Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Basic Cognitive Processes

Lecture – 31
Memory - III

by
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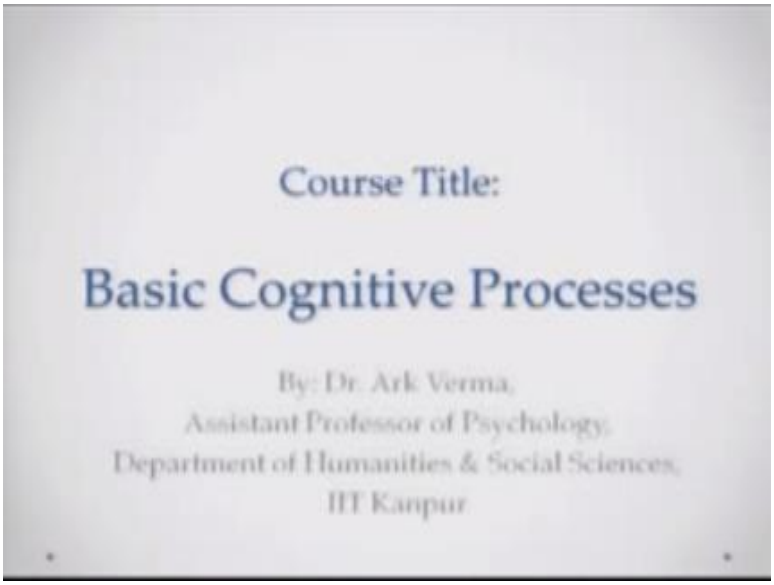

Hello everyone welcome to the course basic cognitive processes I am Dr. Ark Verma from IIT Kanpur.

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we have been talking about aspects of memory in our recent lectures we covered sensory memory in verse of this series and we talked about short-term memory in the last lecture. Today I am going to talk to you about another aspect of short-term memory let us say a rethought version of what short-term memory will be doing and the name given to this is called working memory. Now the concept of working memory as opposed to short-term memory was put forward by Alan Bradley. Alan Bradley one of the most influential researchers in memory basically proposed that short-term memory processes must be dynamic and they must also consider the number of components that can function separately.

Now one of the ideas why Alan Bradley must have thought so is that short term memory or let us say if you liken it to the RAM of your computers it deals with a lot of information it deals with a variety of information and it manipulates these variety of information whereas the whole concept of short-term memory might be taken to think, that it just passively stores information for some time before it passes on to the long term memory. So these were some of the conceptual differences which probably led to the formation of this concept of working memory. So according to this idea with this in background it can be probably proposed and Alan Bradley

might have thought that, the digit span task must be handled by a separate component altogether while comprehending of the paragraph.

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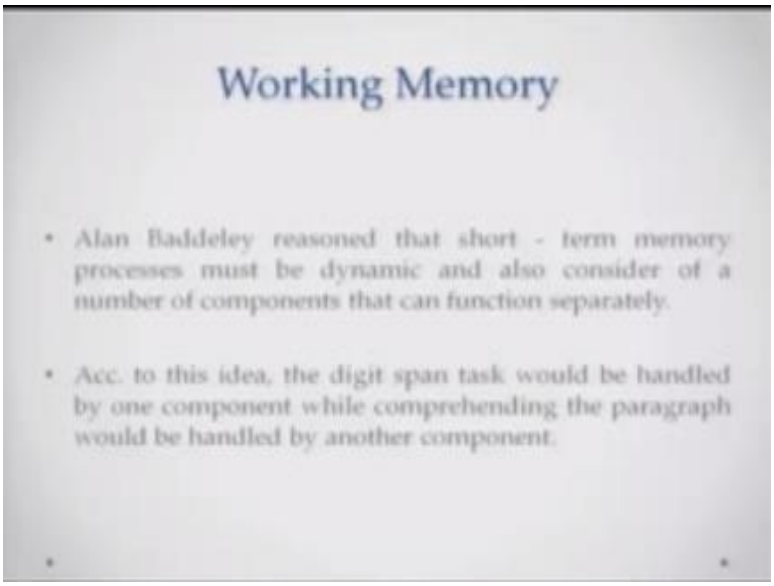

If you remember speakers study as well might be handy by a different component.

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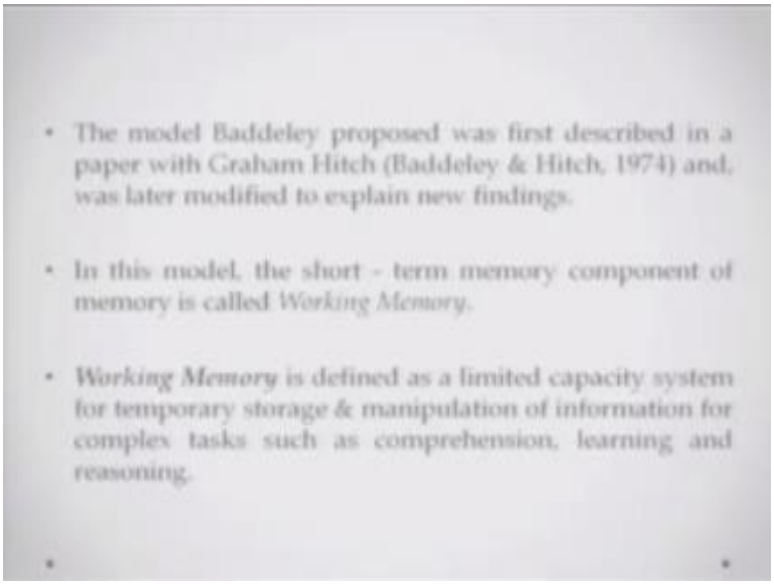

The model badly was proposing was first described his paper by Graham hitch and the paper was written in 1974 badly and hitch and it was later modified, so later versions and more recent versions have also come of that model but this model basically says that short-term memory it has a very specific component called working memory and working memory they define as a limited capacity system for temporary storage and manipulation of information and this temporary storage and manipulation of information is basically dependent on complex tasks such as comprehension learning and reasoning whatever, the person might be called upon to do. Whatever task you have at hand you probably take it to what is called working memory.

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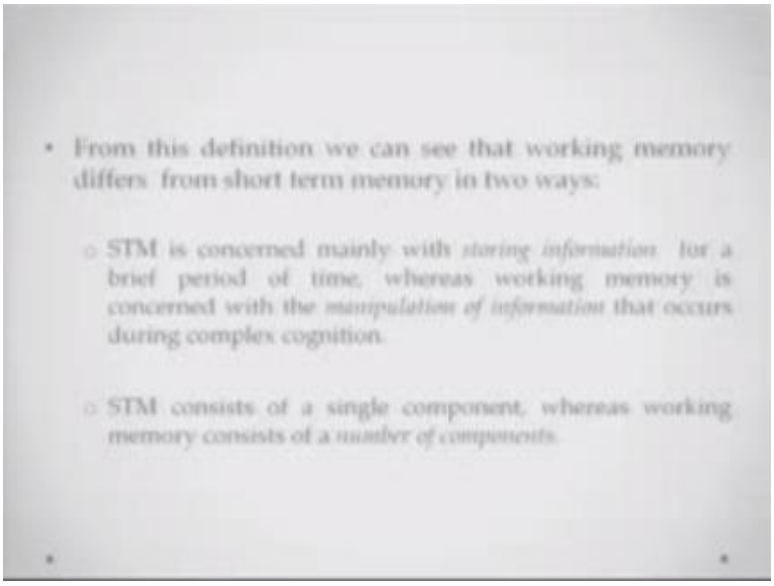

From this definition we can say that we are actually talking of a more dynamical system as opposed to what the initial conception of short-term memory was, so two differences might be pointed out that why short-term memory is concerned primarily with storing information manipulation of information is basically the job of working memory, also short-term memory has been thought of as consisting of a single component why in working memory you can think of different independent components, different components working in an independent fashion though they might be interconnected as well .

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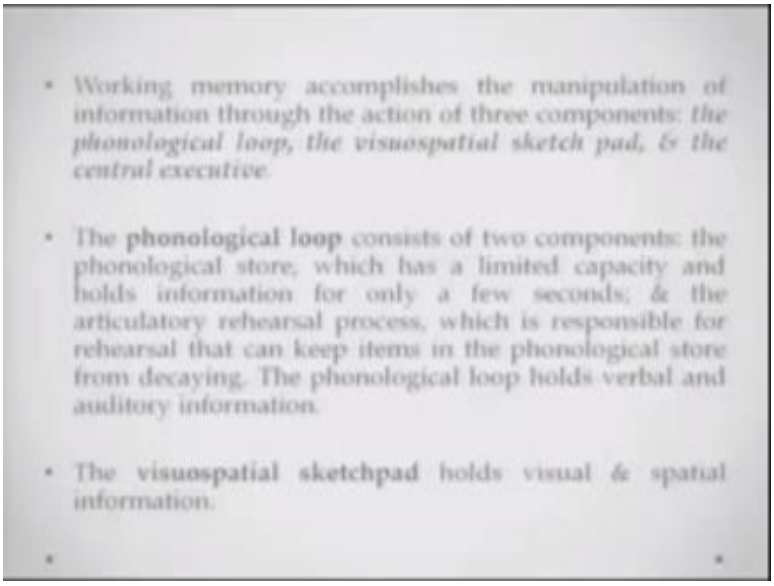

So working memory as such again given this new conception accomplishes the manipulation of information through the action of three components. As proposed by Alan Bradley the components are the phonological loop the visual spatial sketch pad and the central executive phonological loop, it is supposed to consist of two components it consists of the phonological store which is a limited capacity store and holds information for only a few seconds and the articulator rehearsal process which is responsible for the rehearsal that can keep items in the phonological store from decaying. Suppose somebody told you a phone number to memorize and before you find a pen or before you find you know your cell phone just now you know quickly type that number and do you might want to keep repeating that, so that the information this verbal information or let us say this phonological information is maintained in the phonological.

This for logical so as I already said holds verbal that is language like an auditory information that is the one of sounds, the visual spatial sketchpad on the other handholds visual and spatial information anything about the visual world anything about location of objects those kind of things if you are given a task of keeping three bags in the boot of your car and you have to just you have just been asked that do you think these three bags will fit in the boot of my car you might want to really visualize what the boot of your car looks like and try and fit these things in

an imaginative fashion before saying yes to this question. This kind of information this kind of manipulation is basically suppose we achieved via the use of this visual spatial sketchpad. The third component basically is the Central Executive.

