Cognition and its Computation
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Lecture - 38
Memory

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Hello and welcome back. So, today we are going to discuss about Memory processes. We have spoken about learning so far; but today, before we start the class, I would ask you all to focus on the slide in front of you and try and recall or rather remember, what you are seeing ready.

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So, how many objects could you remember from that list? Let us take a look at the list again. So, how many could you remember? Is it that you have remembered a certain group of objects or have you just remembered, what was in the center or what was bright? So, the apple, the guitar, the bulb, the rainbow did they draw your attention or did you look at objects as a group like, the telephone, the clock, the chair, the computer is it a certain category that you are following.

Now, the strange thing is that, each individual has a different way of looking at this image and remembering, the or I should say, in very simple terms registering, the objects and or the names of the objects. Now, if I had asked you to write these draw these as you have seen them, it is not a question of how good an artist you are, but the representation of these images would be a little different; even if they were simple figures, why is it so? Is it because, you lack the skills in drawing.

No, its probably because of the way you have stored that information and when you get it back, when you try and draw it, you are trying to get it from the registration that you have made; not from this original picture.

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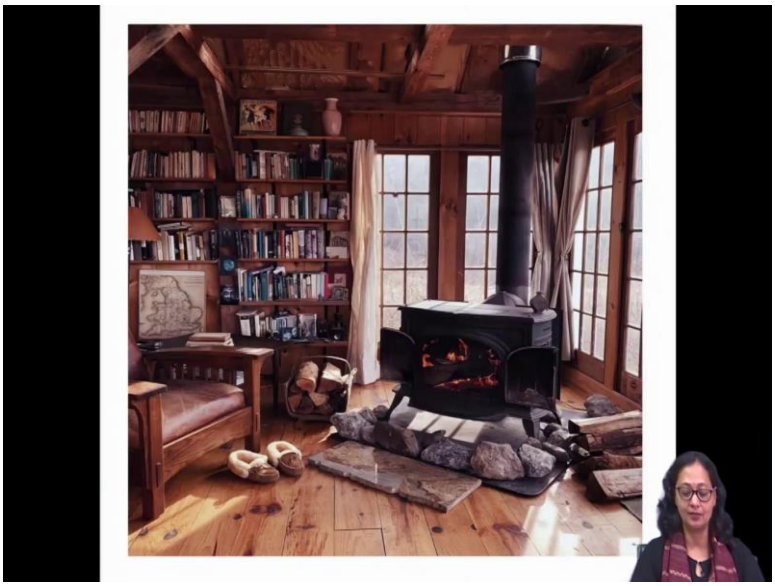

Now, let us look at another slide. So, are you ready? Pause the video and look at the slide; ok. So, how many things, do you remember from that image? Ok. Let us see, how many curtains were there? Was there a globe? Were there a pair of shoes? Was there a vase? Now, when I am seeing this, are you imagining it on your frame on your space, virtual space and trying to think of the placement of the objects?

Just think back to Tolman's theory of creating cognitive maps and see, if you can relate it. Now, let us go back to the image again ok. So, how many of you remembered the map? Was there a globe? No, there was a vase, how many curtains were there? Were there any shoes? No, there were slippers, slip one's, ok.

Now, which picture was easier to remember? When I do this in class, many students have told me that this is easier than the previous one; again, some of course, have different view; the reason, they gave is this is a continuous picture and you can relate it you can look at it as an image as a whole, and if you look at the position once, you are easily able to remember it. So, this is more natural to our surroundings.

The previous picture is more discrete. So, the placement of the bulb could have been here and the airplane could be here. But for this picture, the rocks could not be here; that would be to anachronous or the slippers, would not be here, you would remember it if it were, but then, this is this seems to be the natural position. So, it is you know, if you look at the scene once, if you grasp it as a scene; it is easier to remember.

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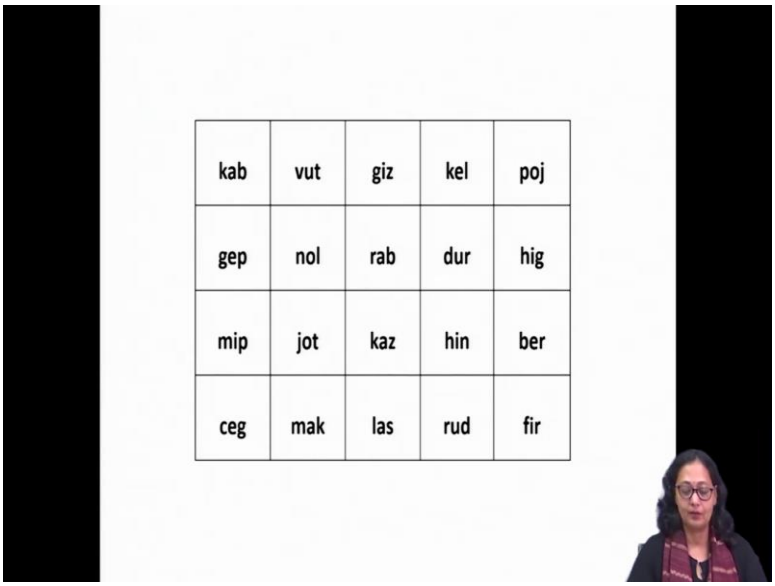

So, going by that, now let us look at this image and moving on, how many words do you remember? Let us see, how many words you remember? Now, these are nonsense syllables; these words do not mean anything. It may mean something, in a different language, but not in English. So, this is a little tough; if you are just reading the way, or just looking at the spellings of the word instead of hearing it, if you are just looking at the words, it is tough; because it does not mean anything.

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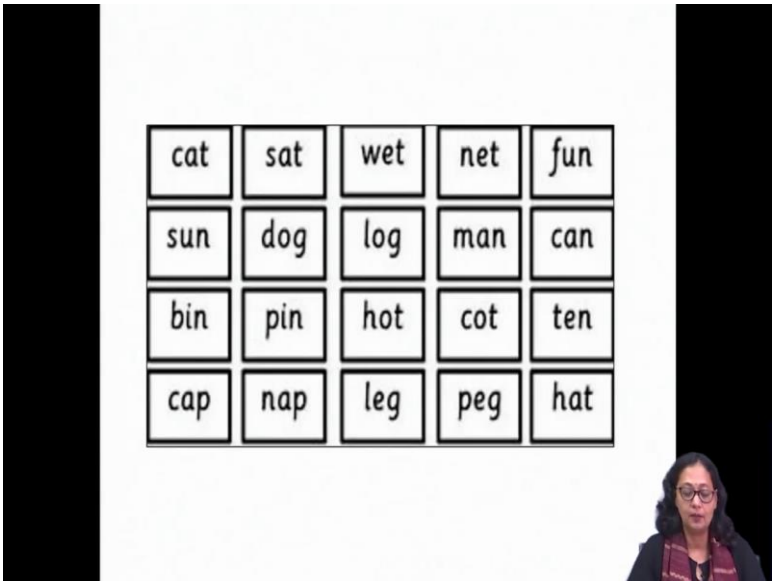

On the contrary, this list, do you think this will be easier to remember? Of course, it will be; in comparison to the previous one. Because, these words have a paired meaning. So, you and when you are mapping it to the meaning, it becomes easier to recall. So, you are also associating with associating it with somebody, something else. So, the cat may be associated with the name, or your cat, or you know you can put it, together as a cat sat on a wet, net, having fun.

So, you know, the way you store it that is also important. So, it has been seen, that for meaningful words, people remember it more.

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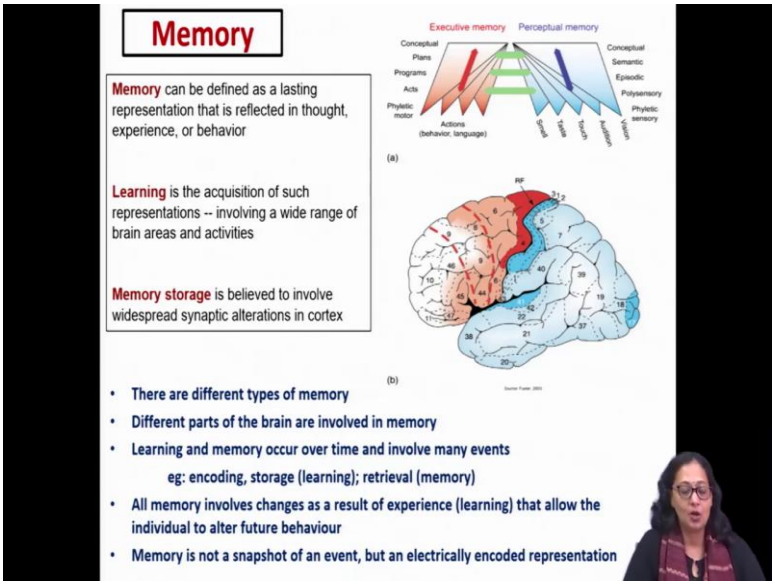

Now, we just I just gave you four examples of different kinds of inputs and the way we strategize and remember them, are also different. Now, this brings us to the core discussion on memory. Now, in the first class on learning and memory, I had told you, I had asked, why it may be a question that, why do we not discuss about learning more? And we, the recent books in neuroscience and psychology generally talk about, memory principles. So, the simple reason being that, learning is a part of the memory process. So, the learning is the acquisition of knowledge and representations.

