Lecture 34:

Neural Basis of Language Comprehension & Production

Hello and welcome to the course, introduction to the psychology of language, I am Ark Verma from IIT Kanpur. And this is the seventh week of the course, in this week we are trying to sort of revise whatever processes, with respect to language that we have already read about and what we're trying to add, to that is we are trying to add the neural basis of each of these functions. So, that is basically, what I have been doing in the last three lectures a week. And today I take that further, with talking a little bit more about, language comprehension and production, let us move ahead.

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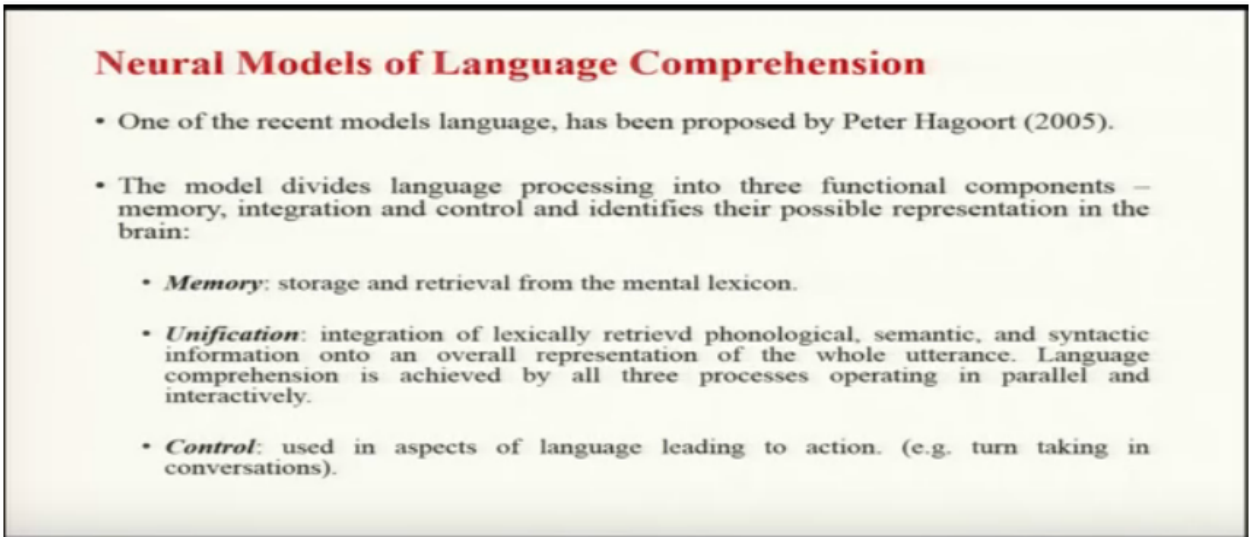

Now one of the models of, language or organization of language in the human brain, was given by Peter Hagoort and basically this model what it does is it divides this language processing system .The entire system of producing speech or comprehending speech and whatever is involved in say for example, in negotiating different aspects of speech, the model kind of divides all of this into three functional components, it says that memory is used, integration is needed and a sort of control is you. So, we're mostly going to talk about, language comprehension with respect to this model. And it says there three processes, the first process is memory and memory is basically involved, in the storage and retrieval of items from the mental lexicon.

Now one of the earlier lectures, in this week we talked about mental lexicon. And we talked about the, fact that the mental lexicon contains all the information about the words that is to be stored. And this information is a variety of things, it is a syntactic information, semantic information you know kind of word that is what kind of arguments, say for example if it is a verb all kind of argument it comes with so, on and so, forth. So, that information needs to be stored and retrieved again and again, if you are to say for example eyes that comprehend never delivered or produce a particular word and you need that information in order, to make the correct attendance. The second sort of information or the second process, a major process, in this model is the process of unification. And the process of unification, basically a kind of is there if you are trying to comprehend something, you'd need to you know integrate a variety, of sources of information, you'd need to integrate lexically, retrieved phonological, semantic and syntactic information. And then on the basis of combination, of these three factors from an overall representation, of the whole Utterance. So, if you remember in the last lecture is talking about, how context is really very necessary in order to understand the whole word. And with the word you need say

for example, the phonological form or the visual form, also then you need say for example, you know the lexical access, part is there and you will get the semantic and syntactic information, even further than that you actually go and need to, integrate the word, into the whole sentence or into the whole conversation. So, all of those unification processes are, given aware special importance, in this particular model. And the model kind of says that language comprehension basically, you know, is achieved by all of these processes, they are functioning in parallel and together achieving or together converging, to a particular result. Then the final process that this model talks about is the process of control. And the process of control, basically says that this is something that is used, in you know daily conversation, say for example if you are having a conversation with somebody, you would speak some you would speak something, wait for them to listen and react to that and you'll again speak something and the other person, will speak something.

