Lecture 20: Meaning in the Brain

Hello and welcome to the, course introduction to the psychology of language. I am Dr. Ark Verma from IIT Kanpur. And we are in the fourth week of the course, we're talking about word processing, different aspects of meaning, different aspects of accessing the lexical form that is lexical access and in the last class we talked about, ambiguity resolution and also a little bit about, how lexical access might be based in the brain. Today's lecture we mostly talk about, how you represent meaning in the brain and we kind of

it will go a little bit, neuroscience II in a bit and I would kind of you know appreciate if you remember, some of these facts, clearly. Now the question that, we need to ask today is that how is meaning represented in the brain, in the last lecture, we saw that a knowledge related to the semantic, knowledge literally the you know the meaning aspect of the concepts, is being stored separately, whereas knowledge related to the word form, is being stored separately. So, it kind of already tells us that yes the meaning part, related towards versus the word form is separately handled. And it's not only separately handled, in terms of a cognitive model, varyingly say you know, till this point is lexical access and after this is meaning-making, it is actually also separately handled in the brain. So, that is what we kind of got from the last you know lecture, from this whole you know section, on neural basis of lexical access. Today we might kind of zoom, in a little bit more closely on the semantics part. So, let us talk a little bit more closely about, where it is and what different kinds of brain areas, are involved, in storing, meaning in the brain. Okay? So, this is what today's talk is going to be about.

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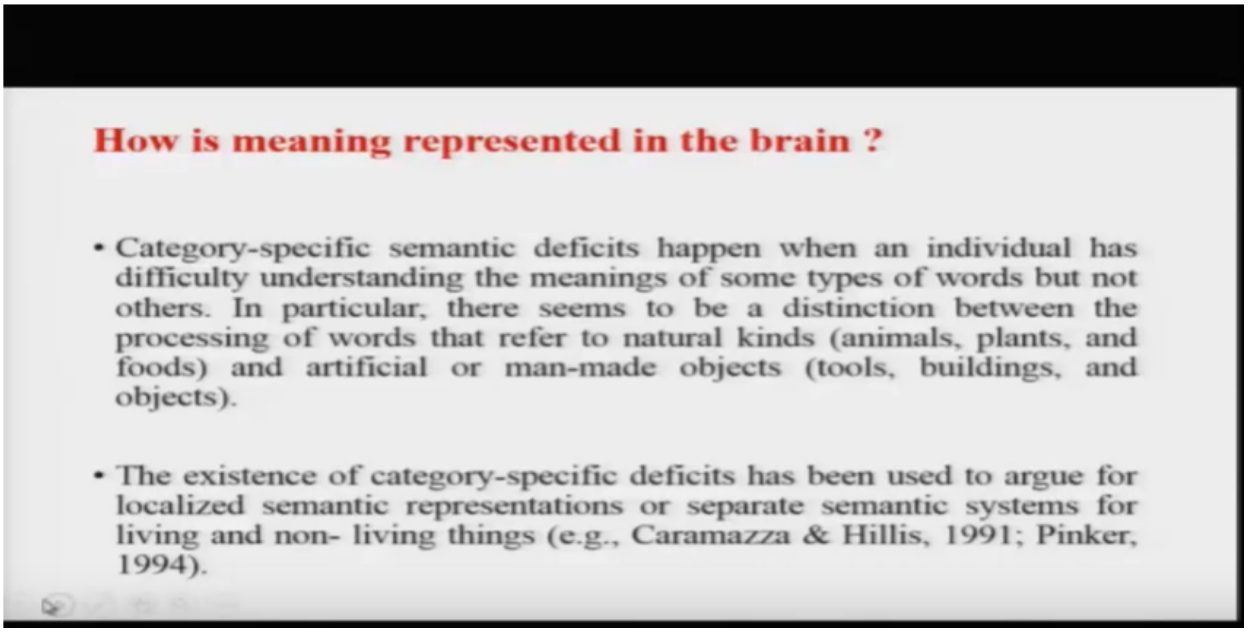

Now category specific semantic deficits we talked about neuroimaging you know neuropsychological, approaches and people who have sorts of brain damage. So, category specific semantic deficits have been shown, they have shown that you know an individual have, has category, specific semantic deficits, people could have difficulty, understanding the meaning of some type of words, whereas others, you know whereas they will be fine with other kinds of words. So, the idea is, I'll give you an example. So, people could have, deficits related to tools or they could have deficits related to natural kinds or they could have deficits related to a particular animal or plan you know people and so, on and so, forth. So, category specific semantic, listed basically means that your meaning system is, fractured but the fracture is only limited, to one category, you know if the friend you are deficient in understanding the meaning, but that is only for one kind of you know categories. Okay? So, in particular what has been shown, is that

there seems to be a distinction, between the processing of words that refer to natural kinds. So, animals plants people foods those, kind of things, versus artificial or man-made concepts, say for example tools, buildings and other kinds of man-made objects. So, there is this very interesting distinction that has been you know coming up, with respect to when you look at patients, having category specific semantic, deficits that is one, also the existence of this category specific semantic deficit, has kind of led to different kinds of theories, in the neuro psychology, neuroscience literature, one of these theories, basically, argues or says that it might, be that in the brain, there are specialized locations, you know specific, localized centers that store one particular kind of semantic representations. So, the idea is that there could be separate semantic systems, for separate kinds of you know, separate categories of objects, very broadly speaking, they could be centers in the brain that are only taking care of natural objects, you know things like animals plants, people foods, so many different things and there could be several centers in the brain that are taking care of, you know, these kind of things say for example, natural sorry man-made artifacts, like two weeks, buildings, houses ,you know all of those, those kinds of things. So, they they're probably, you know can be a distinction, between these two regions. Now these localizations,

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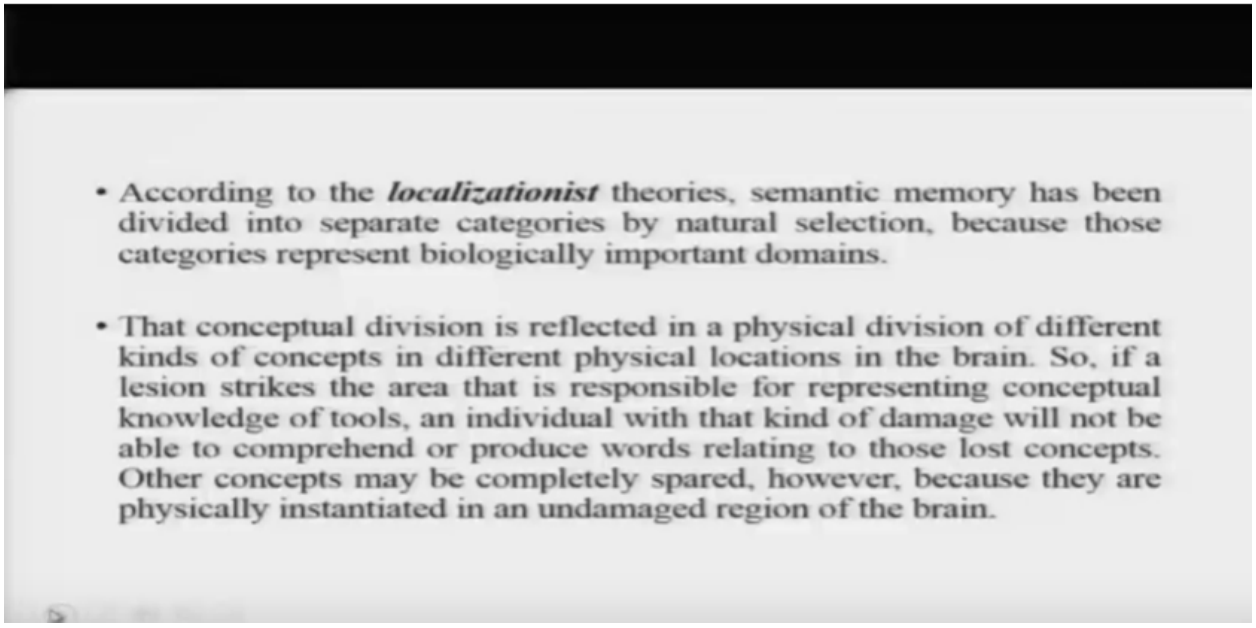

approaches basically, they say the semantic memory and can be divided into separate category, usually by natural selection that probably has happened, in evolutionary sense, because those categories represent biologically important information. So, for example for our survival, it might have been necessary, to you know process, the natural objects much more closely, much more detailed, as compared to the, you know artifacts that are man-made. And because of that because of our interaction with the world, we've kind of developed a system that have been natural kinds have stored here and the process in some more detail, as compared to man-made kinds are stored, in this part of the brain and are stored in whatever you know detail that is relevant to them, this conceptual division between, the natural kinds and the artifacts, is very

interesting and it could basically, tell us that it could be reflected, in the different physical organization, in the brain. So, if a lesion strikes the area, suppose there is this particular area, of the brain that gets damaged. And this region basically, is more involved in representing, the natural kinds of information, what would you expect; you would expect that all knowledge, about natural kinds shall be affected, because of the lesion in that particular area. Okay? So, in an individual with that kind of damage, should not be able to comprehend or produce words, relating to that entire category, whereas other concepts might be completely spared, say for example, the whole to put it very simply, there is this brain, this part stores natural kinds information, this part stores man-made kinds information, if lesion happens in this part, the entire knowledge about the natural kinds information goes away, by the entire knowledge about, the artifacts and man-made kinds, stays, preserved that is the argument that they're trying to make.