While memory, is creating an impression or a representation of this knowledge on your brain and this is reflected in our thoughts, experiences, our actions and behaviors. And, memory storage, when we talk of memory storage, it involves a wide area, widespread area of the human brain. In fact, even in animals, and it is not correct earlier, it was very

very specifically spoken of as you know, areas, anatomical areas that are responsible for memory.

Now, memory is widespread across the cortex. It is in fact, many of the subcortical areas are also related to emotional memory. But, so, we cannot restrict memory to specific anatomic and anatomical areas only; though some areas, have a dominant role to play in memory processes, when we discuss later in the classes, when we discuss about the Broca's area and the Wernicke's area, you will see how important they are in language and memory processes.

So, when we talk about memory, we must understand that there are different kinds of memory and different parts of the brain that are involved and learning and memory, occur over time and involve many events. So, the primary three events, in memory processes are encoding, storage and retrieval processes. Now, encoding is the registering of the information.

So, it has to go beyond a certain threshold for that information to be registered. At this point in time, I may have multiple microorganisms, on my skin; but, I am not being able to register their presence, because it has not crossed a certain threshold. Now, once it crosses a threshold, certain threshold, I will be able to feel the temperature or the pressure and that is the initial stage of registering.

This information of registration is encoded and stored within the memory processes; within the brain system and this storage process is where the consolidation takes place, where the learning happens. And, when we recall retrieve that information back to our regular world to perform an action, or it may not be always our actions in time and space are not representations of only the past.

But, an evaluation of the current situation, with inputs from the past templates that we have already stored; that is where, the retrieval process takes place. But mind you, how we store information is solely representative of how we are visualizing them and how we are encoding them. So, that is what makes two individuals, representations different; that is what makes, you know two anecdotes of the same event, different. So, memory is not a snapshot of an event, but it is an electrically encoded representation.

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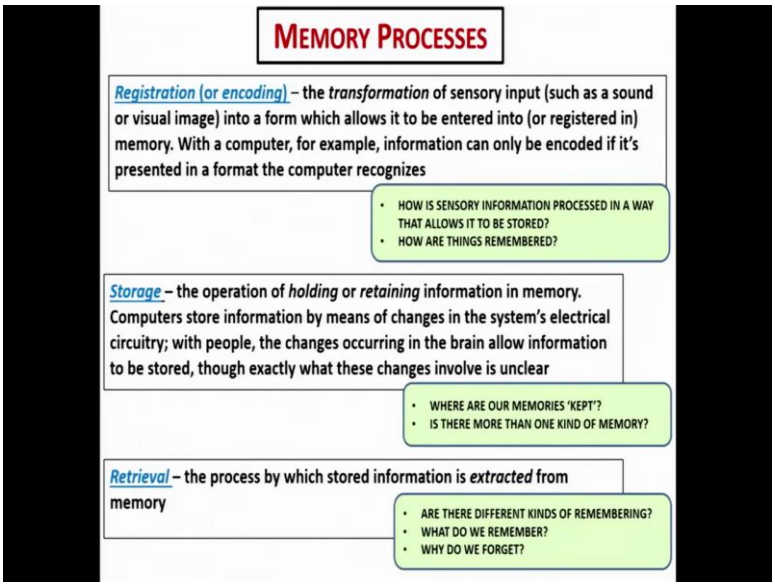

So, as I just mentioned. So, the three primary processes of memory are registration or encoding, storage and retrieval. And registration is the transformation of sensory input and storage is the operation of holding or retaining information. Now, this concept of registration storage and retrieval processes was this analogy was taken from computers. And, how computers store information it is similar, it is similar the analogy has been used, that the brain stores in information in a similar pattern.

But, the system is through electrical circuitry and how we do it? We know of certain processes that are involved, but how we do it is still not very clear to us now. So, retrieval processes is by which stored information is extracted from the memory and as I said, I repeat again, that it is very different for different individuals. Because of the way we are registering that information.

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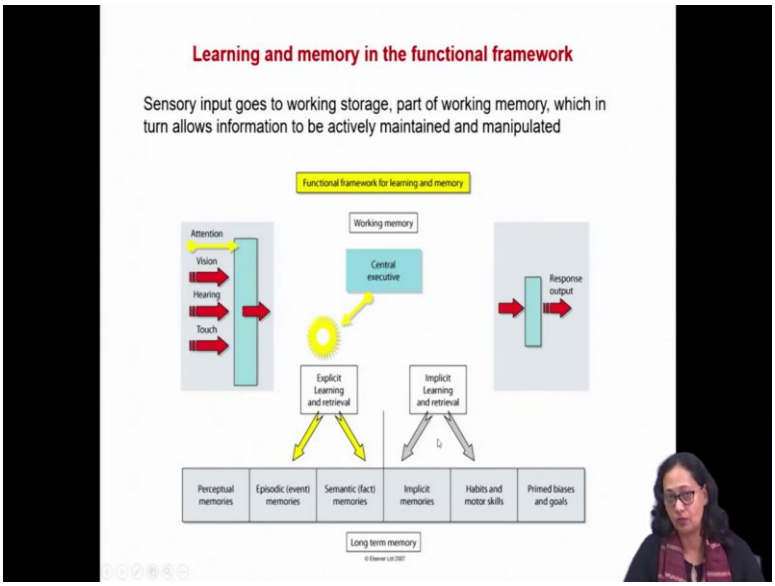

Now, this is a representative model of memory of functional framework of learning and memory that I have taken from Xavier 2007. And, so these are the inputs that go on to the working storage and which in turn allows information to be actively maintained and manipulated. And these so there is a conscious explicit learning that is again stored into episodic memories and semantic memories I will get back to this.

And a part of it, which is not conscious that is implicit learning and it creates implicit memories; so, there may be an influence on our action active behavior, conscious behavior, due to a priming that has happened or due to procedural learning of habits and motor skills. And finally, there is a response output. So, there is a part of it, that goes to the long term memory and part of it which is being used in the active situation itself.

And each situation that I am talking to you right now, input from my past how to speak the language in English? How I am supposed to frame the sentences? How I am assimilating the knowledge of my learning so far? All these combined and the presentation scene right now; that I am delivering this talk; all this combined, I am you know actively getting things, from the long term memory; assimilating things from the current situation, and redistributing it.

Also, as I explained, I am keeping some traces, sending some traces back to my long term memory. And, they are being stored, for further reference. I make changes as I go.

So, say suppose, this was a live class, a physical class, where some students, asked me questions and gave me some inputs; new research inputs.

I modulate my knowledge system and store it back; the next time when I retrieve it, how well I have stored it, will actually make be responsible for how I will remember it and once I recall it back, if I have stored it well and I recall it back, it will be a new knowledge, it will be or a modulated knowledge with the extra information. The extra information was not from long term memory; the extra information was picked up from the working memory, from the real time situation ok.

So, this is how we keep that is why it is an ongoing event of learning and memory. So, it is continuous throughout our life we learn and throughout our life our memory processes are active.

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So, you know there are times, we do forget and one of the; one of the times when our memory function gets affected is when we are in a substance use state, in a mentally ill state or even in degenerative disorders like dementia. So, this these are some of the primary times, but beyond that also.

So, many times, when we are, when we say, I cannot remember, it may mean different things; it may not necessarily be the effect of dementia or an amnesia or a severe shock; but, it can also be; because, we have not been able to register it properly, we have not

been able to encode the information properly or store the information properly; just to give you an example.

So far, if you just pause the video and think about what I have said in this lecture so long, so far? So, how many points, how many words do you remember? Now, there will be many that you will have forgotten; one, because of repetition the other, because of new information taking its place; third, because the registration time was not enough, before you could register, one input properly there was another flow of information.

So, informations forgetting you know when we talk of I cannot remember, it may mean different things, a poor memory may mean different things. So, it is not only a storage failure it can be a storage failure, it can be an encoding failure, it can also be a retrieval failure; the way I have, I am trying to retrieve, I learned it in a certain way, but the way I am trying to retrieve it is very different from the way I have stored.