So, that kind of you know turn-taking or suppose if you are a bilingual on the basis of and you know two languages fairly, well and you're comfortable with both the languages, you still would use one particular language, to talk to one specific kind of person. So, for example you would have in your life, people who would who you would only converse in your l1, which is your native language, say for example in my case that is Hindi. So, I have certain people whom, with whom I will only conversate in Hindi. And then I also have certain people who I would only conversation, for example peeping from work, I mostly conversate with them only in English. So, all of these kind of control processes, say for example you know production part and also comprehension because this model, is mostly about comprehension. So, maybe if you if you have to stick to that, understanding say for example what each of the language, you know symbols actually mean and what is the overall conceptual idea. So, all of this you know control part, is basically done, by this component of control. So, this model has memory, unification and control. Now let us look at it a little bit,

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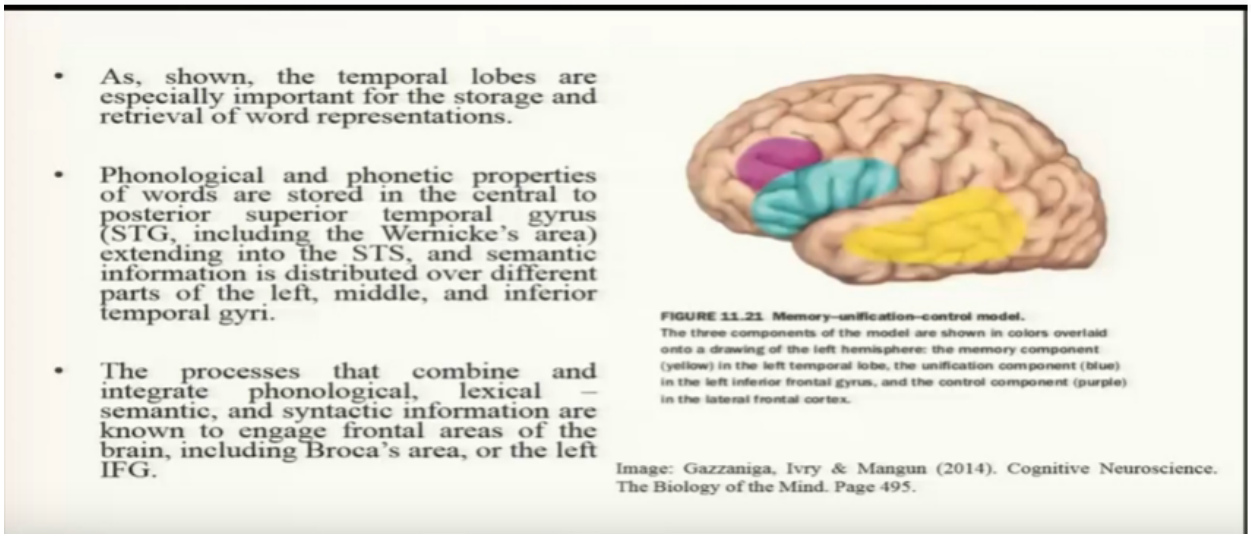

more closely in terms of the brain here on the right you can see this, particular figure or from the Seneca, you will see that the memory areas, are mainly in the temporal lobe, which is basically, the areas in the yellow and then there is a unification areas, are in light blue and then the control areas are slightly further up in the frontal lobe, which are in purple. So, these are the three areas, which are as per Peter Hagoort, carrying out this entire processing of language, with respect to memory you know, storing and retrieving

information, unification integrating multiple sources of information, to arrive at correct representations and control. So, all of this is happening, now as shown here, as I already said the temporal lobes are especially important for the storage and retrieval of word representations, phonological and phonetic properties of words, are stored in the central, to posterior superior temporal gyrus, including the Wernick's area. So, the areas in the yellow, it extends into the superior temporal Semantic on the top and cementing information, basically is found distributed, over the different parts of the left middle and the inferior temporal gyrus. So, this broad huge region is the one that kind of is doing the storage part, the process is basically that combines and integrate phonological lexical semantics and syntactic information, are known to engage the frontal area. So, they are above this particular sulcus, which are sort of also extends a little bit near the Broca's area or the left inferior frontal gyrus. So, that is basically the area in the in light blue here.

