Advanced Cognitive Processes
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Lecture – 06
Knowledge – V

Hello and welcome, I am doctor Ark Verma from IIT, Kanpur and we have been talking about knowledge in this course on advanced cognitive processes. Now, I will try and make you remember what else we have been talking about. So, we started talking about knowledge ah when we started talking about what a concept is, we started talking about what are the various ways people use concepts, what basically does a concept afford us, how does it afford us to categorize and classify the information in the visual world or information in the world around us or environment around us into various understandable boxes.

So, you know that you know something is an animal, something is a mammal for that matter something is a you know some object is a chair and a chair is needed to is you know affords sitting or a table afford keeping your stuff on, those kind of things we were starting we basically began with something like that then we talked about different approaches to this categorizations, we talked about whether you are using a prototype approach or whether you using an exemplar approach to making these categorizations.

We also talked about one of the very famous networks, we talked about the semantic network theory which was the first program proposed by Collins and Quillian, we talked about that because it was the first networks theory what did it mean what is actually a semantic network. So, things like say for example, in a semantic network there could be a objects or things like animals or fruits or plants at particular nodes and those are connected to other nodes via these links which are property links is, has or can those kind of things.

In the next lecture we talked about parallel distributed processing. We talked about the newer architectures and how parallel distributed processing basically works. Also, in the recent lecture if you remember, I was talking about when some of the broader uses of knowledge. Some of the broader use of knowledge require basically involve us having larger schemas. It involve us having a script that we kind of you know almost automatically run. See, for example, a script to go to a restaurant or script to go to a school or how do you know visit a dentist, those kinds of things.

So, if you see we have in some sense you know we have been talking about what basically it is to have knowledge, we have pondered a little bit about the structure of what knowledge is and we have also talked a little bit about, say for example, how people have been using knowledge in different ways you know.

Starting even from the first lecture when we are talking about you know what is it that a concept affords us you know what do you know about the world which is embedded in concept and you know we talked about things like, say for example, if I am saying in apple and apple has a concept can tell us quite a few things you know. In apple as a concept tells us that it is a fruit, that it is sweet, that it is red in colour, it also tells us that say for example, is found in Shimla, California, it might tell us that you know somebody likes eating an apple or it could remind us of things like you know an apple a day keeps the doctor away and those kind of things.

From there, we have you know moved on to a slightly broader ways things like if you talk about the last lecture, we were talking about what are broaden ala we do not really see their world only in concepts you know we see say for example, see the world in ways in how we are using our knowledge to interact with the world. Say for example, that was basically the point of you know the schemas and the scripts that we were talking about.

Today's lecture is going to be based upon something which is which has to do with making the connection between the you know the metaphysical that is cognition with the slightly physical aspect of it that is the brain. So, I am going to talk a little bit about how knowledge is represented in the human brain, you know what does the brain do how does the brain understand that this is an apple and this is an orange or say for example, how does the brain represents let us say your cat you know does the brain represent the cat as a whole, is there a place marker cell in the brain which has the picture of a cat and every same time you see the you know cat it this one just lights up these cells are called neurons, if you remember in the last lecture we have talked in some detail about these things, but coming back.

So, is the brain doing that is the brain storing aspects of knowledge at particular sites in the brain and then these particular sites are responsible for us having that knowledge.

Now, today's lecture again I am not going to go into heavy neuroscience stuff and I am not really going to talk about too many of those details, but the point I will try and put forth is the fact that if you make either of the two assumptions and the second assumption is say for example, the brain stores the cat as a set of distributed features.

So, it could either be that there is a place markers and neuron in the brain that stores a picture of a cat and it you know every time you see a cat that picture lights up. We can complicate this story a little bit. So, suppose I say is this particular neuron storing the picture of my cat or is it storing the picture of you know somebody else's cat or a wild cat or you know brown coloured cat or a black cat you know you can ask and you can complicate this story a little bit, but I am not really going there.

I am trying to draw your attention to what might be the problems of such an approach. However, there is another alternative approach that is has been around ever since this one has been is that the brain is basically storing these things in a more distributed fashion. So, the brain is not really let us say storing cat per say, but the brain might be in different areas storing facts that this is an animal you know maybe the name is cat and then physical features say for example, the cat catches mice or the cat eats fish or say for example, things like that cat has fur, the cat has four limbs, it has whiskers you know it has you know it pounces on things.

So, different areas of the brain basically represent these different things. So, it could be a pattern of activity across you know these different neurons and these different things light up in a particular pattern whenever you come across a cat incidentally there is an experiment about a cat which we will be talking about in today's class. So, this is probably going to be the crux of what I have to say in today's lecture. Today's lecture is the fifth lecture on knowledge and the basic point of this lecture is representation of knowledge in the brain.