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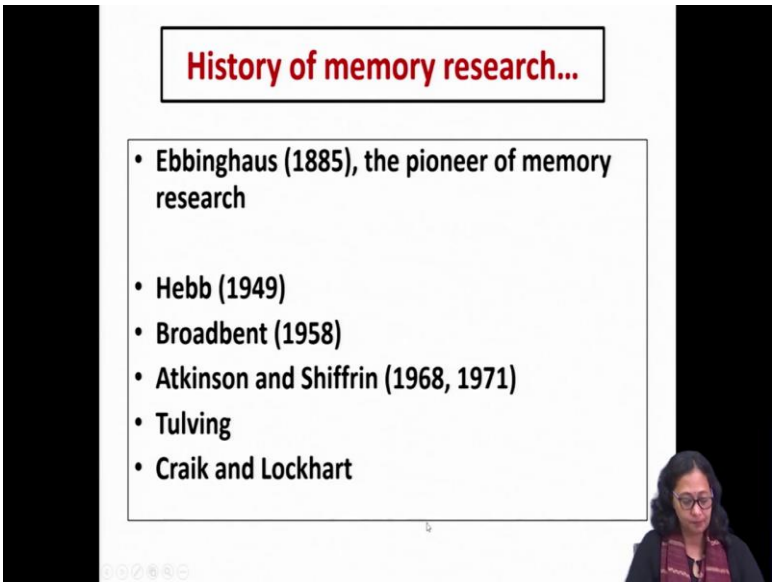

Now coming to history of memory research, there have been a lot of researchers working on memory and the primary father of memory studies is Hermann Ebbinghaus, and he started working on memory in way back in 1885 and a very interesting thing about his work is he was a true scientist following all the you know conjectures or the strictures for in his experimental design. But the and he is the father of nonsense syllables he introduced the concept of nonsense syllables to eradicate, the bias of language, knowledge; past knowledge in memory.

So, we still use nonsense syllables to understand in our memory researches. But, Ebbinghaus limitation was that he had only one subject for his experimentation; and it was himself, but of course, nevertheless he did follow all the stringent rules of research design to work on his experiments, and his contribution to memory, studies, cannot be done without.

Donald Hebb again, we have already spoken of in the previous class, broadbent; Broadbent, you are familiar with when we talked about attention, Atkinson Shiffrin Atkinson and Shiffrin, they gave their theory of memory in 1968 which was again revised in 1971.

Craik and Lockhart and Tulving. So, in today's class, we will be talking about these three models, last three models of memory and they have had there are many new theories; but we will just focus on, as an introductory session, just to give you a brief idea about the memory theories memory models, classical memory models.

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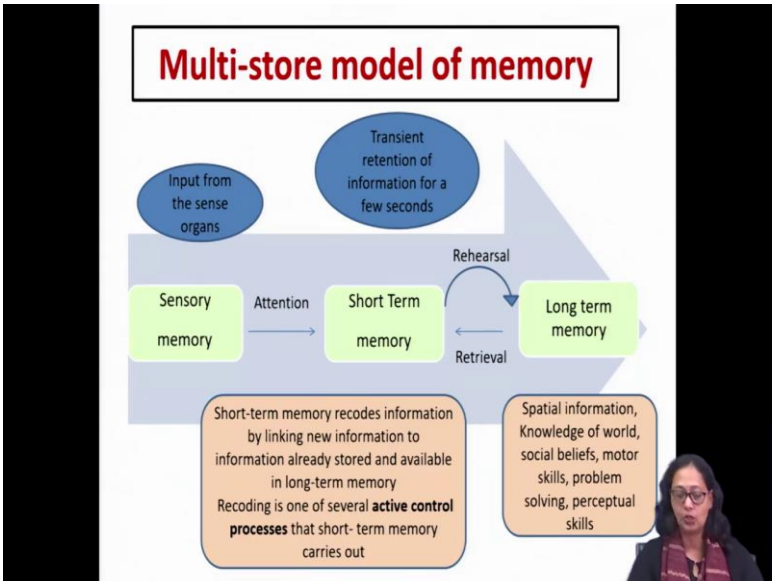

So, to start off with the multi store model of memory by Atkinson, Atkinson, Shiffrin was given in 1968 and revised later in 1971 and this is also known as the dual model of memory. Before this, memory was thought of as a unitary concept. So, one has memory or one does not have memory. But Atkinson, Shiffrin brought about, this division of sensory memory, short term memory and long term memory.

So actually, you if you compare it, with the, this was developed with the analogy of the computers. So, imagine the time in the 60's when the when there is a huge amount of research being done in computer science. So, if the all the sciences were influenced by each other and Atkinson Shiffrin took their idea about, memory storage as from the using the analogy of the computer.

So, if you think of the ram and the rom, as the short term and the long term memory; you will get, what I am trying to say. So, the sensory memory, so, what they spoke of is sensory memory where; so, when you are just aware of the information. So, when your sense, sensory receptors are aware of the input; I hear a sound, that I hear the sound or that I feel the pressure is the threshold; is that it has crossed the threshold, is this awareness is sensory memory.

So, it is just within the remnants of the sensory receptors. Once, I focus on that input, from this receptors, then it enters the short term memory and the short term memory is a small restricted storage space which record records information by linking new information to information already stored.

And, it recodes it and is it again has a very very short retention period and from here, again. So, paying attention to inputs on the sensory receptors, leads it to reach the short term memory storage space. Because, the space is restricted, if the information is not required, beyond a certain amount of time. So, beyond this current time and space, it will be removed from the storage and done away with.

But, if it is important and it may be important for the survival of the species or in any other way, be helpful to the individual; it will be transferred to the long term memory. Now, how do we transfer it to the long term memory? So, there is a some kind of a cognitive strategy that is used to transfer the information to long term memory. So, they what are the cognitive strategies? One can use some kind of a planning; so, you focus attention earlier.

Now, you focus some strategy. So, the strategy could be planning, a chunking strategies of putting clubbing things together or you know relating it with some meaning and thereafter, connecting these together to shift it to long term memory. Spatial information, knowledge of the world, social beliefs, motor skills, problem solving and perceptual skills are all stored in long term memory.

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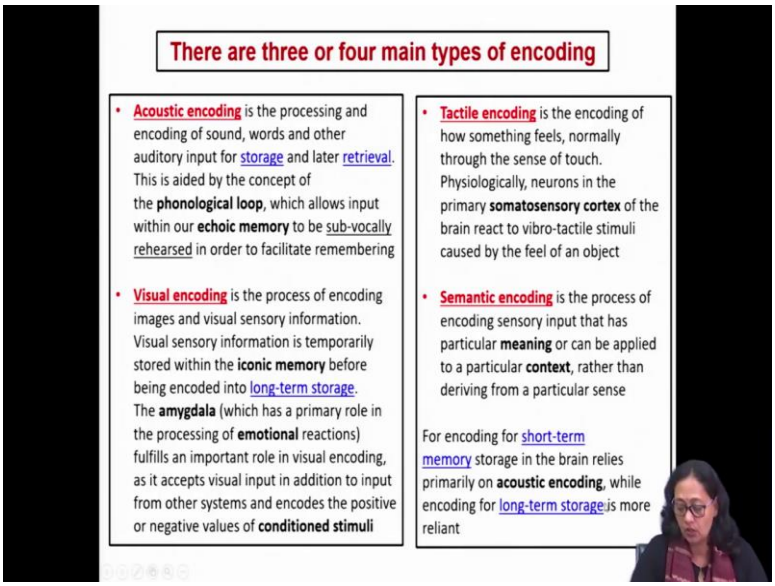

Now, how is this information encoded? So, there are four kinds of encoding processes, one is acoustic encoding and as you can understand, it is from the sounds and all the other auditory inputs; which is used for storage and later retrieval. And this is aided by the phonological loop, which allows inputs within our echoic memory to be sub vocally rehearsed. So, when we are encoding that information, when we are storing that information, you know making meaning out of it and storing that information.

We often, we rehearse it sub vocally. So, the next is visual encoding and this is as the term goes, it is the process of encoding images and other visual sensory information and here it is temporarily stored within the iconic memory, before being encoded in long term storage and the third is, the tactile encoding; which is encoding of textual sensation and physiologically, the neurons in the somatosensory cortex of the brain react to this vibrotactile stimuli, caused by the feel of an object.

The memory of that touch is by the primary somatosensory cortex. And finally, semantic encoding is the process of encoding sensory input, that has particular meaning or can be applied to a particular context; rather than deriving from a particular sense. So, primarily for short term storage encoding is relies on acoustic encoding while encoding for long term storage is more reliant. So, the others are also used in long term storage.