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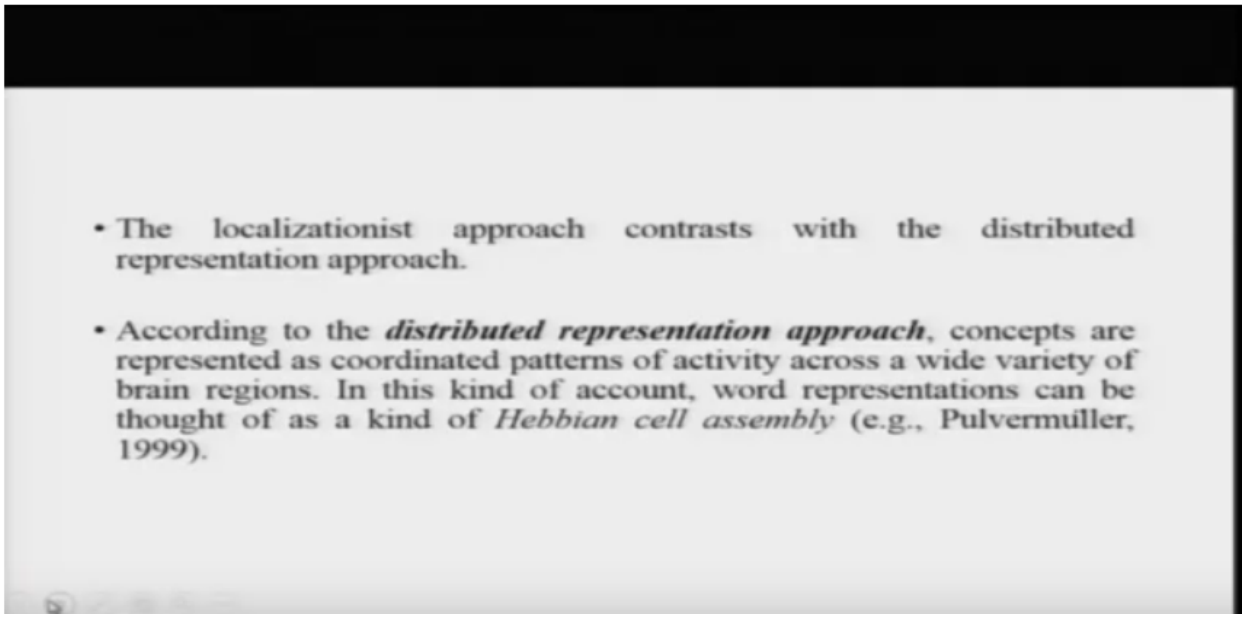

Now the localization is approaches, kind of you know are contrasted, by other kinds of approaches, which are the distributed representations approaches. And the distributors the representations approach, basically says that concepts are represented as, coordinated patterns of activity, across a wide variety of brain regions. So, they say that it's highly improbable that one particular area, in the brain is storing all of one kind of knowledge, what they say on the contrary, is that any kind of knowledge for that matter is distributed across the brain. And so, even if a brain lesion affects, a particular area of the brain, it should not take up all kinds of knowledge with respect to that category, because the category it in itself was stored, across the you know different areas of the brain, in a much more distributed fashion. So, there is this contrast between localization, aster approaches and the distributed representations approach. And this is the contrast we will be, looking into more closely, as we move forward in this lecture. Now this whole pattern, you know this whole concept of, things being stored in a distributed fashion, was you know very well taken up by Donald Hebb, he was a neuroscientist,

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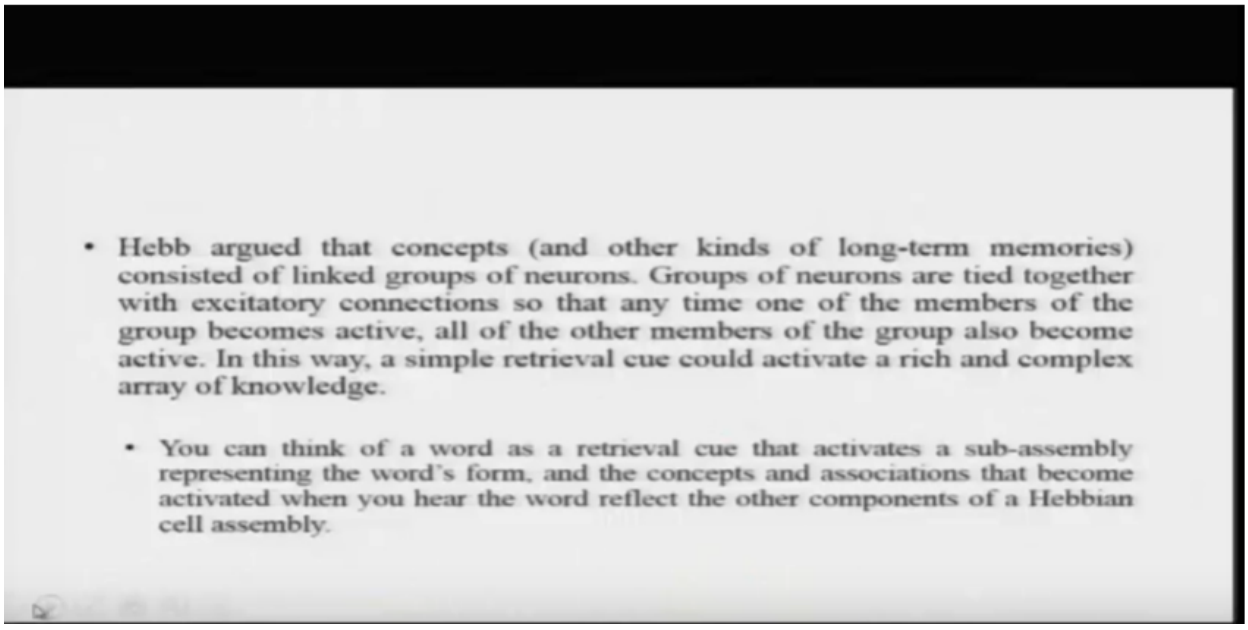

and he believed that concepts, consist of our townships could be represented in, a linked group of neurons. So, the idea is that there are groups of neurons that are tied together, with excitatory connections. So, that at any time, any of the members, of the group becomes active, all the members of the group will become active, you can kind of look at it as, say for example, there is this array of neurons a, a, b, c, d, e, f, g, h and this array of neurons, is storing one concept, let us say this pen. So, this area of neurons probably, is coding for different features of the pen and as soon as one of the feature gets activated, by you know whatever way I mention, I mentioned the pen or I you know move the pen across my visual field or whatever, this entire, array of neurons will get activated. So, because this whole thing was distort in a very distributed fashion, even if I lose one or two you know neurons from this assembly, I would still retain, other kinds of information that are stored by this paired neurons. Okay? That is the idea and this is basically, you know some one of the principles that was, you know, involved in what was referred to as and a heavy and learning paradigm. Okay? So, in this way, what happens is that a simple retrieval cue, something that could activate only one of or two of the array of that particular neurons, could help me you know remember that entire concept. So, for example word, could act as a retrieval cue that activates a sub-assembly, that represents the words, form and then eventually, because of activity there, things linked to the conceptual and semantic information also starts becoming activated, these kinds of arrangement have been called as,' Hebbian Cell Assemblies'. Now yeah you need to look at this idea a little bit more closely. So, what was done by PulverMuller the PulverMuller said that you know such assemblies form, when different groups of neurons,