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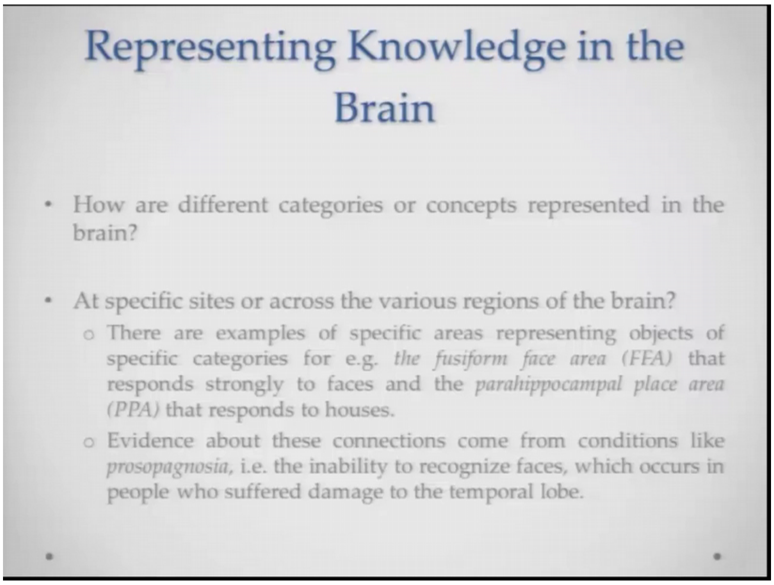

So, again let me let me come back to the original question that I am going to ask in this. The original question in this in today's lecture that we will be talking about is how are these different categories in different concepts that we have been talking about till now represented in the human brain and there are different kinds of evidence that have been coming up. So, if you did not believe that you know there could be a particular cell or a particular neuron that could be representing a cat let me give you a couple of examples

So, in the brain, in the human brain there is an area called the fusiform face area, is basically one that responds very strongly to faces. So, this is an area that and that lights up almost always whenever you are seeing a face. Suppose, in an experimental task you are made to see faces and some other object let us say you know houses or let us say letters or anything else; whenever you are processing the face let us say telling me that whether it is a face or an orange or whether it is a face or a house this is the area that will help you make that decision. So, this area is called the fusiform face area.

And, then there is another area in the brain which is referred to as the parahippocampal place area. Obviously, it is in the parahippocampal region and this is the area that selectively responds to houses. So, we have one area in the brain that is responding to faces, we have one area which is selectively responding to houses. Can we say at this point that this is the area in the brain where all your knowledge about the face is stored or can you say that this is the area you know in which all your knowledge about house is about houses in general is stored?

Now, again to take this case a little bit forward people have also shown that when you know when people suffer injury in either of these two areas that there is a sort of deficit that surfaces and that deficit is called prosopagnosia. If you are talking about fusiform face area if somebody's suffered somehow some damage due to you know brain haemorrhage or some accident to the fusiform face area there is defect that comes up which is called the prosopagnosia. Prosopagnosia is basically inability to recognize faces. So, people who suffer damage to fusiform face area suffer which is in the temporal lobe cannot successfully recognize faces.

So, again it is a you know evidence in favour, but can you really run with this is it possible that the person is not recognizing any face or how is it really happening. We are seen again if you remember the earlier classes we have talked about the fact that people may not be able to just recognize by face, but they are able to recognize by voice you know prosopagnosia patients can recognize the people they are around with by their voice for example.

Now, is just the visual configuration of face damaged or all the other knowledge related to that face is damaged? If, say for example, damage to the fusiform face area would have taken all your knowledge about the face then we are probably talking about specific regions and specific concepts, but we see even in patients of prosopagnosia that the visual configuration processing is damaged, but the idea is that they can process they can recognize the individuals by listening to their voice and everything else about them kind of comes back.

So, you know the person would recall that this is my brother or this is my sister and I have played with him for you know earlier part of my life and we used to do these things. So, again everything else is intact only the visual processing is probably damaged. Now, this is one of the reasons why theories which have very strongly suggested in the past that specific areas of the brain might be representing specific concepts have not really worked so well. So, the generally accepted notion is the fact that the brain representations or the brain basically represents stimuli in a more much more distributed sense.

So, different kinds of stimuli cause activity across a variety of brain areas, because there is, obviously, I mean it could be logical also if you look at it like this there are different aspects of knowledge about that you know different aspects of knowledge about a particular concept and obviously, in that sense it is stored in different areas, the motion is stored in different area, the different kind of you know visual processing things are stored in different area, auditory information if there is such stored in a different area that is all possible that is basically what the more accepted motion of this is here.

So, why is this happening? What is it you know, why is this distributed processing happening? So, if you try to answer the why of this it is basically what I was saying. So, objects basically consists of many properties things like texture, form, colour, motion etcetera also there are other kind of property suppose behavioural properties you know like cats catch mice, they sleep during the day, they fight with other cats, they might also have different other properties like you know emotional properties say for example, you are very attached with your pet cat you know those kind of things.

So, the representation of objects things like say for example, a cat would then necessarily activate in many different areas of your brain they would activate the sensory processing areas, they would activate the motor processing or motor planning areas, they would also activate higher level areas where your emotions about the cat or the memories about the particular cat are also you know coded like that, also your limbic system emotional areas maybe if there is some fear that you have a dash to cats maybe the amygdala is going to get like that.

\So, I am not really talking a lot of you know theory or stuff here I am just trying to give you a basic hang of what I am talking about when I am saying that it is more accepted that the brain represents stimuli in a much more distributed sense. Let us take this a little bit further.