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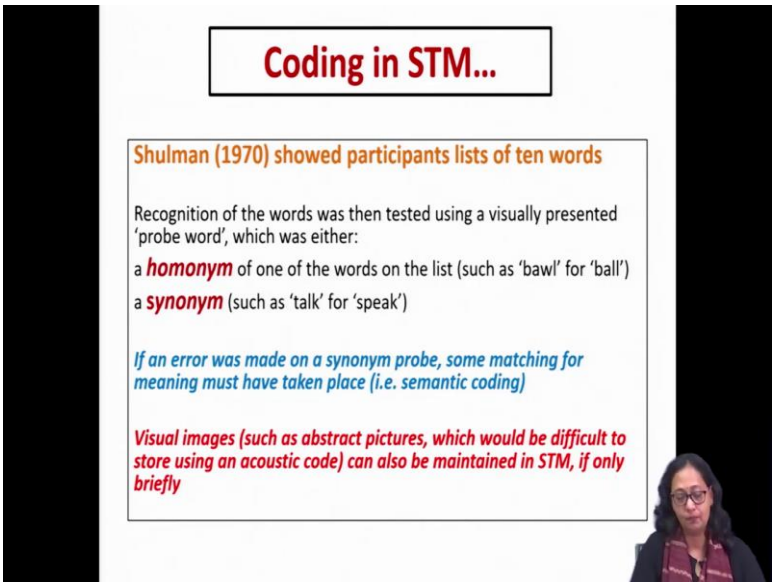

Now, Shulman showed through his experiment, how coding is done in STM or short term memory. And he showed that so, in his experiment, he presented participants with ten words and he the recognition of the words were tested with either the probe with a probe word. So, with a ball, it was either given as bawl b a w l, bawl which would be a homonym; again to the word ball. So, that was the probe word, or it was given as a synonym. So, for say for the word talk, the synonym presented, the probe word presented was speak.

So, it was seen whether the individuals could remembered, the words and they it was seen that, if an error was made on a synonym probe, there must be some kind of a matching that showed semantic coding. So, initially though acoustic coding was considered to be the primary coding procedure in short term memory, Shulman also showed that semantic coding does take place.

And he also mentioned, that visual images, which would be difficult to store using an acoustic code, can also be maintained in STM, but very briefly.

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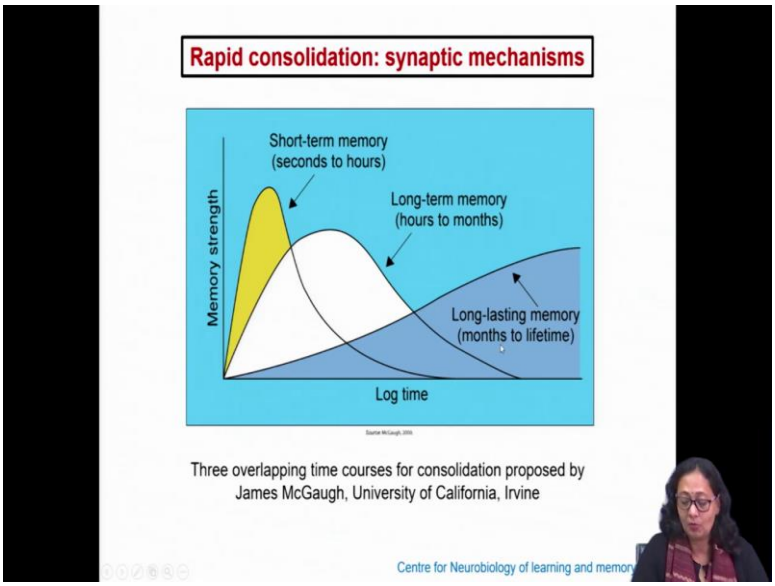

So, this slide I have taken from the center for neurobiology of learning and memory Irvine and this shows that how the memory strength is maintained over time and as you can see, that the short term memory, the memory strength is higher for a very brief amount of time ok.

And it peaks early, the similarly long term memory spreads over time and long lasting memory, they are created slowly, but they last from months to lifetime. This is a flow chart, that the long lasting memory; this is something that we actually ask when we do memory assessments in bedside psychiatry.

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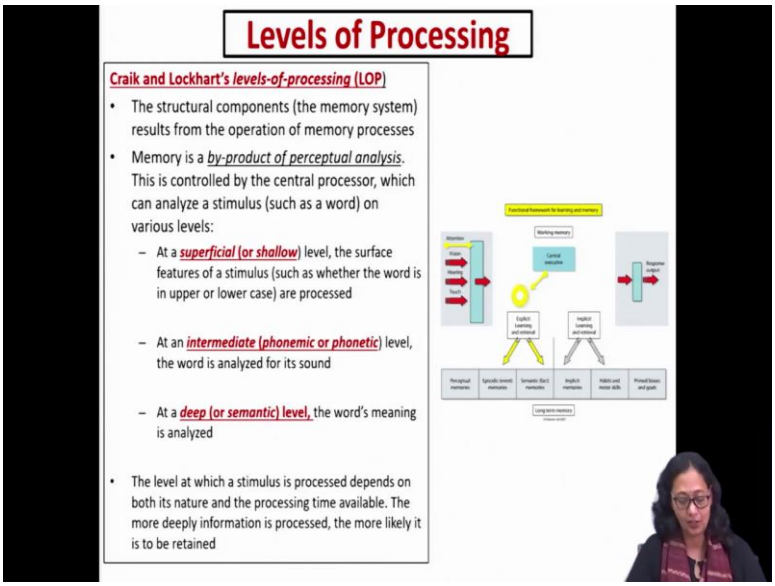

So, now, moving on to the next theory of memory, was is Craik and Lockharts levels of processing, memory, theory. And what Craik and Lockhart implied or they their criticism of Atkinson Shiffrin was, that these are not boxes, where information is kept; but input in the memory system is analyzed by is processed on different levels and that actually is responsible for how much we will remember. So, for them they said that memory is a byproduct of perceptual analysis.

And there is a central processor which can analyze a stimulus at various levels. So, inputs may be analyzed at a superficial or shallow level. So, basically, on the basis on the emphasizing on the word itself; now, as you can understand, that unless, there is a meaning that is added to the word, it will be tougher to remember. So, just think about the nonsense syllables that I showed you at the beginning of this session today and it is tougher to remember those nonsense syllables.

Because, they are stored without any additional input or they are stored with no meaning or not even on a phonetic or phonemic level. If you have the words that you can remember now think about it you will probably be able to because you have stored it on a phonetic or a phonemic level. So, some kind of association that you have formed. So, that would be an intermediate level and that helps to the registration to be there for a longer time.

And at a deep semantic level, words meaning is analyzed and that is why, it is remembered for a longer period. So, the level at which a stimulus is processed depends both on its nature and the process processing time available. So, the more deeply, the information is processed the longer it is going to be retained. So, another example that I always talk of relating to levels of processing is, think of a proof reader who is just checking a book for grammatical errors.

The individual may have gone through the whole book, without even knowing what the story is about; why? Because, he has processed it, only on the superficial or shallow level, for identifying the changes in the symbolic expressions of comma, full stop, semicolon, capital letter whatever ok. But, if he was if he or she was doing it on a semantic level, then the, the story would be registered longer.

So, this has a very very important contextuality in education, where we say that you please learn, when you are learning something, please learn it with meaning. So, it is easier to retain that information and you can retain it for longer.

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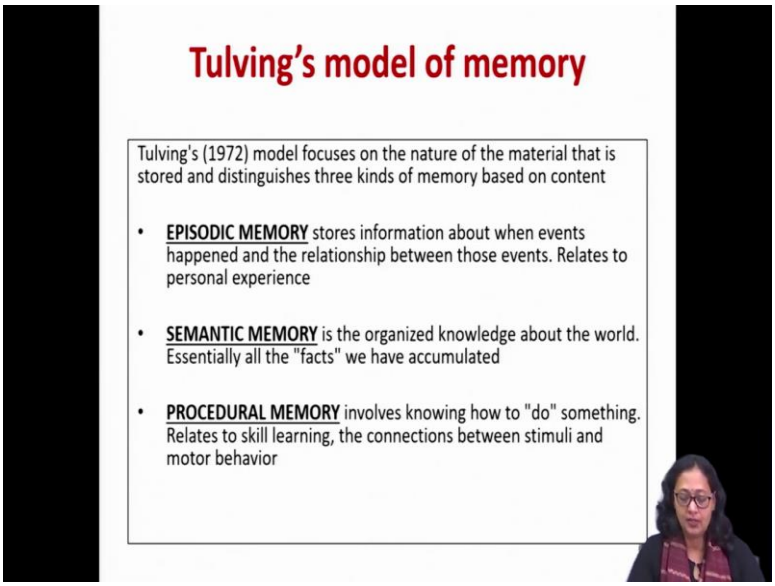

The next model of memory was given by Tulving, in 1972 and here he Tulving distinguishes three kinds of memory, based on content; one is episodic, the other semantic and procedural memory. And episodic memory stores information, when events happen and so, its about event related information, semantic memory as you can

understand is facts and knowledge about the world and procedural memory, as you already know is the connection between stimuli and motor behavior.

