INDIAN INSTITUTE OF TECHNOLOGY, KANPUR

NPTEL

NATIONAL PROGRAMME ON TECHNOLOGY ENHANCED LEARNING

COURSE TITLE
INTRODUCTION TO THE PSYCHOLOGY OF LANGUAGE

LECTURE-35
APHASIA

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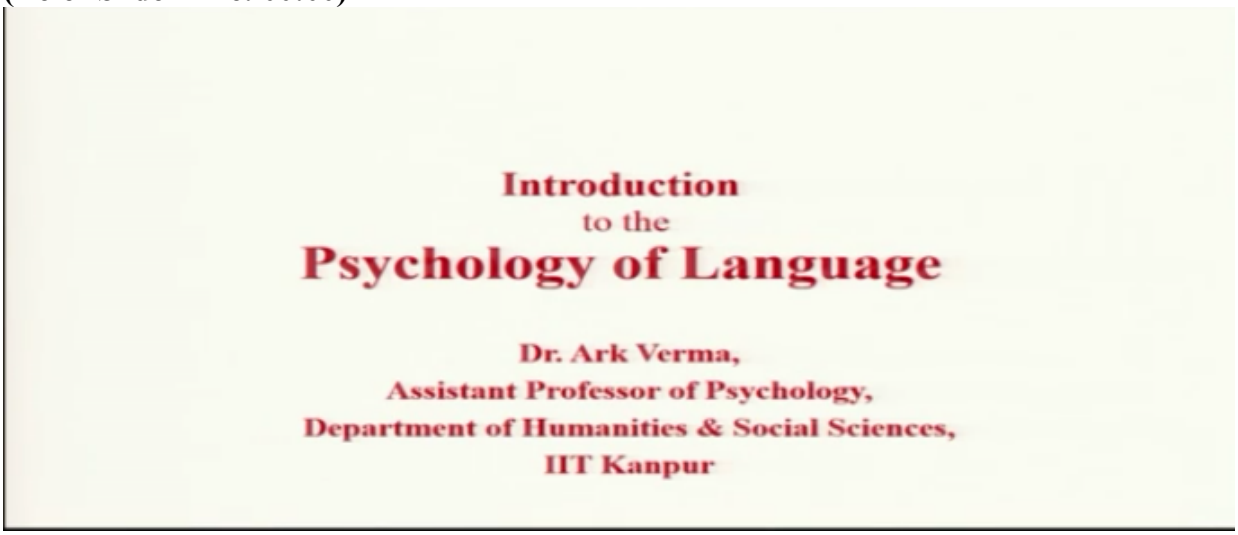

Hello and welcome to the course Introduction to the Psychology of Language, I'm Ark Verma from IIT Kanpur. We are in the seventh week of the course, and in this seventh week of the course and now we'll be talking about the last lecture of the week.

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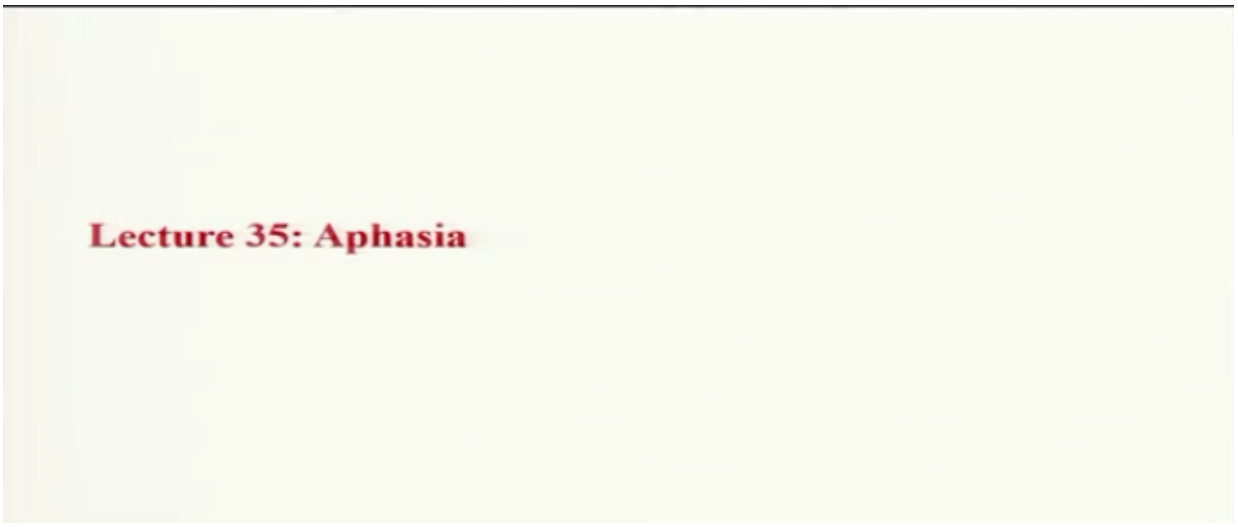

Now in this lecture I'll talk to you about Aphasia, which is a particular disorder of language, results basically from damaged to the areas of the brain that are involved in processing different aspects of language.

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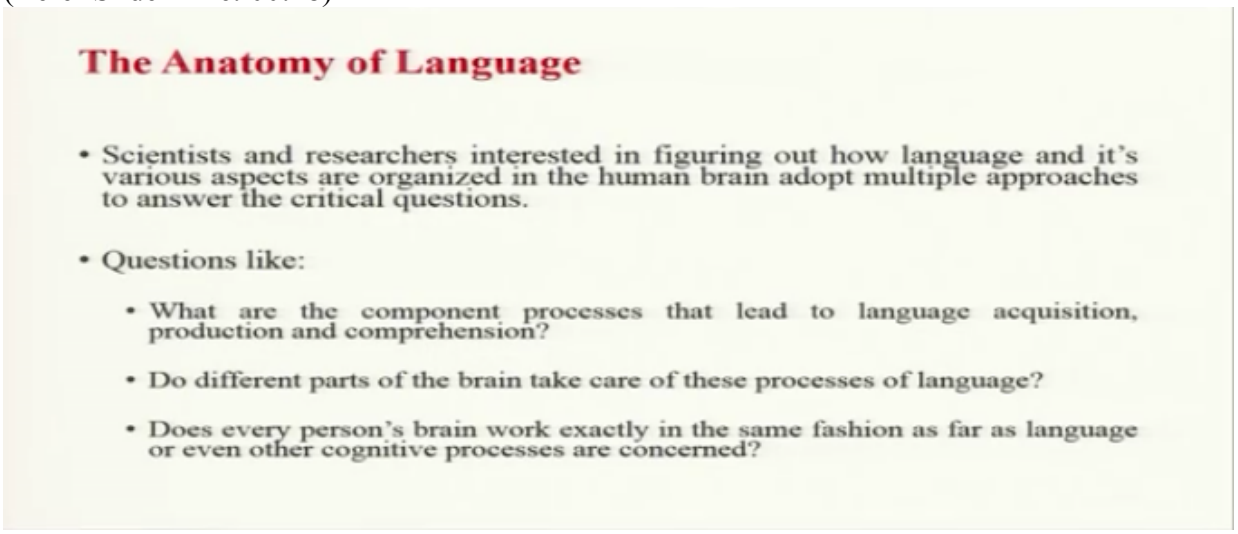

So now this I'm trying to talk about that, now even before we go there let's find recount what we have been doing you know about doing here so far, and that is basically to try and uncover the anatomy of the language, to uncover basically you know questions, to answer questions like say for example language for say has so many different component processes, I think that they are involved in acquisition, things that are involved in production and comprehension, and what are these different component processes, so one of the very important aspects even before you ask a question about the anatomy of the language is anatomy of the language is that what are the component processes, because it cannot be that one area of the brain thoroughly dedicated to all things language, and the nothing else, or say for example languages is a fairly you know, fairly de-constructible process in a sense that you can't say if you are looking this is production, this is comprehension, this is something else, this is the practical parts, so all of that can be done.

