**Indian Institute of Technology Kanpur**

**National Programme on Technology Enhanced Learning (NPTEL)**

**Course Title**
**Basic Cognitive Processes**

**Lecture-35**
**Memory- VII**

**By**
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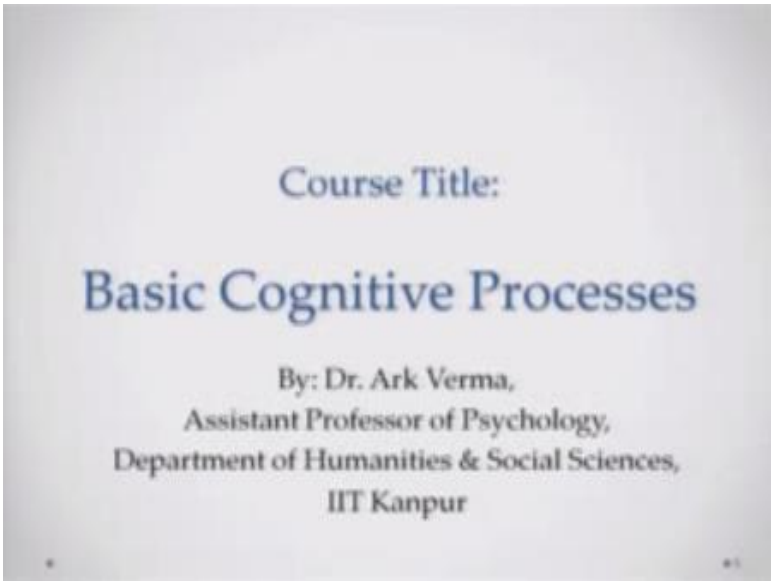


Hello everyone welcome to the course basic cognitive processes I am Dr. Ark Verma from IIT Kanpur we have been talking about memory.

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In the last few lectures and in the last lecture we talked about encoding and he specially talked about what are the different processes by which you can encode information to your long-term memory, we talked about a variety of encoding processes and we showed through the use of these different experiments that how these different encoding you know processes the different kinds of encoding procedures can have an impact on your retrieval how good or how bad your retrieval of that you know content will be later.

In today's lecture we will talk a little bit in more detail about retrieval and we will also talk about you know this mental function of memory is realized in the brain you would have noticed that you know in one of the earlier lectures also we have been talking by in by about how different areas of the brain are involved in memory, but we will try and do a more detailed analysis of that relationship now let us talk about what retrieval is.

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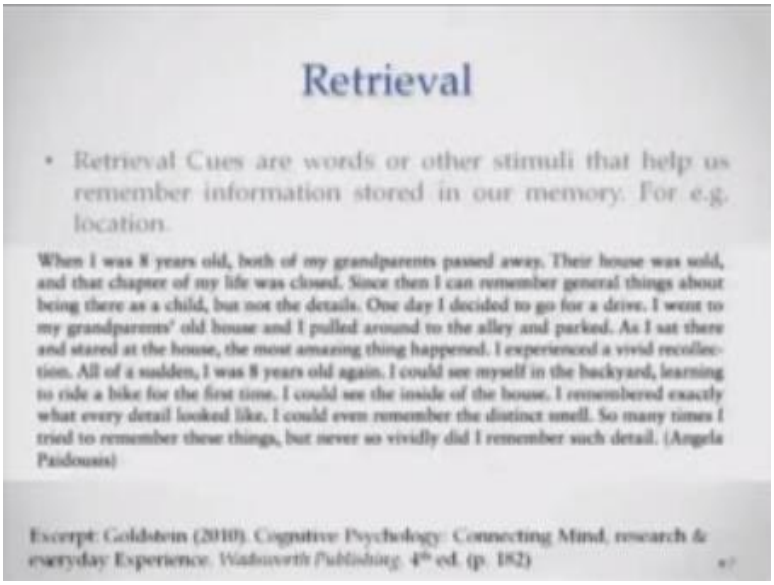


So retrieval is basically when you are trying to bring back information from your memory in order to you know use it or in order to describe it to somebody and so on and so forth, one of the important aspects in retrieval is if you are presented with information that can help you retrieve that any you know content more easily or seamlessly so retrieval cues become very handy then what are retrieval cues retrieval cues of words or other stimuli that help us remember information that is stored in our memory.

Say for example there is this excerpt I have taken from Goldstein and it describes a child is going back to a place where he had spend some of some of his childhood at his grandparents house and what he does is I this child goes to the unbalanced house and kind of his moving around the house there are, so many things in the house that will remind him of episodes and things that the experienced while he was let us say 8 years old 10 years old and was spending this holidays in that particular house.

Now each of these stimuli each of these stimuli or say for example if they are ever written or something like that at that place will act as cues of retrieval of that information that has been you know along past and apparently forgotten till this particular moment you might also recall say for

example you know in your own experience if you meet somebody you know who you have not seen for ten years or 5 years or 15 years may be just the sight of that person reminds you of the kind of experiences you have had together of the kind of you know conversations you might have shared with each other and everything around that era kind of gets relived in just a flashback.

So this is basically what retrieval cues are now there are also different recall methods which might basically affect how well or how poorly you will recall particular kinds of information so I will just describe two kinds of recall methods to you.

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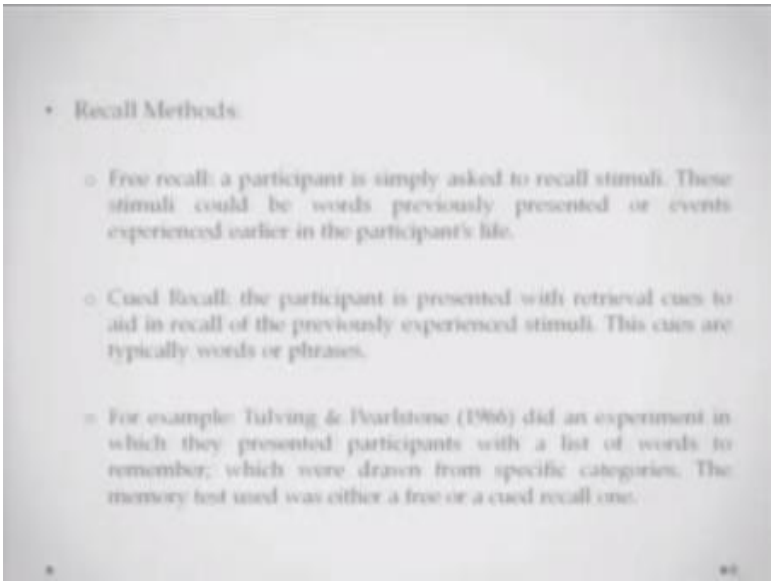


So free recall is basically when a participant is simply asked to recall a stimulus if everybody is just said that whatever you learned in class today and the child is come home and maybe one of the parents is just asking repeat to me whatever you have learned in the class now you are not giving any cues you are just asking this child to repeat straight out of his memory whatever you know about a particular subject that he or she might have learned in this school, so these you know things and these kind of stimulus that you can ask you know when to use a free recall with could be about previously represented events or experience that have happened in the past life.

Something like whatever he had experiences he had in the school cued recall could be when the participant is already presented with retrieval cues to aid in recall of the previously experience table I say for example if you if one of the parents is you know taking up a book and he is saying which pages did you cover in class today and then from that you know from the number of pages that the child points out the parent is reading out some sentences in asking whether you learned about this and what did you learn about this particular topic.

This will basically be an example of cued recall so you are giving the child some cues has to recall that information and in that sense you know you are giving him in some sense some help you know to recall that information from, now experimental demonstration of the same could be found interviewing in pearl stones experiment in 1966, so what they did was in an experiment they presented participants with a list of words to remember and these lists of words were drawn from specific categories.

The kind of recall they would ask these partners to undergo would could be either a free recall or a cued recall.

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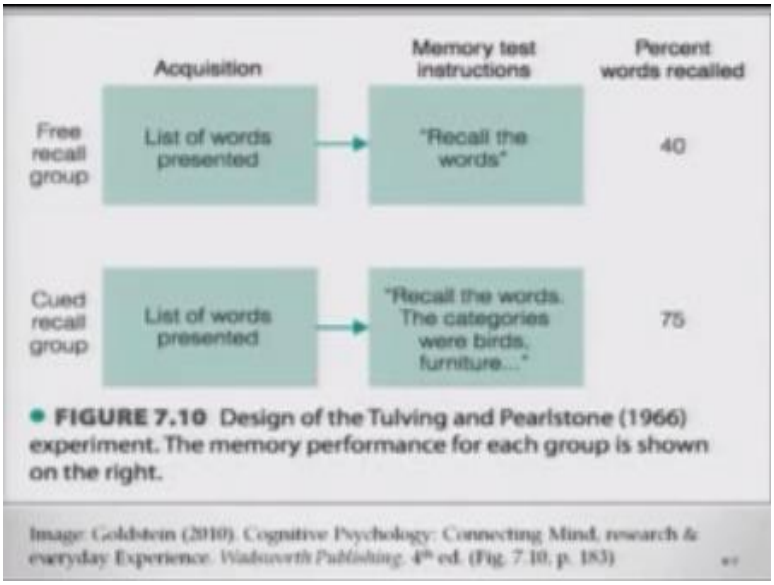


The list of words will be rescinded and the memory test instruction will be just recall whatever lists of words were repeated to you in a second condition or with the second group which is the cued recall group you present the list of words in the acquisition phase and then you tell them to recall all the furniture's that you know all the furniture names that you heard or let us say all the bird names that you heard now what are you doing here you are basically giving them a category and they can now fill up those categories with whatever words from the list.

They remember that fall in this category what happened as the result you can already see that the percentage of words recalled is much better in case of cued recalled as compared to in a free recall.

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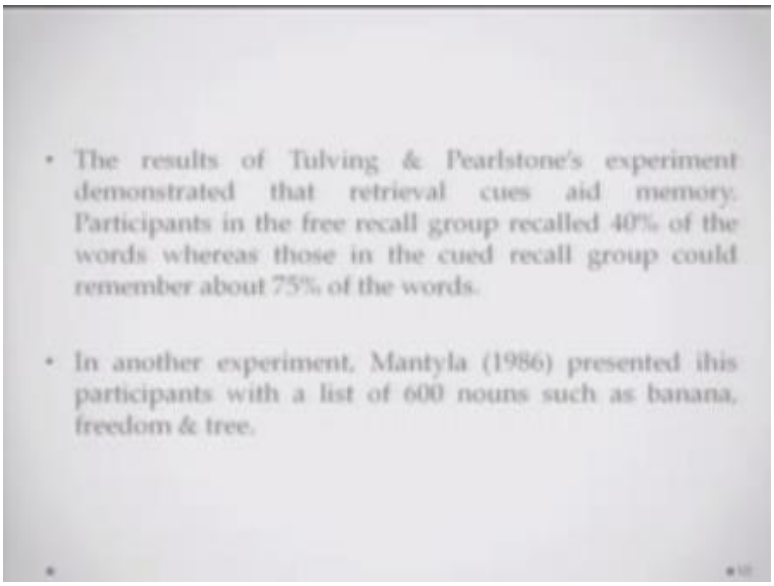


So the results of this particular experiment Tulving in pursuance experiment demonstrated that retrieval cues do aid memory participants in the free recall group perform much worse than the participants in the cued recall group in another experiment Mantyla 1986 presented his participants with a list of 600 nouns such as banana freedom tree and so on and so forth, now during the learning phase the participants were told to write down three words they could associate with each node.

