss in detail about the role of different lobes in memory. This understanding is important for us to know as we discussed earlier that initial formation of memory is dependent on hippocampus. But once it becomes old, once the information becomes old, then it becomes independent of a structure. And that is the reason why in Henry Mollison case, we noticed that after the surgery, the individual, the HM was not able to form new memory.



Source: Bird and Burgess (2008)

However, his old memories were intact. To understand this thing in clarity and the role of different lobes in the memory can give us a deeper insight to memory. Researchers and the researchers working in these brain regions separately that how the memory and these different brain regions are coordinating with each other. So as we see here, the medial temporal lobe. The medial temporal lobe plays a major role and this was the brain region which was being dissected from the HM case.

A 27 year young individual who was suffering from blackouts and seizures to as a remedy the lobotomy was performed. The lobotomy at that time was so rough the doctors performed the lobotomy, but there was the surgery was so crude that it not only compromised the middle temporal lobe, but some adjacent areas and over period of time we saw that there was a progressive dementia been observed in the individual. Such understanding today's lecture we will see has come forward from the brain dissection study which has been performed after HM's death in 2008. The medial temporal cortex is involved in the memory processing.

This has been established fact and notion and we know this thing from the famous case of HM. The medial temporal lobe is involved in encoding of information. That is the reason why the new formation of the memory was difficult and was being challenged in the HM case because this brain structure was not present in the HM. This area is not the storage side, neither this is the representational side of the information. But this side is holding the information for temporary period till the information get transferred from short-term memory to the long-term memory.

Left side of the brain, so two sides of the temporal lobe, there are two sides of the temporal lobe. So left side of the temporal lobe is involved in verbal information, verbal processing, while the right temporal lobe is involved in the spatial information, the object which is moving in the space, the angle, the orientation and many other details in that regard. The role of medial temporal lobe in memory, how was it being studied in the HM, is that people conducted a study by the Mishikin and Delacour. They did a very simple study where the non-matching and matching simple task was done recognition task where

they have to match the information presented to them with their stored information so in this task the monkey the primates were being used and in this simple design the monkey just had to indicate which stimulus was novel in nature and which stimulus is not novel in nature the matching of the novel is stimulus because they do not have a consolidated and experienced information about the novel or information So, there will be no match.

However, if the primate has already experienced with the stimulus, then there would be a matching involved here. So, the recognition task was there. They just had to match the stimulus. The first sample is presented over the central well. So, the well was there.

As you can see, the two wells are there. These two wells are there and then the object was being placed near the wells. So the task was very simple. The monkey just have to identify in which well the food is presented. That was the goal for the monkey.

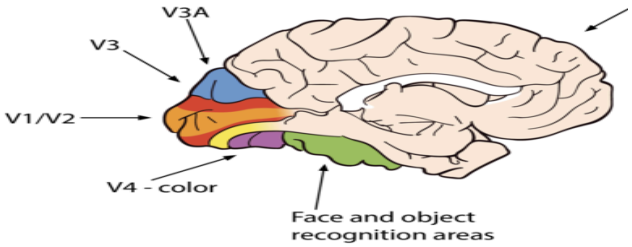
So by retrieving this, by displacing the object, monkey has to acquire that. The choice is proposed to the monkey. The monkey just has to identify the noble object. So as you can see here, there is a Costco ball. And then there is a can and then the can is placed near the one well like this so if the monkey is being trained with this object that every time the this object is near to this well the monkey is getting rewarded in the next trial when this novel stimulus is present in near the well, the monkey has to match it if the stimulus is being seen or unseen.

In case of matching, the monkey will be rewarded with the food. In the case of non-matching, the monkey will not be rewarded with the food. So, Mishkin demonstrated that the lesions, so the two sides of the lesions were being performed. First lesion was the amygdala. The amygdala is, we know that it is a primitive structure involved in emotional information.

So once the lesion is being performed at the amygdala, primate was able to do the matching task. However, when the lesion was being performed at the hippocampus, then leaving the amygdala intact, then the individual suffered with this matching task. This indicated that the two sites, amygdala and hippocampus are the important sites. But if the amygdala is being impaired, leaving hippocampus intact, then a primate can do the

matching easily and get the reward. However, when the hippocampus is being impaired and amygdala is intact, then individual is failing to do the matching task.