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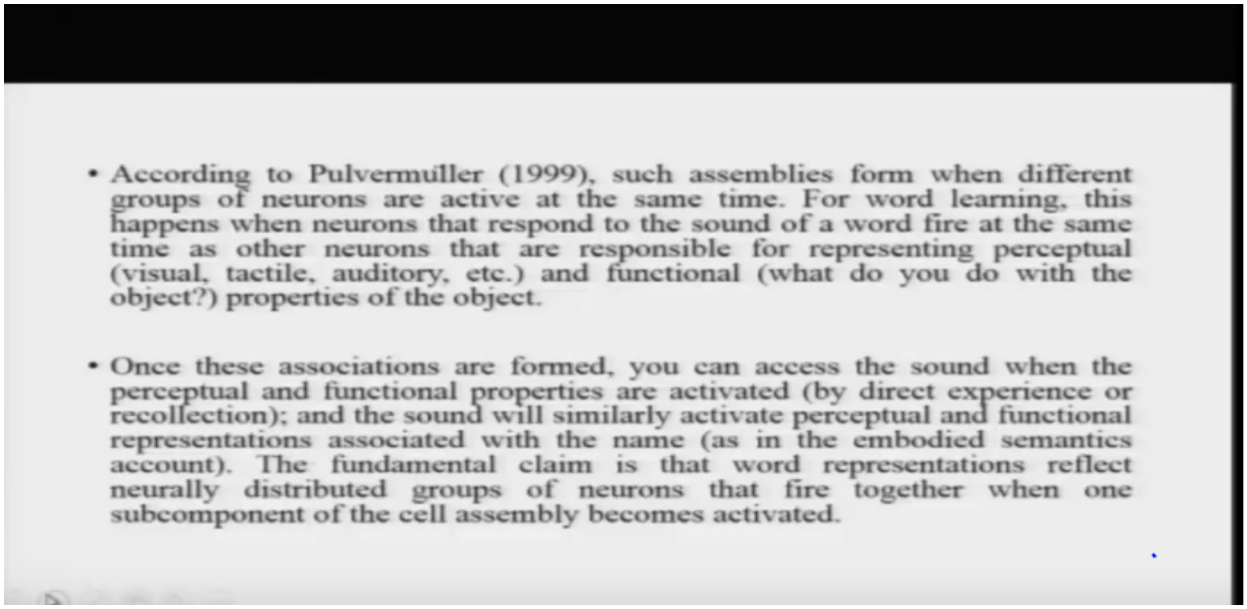

you know are active at the same time? So, if different groups of neurons are active, when I'm showing it the pen or the cell phone or chair or table, all of them at the same time, are coding different aspects of this object, because they're all at the same time coding different aspects, of this particular object, this they will basically you know, a sort of you know the way, to say this is that neurons that fire together, they will get wired together, because they fired together, with respect to you know this particular moving object, in my visual field, they will get connected to each other, by virtue of this common activity and they will kind of get, you know knitted together in sort of a network. Okay? And so, forward layering what could be happening is that my neurons respond to the sound of the word. And if the neurons responding to the word, fire at some time as this you know at the same time, as other neurons that are responsible for coding, things like color shape form, you know a motion and the writing of things you know visual tactile all kinds of impressions, all of these things will get knitted in, one you know pattern that pattern, is basically going to represent that particular object in all its entirety. So, from the word form, till the you know the form of the object, the color whether it is moving or not what is it used, for all of that information, will then get coded into this hebbian cell assembly, in this organization of this bunch of neurons. Now once these associations are formed once the brain kind, of learns to represent concepts, in such a distributed fashion, what you could do is you could access you know the sound, when the perceptual and functional properties, are activated and the sound, will appropriately activate the perceptual and functional, representations, associated with the name. So, as soon as you hear the name, everything related to that object kind of starts getting activated slowly, at the same time. And the fundamental about, this entire position is that word representations, reflect naturally distributed groups, of neurons that fire together, when one sub component of the cell assembly becomes activated. Okay? So, this is, this is the way, this is being put up.

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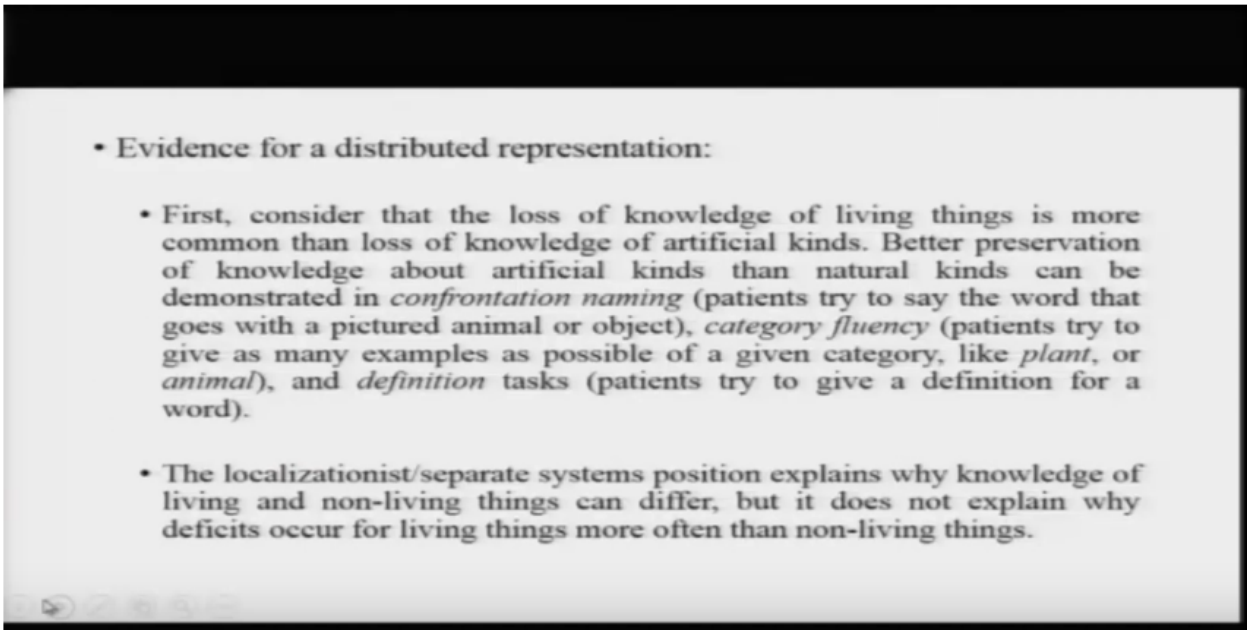

Now is there any evidence for such a distributed, representation idea. So, there is apparently, first now suppose you consider that loss of so, what are the first was the evidence comes from that if you look at more closely, in this you know, semantic category deficit or you know category, specific semantic deficit patients, what you find is that your loss of knowledge of living things, as one category example, is more common than loss of knowledge, for artificial kinds. So, what is more prevalent, if people would have lesion, there is a higher chance that they would lose, some knowledge, about the living things, natural kinds, versus they will lose knowledge about the, man-made artifacts. Okay? So, that is one observation and say for example, it has been saying that better preservation of knowledge, about artificial kinds and that natural kinds, can be demonstrated in different kinds of tasks, way for example the confrontation naming tasks, confrontation naming tasks is simply, you kind of you know show the person a picture of that particular object or that particular natural kind and you ask them to name. And you see that you know for some kind, of objects they are more deficient, as compared to some other kind of orbs that's the idea, that's how you will check it. Now the localization, separate, position basically explains by knowledge of living and nonliving things can differ, because they say that you know they are being stored separately, but it does not really explain, why deficits occur primarily for living things more, often than for non living things so, it says that. Okay? One kind of knowledge will be gone, while the other will be preserved, but it does not really say, why one kind of knowledge is more probable to go off, to go off, as compare to the other kind of knowledge that is what something that they don't really talk about. Now the second observation is.

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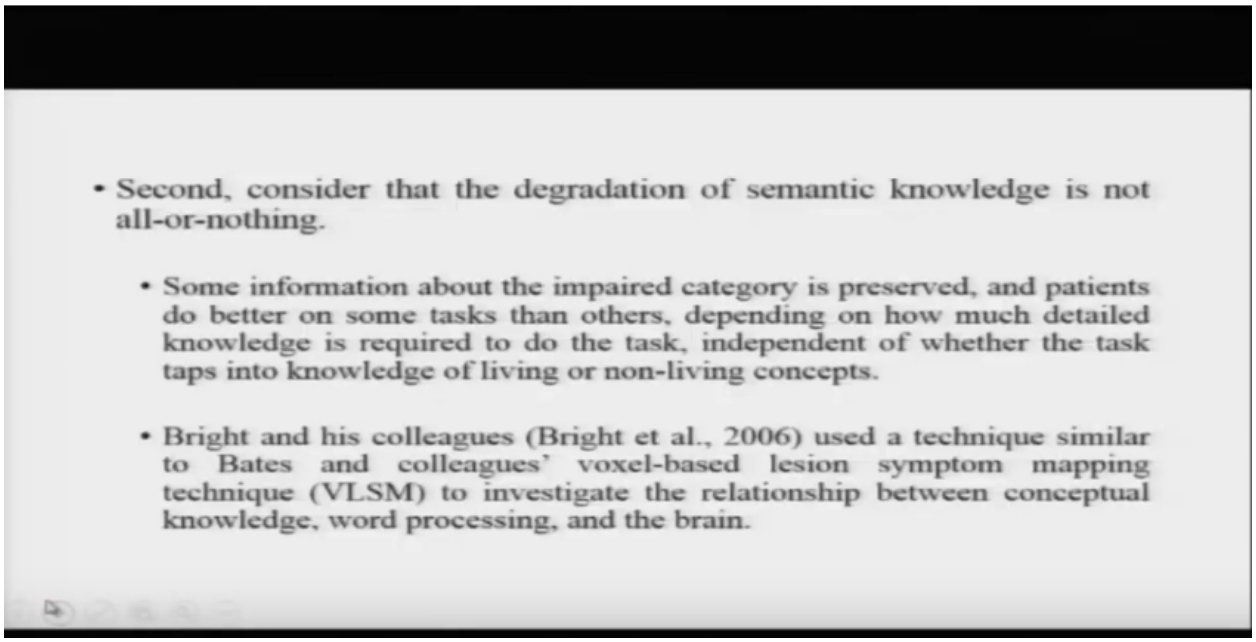

That the degradation of semantic knowledge about any of these categories, is not all or none, you know it does not happen at entire knowledge is gone. So, some information about the, impaired category is always been, found to be preserved and patients do better on some kinds of tasks that tap those features. And they do worse on some other kinds of tasks that tap, you know the deficient features. So, depending upon how much detail is knowledge is required, to do the task, independent of whether the task taps into the knowledge of natural concepts or man-made concepts, you can see differential patterns of deficiency. Okay? And so, there's this particular experiment brightly and colleagues did in 2006 and they what they did was they wanted to test this out. so, they used a technique similar to Bates and colleagues the voxel based lesion symptom mapping, technique, it's an fMRI kind of scenario where you basically look at, you know what lesion has led to, what kind of symptom of deficit. Okay? So, they wanted to investigate the, you know the relationship between conceptual knowledge, word-processing and the brain and in the brain. So, they basically wanted to look at that.