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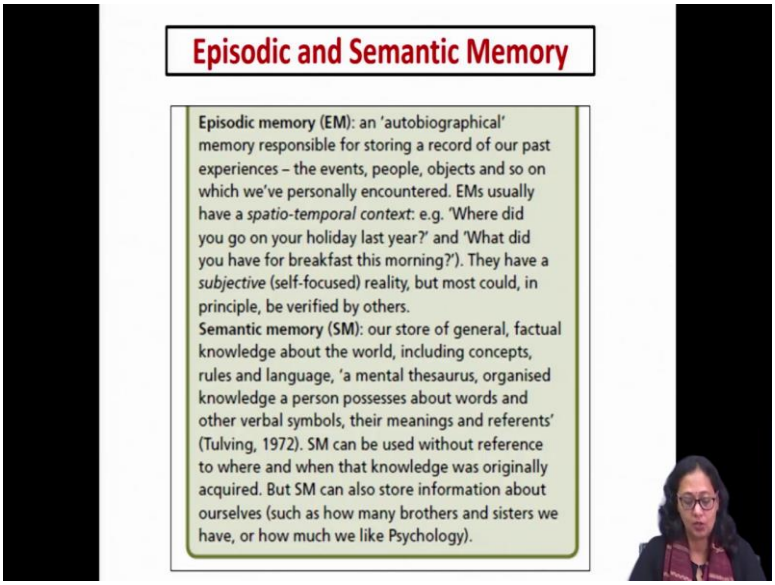

So, episodic memory is a kind of an autobiographical memory and it stores a record of all our past experiences, events, people, objects, all that we have encountered over a spatiotemporal context. Semantic memory is more like a mental thesaurus. So, it keeps all the knowledge of events, of knowledge of facts, words so, definitions. So, everything that is related to knowledge, is stored in the semantic memory.

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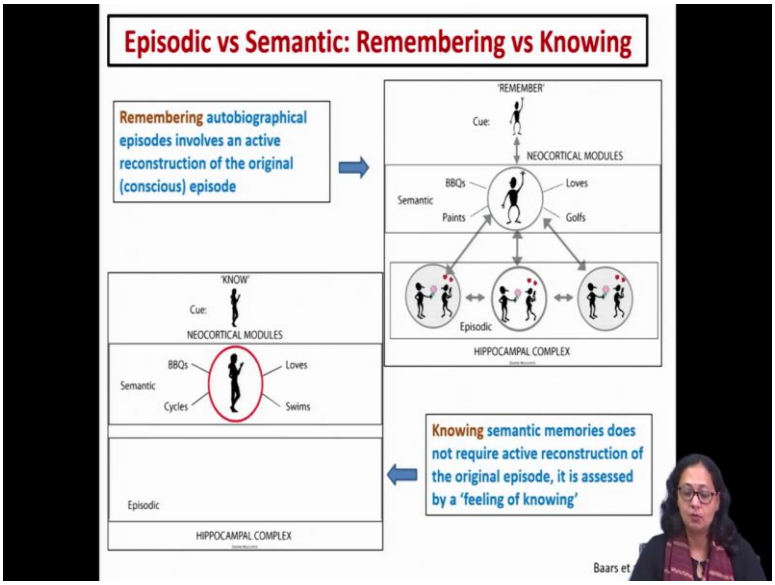

Now, episodic versus semantic may be put forward as remembering versus knowing. So, remembering, autobiographical episodes involves an active reconstruction of the episode. So, when we are thinking about episodic memory, we bring in events. So, we talk of events; on the other hand, semantic memories are knowing. So, there is no active reconstruction required, you know a person is like this; you know, this is the meaning of the term; you do not have to go to referential events, to explain something that is knowledge that is existing in the form of knowledge.

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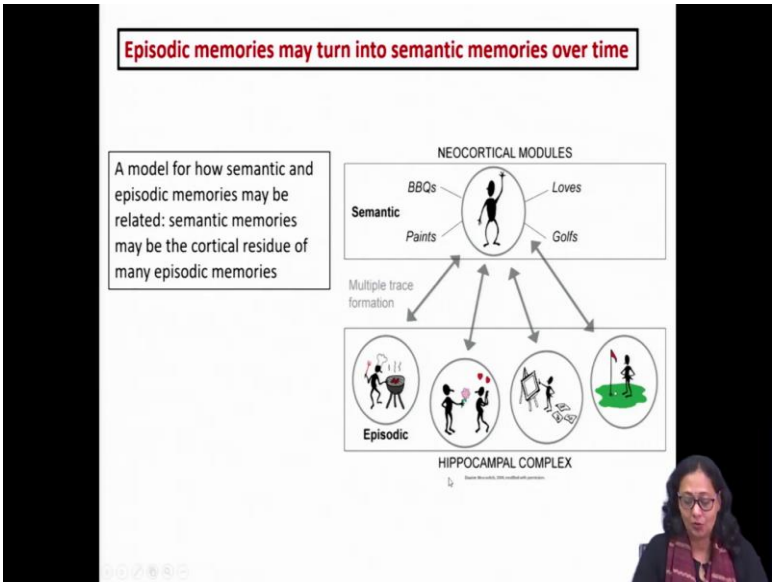

Sometimes, episodic memories can be turned to semantic memories over time. So, with time, with events, say barbecue here or expression of love or painting or golf over time, you know what barbecue means. So, this is the way we learn and remember. So, that it, then it becomes easier, over time when the information is stored is as knowledge; where its a group of episodes together form a knowledge. And once, that knowledge is formed, then those episodes are not required. So, you it takes lesser space to store that information.

So, you know it, you do not have to take references of events. So, if you know, the Newton's laws, you do not have to think of each teacher in from 6 to 12 or beyond that; whose told you about, Newton's laws and how he explained it; you know it, because you learned it, you might have learned it in a graded fashion over the years; but by now you know it and that is it. So, that has become a semantic memory now.

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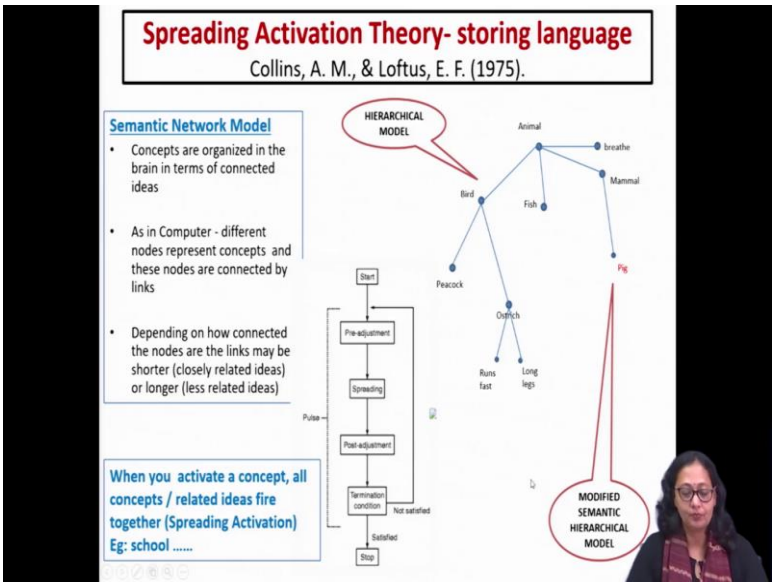

Now, from this semantic memory, the there is a new model, that was developed that is known as the semantic network model, that gave into spread of activation theory to explain how language is stored and this was given by Loftus and Collins and what they tried to show is that concepts are organized in connected ideas and these connected ideas are different represented as nodes. So, again this has been influenced by the development of computer science and this model, is well studied by computer scientists also and AI students.

So, and these nodes are connected by links. So, these are the different links that connect the nodes; and depending on how connected the nodes are the links may be shorter; that is closely related ideas or longer less related ideas. So, say if you think of an animal, so the first you may have shorter nodes to other animals that the, that you can reach faster. So, if you, if I just ask you right now, think of an animal; the first thing that comes to your mind maybe is a domestic animal or a wild animal like the lion, tiger ok.

How many of you thought of the penguin? But, it is an animal; now, the node is distant, when we talk of say, say I tell you a uniform; first thing that comes to your mind probably, police, army, school, sports. How many of you thought of the astronaut? No, that node is far away. So, when you activate a concept, all concepts that are related to it get activated. So, see it is very near Hebb's theory ok.

Now, say, the moment you mention school, your schools name may come, but or school uniform, children, teacher, books, ICSC, CBSC whatever, ok. Now, these are all related nodes that get activated. Now, this also gets modified with time; say, you have a some new idea, new animal that you have learned say, you have developed this new knowledge of another animal and you there is a kind of an adjustment that is done. So, beyond that adjustment, that gets pulled closer.

So, we refine our tuning, we refine and fine tune our ideas of semantics, the network gets fine-tuned over time and how we connect our ideas, that gets fine-tuned over time, as per post adjustments.