This was a very simple task to indicate that the role of medial temporal lobe in the memory processes. Now, to do such a study with the monkey is easy because we can do the lesion, we can do the lobotomy with the animal model easily than the human beings. Now, the time when this surgery was being performed, the early 1950s and 60s research, the lobotomy was quite popular. However, to establish the relationship with the



hippocampus, with the memory, with the other brain regions was still very complicated. Researchers working with different brain regions came up with the notion that memory do play a role with the different types of lobes and as the information is getting old and old it becomes dependent on the other brain structures rather than on the central storehouse of the memory, that is hippocampus so here in the occipital lobe, what they did they just demonstrated that visual area has been divided into V1, V2, V3, V4 and V5 so V3 has been divided into two brain regions.

Source: https://www.coursehero.com/study-guides/wmopen-psychology/outcome-vision/

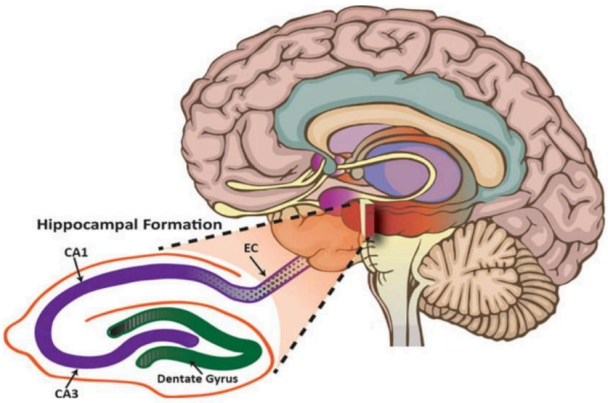
But the brain region which is important for the memory researchers to investigate. Though this brain region has nothing to do with the memory storage or encoding. But this structure plays a role in the retrieval recognition tasks. The brain region which is responsible and extensively investigated was the V4 area which is related with the color processing. But this brain region is not contributing anything in the memory encoding or storage process.

So let's say we have seen a movie, we have been seeing a movie and I give you earlier also example of the Shah Rukh Khan movie. Here let us take a movie example of X-Men where you see Jennifer Lawrence. actress playing a role of Mystique. And when she is

playing a role, the moment we think about the X-Men movie, several characters start to come along with their costumes, along with their personality, along with their details. Now here when we recall these information, memory is playing a role. Along with this, we are also acquiring the visual information, the color of the X-Men character here.

Or when we talk about the Mona Lisa, the famous painting Da Vinci, then we think about also where it is being established in France, which museum it is located. There we require that. But the information related to the Mona Lisa, the color, the texture, the visual information, that is dependent on the occipital cortex or occipital lobe here. Similarly, the color of the banana or the traffic light signal red, green, blue.

One thing is very clear is that these information and having an insight from these different the involvement of these different brain regions indicate that the association and the projection of these brain areas to the hippocampus and from hippocampus to these areas Indicate a bidirectional flow. So memory do depend on these areas but these areas



do not play any role in the memory formation just like the several locations we have discussed about earlier. Okay. So this is an important part and also one important aspect is there that what is this color?

Source: https://www.creative-diagnostics.com/blog/index.php/what-is-hippocampus/

Yellow, green, blue, orange, red. This decision making is being taken care by the frontal cortex also. So visual area may be providing an insight to us about the color, the nature of the color, the details of the color, and this stimulus if we have encountered seen earlier or not which is having a projection from the hippocampus the decision making also being coming from the frontal side. So if you see this thing in detail, the role of hippocampus is

well established and we know that as in the medial temporal lobe was being removed the adjacent area and then we start to have a challenging task to register new information.

Hippocampus does a very simple task. It's a very primitive structure and we know that what it does is just explicitly transfers the information and seen as the site for the permanent storage. This notion of permanent storage became very clear from 1950s until date it is very clear that initial storage, initial storehouse it is. After the initial information has been consolidated for some time, then the information passed down further to the different parts of the brain for a long period of time. So damage of this hippocampus impairs the formation of new long-term memory because as we know that the initial formation of the memory, this brain region is important for us.