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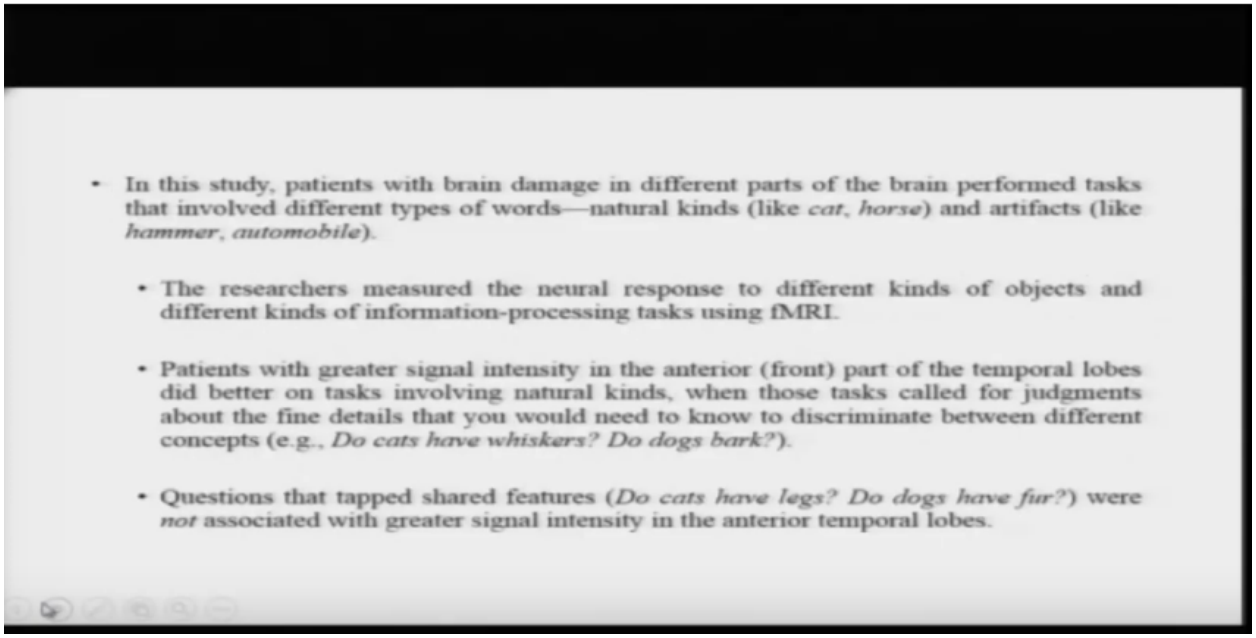

In this study what they did, Was they had patients with brain damage, named perform different kinds of tasks that involved different kinds of words. So, there were could be words of two kinds, natural kinds and artifacts and there could be different kinds of tasks, associated. And via while you know they were in the person it would be doing this task, the researchers would, basically measure, the neural response different kinds of objects and different kinds of information, processing that is happening just look at it bit more closely, patients with greater signal intent, showed greater signal intensity in the anterior part of the temporal lobes. And they were doing better, on tasks involving natural kinds. So, anterior part of temporal loads is probably involved in dealing with the natural kinds. And when those tasks call for judgments about findings. So, there are three things here, what is the task? The task is you know a judgment about fine details. So, things like you know do cats have whiskers? Do dogs bark? Do some things like this? so, you are accessing fine details, of a particular time. So, you're talking about fine details, you're talking about a particular category, in natural times and you're talking about the kind of task, you know that is being done. So, all three you have to take into account, questions are tabbed on shared features, do cursor legs? To dogs have fur those kind of things, were not associated with greater signal intensity, in the anterior temporal lobes. So, what is happening here? A particular region of the brain, is showing more activity, when a particular task, is being asked to do for a particular category. So, that is that is what is happening? Now if the knowledge of natural kinds,

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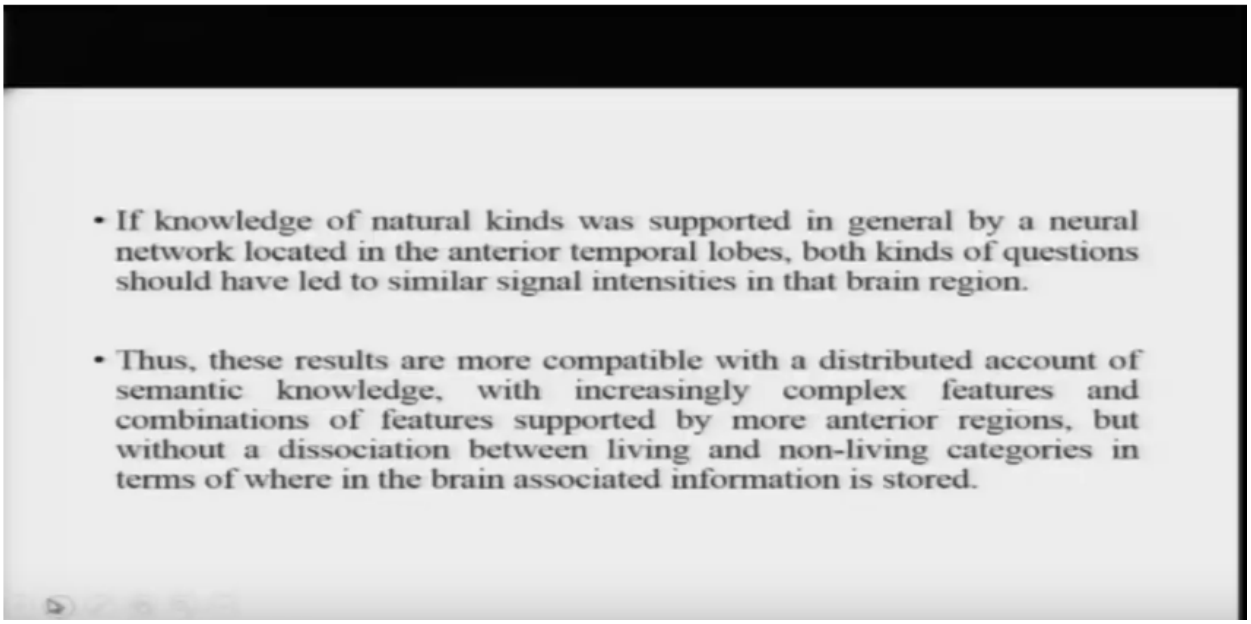

were supported in general, by a neural network in the anterior temporal lobes, which would be the localizations, position both kinds of questions, should have shown similar kinds of activity. So, even if I am asking the question about, shared feature or I am asking question about fine detail feature, the same area should be activated, if all the knowledge is stored here that however was not the case. So, these results therefore are more compatible, with the distributed account of semantic knowledge, with increasingly complex features and combination of features, being supported by more anterior regions and with the dissociation, between living and nonliving categories being stored, in a separate region. Okay? So, at least that much you can say.