So that was done for example for a banana they could write say for example it is yellow in color punches are made out of red and it is edible, so any no three versus the participant could generate themselves.

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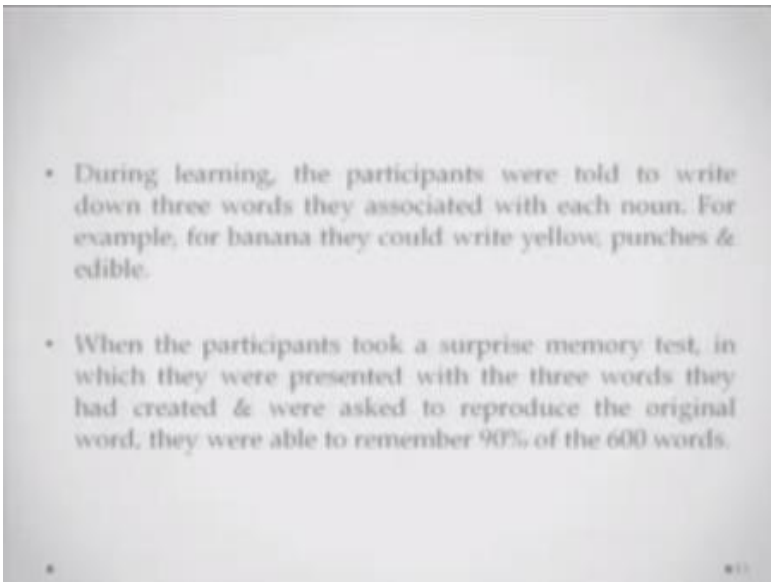


When the participants took a surprise memory test in which they were presented with three words they had created and asked to reproduce the original word they would remember are upto 90 % of the 600 words that they were made to learn.

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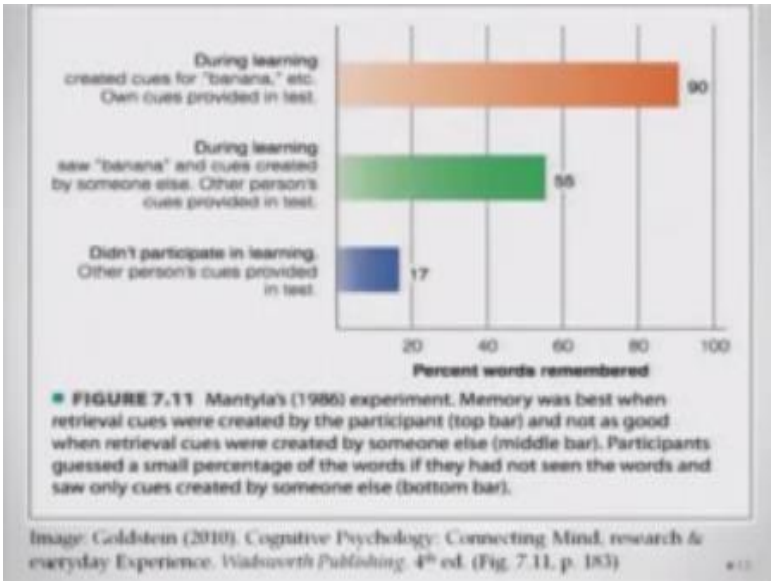


**FIGURE 7.11** Mantyla's (1986) experiment. Memory was best when retrieval cues were created by the participant (top bar) and not as good when retrieval cues were created by someone else (middle bar). Participants guessed a small percentage of the words if they had not seen the words and saw only cues created by someone else (bottom bar).

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. Wadsworth Publishing. 4th ed. (Fig. 7.11, p. 183)

So here you can see the results, if they were you know given cues that they had presented themselves they recall was around 90% if during learning for this or the banana and the queues created by somebody else were given, so somebody else kind of tries to give cues then the performance is slightly worse but it is very good but if you know that there is no cue provided then their performance of recall is much lower it is even less than and 20 %.

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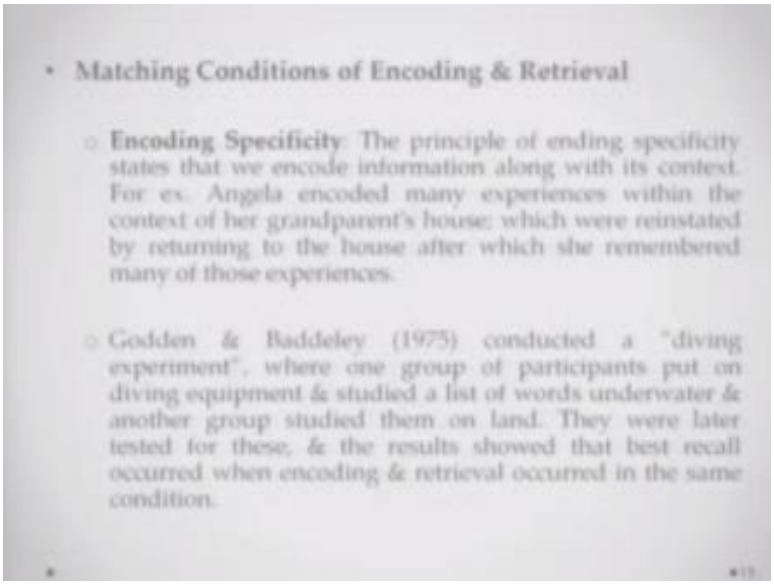


So you see that cued recall kind of helps participant retrieve information better information learned could be information could be learn to the almost the same extent, but you do not have a proper retrieval cue to bring it out let us talk about some of the conditions wherein you can have good retrieval scenarios so one of the aspects of when you are matching encoding and retrieval is this concept of encoding specificity, now encoding specificity is basically when you are encoding or learning new information given a particular setting.

If you kind of revisit that setting that information becomes easily available to you and that information becomes more easily retrievable if you remember the you know the child is going to the grandparents house example given that the child was going through this house after 10 15 20 years and the child was interacting with objects that have been in the house, since that time all of those objects are acting as retrieval cues for you know the memories of that time but that entire setting that entire presence.

In say for example one of the rooms where the child would have lived or played that entire setting basically makes this available because the information was encoded or learned or the experience had been gone through in that room, so that is basically an example of what encoding

encode specificity could be like Godin and badly in 90 and 75 they conducted what is called a diving experiment they are in one group of participants put on a diving equipment and studied a list of words while they were underwater and another group of participants studied a list of words when they were on land they were later tested for both of the groups were tested for this list of words and the results showed that the best recall occurred when the encoding and the test conditions were matching so I will show you the results right here so you can see at the extreme left and the extreme.

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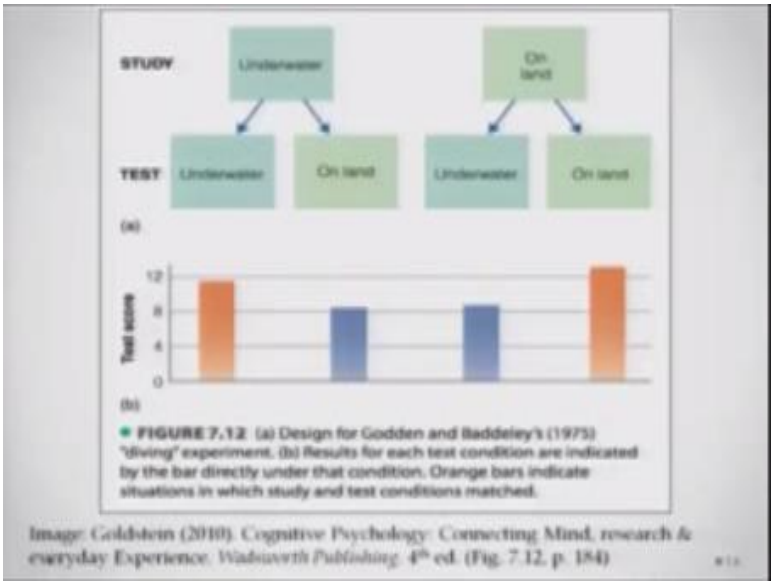


Right both the part and the encoding and retrieval conditions are matched and the performance is maximal.

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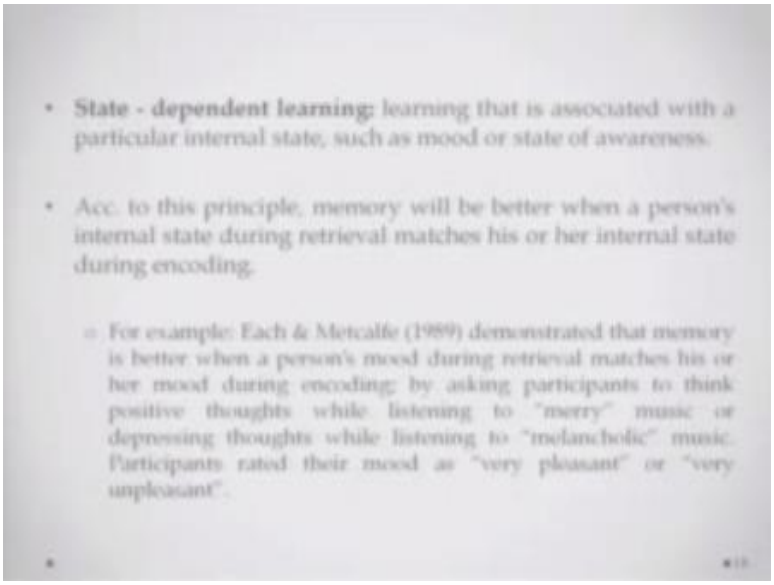


Another simple example of encoding specificity or a similar example to encoding specificity could be state dependent learning, now state dependent learning is basically about that information that is learned in a particular internal state such as a mood or a state of awareness say for example if you are excited or happy or even angry and you are saying some things and some information is being told to you versus if you are in a weak state of awareness or you are slightly drowsy or if you are under the influence of some you know drugs or something information.

That you kind of are gaining under those states of awareness or under that under the influence of that particular mood will be very readily available to you once you are in that same mood again so according to this principle memory will be better when a person is internal state during the encoding part during the retrieval part matches his or her internal state during encoding of that information, so for example each and mid-calf basically they did this test they demonstrate and that person is memory is better when a person is mood during retrieval matches his mood during the encoding part.

So they basically ask participants to think positive thoughts by listening to merry music or depressing thoughts while listening to melancholic music and then the person is were later asked to rate their mood, so as very pleasant up to very unpleasant.

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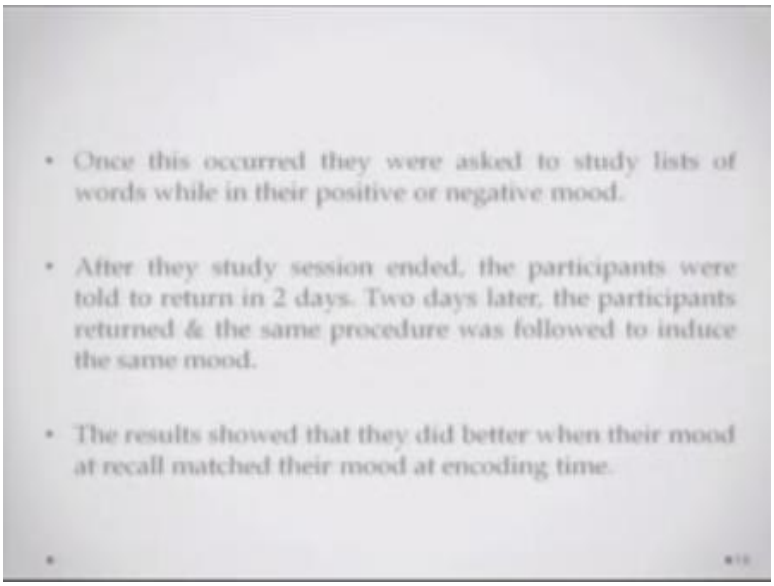


Once this has occurred they were asked to study lists of words about positive or negative so once mood was established they were asked to this list of words we should about while they were still in there positive or negative mood after this study session ended the partners were told to return after two days two days later when the partners returned the same procedure was followed to induce the same mood, so now what is happening is they are probably in the same mood as in when they had learned that information.