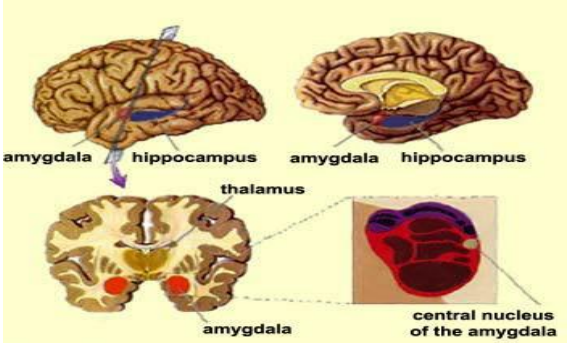
And the research studies conducted with Henry Mollison and because of his generous effort and generous cooperation, Our understanding about the role of hippocampus, working memory, short-term memory, long-term memory has been deepened. Imagine if we did not have HM case, if HM did not have any seizures or if HM did not have any blackouts, Then, the lobotomy performed on him and the removal of this hippocampal and residual area would not have given such deeper insight and we would have been lagging behind in the memory research. So, extensive damage to the hippocampal formation can produce complete loss of the new explicit membranes.

We have to be very clear that the nature of the memory, the different types of memory, the different types of storing the information also play a major role generally and it is an important concern here how we are registering the information and is it very direct or indirect in nature. Hippocampus serves the story of the event rather than specific facts. And this we have studied in the previous example where the HM was being asked about the public events. HM was being asked about the facts, the important dates. In that we understood that HM was able to retrieve and recollect information about the specific event from the period of 1950s and 60s.

As the period passed by in the period of 1970s and 80s, there was a huge gap. He was not able to retrieve and recall. So at least with the hippocampus, we know that is the primary

source of the information and registers the information. It is very important for us to understand the role of amygdala in memory. Amygdala is a site of emotional information.

It registers information which is emotional in nature. Emotion, if we do the classification, then there are six basic types of emotions. Amygdala plays a connecting role between how these emotional information and the memory is required. We do have biasness towards the emotional memory formation and in emotional memory formation, negative or unpleasant memory formation get stored, consolidated quicker, faster and robustly than the pleasant and neutral information one. Secondly, threat memory information has evolutionary advantage over the others.



Source: https://thebrain.mcgill.ca/flash/i/i_04/i_04_cr/i_04_cr_peu/i_04_cr_peu.html ; SM's brain.

It is also known highly connected hippocampus and the hypothalamus are connected densely that dense projection of neurons are there between the hippocampus and hypothalamus and hypothalamus is associated with emotion so the because of this dense projection, the once the neurons get activated in the hypothalamus they somehow send the signal to the hippocampus or when hippocampus get activated then it sends projection to the hypothalamus. Due to this highly connection between the two brain regions, any information which is coming together either at hippocampus or hypothalamus, they lead to robust memory or robust memory formation. Amygdala is associated with fear conditioning and emotional learning. This is an established fact and we know this thing.

And in the case of SM, we knew that when this emotional site is being removed due to hypercalcification, then SM was not able to form a threatening memory. She had an understanding, concept, knowledge about the other types of emotion. However, she was specifically was not aware about the threat information and threat memory. Though as the researcher reported that she did have an understanding about the self of fear processing rather than this conscious experience of the threat.

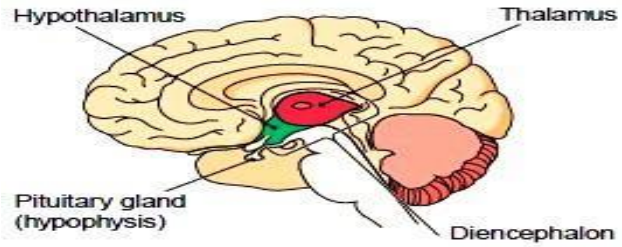
The additional brain regions involved in the memory, is the diencephalon and this is an important part because it can be seen as a brain stem and the central nervous system is passing information through this diencephalon. It goes to the peripheral nervous system and the information from peripheral nervous system is also coming back to the central nervous system using the same pathway. This diencephalon comprises of thalamus and hypothalamus and we knew earlier as we were discussing about it that hypothalamus is the site of the emotional processing. Thalamus is served as the rooting center.