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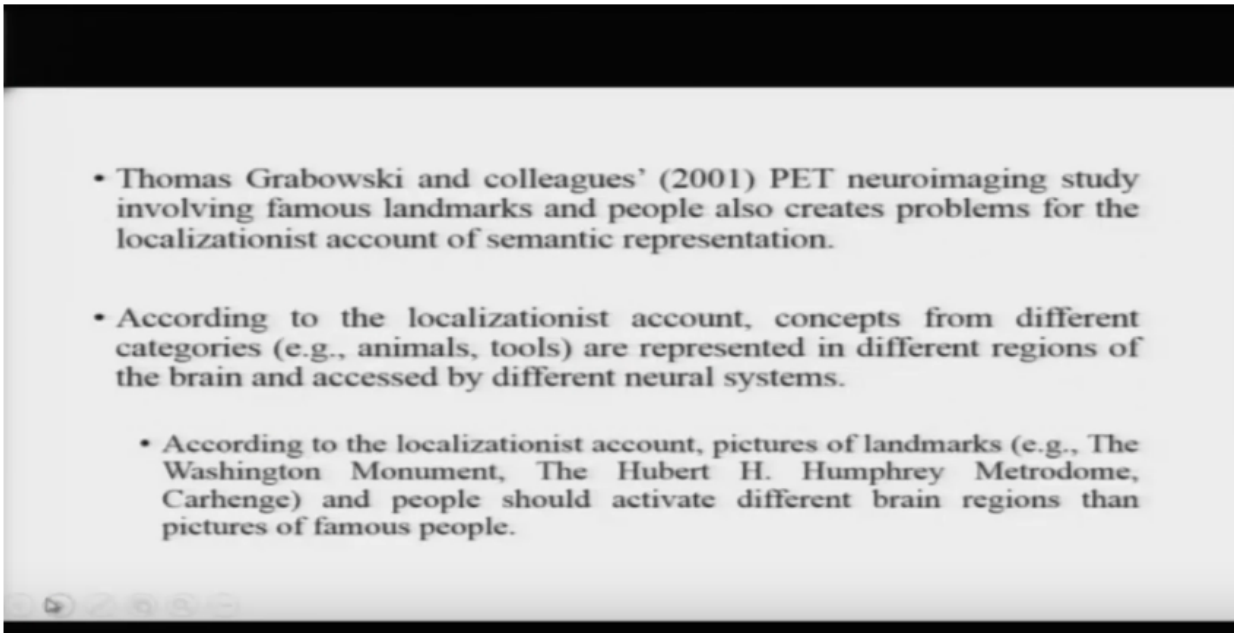

And I'm moving on to a different kind of study, Thomas Grabowski and colleagues; they did the spec neuroimaging study. And the study involves two kinds of slimily, this involved famous landmarks, you know Eiffel Tower and you know you know art they try those kind of things, Gateway of India, those landmarks kind of things and famous people. So, famous landmarks, famous people and this is what they wanted to test? Now according to the localizationist account, concepts from different categories should be represented in different regions of the brain. And should be accessed by different kinds of neural systems. According to the localizationist account, what could you predict from here, is that pictures of landmarks. So, they had landmarks, like the Washington Monument yeah you know you but Humphrey Metrodome etc, should activate different regions of the brain, as compared to pictures of famous people. So, that was the prediction.

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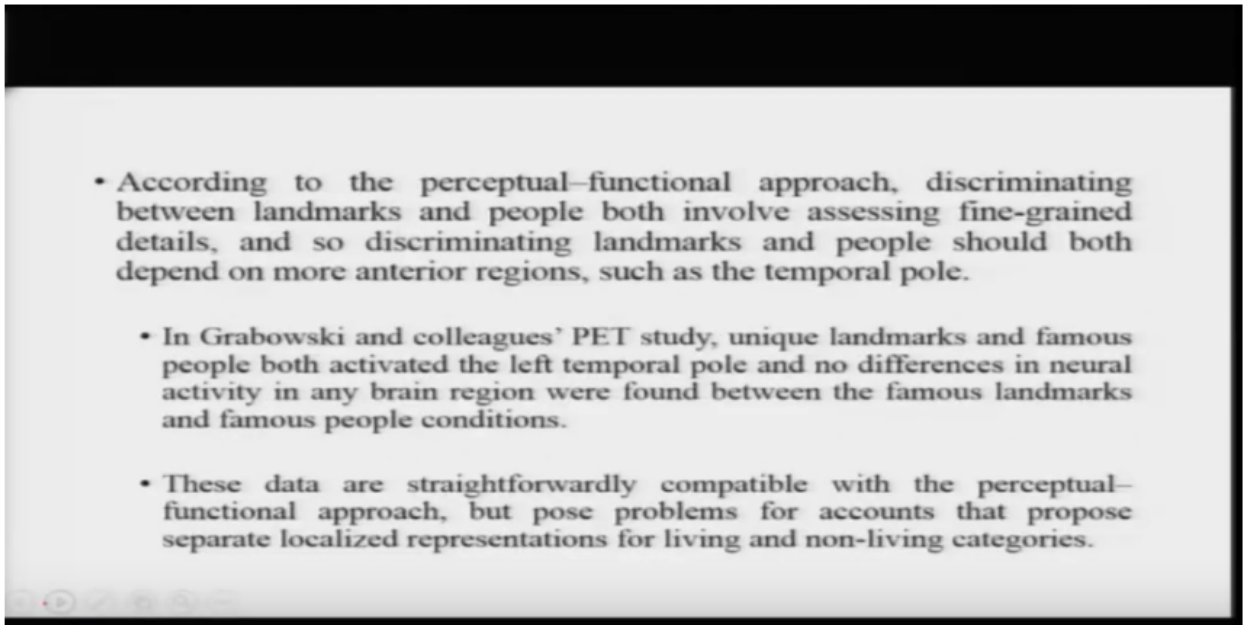

According to the perceptual function or the distributed approach, discriminating between landmarks and people both involve assessing fine-grained details, Okay? So, it basically is not about the category, but it is about, what kind of information you are trying to activate, since both of them involve assessing, fine-grained detail in a particular task. So, basically they should activate similar regions, because the task is similar, then you know in, in its approach, such as say for example regions like the temporal pole for that matter, what did they find? In Grabowski expect study, unique landmarks and famous people both activated, the left temporal pole and there were no differences found in the neural activity, in any brain region, with respect to, you know whether you're responding to famous landmarks or you responding to the famous people conditions, what does this tell us, it tells us something that in a perceptual functional, approach or say for example the distributed, approach because that's basically a subset of this one, is fairly compatible that is something that you could go, more closely by as opposed to the localization,

approach for storing categories. So, that is that is something that you can say, now this perceptual function or the correlated features approach, tells us something a little bit more.

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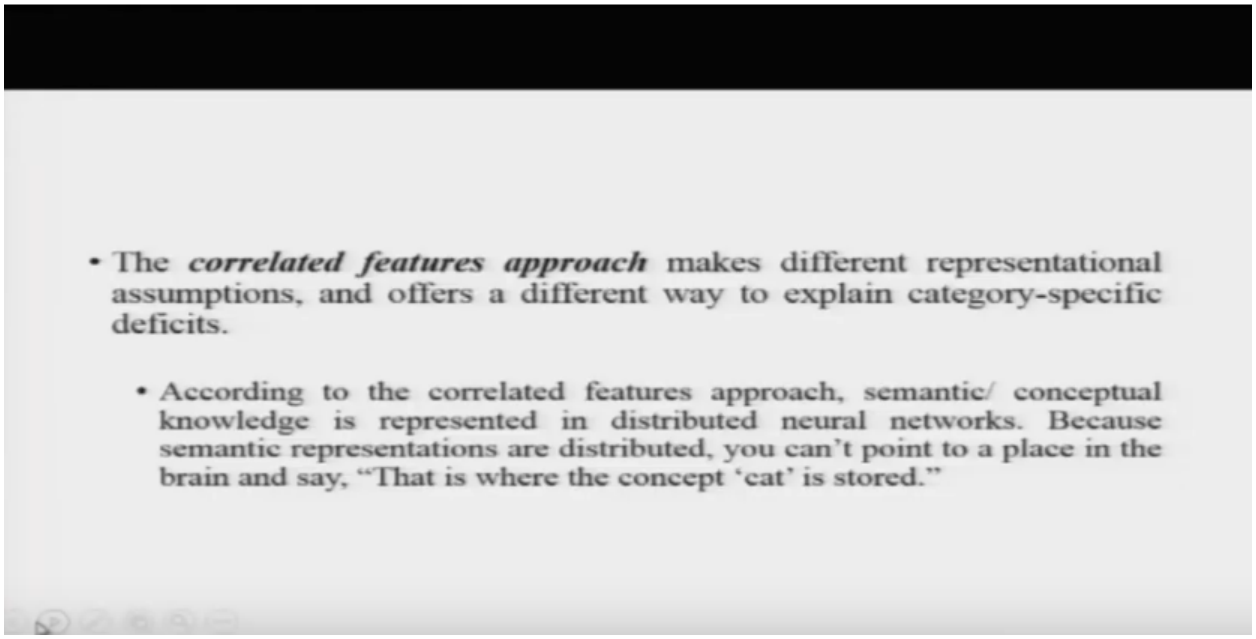

In a bit more detail and what does it say, it says that that there could be different representational, assumptions and it basically kind of tries to explain the category specific semantic deficits, in this particular way. So, what does it say it says that you know correlated features, the semantic conceptual knowledge, is represented in distributed neural networks that is given, because semantic representations are distributed, you cannot point, pin point into place and the brain says this area is where the concept of cat or the series where the concept of natural category, is stored whereas this other area, is where the concern you know the information about, man-made artifacts. So, they say, you cannot really distinguish between these two things, which is again the tenant of the distributed approach. And if you look at this more closely, first when you hear the word cat.