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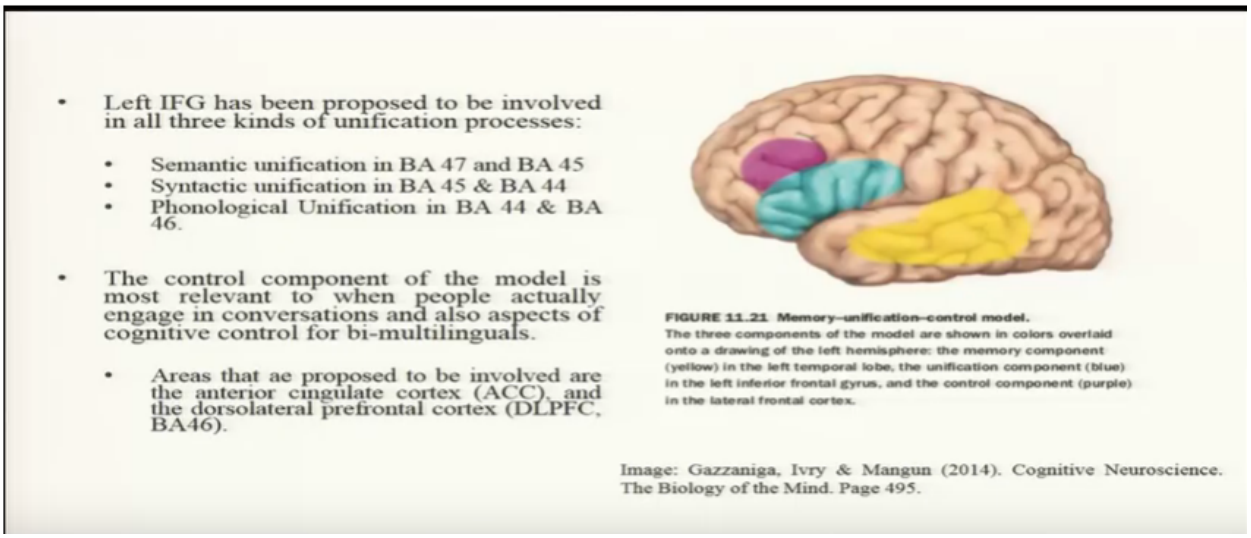

Now this left inferior frontal gyrus basically, has been something you know, proposed to be involved in at least three kinds of unification processes that are needed. The semantic unification, is done in areas B, BA 47 and BA 45 now this is basically BA basically refers to Broadman snomint lectures, you can if you pick up a you know brain atlas at some point in time basically, fine this is a scheme of nomenclature which Paul Broca established. So, BA basically, means broad means area for this fire forty seven and forty five, syntactic unification, happens in broad min Syria forty five and forty four forty four is Broca's area. And phonological unification, happens in areas 44, 45 and 46 44 and 46, which are basically, also by the way covered in this light blue zone. Right? Here now the control component, of the model the one in purple here, is basically something that's most relevant to when people are actually engaging in conversations, as I was saying and also aspects, of cognitive control, for bilingual and multilingual, we'll talk about that in the next week when you're talking about, bilingualism in more detail. Now these areas are proposed that are proposed, to be involved more specifically, our areas in the anterior cingulate, cortex and the dorsal lateral prefrontal cortex. So, these are again the areas, which are already covered in the purple zone. So, this is again, this was just one model of how comprehension or language processing might be happening. And Peter Hagoort, kind of broke breaks these down into three major you know, three major parts into

how language comprehension is done and this is how we saw that okay these are the areas, which might be that language comprehension circuit.

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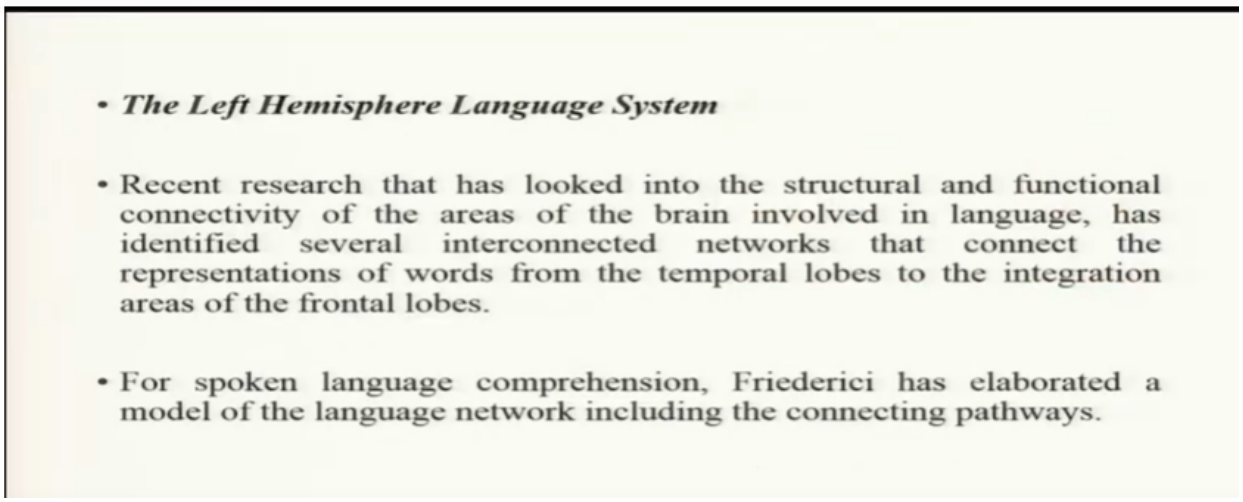

