Introduction to Brain & Behaviour
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Week 7 Lecture 34: Language Comprehension - II

Hello and welcome to the course Introduction to Brain and Behaviour. This is Doctor Ark Verma from IIT Kanpur. We are in the seventh week of the course. And I will continue to talk to you about Language Comprehension.

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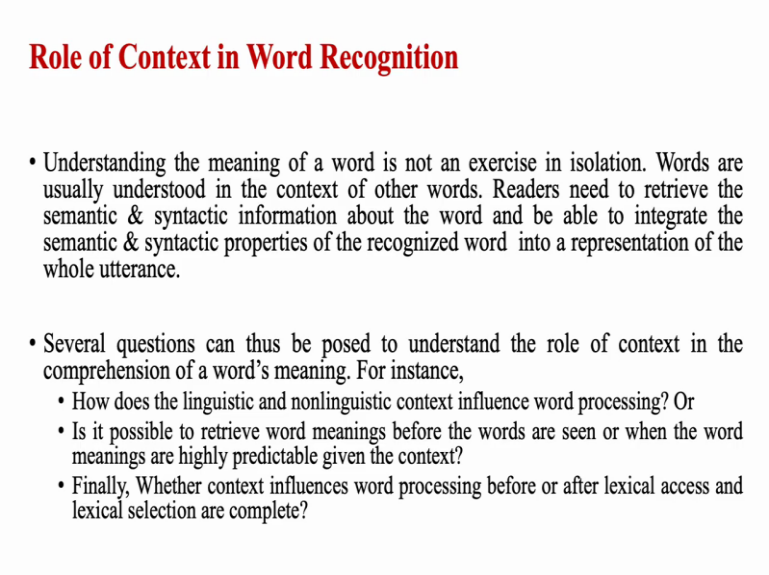

Let us talk about the role of context in word recognition in the last lecture we talked about we talked in some detail about spoken word comprehension, we talked in some detail about written word comprehension, but we have not really talked in any detail about the role of context in word recognition. See why is context important?

Context is important basically because we do not really read the words in isolation, or we do not really hear words in isolation. We typically read them or hear them as part of the larger narrative, as part of a larger conversation maybe some kind of you know text and reading or and having a conversation with somebody or and listening to a program podcast or something and so on. So, understanding the meaning of the word is not really an exercise in isolation.

Typically words are understood in the context of other words, okay? So what the readers or listeners need to do is they need to retrieve the syntactic and semantic information about these words, and will be able to integrate the syntactic and semantic properties of the

recognised words into a representation of the whole utterance. See, for example let us talk about an example of you know a a word that can have several meanings.

Basically what meaning of that word, say for example, synonyms what meaning of that word is being used in a given context, needs to be understood in the reference of that context itself. We will come to this in a bit. Now several questions can therefore be posed to the posed to understand the role of context in a comprehension of words meaning. For instance, how does the linguistic and non-linguistic context influence word processing.

Or is it possible to retrieve word meanings before the words are seen or when the word meanings are highly predictable in a given context? Finally, somebody would ask whether context influences word processing before or after lexical access and whether lexical selection influences are complete. Say for example, that if you made the lexical selection only the meaning of the word that is appropriate to the context is going to come up.

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- Lets take an example, "*The tall man planted a tree on the bank.*"
- Here, the word "*bank*" can mean both "financial institution" and "side of the river".
- The semantic integration of the meaning of the the final word *bank* into the context of the sentence allows us to interpret *bank* as the "side of the river" and not as a "financial institution".
- A few questions can be asked like,
  - Whether the sentence's context influence the activation of the multiple meanings of the word *bank?* Or
  - Do the contextually appropriate meaning of the *bank* and the contextually inappropriate meaning become briefly activated regardless of the context of the sentence? Or
  - Does the sentence context immediately constrain the activation to the contextually appropriate meaning of the word bank?

Let us take an example of this sentence "The tall man planted a tree on the bank." Now here the word "bank" can mean both, a financial institution, or the side of the river. Now the semantic integration of the final word bank into the context of this overall sentence allows us or say let us say biases us to interpret the meaning in terms of the side of the river and not as a financial institution.

However let us say you know, there are so many beautification project etcetera that keep on you know happening in our cities. May be there is some beautification going on let us say of a particular bank and you know there is some place in the city next to the bank where trees

can be planted. So, it basically you know it it has to the the understanding of the meaning of a particular word really need to go in consonance with the overall context.

For 90 percent of the times in this sentence you would basically be biased to understanding the meaning of the word bank as side of the river, because that is more usually the place where people plant trees. Now in this context a several important questions can be raised. Say for example, whether the sentences context influences the activation of multiple meanings of the word bank? Say for example, the tall man planted a tree on the bank, will this activate both the meanings of the word bank or it will just activate one given meaning. Okay?