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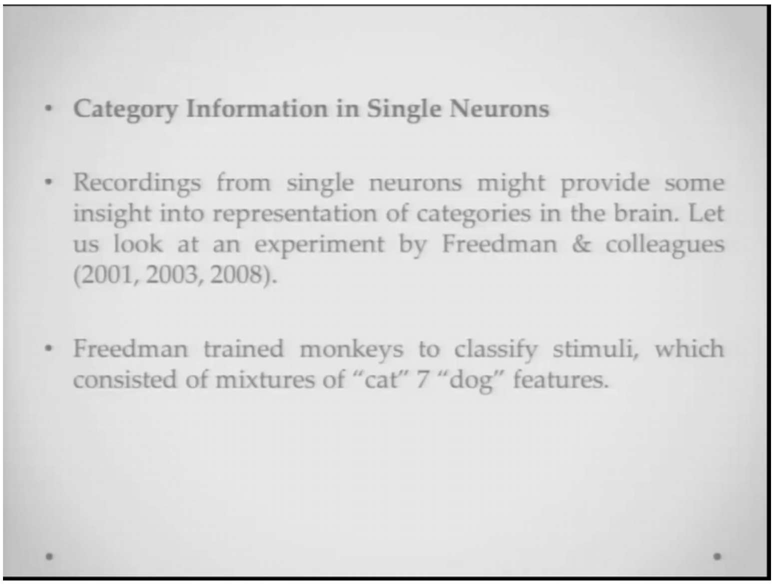

So, people have tried to look at single neurons. People have tried to look at what aspect of particular stimuli is encoded or is possibly stored by a single neuron. So, Freedman basically did this very interesting study and he wanted to look at a single neurons and what are the aspect of particular stimuli a single neurons have story. So, he basically started taking recordings from single neurons of a monkey's brain and the idea was that he wanted to check, how does a monkey represent you know particular concepts say for example, a cat or a dog.

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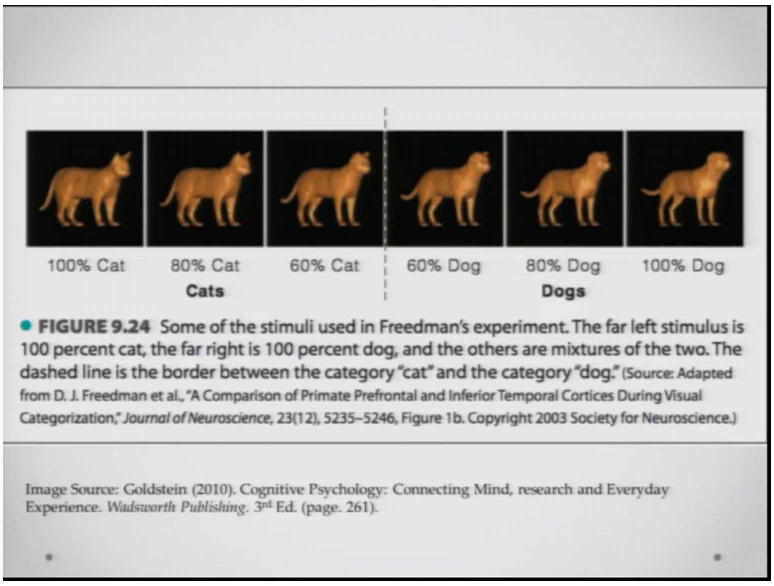

So, they he actually asked monkeys basically trained these monkeys to differentiate between two stimuli; one was a cat and one was a dog. So, you can see here in this figure to my extreme left is a 100 percent cat and to a extreme right is a 100 percent dog and in the middle there are mixtures of features from both the cat and the dog. And, the idea is that the monkey has to be able to decide the crossword point is when something is a 60 percent a cat or something a 60 percent a dog and the monkey has been trained over and over again you know with repeated trials with multiple trainings procedures that the monkey should be able to distinguish between when something is a cat or when something is a dog.

So, this is the basic task that they asked the monkey to do.

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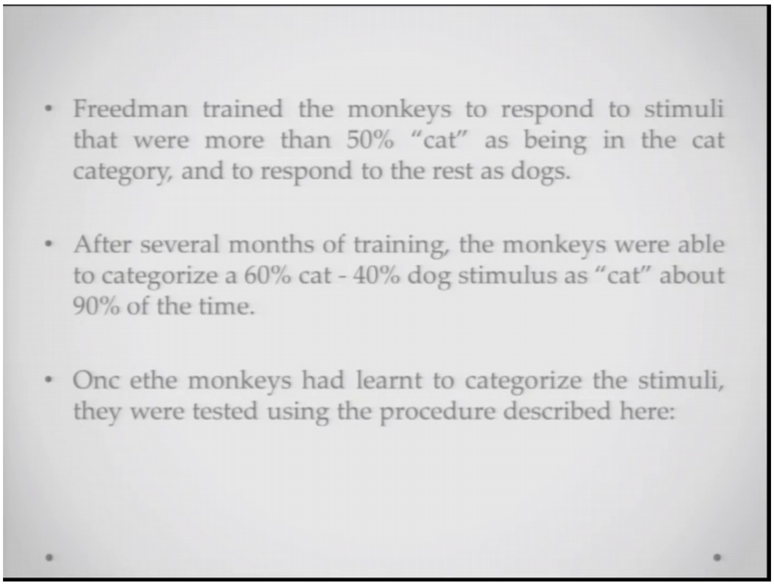

So, they trained whenever a particular service was more than 50 percent cat the monkey should be able to tell it as a cat do something press and give a response when it is more than 50 percent a dog and you know play something else and say that it is a dog. This is the training that was given.