The results showed that they did much better when their mood at recall was matching their mood at you know when the encoding was happening here in you can see again in the extreme right and extreme left you can see when the encoding mood and the retrieval mood matches the performance is better when the encoding mode and the retrieval mood and does not match the performance is slightly lowered.

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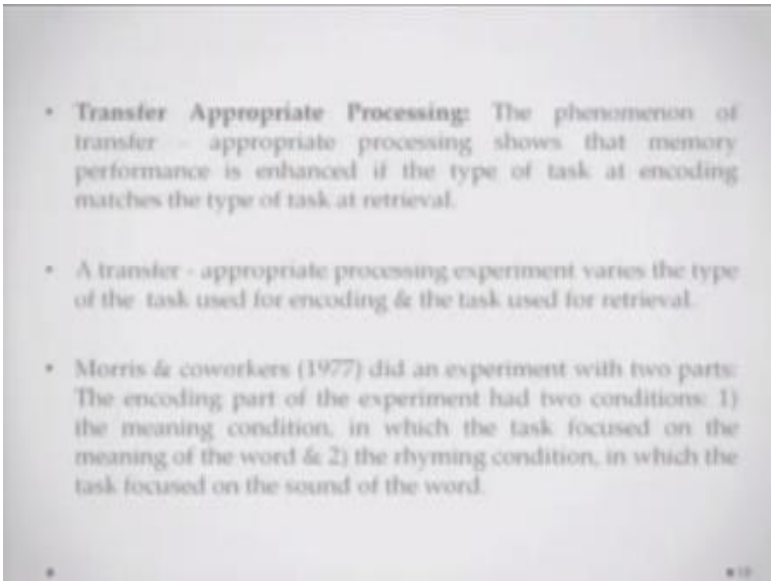


Another aspect again of encoding specificity or a similar example could be transfer appropriate processing now transfer appropriate processing is basically that memory performance is enhanced

If the type of task at encoding matches the type of task at retrieval, so if you are doing something say for example transfer an example of transfer appropriate processing could be say for example if you are doing the same thing file you know you are learning something and you are doing the same thing while you are retrieving so I will give you an example modest and co-workers in 1977 they did then experiment with two parts.

The encoding part of the experiment had two conditions first was the meaning condition second was the rhyming condition, in the meaning condition they had to focus on the meaning of the word in the rhyming condition there to focus on the sound of the word.

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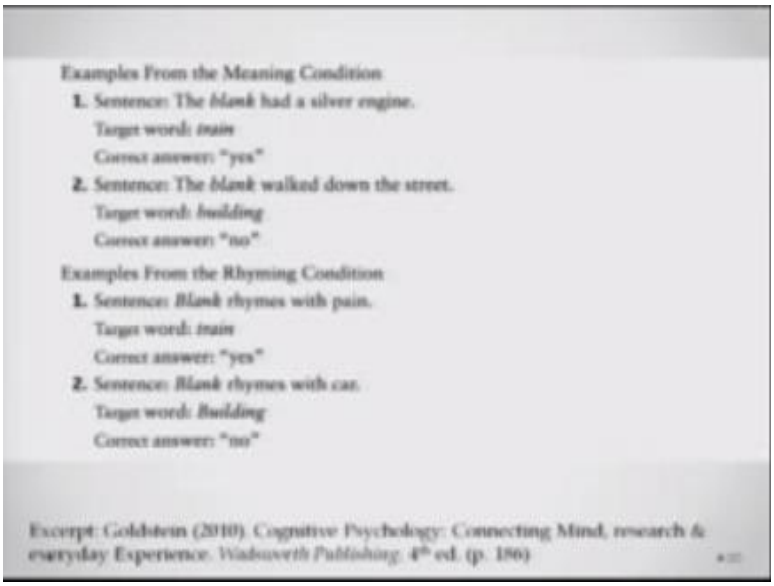


So and demonstration could be something like this here you can see so they are sentences, there is a blank had a silver Indian so what they have to do is let us come back to this participants in the board conditions during the test part they heard a sentence with one word replaced by blank and two seconds later they heard a target word, the task for the memory group was to answer yes or no based on the meaning of the word the task of the rhyming group was to answer yes or no based on the sound of the word.

Now you see what the task is so from the meaning condition the sentences the blank had a silver initial the target word is strained so now the person has to answer whether the meaning of the word train matches that blank. Similarly the blanked walked down the street not the and the target word is building participant has to on the meaning of the word building decide whether it can fit in that blank or not okay.

This is the meaning part the second part is the rhyming condition so blank rhymes with pain department and the target word is let us say train and the person has to say yes train rhymes pain or maybe if there is another word it is not, the second word is the blank rhymes with car and the target word is building, so now here so say because building does not rhyme with car he has to

say no. so what you are seeing is in these two conditions the participant is doing something related to meaning in the second condition the person is doing something related to rhyme of these different words.

Now in the retrieval part of the experiment this was the encoding part in the retrieval part of the experiment participants of both the groups were given a rhyming recognition test, so for the test partisans we represented with 32 words.

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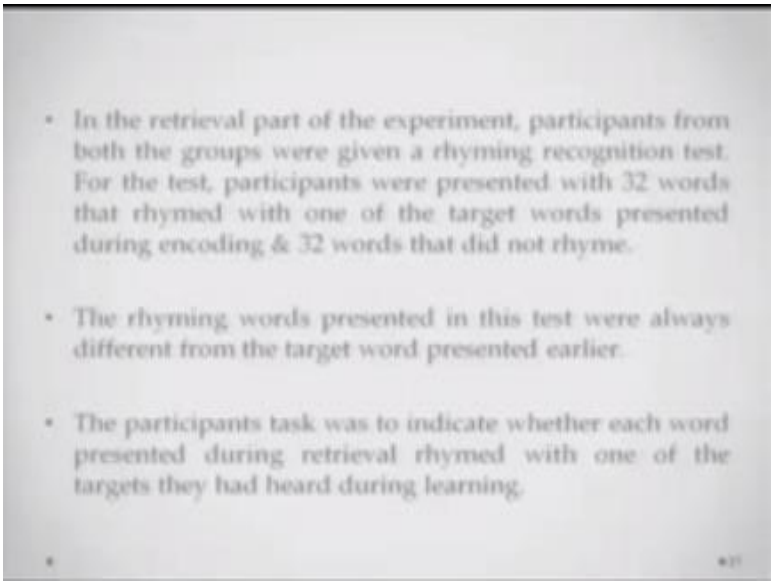


That rhymes with one of the target words during encoding and 30 towards that did not rhyme so the list contained of 62 words, 32 range with the target words 30 and one did not and the other 32 did not the rhyming was presented in this test because it is a new case is always different from the rhyming words we represented during the target you know which were presented earlier. So participants task was to indicate whether each word presented during retrieval rhymed with one of the targets that they had seen that they had heard during learning.

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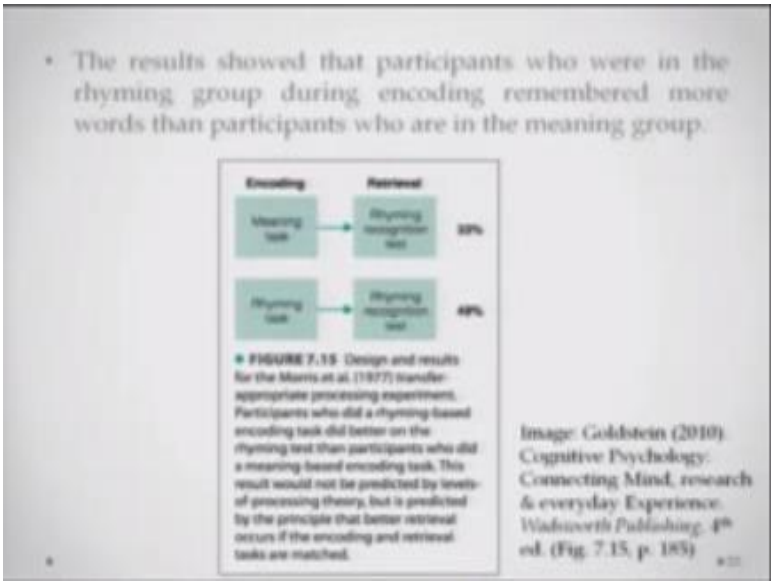


The results showed that the participants who were in the rhyming group during encoding remembered more worse than the participants who are in the meaning group, so encoding during meaning task and retrieval in the rhyming condition was a much poorer encoding during rhyming tasks and retrieval during Raymond tusk was much better.

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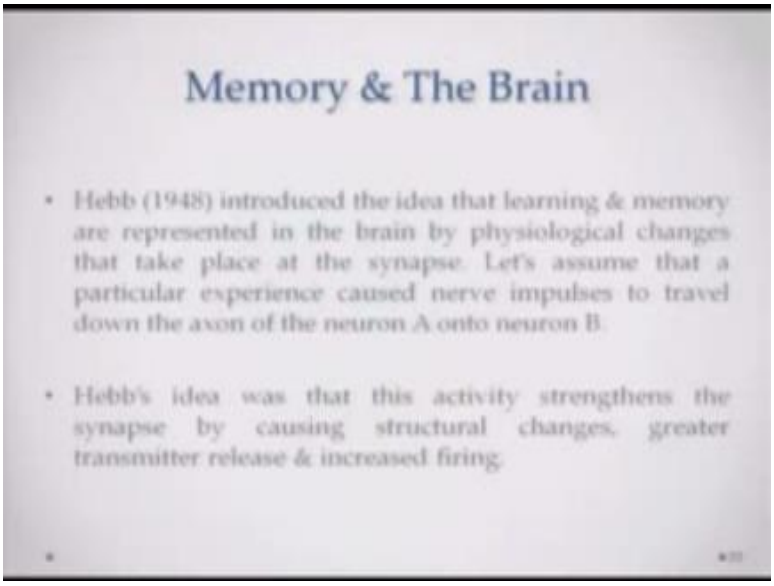


Now coming to memory and the brain Donald Hebb in 1948 introduced the idea that learning and memory are represented in the brain by physiological changes that takes place that take place during a synapse, now if you remember the after we did on brain and behavior you might want to recall all of that for you know getting these concepts now. Now let us assume that a particular experience that when a particular experience happens neuron a fires and it causes in a sense an impulse to Union B and then neuron B as well fires.

So Hebb's idea was that this activity strengthens the synapse by causing structural changes greater to neurotransmitter release and increase firing.