Now moving further we have seen that you know language per say or most of these functions that we've been talking about, per say, are mostly situated in the left hemisphere. So, recent research basically and also say for example research, you know from Paul Broca Stein, has looked into the structural and functional connectivity, of the areas of the brain that are involved in language. And basically the research has identified several, interconnected networks. So, it's not like just one area. So, it's not more like the you know localizations or connections thing, it's more like this entire, you know there is so, many areas which are all interconnected to each other. And this entire network, sort of achieves the task of language production in comprehension. Okay? And these networks basically, you know store word representations, from the temporal, lobes and the integration, areas are in the frontal lobe so, all of these areas that is that what we're talking about. Now for spoken language comprehension, any referedichy basically has elaborated a network, of language pathways. So, now that this is the network that kind of helps us in understanding, spoken language let us look at that.

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- In this model four kinds of pathways are proposed:
  - Two ventral pathways connect the posterior temporal lobes with the anterior temporal lobe and the frontal operculum.
    - These ventral pathways are supposed to be involved in the comprehension of the meanings of words.
  - Two dorsal pathways connect the posterior temporal lobes to the frontal lobes.
    - One of these connects to the motor cortex, and is involved in preparation of speech utterance.
    - The other dorsal pathway connects the Broca's are with the STS and the STG, and is supposed to be involved with aspects of syntactic processing.

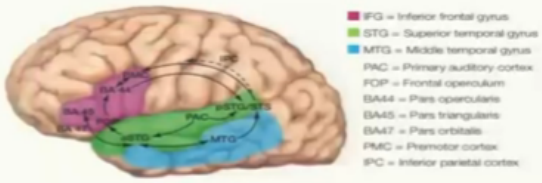

FIGURE 11.22 Cortical language circuit proposed by Angela Friederici, consisting of two ventral and two dorsal pathways.
The black lines indicate direct pathways and direction of information flow between language-related regions. The broken line suggests an indirect connection between the pSTG/STS and the MTG via the inferior parietal cortex. The ventral pathways are important for comprehension of the meanings of words. The dorsal pathway that connects to the premotor cortex is involved in speech preparation. The other dorsal pathway connects Broca's area (specifically BA44) with the superior temporal gyrus and superior temporal sulcus and is involved in syntactic processing.

Image: Gazzaniga, Ivry & Mangun (2014). Cognitive Neuroscience. The Biology of the Mind. Page 496.

Here is in this model on the right side, you can see that there are these particular areas; here you can see broad men's areas slightly more clearly labeled. So, you have BA 45, 47 APA 44 you have premotor cortex, as in PMC you have the inferior you have the IPC, which is your inferior parietal cortex, you have posterior superior temporal gyrus superior temporal sulcus, you have the primary auditory cortices you have anterior superior temporal gyrus, middle temporal gyrus. So, all of these areas are here and by, arrows you can see that they are connected, to these particular pathways. Now in this model, the model that has been put forward by any referedichy with respect to spoken language comprehension, the model basically says that there are four pathways. And it says there are two ventral pathways, pathways is slightly towards the bottom so, you can see here, a four particular pathways bottom. So, one that basically is from superior temporal gyrus, two primary auditory cortex two anterior superior temporal gyrus and further on and there's a lower pathway that kind of starts from superior temporal sulcus, to medial temporal gyrus and moves further to broad - area 45. Now these two ventral pathways, basically are connecting the posterior part of the temporal lobes, with the anterior parts of the temporal lobe and also the frontal operculum, will see the frontal operculum is somewhere in the blue here. Okay?

These ventral pathways basically, what they are doing is they're supposed, to be involving comprehension, of meaning of words. So, broadly this is the area that kind of helps you understand meaning. Okay? And there are these two dorsal pathways, if you see on the top starting from the green area, posterior temporal gyrus broad means area 44 and superior temporal sulcus to the premotor cortex. Okay? So, these two dorsal pathways on, the top basically are connecting the posterior part, of the temporal lobes to the frontal lobes. Now these two pathways basically so, one of these basically which connects to the motor cortex, the one on the top that is STS to IPCN PMC. Now that pathway basically is involved in the preparation of speech utterance. So, if you're hearing, something and you want to speak something, back or repeat it that thing, then the other dorsal pathway basically, the other dorsal pathway that starts from superior temporal gyrus Broca area 44, it connects and basically has connections, with the STS and STS TG as well, it's basically supposed to be involved with aspects of syntactic processing. So, now you see there are these two frontal ventral pathways and two dorsal pathways, among these four pathways, basically we are getting the comprehension part, we're getting a motor preparation part and you're also getting the syntactic processing part. So, this according to any referedichy is also a model of spoken language comprehension.

