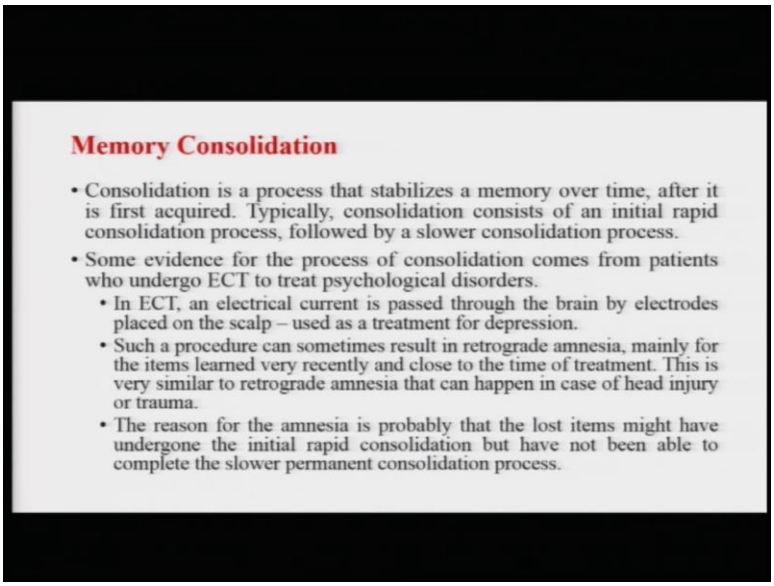
Introduction to Brain and Behaviour
Professor Ark Verma
Department of Humanities and Social Sciences
Indian Institute of Technology, Kanpur
Lecture – 25
Memory Consolidation

Hello and welcome to the course Introduction to Brain and Behaviour. I am Doctor Ark Verma from IIT Kanpur. This is the fifth week of the course and this is the final lecture of the fifth week. We will talk a little bit about memory consolidation.

(Refer Slide Time: 00:25)



Consolidation of memory is a process that stabilizes a particular memory over time after it is first acquired. So, the first time you have a particular experience you perceptually encode it. We were just talking about it in the last lecture. You perceptually encode it. You store it and then what is needed is you need to kind of go over the information again and again so that it forms a stable trace in your memory and is available for recall.

Typically consolidation consists of an initial period of rapid consolidation when you are just going over something like rehearsing it maybe and is followed by a slower consolidation process which basically establishes the information as a sort of a more permanent, more relatively stable trace in your memory. Now, there is some evidence for the process of consolidation which comes from patients who undergo ECT to treat psychological disorders. ECT is electro

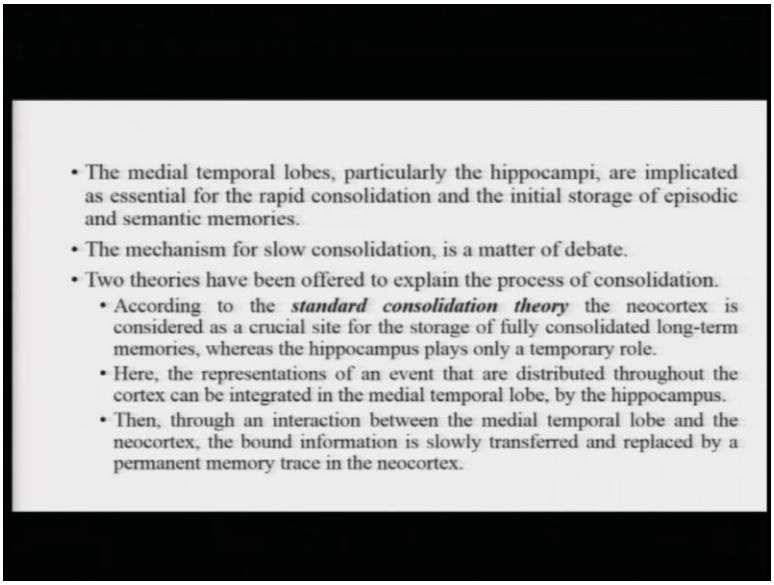
convulsive therapy and in this basically an electric current is passed through the brain by electrodes placed on the scalp.