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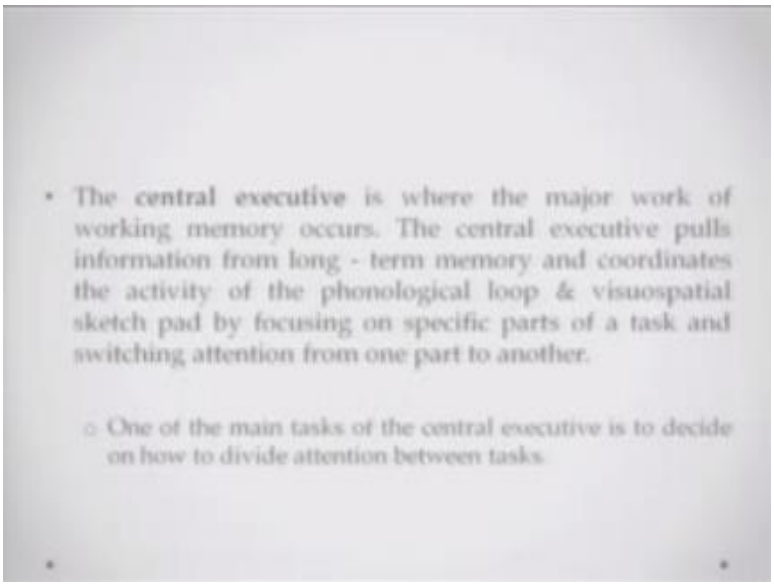

When they are in the major work of the working memory occurs the central executive pulls information from the long-term memory and coordinates the activity of the phonological loop and the visual spatial sketchpad by focusing on specific parts of a task and switching attention from one part of the task to other. Suppose it is like desk secretary where you go and give the task and the secretary decides where this particular file needs to go to, whether it needs to go to phonological loop or it needs to go to the visual spatial sketchpad. So one of the main tasks also this one illogically loop is to decide how to divide attention being in between two tasks.

So if you are given a task to working memory the Central Executive is the process that will decide whether and how this task is supposed to be handled which parts of the task will be handled by the phonological loop and which parts of this task will be handled by the visual spatial sketchpad. Here you can see a graphic representation of the phonological loop.

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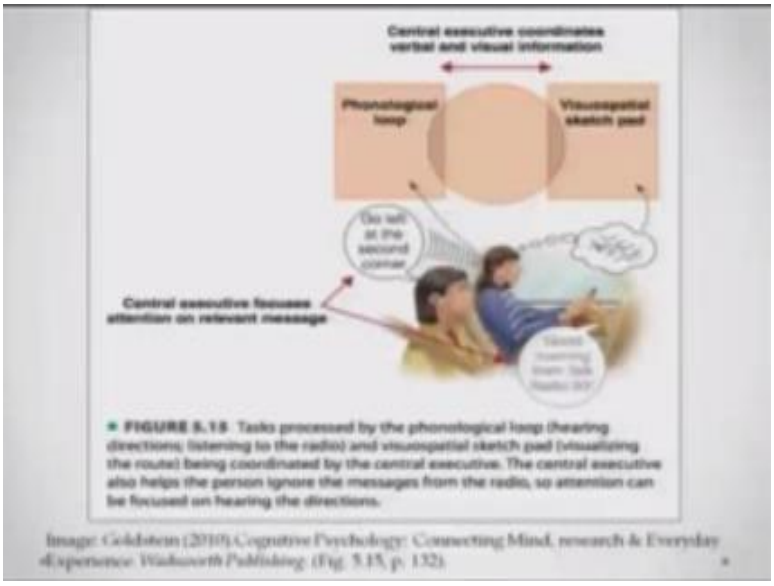

And the visual spatial sketchpad you will see that the circle which is the central executive it is kind of coordinating between those these two things, an example given from in this figure by Goldstein is basically when you are kind of you know listening to instructions and sales driving the car, you are listening to nurse exchange and maintaining them in your phonological store while you are actually visually and spatially coordinating the car on a different path according to whatever the instructions are being given to you. So this is one very dynamic kind of an example wherein you are basically using both the phonological loop and the visual spatial sketchpad at the same time in the same task.

Let us elaborate a little bit on the phonological loop what are the different effects what are there search findings in this, so the phonological loop one of the major findings.

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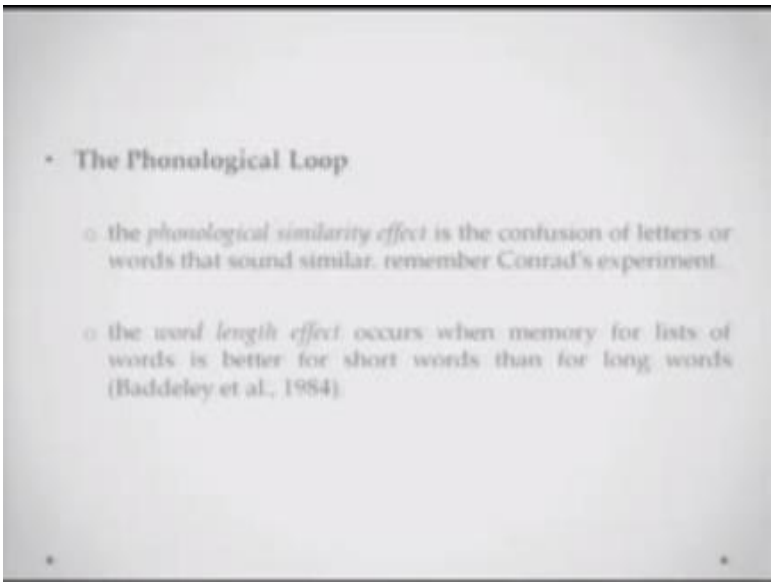

In the related the phonological loop is called the phonological similarity effect which is basically that, if you are kind of trying to maintain letters or sounds which are very similar those might be confused with each other. If you remember Conrad experiment he did this experiment with the people who were asked to remember digit and who were asked you remember let of the English alphabet and they were confusing they are making some mistakes but more importantly the mistake was basically being made, on those letters which sounded very similar to each other like the s and the F example that was there. Also another effect about the phonological loop is the word length effect, word length effect occurs when memory for the list of words is better for short words and than for long words if.

I give you a list of words to remember and some are like three or four letter words and the others are five or six or seven letter words, maybe then the typical finding is that the memory for shorter words is better, than the memory for longer words. Another important phenomena is called article entry separation articulator separation is one of these ways.

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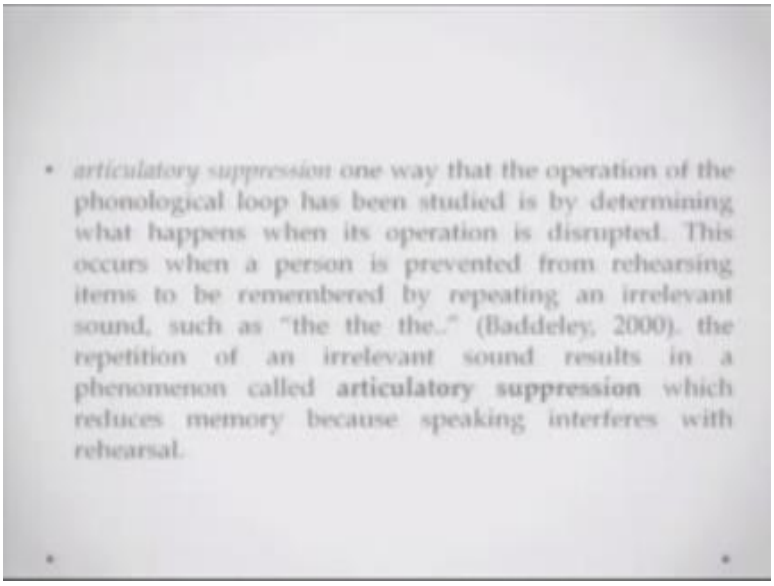

Wherein the operation of the phonological loop can be disrupted, so this occurs when a person is prevented from rehearsing some verbal information by asking them to repeat an irrelevant sound, so if I have to ask you to remember few phone numbers maybe a list of phone numbers but I say okay you have to remember, this still vital during remembering this you still have to keep saying any error and sound like that or whatever so what happens here is that because you are kind of repeating these irrelevant sound, it blocks the rehearsal space for the numbers that I have given you and that results in what is called and what has been described as Article III separation. You cannot maintain too much verbal information at the same time in the phonological that is why this particular phenomenon occurs.

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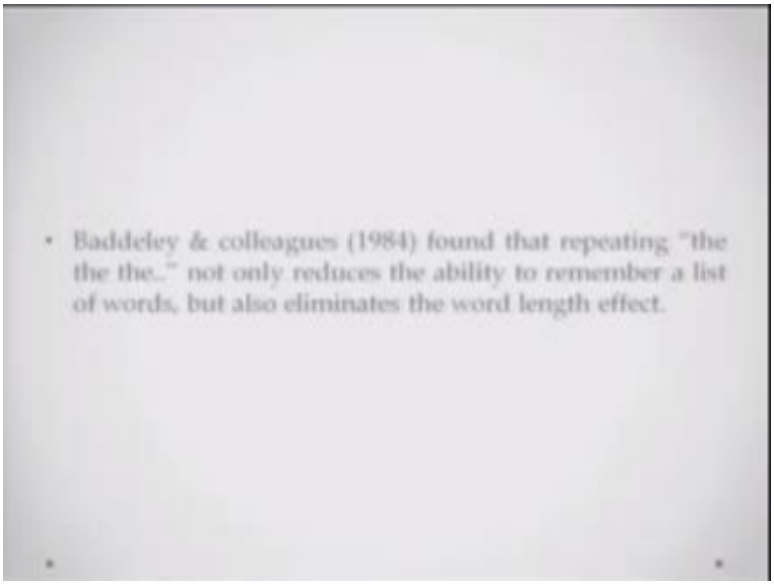

Baddeley in colleagues they basically found and they did this a very simple experiment that repeating the, the, the, the, and continuously not only reduces the ability to remember a list of words but also eliminates the word length effect.