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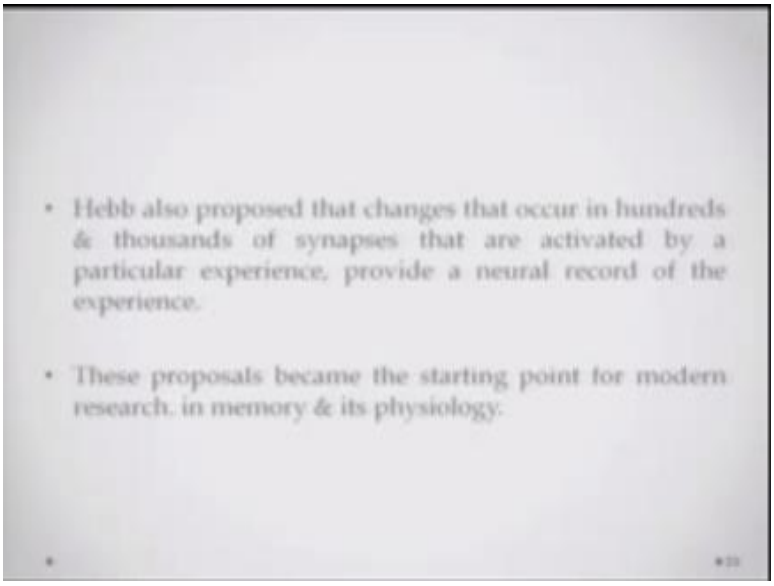


The Hebb also proposed that changes occurs in hundreds and thousands of synapses that are activated by a particular expense, say for example if you are learning a particular skill if you're learning let us say sword-fighting for the first time there are constantly a lot of changes that are going on in your brain with kind because you are learning a completely different motor activity. Now these proposals became the starting point for modern research of memory and its physiology.

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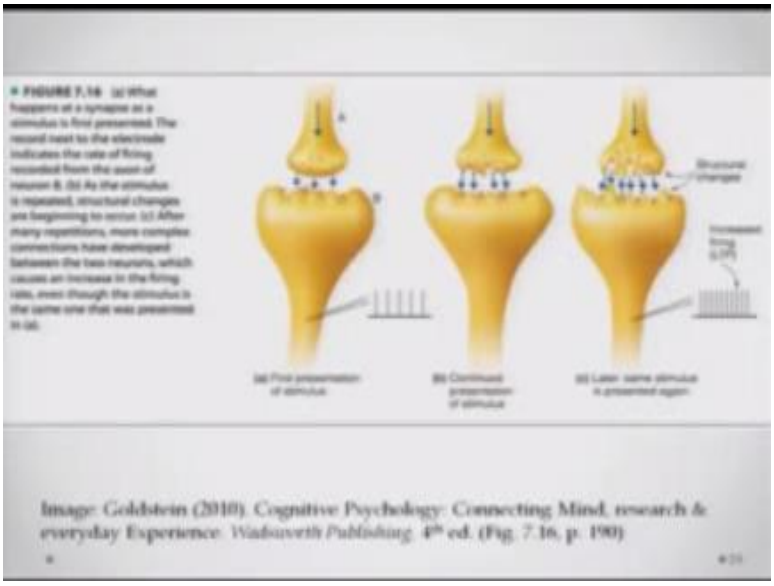


Say for example here you can see that you know what is happening at a synapse and they are kind of trying to record this using some technical single cell recording I will elaborate about this in a while.

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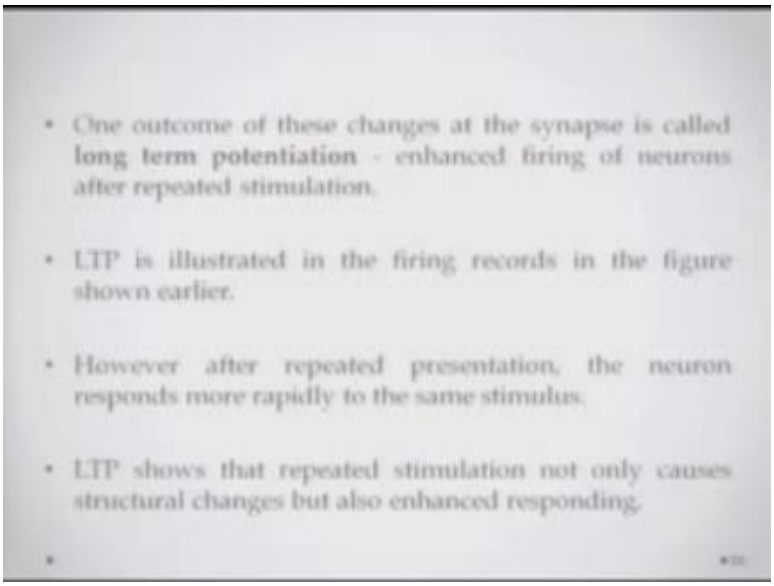


Now one outcome of these changes which have is proposing happening at the synaptic level is called long term potentiation, what is long term potentiation is basically enhanced firing of neurons after repeated stimulation, say for example if you are learning one skill again and again you are practicing again and again there is the neurons that fired in the first instance of learning that skill will fire again and again on the second, third tenth and 15 instances of the same skill and in that sense they will basically learn that skill so in that sense you are learning of that skill is being encoded at the neuronal level.

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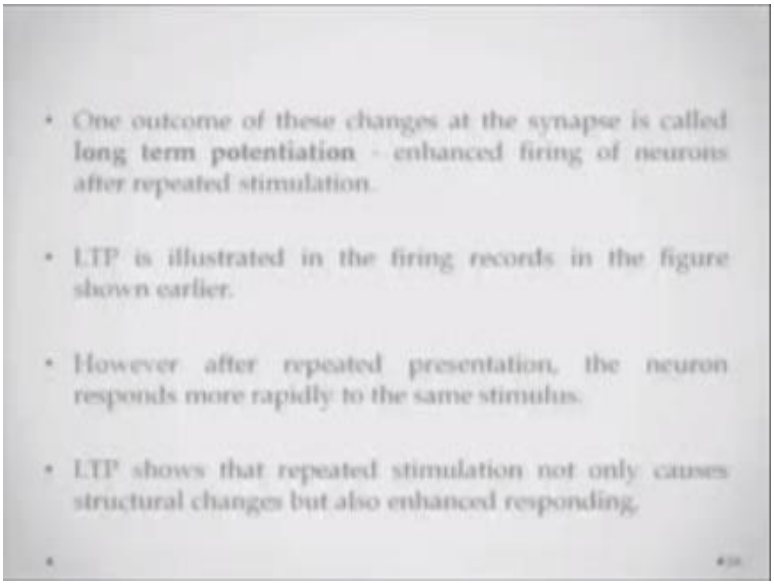


So LTP basically you know shows that repeated stimulation not only causes structural changes but it also leads to enhanced responding.

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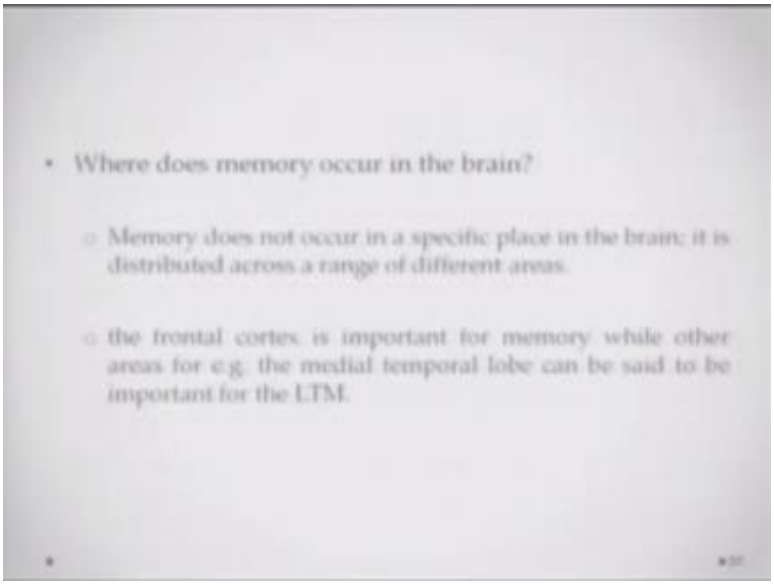


Now if and I think this question a lot of people would have asked many at times but where does memory you know occur in the brain is it one part of the brain that all the memory for everything sits or is it say for example the entire brain that the memory sits how is it actually done. Now let me tell you that memory does not really in a specific site in the brain or a specific place in the brain it is distributed across a range of different areas the frontal cortex is important for memory why for other areas like the medial temporal lobe can also be said to be important for memory.

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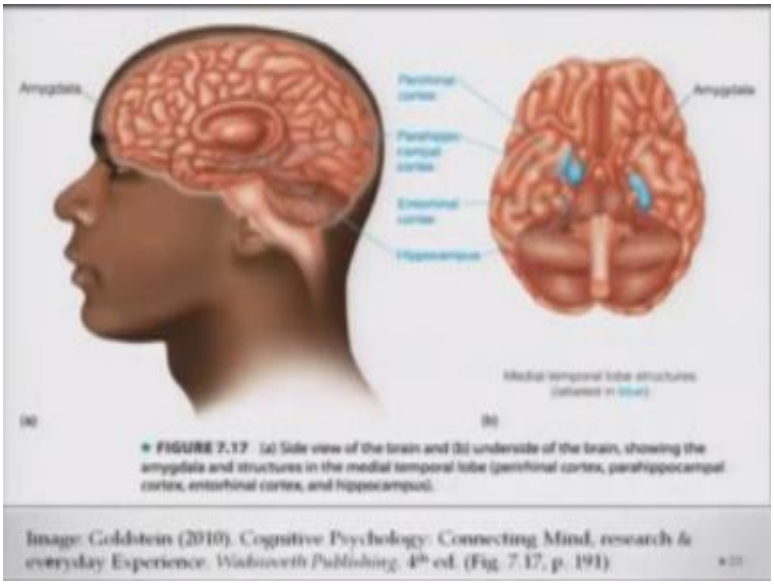


Here you can see the perirhinal cortex, the parahippocampal cortex, the entorhinal cortex, the hippocampus and the amygdala are some of the structures which are considered very important as far as memory is concerned.

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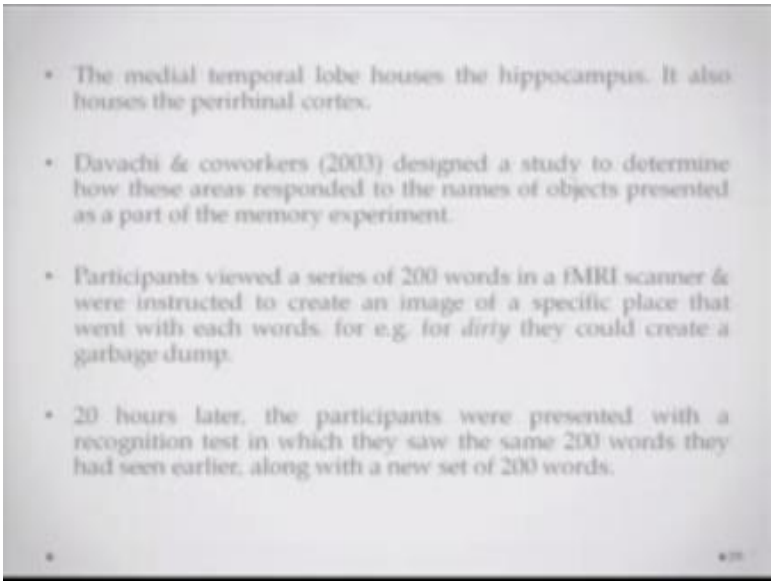


The medial temporal lobe houses the hippocampus it also houses what is called the peri renal cortex, now the Vashi and coworkers in 2003 they designed a study to determine how do, these areas respond the name of the objects presented as part of a memory experiment. So participants were shown around 200 words while they were in an FMRI scanner and they were instructed to create an image of a specific place that went along with each of these words see.