This is typically used for treatment of disorders like depression and what happens is that in such a procedure sometimes people suffer from or during due to such a procedure sometimes people suffer from what is called a retrograde amnesia mainly and this retrograde amnesia is mainly for the items that are learned very recently and close to the time of treatment. So, something just happened 1 hour ago or 2 hour ago or maybe a day ago than when this treatment was given. This is very similar to the retrograde amnesia that can sometimes happen in case of a head trauma or a head injury.

Now, why is this happening? Why is this retrograde amnesia happening? The reason for this kind of retrograde amnesia is probably because the lost items might have although they might have gone the initial rapid consolidation process but they have not been able to go through the complete the slightly slower permanent consolidation process.

So, because that permanent consolidation process has not taken place the person due to that injury has not been able to stabilize that memory and loses that memory. It is very common when sometimes people suffer from injuries, sometimes they get into accidents. It is very very common that people do not really remember the last 24 hours prior to the accident or sometimes even larger amount of time.

(Refer Slide Time: 02:50)



The medial temporal lobes, particularly the hippocampi, left and right, are implicated as an essential for the rapid consolidation and the initial storage of episodic and semantic memories. Now, the mechanism of this slow consolidation is not really very very clear. How does this mechanism of slow consolidation take place and how are the hippocampi involved in this or how is the medial temporal lobe involved in this is not really very clear. Two theories have been offered to explain the process of consolidation.

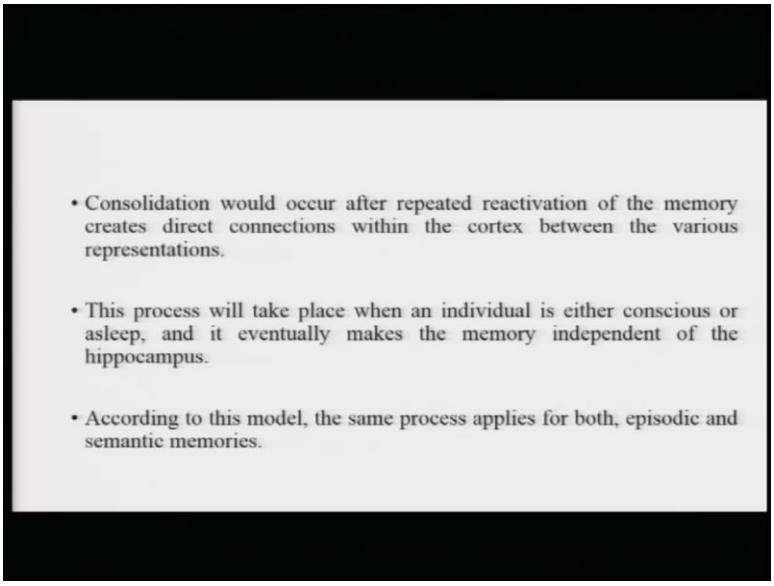
According to the standard consolidation theory the neocortex is considered as a crucial site for the storage of fully consolidated long term memories whereas the hippocampus only plays a very temporary role. So, the idea is what we are trying to say here is that for all long term memories the neocortex is a site which is sort of storing these memories whereas the hippocampus basically plays a transitional role. It plays a very temporary role. How is that? Let us see.

The representation of a particular event that is basically distributed throughout the cortex and can be integrated in the medial temporal lobe by the hippocampus. Now, how is this representation distributed across the cortex? The idea is that when somebody is undergoing a particular event and let us say perceptual processing of a certain kind is happening, the perceptual processing is distributed in nature as you have seen earlier and this basically the representations are therefore distributed in the entire neocortex.

What the hippocampus does is it converges because it receives this convergent input, it puts together and binds together all of this information. So, through an interaction between the medial temporal lobe and neocortex this bound information is slowly transferred and replaced by a permanent memory trace in the neocortex.

So, what is happening is that the hippocampus binds this information together and this is slowly transferred and is replaced as a permanent memory trace in the neocortex. So, where is the memory actually being stored? It is in the neocortex and what is the role of hippocampus? The hippocampus is just binding together different aspects of or different representations of a particular event or an episode.