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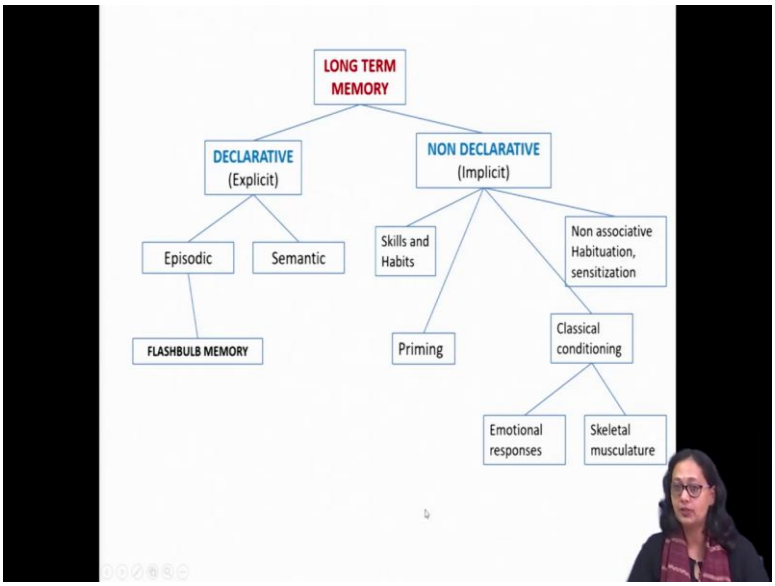

So, now moving to the this is a memory flow chart which will help you to understand, the concepts of long term memory better. So, long term memory can be divided into declarative and non-declarative or its also known as explicit and implicit; explicit memory is in divide into episodic and semantic and episodic memory may be flash bulb memory; an example of flashback memory is ok.

What were you doing when the day, when India won the cricket world cup? We remember it, flashback memories are related to events, important events in life ok. So, if I ask you, what were you doing on 23rd November, last year; you might not be able to say, but if 23rd November happened to be Diwali or you know some your birthday or

some other event that is important, then the you have connected the memory of that event with that your personal actions.

So, that way we remember things non declarative memory is one of it is skills and habits; the other is priming, we have already spoken about classical conditioning and a non-associative habituation and sensitization. So, this is a flowchart, if you remember this is this becomes easier for you to store you know get an idea about the memory map; cognitive map of memory.

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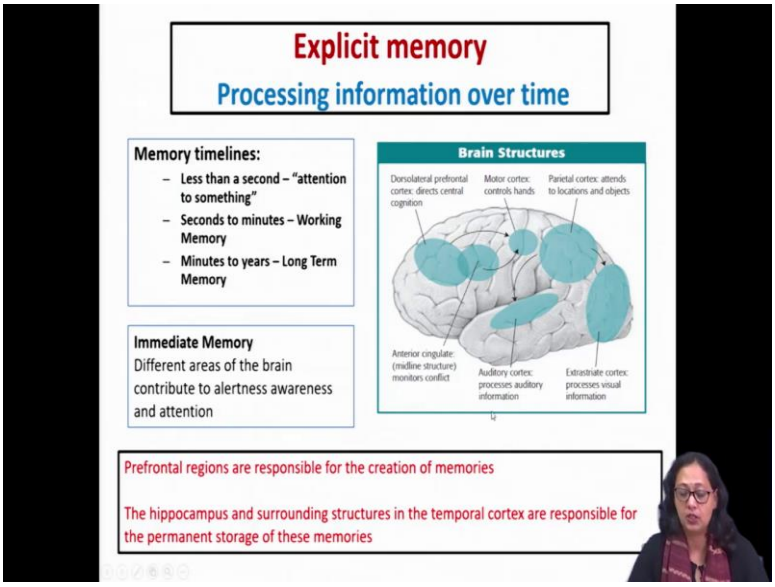

Now, I am not going to talk too much about how, which are the brain structures that are important in memory? Because, the latter classes will be taken up for this, but we must understand one thing, that the prefrontal regions are very are responsible for the creation of memories and especially, in memories where we are consciously paying attention; the hippocampus and other surrounding structures in the temporal cortex are also are responsible for the permanent storage of these memories.

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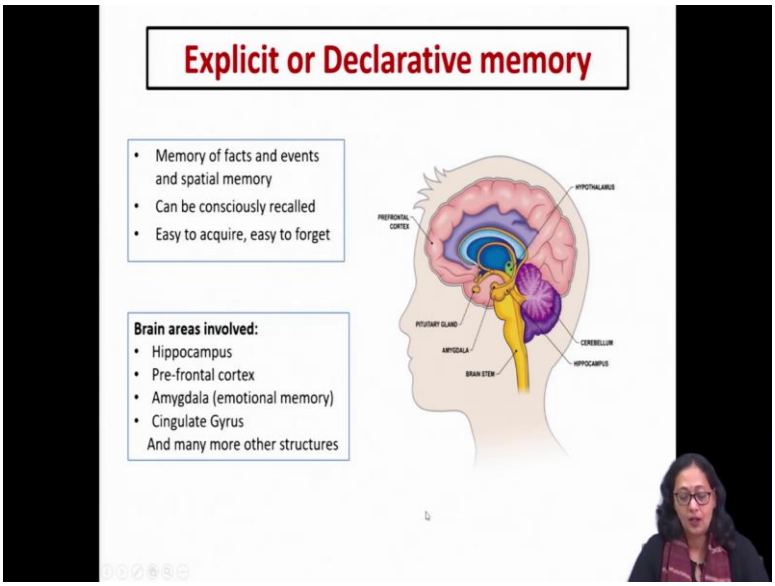

So, the brain areas, involved in explicit or declarative memory are hippocampus PFC, Amygdala, Cingulate Gyrus and some other structures.

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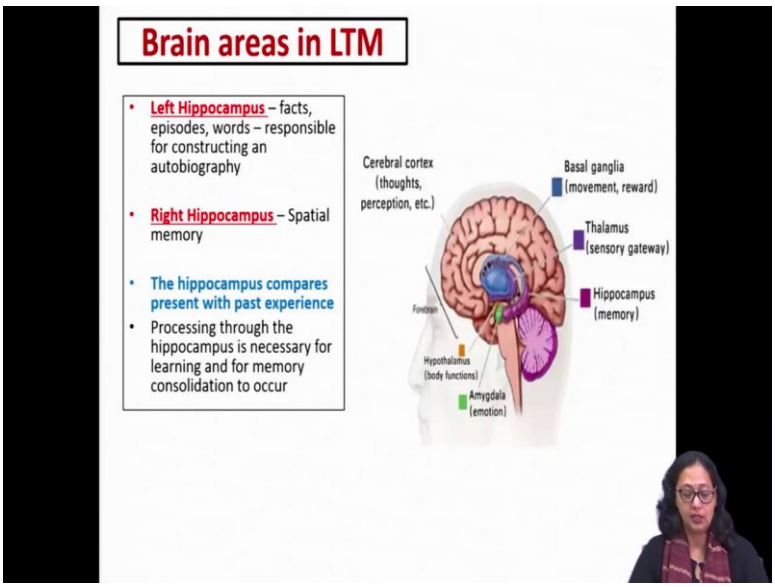

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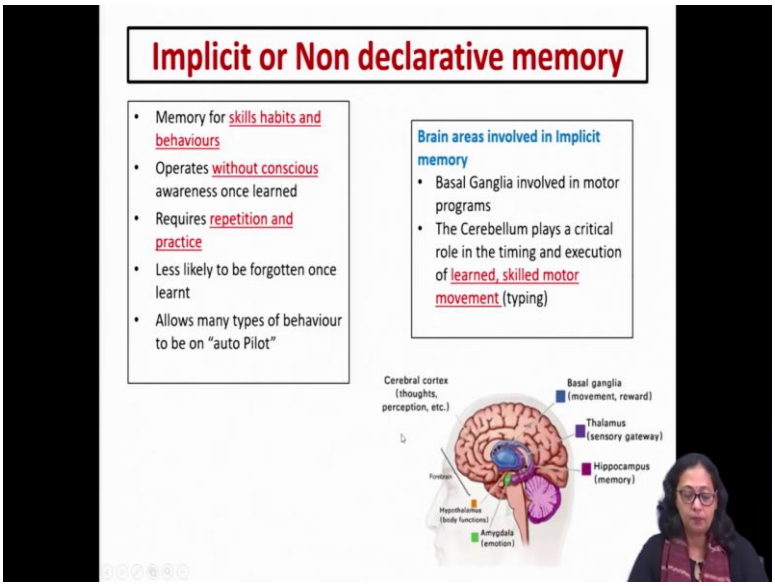

Later on, in the classes, we will be explaining these more in detail while, the for implicit memory that is more for skills habits and behavior which are operating without our consciousness; they require more of the subcortical areas and the basal ganglia is very important for motor learning and memory and the cerebellum plays a very important role in learning skilled motor movement; like typing and playing the keyboard and drums.