If you kind of can come up to atomization of what language broadly is, and into what kind of component functions it can be broken down to, then the question make sense that okay, does, is there one area in the brain that takes care of all of these component functions, or all of these component functions are distributed across the brain, distributed across different areas in the brain, okay, so then that question sort of makes sense.

Another question that you can ask is also say for example is suppose you say that areas X, Y and Z take care of component you know functions A, B and C, is this true for everybody? You know is every person's brain by didn't much in the same way as far as this language is concern, so there are these 2, 3 questions that you know people actually generally put up when they are talking you know or trying to read or investigate about the anatomy of language or the neural basis of language.

And as you know and I have talked about this earlier result that two at least, when two very important methods that scientist used, one is you know neuroimaging, the normal individuals brain you know you get these individuals to the lab,
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- Two of the important methods used by researchers include:
  - Neuroimaging the brain of normal individual while they are performing tasks relevant to language (production, comprehension or even more secondary tasks).
  - Investigating the linguistic capabilities of individual who have suffered various degrees of brain damage.
- Both these methods are expected to provide clues to the neural basis of language and it's various component processes.

you ask them to perform particular language in a functions and then you are sort of you know checking their brain out in terms of, okay when production was happening, these are the areas that lit up if the comprehension is given, these are the areas of the brain that lit up in that ways.

A very important source of this sort of information, actually also comes from assessing the linguistic abilities of individuals who have suffered some form of brain damage, so the idea is this is where it all started basically long time ago, this is where it all started when you look at the individuals brain who has some major lesion or you know damage to the brain, and you kind of say acha corresponding to this damage in this area of the brain, what are the cognitive abilities that are lost, and that kind of helps you make you know direct connections between the brain, areas of the brain and the cognitive functions.

Now both these methods have been used by you know linguist and neuro scientist and cycle investors to look at the various component process of language and their neural basis,
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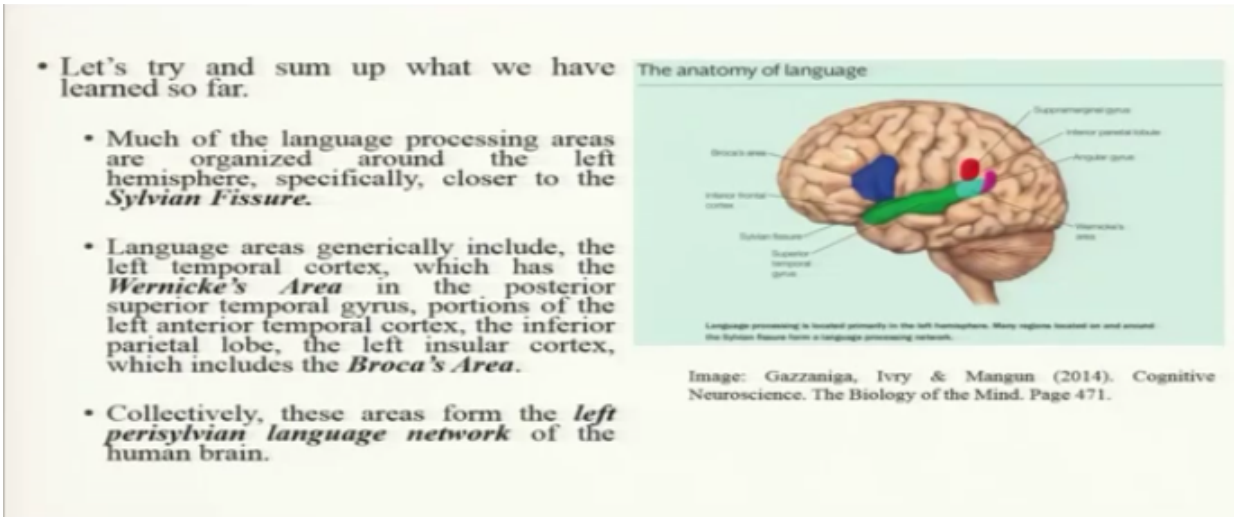

so if you try and sum up all of what we have done in this week, if you try and make a summary of all of that this is sort of, these are the sort of the areas that we have majorly talked about, so in the figure you can see that in perplex the Broca's area has been mentioned so many times, here below that is the inferior from the cortex I talked to you about superior inferior in the last class, then this one is the Sylvian Fissure, the ridge that is there, you know in that separates where the frontal and the temporal lobe this particular ridge right here, this ridge is called the you know a Sylvian Fissure.

Then you have the superior temporal gyrus, this particular you know bulge is called superior temporal gyrus, here you have basically this Wernicke's area in the light blue, you have the inferior parietal lobule here, and then you have supramarginal gyrus here this one, so you have all of these areas which are basically implicated in different degrees to actually performing the different component processes of language, you know it's kind of look at that in some detail.

Now much of the language processing areas are actually organized around this Sylvian Fissure, that the fissure that I was talking to you about this one, okay.

Language basically in that since, yeah, so language area is generally include the left temporal cortex which has the Wernicke's area here, and in the posterior temporal gyrus in the back portion of this temporal gyrus and the left anterior temporal cortex, so left part and the front I'll leave it, the inferior parietal lobule and the left insular cortex basically which includes the Broca's area, so this is the set of area that has been implicated.
Collectively all of these regions are supposed to construct what is called the left Perisylvian language network, so just mostly in the left side and around the Sylvian Fissure this is the network of language, this is the set of areas that are basically involved in understanding or producing language.

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- It's not that the right hemisphere does not participate at all in language processing.
  - The right superior temporal sulcus helps in processing the prosody, the right prefrontal cortex, middle temporal gyrus and the posterior cingulate activates in response to metaphors.
- Further, as language production, perception and comprehension involve both motor movement ad temporal aspects; the entire set of cortical (premotor cortex, motor cortex & the supplementary motor area), subcortical structures (thalamus, basal ganglia & cerebellum) involved in movement planning and execution also have key roles to play in language.

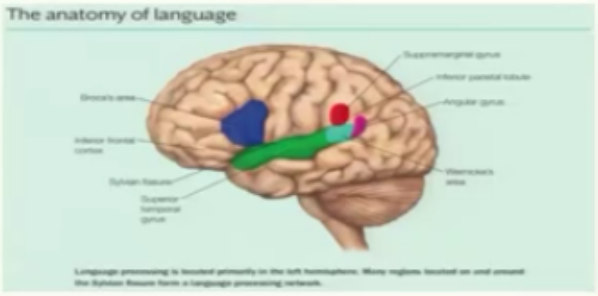

Image: Gazzaniga, Ivry & Mangun (2014). Cognitive Neuroscience. The Biology of the Mind. Page 471.

Now it's not that the right hemisphere does not do anything, the right hemisphere basically also participates in certain specific aspects of language processing, for example the right superior temporal sulcus actually helps in processing prosody which is the you know tonal quality, tonal aspects of speech, the right perirhinal cortex in the middle temporal gyrus and the postcentral gyrus actually likes up in response to metaphor, so humor metaphoric comprehension, irony, all of those figurative aspects of language are majorly mediated by the right hemisphere regions as well, okay.

Further say for example as language production perception and comprehension involve both motor movement and temporal aspects, the entire shed of cortical that is premotor cortex, motor cortex and SMA, and sub cortical the thalamus basal ganglia and cerebellum are also activated at different times when language production or comprehension is being carried out, so this is just to sum up the anatomy of language, this is all of the areas that we have talked about till now, okay.

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Aphasia

- One of the most important developments which paved way for modern neuroscience, happened arguably, when a French neurosurgeon Paul Broca, came across a patient named Leborgne.
- Broca found out that Leborgne, had severe impairments in normal speech production; he could attempt to speak with great difficulty and even then he could say "tan", and some swearwords resulting out of frustration.
- In some time, Broca found another similar patient, named Lelong, who also had severe impairment in speech production, could say hardly about 5 words.