Also we can ask for example things, like do contextually appropriate meaning of the word bank and the contextually inappropriate meaning of the other word bank in this case here become both of them become briefly activated, regardless of the context of the sentence? Or finally we can ask the question is that, does the context sentence context immediately constrain the activation to the contextually appropriate meaning of the word bank?

So, that the other meaning that of the financial institution does not get activated at all. Now here you can take a bit of a pause and just try and understand, what are the questions that I am asking. First is that, does the context of the sentence, the tall man planted a tree, have any role to play in the activation of the meaning of this word bank? Okay? Now if it has a role to play, does it constrain the activation to just activating the meaning of the word bank that is basically the side of a river and the other meaning that is basically the financial institution part does not really get activated at all. Okay?

The other thing would be that say for example, in respective of the context of the sentence, because we know this word both the meanings of this words of the word basically the financial institution and that meaning of the side of the river, both of them will get activated regardless. Okay? So, you have to sort of you know just deliver to your experiences to see what typically happens. Now if we look closely, there are at least two types of representations that…

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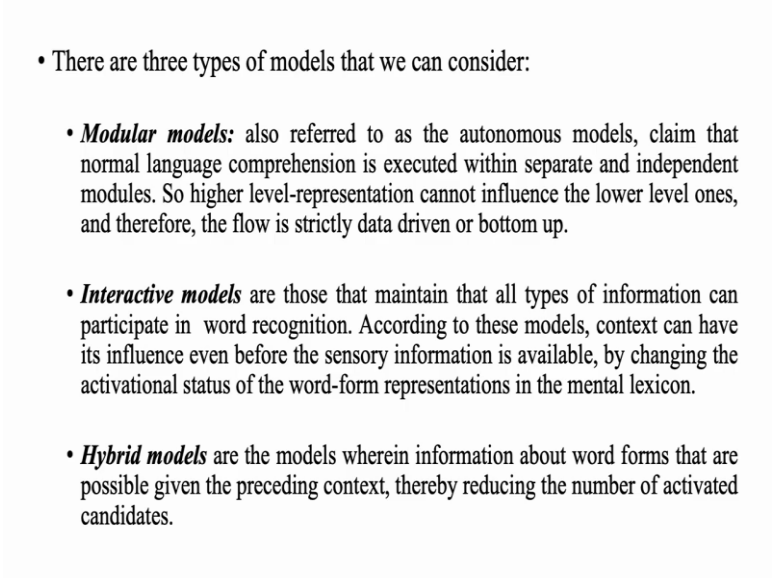

Now there are three types of models that we can consider, okay? Modular models. See modular models basically are referred to as more autonomous models, and these models actually claim that normal language comprehension is executed within separate and independent models okay? So, language comprehension is separate from all other kinds of cognitive activity and it is done in a separate module and has nothing to do with a sensory, processing, etcetera. (06:28)(Professor speaking in Hindi)

So, what this model actually says is, that higher level representations, conceptual representations basically will not have a chance to influence the lower level representations, and therefore the flow of information is strictly from bottom upwards, okay? Now there are other kinds of models, interactive Models. Interactive models are models that maintain that all types of information can participate in word recognition, the broad information, conceptual level information, and also sensory information.

Now according to these kind of models, context can have its influence sometimes according to these models context can have its influence even before the sensory information is available, by changing the activational status of the word-form representations in the mental lexicon. What does this means? Suppose because of this you know because of I was already talking about my village and I was already talking about the river and the village, what this will do is, this will automatically preclude any other possible meaning that can be activated.

So your attention will not even go on the second probable meaning it will just focus and it will only be there to activate the first meaning, which is the side of the river. Then there are other kinds of models that are referred to as the hybrid models. Now these hybrid models

basically are models wherein information about word forms that are possible given the preceding context is basically activated. Okay?

So, it basically reduces the number of activated candidates, since already it is clearly similar to the interactive part, but that one was taking both higher and lower in function. In hybrid models, information from about word forms basically that are possible is activated. So every other thing that is not congruent to the context will not get activated at all.

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- A study was conducted to contrast the usefulness of the modular vs. the interactive models by Zwitserlood (1989) involving a lexical decision task. The participants were asked to listen to short texts such as

"*With dampened spirits the men stood around the grave. They mourned the loss of their captain.*"

- At different points during the auditory presentation of the word *captain*, a visual target was presented.
- This target stimulus could be either related to the actual word *captain* or to an auditory competitor for e.g. *capital.* In the current example, target words could be like *ship*, i.e. related to the word captain or *money* i.e. related to word capital. In other cases, a pseudoword would be presented.
- Participants were asked to decide whether the presented target was a word or not (i.e. a lexical decision task).