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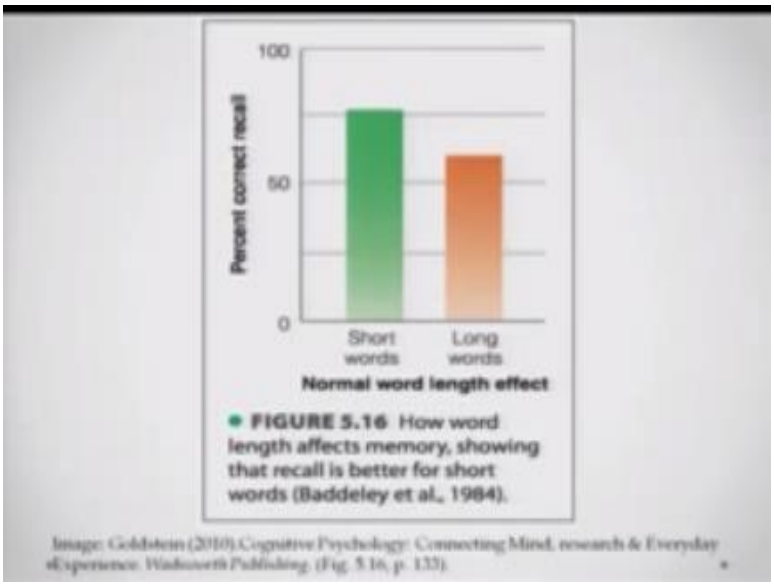

Here you can see the typical word length effects they were percentage recall of shorter words is much higher than longer words.

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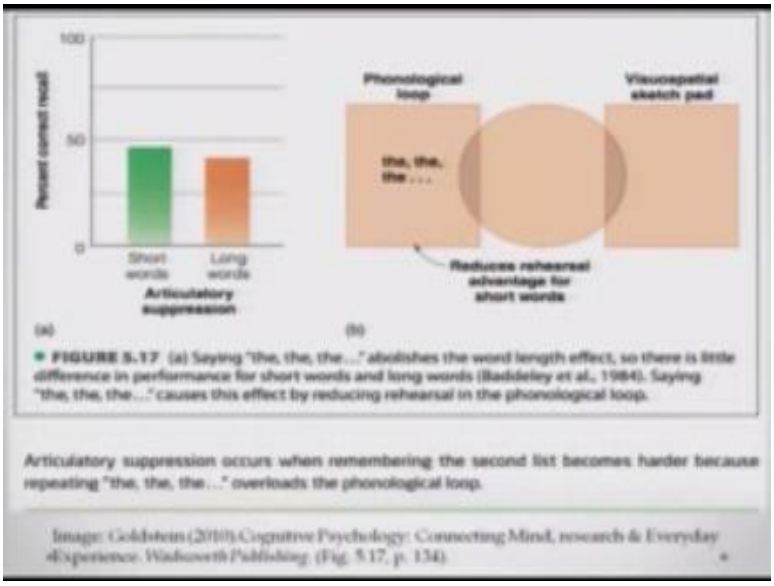

But when participants are asked to repeat the continuously you see that the advantage for the shorter words is completely you know or almost gone and the total percentage of recall is almost equivalent to what it is for the longer words.

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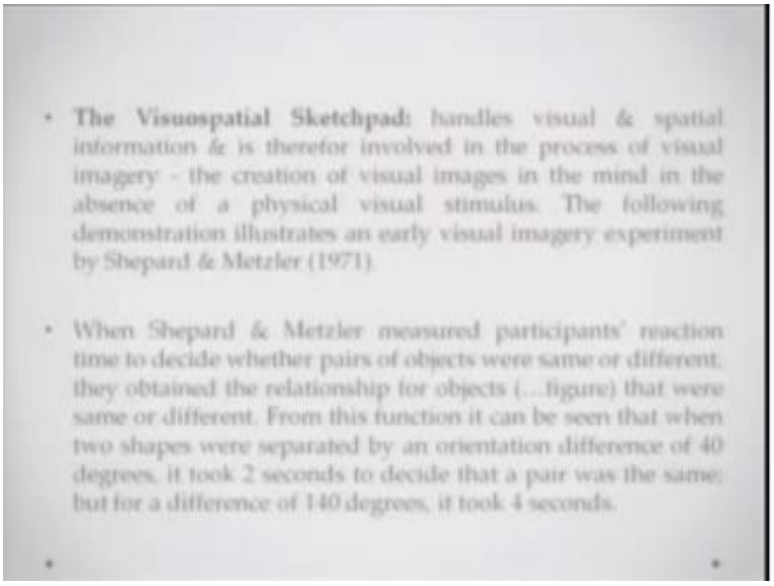

Coming to the visual spatial sketchpad, now the visual spatial sketchpad I handles visual and spatial information and is therefore involved in the process of visual imagery you know, the example I gave if you have if somebody asks you that whether these three or four bags will fit in the boot of your car, you will have some memory of how the boot of your car looks like what are its dimensions and what you will try to do is you will try to fit each of these bags imaginarily in an imaginative way in your car and you will say that okay maybe this bag will be put horizontal this bag will be, what vertically maybe I will slam this bag over this one and this is how it will fill up, so this is basically a typical example of visual imagery and visual imagery is obviously achieved by what is called the visual spatial sketchpad.

Now another very interesting and very famous experiment about visual imagery was done by a shepherd and Metzler in 1971, now Schaefer and Meir measured participants reaction time to decide whether a pair of objects were same or different, so they made these imaginary objects and the task of the participants was to tell whether the two objects are the same or they are different. So from this function they are trying to see how the partnership perform it could be seen, that when two shapes were separated by an orientation difference of around 40degrees it took two seconds for the participants to decide that the pair was same and but for a difference of

140degrees it took around four seconds. So the whole idea is that say first I will show you the figures the figures are like this.

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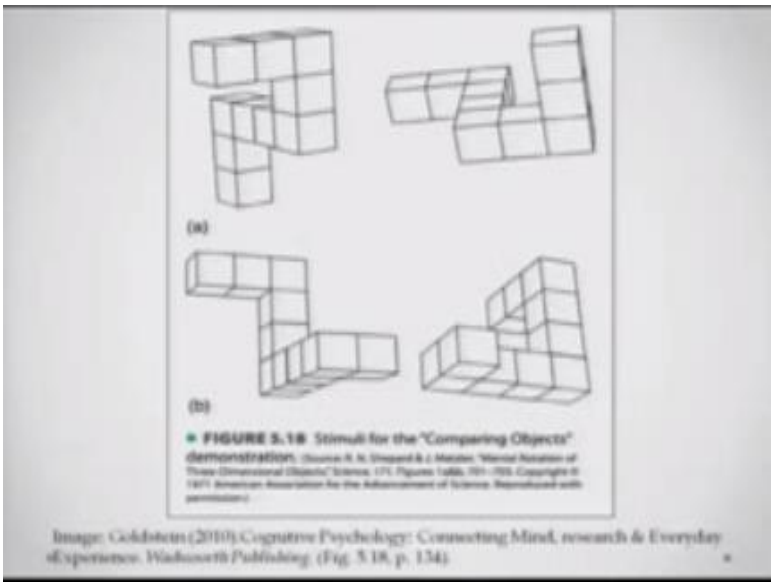

So if I give you know one pair in panel A and the other pair in panel B what you have to do to achieve this task is basically try and mentally rotate the first figure and finally see whether it resembles the other figure in panel B or say, for example if you to try and rotate the first figure in panel B and see whether it matches the second figure in panel B. So you will have to maintain this in your memory and then rotate it and then try and match it with this figures with the second figure and here you can see as the number as the angular difference between A and B.

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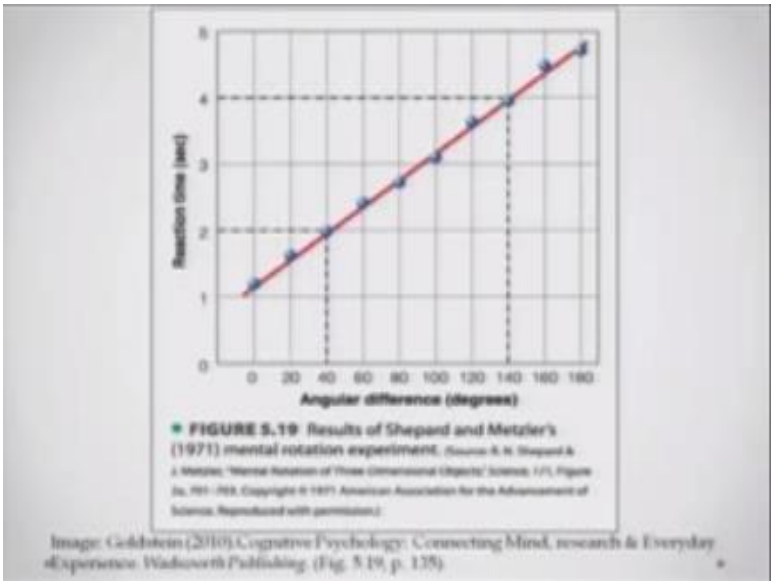

As orientation differs the time taken to recognize or the time taken to say whether that is the same or different also increases.

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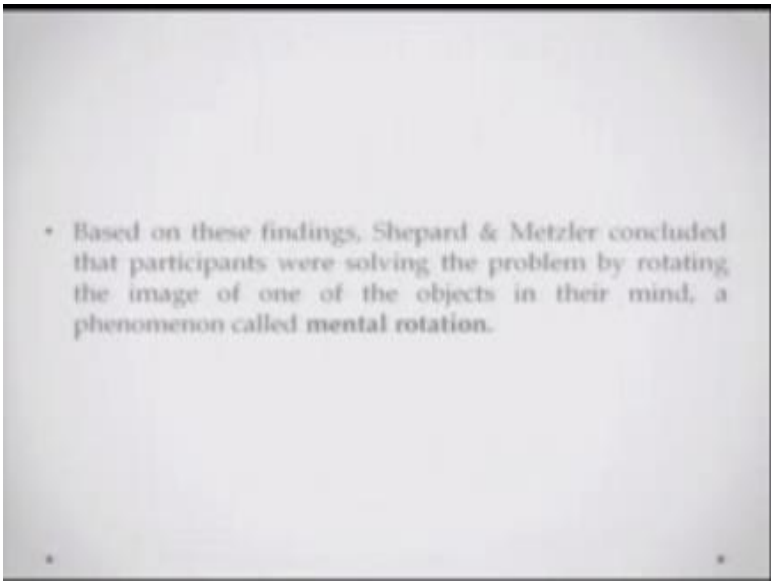

Based on these findings Shepard in Metzler concluded that participants was following the problem by rotating the image of one of the objects in their mind a phenomenon which was later named mental rotation.