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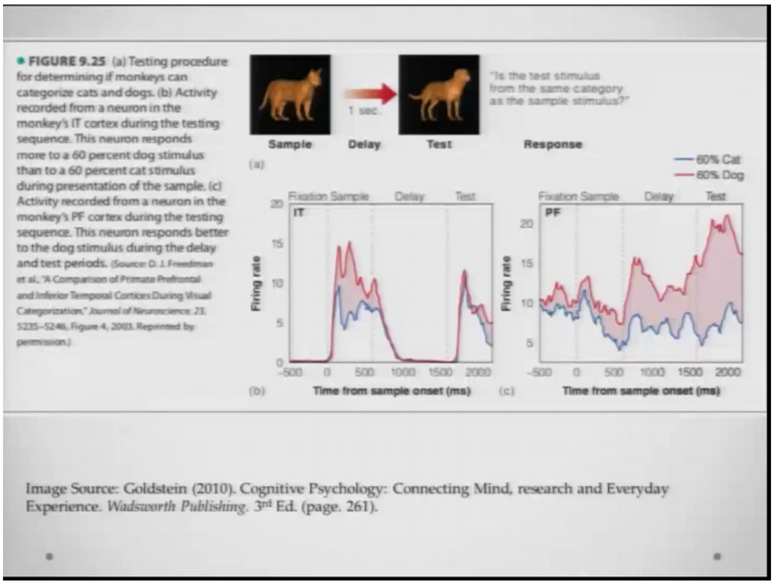

Then, they actually conducted an experiment the test procedure was something like this. So, a first sample was shown, you can see here on the left a sample is shown, the sample is a cat and then there is a one second delay and then the test a sample is shown. And, the monkey has to look at the test sample and basically answer the question, say is the test stimulus from the same category as the earlier sample stimulus.

So, monkey is really just have to compare the test stimulus with the sample stimulus and decide whether both of them are same or some visual analysis is basically required here and also some memory of the fact that you know you saw the sample.

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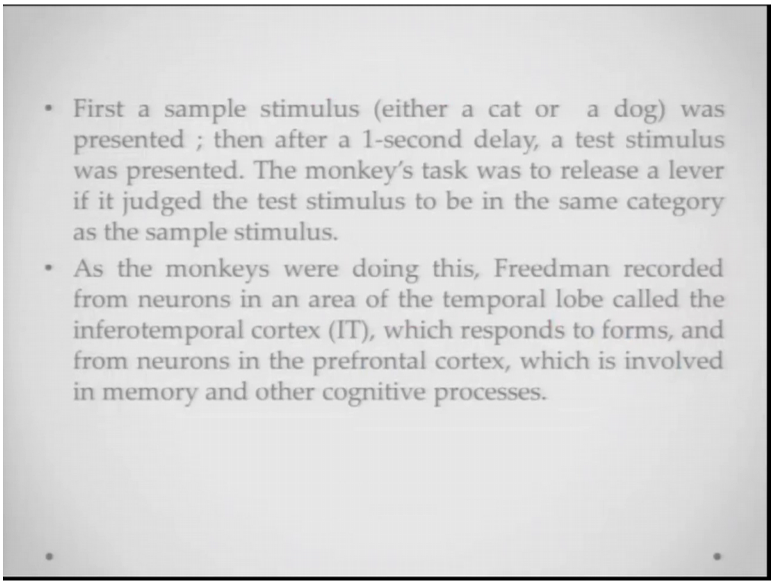

So, I will just describe this procedure in a little bit more detail. So, first a sample stimulus either a cat or a dog was presented; then after 1 – second delay, a test stimulus was present. The monkey's task was to release a lever if it judged that the test stimulus was same as the sample stimulus or do something else. As the monkeys were doing this, now this is the main part, Freedman basically was recording neurons in an area of the temporal lobe called the inferotemporal cortex, so, one neuron from the inferotemporal cortex and neuron from the prefrontal cortex. So, two kinds of neurons were basically chosen and two neurons were recorded.

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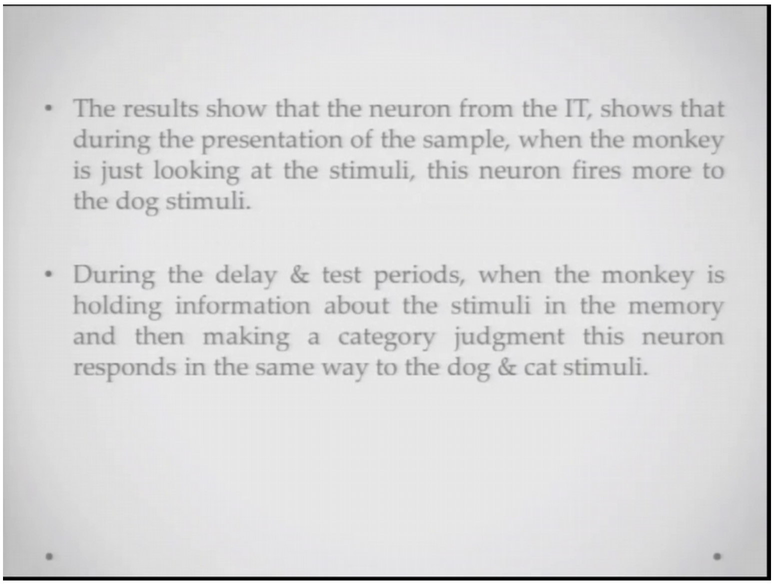

Now, if you look at the results I will go to the results in the graphic form very soon. The results basically showed that the neuron from the inferotemporal cortex, the IT, shows that the presentation of the sample when the monkey is just looking at this stimuli, this neuron fire go to the dog stimulus. So, the neuron basically is doing the visual analysis properly in this case, I am talking about the trial that I just presented. During the delay and test periods when the monkey is holding information about the stimuli in memory and then making category judgment this neuron responds in the same way to the cat in dogs.