Now there was a study conducted to contrast the usefulness of the modular versus the interactive models and this was done by Zwitserlood in 1989 involving a lexical decision task. If you remember the lexical decision task is where you were presented with words and you are asked whether this given stimulus is meaningful word or it is not. Now the participants were asked to listen to short text such as, "With dampened spirits the men stood around the grave. They mourned the loss of their captain." Okay? So, this is a short text which these people will be asked to listen to.

At different points during the auditory presentation of the word captain, a visual target was presented. (09:08)(Professor speaks in Hindi). So, this target stimulus could be either related to the actual word captain, say for example, you know auditory competitor like a word capital. So, in the current example the target words could be like you know ship that is related to the word or money that is related to the word capital. In other cases, a pseudo word could be presented. Now participants in this task were asked to decide whether the presented target word was a target was actually a word or not. So, lexical decision task.

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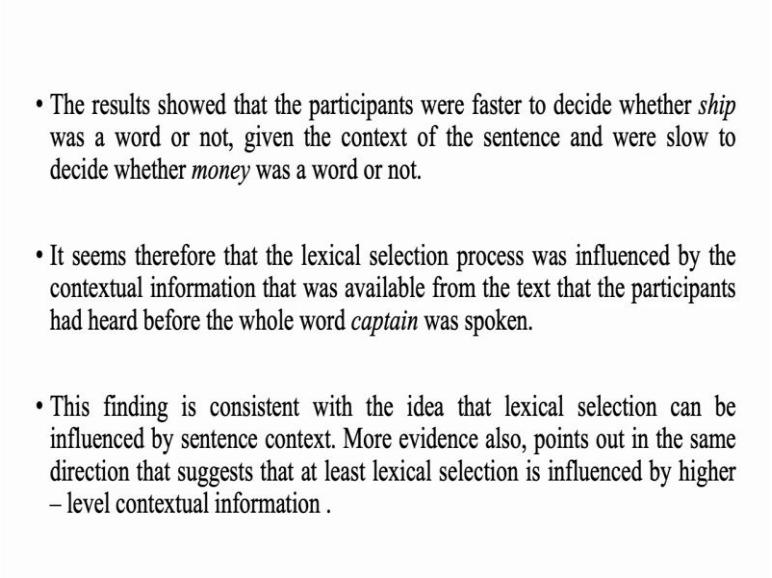

Now the results showed that the participants were faster to decide whether ship was a word or not, given the context of the sentence and were slow to decide whether money was a word or not. Okay? So, basically this is what is happening. Now they are presented they could decide whether ship was a word or not given the context of the thing because obviously we are thinking of the ship's captain. But they could not decide whether money was a word or not, or they were faster to decide.

It not that they are not able to perform this, but they had a minute differences in the timing that we are basically counting upon. Okay? So, they were slightly slower in deciding whether money was a word or not. So it seems here, if you look at this experiment in some detail, it seems therefore that the lexical selection process is influenced by the contextual information that is available from the text and that the participants had heard (before) heard before the whole word captain was spoken.

So, because this whole you know preface has been given because the whole short text has been given, they are already partially activating the word for captain and that is probably allowing them to identify that word slightly faster as oppose to any other word. Now this finding is consistent with the idea that lexical selection can be influenced by the sentence context. More evidence also points out in the same direction that suggest that at least lexical selection is influenced by higher-level contextual information.

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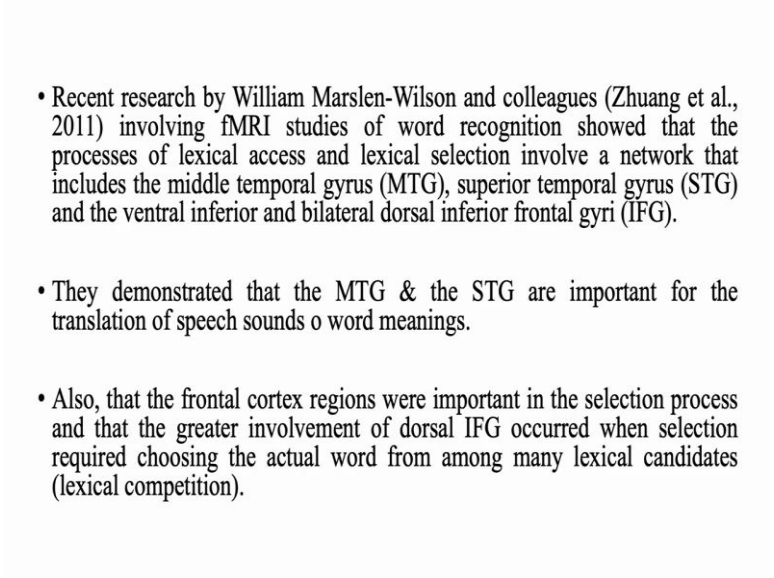

So, some experiments were done in this regard by William Marslen-Willson and their colleagues Zhuang in Zhuang and colleagues Zhuang and (())(0:11:34) basically involving fMRI studies of word recognition and actually they showed that the process of lexical access and lexical selection involve a network that includes the middle temporal gyrus, the superior temporal gyrus, and the ventral inferior and bilateral dorsal inferior frontal gyri.