For example if you hear the word dirty you can imagine say for example a garbage dump or maybe a railway platform. Now 20 hours later the participants were presented you know a recognition test in which they had the same 200 verse that they had learned during the earlier phase and with some you know around 200 new words.

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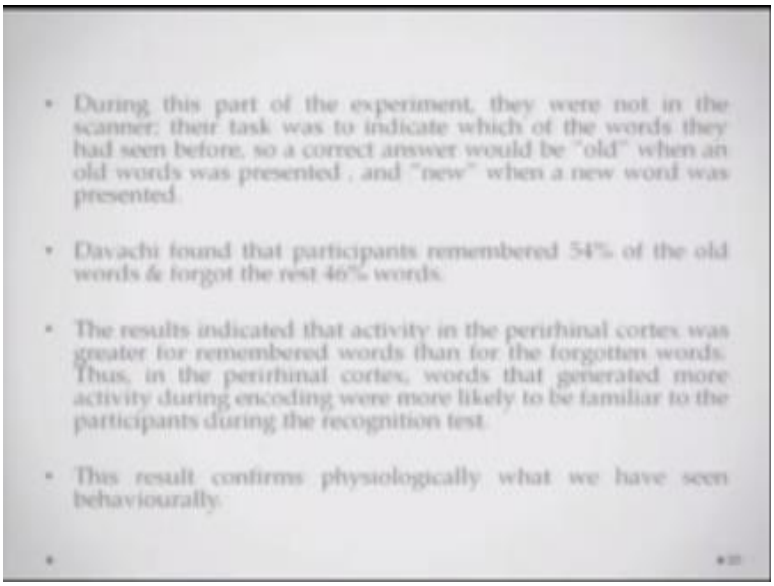


During this part of the experiment they were not in the scanner and so the first testing phase was now out of the scanner and they were in basically talked about which other words they had seen before, so a correct answer would be old when the word present it was already seen earlier and new when the effort was not presented earlier. Now watch he found that partners remembered 54% of the older words and forgot the rest 46% of the words.

These results basically indicated that activity in the perirhinal cortex was greater for remembered words than for forgotten words and so it could be concluded that the peritoneal cortex you know in the peritoneal cortex the verse that generated more activity during encoding were likely to be familiar to the participants during the recognition test, so what basically they found is those words that were old generated more activity in the parental code those words that were new generated less activity in the perirhinal cortex.

So it kind of tells you that the pyridine cortex is that area of the brain which kind of codes for familiarity which kind of will tell you that this is some stimulus I have interacted with earlier.

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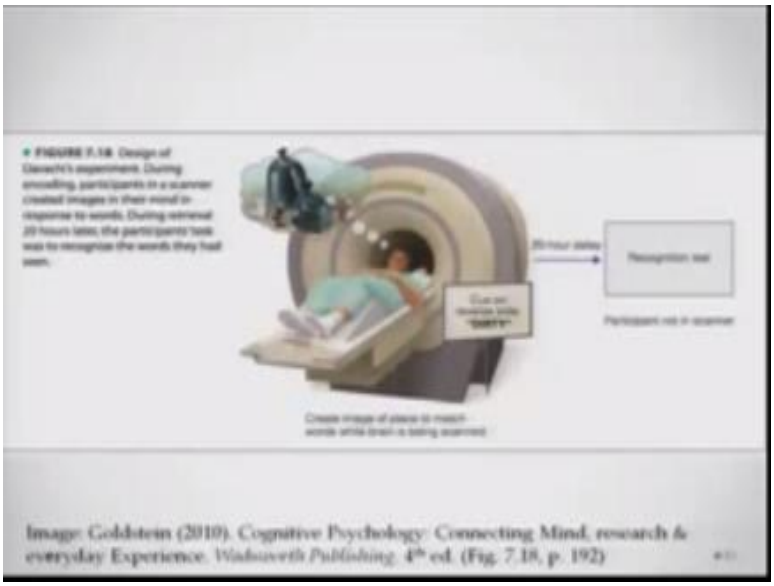


This is the setup of Demacian colleagues study the parts mint is in you know FMRI scanner and is imagining a place associated with this world.

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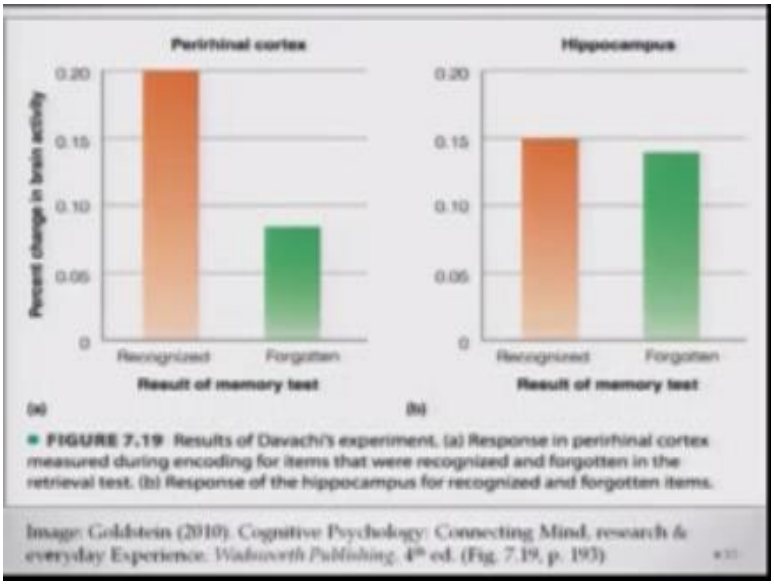


FIGURE 7.19 Results of Davachi's experiment. (a) Response in perirhinal cortex measured during encoding for items that were recognized and forgotten in the retrieval test. (b) Response of the hippocampus for recognized and forgotten items.

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.19, p. 193)

So here in you can see the result.

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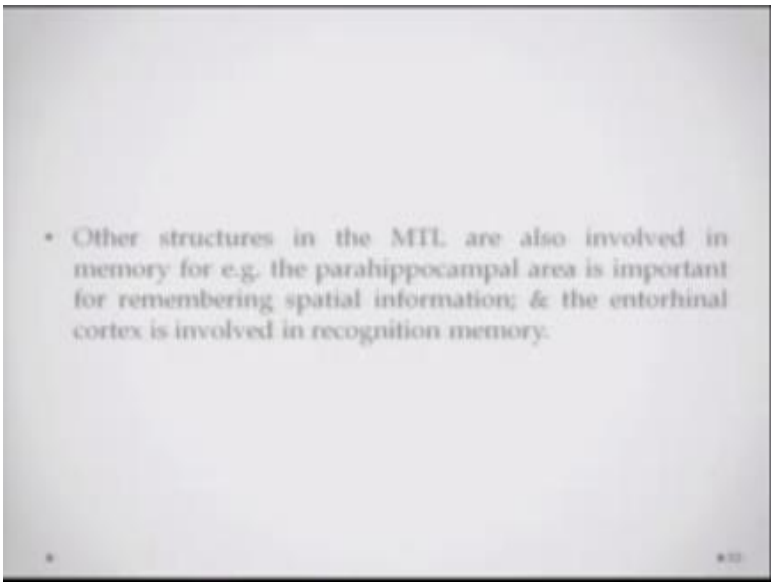


Other structures in the medial temporal lobe are also involved in memory for example the parahippocampal area is important for remembering spatial information and the entorhinal cortex is responsible forusing recognition memory. Now let us talk about memory consolidation every time you retrieve some information you kind of need to recover consolidate that memory as well, so consolidation refers to the process that transforms the newly formed fragile memories to more stable and permanent state where they are more resistant to disruption or change.

So if you are going through a particular experience that memory will be formed but it needs to be consolidated before it kind of goes to a more stable and more permanent stage.

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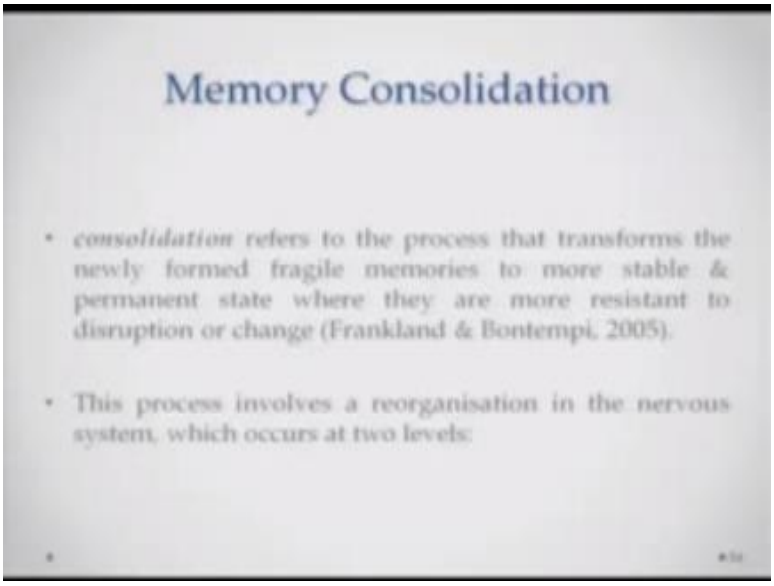


Now this process involves reorganization in the nervous system which kind of occurs at two levels.

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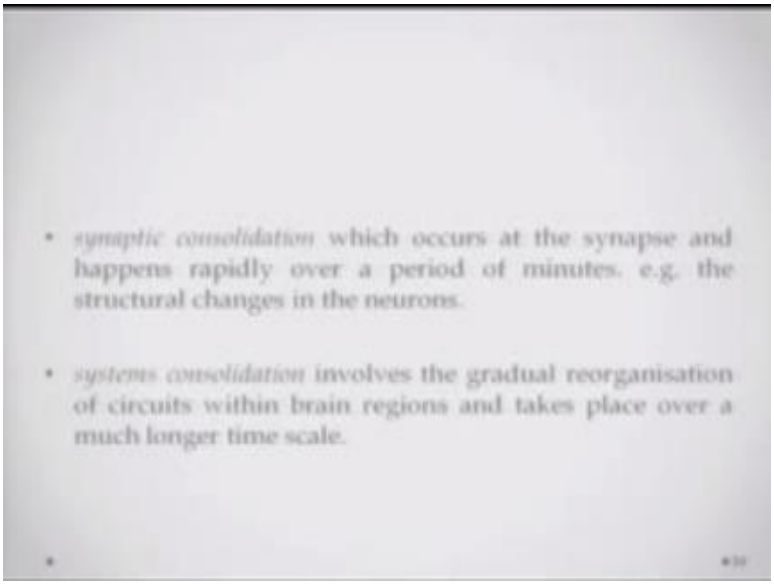


Synaptic consolidation which occurs at the synapse level and happens rapidly over a period of minutes whatever structural changes are going on in the neurons with respect to that experience you are having, second is systems consolidation which basically involves a gradual reorganization of the circuits within the brain regions and basically takes place over a much longer time. So it is kind of happening more gradually and kind of leads to better you know organization of that entire circuit.