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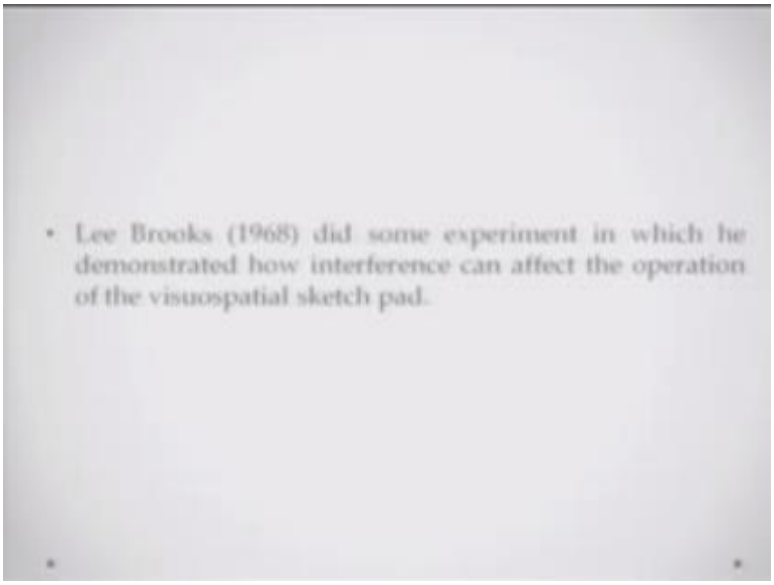

Now Lee Brooks also did some experiment in which he demonstrated how the interference can affect the operation of the visual spatial sketchpad.

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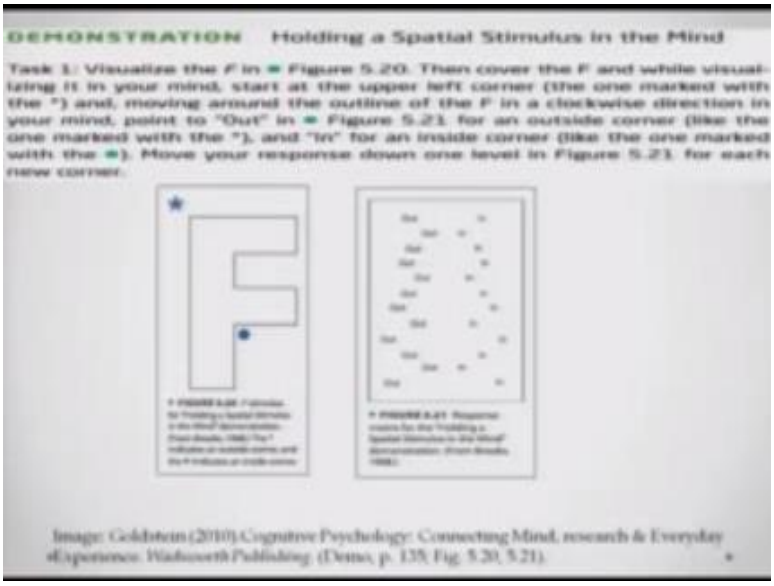

So what he did was he the task was something like this there are two figures here 5.20 one from Goldstein's cognitive psychology now the task is basically to visualize the figure F in 5.20 maintain it then you cover it while visualizing this in your mind still and then what you do is you start at the left most corner, left top corner and actually you move around to the around the outline of the F and what you have to do is for an outside corner say in and for an inside corner say out. So you have to kind of move around the trajectory of this figure and say in or out take that decision.

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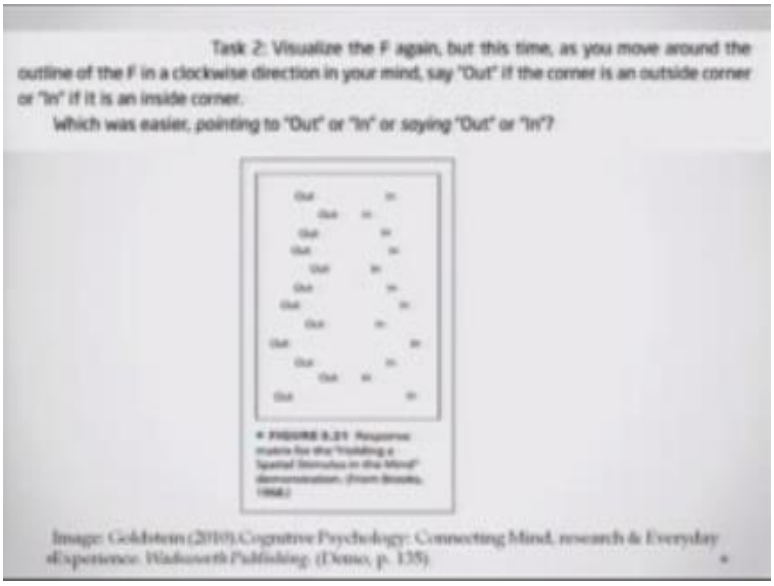

Now a different task could also be that you visualize the F again but this time you move around the outline of the F in a clockwise direction and in your mind say out if the corner is an outside corner in if the corner is an inside corner remember, you doing the opposite of this in the last task.

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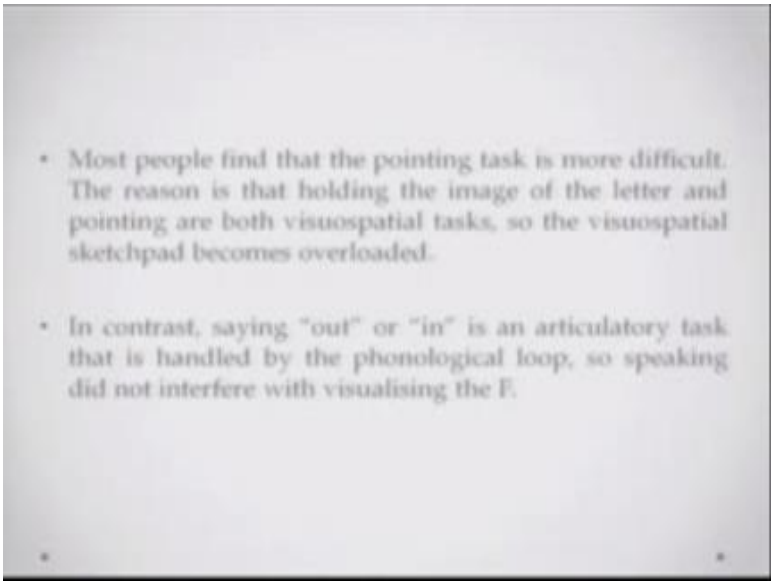

They asked many people to do this task and they found that most people find the pointing task much more difficult, the reason is that holding the image of a letter and pointing are both visual spatial tasks. So the visual spatial sketchpad in that sense becomes over loaded, in contrast saying out or in an articulate task that is handled by phonological loop, so speaking does not interfere with visualizing F if you remember again I will remind in this first task.

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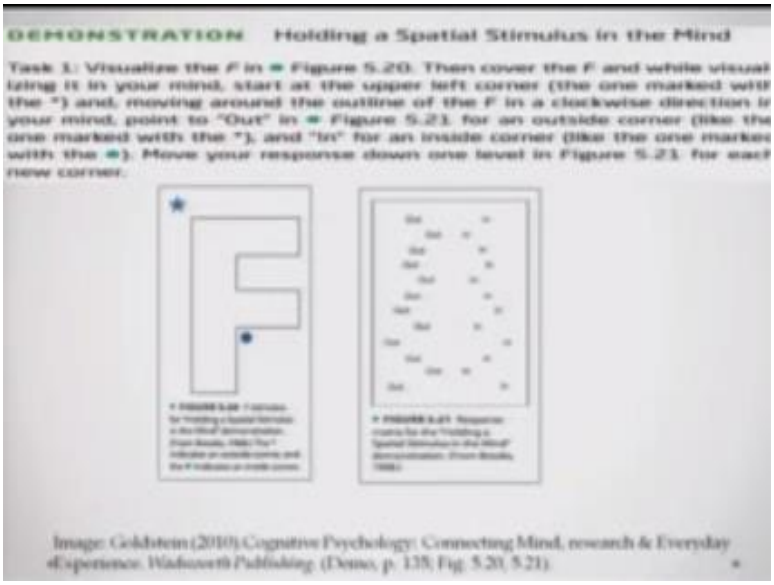

You have to mentally point out or in where in this one you have to say outer so that is why in the second one the visual spatial sketchpad, does not really get overloaded because some of the information is verbal and has shifted to the phonological store, now coming to the central executive now the Central Executive is the component that makes.

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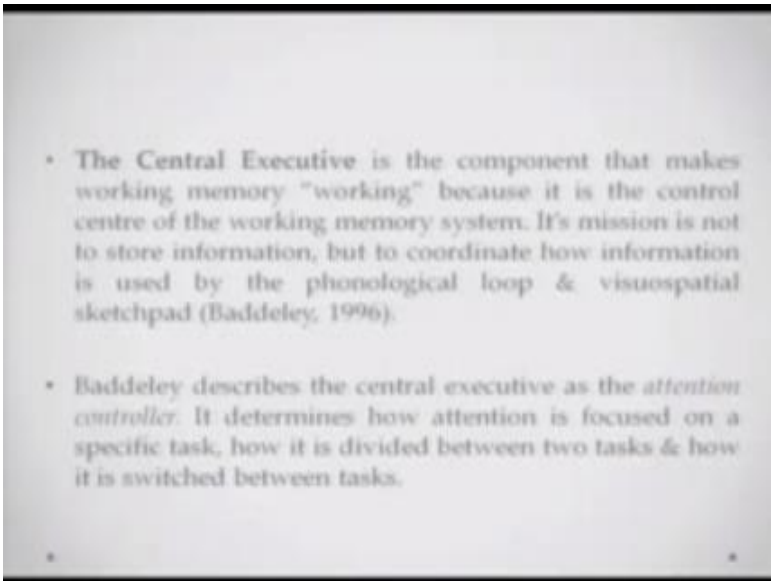

The working memory actually working you are describing that sometime back, so it is the control center of the working memory system it is may is not to store information but to coordinate, how information is going to be used by the two working components. Now Bradley describes the central existing as the attention controller, he says that this one determines how attention will be focused on a specific task and how it will be divided in the two tasks depending on the task demand and how easy or difficult a task will be.