So, some kind of processing is happening here you can see. If you can see the sample on the left is from the inferotemporal cortex and the sample from the right is from the prefrontal cortex. You will see when the sample is there basically the neuron is firing more for the dog which is the red one and during the delay and the test there is typically no difference. In the prefrontal cortex you will see that a neuron is firing except differently to the dog and to the cat stimuli, even though the firing for the dog is much more. And, basically if you see the figure here as the time passes the there is a much more divergence between the cat firing and firing. So, some kind of differentiation to the responses is also there.

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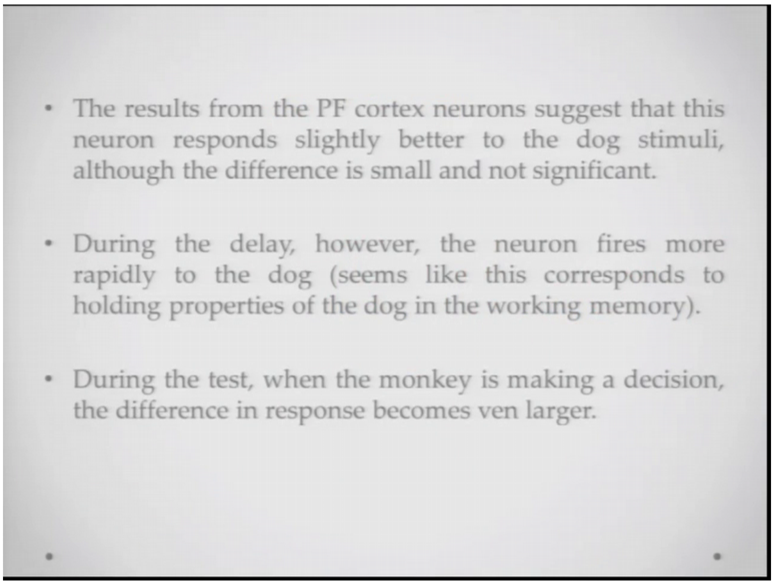

So, the results from the prefrontal cortex basically suggests that this neuron responds slightly better to the dog stimuli as you saw, although the difference is small and it is not really significant in any sense. During the delay, however, the neuron fires more rapidly to the dog seems like this correspond to holding properties of the dog anyway. Monkey is basically trying to recollect the properties of what the dog is, so, the delay is there. During the test, when the monkey is making a decision the differences in responses you can see they actually become much larger. So, the divergence is much clearer and you see that the some kind of decision is made. So, this is a thing.

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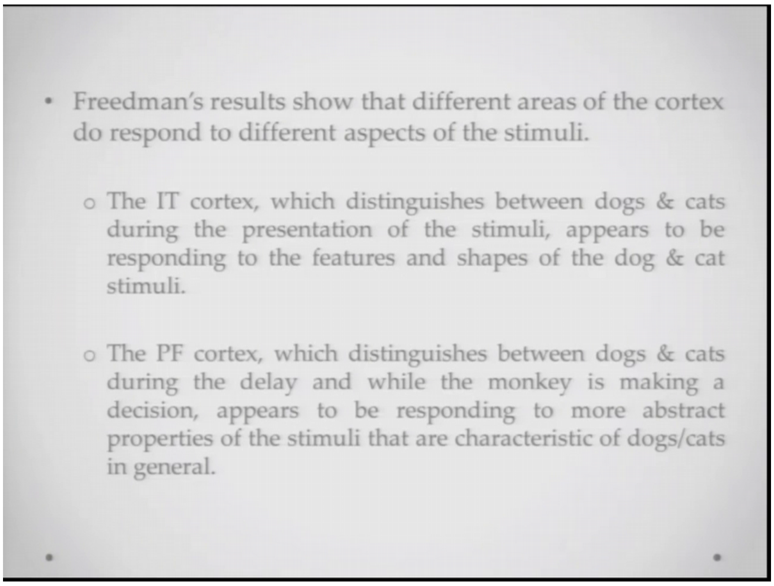

So, Freedman's results tell us that the different areas of the cortex might be responding to different aspects of the stimuli. The inferotemporal context which distinguishes between the dogs and cats during the presentation of the stimuli appears to be responding to the features and the shapes of the dog in cats stimuli. So, you can see here that when the sample is presented then there is a differentiated response on the inferotemporal cortex; basically, telling us that some kind of sophisticated visual analysis is being carried out here.

The prefrontal cortex which distinguishes between cats and dogs use because you saw in the test phase the activity diverse pretty much is basically making a decision and this decision is basically, it is also probably based on the more abstract properties of this simile that are characteristic of dogs and cats in general.