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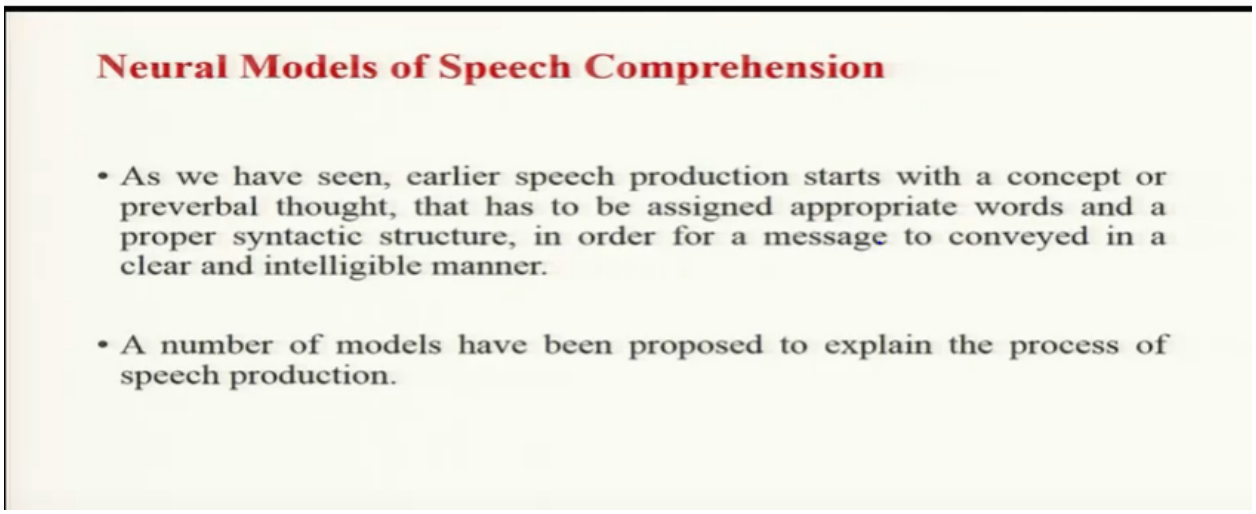

Now let us move, slightly further ahead and look into speech combinations or more detail. Now we've seen that for example speech production starts, with a you know concept of pre verbal thoughts. So, basically this is a new model of speech production. Now as we've seen speech production, we've seen in levels model you seen, Gary del, Del small says well. So, the idea is that, if you have to speak something, it has to start from a place where, there are no words, it starts from zone where there is pre verbal thought. And you start basically, with that and then that pre verbal thought has to be, you know assigned words. So, it will kind of you know from there and then assign structure, you know you do morphological, phonological, encoding you create the phone and phonetic industrial score and then you finally articulate it. Okay? So, a number of models as, you know have been you know proposed, about a speech production.

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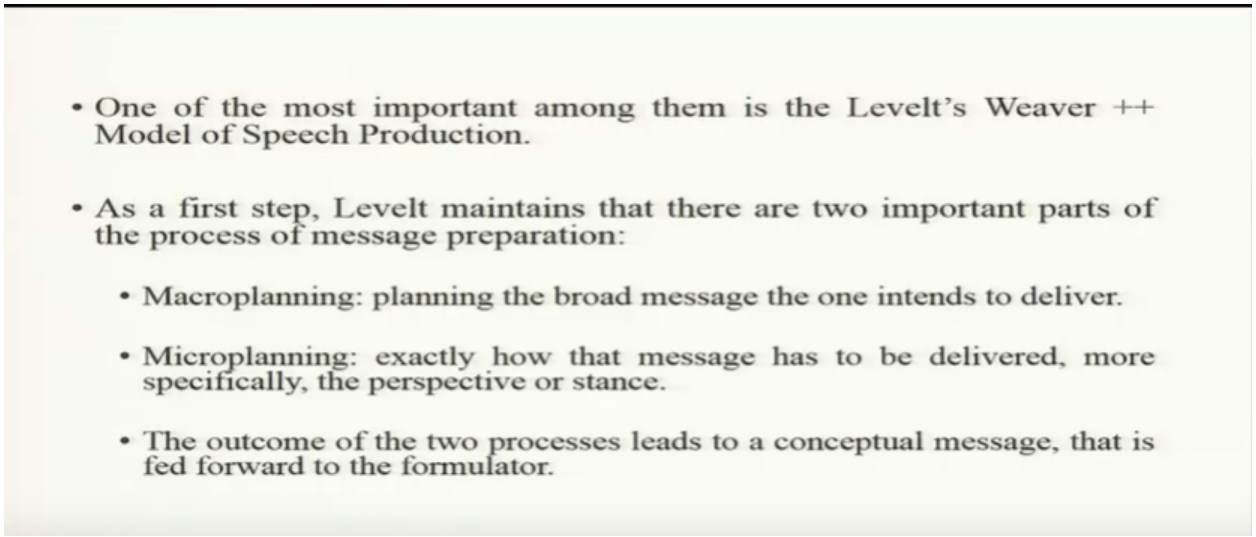

And one of the most important models is a levels model, of speech production that is the Weaver plus, plus one of the things that you can see is that even prior to the conceptual message, there is you know. So, label says that two kinds of planning, the superior micro planning and macro planning, macro planning is the broad message that you want to deliver. And micro planning is how do you, you know formulate that message into exact words and syntactical structure and deliver the message.