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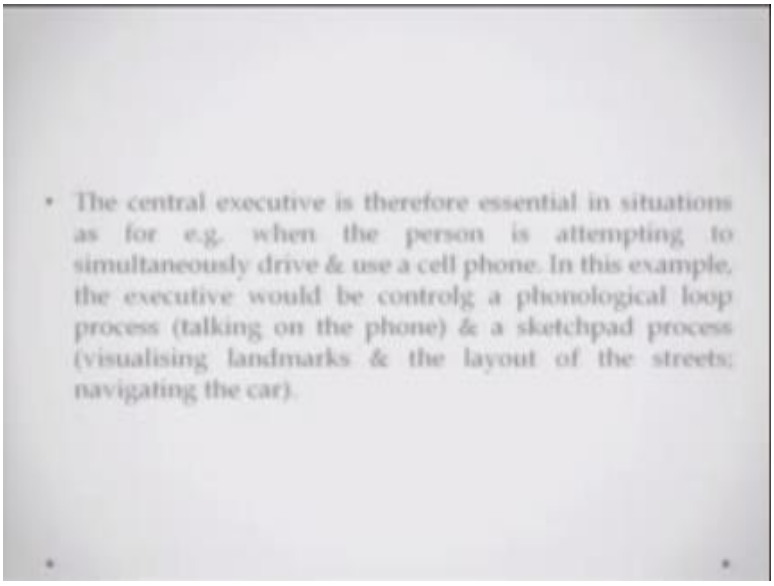

Now the Central Executive is therefore essential in situation say for example if a person is attempting to simultaneously drive and use a cell phone, now that it is advisable to do so somebody is trying to do that then a Central Executive is basically and it will spring into action, now in this example the Central Executive would be controlling the phonological loop process that is talking in the phone, the sketchpad will basically be doing the navigation which is basically identifying the landmarks and the layout of the streets and taking the car off one of.

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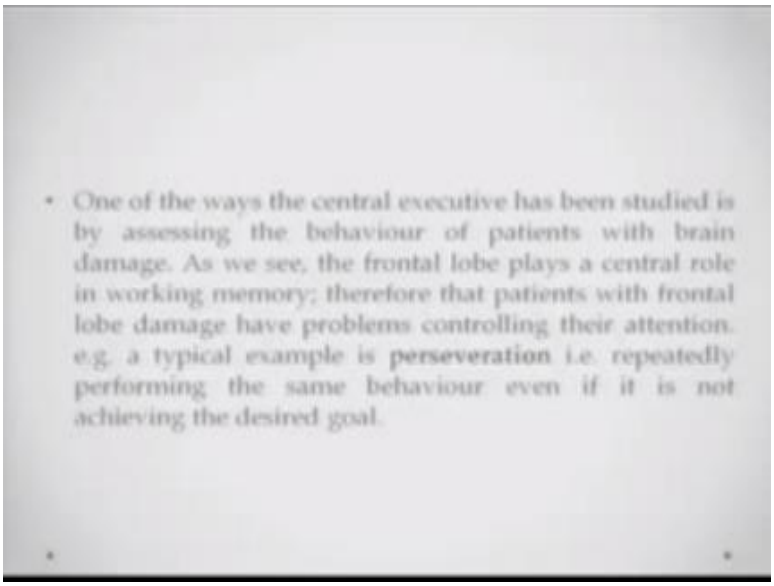

The ways the Central Executive has been studied is by assessing the behavior of patients with brain damage as, we have seen the front all o be is supposed to play a central role in working memory therefore patients with frontal lobe damage have found to be having more problems with attention control. For example a typical example would be perseveration that is repeatedly doing the same behavior again even if the one does not achieve the desired goal.

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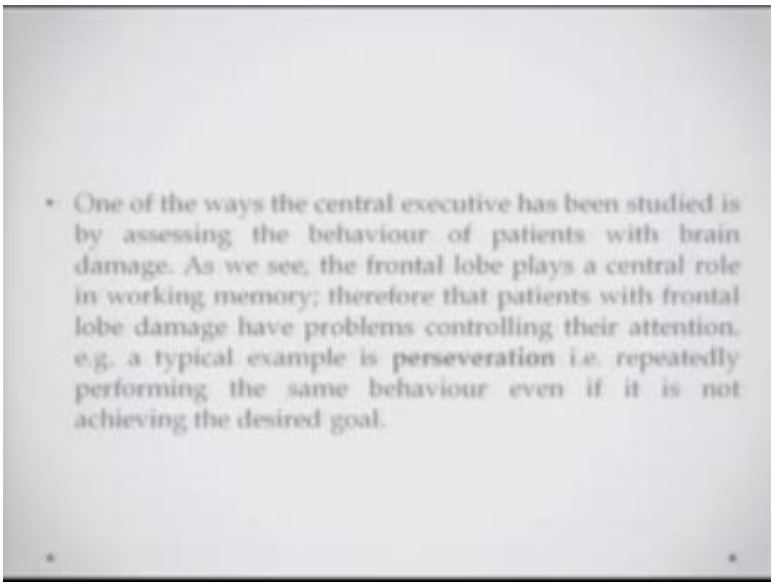

Now say for example I will give you an example a problem that can be easily solved by a rule that pickup the red object, a person with friend lobe damage might be responding correctly on each trial as long as the rule stays the same, as soon as you change the rule the person with front al lobe damage will find it very difficult to adapt to the new rule and it will continue doing the same task again and again we will continue picking the red object again and again, even though the rule has already changed. So they have why is, this because they are having difficulty in changing their attention from the first rule to the second rule that is what the problem here is.

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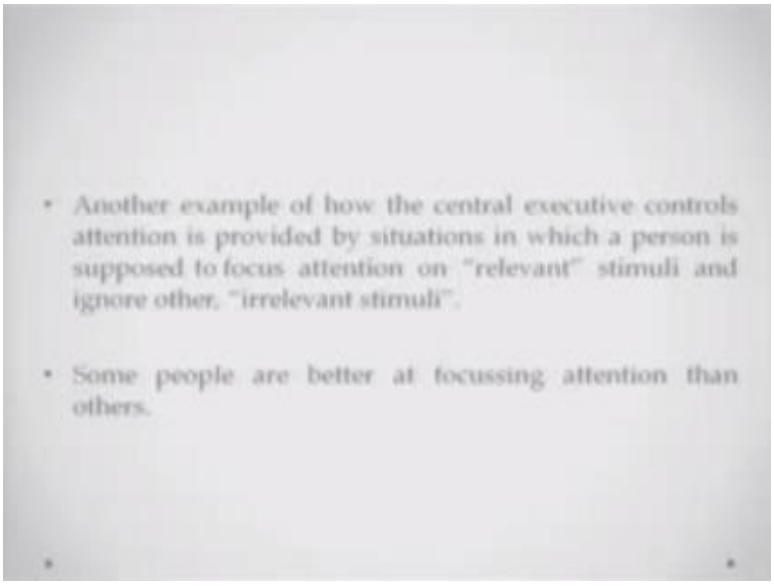

Another example of how the central executive controls attention is provided by situations in which a person might be focused you know might be supposed to focus attention on some relevant stimuli by ignoring the other irrelevance, in visual search kind of a scenario you have to focus your attention on the targets while at the same time ignoring the distracters, some people have been found to be better at focusing attention than some others. Another component here another important aspect here could be the episodic buffer, which also is part of this working memory thing, now the episodic buffer basically you know is something it is basically one aspect of working memory that can hold more than it would be expected based on just the phonological loop or the visual spatial sketchpad.

So for to account for this extra information that are held in the working memory one might even has proposed what is called the episodic buffer.

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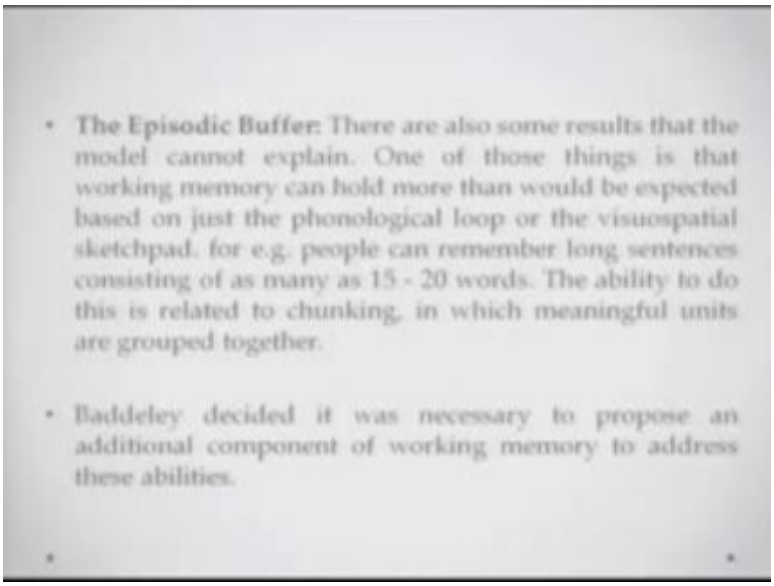

For example people can remember long sentences of consisting as many as 15 to20 words now, the ability to do this is achieved by a chunking which we have talked about earlier in which meaning have been lumped together have been joined together. Now Bradley decided that it was necessary to propose an additional component of working memory like the episodic buffer to address these different kinds of abilities which are not being explained already by the phonological store and the visual spatial sketchpad.