So having done that let us move to Aphasia now, okay, now Aphasia basically is a very interesting disorder, and it's a very interesting story attached to how Aphasia kind of you know

was discovered and it came up, and it so happened that this French neurosurgeon called Paul Broca came across this particular patient called Leborgne, and Leborgne basically and probably not pronouncing the name correct, but LeBron basically let's call LeBron so this patient called LeBron came to Paul Broca and Paul Broca observed that this guy had severe impairments in production of speech, and he could attempt, even if he could, you know he was trying to say something he could not say much, he could at best with a lot of effort only say things like tan, so that's why in a lot of neuropsychology, in the lot of neurosciences is known as tan itself, and his name kind of started to be called tan, because he would only utter tan, and maybe some swearwords etcetera because of frustration and nobody is understanding him, but majorly this guy had very severe impairments in production of speech.

Now in some time also Paul Broca again came across another patient called Lelong who also had severe impairments in speech production and could hardly say about a maximum of around 5 words,
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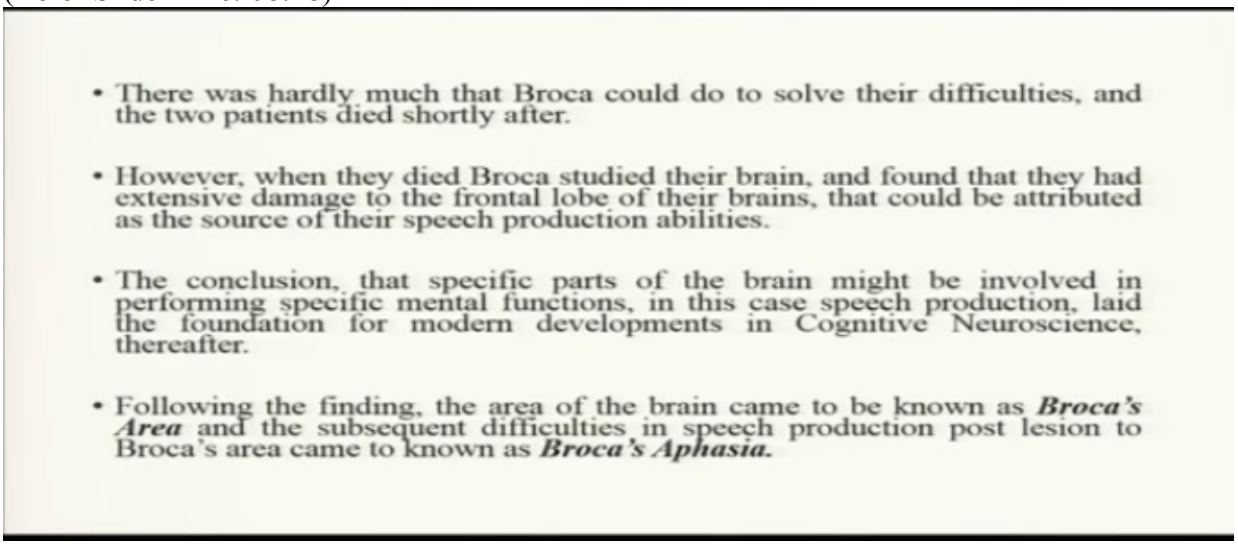

now there was hardly you know anything that Broca could actually do to you know solve the difficulties and both the patients died shortly after, but once they died Broca tried to study that brain and they found, and they found that they had, both of them had extensive damage to the frontal lobes of their brain, so the frontal lobes mostly in the left hemisphere were extensively damaged and that is what was basically you know, that kind of damage was what, was attributed as a source of their language or speech production difficulties.

The conclusion that was made, in the conclusions that was made on the basis of these two patients basically was that specific parts of the brain might be involved in performing specific mental function, this was the beginning of the localization era so to speak, and kind of late the foundation for lot of later research that happened in cognitive neuroscience, this particular area that Broca found out was directly responsible for production of speech and lesion to which can lead to impairment in production speech, later came to be known as Broca's area and the loosely the symptoms of this particular you know speech production disorder were clubbed together and that was called Broca's Aphasia.

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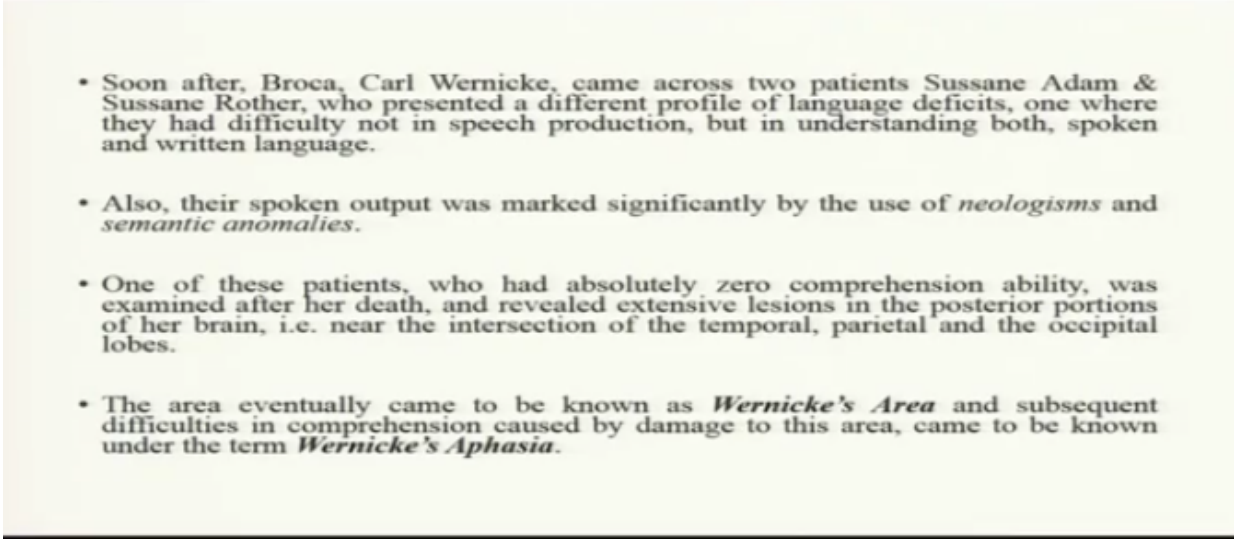

Now this was one part of the story, the next thing that also very importantly happened was that there was this guy Carl Wernicke, he was a German doctor, he came across two patients Sussane Adam and Sussane Rother and both of these patients presented a slightly different profile of language deficit, they had difficulties was more about comprehension of language, both spoken and written, obviously whenever they spoke also would have hard certain kinds of difficulties, what majorly there problem was about understanding language, they could not really understand a lot, okay, and even if they speak, even if they were speaking they were making up new words and they were basically a lot of semantic anomalies, remember N400 in the lecture before the last one, so there is a guy speaking completely in the sort of the sense that didn't really make a lot of sense.

Now one of these patients I think probably you know Sussane Adam had absolutely zero comprehension ability, and when she was examined after her death, it was found that she had extensive lesions in the posterior portions of the brain, you know, more towards the temporal parts of the brain, basically at the intersection of the temporal parietal and occipital lobes, so that's what we saw sometime there.

Now this area eventually then came to be known us Wernicke's area, because Wernicke was the first one who kind of came across these patients and then to the damage of these areas to their language comprehension abilities, and this kind of profile basically was clubbed under very loosely what is called Wernicke's Aphasia, so this are the two kinds of things that happened.