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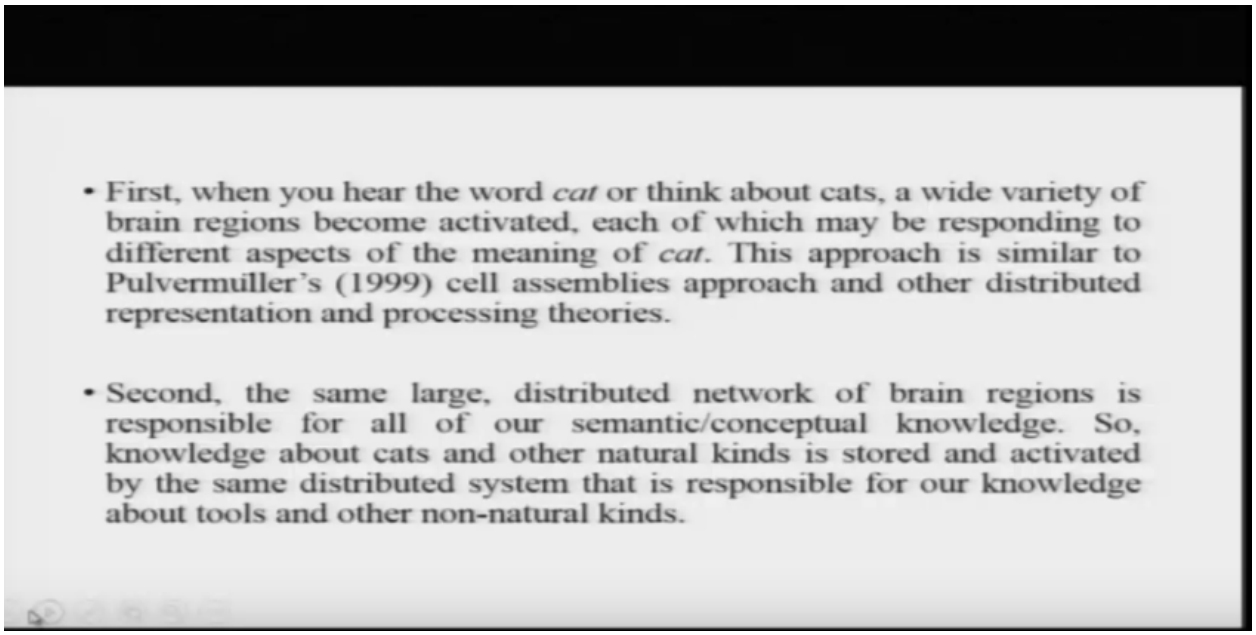

Or think about cats a wide variety of the brain, regions would get activated, each of which may be representing different aspects of this concept cat. Okay? And this approach will be similar to what PulverMuller was saying or say for example, you know the whole concept of hebbian cell assemblies. Secondly what happens? Is a large distributed network of brain regions, could be responsible for all of the semantic conceptual knowledge in, in that sense and so, what you could say from there, is that knowledge about cats and all other natural kinds, is stored and activated by the same distributed system that is representing knowledge, for the man-made artifacts and other kind of categories as well So, they're saying is that it there is the same generic system, a distributed system that is storing information about, all of these different kinds of categories. But if you have to say this, if knowledge,

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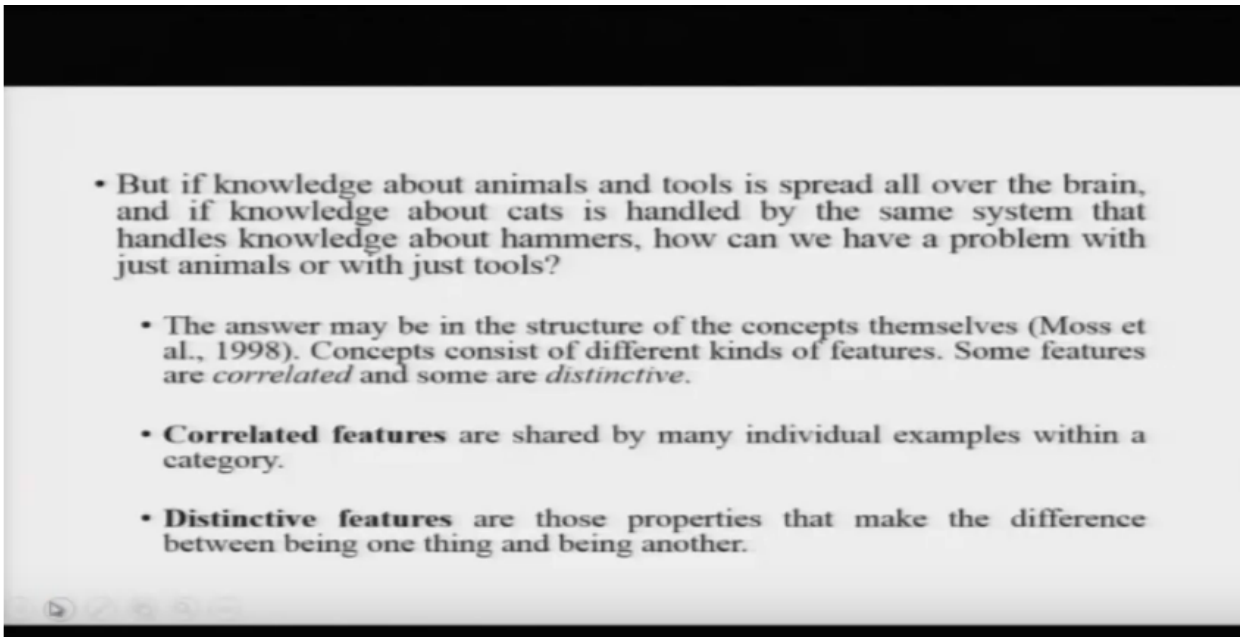

about animals and tools is spread all over the brain. And if knowledge about cats is handled by the same system, as knowledge about tools, why is it that we have sometimes a problem, with you know the natural kinds and not there, there are tools or vice versa. Now the answer basically to this question, could be from as far as this approach is concerned, lies and you know lying in the structure, of concepts themselves. So, the idea is some of these concepts, if you look at concepts if you look at say for example when you're talking about the semantic networks theory earlier, basically, could be that some of these concepts are made up of, I mean mostly concepts could be made up of different kinds of features. So, they could be distinctive, features and they could be correlated features. So, in a particular category, they could be features that are correlated, with other members of the category or other members from outside the category as well, where a certain, particular features, will be very distinctive. Okay? That kind of established the unique position of that specific concept. So, they every concept would have some distinguishing features, versus some correlated features, let us look at this more closely. So, correlated features say for example could be if you talk about animals, all of them most of them say well have four legs, they have two years, they have a tail etcetera, these are correlated features, but they could still have some distinguishing features as well. So, if you kind of you know look in more closely, you know there could be something some things, very clearly say for example and distinguish, from the cat from the dog, say for example the snout, you know the dog has a slightly elongated sound, as a cat it's not that could, be the distinguishing feature, of these two concepts. Okay? So, you have to kind of look at concepts not in terms of broad categories, but in terms of what features are you going to talk about, are you going to talk about, correlated features, which are common across the category or are you going to talk about, distinctive features that are and you know unique to that particular concept.

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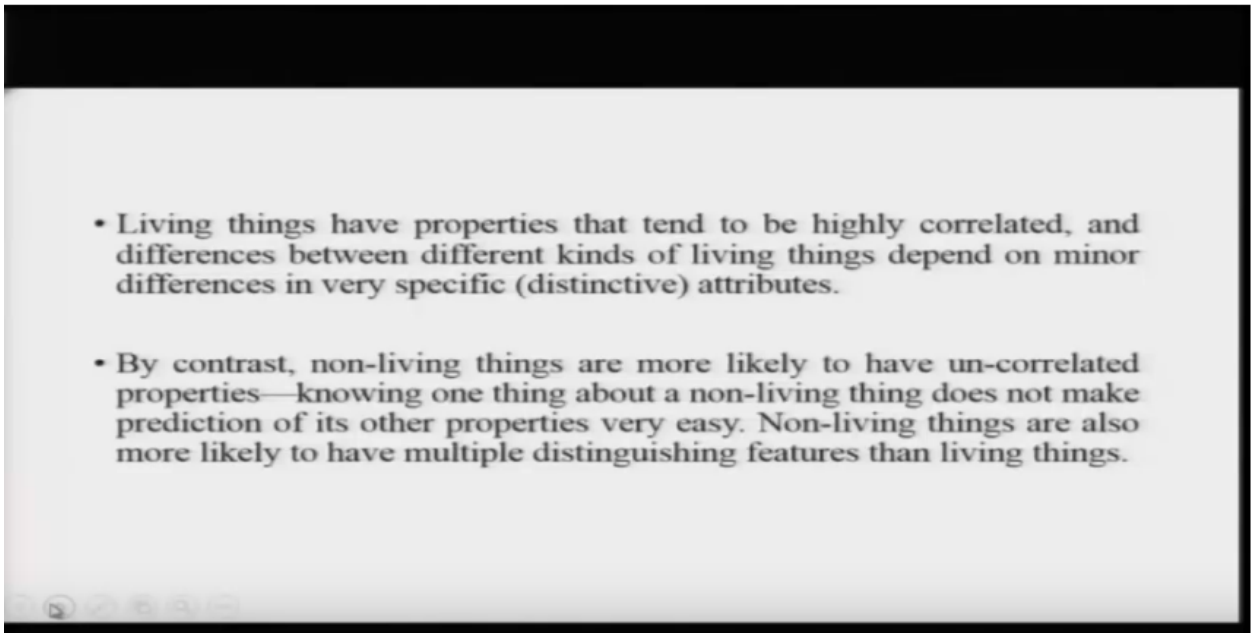

Living things it has been found have properties that tend to be highly correlated as I was saying in a four legs, tail whiskers ears. So, on and you know differences between, different kinds, of living things basically depend upon very minor differences, in very specific attributes the snout for example, by contrast nonliving things have highly uncorrelated, properties and basically knowing about one set. Now one set of living and nonliving things does not really make you knowledgeable about all the other kinds of so, for example man-made objects are really very disparate. So, chair and table are so, very similar but chair and pen or a chair and a camera and other things are actually very, very distinguished from each other. So, the idea is that living things have more correlated features than distinctive features, whereas nonliving things have more, distinctive features, than correlated features.