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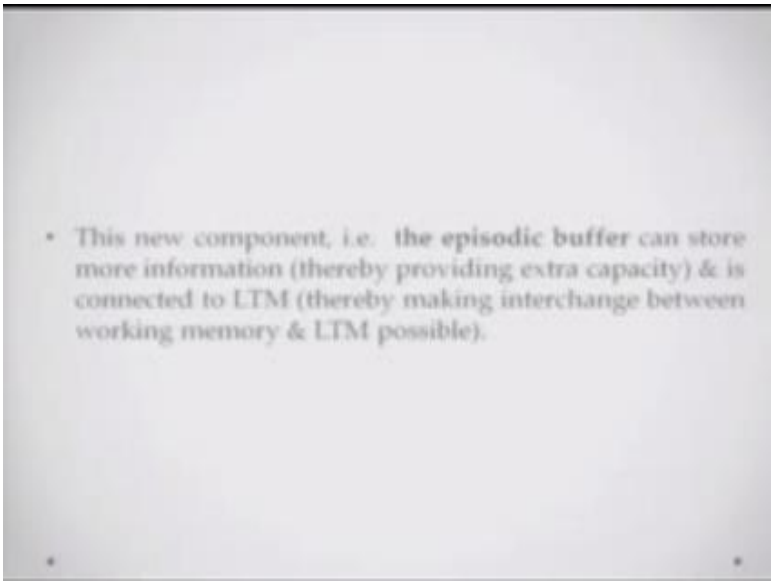

This new component that is the episodic buffer can store more information thereby providing extra capacity and it is already connected to the long-term memory, thereby making this exchange between long-term memory and working memory possible because even if you are working at new information even if you are manipulating new objects in the world which you are being given you are certainly drawing upon the scale and experiences that you've gained and that is stored in the long-term memory. Here is the complete model of a Bradley is working memory model.

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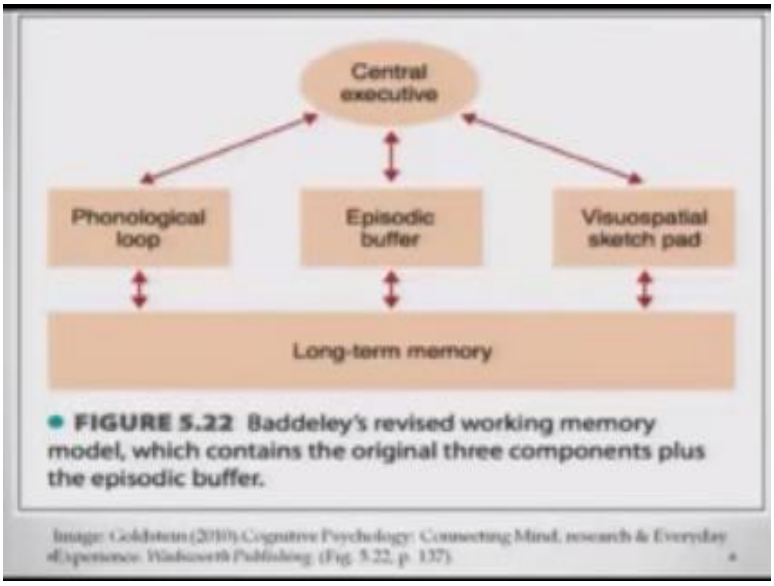

And hearing you can now see all the four components, so there is the Central Executive, there is the phonological loop, there is the episodic buffer and the visual spatial sketchpad and each of these in their own way will interact with the long-term memory, this is a complete model which has been used to explain so many findings, so many research findings from working memory.

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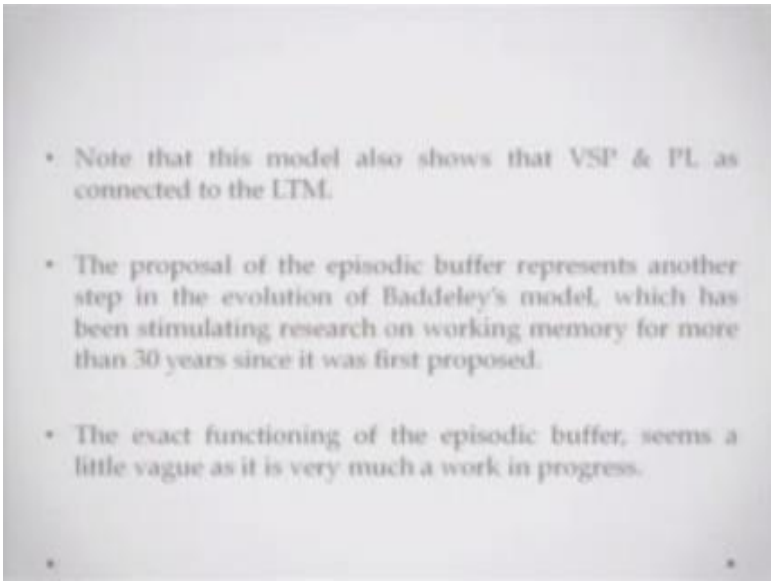

Now note that this model also shows that visual spatial sketchpad and phonological Loup also are connected to the long-term memory. Now the proposal of the episodic buffer represents one step in the evolution of bad lease model because the initial model did not have the episodic buffer provided for, this has been stimulating research in memory for over 30 years since it was first proposed in1970s.

Now the exact functioning of the episodic buffer still seems a little vague it is not really been completely specified but it is supposed to be a very important aspect. Now let us come to how the working memory is specified in the human brain, now there have been quite a few ways in which people wanted to study how does memory really exist in the brain or how do you know look at the brain and say something about working memory. Now four of these things have been done say for example analysis.

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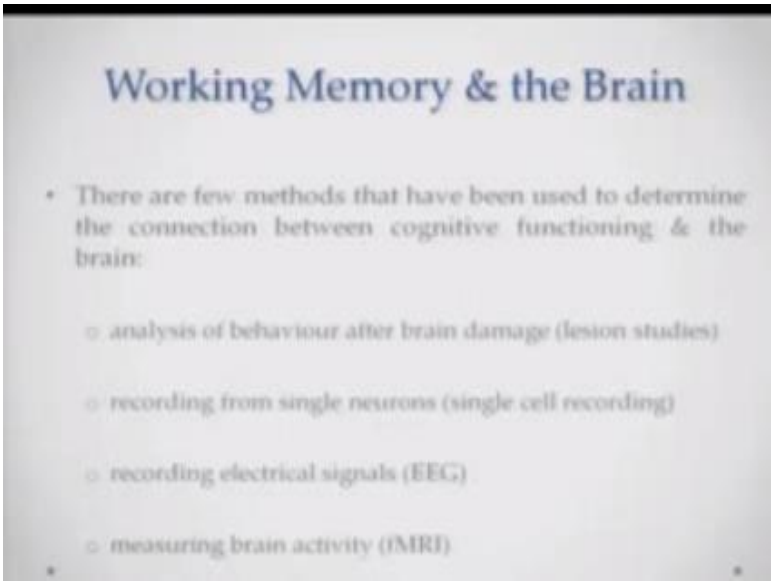

Of the behavior after brain damage when people have brain damage in areas which are supposed to be related to a memory per recordings have been done from single neurons single cell recordings, this is basically limited to animals and not really humans, then EEG signals which is electro encephala graph if you remember the methods chapter I have talked about that if you remember the method chapter I have talked about it might be a good time to go back and refer to them.

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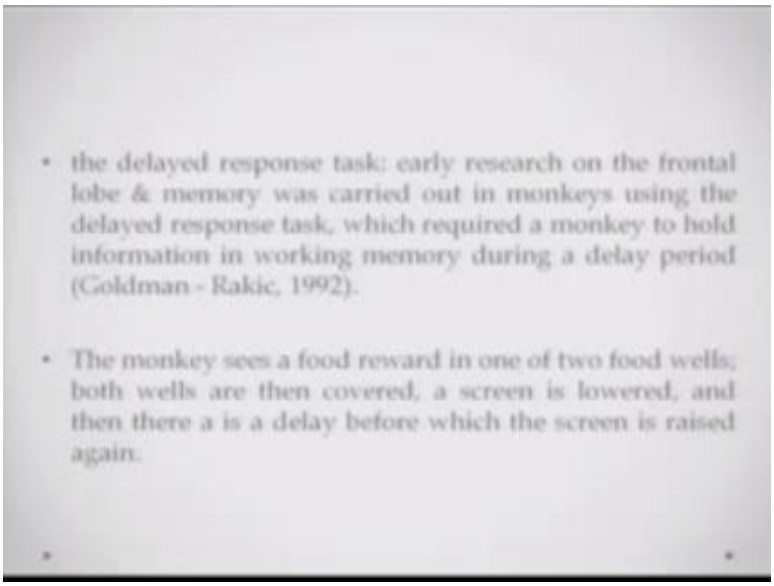

Now one of the tasks was done with the monkeys so the delayed response tasks, now early research on frontal lobe and memory was carried out in monkeys using what is called the delayed response, to us basically this task required the monkey to hold information their working memory during a delay period, so that is why delayed response task.

Now what happens in this task is the monkey sees a food reward in one of two food bills the monkey is inside the cage there are two food wills outside the monkeys cage and the both wills are covered the monkey sees that the food reward is kept in one and then they are covered and then a screen is lowered so that the monkey cannot see you know where this is so you cannot maintain that information and then after this delay the screen is raised.

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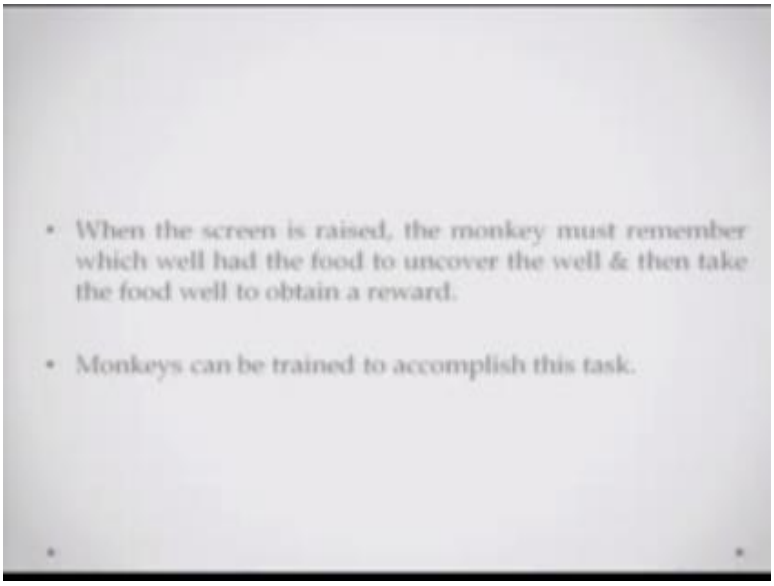

But the monkey has to do is that it must remember which of the food well had already received the food before it was covered and then uncovered that well and take the food out and eat it that is very simple and monkeys can be trained to occur this to us.