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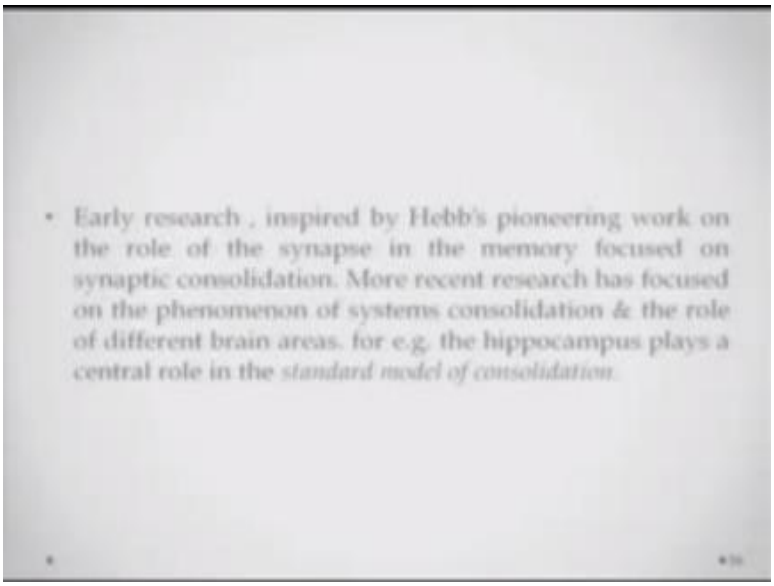


Early research inspired by helps pioneering work on the role of synapse and memory focused on synaptic consolidation so early research is more about synaptic consolidation. More recent, recent research has now focused on the phenomena of systems consolidation and the role of different brain areas or the entire networks in the brain areas and how they contribute to forming memories. So hippocampus plays a role in the standard model of consolidation let me talk to you about what the standard model of consolidation is.

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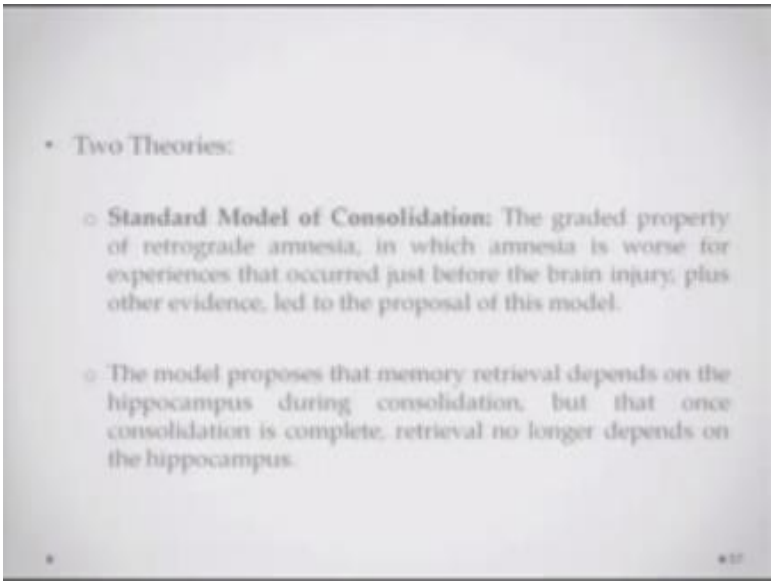


There are two three days the first is the standard model of consolidation and basically the point is the graded property of retrograde amnesia in which amnesia is worse for experiences that have occurred just prior to brain injury plus other evidence have kind of led to this model, so the model kind of proposes that memory retrieval depends on hippocampus during consolidation but once the consolidation is complete it does not in any longer require the hippocampus.

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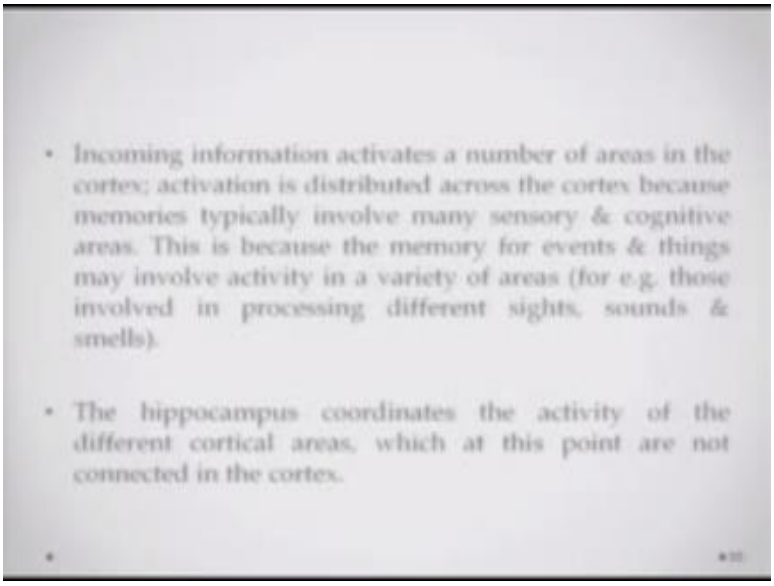


So incoming information is supposed to activate a number of areas in the cortex, activation is distributed across the cortex because memory typically involves so many sensory areas getting activated and other cognitive areas in which you are thinking and deciding about these things so this is because the memory for event and things may involve a lot of activity. The hippocampus is kind of the area is going to coordinate this activity of these different cortical areas, so it will be cortical areas related to the sensory in information about this experience there might be cortical areas activated which have to do with the higher cognitive process like thinking, deciding and those kind of things.

Hippocampus is the area which will coordinate this activity in this network of areas.

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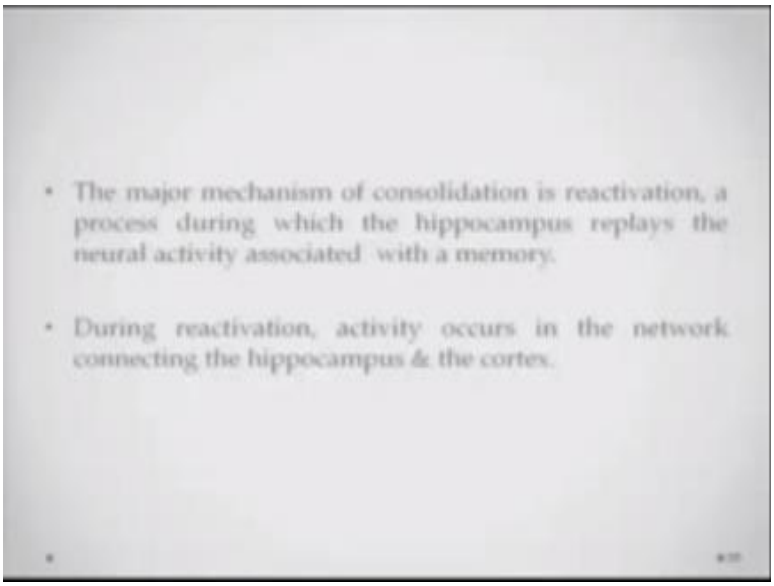


The major mechanism of consolidation is called reactivation a process in which the hippocampus is replaying this neural activity associated with a particular experience or memory. During reactivation activity occurs in the entire network connecting the hippocampus and the cortex so well this activity leads into the formation of connection between these cortical areas the major areas of the brain, remember we are not talking about synaptic level connections here this reactivation process occurs during sleep.

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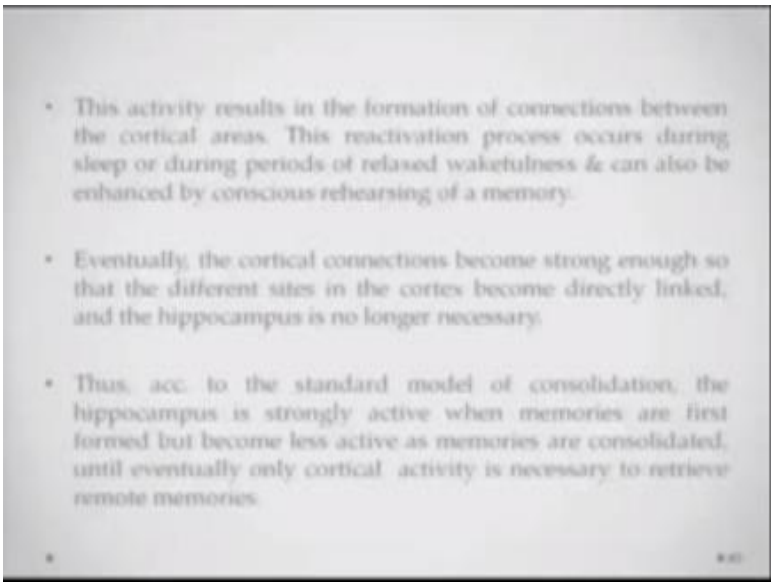


Or during periods of relaxed wakefulness and can also be enhanced you know by conscious rehearsing of a memory.

So if you have learned something if you learned some material it might be a good idea to at some point you know in a relaxed State try and remember what all you learn during the class so what you might be doing is probably you know doing some kind of a systems consolidation wherein you are rehearsing this entire thing eventually the quadrille connections become strong enough so that the different sites in the cortex become directly links and the hippocampus became is no longer necessary.

So after the consolidation is done memory is you know placed and is in a distributed fashion across the brain you do not need the hippocampus again to bring out that memory so according to the standard model of consolidation the hippocampus is strongly active during when the memories are first formed but much less active and the memories are consolidated until eventually only cortical activity is necessary to retrieve these remote memories.

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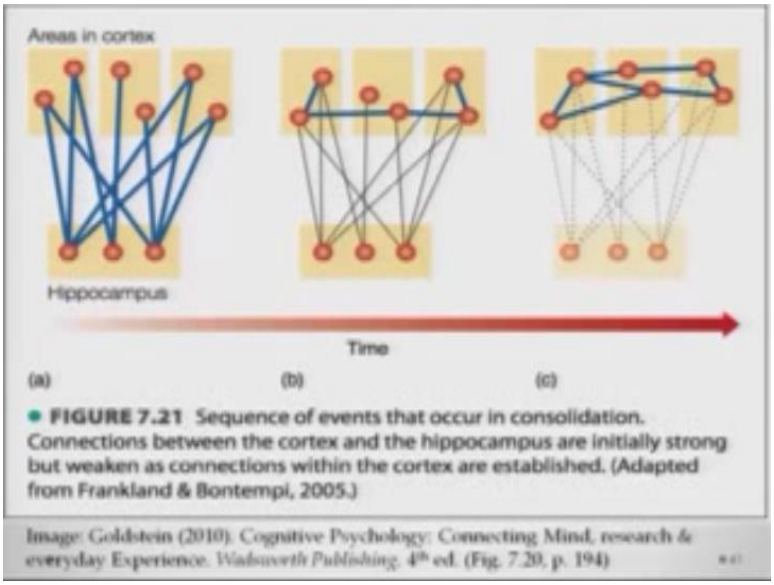


**FIGURE 7.21** Sequence of events that occur in consolidation. Connections between the cortex and the hippocampus are initially strong but weaken as connections within the cortex are established. (Adapted from Frankland & Bontempi, 2005.)

Image: Goldstein (2010). Cognitive Psychology: Connecting Mind, research & everyday Experience. *Wadsworth Publishing*. 4th ed. (Fig. 7.20, p. 194)

This is kind of you know a representation of how over time these network article networks might get strengthened with respect to you know newer memories.