They also demonstrated that the middle temporal gyrus and the superior temporal gyrus are important for the translation of words or translation of speech sounds to word meanings. Also the frontal cortex regions were found to be important in the selection process and greater involvement of the dorsal inferior frontal gyri was occurred when selection required choosing the actual word from many lexical candidates. So, lexical selection appears to involve the dorsal inferior frontal gyrus.

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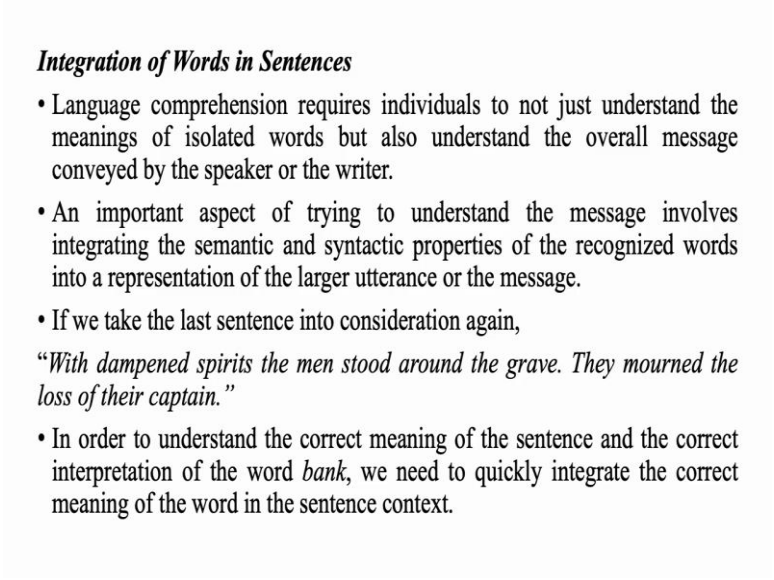

Let us talk a little bit about integration of words in sentences. Now language comprehension is supposed to require individuals to not just understand the meanings of isolated words but also understand the overall message what is being said? What is the point of this whole conversation? Now an important aspect of trying to understand the message involves integrating the semantic and syntactic properties of the recognized words into a representation of the overall utterance or the larger utterance of the message.

So, let us say if we take last sentence into consideration again I am reading it out, "With dampened spirits the men stood around the grave. They mourned the loss of their captain" Now in order to understand the correct meaning of the sentence and the correct interpretation of the word bank, we need to quickly integrate the meaning of this word bank to the overall you know overall context.

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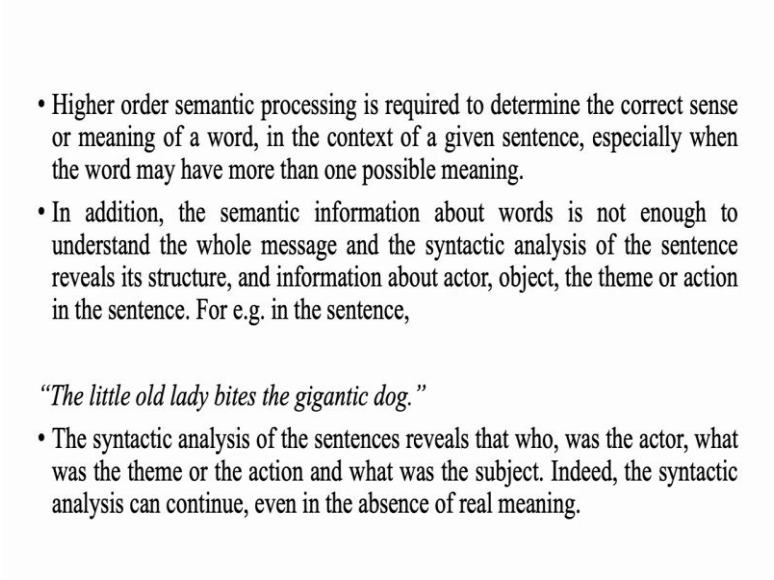

Now higher order semantic processing is actually required to determine the correct sense or meaning of the word in the context of a given sentence, especially when the word may have more than one possible meaning. So, okay? In addition the semantic information about words is just not enough to understand the overall message and therefore a syntactic analysis of the sentence is needed. The syntactic analysis of the sentence will reveal its structure and the information about what is the actor, what is the object, the theme, or the action in the sentence.