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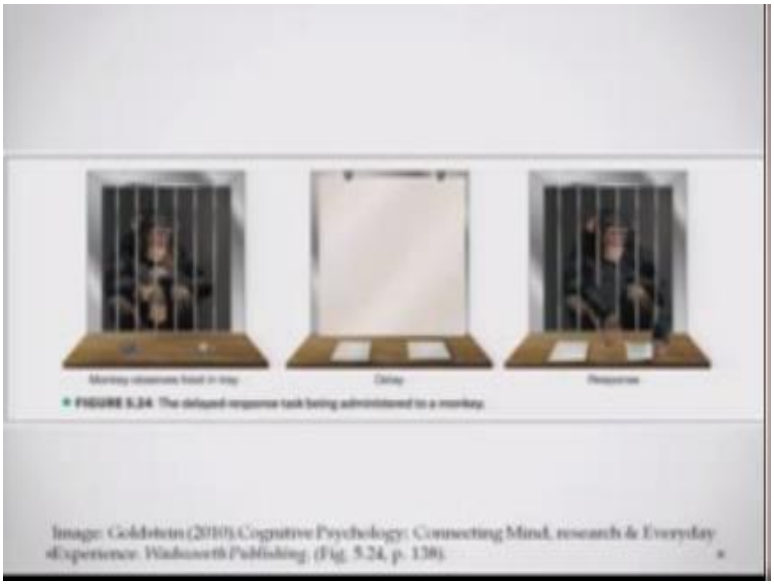

This is the setup of this particular task.

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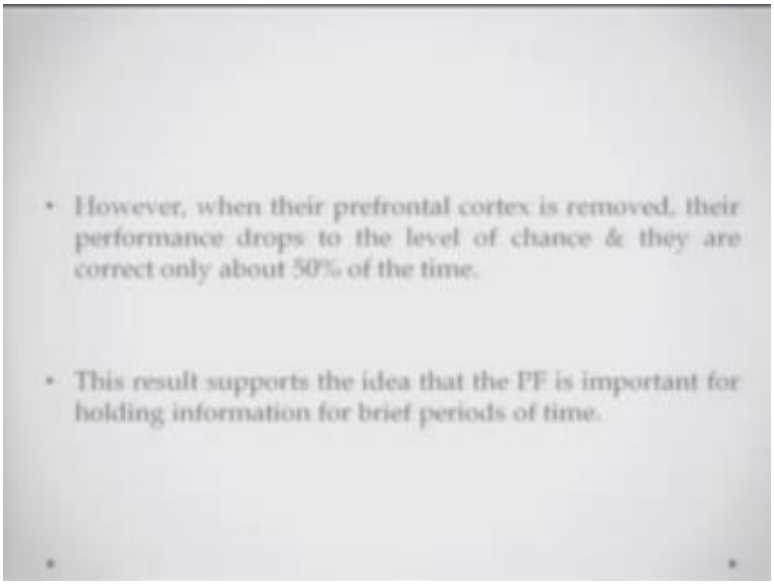

Now however when the prefrontal cortex was removed their performance monkeys performance dropped to the level of chance and they were found to be correct only 50% of the time, now this basically supports the idea that the prefrontal cortex is very important for holding information for brief builds of time does.

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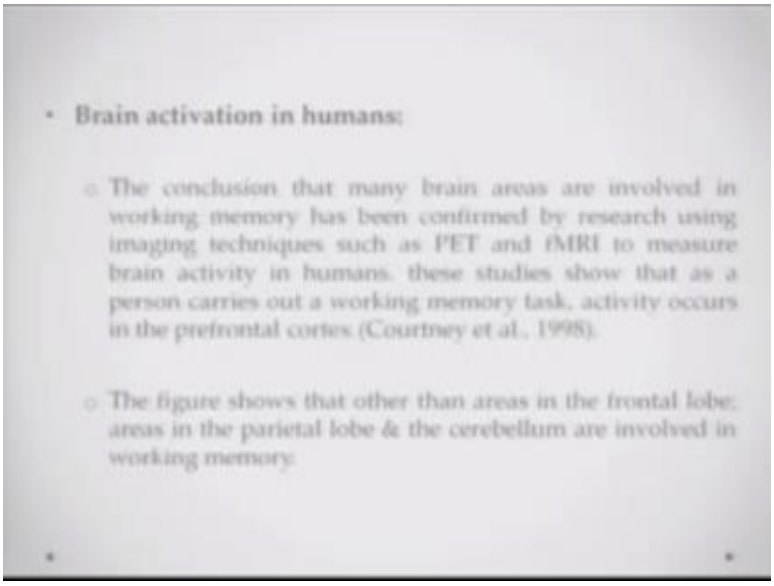

This happen in humans as well is these the same areas in humans as well, so people have also investigated the brain activation in humans. Now the conclusion that many brain areas are involved in working memory has been confirmed by research using neuro imaging techniques such as PT that is positron emission tomography and functional f MRI and functional MRI, basically the idea is to measure the brain activity in humans in response to tasks which involve memory or working memory.

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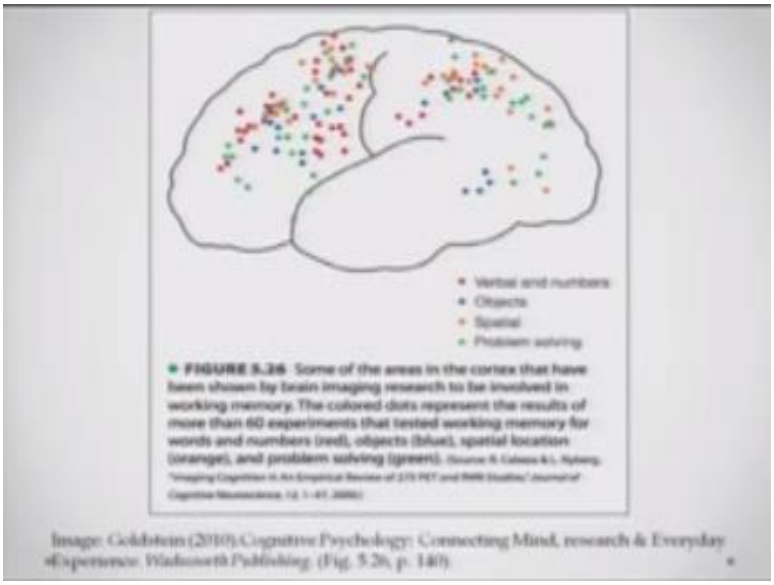

Now here is the figure it shows that what are the different areas found in humans which are found to be involved in memory operation, so you will see that there are particular areas which are involved with verbal and numeric information other areas involved with objects information other areas with spatial information and problem-solving, all of this is very well demonstrated in this figure from Goldstein's book.

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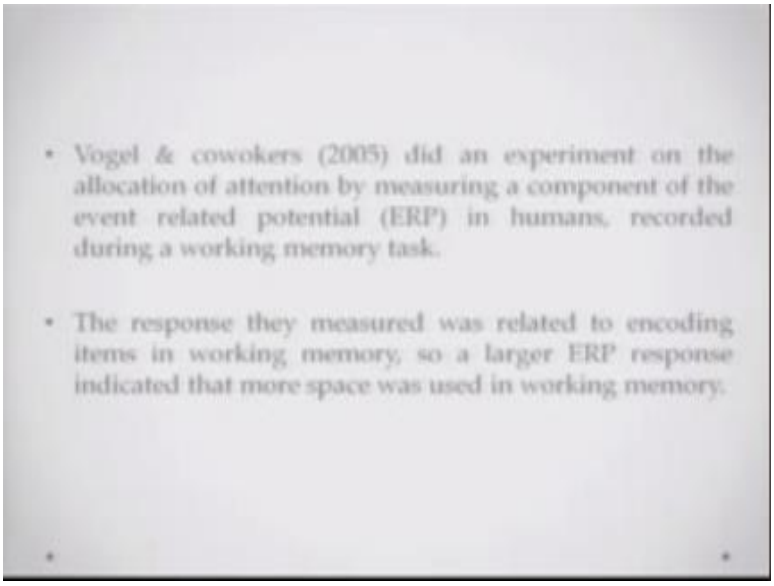

Now Vogel in co-workers they did an experiment on the allocation of attention by measuring a component of a component of ERP in humans which is recorded during a working memory task now the response they were measuring was related to encoding the number of items in working memory, so a larger p response would indicate that more space was used in working memory, so they previous on the basis of previous research they determine that which component generally is involved in working memory and then they were doing this task to see that if the task we are giving involves more or less working memory.

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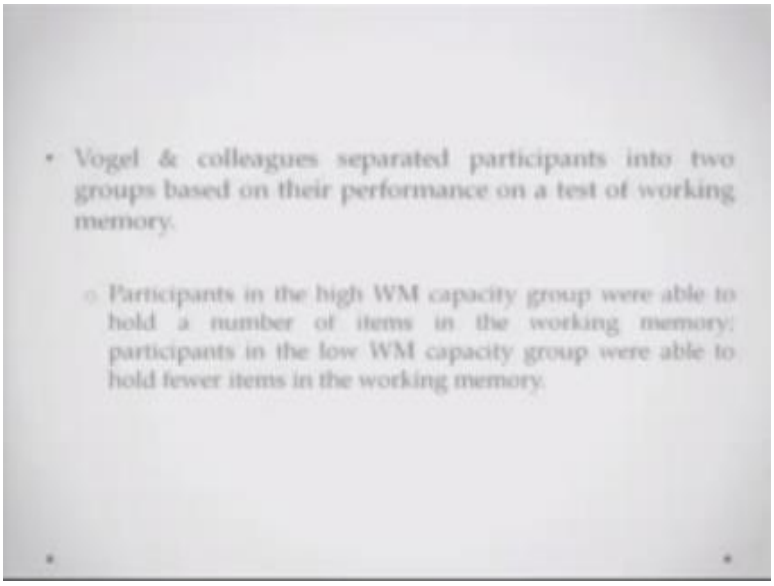

So Vogel in click separated participants into two groups based on their performance on a particular test of working memory, now participants in high working memory capacity group those who had higher working memory capacity were found that they were able to maintain a larger number of items in working memory as compared participants with low working memory capacity.