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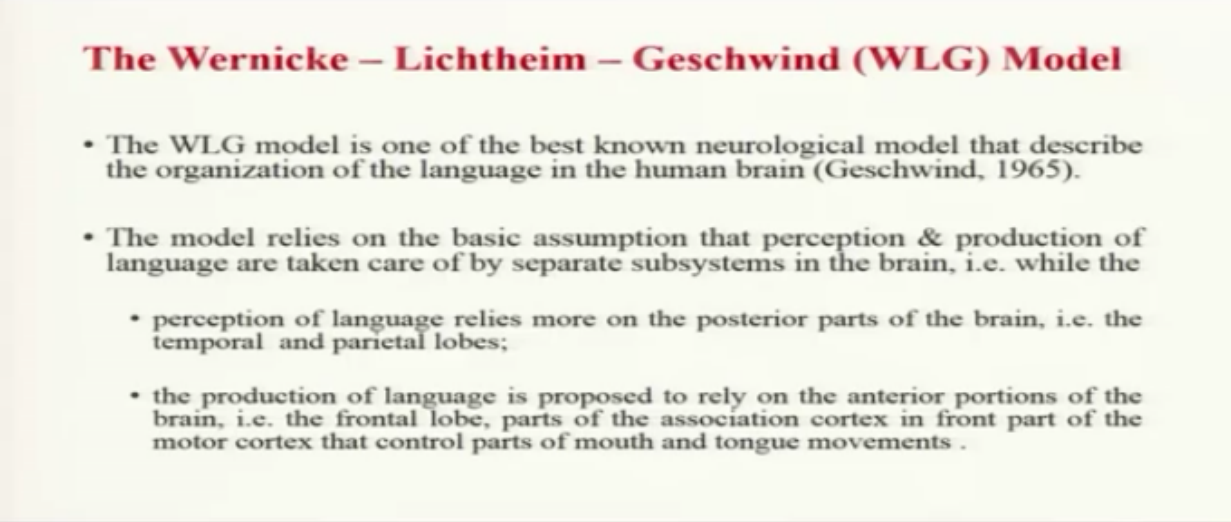

Now in the basis of the word that Broca kind of had done, and Wernicke kind of further that was investigated the lot, and basically along with two other prominent scientist of the time Lichtheim and Geschwind, basically they together gave a particular model of how language might be organized in the brain, now this is a very, very important model, and a very important model for mainly for neuropsychologist who have actually kind of a these models you know create and test predictions of what kind of damages would lead to what kind of language difficulty, what kind of damages in the brain would lead to what kind of difficulties in language.

Now this model came to be known as the Wernicke Lichtheim Geschwind model, is one of the classical and one of the most important models of language organization, and this model basically rested on the basic assumption that perception and production of language are taken care of by separate systems in the brain, so this is the time where people already start saying okay language production system is different language, comprehension system is different, and obviously they must interact at a particular point, so they said that perception of language relies mostly on the posterior parts of the brain that is the temporal and the parietal lobes, and production of language basically relies on the anterior portions of the brain, the frontal lobe and parts of the association cortex in the front part of the motor cortex.

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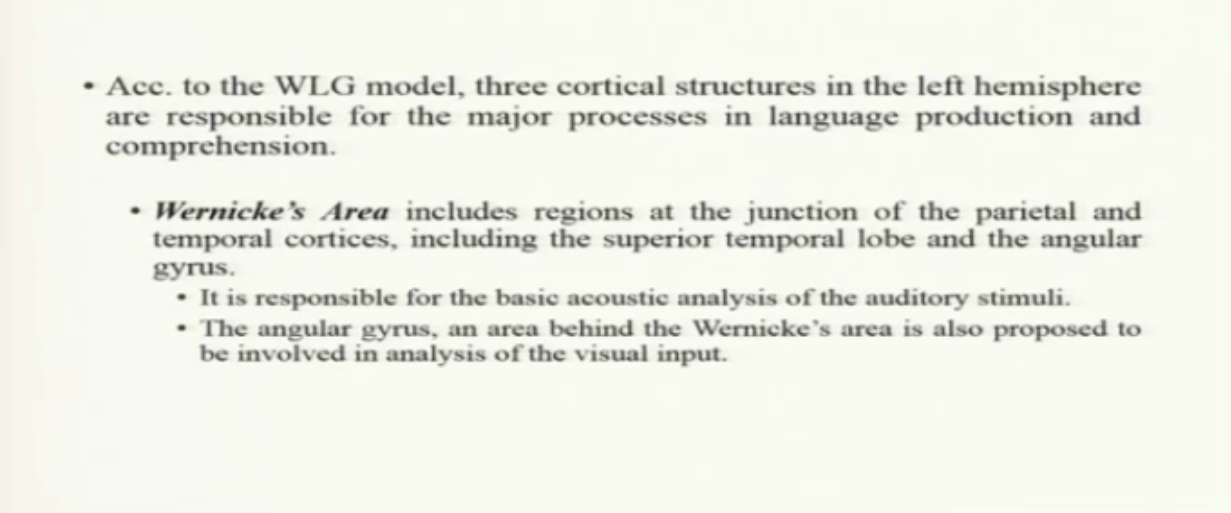

According to this particular model, according to Wernicke Lichtheim Geschwind model or the WLG model which we'd like to say, three cortical structures in the left hemisphere are most important for processing and producing language, there is this Wernicke's area which include the region at the junction of the temporal and parietal cortices, also includes the superior temporal lobe and the angular gyrus, this one, this region they said Wernicke's area is responsible for the basic acoustic analysis of incoming auditory stimuli, you kind of break that down in to you know phoning and create a phonological code, and from the phonological code you kind of makeup meaning.

The angular gyrus in area behind the Wernicke's area is also proposed to be involved in the analysis of visual input,
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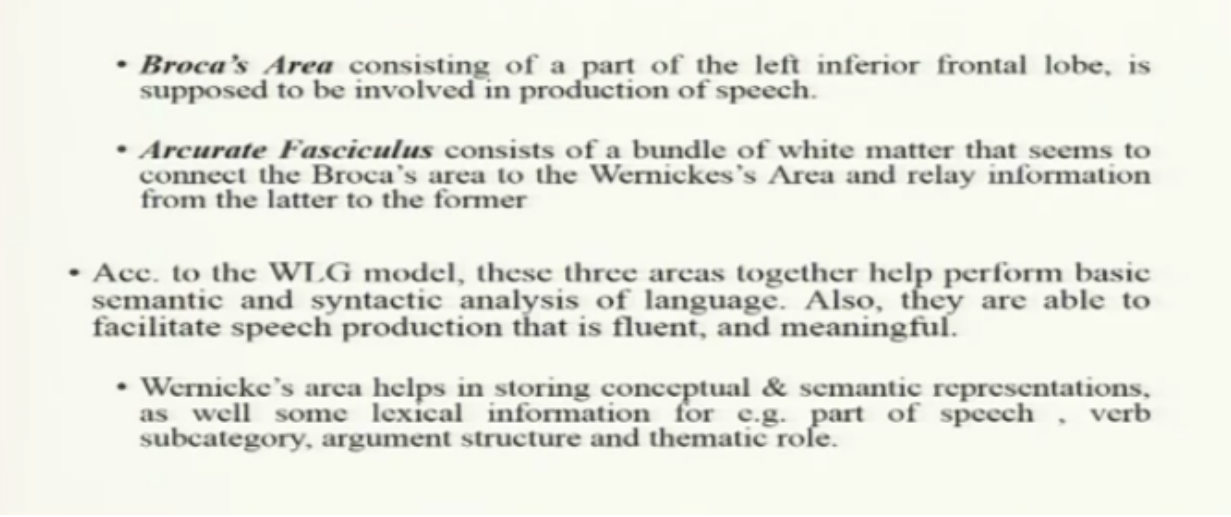

so both spoken input and visual input are both been analyzed in the Wernicke's area or surrounding area, that this is the area that is helping us comprehend stuff, then there is a Broca's area in the left inferior frontal lobe and which is directly implicated in production of speech, and then there is this connections of white matter, bundle of white matter that was found to be connecting the Broca's area in the front, and the vertex area in the backend, these connections directly was been done by these fiber tracks, fissure together effort to as the Arcuate Fasciculus.

Now this Arcuate Fasciculus basically performed the major job of relaying the phonological information to the motor stores, and also say for example you know basically because these two areas will need to talk in order to, see for example if you speak we understand as well, and when we understand we can speak that as well, so that kind of communications basically were to happen between the Wernicke's and the Broca's area and this communication or conduction of information really of information was done by this bundle of white matter called the Arcuate Fasciculus.

Now according to the Wernicke Lichtheim Geschwind model, these three areas together would help us perform the basic semantic and syntactic analysis of language, also they are able to facilitate speech production that is both fluent and meaningful, so if any of these connections were to be damaged that would lead to different times of difficulties.