(Refer Slide Time: 05:01)



Now, consolidation would occur after repeated reactivation of memory creates direct connections within the cortex between various representations. Suppose you are talking about an event of going to a particular restaurant. You enter the restaurant from a particular door. You go and sit at a particular chair and there is one individual who comes to you with the menu and there are separate representations of this entire thing.

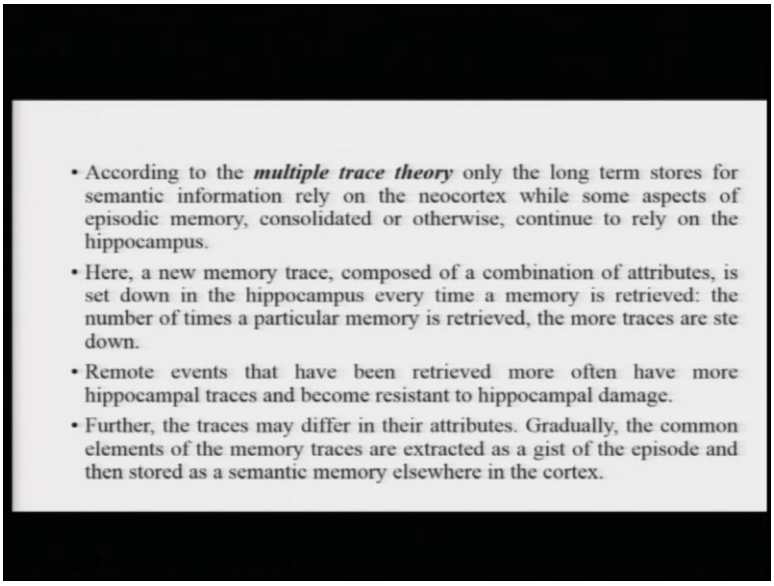
Now, when you repeat that say for example and you come back from this restaurant you talk about that restaurant to your friend and to another friend and to another friend. So, what is happening is every time you are recalling this entire episode, you are reactivating this memory and repeated reactivation of this memory is basically forming or helping to form direct

connections within the cortex between these various representations within these various facets of the entire episode.

So, all of these information is getting linked with each other and the memory trace is being solidified. It is being consolidated. This process will take place when an individual is and this process is basically will take place when an individual is either conscious or sometimes even asleep and it eventually makes the memory independent of the hippocampus.

So, now once the memory is stored as a permanent trace in the neocortex then the role of hippocampus is not so much. So, the memory becomes independent of the hippocampus. Now, according to this model the same process applies for both episodic and semantic memories.

(Refer Slide Time: 06:34)



Now, there is another theory that has been offered. The other theory is called the multiple trace theory and according to this multiple trace theory only the long term stores for semantic information rely on the neocortex where while some aspects of episodic memory consolidated or not continues to rely on hippocampus.

So, the idea here is that a new memory trace which is composed of a combination of different attributes is set down in the hippocampus every time a memory is retrieved. Every time a particular memory, every time you talk about a particular incident to somebody this new memory trace is set down in the hippocampus.

It is sort of laid out in the hippocampus and the number of times a particular memory is the more traces are set down or set it down in this hippocampus. So, the hippocampus kind of is getting a revised recording or say for example a revised representation of that particular event, of that particular episodic memory.

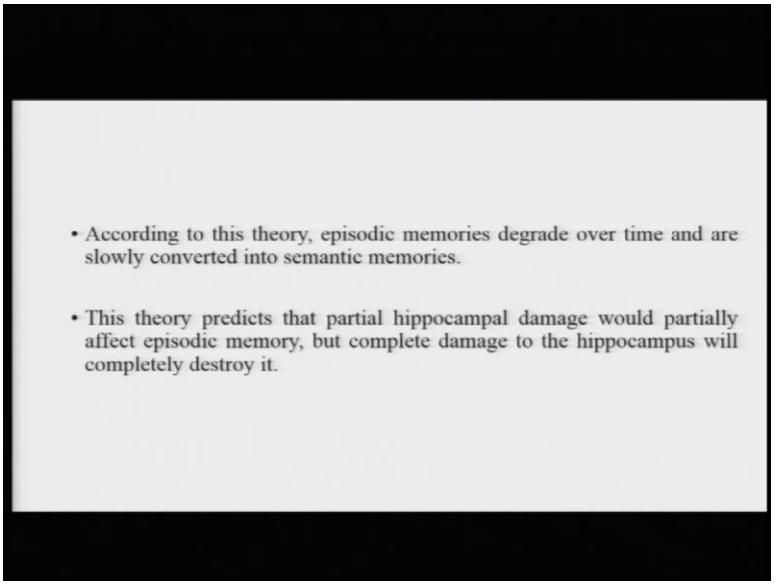
Now, remote events that have been retrieved more often have more hippocampal traces and therefore become resistant to hippocampal damage. Say for example, you might have an incident from your childhood. Suppose your fifth birthday or your eighth birthday that you might remember and you might basically narrate it to your friends many a times.