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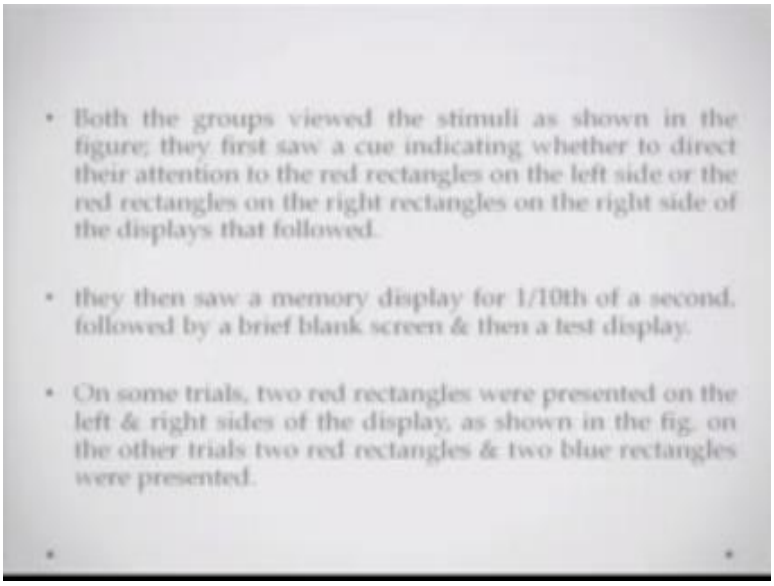

Both the groups viewed this simile as shown in the figure I will just show you the figure right now and they first saw a cue indicating whether to direct their attention to the left side red triangles on the left side or the red triangles on the right side of the displays and then they saw a memory display for around one tenth of a second followed by a brief blank screen and then it was a test display. Now on some trials what happens is that I will just show you the figure.

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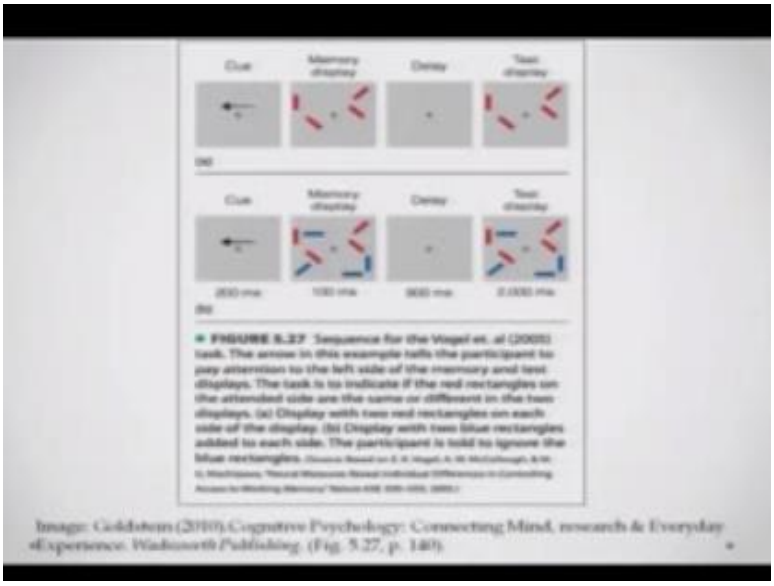

Now so this is the thing there is the fixation cross and there is a cue and then there is the memory display button they have to remember where this red rectangle ekes are and then there's a delay and then there's a test display okay so they have to determine whether an ID rectangle is still there or not now on some press the red and the two red rectangles presented on the left and right side of the screen as shown in the figure here in panel a but on a few other trials two blue rectangles were also presented they were also added to this entire array here you can see trial panel B wearing the blue rectangles have also been added in addition to the already present red rectangles so the amount of work in maintaining this will slightly become harder.

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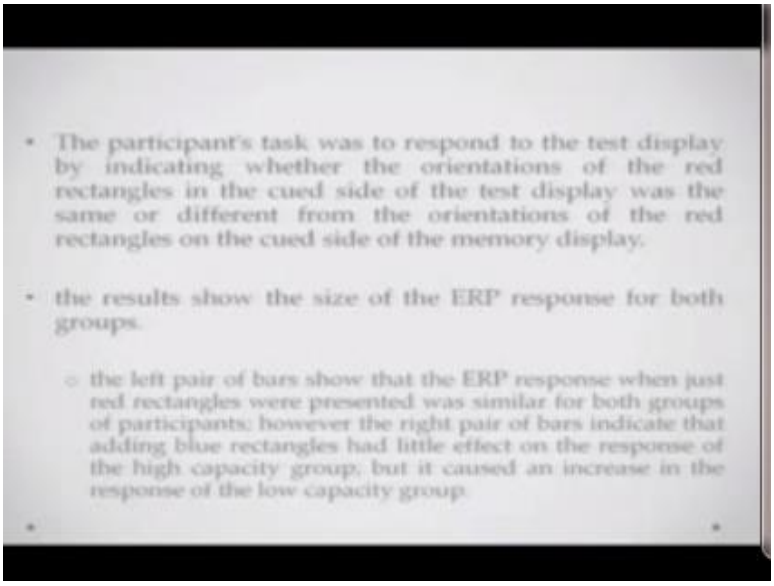

So the participants task here again was to respond to the test display by indicating whether the orientations of the red rectangles in the cued side of the test display was the same or different than of the memory display so they would have to maintain both that it is a red rectangle and it is orientation now the results show that the size of ERP for both groups they'd kind of try and compare the size of the ERP component for both the groups the left pair of bars here shows that when they were two red rectangles it was still a higher response for the low working memory capacity group but a good but a lower response for a high working memory capacity group but if you see in the second panel in the right pair of Merce you will see that addition of two blue rectangles does not increase the response too much in the high working memory chipciti group is but it kind of causes drastic change in the response in the erp response of the low working memory capacity group.

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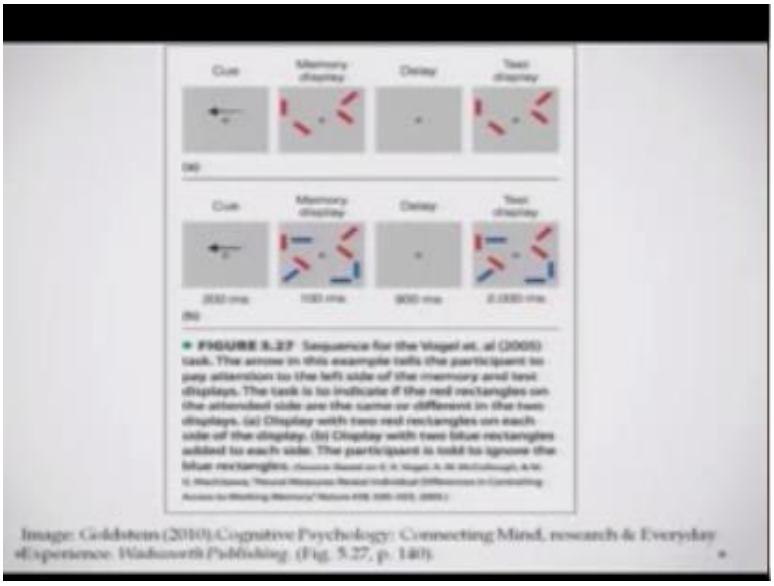

So what is basically happening here is that by addition of two extra red blue rectangles in the display you are increasing the amount of effort in the participants and the low working memory capacity participants because this task involves ignoring the blue rectangles as distracters the low working memory capacity participants are finding it hard to ignore that and that is why they are a RP response to this task the one shown in panel B here is much higher now what is this tells us and now the fact that adding the two blue rectangles had little effect on I am just kind of repeating this so that you kind of follow this.

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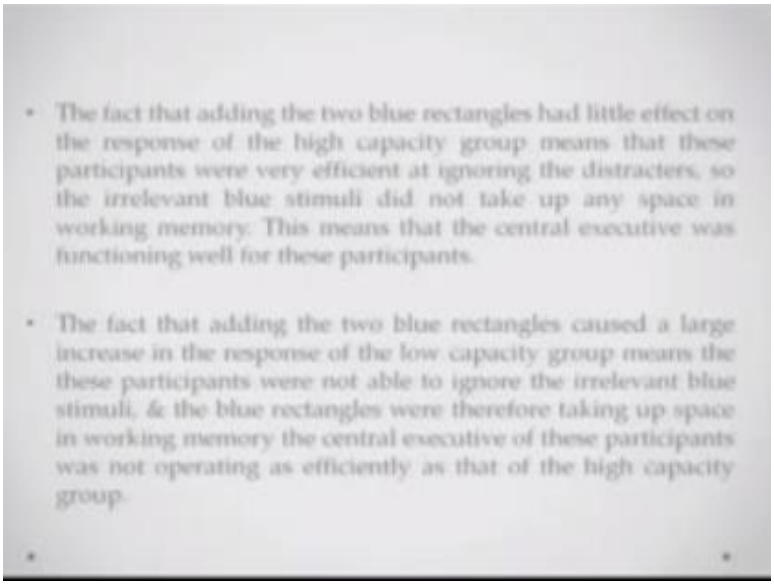

So the fact that adding the two blue rectangle is had little effect on the response of high capacity group means that these participants were very efficient at ignoring the distracters so their relevant blue stimuli did not do much damage and did not take up any space in there working memories this means that the central executors was functioning well for these participants the fact that adding the two blue rectangles caused.

A large increase in the response of the lower working memory capacity group means that these partisans were not able to sufficiently and properly ignore the blue rectangles which were anyways irrelevant to the task whether the task has not changed so it tells us blue rectangles were acquiring a lot of space in their working memory and their central executive was not operating as efficiently as that of the higher working memory capacity group.

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Now what can we conclude from this we can conclude that and Vogel in colleagues basically conclude that some people is central executives might be better than others at allocating attention and at controlling this whole workflow information during a particular task so I think that is all about working memory and in the next lecture we will talk about some other aspects of memory thank you.

Acknowledgement

Ministry of Human Resources & Development

Prof. Satyaki Roy
Co – ordinator, NPTEL IIT Kanpur

NPTEL Team
Sanjay Pal
Ashish Singh
Badal Pradhan

Tapobrata Das

Ram Chandra

Dilip Tripathi

Manoj Shrivastava

Padam Shukla

Sanjay Mishra

Shubham Rawat

Shikha Gupta

K.K Mishra

Aradhana Singh

Sweta

Ashutosh Gairola

Dilip Katiyar

Sharwan

Hari Ram

Bhadra Rao

Puneet Kumar Bajpai

Lalty Dutta

Ajay Kanaujia

Shivendra Kumar Tiwari

an IIT Kanpur Production