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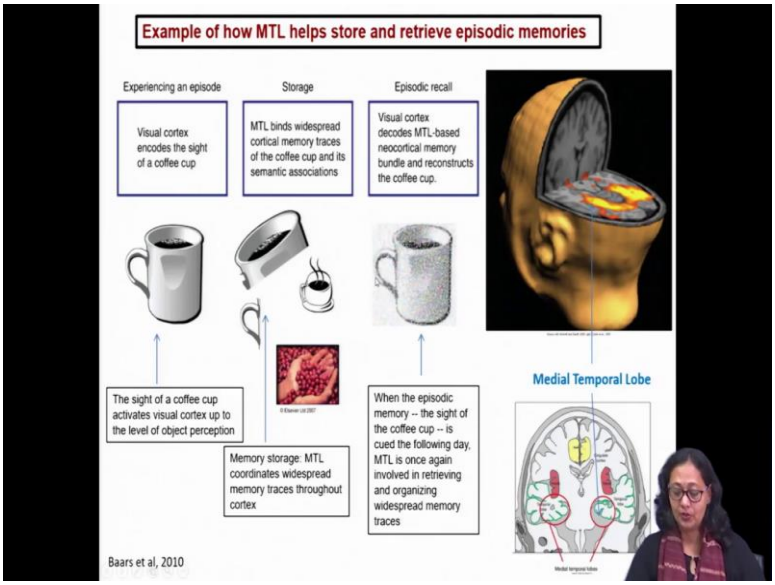

So, this just to give you a brief idea about I had mentioned that we do not store snapshots, but we store information in different ways; each individual does it in different

ways. So, how do we do it? Just to give you a brief example. So, the visual cortex, when you look at a cup, when you look at a coffee cup and you are experiencing an episode. See the sight of the cup, now you have activates visual cortex for object perception.

So, this is one, there with the cup; I said a coffee cup. So, if there are addicts of coffee, who are listening to the stock, you might also be able to smell the coffee or you know you can think of the beans. So, the when we are storing this input, you are storing the image of the cup, the you know, different elements are broken up into and along with that the smell the touch you know that the look of it the taste of it.

So, all this gets stored. So, when there is a recall, so when there is an episodic recall, the visual cortex decodes the information, ok; from the neocortical memory model and reconstructs the coffee cup. But with this coffee cup, the other inputs have also got associated. So, you might have thought when you were storing this information, along with it, sitting at a particular place on your breakfast table and drinking coffee that might have got stored along with.

So, all that information, when you are recalling all that comes back just to give you an example, think about a mango pickle, at this point in time think about a mango pickle, that is sour and tasty. How many of you have your salivatory buds flowing you know activated?

For most of the people, who are familiar with the taste of a mango pickle, you will have your active salivation, you will have you know many of you can smell it, many of you may also have the image of the bowl or the you know the glass container, or wherever its kept or you may think of your grandmother or something associated.

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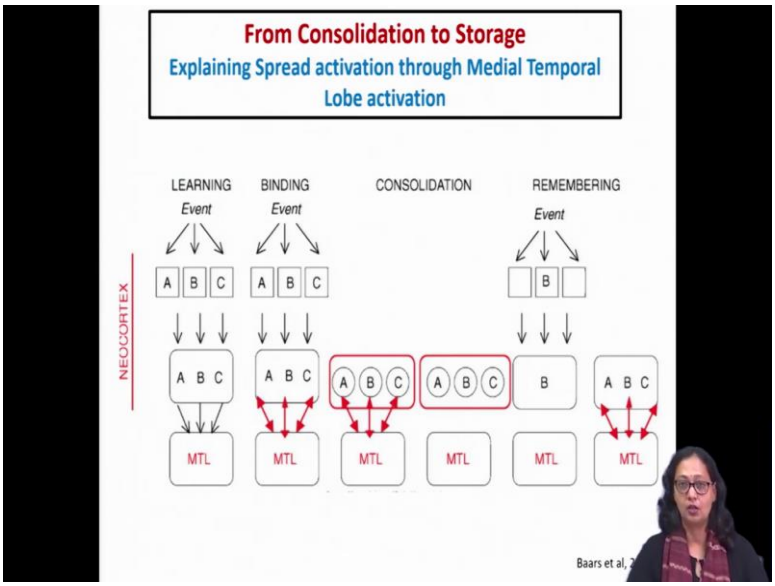

So, when we store information, what I am trying to say is, that you know when you are learning an event so, there are there may be several inputs of the event; the MTL or the medial temporal lobe they bind these together and the consolidation happens, when the consolidation happens, these are not separate units; they get binded together ok and when you are remembering, even one small unit may be able to trigger the rest of the event. So, this will be spoken to you later in more details.

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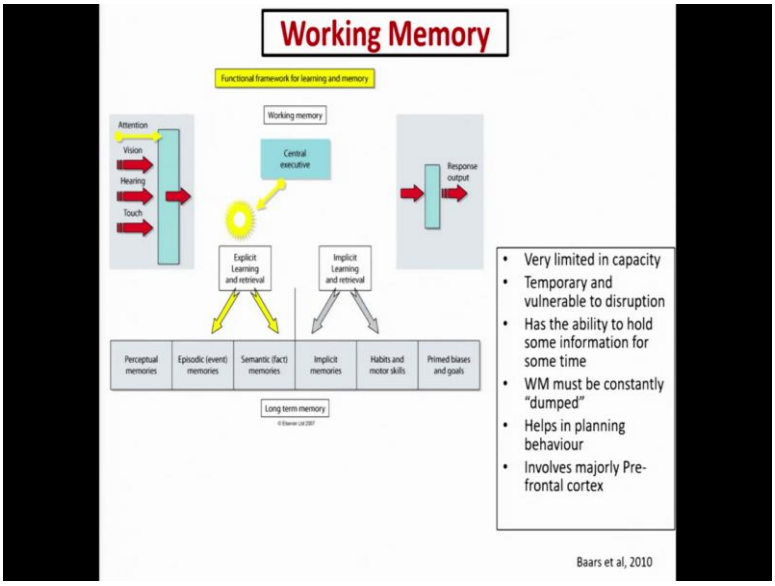

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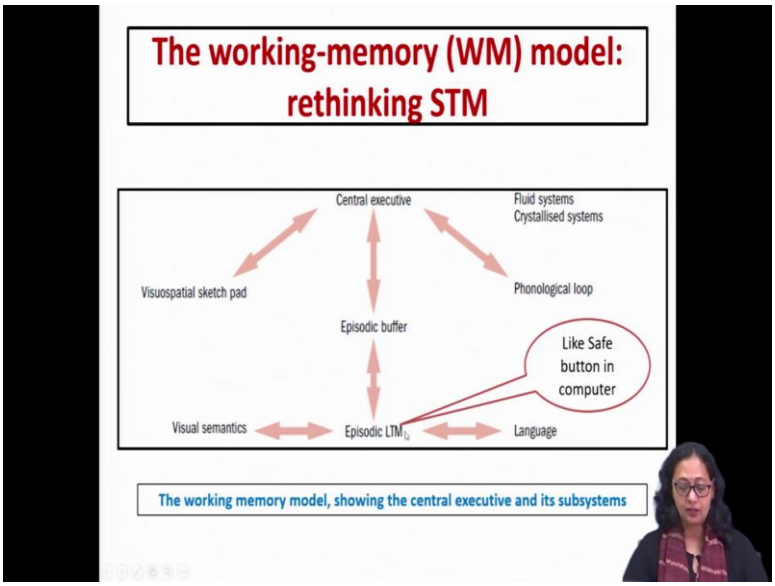

So, I guess we will not go further into working memory also, but just to give you a brief idea about working memory, there are three parts of the working memory; baddeley gave this model and they are the visual spatial sketch pad the central executive and the phonological loop and I have already mentioned about the phonological loop earlier; and the central executive is the involves the higher mental processes.

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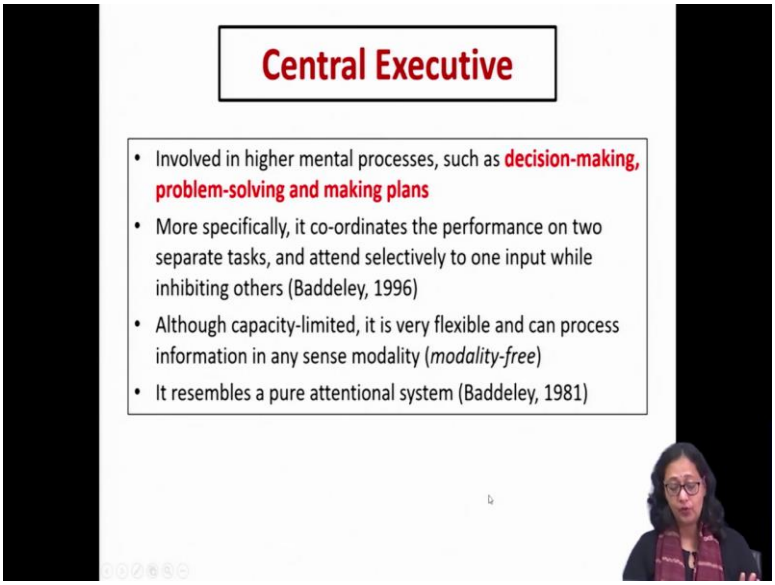

So, it is the coordinating center and it coordinates the performance of the two on two separate tasks and attend selectively to one input while inhibiting others. But, though it is capacity limited, it is very flexible and modality free.