For example, "The little old lady bites the gigantic dog", okay? The syntactic analysis of the sentences reveals that who was the actor, the little old lady. What was the theme, biting is the theme or the action. And what was the subject, dog is the subject. Indeed, the syntactic analysis can continue, even in the absence of real meaning. There was obviously the real meaning of the sentence is highly improbable.

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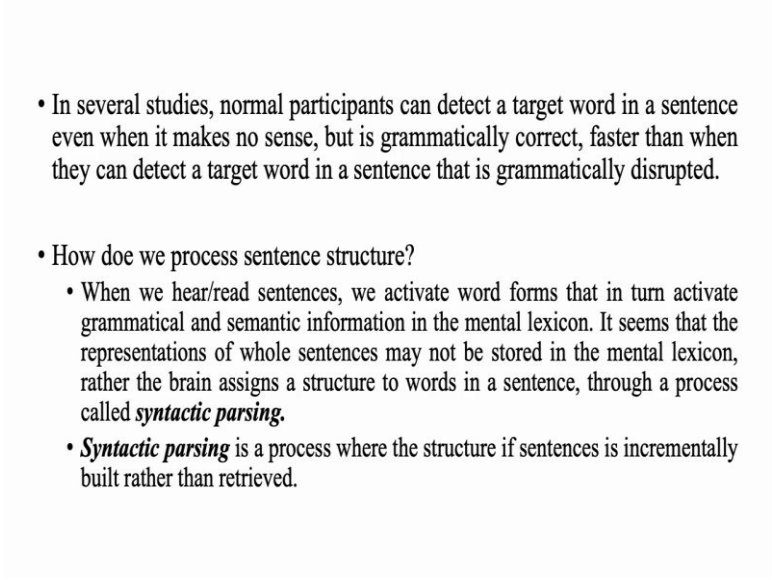

In several studies, normal participants have been shown to detect a target word in a sentence even when the sentence does not make any sense but is grammatically correct. So, people are faster at doing this than when they can detect when they are asked to detect a target word in a sentence that is grammatically disrupted. So, if grammar is there then people perform slightly better in this word target world detection tasks. Now how how how do we process sentence structure?

When we hear or read sentences, it is assumed that we activate word forms that in turn activate the grammatical and semantic information about this word forms in the mental lexicon. It seems that the representations of whole sentences may not be stored in the mental lexicon. Rather what probably happens is that the brain assigns a structure to the words that are inactivated in a sentence, through a process called syntactic parsing. More specifically syntactic parsing is a process where the structures of sentences is incrementally built rather than retrieved.

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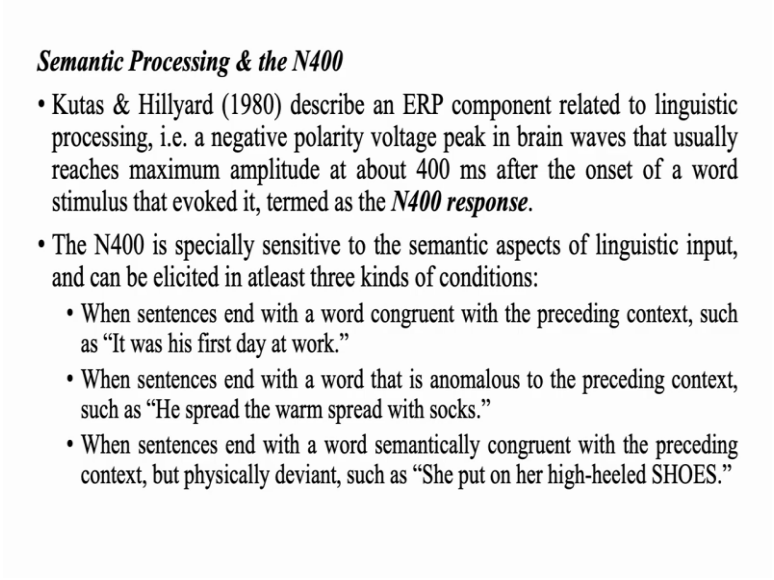

Let us talk about semantic processing and the N400. Now Kutas and Hillyard in 1980 described an ERP component that is related to linguistic processing. So, this ERP component had a negative polarity voltage peak in brain waves that actually reaches around the maximum amplitude at about 400 milliseconds after the onset of a word stimulus that evoked it, termed as the N400 response. The N400 is especially sensitive to the semantic aspects of the linguistic input, and can be elicited in at least three kinds of situation.

When sentences end with a word congruent with the preceding context, such as, "It was his first day at work". Congruent sentences end with word that is anomalous to the preceding context, say for example, "He spread the warm bread with sauce". The third is when sentences end with a word that is semantically congruent with the proceeding context but physically slightly deviate, say for example, "She put on her high-heeled SHOES". Here the word shoes is printed in upper case. The words preceding the word shoes are all in lower case and therefore it is physically deviate and therefore it might elicit a N400 response.