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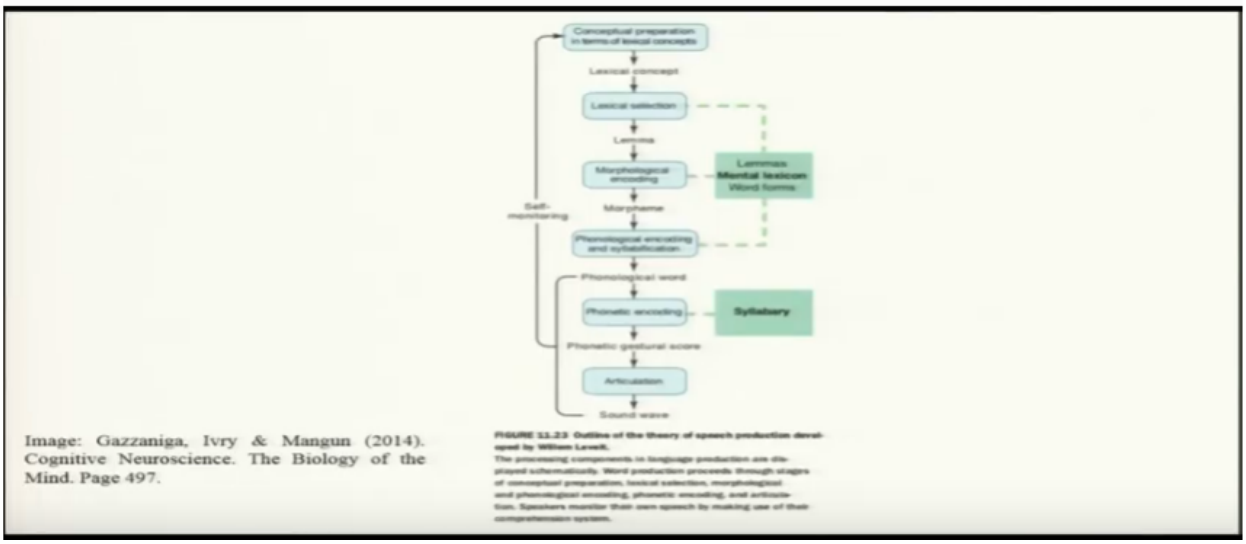

Image: Gazzaniga, Ivry & Mangun (2014). Cognitive Neuroscience. The Biology of the Mind. Page 497.

So, just to make you sort of remember this, this is how this is how the Weaver plus, plus model, of William level looked like, you can see at the top there is the conceptual preparation stage, from the conceptual preparation stage, you basically try and search, you know whether my ideas have words in my language. So, that is the point, we are you kind of are looking for lexical concepts; you might have one or many lexical concepts that might be able to convey your idea. So, then you have to do lexical selection, you select a particular word, once you selected a particular word, you kind of activate the lemma associated with it, if you remember level meant lemma to have both, syntactic and semantic information, once you have the lemma and you finalize basically that. Okay? This is the word form that you know I have to say, say for example, if I were to talk about speaking or playing or sleeping or I have to talk about the past tense of these, verb forms any of this, all of that will be specified in the lemma and from the lemma then, because you sort of have an idea, you will do morphological encoding. Okay? So, a activate the verb form speak, activate the suffix ING. So, that part once you have the morphological encoding started, you will you know activate the exact morphemes, speak and ING, then you go to the phonological encoding part, starting to activate, the basic sounds that make, each of these morphemes, once you are kind of activating, the sounds you realize that you know it has to be put in a syllable like structure. So, you do the solidification putting, their slots together and so on. And then basically you may move into, you know finally creating the phonological, but once you sell it once you celebified the message, everything is sort of ready, you put that into a phonological word form. Okay? This is how something will be uttered and once you have that then the final step that is there is to also add the nuances of phonetics. So, you kind of also add how this, you know particular, phoneme has to be delivered. So, is it hamburger or a hamster and those kind of things are done, in the phonetic encoding stage, once you've sort of done the phonetic encoding, then the gestural score is ready, you just have to implement that basically, as a that

will make your article eaters move in particular configurations, to deliver the message. So, this was the model.

