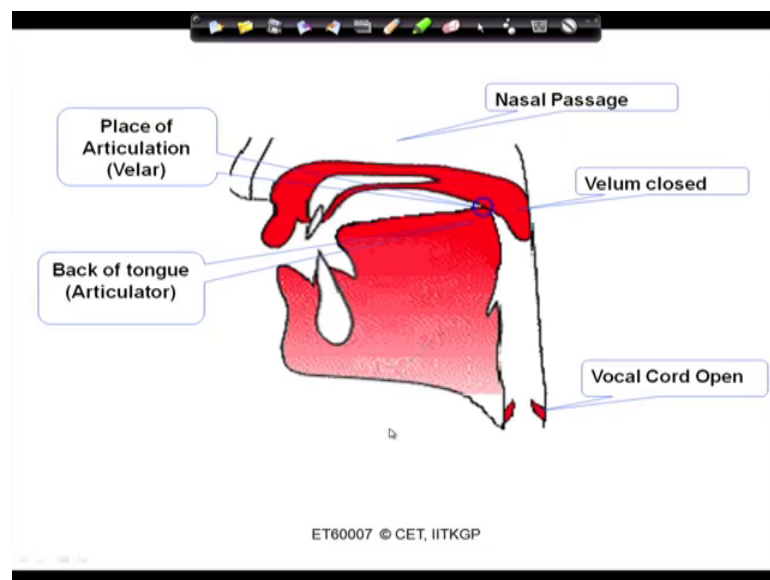


Digital Speech Processing
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Lecture – 07
Articulatory And Acoustic Phonetics

So we are describing the place of articulation. So, better if I if I show you the pictures let us show you this pictures.

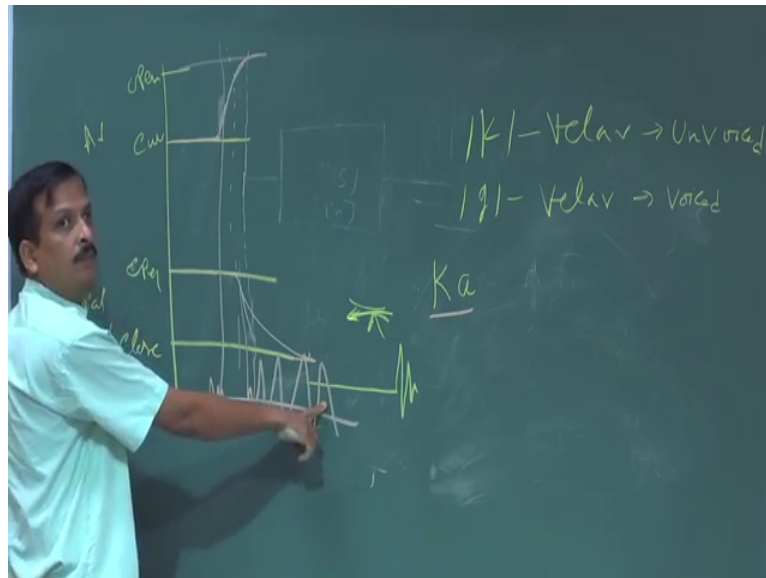
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Can you told me which is the place of articulation. It is written, if you see the place of articulation back of the tongue touches the back cavity this velar region. So, velar region it is touches. So, it is place of articulation is velar now vocal cords are open. So, I can say it is a unvoiced unvoiced velar unvoiced velar what is the unvoiced velar sound symbol if you see the IPA chart it is k unvoiced velar. So, there is another variety that can be vocal cord can be closed if you see here place of constriction is same, but during the constriction vocal cord is also closed.

So if the vocal cord is closed then I call it is a voiced part of the velar.

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So, it is ga. Now ko if it is ko is for same sound plosive ko is a plosive sound. So, manner of articulation this place of articulation both are velar. Velar, both are velar place of articulation both consonant are placed at velar position. In here manner of articulation as per the glottal vocal cord it is called unvoiced it is called voiced. Unvoiced or voiced, now if you see physically that if a constriction is happened in a tube and back of the tongue there is a air pressure is building up. Here the air pressure is building up and the constriction is happen.

Now, if the air pressure is building up then suddenly it wants to burst. That is why we call it is a plosive sound now during the that for the portion. So, there is a 2 kinds of movement. If you see here articulation has to be released if it is released then a plosion will be happen. Now if you see any consonant we cannot produce a single consonant alone, because during the (Refer Time: 03:07) production of the ko articulator is completely closed vocal cord is opened, so that means no signal is coming out from the mouth. Then how do you know it is a ko? So, if we see we said none of the consonant can be produced signal it has to be produced with a vowel. So, I can say ko and a is ka I can produce think about the production sequence. If I want to produce the ka during the ko the back of the tongue touches the velar position and it is totally closed cavity is totally closed. Then suddenly it has to be burst talk when the cavity will be the constriction will be open then there will be burst sound will released.