It has been repeated several several times. So, what has happened is that this is a remote event and because this has been repeated so many times across the length of time it has become more stable and it has become resistant to damage of the hippocampus. On the other hand, more recent events have not received as many memory traces and so what will happen is that they are not resistant to hippocampal damage. Let us look at. Now, the traces may differ in their attributes.

So, what happens is gradually the common elements of the memory traces are extracted as a gist of the episodic and then stored as the semantic memory somewhere in the neocortex. So, that title of information sort of becomes almost like a semantic memory, almost like a fact. Say for example, who did you invite or what was the shape of the cake at your eighth birthday.

If that has been repeated so many times again and again now some gist of that episode from the birthday is basically taken up and is stored as a semantic memory as a fact in the cortex. So, therefore when you are going to recall say for example, things like what was the shape of the cake at my birthday then this recall will not be dependent upon the hippocampus.

(Refer Slide Time: 09:12)

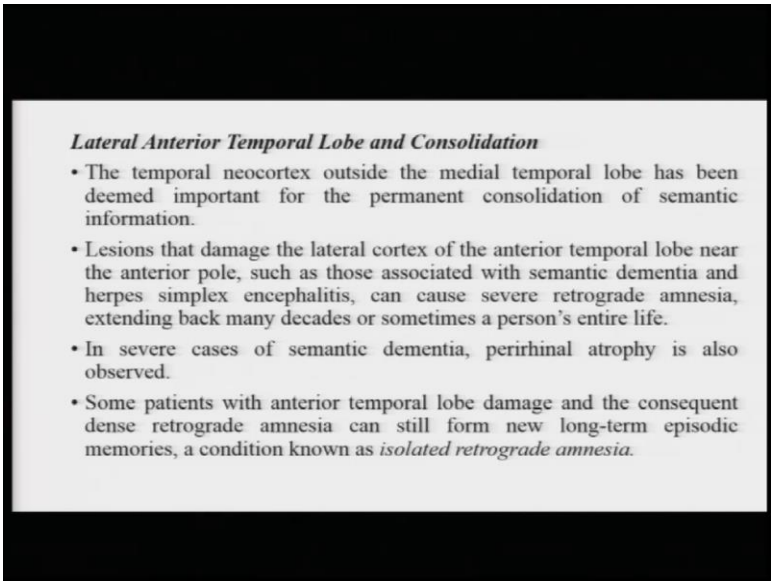


Now, according to this multiple trace theory, the episodic memories typically degrade over time and therefore are slowly converted into semantic memories. Now, what is this? Once you have first undergone a particular experience. Suppose you went to a particular party yesterday or something like that. The events in that party, everything that happened in that party basically is very very fresh today but it will not be as fresh tomorrow, a week later, a month later, an year later, 5 years later or 10 years later.

So, what happens is this episodic memories, the entire episode will become more and more condensed, will become more and more degraded over time and then what will remain is only just the gist. Once the gist is there, it us treated as a semantic memory. It is treated as a fact and it is basically established as independent from the hippocampus and it is established or parked in the neocortex.

So, this theory basically predicts that partial hippocampal damage which partially effect these episodic memories but complete damage to the hippocampus will completely destroyed. So, I think this is all that I wanted to tell you about consolidation and the role of hippocampus.