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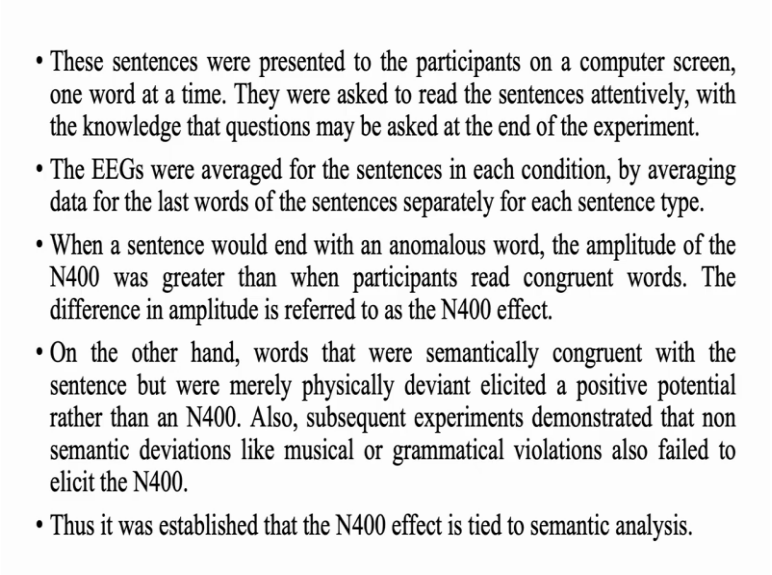

Now, these sentences were presented to the participant on a computer screen, one word at a time. They were asked to read the sentences attentively with the knowledge that questions may be asked at the end of the experiment. The EEG's were averaged for the sentences in each for each for the sentences in each condition by averaging data for the last two words of the sentences separately for each kind of sentence. When a sentence would end with up in an anomalous word, or the amplitude of N400 was found to be greater than when participant read congruent words. Okay?

The difference in amplitude is referred to as the N400 effect. (0:17:39)(Professor speaks in Hindi) Now on the other hand, words that were semantically congruent with the sentence but were merely physically deviant elicited a positive potential rather than an N400. So, it did not really (redu) increase the N400. Also subsequent experiments have demonstrated that non semantic deviations like musical or grammatical violations also do not elicit the N400. So, it was established that N400 is typically tied to semantic analysis or in simpler words when there is a semantic anomaly, when there is a meaning anomaly in a given sentence.

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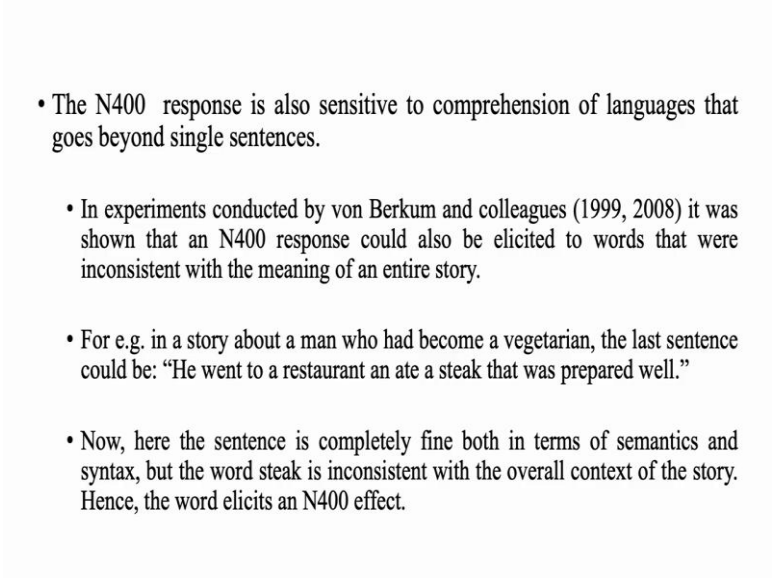

Now this N400 responses have also been found to be sensitive to comprehension of languages that goes beyond single sentences. Okay? Say for example in an experiment done by Von Berkum and colleagues, it was shown that an N400 response could also be elicited to words that were inconsistent with the meaning of the entire story and not just of that sentence. For example, in a story about a man who had become vegetarian the last sentence was, "He went to a restaurant and ate a steak that was prepared well". Okay?

Now, because this the whole story is about how this person became vegetarian, what were the troubles, etcetera, and then the last sentence (enter) last sentence ends by this particular sentence, that he went to a restaurant and ate a steak. Steak is a non-vegetarian food and therefore N400 will be activated here because this last sentence is inconsistent with the overall message of the story. Now here the sentence already I am sure you would see that the sentence is completely fine, both in terms of semantics and syntax is also correct, but the words steak, because it is inconsistent with the overall context of the story, elicits the N400 effect.