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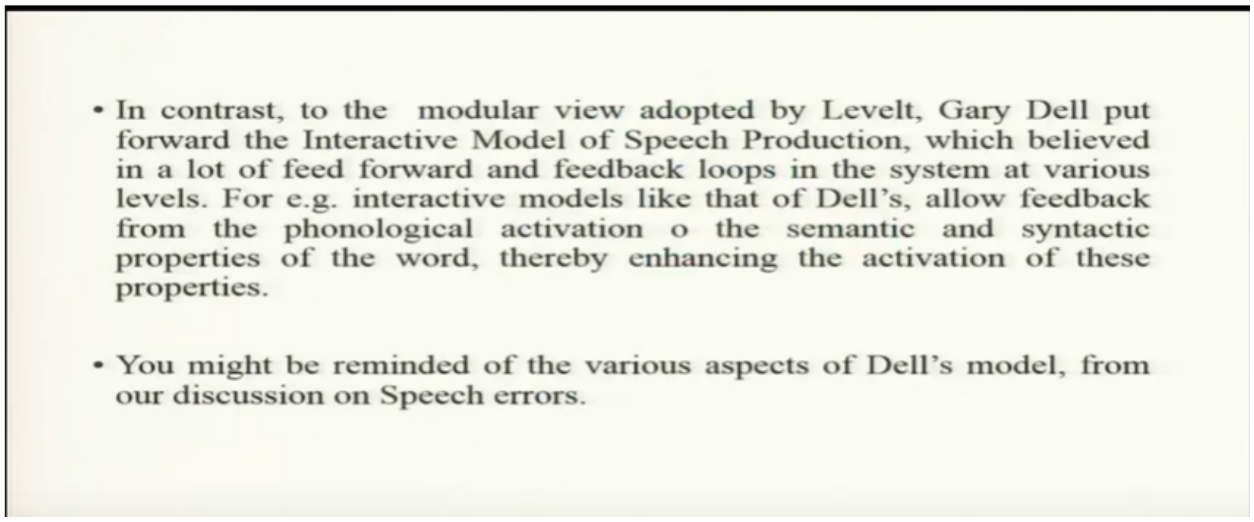

Let us now, look at how is this model, sort of specified in terms of the brain. Now this was one model, by the way the other model, was Gary Dells interactive model of speech production, we kind of read a lot about this in the errors, in the area, where we are talking about, speech errors and interactive model. So, one of the differentiating factors of this interactive model, as compared to the levels, model is that these models allowed, feedback and they allowed phonological ,activation. So, feedback from the phonological activation part, to the semantic and syntactic properties other words. And that sort of kind of may made, it a lot for to-and-fro system and could, in that sense explain a lot of errors like say for example the lexical bias effect and those are and then those kind of things, that kind of show that. Okay? You know these are the possible processes that are happening, in speech production.

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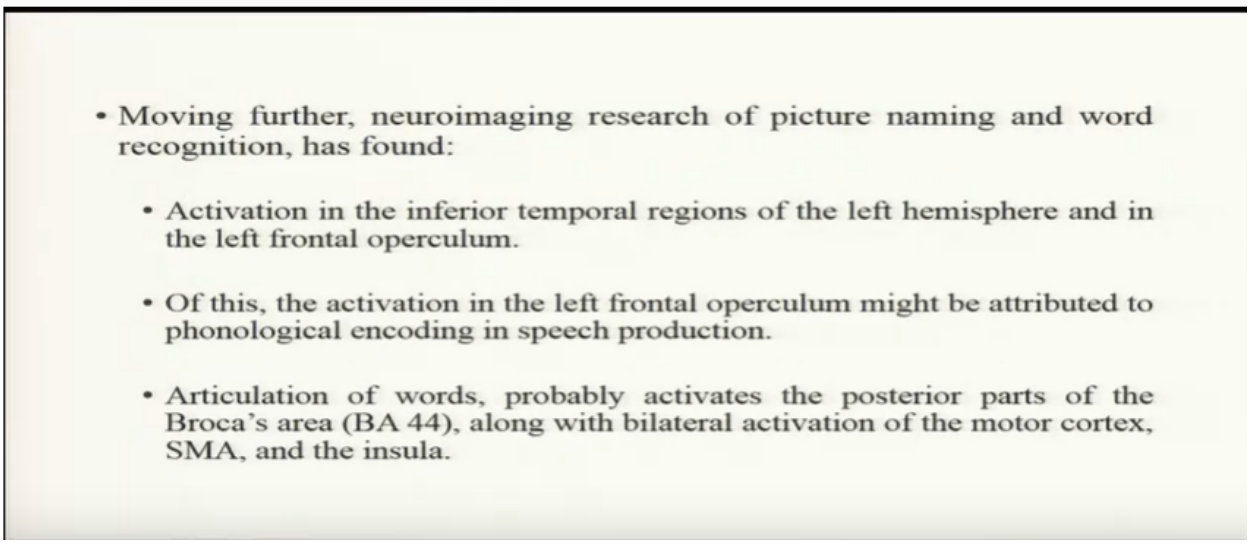

Now also if you move further, we did talk a little bit about, picture naming and word naming. Now about the neural areas that might be involved in doing this. So, activation has been observed, in the inferior temporal regions of the mainly of the left hemisphere and in the left frontal operculum, when picture naming is being done, also of this the activation the left frontal open cooler might be attributed the phonological encoding part. And articulation of word basically is you know activating the posterior parts of the Broca's area that is BA 44. Also it kind of activates the bilaterally, the you know motor cortex the supplementary motor area and insula. So, these are some of the areas that are involved, basically in the production of speech.