Wernicke's area would help in storing an conceptual and semantic representations as well as lexical information which we saw that is present in the mental lexicon,
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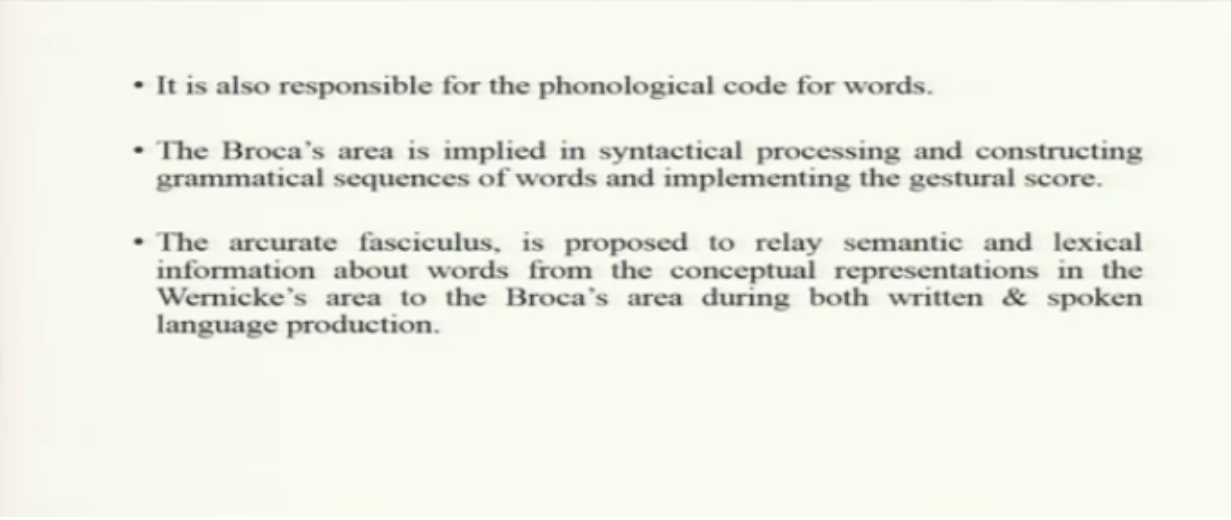

it's also responsible for the storing the phonological code for words, the Broca's area was implied in syntactical processing and constructing grammatical sequences, and the Arcuate Fasciculus as I was saying is basically proposed to relay semantic and lexical information about words from the conceptual representations in the Wernicke's area to the written and spoken production areas in the, you know, regions in the Broca's area or there about.

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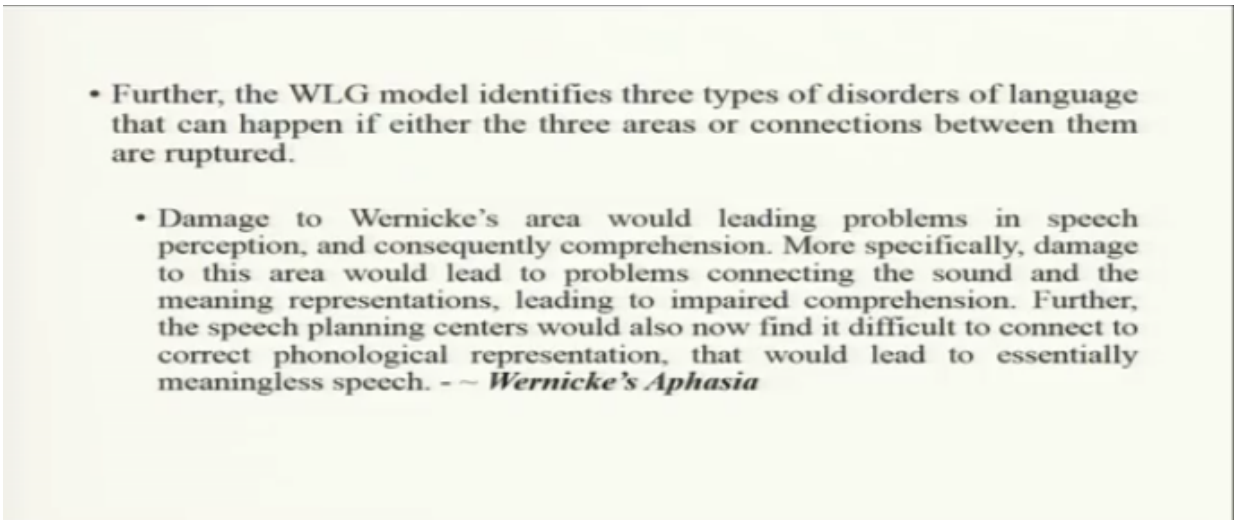

Further the WLG model identifies three types of disorders that might result if any of these areas were to get damaged or the connections between them were to get damaged, so the proposals were like damaged to the Wernicke's area would lead to problems in speech perception particularly comprehension, and most specifically the damaged to this area would lead to problems connecting the sound the meaning representations, okay, leading to impaired comprehension, this is basically what is the major problem here.

Further the speech planning center would also now find it difficult, because we don't have the phonological code to speak correctly, so there is not, they will find it difficult to create correct phonological representations that is what was leading to, that's what would lead to essentially meaningless speech, so this is basically the profile of the Wernicke's aphasias.

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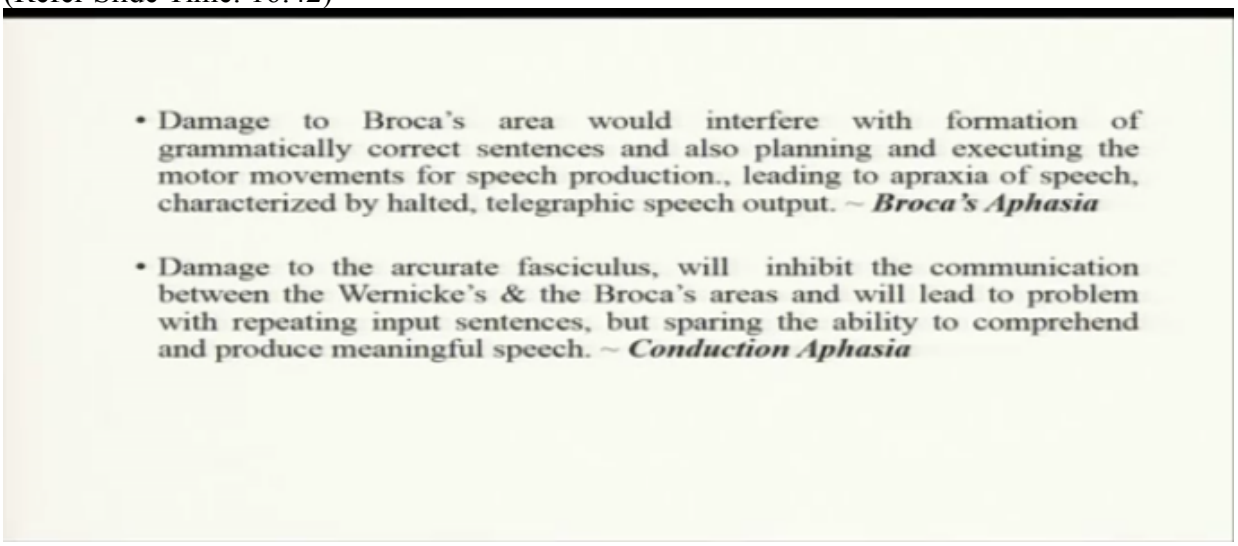

If Broca's areas were to get damaged this would interfere with the formation of grammatically correct sentences also planning and executing the motor movements for speech production, you know, moving all these articulate us would become very difficult, this also lead to something like apraxia of speech you know, you know hesitated, halted, telegraphic kind of speech and that will probably characterized mainly Broca's aphasia.

Now the issue with Arcuate Fasciculus will elaborate the communication between Wernicke's and the Broca's areas, and therefore will lead to problem with repeating input sentences, but sparing ability to comprehend and produce meaningful speech, so both areas Wernicke's and Broca's alright, but the connection between them is broken, so by themselves it will probably be able to do some things, but you know being able to repeat something that is heard is kind of going to be suffered, so that is the conduction aphasia profile.