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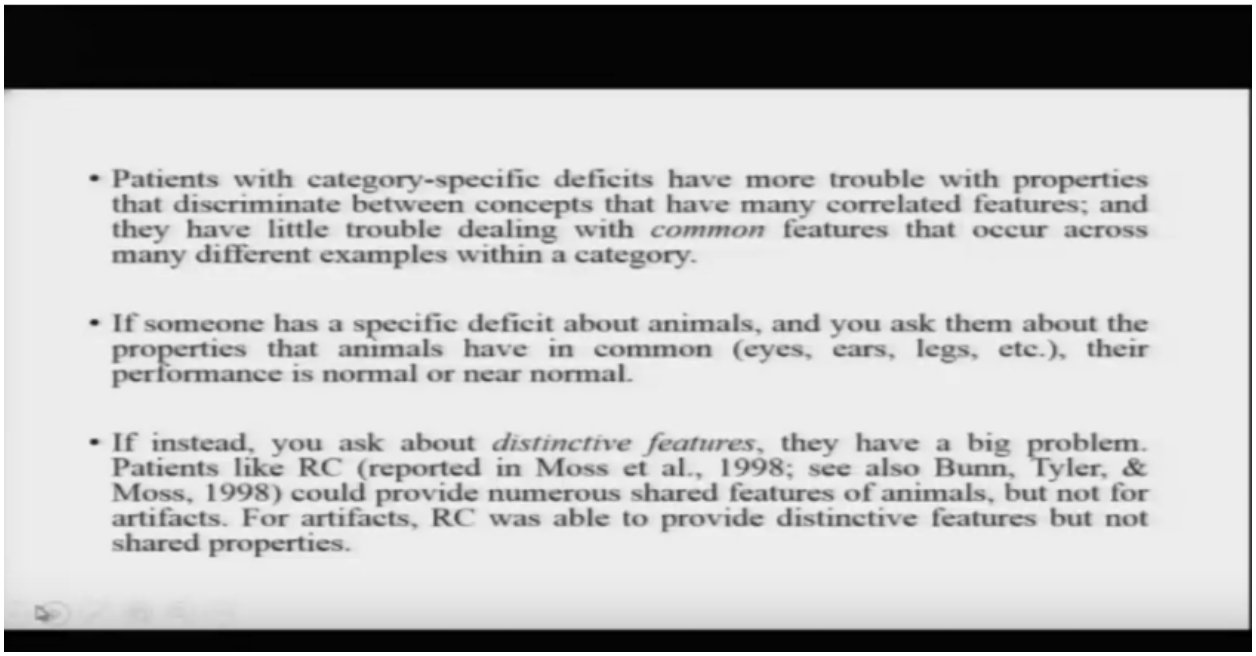

Now patients with category, specific semantic deficits have been found to have more trouble, with properties that discriminate between concepts that have many correlated features. So, if concepts have many correlated features, category specific semantic deficit patients, basically we have more trouble, distinguishing between these particular concepts. And they have little trouble dealing with common features. So, shared features, they don't really have a problem, but distinctive features they have a problem. Okay? So, for example, it could be that if someone has a specific deficit about animals. And you ask them about the correlated features, they might still be performing, as near to normal, but as soon as you ask start asking them about distinctive features, of this category, animals that is where you'll find that they will suffer. Okay?

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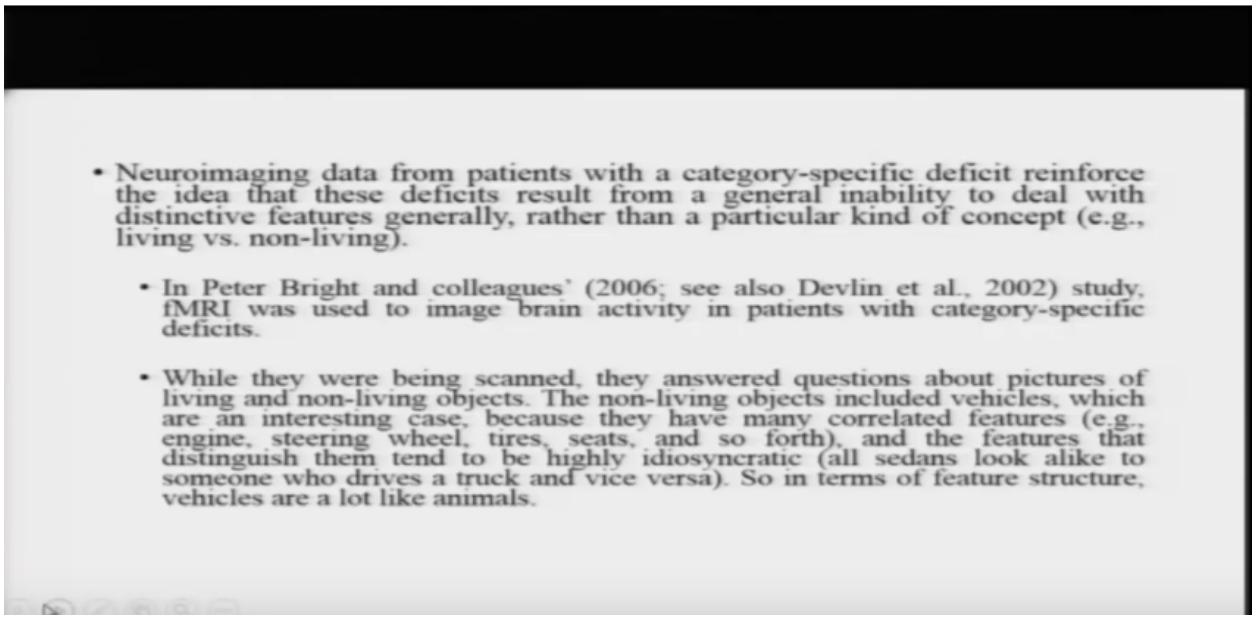

Neuroimaging data, moving on to some data neuroimaging data from patients, with category specific semantic deficit actually reinforce this idea. And they it is that these deficits, you know really stem, from a general inability to deal with distinctive features, rather than the entire category itself. So, they did this study in peter Bright study 2006 and they found they used fMRI to image the brain activity in patients with category specific semantic deficits, while they were being scanned the answered questions either, about both kinds of categories. So, living objects and nonliving objects, they are the nonliving objects including vehicles, which are an interesting case because vehicles, for that matter are very similar to living things, because they also have very common characteristics, say for example all vehicles will have four wheels, they will have a visor in the front they will probably have a steering wheel and so on. Okay? All sedan symbolism and the differences between vehicles, will vary will be very idiosyncratic. So, say dance, was as hatchbacks and so, on that is the difference, is rather minute I would say. Now in this fMRI experiment, some of the questions were asked about shared features. So, does this have tires, does it have eyes so on.