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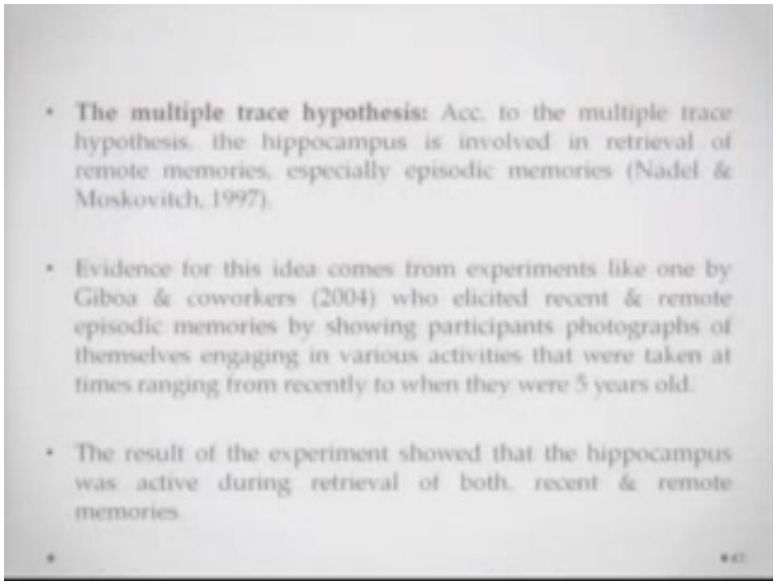


The other model is that multiple trace hypothesis according to the multi will create hypothesis the hippocampus is involved in retrieval of remote memories and especially episodic memories evidence for this idea comes from experiments like the one by give away and co-workers who elicited recent and remote episodic memories by showing participants photographs of when they were 5 years old till very recent for the graphs.

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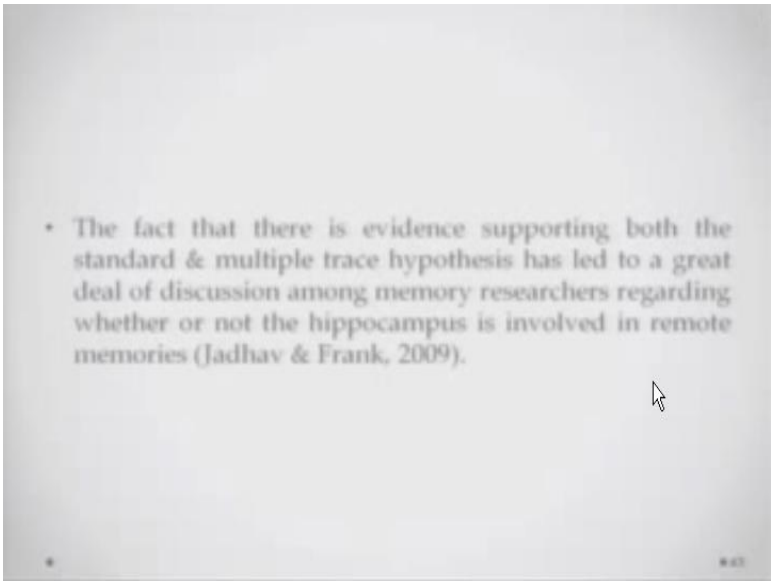


The result of this experiment showed that the hippocampus was active during both recent memories and remote memories now the fact that there is evidence supporting both the involvement of paper cameras in both recent memories and remote memories it has led to a lot of discussion among memory researchers as to whether or not hippocampus is involved during the retrieval of remote memories.

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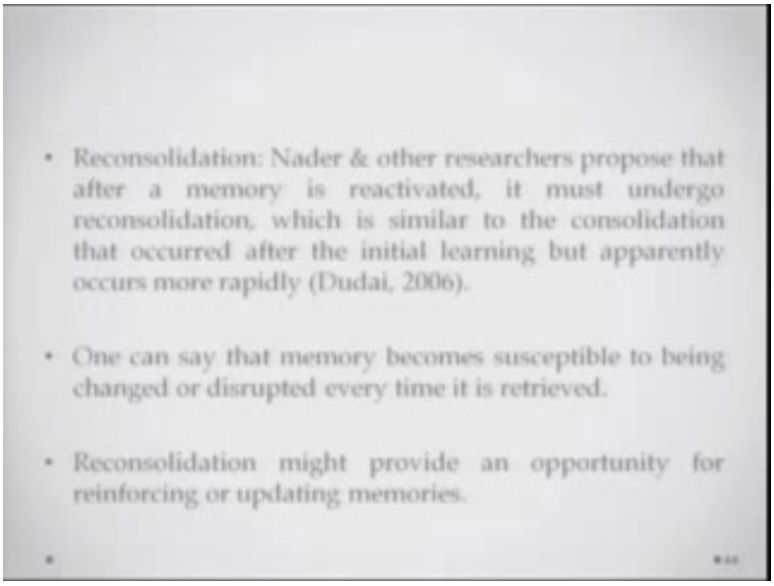


Now interesting concept of after consolidation is the concept of reconsolidation now nada and researchers have worked in this area and they proposed that once a memory is reactivated it must undergo what is called a reconsolidation which is a similar process to consolidation that occurred after the initial learning but this happens much more rapidly so one can say that memory becomes susceptible to being changed or disrupted every time it is received every time.

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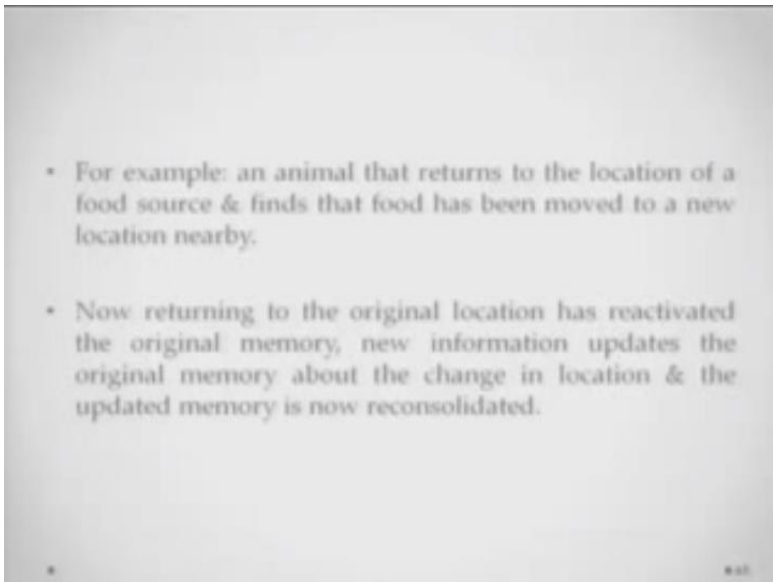


It is retrieved every time you kind of remember something again it might be you know a susceptible or amenable to change or a manipulation so reconsolidation might provide an opportunity for reinforcing or even updating new memories for example an animal that returns to a location of a food source and finds that the food has been moved to a different place can kind of you know benefit with reconsolidation he will update the new memory with the fact that now the food is not here it is probably moved to you know location B.

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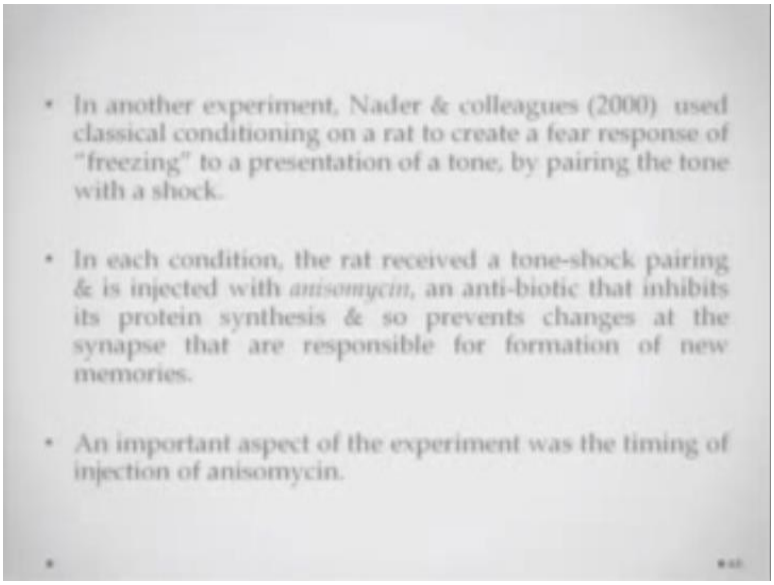


So this updating will happen and the updated memory will be reconsolidated good experiment was done by another increase they use classical conditioning to create a fear response of freezing and to presentation of atone so they did is they present in the paired a tone and an electric shock for a rat and then what they did was they injected their act with any some icing and he summarizes an antibiotic that inhibits protein synthesis and prevents formation or consolidation of memories.

So an important aspect of this experiment was around the timing of you know when the injection of any so mice in this given in condition one where that received the pairing of the tone and the shock on day one and received the animation on day two on day three it was checked it was played the tone was played and it was checked.

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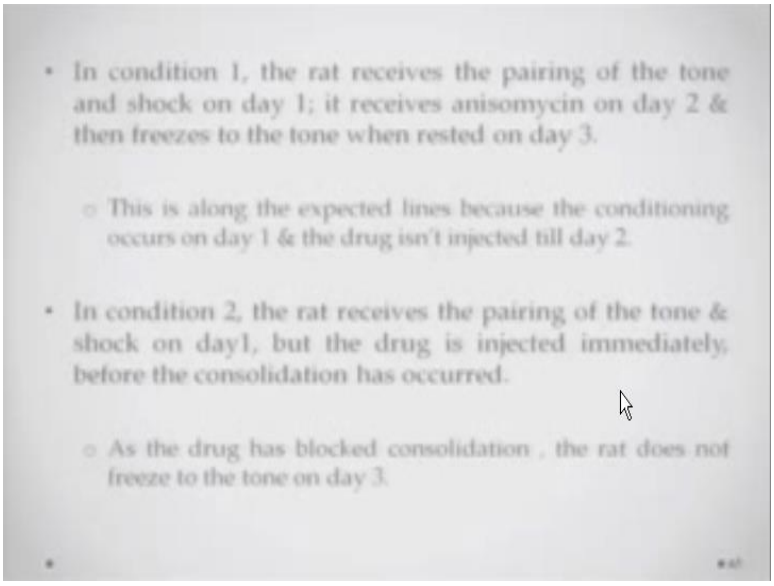


At the rat did you know freeze to the tone this is expected because conditioning already happened on day one and an estimation was not injected until date to in condition to the rat receives a pairing of the tone on in shown in shock on day one and it is immediately injected with any summation on day three when the rat is tested with the tone it does not freeze because that connection between tone and shock was not formed as any injected immediately.

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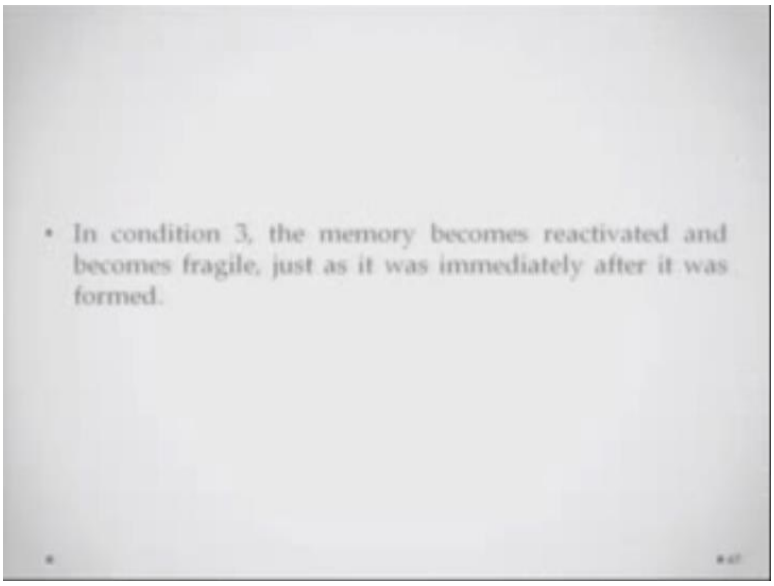


In day three what happens the memory becomes are activated and becomes more fragile and just as it was immediately being formed.