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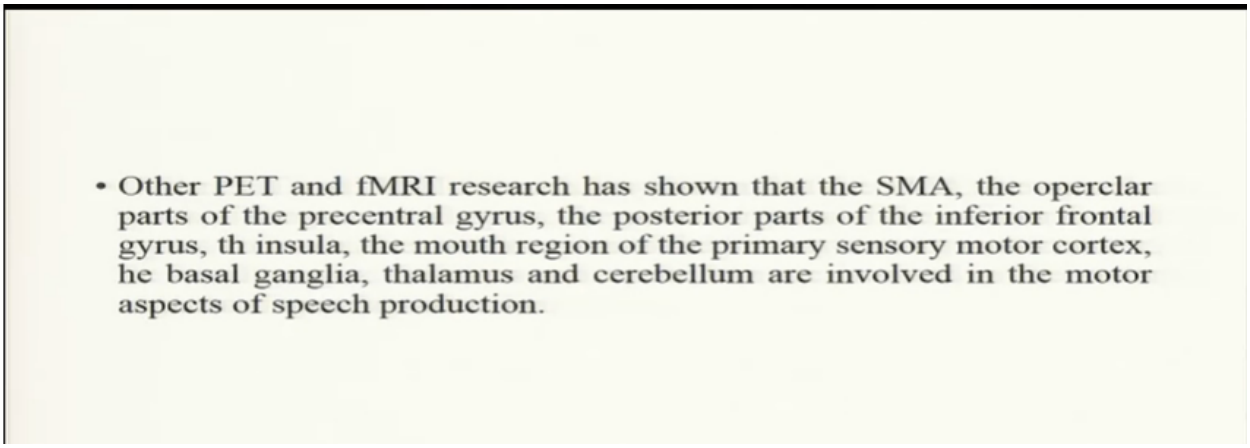

Now other studies also using different methods like, PET and fMRI have also shown that the supplementary motor area, the over regular parts of the precentral gyrus, the posterior parts of the inferior frontal gyrus, the insula and the mouth regions of the primary sensory cortex, are also in sort of, you know activated, along with the regions of the subcortical structures, like basal ganglia thalamus and cerebellum, all of them are involved in the motor, aspects of speech production finally delivering, you know, speech say for example, which areas if you might be asked, which areas implement, the gestural

score, these will be the areas that are kind of actually, you know making, all the muscles move and deliver the message.

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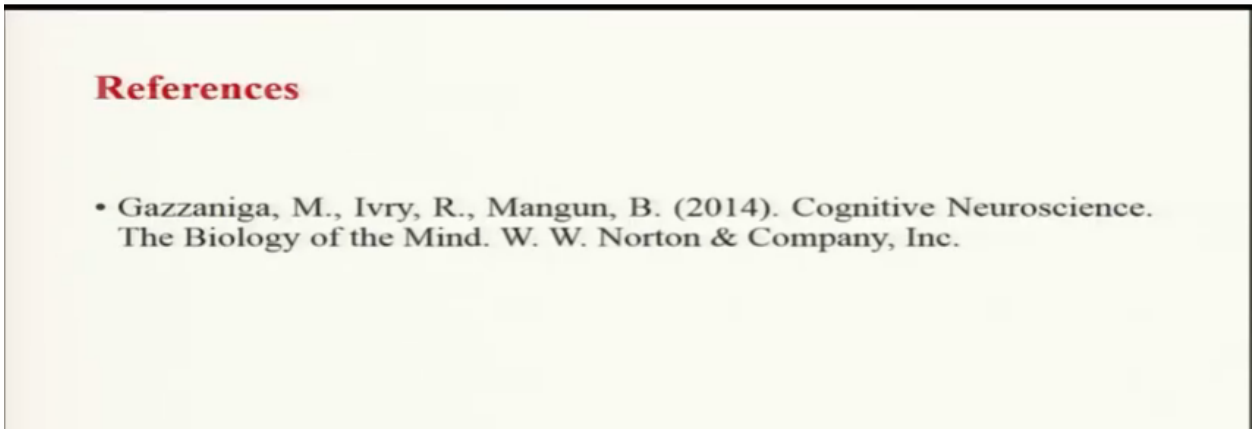

So, I think this was all about, you know neural basis of speech comprehension and speech production, we'll talk about a different aspect of language and the neural basis, thereof in the next lecture. Thank you.