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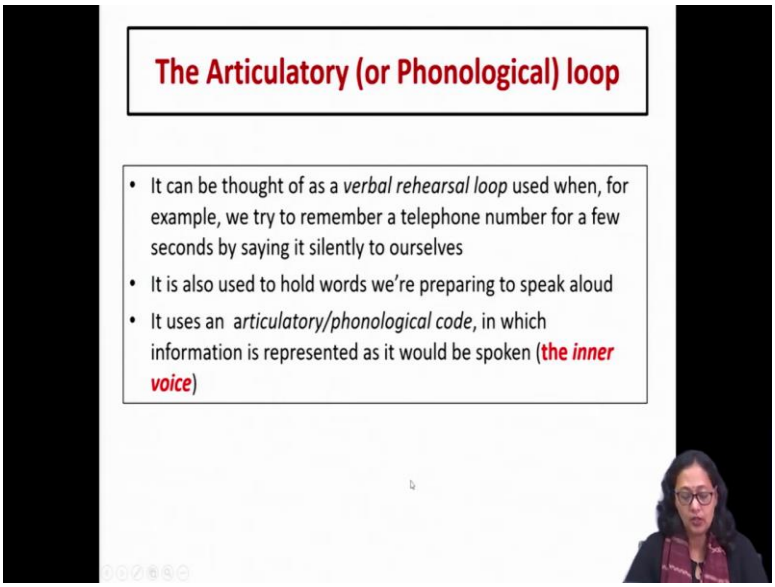

So, now on the other hand, the articulatory or the phonological loop is auditory dependent and it is a verbal rehearsal group as I said, that many a times, we sub vocally rehearse information and this is how we try most often, when we try to remember something in real time in physical during an action, we try to use this verbal rehearsal loop.

So, like remembering a phone number to type it or easier still remembering an OTP we say it loud or we sub vocally rehearse it before typing. So, also it uses a an articulatory or a phonological code in which the information is represented as it would be spoken.

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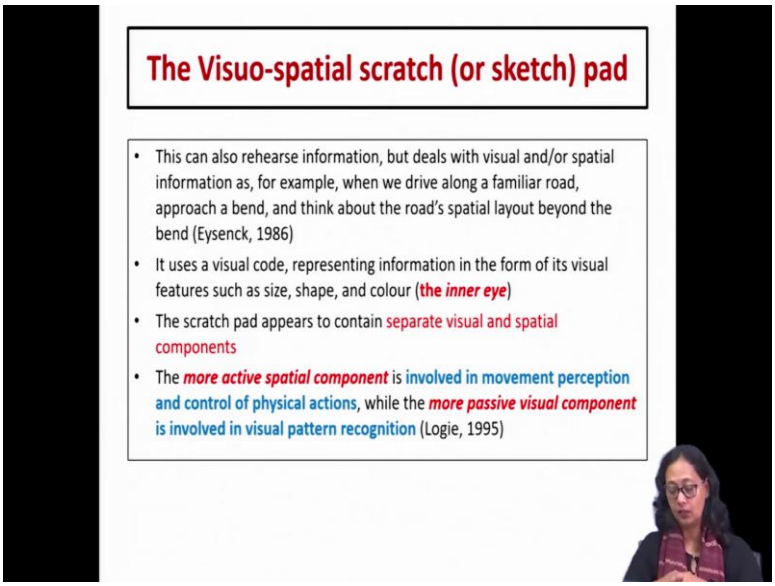

Now, the visual spatial scratch pad or the sketch pad is again a representation in a visual code and it may be it is represented in size shape and color. So, it is like a virtual eye. So, you are imagining the information, ok before actually putting it down the scratch pad appears to contain separate visual and spatial components and the more active spatial component is involved in movement perception and control of physical actions while the passive visual component is involved in pattern recognition.

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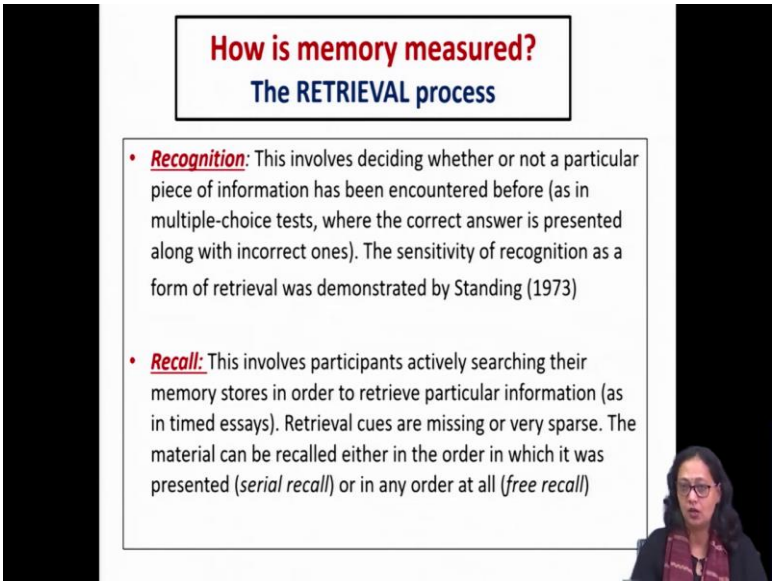

So, these have been long researched and working memory the concept of short term memory has been replaced by the concept of working memory in today's research. And working memory, the role of working memory in the work the role of attention in working memory is again a very very important factor; when we talk of memory systems in neuroscience.

Finally, I will end this talk with just to give you a brief idea about how memory is measured. So, many of you are familiar with recall. So, when we talk of, how much you have learned; the evaluation is done through recall and it may be a free recall or a serial recall. So, if you have made a person learn something you can ask the person to remember it randomly or ask it in a serial fashion.

The other is by recognition; you are say for the first image of multiple objects that I showed you; if I present it with a group of other image other images together other objects together; how many can from the first list can you remember? That would be recognition; that is what we try and follow in our multiple choice questionnaires. So, MCQ's, where you know you are given four options, perhaps with three of them not matching with the original response, but close together.

Now, whether you can recognize the answer. Many times recall is tougher when especially when you have no because there is no queue that is provided, but recognition can be tougher if the associations are very close. So, if the four options for MCQ are very close to each other though you know the direction of the answer the exact answer unless you are very sure of it may be wrong.

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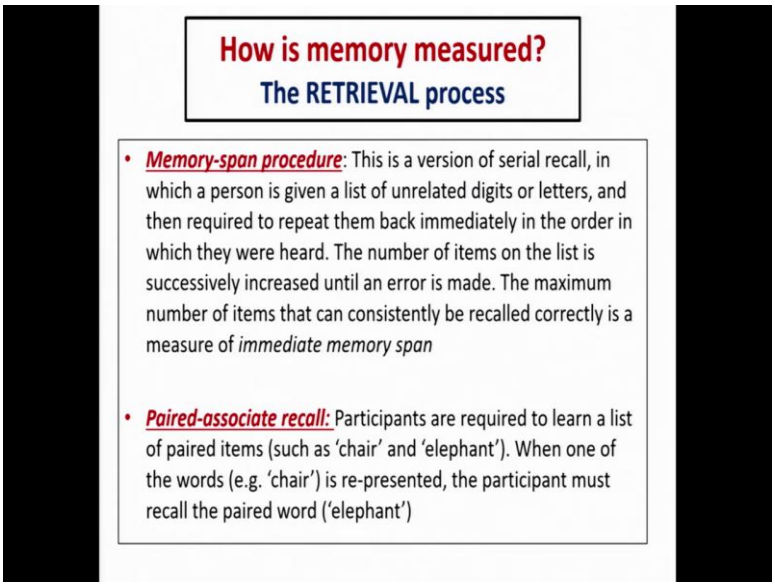

So, memory span procedure is a another way of measuring memory and this is another version of serial recall in which a person is given unrelated digits or letters, and asked to repeat them immediately in the order in which they heard it. The gradually the number of content is increased we generally do this for digit span also. So, sometimes, it is asked to repeat directly or as a reverse order and this often gives us the idea of an immediate memory span.

Paired associate recall is another way of measuring memory, in you know in daily assessments and participants here are asked to learn a list of pairs and when one is presented the participant must recall the paired word. More often, than not priming experiments, priming experiments are done with paired associates. So, this has I will end here this has been a very detailed session and in fact, I well it has taken up more of an hour more than an hour, I am sorry for that.

For further inputs, if there is a lot more that remains to be said when we talk of memory, Professor Sharba Bandyopadhyay will be talking about the neuroscience of memory I, that is why I did not touch on it there is lot more to be said. So, what I will do is we will probably share with you, some of the other notes and links for memory studies.

So, thank you.