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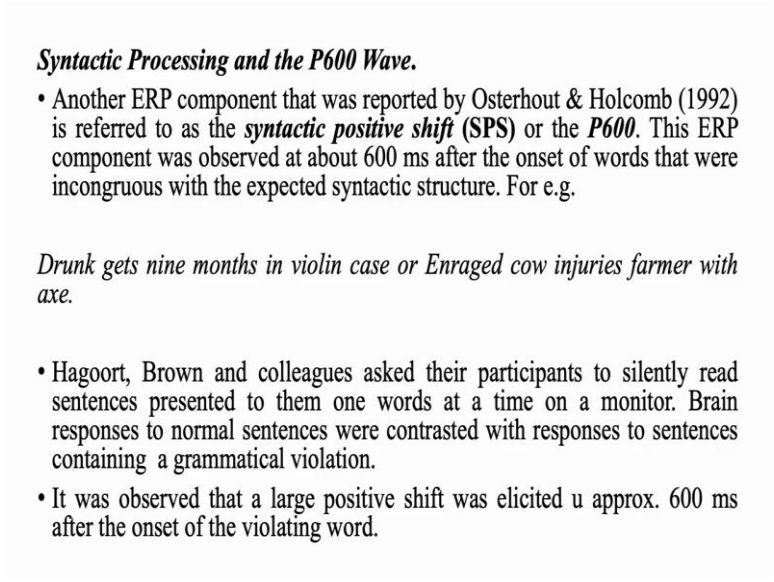

Syntactic processing and this P600 Wave. Let us talk a little bit about this syntactic processing aspects. Now another ERP component was reported by Osterhout and Holcomb in 1992 and is referred to as the syntactic positive shift or SPS or the P600. This ERP component was observed at about 600 milliseconds after the onset of the words that were incongruous with the expected syntactical structure.

Okay? So for example if you come across sentences like, Drunk gets nine months in violin case or Engaged cow injuries injures a farmer with an axe. Okay? So, both of these sentences syntactically are creating ambiguities okay? Hagoort, Brown and colleagues asked their participants to silently read these sentences presented to them, one word at a time on a monitor. Brain responses to normal sentences were contrasted with brain responses to sentences that contained a grammatical violation. What they observed was a large positive shift that was elicited approximately around 600 milliseconds after the onset of the violating word.

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- The ***P600*** effect also shows up in response to a number of other syntactic violations as well, and it is elicited both, when the participants read or hear the sentences. The effect has been validated in several different languages by now.
- Finally, Kuperberg & coleagues (2003,2007) have shown that the P600 response can also be evoked by a semantic violation in the absence of any syntactic violations. For e.g., when there is a semantic violation between a verb and its subject but the syntax is correct, such as in the sentence,

" *The eggs would eat toast with jam at breakfast*."

- In the given sentence, there is neither a semantic nor a syntactic violation, instead there is a so-called thematic violation in the sense that "eggs" cannot eat.
- Such sentences may elicit a P600 response as the syntactic analysis of the sentence is challenged by the semantic relations of the words in a sentence.

The P600 effect also shows up in response to a number of other kinds of syntactic violations, and it is elicited both, when participants are reading or hearing the sentences. This effect has also been validated in several different languages. Now finally, Kuperberg and colleagues in 2003 and 7 have shown that the P600 response can also be evoked by a semantic violation in the absence of any syntactic violations. Say for example, if there is a semantic violation between a verb and its subject but the syntax is correct, you can still see the P600 effect.

Say for example, "The eggs would eat toast with jam at breakfast." Now syntactical everything is alright but semantically there is a violation because we know that eggs are not capable of eating. Okay? So, such sentences may exhibit a P600 response such as because even as the syntactic analysis of the sentence is challenged by the semantic relations of words in a sentence. So, basically a it is like you know the system is surprised as how eggs are coming as the subject of the sentence as but not with the not at its right full place as object of the sentence.

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- Syntactic processing is also reflected in other types of brain waves as well. For e.g. Thomas Münte & colleagues (1993) and Friederici and colleagues (1993) have described a negative wave over the left frontal areas of the brain.
- This ERP component has been referred to as the ***left anterior negativity*** **(LAN)**, observed when words violate the required word category in a sentence (e.g. as in "the red eats,", where noun instead of verb information is required), or when morphosyntactic features are violated (e.g., as in "he mow").
- The LAN arises at about the same latency as the N400 component but a different voltage distribution is observed over the scalp.

Syntactic processing is also referred to is also reflected in other types of brain waves as well. For example Thomas Münte and colleagues and Friederici and colleagues have described that a negative wave over the left frontal areas of the brain, and this is basically referred to as the left anterior negativity or the LAN.