So where the information need to be rooted and where the information has to be passed down that something has been part of this thalamus and we can see that the hippocampus, the site of amygdala on top of it, hypothalamus. All these structures are associated with each other. They are present there in the same location and so one could easily guess and one could easily understand that the dense projection, dense connectivity is there between these brain regions. Damage to any one of these regions may damage the other brain structures processing also. These are primitive structure by the way.

So which means that evolution, whatever evolution or whatever evolution has provided to human brain has been seen as a neocortex, this upper regions. But these structures has not undergone so much evolution. The diencephalon connections between the medial temporal lobe and the hippocampus with the prefrontal cortex. Because of this positioning of the hippocampus, you can see and yesterday also we were discussing about it that the projection from the hippocampus is at the frontal cortex. Similarly, the dense projection of this hypothalamus to the hippocampus is being extended to the frontal cortex.

The frontal cortex due to evolution has evolved much and that is why the higher cognitive capabilities human beings has come up with. That is how we reason, that is how we became the problem solver, the problem solver and in doing so we have been doing the task effectively, efficiently and performing day by day better and better in our decision making. Damage to this diencephalon can result in the memory deficit because the information flow from the hypothalamus down the line and from down the line to the central nervous system may get hampered. As a result, there will be some deficiency in memory can be seen. As a result of this, we have also seen that the common type of syndrome due to memory deficiency is the Korsakoff syndrome.

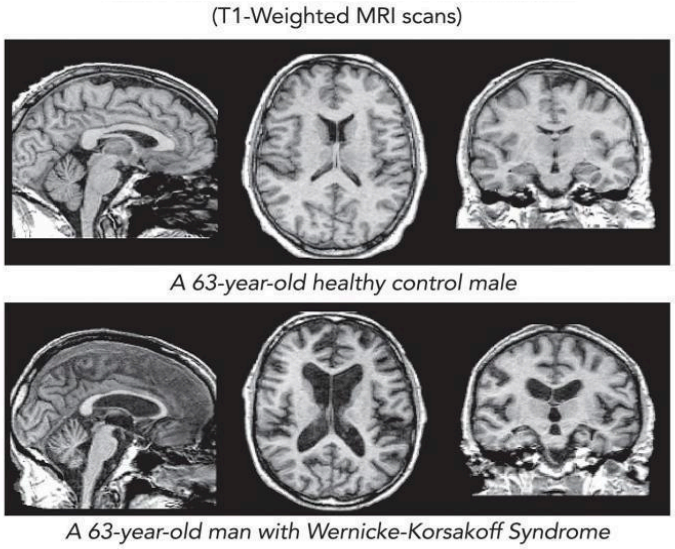
This is also happening because of the hyper alcoholism, a person who is alcoholic in nature. This is an amnesic syndrome, which means that there is a memory loss in an individual. The person is not able to remember, retrieve information though one has to be clear here and I think this is subject to research also that we still do not know if the information exists in the brain or not is it a problem of the recall that person is not able to recall it or is it the problem of the recognition or is it the problem of the failure in the connection as well. So there could be a number of reasons the human brain, the human central nervous system is very complex in nature. so one should not rule out the fact that at some level the projection may not be working, at some level the retrieval may not be working, at some level the recognition may not be working as well the input may be fine but the output If not there, then n number of reasons could be there because the central



nervous system can be seen as a black box.

Source:https://www.toppr.com/ask/question/describe-briefly-the-diencephalon-of-human/

Another point here is the damage to this diencephalon when we are talking about it, Korsakoff syndrome. Deficits in new learning is there, which is that the individual cannot do the new formation. Any new task cannot be learned by an individual who are having the Korsakoff syndrome. Deficits in retrieving well-stored information, retrieval of information as per the literature suggested that the person may not be able to retrieve the information. An inability to distinguish what is true and what is false, what is fictional, what is real, the person may suffer with this.



