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**Lecture - 47**
**Components of Speech, Speech Production**

Welcome. You have been introduced to the idea of speech and language and here, we will consider the different components that create speech or how speech is produced and how or what parts of the brain actually control these the speech production and the associated structures that are involved with speech.

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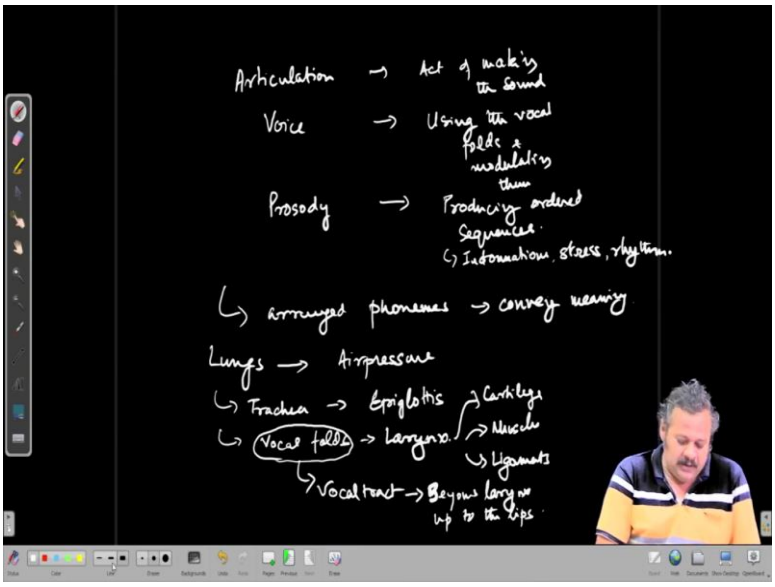


So, if we think of speech, speech has primarily three components as you may be aware its articulation, which is the act of making the sound that, has to that is creating the speech then there is voice, which is basically using the vocal folds and modulating them. So, this gives overall structure to the speech and then there is prosody which is probably the most important part and that is producing ordered sequences, which may have may require different intonations, stress, on particular elements and rhythm.

So, all these three things together actually produce speech and the it is essentially putting together vocalizations that are produced by us and that lead to particular sounds called

phonemes. And its the arrangement of phonemes that are produced and that conveys some meaning. So, the arranged phonemes that convey some meaning to whoever we are communicating with. So, we will revisit this aspect when we think of how to study speech or similar vocalizations with some rudimentary aspects of speech in animal models.

So, what are the structures that are involved with speech and. So, as you are familiar it is first of all the lungs are required and it is the source of the air pressure that is required to produce the sound. So, the lungs opens up into the trachea and this ends at the epiglottis, which actually stops any other element other than air to get into the tracheal path and to keep the air pathway separate from our food path.

And so, it is in here in this part of the trachea that we have the vocal folds or essentially the larynx, which is made up of a number of structures cartilages, muscles and ligaments. These together from form the larynx and then it is the vocal tract after this the vocal tract after this from the vocal folds that, is also involved in production of the sound or rather giving a spectral shape or shaping of the spectrum of the sound that is being produced from the larynx.

And that this part is essentially beyond the larynx after the larynx up to the lips. So, this includes the oral cavity and. So, we will not go into the detailed mechanics of speech production and how this can be modeled although there are fairly good models of vocal production that are already existing both mechanical and even electrical equivalent models for vocal production. And we will look into only first the aspects that are involved in the speech production in these kind of with this kind of structures.

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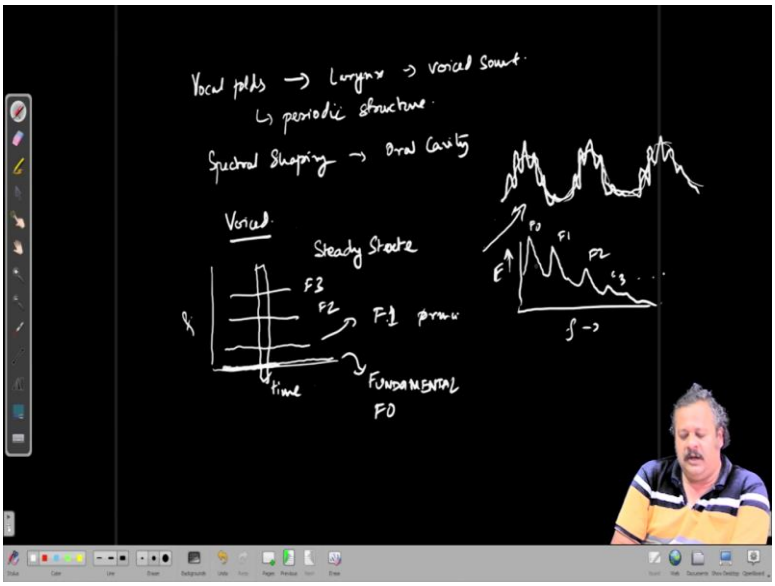


And so, as we said the vocal force or the larynx is actually generating our voiced sound or is generating the periodic structure if at all periodic structure required in the production of speech. So, next the spectrum is imposed on top of this periodic structure with spectral shaping and that is done by the oral cavity or the vocal tract.