(Refer Slide Time: 10:25)

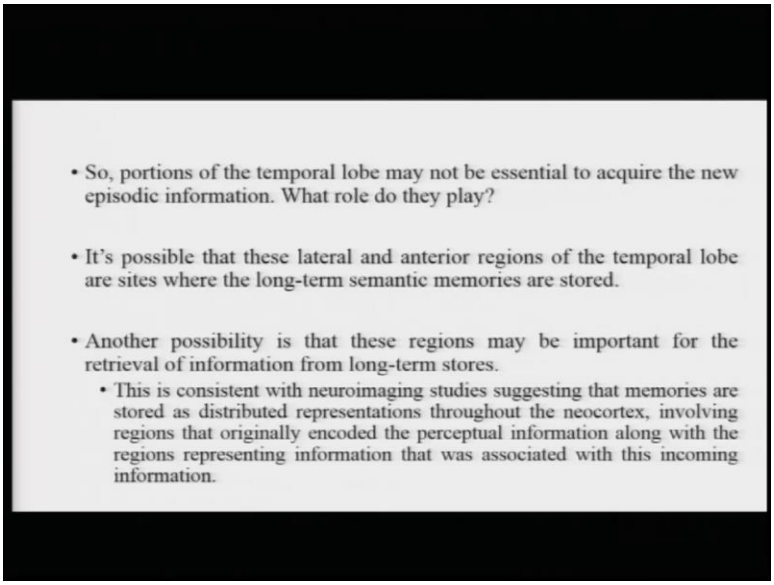


Now, let us talk about the lateral anterior temporal lobe and consolidation. Now, the temporal neocortex which is the temporal lobe outside the medial temporal lobe has also been deemed very important for the permanent consolidation of semantic information, information about facts. Now, the lesions that damage this lateral cortex of the anterior temporal lobe near the anterior pole such as those associated with semantic dementia or herpes simplex encephalitis can actually cause severe retrograde amnesia.

So, this anterior temporal lobe lesions can actually call severe retrograde amnesia that can extend up to several decades or sometimes the entire life of the individual. So, there has to be some role for this region in the process of consolidation. Now, in severe cases of semantic dementia perirhinal atrophy is also observed.

So the atrophy of the perirhinal cortex is also observed. Some patients with anterior temporal lobe damage and the consequent dense retrograde amnesia however can still form new long-term episodic memories, a condition which is known as isolated retrograde amnesia. So, these people will still have retrograde amnesia but they are able to form some new memories. So, the amnesia is limited to only past memories, older memories.

(Refer Slide Time: 11:48)



Portions of temporal lobe may not be essential to so basically from isolated retrograde amnesia what you can basically deduce is that portions of temporal lobe may not be essential to acquire new episode in information. So, what is the role that these regions of the temporal lobe play? It is possible there have been a few proposals. It is possible that these lateral and anterior regions of the temporal lobe are sites where the long-term semantic memories are stored.

So, these can be sites where these long-term old semantic memories have been parked and when there is damage here that is why you suffer from severe retrograde amnesia. Now, another possibility that has been offered is that these regions may be important for the retrieval of information from long term source.

It is not that these regions are actually storage houses of information but they might just be acting for retrieval of this information from wherever this information is stored in the entire neocortex. This is consistent with neuroimaging studies that suggests that memories are stored as distributed representations throughout the neocortex and some regions like this anterior temporal lobe regions are actually responsible for retrieving them.

So, basically what are these regions? The memories are distributed throughout the neocortex involving regions that originally encoded the perceptual information. Remember something that we are talking about in the next in the last lecture. Regions that were basically involved in

encoding perceptually these pictures or these words or these sounds actually were the same regions that were activated during the retrieval.

So, this is consistent with what we are trying to say here. So, neuroimaging studies have suggested that memories might be stored as distributed representations throughout the neocortex involving the regions that originally were involved in encoding this perceptual information along with regions that are involved in representing this information and basically associating this with new incoming information.

So, there are these regions in the brain that are perceptually processing this incoming information and associating this incoming information to originally stored knowledge to the older information. So, and the anterior temporal lobe areas might be the areas that might be facilitating this task basically is probably very important in the processes of retrieval of these long-term memories. So, this is all that I wanted to talk to you about the chapter in memory. We will start with the chapter on emotion in the next week. Thank you.