Source:https://www.niaaa.nih.gov/publications/brochures-and-fact-sheets/wernicke-korsakoff-syndrome

kind of notion all the time because of the failure in the information. So the brain when it is sending an information down the line to the body then the information which is coming down to the body the same information or the expects the feedback from the body itself. So, when this mismatch is there, when there is a, you know, there is a gap and there is a dysfunctioning in sending the information down the line, then true and false memories can be seen. Now, what you, on your screen, what you see is a 63-year-old young man with the Wernick-Korsakoff syndrome having a problem and you can see compared with the healthy control you can see a ventricles which are hollow as a result some of these

brain regions one could easily see and understand what is happening so a 63 year old person normal healthy individual and a 63 year old person with a korsakoff syndrome here you can easily see the hippocampus parahippocampal areas are being compromised in addition to that, okay.

So, our 27 years old young individual whose contribution changed the memory research and provided so much insight, gave us so much insight that how the memory formation is happening, what is the root cause behind memory formation, how memory is becoming independent of different areas, what are the different areas involved in the memory formation or storage of the memory information? How the initial formation of memory requires hippocampus and how its dependency on the other brain areas is important and crucial for us. So when an individual underwent to the having an enough blackouts and seizures doctor suggested that a minor surgery can solve this problem this minor surgery nobody expected nobody anticipated that could go could take in turn in such a way that a person will be will be having a memory loss problem an individual may be having a problem not to form a new information leaving his old memory intact. So when the surgical experiment was being performed, medial temporal lobe including hippocampus and amygdala were being removed.

After the surgery, HM was severely amnesic of the event. After the surgery, his seizures came down, blackout reduced. Excellent experiment was successful. However, very soon people realized that the young individual, 27-year-old, was incapable to form new memory. And this failure resulted into an amnesia, which later we called it anterograde amnesia.

Profound inability to learn and retain new information, facts and figures, HM personality, perception, intelligence did not change. Unlike the case 100 years ago, Phoenix Gage, where the railroad worker was working with the mining experience. Working while doing the mining. Got his frontal cortex damaged.

He survived the incident. However his personality changed totally. After 100 years when HM case. We realized that okay. The brain structure which has been removed.

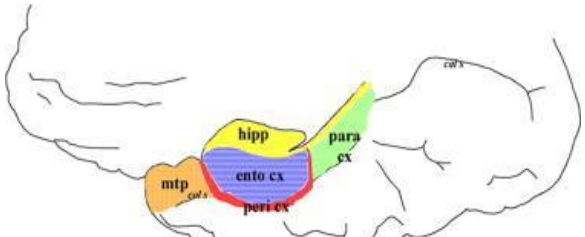
Has nothing to do with the personality. So leaving his personality intact. However. He was not able to form new memory. He did not have problem with the short-term memory.

However, moving the information from short-term memory to the long-term memory was a challenge. And in doing so, hippocampus projection to the frontal cortex plays a crucial role in this regard. So, if an individual is not having that, then the problem may arise. So, short-term memory was intact. However, leaving the long-term memory impaired.

Unable to recall the current date, where he lives, what he did for the breakfast or whom he have met, few minutes later, few minutes earlier and these things just short term memory was fine but when the long term memory we are talking about that became intact as a result he was not able to form new memories. The analysis of HM case reflected upon with several forms of behavioral disabilities to the world community and researchers gain lot of insight from his finding and studying with him. Several cognitive functions of the brain, the limitation of the brain and his studying HM case findings from the HM suggested us the localization of the brain functions localization of the brain function at the time 1950, where it was limited and it was believed that memory do not require specific brain structure memory consolidation is scattered whole brain.

But HM case gave us an insight that no, there is a specific brain structure which is required for the consolidation processes. If that structure is not available, then the consolidation of a new information will be compromised. Similarly, the other type of cognitive processes, language, we found different area. Attention, we found different area. Perception, we found different area.