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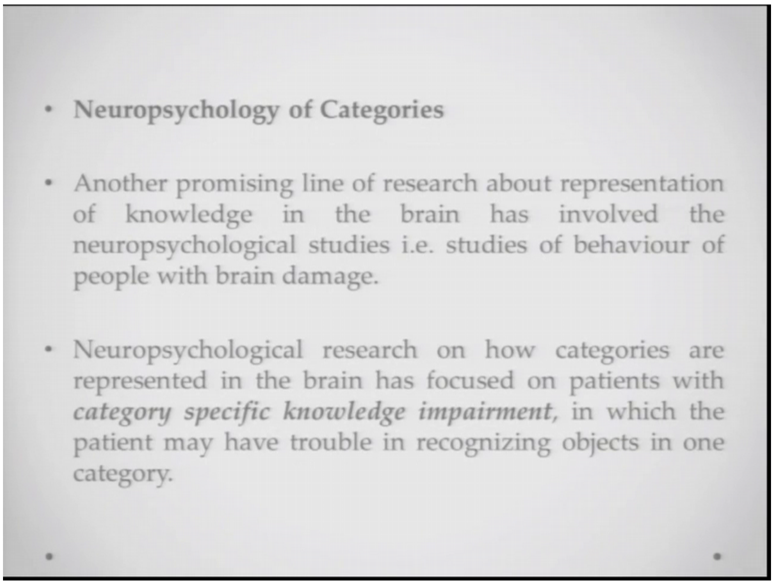

So, this is again it does not really tell us a lot, but this experiment tells us that it might be possible that even though there is not a single place where a particular concept is housed, but the way these different areas of the brain respond to particular stimuli might be different. So, again it tells us that there is some water in the argument the fact that the brain is representing knowledge in a much more distributed sense.

Now, that was that people have also starting you know looked at the neuropsychological side of things. There has been a lot of research about representation knowledge in the brain via neuropsychological studies. What are neuropsychological studies? Neuropsychological studies are studies of the behaviour of people with some kind of brain damage. Now, this brain damage can be developmental, congenitally or due to some reason developmental lags or it could be acquired by some accident or something.

Now, neuropsychological researches on how categories are represented in the brain are has been focused on the patients with category specific knowledge impairments. Say, for example you are talking about prosopagnosia earlier, people like this who have category specific knowledge impairment, in which the people might have trouble in recognizing objects in one of the you know one category.

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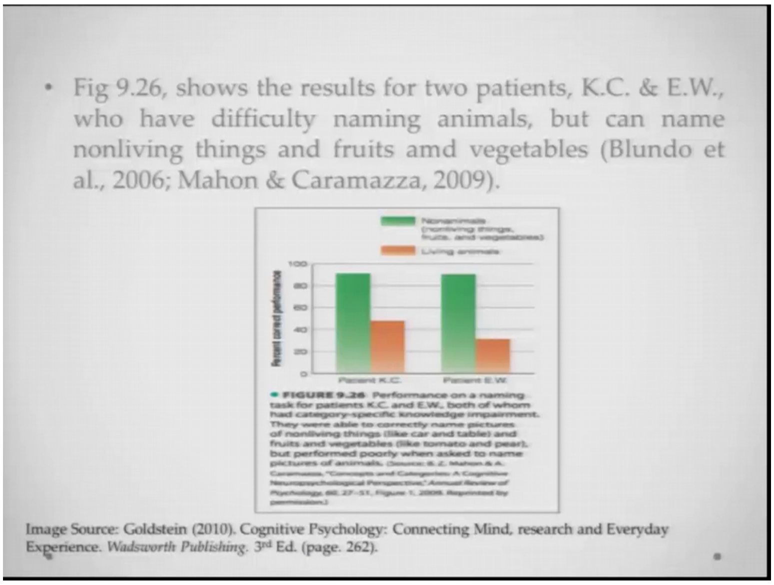

So, you see you know these are basically results from two patients K. C. and E. W., who have difficulty naming animals, but have been found you know perfectly fine with naming nonliving things like you know fruits and vegetables you see, patient K. C. responds you know the correct performance is over 80 percent for non living things, but under 50 percent for living things.

Similarly, similar pattern is there in patient e w s well and both of these are basically derived from a study from Blundo and colleagues or Mahon and Caramazza and this is the figure is sourced from Goldstein’s book on Cognitive Psychology.

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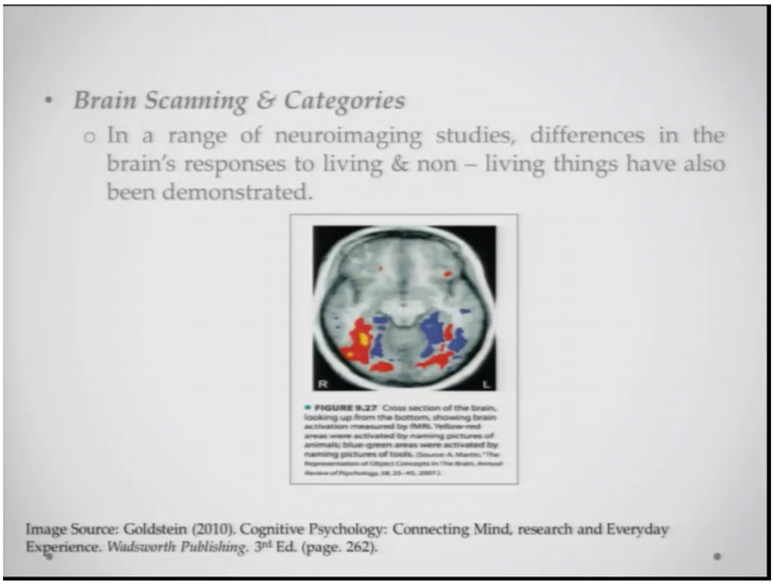

Now, moving from neuro psychology people have also looked at brain scanning and people have actually tried to look at when participants are making these differences and somebody is scanning the evidence. So, it is not really possible to conduct single cell recordings in human beings because of ethical concerns, really want to make an incision in somebody's brain and check.