It is typically observed when words violate word category in a given sentence, say for example, as in "the red eats," now the red cats is more red cars is more suitable here as opposed to the word red eats. Now here basically a noun was expected instead of a verb and therefore this violation will lead to eliciting the left anterior negativity. Now LAN arises at about the same time as the N400, but it has some different voltage distribution over the scalp.

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- Some brain-damaged patients been shown to have severe difficulty in producing sentences and understanding complex sentences. Such deficits are apparent in patients with ***agrammatic aphasia*** who generally produce two-or-three words sentences consisting exclusively of content words and devoid of function words.
- These patients have difficulty in understanding complex syntactic structures. So when these patients hear the sentence,

"*The gigantic dog was bitten by the little old lady.*"

- They will most likely understand it to mean that the lady was bitten by the dog.
- Such a problem in assigning syntactic structures to sentences, has often been associated lesions tat include the Broca's area in the left hemisphere, suggesting that the left inferior frontal cortex is involved in syntactic processing.

Some brain-damaged patients have actually shown the ability have actually been shown to have severe difficulty in producing sentences and understanding complex sentences. These kind of deficits are common in patients who have agrammatic aphasia and who generally produce two or three words sentences consisting exclusively of content words and completely devoid of function words, the article and prepositions etcetera.

Now these patients have been shown to have difficulty in understanding complex syntactic structures. So when these patients let us say if they hear a sentence, like "The gigantic dog was bitten by the little old lady." They will most likely understand it to mean that the lady was bitten by the dog. Okay?

Because they will not really be able to understand that this is in passive form, this is the passive structure of the sentence, So this kind of problem in assigning syntactic structure to sentences has often been associated with lesions that include the Broca's area in the left hemisphere, suggesting that the left inferior frontal cortex is involved in some kind of semantic syntactic processing.

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- Neuroimaging evidence from recent research by Caplan and colleagues (2000) offer some clues about syntactical processing in the brain.
- In these studies using PET methodology, participants were made to read sentences varying in syntactic complexity. Caplan and colleagues found increased activation in the left inferior frontal cortex for the more complex syntactic structures.
- In other research, manipulations of sentence complexity have led to the activation of more than just the left inferior frontal cortex. For e.g. Just & colleagues (1996) showed activation in Broca's area and Wernicke's area and also homologous areas in the right hemisphere.
- PET studies have identified portions of the anterior superior temporal gyrus, as another candidate for syntactic processing, a finding that was confirmed by Dronkers and colleagues (1994) as well.

Now neuroimaging evidence from recent research by Caplan and colleagues also offer some clues about syntactic processing in the brain. In some of their studies using PET methodology, participants were made to read sentences varying in syntactic complexity. Caplan and colleagues found increased activation in the left inferior frontal cortex for the more complex syntactic structures. In other research, manipulations of sentence complexity have also led to the activation of more than just the left inferior frontal cortex.

For example Just and colleagues in 1996 showed that activation in the Broca's area and Wernicke's area also homologous areas in the right hemisphere were also when people was reading complex syntactically complex sentences. PET studies have identified portions of the anterior superior temporal gyrus, as another candidate for syntactic processing. A finding that was confirmed later by Dronkers and colleagues in the year 1994.

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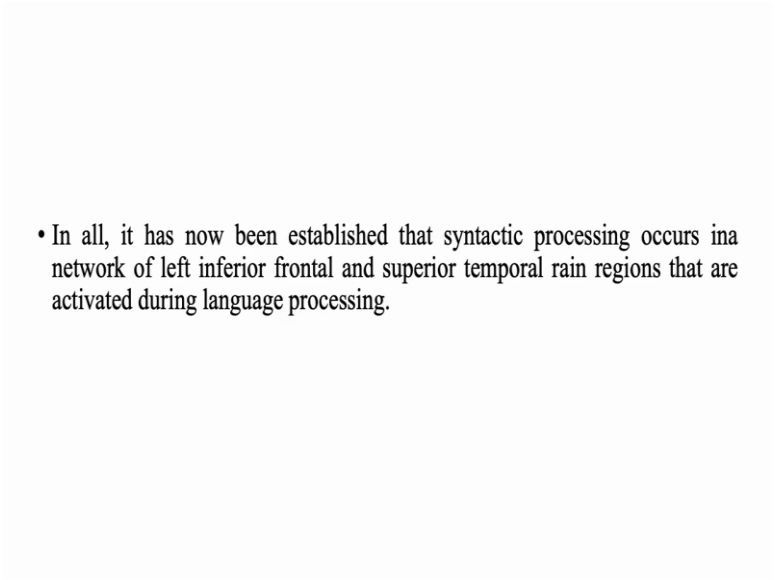

All in all you can say, that it is now been established that syntactic processing occurs in a network of left inferior frontal and superior temporal brain regions that are activated during various aspects of language processing. I think it was all for this lecture thank you for listening.

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