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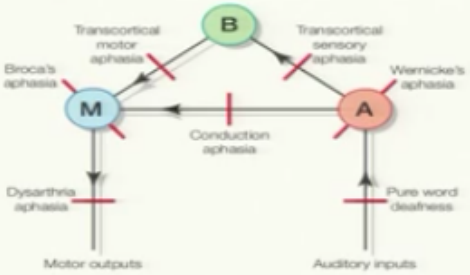

FIGURE 11.4 Lichtheim's classical model of language processing. The area that stores permanent information about word sounds is represented by A. The speech planning and programming area is represented by M. Conceptual information is stored in area B. The arrows indicate the direction of information flow. This model formed the basis of predictions that lesions in the three main areas, or in the connections between the areas, or the inputs to or outputs from these areas, could account for seven main aphasic syndromes. The locations of possible lesions are indicated by the red line segments. A = Wernicke's area. B = conceptual information stores. M=Broca's area.

Image: Gazzaniga, Ivry & Mangun (2014). Cogntive Neuroscience. The Biology of the Mind. Page 474.

Now we kind of have talked about the model, we have kind of talked about its implications, let us now look at some of these detail, some of these disorders in some detail, now this is by the way the Wernicke Lichtheim Geschwind model, you can see that on the top there are this conceptual centers in B, the Wernicke's area is basically represented by A, and Broca's area represented by M, so damage to M basically is leading to Broca's aphasia, damaged to A is leading to Wernicke's aphasia, and there are also disorders that are happening if the connections are getting damaged, so if the connection between A and M is damaged, you see conduction aphasia appearing and they are also if M and B is damaged you have transcortical motor aphasia, M and B is happening then you have transcortical motor aphasia, if A and B connection is going off then you have transcortical sensory aphasia.

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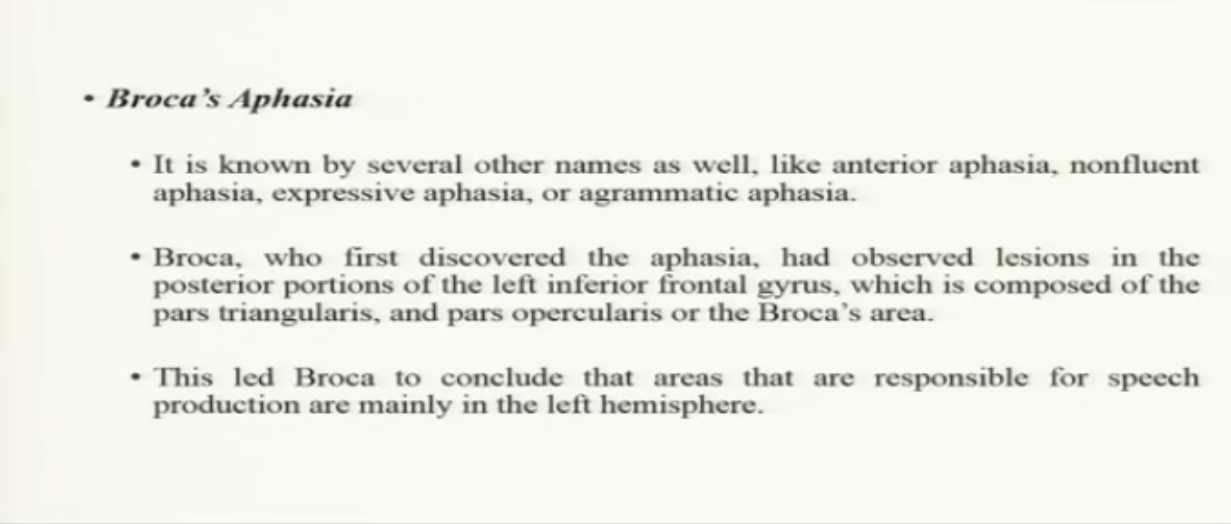

Now this is the model, let us look at this model in more, a little bit more detail, what is happening in Broca's aphasia? It kind of almost sounds like a reputation, but say for example Broca's aphasia typically happens because of lesions in the posterior portion of the left inferior frontal gyrus which kind of composes, it composed of the pars triangularis and pars opercularis, okay.

Broca's aphasia is also known by several different names like agrammatic aphasia, expressive aphasia, anterior aphasia or non-fluent aphasia, because the speech is non-fluent, it is about expression and so on, basically this kind of profile of damaged led Broca to conclude that these are the areas which are specifically responsible for production of speech.

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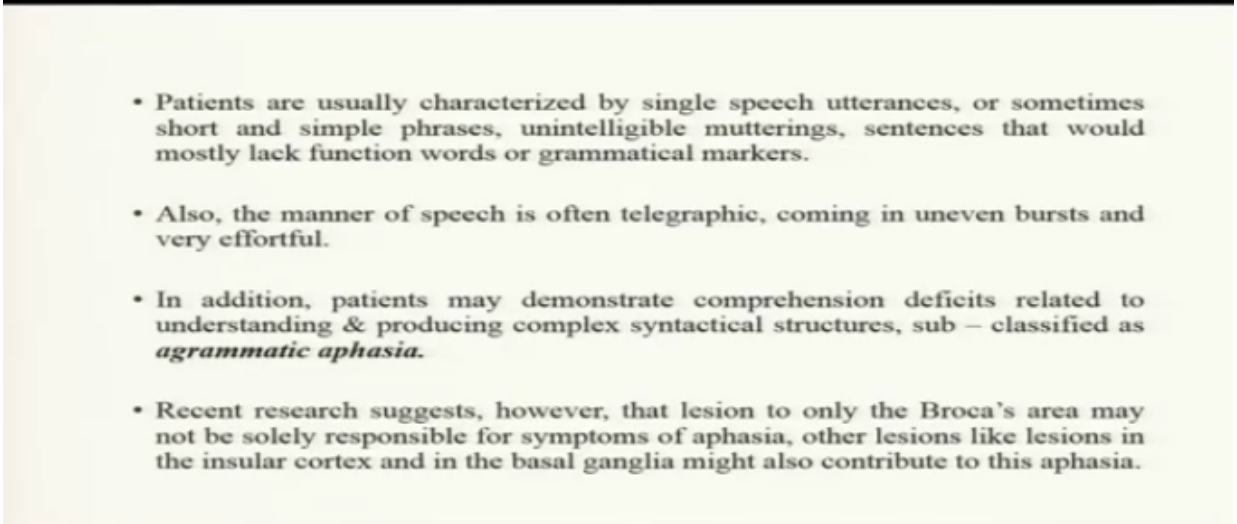

Patients of Broca's aphasia usually are characterized by single speech utterances, so like for example Leborgne could also say tan, tan, tan, he could say nothing else, so people would just probably be able to say one words or two words at a time, or sometimes very short and simple phrases, sometimes unintelligible mutterings, even if say for example if you know the damage is not so severe and people can create some sentences, they would, the sentences mostly be like you know lacking functional words more like say for example just content words, so noun,

noun, noun, so rat, eat, cat, rat is eating the cat, something like that will not be there, actually cat eating the rat, and they also be the fairly deficient in grammatical construction, so the sentences, the constructions that these people will make will hardly be any, hardly be grammatical.

The manner of the speech, the way in which they speak is also be telegraphic coming in uneven burst and also very, very effortful, so they will not be able to do that, in addition say for example of a certain subclass could be that you know they have complete, they might demonstrate comprehension deficits relating to understanding and producing you know complicated syntactical structures, so this subtype could be called agrammatic aphasia.

Now recent research have a suggest that it's not only this setoff area that could lead to Broca's aphasia or similar symptoms, it could be other areas as well which would involve the insular cortex and the basal ganglia, and some other areas as well.