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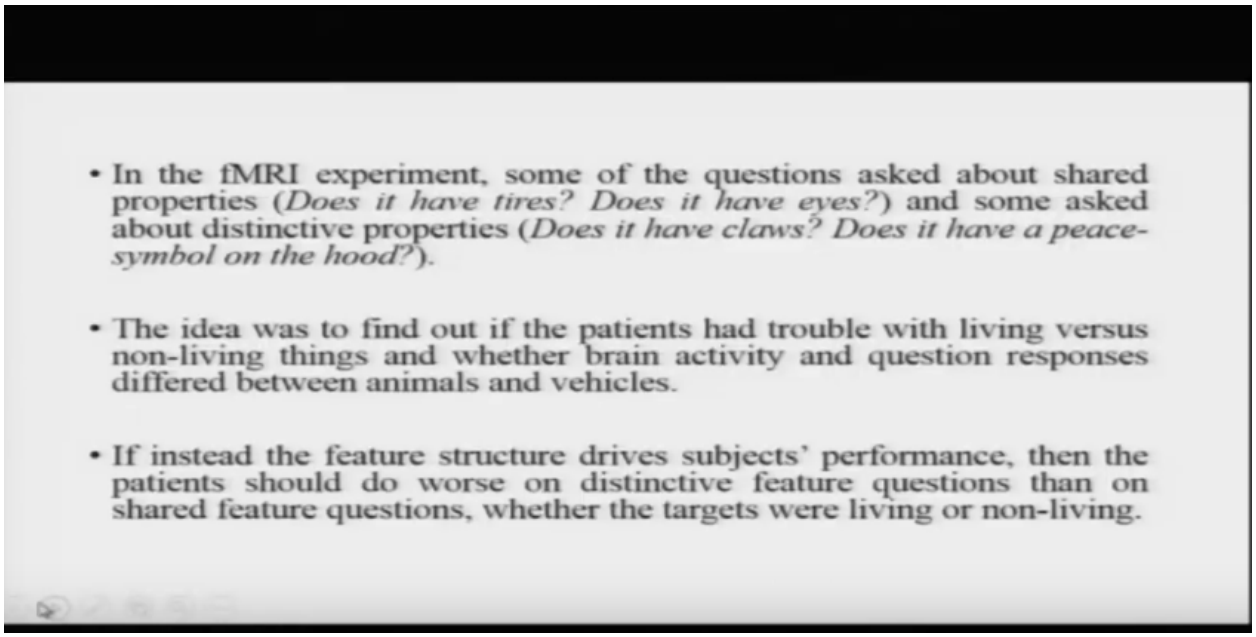

And some work some of the questions were about distinctive, properties does it have claws does it have a peace symbol, on the hood. So, again you see the two kinds of questions, are being asked to both categories. The idea was to find out, if the patient's had trouble with the living versus nonliving ID, concepts that is one whole category versus the other whole category or one specific kind of question, irrespective of the category. So, are they having problems with distinctive questions, regardless of the category or shared information regardless of the category or no they lose everything about, one category, but retain everything about the other category that is what is being tested here? So, if instead the feature is structured and drives the subjects performance, then the patient should do verse on distinctive features questions, then on shared feature questions, regardless of what is the category in question.

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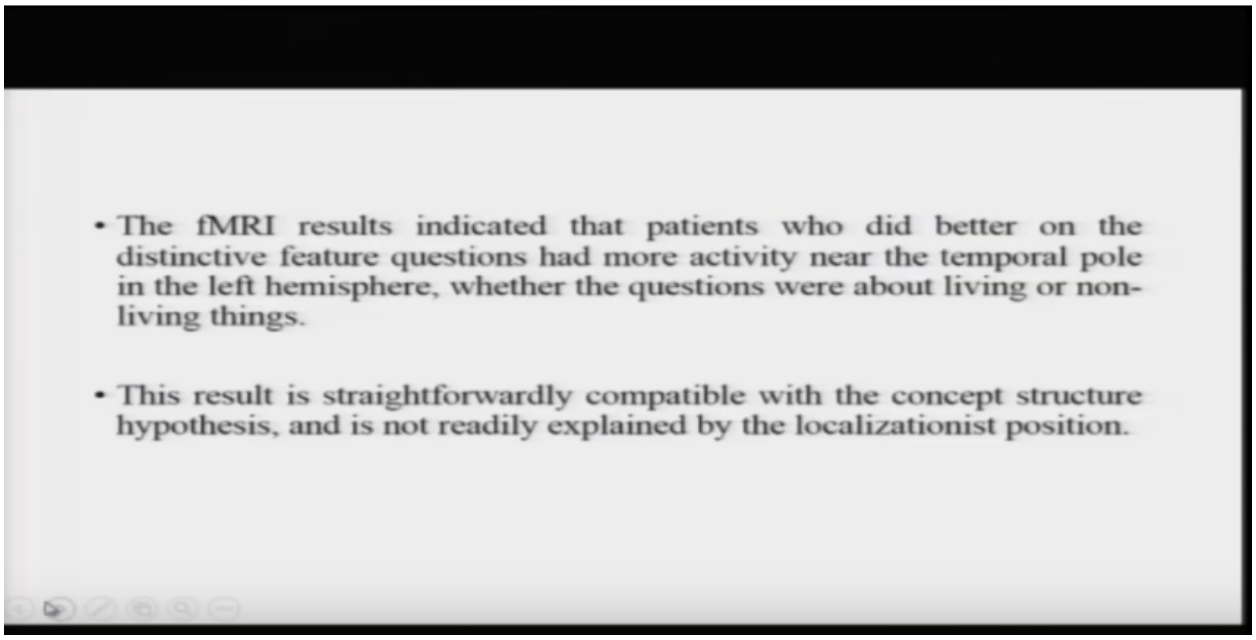

The fMRI results actually indicated that the patients, who did better on distinctive feature questions, had more activity in the temporal Pole in the left hemisphere. And it was regardless of whether the questions or were about nonliving kinds or living kinds, this result in that sense is straightforwardly compatible, with the concept structure hypothesis, which says that, knowledge is not really organized by categories, but it is organized by correlated or distinctive features of across these categories, also that knowledge is stored, in a much more distributed fashion across the brain, as opposed to one particular site, storing all the knowledge about a particular category, moving on this concept structured,

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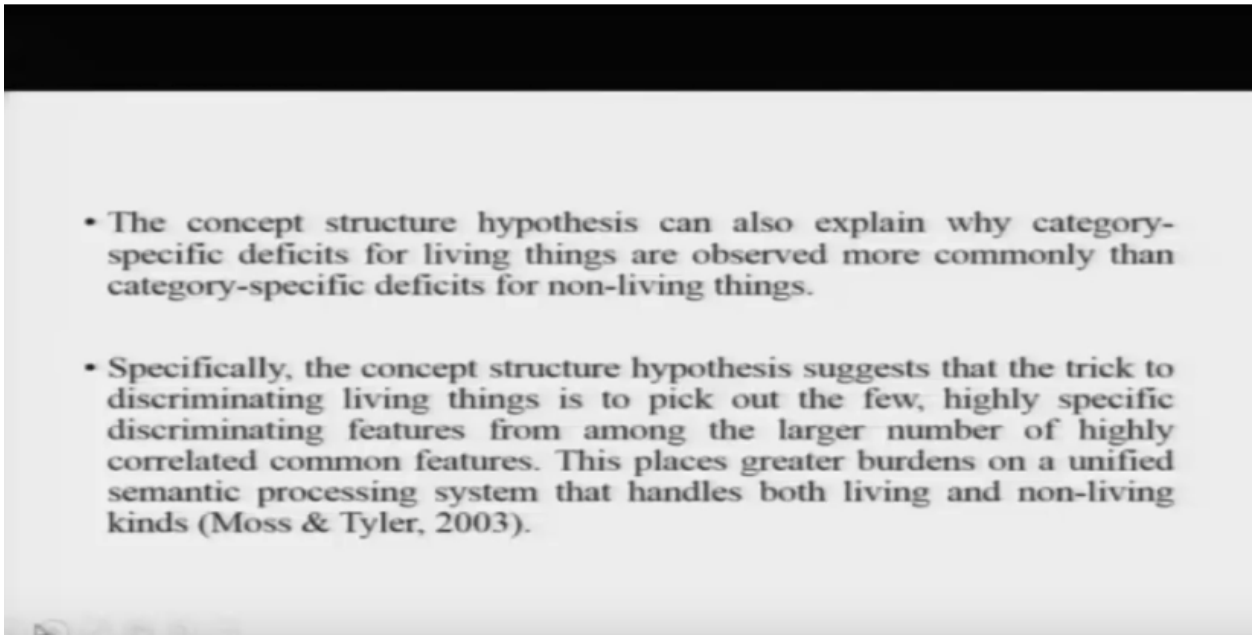

hypothesis also kind of tries to explain, why category specific semantic deficits for living things, are much more common, than category special semantic deficits for nonliving things. And the explanation they give is that the constant you know the trick to discriminating living things, is mostly, about by picking some of the highly specific discriminating features, from a large number of highly correlated, common features. So, distinctive features is something that you know is really needed if you have to kind of you know negotiate between different instances of the living categories. This is sort of heavy this places greater burdens on this unified semantic processing system. That handles both, living nonliving objects and that is why you would see that if a person had a person has lesion, the he would be more severely affected with the living things, as compared to the nonliving things, this is basically you know something that you can take away or conclude from here and this will be all from me with respect, to you know the chapter on word processing, just to sum up just to revise what did we talk about we talked about, you know word being represented in two separately in terms of form and meaning and then we say talked a little bit about meaning say for example, sense, reference introspection semantic networks, association, embodied semantics, then we kind of again, sort of got into this whole concept of how lexical access is done. So, we talked a little bit about, the lexical access in three different generations of models, we talked then a little bit about say for example, how meaning could be stored, ambiguity resolution you know how whatever, how this lexical access is based newly, word form information and cons information, is being accessed from separate parts of the brain. And today's lecture we talked a little bit in more detail about how, concepts or meaning can be stored in the brain in a distributed sort of a fashion, as opposed to a localized sort of a fashion that will be all for week four. Thank you. In the next week, we will talk mostly about sentence processing. Thank you.