Now, there are many ways in which this shaping can be done and that leads to the different kinds of speech sounds that are created and that is. So, if we think of vowels they are basically voiced sounds that have if we talk of the spectro temporal representation then, this is time and this is frequency. And what we will draw are contours of energy in time and frequency that represent vowels.

And these are usually steady state in nature that is the frequency and components over time remain the same that is, they have a fundamental frequency that is low frequency that is providing the basic period fundamental or F naught, which provides the original periodic structure in the speech.

So, if we think of it in some way it is the periodic structure that is produced and it is then manipulated or modulated in particular ways to produce different kinds of vowels and so, those are basically what we call. So, this is F0 or the fundamental and those finer modulations are higher frequencies like the first formant F1 you know F2, F3 and so on.

So, if we look at the spectrum of speech or not speech a vowel what we or some or which has a waveform like this, what we will see is this is the frequency axis and this is energy or power. We will have a high energy in the fundamental and then peaks at F1, F2, F3 and that die off. So, this is F0, F1, F2, F3 and so on. So, this we had discussed in our auditory circuit's lectures.

Here what we are saying is what actually creates these elements F0, F1, F2, F3 in when we are producing the speech. So, the fundamental or the periodic part or the voiced part is produced by the vocal folds when air is exiting from the lungs; that is, modulated by the vocal folds or the larynx that produce this periodic structure, which is then shaped in the oral cavity or in the vocal tract, which is from the end of the trachea to the lips and there are many ways in which this modulation can be done. So, that is for vowels.

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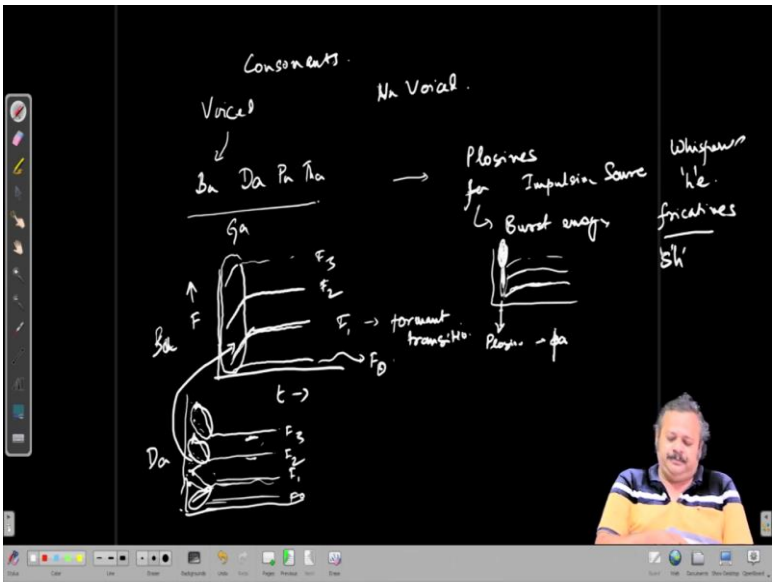


Similarly, we will have consonants; and the consonants can be voiced or not voiced or unvoiced. So, voiced consonants are like the Ba Da Pa Tha and so on. That is they have an associated voicing that is that the language is involved in the production of the consonants, but they are even Ga.

So, what these are manifested as is with formant transitions; that is the if we take this is time and frequency axis just like we were showing this is the spectro temporal representation then a Ba like sounds Ba sound appears so, that this is the fundamental F naught. And the F1 actually shows a change in the frequency over time so; the F 1 has a

formant transition. Similarly F 2 also has a formant transition and F 3 and so on. So, it is these transitions, which are created by the are created by the vocal tract from the voiced part produced by the larynx.

So, the different kinds of transitions then produce the different sounds and. So, if we have this as Ba then a transition like this would give make the sound Da. So, this is F 0 this is F 1, F 2, F 3. So in fact, with this transitions are associated categorical perception that is there is a boundary between the starting points of the transitions to the final formant.

So, these steady state regions of the formants are same in the Ba and Da the steady state portions are same. It is only the starting point of the different formants that make a sound Da or Ba. So, what we also know is that if we have a transition from here instead of the earlier frequency we still perceive this sound as Da. And we do so, for all the transitions up to a boundary point where, the percept of the sound converts to Ba and that is going when the transitions go upwards from downwards.

So, this when we transition from here to here to we can see. So, all the transitions that are going downwards for F 2 and F 3 are identified as Da or perceived as Da and these are perceived as Ba. So, similarly there are other consonants that are possible that are plosives like fa; that is, producing sounds with the oral cavity as a impulsive source.

So, that is fa then ta or these kind of impulse and they are manifested with a burst of energy in the spectrogram. So, a Pa would also have formant transitions, but it has a high energy burst frequency in this region and in the initial region, which is the plosive part of it makes it Pa.