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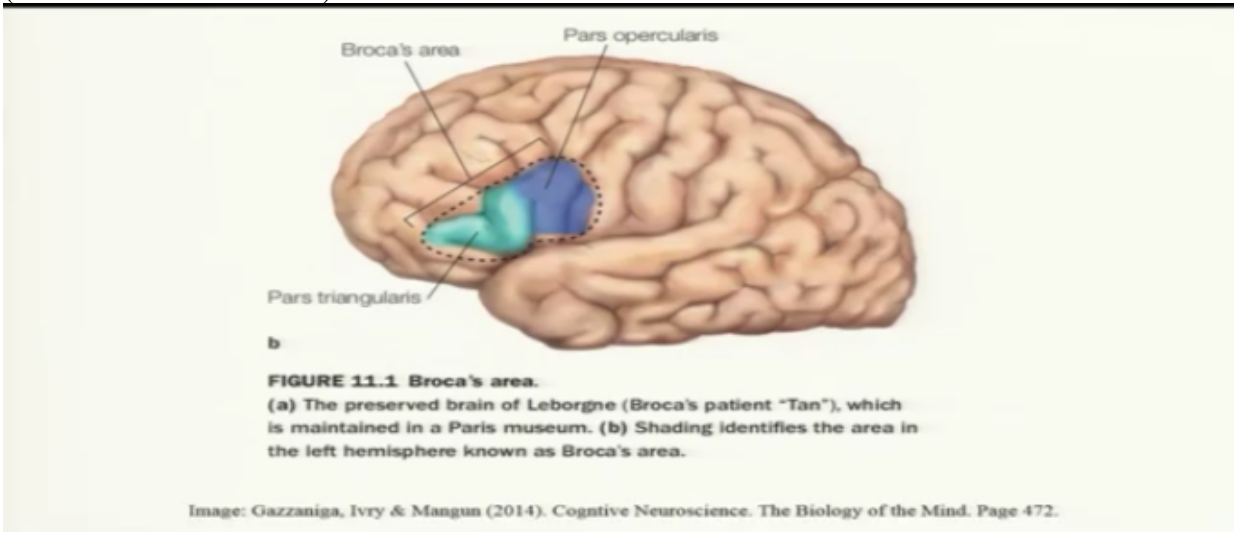

FIGURE 11.1 Broca's area.
(a) The preserved brain of Leborgne (Broca's patient "Tan"), which is maintained in a Paris museum. (b) Shading identifies the area in the left hemisphere known as Broca's area.

Image: Gazzaniga, Ivry & Mangun (2014). Cogntive Neuroscience. The Biology of the Mind. Page 472.

Now this is basically what the Broca's area looks like and you have the pars triangularis and pars opercularis, here in combination all of this is referred to as the Broca's area.

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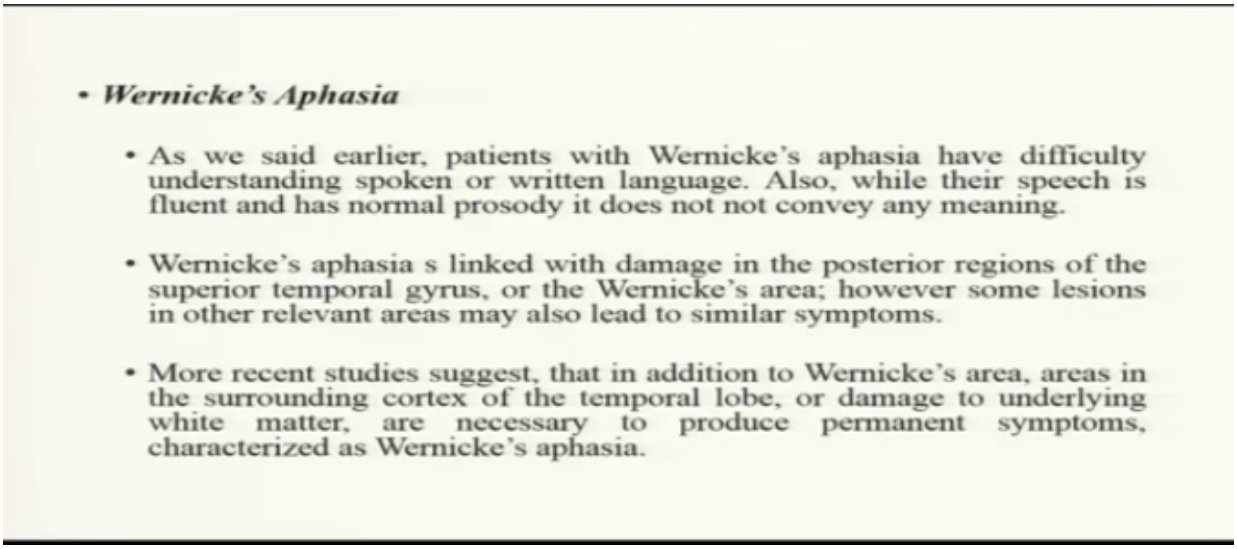

Now let's talk about the Wernicke's aphasia, as we had, as we said earlier patients with Wernicke's aphasia will have difficulty in understanding spoken or written language, also while the speech say for example while the fluent, and the preferred it would be normal, it would essentially be meaningless, okay, Wernicke's aphasia is been linked to damage in mainly in the posterior regions of the superior temporal gyrus, so back of the superior temporal gyrus and also some lesions basically in other relevant areas say for example near the STA and others could also leads to similar symptoms like in Wernicke's aphasia.

Now more recent studies have suggested that in addition to Wernicke's area regions surrounding the, in the surrounding cortex, areas in the surrounding cortex of the temporal lobe or say for example damaged to underlying white matter could also kind of leads to you know is also necessary actually to produce permanent Wernicke's aphasia like symptoms, just a small damage to Wernicke's area or the you know temporal lobe might not leads to Wernicke's aphasia, other regions in addition are also needed.

Now coming to conduction aphasia, conduction aphasia basically as I was saying, is results from the damaged between, damage to the white matter tracks that connect Broca's area with the Wernicke's area, patients basically can understand the words that they hear or see and they could hear their own speech, but they don't, they are not able to you know perform any kinds of online correction, they will not be able to correct these things all the fly, now these patients also show problem in producing spontaneous speech as well as repeating speech that they have heard, you know, generally people can kind of do that.

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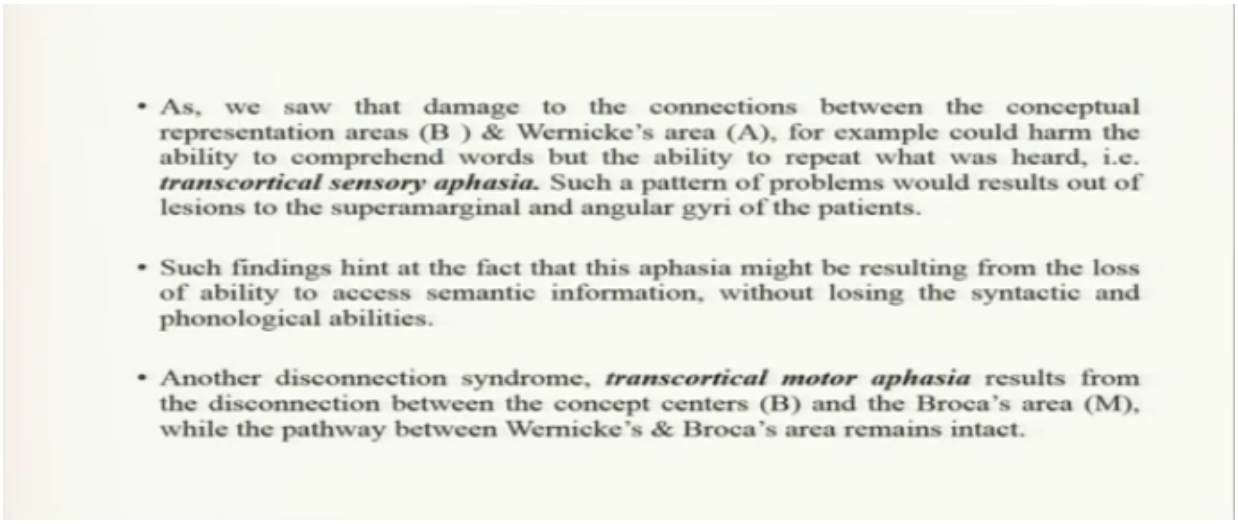

Now moving further if you saw that the connection, if they damages between you know the conceptually B and you know Wernicke's area A, this would basically leads to a particular profile which will be called transcortical sensory aphasia and the profile would look like say for example people be having the ability to comprehend words, but they will not you know have the ability to repeat whatever they are hearing, so this is that specific kind of thing, and such a pattern would mainly result out of lesions to the supramarginal and the angular gyra of these patients, such findings kind of actually hints that aphasia this sort of aphasia might be resulting from the loss of the ability to access semantic information without really losing the syntactic and phonological abilities, because anyway the Broca's area is still alright, okay.