Motor movements, we found different brain regions. The analysis of HM brain revealed important points to us. Firstly, the medial temporal lobe is required to encode some new information. So, medial temporal lobe was an important brain region. But some memory functions remain intact after the MTL damage also which means that the nature of memory is different for different tasks and the nature of memory when it is different then the different brain structures is also being required not all types of memory require the



medial temporal lobe different types of memories some may do not require the MTL lobe.

Source: Barbeau et al. (2004)

So, if MTL is intact, then good memory formation is possible, but if MTL is impaired, then memory formation, new memory formation would be compromised, but not for all type of memories. Secondly, some past memories survive the MTL, may not be permanent storage site for the long-term memory. So, okay, some memories exist there, which means that the MTL is not the site for the permanent storage. So another important point, role of MTL must be time limited. So in memory formation, two important facts as a memory researcher, one has to remember that memory consolidation or reconsolidation or learning processes is dependent on protein synthesis or time dependent.

So either at what time point the consolidation has started, at what time point the reconsolidation has started, at what time learning is happening, at what time interference is happening, all the sort of time plays a major role here, one. Secondly the protein synthesis, whenever the consolidation, learning, new learning, old learning, relearning, over learning is happening, protein synthesis is undergoing. What you see on your screen here is the brain structures, hippocampus, entorhinal cortex, perirhinal cortex, all these perirhinal cortex, they are the adjacent radius. And in the case of HM, this entire section, this entire 8 cm, approximately 8 cm, 8 cm structure was being removed by the doctor, in order to treat the HM for the seizures and the blackouts.

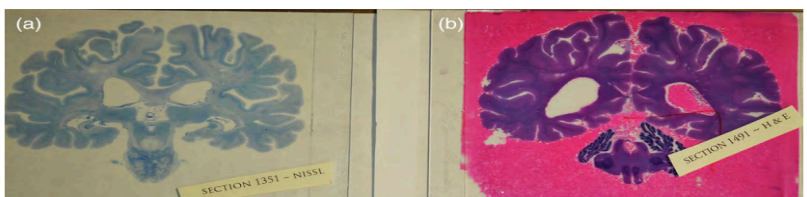
Now, some people argue that was it ethical to remove this thing, such brain structure? Well, it is subjective in nature. The young individual who was suffering from several seizures per day, several blackouts per day, but after the lobotomy, when his seizures and blackouts were being reduced, it was a big relief to the young individual. The same, taking this thought further down the line, his lobotomy not only gave us deeper insight

about the memory processes, but also resulted into the development of several memory consolidation theories in this direction and provided us, give us a deeper insight into it. Though the limitation came a little late in the period of 1980s, 1970s and 80s when researchers wanted to use the imaging method and imaging tool to understand the Henry Mollison brain.

But the time of surgery in 1953, if the researchers, if the doctors, surgeons, neurosurgeons have used what type of metallic clip to bind the brain regions was unclear. So this imaging study failed. Was not being able to be performed that time. With this limitation of knowledge after Henry Mollison's death in 2008, Emerald made an attempt and decided to do the brain section analysis of the Henry Mollison case to get deeper insight and understanding what is really happening to the HM's brain over a period of time, how HM's brain transformed itself from 1953 to 2008, how the white matter, grey matter changed

adjusted themselves how the adjacent areas of the entire medial temporal lobe started to behave when it was gone after the lobotomy. So, extensive detailing was being performed and slicing was being done which was being then digitized. The slicing of the brain was then after the slicing, after the dissection was being digitized and kept it in library for the further analysis down the line. So, till date even after the death of HM 16 years has passed still till date we are using his brain to study the memory processes and understand you can see the empty pocket here ventricles which are here and also some shrinkage you could see the shrinkage which is started to happen in the Henry Mollison case you could see that how the brain is started to shrink here compared to the normal healthy brain.

Such understanding give us an insight that how the HM's brain undergone into transformation post-surgery. We also understood that the dementia, the arise of dementia could be because of the shrinkage site as you can see this area where the slight you know, removal is there. This is a shrinkage and the brain cortices started to shrink because the adjacent area of medial temporal lobe was being removed entirely in the HM case. Such sectional analysis is available in the library and one could easily, based on request, can acquire and study.