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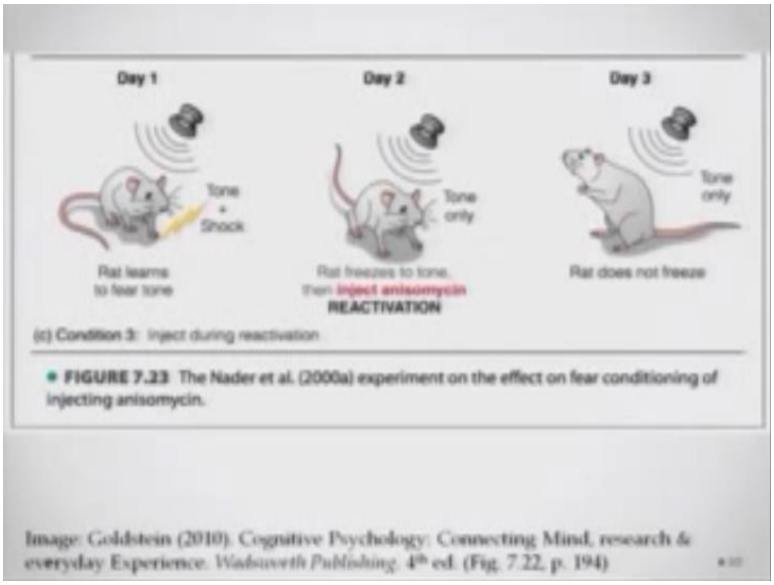


So what was happening is you kind of play the tone there at you know is getting into the freezing wavered and then you place freezing and inject any some icing and then you see that the rat still freezes on day three because the activity or because the memory was they are not reconsolidated does this occur in humans as well.

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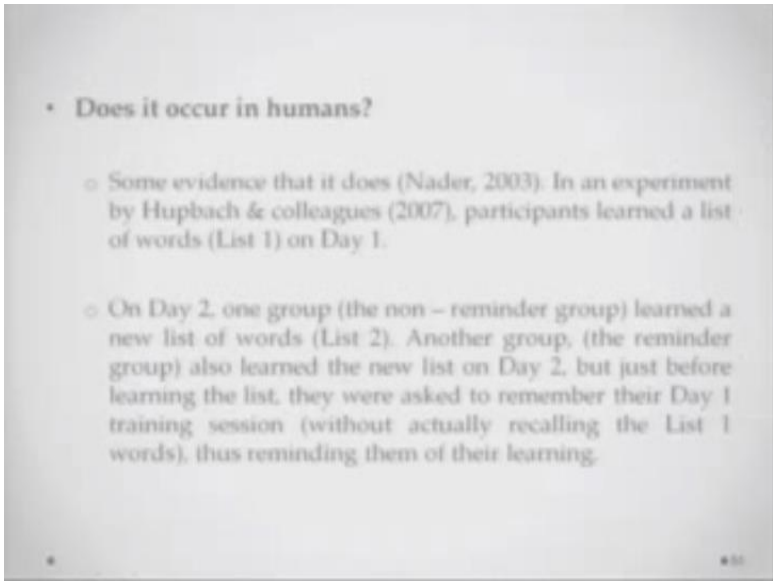


So another basically in an experiment you know Nasser thought that it does and in an experiment by her back and colleagues in 2007 it was shown you know that it actually happens with humans as well so this experiment was very simple a group of participants learned a list of words on day one on day two the other group so there are two groups reminder group and no non day two one of the groups learned the new list offers and another group.

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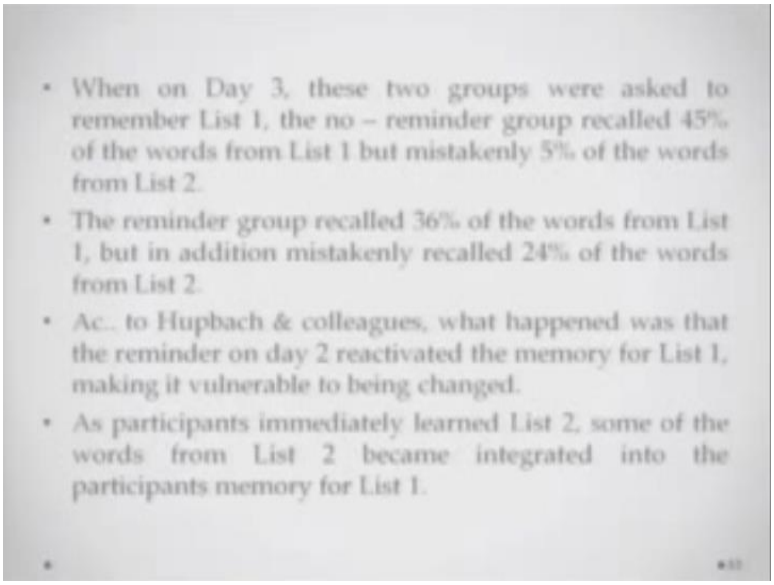


That was a reminder group learned the same list of words when one day three these two groups were asked to remember the list one the no reminder group recalled around 45% of the words from list 1 but mistakenly I remembered 5% of the words from list to the reminder group recalled36% of the words from list 1 but mistakenly they kind of remembered around 40 and 24 percent of the words from list - according to hub back in clicks what happened was that the reminder on day 2 reactivated the memory for list 1.

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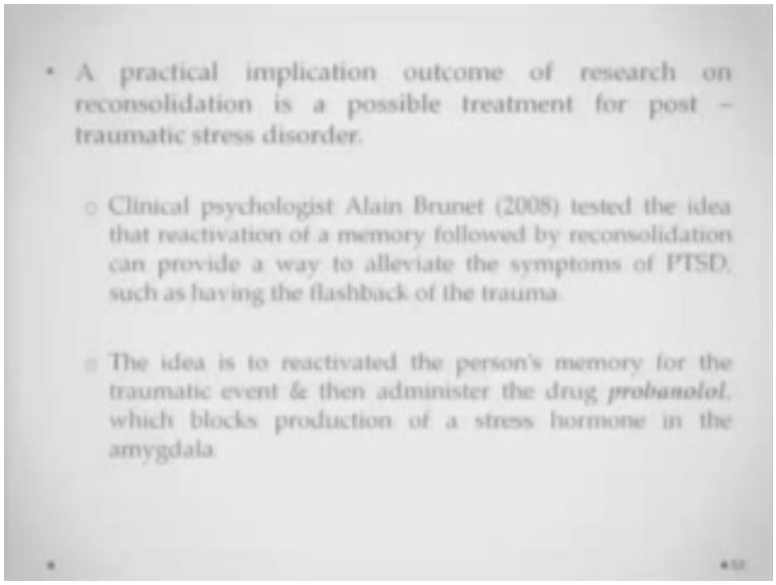


And it became vulnerable to change and in that sense they some of the words from list to kind of you know got mixed up with the words from list 1and that is why they are mistakenly remembering more words from list 2 while they are being asked to recall list 1 as well a practical implication or outcome of research on reconsolidation is a possibly treatment for post-traumatic stress disorder.

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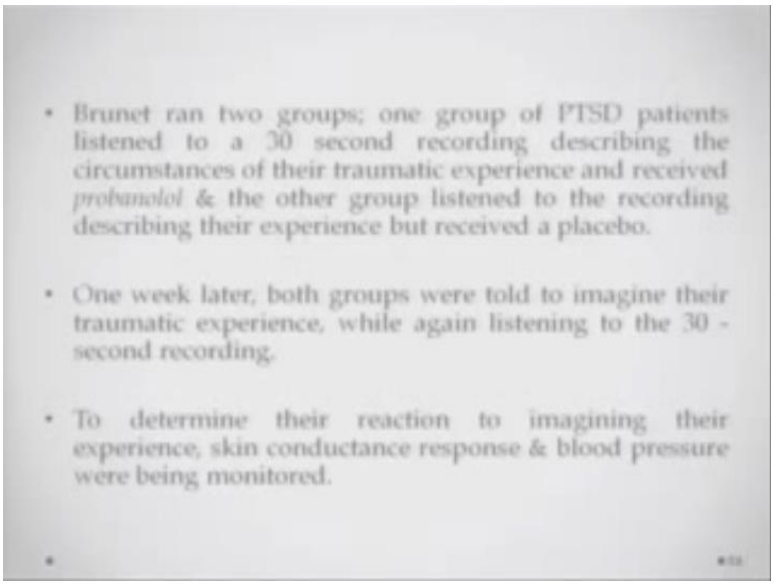


So clinical psychologists Alan Burnett tested the idea that reactivation of memory were followed by reconsolidation can provide a way to alleviate symptoms of what is called the post-traumatic stress disorder this basically involves you know having a flashback of the traumatic event again and again the idea was to reactivate a person is memory for the traumatic event and then inject propanolol basically a drug which kind of blocks the production of a stress hormone in the amygdale.

So what is happening is that he had two groups of PTSD patients both of them listen to a 30-second recording of themselves describing their traumatic experiences and while they are kind of reliving this experience they received probing alone injection while the other group just received a placebo it was found one week later when both groups were told to imagine their traumatic experience again.

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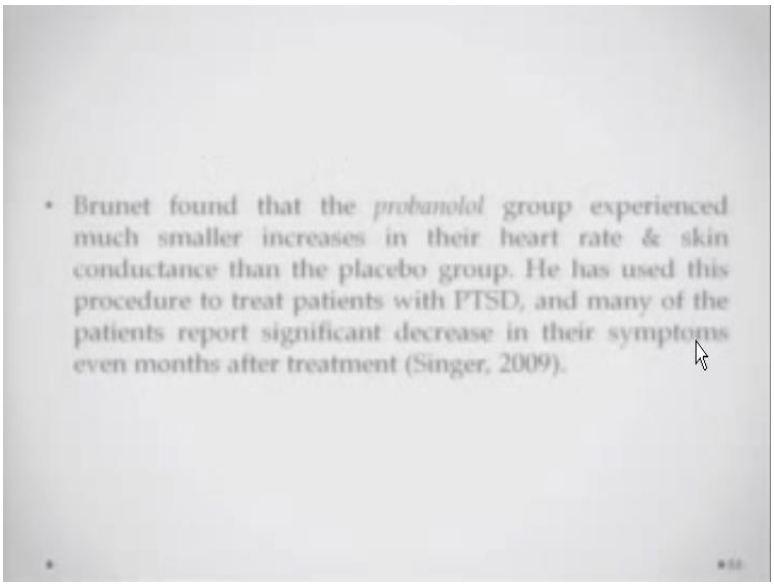


Again listening to this30-second recording it just found you know and then you know to determine their reaction to the imagining this experience skin conducting response and blood pressure were being monitored it was found that the proper neural group experience much smaller increases in their heart rate and skin conductance than the placebo group.

This showed that the reactivation of memory and the absence of reconsolidation and the presence of reconsolidation basically led to you know significant decrease in the symptoms of PTSD even months after this particular treatment so you have talked about retrieval and you know how the brain kind of participates in memory in this lecture and I hope this whole point was clear to you and we will talk about other aspects of memory in the next lecture Thank you.

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