Another disconnections in transcortical motor aphasia can happen when Broca's area and the concept centers that connection is damaged, we will see that will shortly, okay, now this basically would result in say for example the damage to this one, and this basically could result in a sort of a profile where you know production of speech is affected and it could be you know meaningless, the concepts and what is being said is kind of you know that connection is gone.

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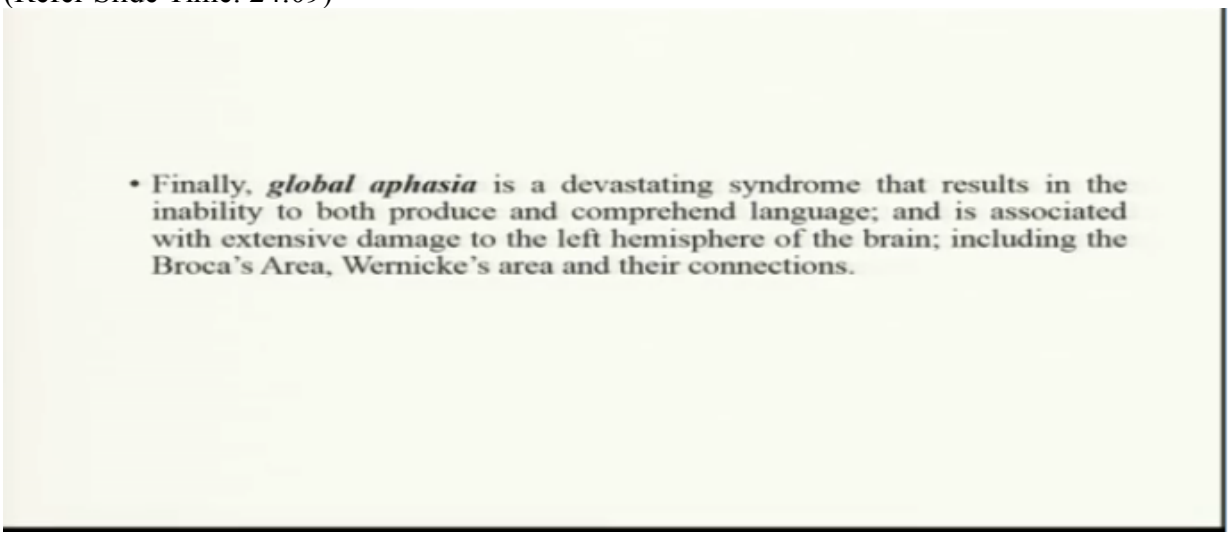

Finally if somebody has extensive damaged to the entire left hemisphere you know all of these areas that we have talked about, the left perisylvian region and temporal regions as well, as frontal regions all of them are kind of get damaged in the connections between them also get damaged, then you can say that the person would suffer from what is refer to as global aphasia which will basically lead down you know lead one to actually experience, complete breakdown of both language production and comprehension processes, that kind of profile would be refer to as global aphasia.

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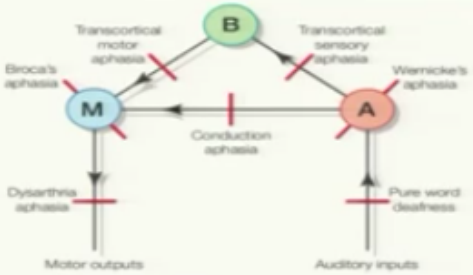

FIGURE 11.4 Lichtheim's classical model of language processing. The area that stores permanent information about word sounds is represented by A. The speech planning and programming area is represented by M. Conceptual information is stored in area B. The arrows indicate the direction of information flow. This model formed the basis of predictions that lesions in the three main areas, or in the connections between the areas, or the inputs to or outputs from these areas, could account for seven main aphasic syndromes. The locations of possible lesions are indicated by the red line segments. A = Wernicke's area. B = conceptual information stores. M=Broca's area.

Image: Gazzaniga, Ivry & Mangun (2014). Cogntive Neuroscience. The Biology of the Mind. Page 474.

So let us look at this once again, you have the concept centers, the conceptual store in B, you have the Broca's area in M, and you have Wernicke's area in A, and basically now you can probably understand the figure and it would be better, damage to A leading to Wernicke's aphasia, M leading to Broca's aphasia, damage to the connection between M leads to conduction aphasia, connections between Broca's and concept area leads to motor aphasia, connection between Wernicke's area and concept centers leads to transcortical sensory aphasia, this is also further you can see some of the connections actually between Broca's area and

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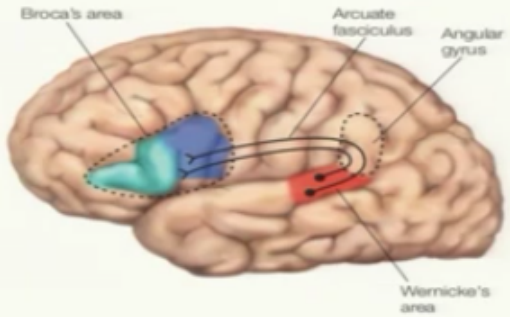
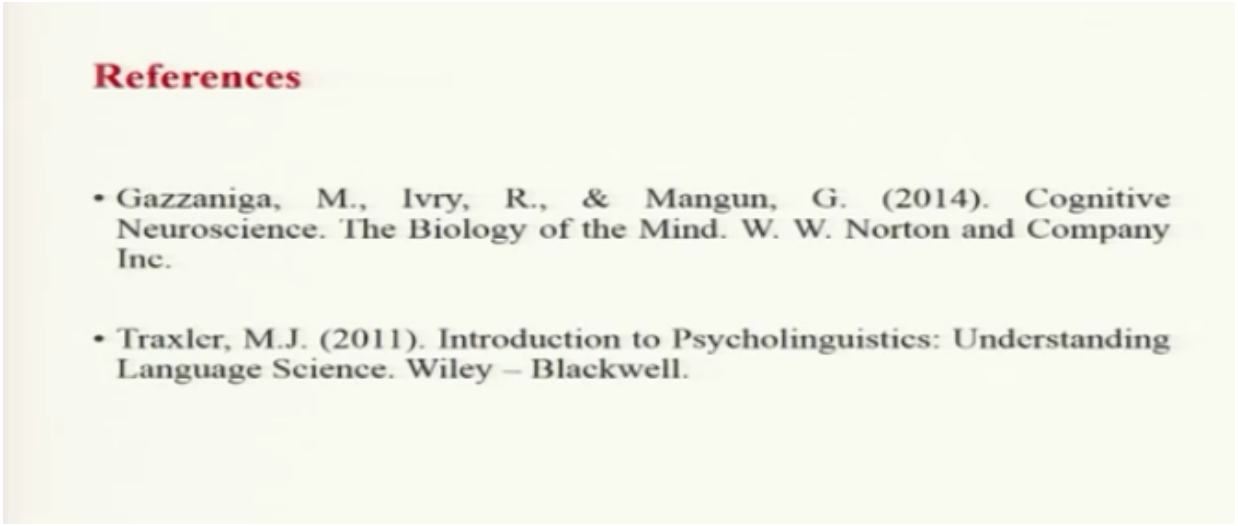


FIGURE 11.3 Lateral view of the left hemisphere language areas and dorsal connections. Wernicke's area is shown shaded in red. The arcuate fasciculus is the bundle of axons that connects Wernicke's and Broca's areas. It originates in Wernicke's area, goes through the angular gyrus, and terminates on neurons in Broca's area.

Image: Gazzaniga, Ivry & Mangun (2014). Cogntive Neuroscience. The Biology of the Mind. Page 474.



Wernicke's area, that's all that I wanted to talk to you about aphasia, and eventually the entire chapter on neuro basis of language comprehension. Thank you.

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