So, there are also whispered consonants that are like he or the h of he and diphthongs and fricatives, which are fricatives are like Sh; which make so, which make sounds that are that depend on where, the or which part of the oral cavity is making this production making is modulating it through a constriction in the oral cavity.

And the different sounds can be different phonemes rather can be categorized into these different classes of whether voiced or unvoiced and whether they are plosives fricatives or whispers or diphthongs and so on; depending on that particular location of modulation in the oral cavity. So, this provides us an idea of what are the mechanical components

that are involved in production of the different phonemes; what we now look into is in terms of producing speech, what is the neural control circuitry.

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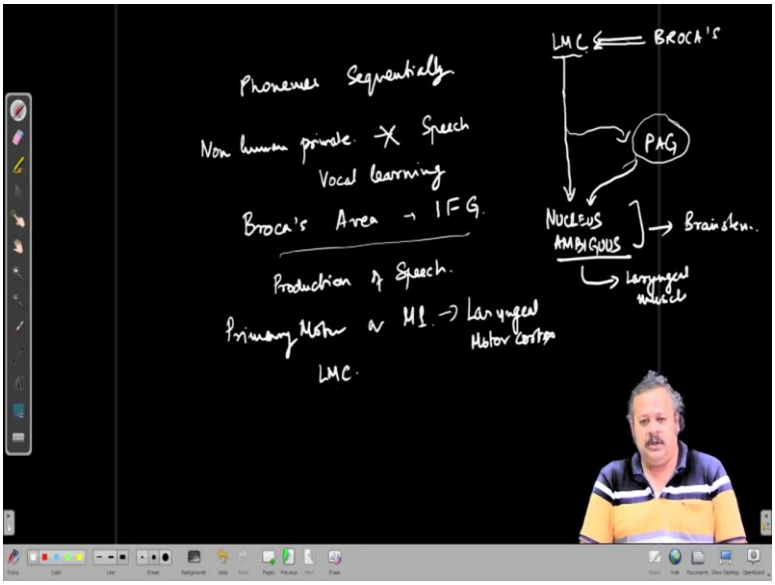


That is actually orchestrating the production of these phonemes sequentially. So, what makes us humans unique in terms of producing speech is that we are the only species that have this intricate way of communication or elaborate way of communication with different intonations and so on. And so, this calls for hardware or machinery that is exclusive to humans.

And what we have found is that although analogous structures exist in the non human primate they still do not produce speech. So, they do not have communication through speech like vocalizations in the sense that and they do not have speech in the sense that there is no vocal learning that is an hallmark of speech.

Although actually in birds we do have vocal learning, but it is again different form of communication and it is you know in non mammals and so, that makes it different. So, what are the structures as you have heard the it is the Broca's area has which is on the left hand side left hemisphere Broca's area, which is in the inferior frontal gyrus area 45 of it and, that region is involved in a production of speech.

So, this is almost a premotor like area, which is the center for planning the production of speech or planning the sequence of speech or planning the sequence of sounds that are

going to be produced, and it is studied with FMRI that it is highly active when there is a long sequence of speech that has to be generated. However, the main control is from a primary motor region or primary motor or M1 region and particularly it is the Laryngeal Motor Cortex or the LMC.

So, in humans the laryngeal motor cortex which controls all the elements of all the elements that are involved in production of speech. Starting from the laryngeal muscles and also the motors neurons that actually move the lips and control the oral cavity its constrictions and so on. And movement of the tongue all of these together are involved in the production of speech and it is coordinated by the LMC.

So, the LMC and Broca's area is highly interconnected and while LMC is part of the primary motor cortex it actually has two projections down into the subcortical regions to control the production of speech. So, one pathway directly projects from the LMC to nucleus ambiguous, which is involved which directly controls the laryngeal muscles.

So, this is in the this nucleus is in the brain stem and this its control of the laryngeal muscles can be enacted directly from the motor cortex, which allows us or give provides us voluntary control of speech this path also projects onto the periaqueductal gray or PAG, which then again projects to the nucleus ambiguous, and is well-known in the production of speech.

So, there is one direct pathway that projects the nucleus ambiguous controlling speech and there is one indirect pathway through the periaqueductal gray that can also control speech in the humans; however, in the primates in the non human primates we do not have a similar kind of projection pathway directly to the nucleus ambiguous. And they are through either the PAG or through the reticular formation in the brain stem.

And there is also another path in the anterior thalamic region or and the anterior stratum actually through, which also the vocalization pathway is controlled. So, anatomically the control pathways are distinct in humans and it is the Brocas area that, actually modulates the or rather provides the plan to the LMC almost acting like the premotor area for any other motor activity.

And LMC then orchestrates the production of the or the manipulation of the mechanical elements that finally, produce the speech. So, with this we come to the conclusion of our

lecture on the components of speech and the production of speech, and we will take our speech perception in later lectures.

Thank you.