But, one of the easier techniques available to assess things like neuroimaging you know you can actually put somebody in an fMRI scanner, obviously, ask them to do so, request them and then check whether that when they are responding to particular kind of stimuli, what is it that is happening in their brain.

So, in range of neuroimaging studies differences in the brains responses to living in nonliving things have also been demonstrated. So, if you see here in the last diagram there was a difference between how people respond to living and nonliving things and in this study here you can already see that there are different areas of the brain that respond to living and non living organs.

So, you can see that blue, green areas are activated by naming pictures of tools which is the inner region and the red, yellow areas are basically activated when people were naming animals. Again, this figure is also saw. So, from Goldstein's book on Cognitive Psychology, but again it kind of makes the point that there are neuroimaging is one of the methods that you can see how people are responding to these different stimuli.

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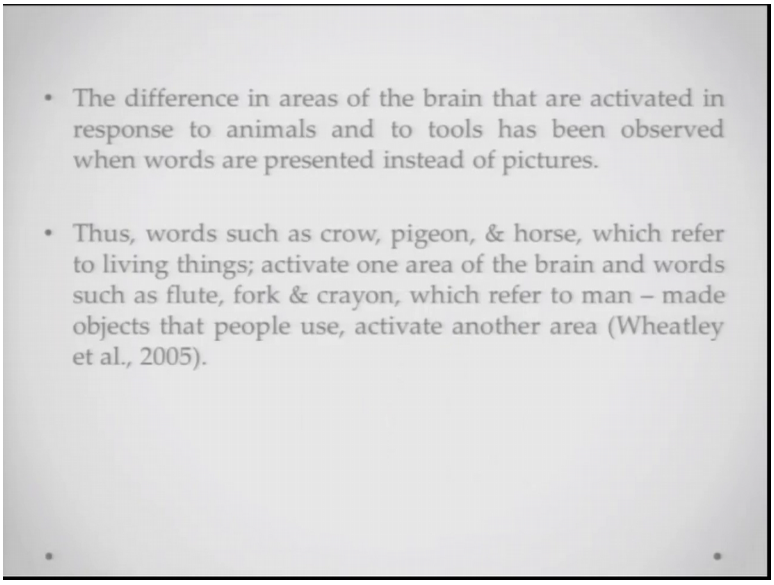

Now, the difference in the areas of the brain that are activated in response to animals and tools has been observed also when words were presented instead of pictures. So, in the earlier you can actually see pictures, but even if you present words, say for example, if I am presenting you know hammer, axe, scissor etcetera, I am presenting you know cat, dog, buffalo etcetera, even in words when you are not really seeing the picture there is no visual analysis of the features happening here.

But, still the difference in activation has been observed. So, word such as crow, pigeon, horse might have activated one set of areas in the brain and words such as flute, fork and crayon might have activate other set. Again, this is from a study from Wheatley and colleagues.

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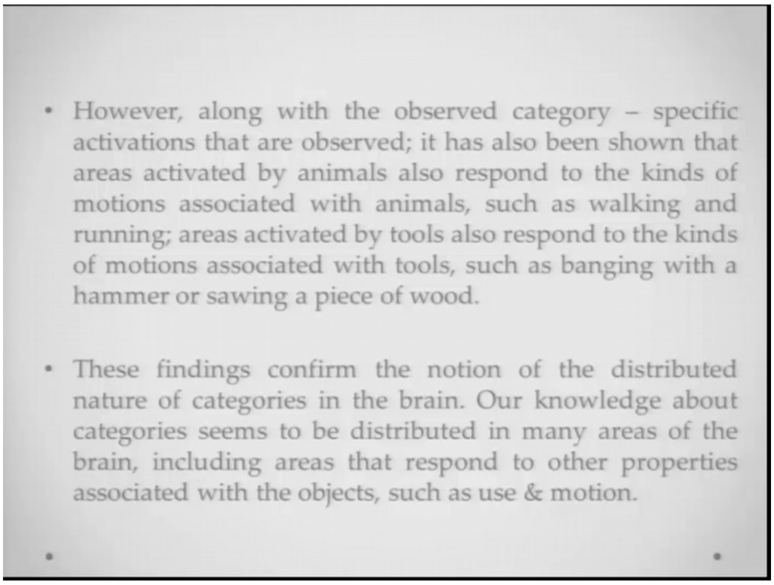

However, the along with this category specific activations that are observed, it has also been shown that areas activated by animals respond to the kinds of motions associated in animals you know, particular kind of motion that a particular animal does such as walking or running also areas activated by tools also respond to the kind of motions associated with tools.