Source: Amaral et al. (2024)

It is very important for us to understand that how the HM case, the one classical case of Phoenix Gauge provided a lot of insight to us about the frontal cortex, how his personality changed and his behavior changed, his skills and abilities changed after the brain surgery. Similarly, how the lobotomy change the behavioral pattern, cognitive pattern in the young individual like HM case and how his life was being transformed. So, neuropsychology study provides us a scope where we understand the brain and behavior analysis. What is the relationship between the brain and behavior?

What is the underlying neural mechanism? What is the underlying bio-mechanism behind certain human behavior is? Analysis of deficits due to brain injury, so when there is a deficiency due to brain injury, yesterday also we talked about the traumatic brain injury, the mild case versus severe case. And we saw that how the brain, you know, the lesions and how the brain shrinkage, shape, size, gyri, sulci, cerebral spinal fluid, how the corpus callosum, even the projection starts to get compromised when such deficiency arises after the traumatic brain injury. New technologies has come forward and providing lot of insight to us such as the invasive methods and non-invasive method.

Due to ethical reason, researchers tend to stick with the non-invasive method. However, invasive methods like PET methodology has been a great aid to the memory researchers to understand how the projections are happening and how quickly these projections are establishing themselves based on the nature of information to be stored over period of time. Several imaging techniques are there and several animal models in this regard has been used such as the optogenetic method seems to have a potential towards the memory research particularly the emotional memory research or the pathological learning and memory research. Imaging, several imaging techniques are there.

I think we have briefly seen earlier and in the coming lecture also we will be introducing that. A lot of insights we received about the normal human brain functioning. How the

normal human beings are registering the information, for how long they are registering this information. what type of information they are able to register without any effort, what type of information they have to put an effort to register that information. So neuropsychology discipline has been kind enough to provide such an insight to us and even today the several case studies have been part of human research.

Let me summarize what we studied today in this class, in this lecture. The role of temporal lobe in the memory and this is an important part, how temporal lobe is playing a major role in this regard. In the processing of verbal information or processing of visual information, per se, medial temporal lobe, the HM case we saw when the entire section was being removed, then how the formation of new memory was being compromised in an individual. The role of occipital lobe, the important role came from the V4 area. V1, V2, we didn't go so much in detail because the role of V1, V2, V3 seems to be little limited with respect to memory.

However, the role of V4 is important. So please note that the role of V4 is important for the color perception, color processing but this V4 is not playing a role in the formation of memory, encoding of information, storage of information. Role of amygdala, the amygdala is the site of emotional information and how amygdala is connected with the memory and its role is important in the formation of memory. We also discussed that the emotional information, unpleasant information has evolutionary benefit over the pleasant information or the neutral information. Role of diencephalon, how the brain system is sending in the information down the line and how the brain system is receiving information from the peripheral nervous system and bringing it to the central nervous system part and how this exchange of information is crucial for the awareness, for the monitoring, for the progress monitoring and these collection of information then is being used by the central executive system to make a decision of

to the self-regulation or emotion regulation and other processes. Korsakoff syndrome, we discussed about it that how the amnesia is resulting into it. This amnesia due to the deficiency or dysfunctioning of the diencephalon and this is also happening because of the chronic alcoholism also. We discussed that the contribution of HM, 27 years young individual in the period of 1953, when we were having a notion that memory cannot be

localized, but HM case gave us clear understanding that memory can be localized. Similarly, other type of

human cognition or cognitive processes is localized. Different parts of the brain is responsible for different types of cognitive processes like perception, attention, language, memory, problem solving, decision making. All these different cognitive processes require different brain regions. we are not ruling out the fact that the projection from between these different brain lobes the projection between these different areas play a crucial role in the memory formation.

Similarly, the projection and coordination between these different brain regions is important for the other type of human cognitive processing. Human brain analysis till date is providing an insight how the shrinkage has happened, how the loss of 8 centimeter brain resulted into the change the life of the HMs. In addition to that, how the shrinkages started to happen near the adjacent areas of this medial temporal lobe and this shrinkage resulted into the dementia in the HM case. So with this, I will stop here and in next class, we are going to talk about different types of research method which is being used in the memory research. Thank you all.