So, there are different areas which are probably coding these motion related properties of these concepts which are animals and nonliving things or manmade objects. These findings if you look at them and us take a step back and try and wonder what this what these things are telling us they tell us that it kind of confirms again reconfirms the notion of distributed nature of categories in the brain.

So, different areas of brain are coding for different properties and that is a different areas of the brain are lighting up when different kind of properties are being tested for. Now, our knowledge of these category seems also be distributed in many areas of the brain including areas that respond with the other properties associated with the objects such as motion, physical form and you know emotional or the kind of characteristics.

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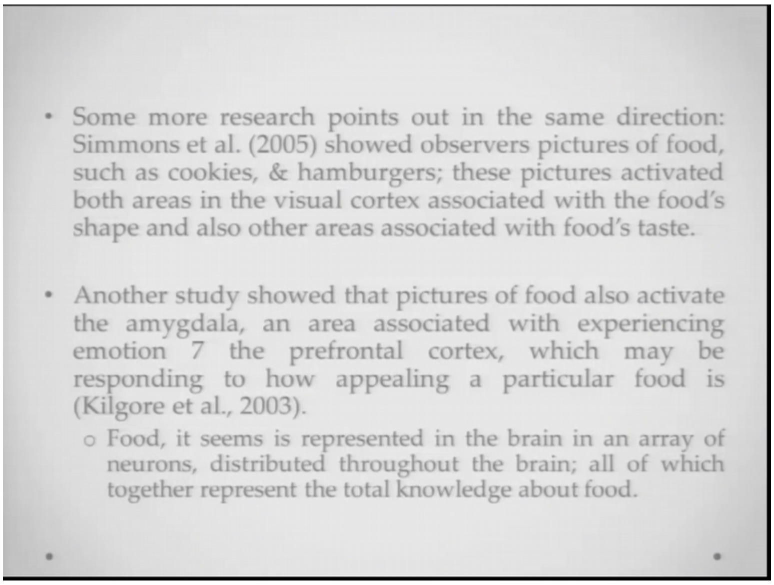

I hope we are still making a point clear that, you know what these differences are and where are they stemming from. Some more research points out in the same direction say for example, Simmons and colleagues, they showed observers pictures of food such as cookies and hamburgers and these pictures were you know found to be activating areas both in the visual cortex which are associated with the foods appearance and shape and also other areas which are basically more associated to the foods taste.

So, even say for example, if you looking at particular food; one area in the brain might be going up and saying this looks good this looks delicious or it does not look delicious and the other area of the brain is basically talking about you know is it delicious or not. So, again in my description I kind of mix the visual and the delicious part, but this is how we think, but the brain might be doing it differently. Brain might be just doing the visual analysis and doing this taste analysis is in a different region, but we generally do not talk like that and in that sense we think like you know delicious foods are probably sold somewhere else.

Let us take another study, another the Kilgore and colleagues basically showed pictures of foods they also showed that pictures of food also activate amygdala that is an area which is associated with the experiencing emotions you know. So, food can have emotional connections to people. We keep hearing about the fact that you do not depressed people eat more or obesity is linked to depression or say, for example, you might in your own experience find that you know if you are in a very heightened emotional state. It is quite a possibility that you know eat more or things like or say for example, you do not want to eat when you're in a heightened emotional state.

So, they actually showed activity in amygdala with response you know responding to pictures of food, which is basically you know probably responding the fact that how appealing a particular food is. So, food in that sense it seems is represented in the brain in an array of neurons distributed throughout the brain. All of it is together represent the total knowledge about the food how does it look, how does it taste whether you like this or not all of those kind of things.

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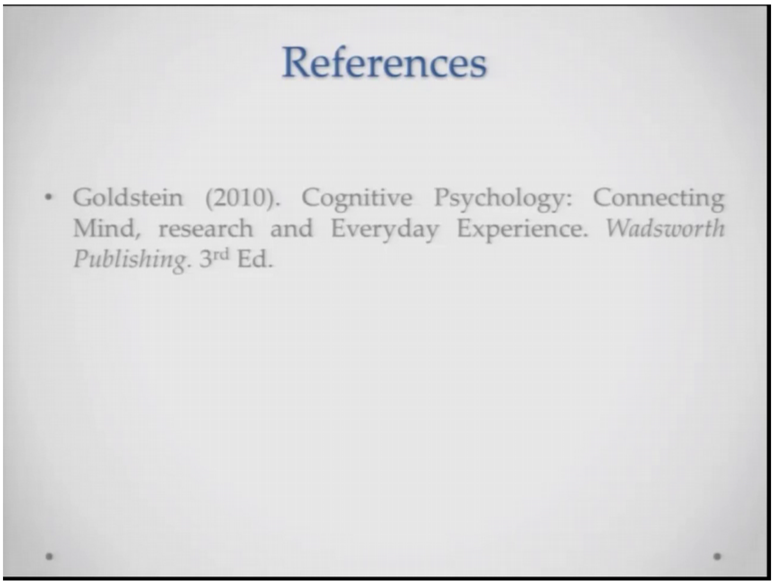

So, that was all from me about knowledge and representation the brain. I am not really going into too much detail about how different neuro-science studies, but I hope I made the point clear that knowledge is stored in a very distributed fashion in the brain and I hope I also made it clear that there are these differences actually stemming from.

Thank you.