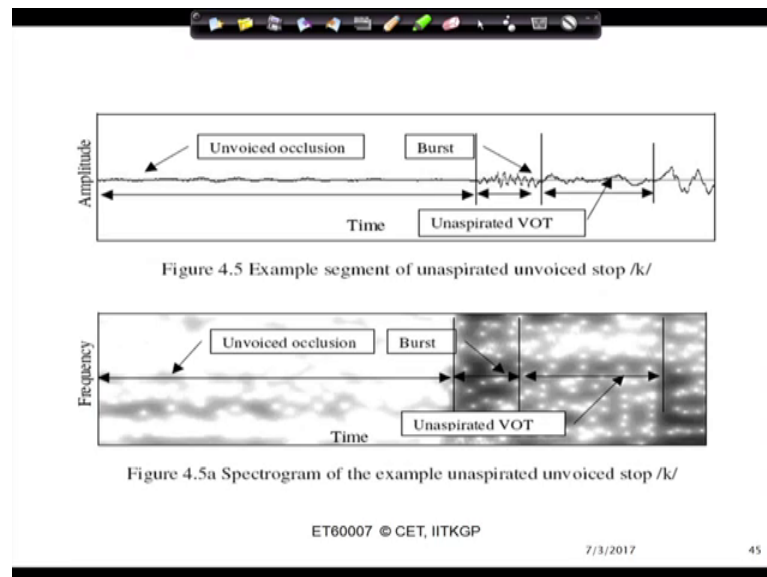
So, if I see the sound plain I will show you in the web diagram also, acoustic signal it is silence no signal. Suddenly there will be a burst, then the burst is happened. So, this vocal that the tube constriction is released, but I have to produce. So, there is a requirement the vocal cord has to be closed to production I require vocal cord has to be closed. So, if I want to close the vocal cords. So, there is a synchronization problem between the articulator close and release and vocal cord close and release. So, there will be a time gap.

So, if I say state diagram let us hear vocal cord articulator is closed. So, velar portion it is closed means articulator is closed. So, articulatory is closed no signal let us this is the articulate or open position, this is closed position this is articulator. Now this is vocal cords or glottis this is closed position this is open position and this is closed position close this is vocal cord. Now articulator is closed during the production of ko I am to produce ka. So, particular ka period articulator is closed. Then suddenly it is want to open. So, the opening is not drastically followed. So, it is open and then it has to be produced lalala tongue has to move to produce the vowel. So, let us the articulator is closed in here like this way lest this is this the not approximate like this point articulator is completely open this point ok.

Now the vocal cord is vocal cord is open during the production of ko. So, this (Refer Time: 06:27) vocal cord is open. Now once it want to produce a it has to close vocal cord has to be closed. So, vocal cord let us vocal cord close is in here. Want to close in here and then it start closing in here, and then complete will be produce in here. Let complete opposition tongue move in here ok.

So, if I see this point burst is occur this silence then burst is occur, then articulatory is not completely opened and it is not exactly. So, there will be a although the vocal cord is also not open, vocal cord is open here not closed. So, vocal cord is closed here. So, vibration is start from here. So, let us this vibration is start, and here I reach the vowel I can show you one picture let us come here.

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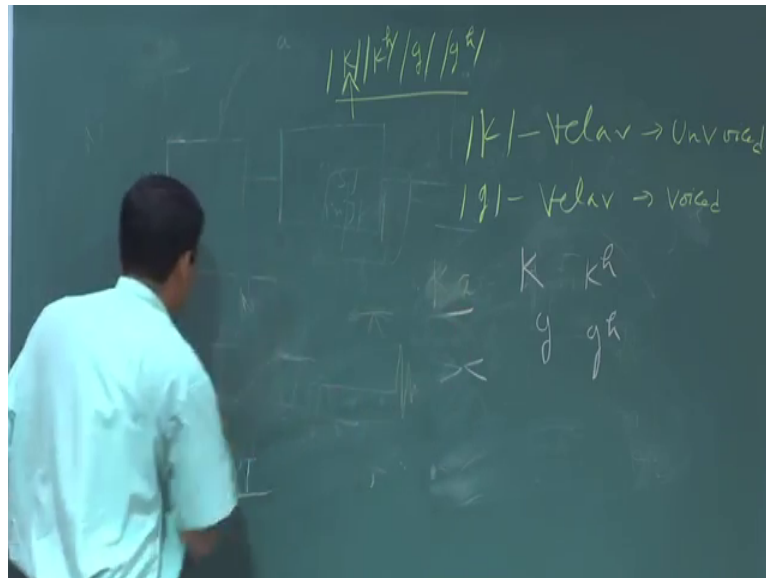


If you see in this picture, so during the production the articulator is closed no sound vocal cords is opened. Articulator is closed vocal cord is open vocal cord is open. So, this period we call occlusion ok.

Now, articulator is suddenly released there is a burst is occur, but articulator released and sudden sound is come and articulate try to move to position of the produced the vowel. Now if you see same time glottis may not be closed. So, there is no voice found. So, there is a voice gradual gap between the articulator closed articulator open and vocal cord closed. So, there is a settling time, that is called voiced onset time d o t (Refer Time: 08:35) voiced on set time. So, then there will be a transitory part of the vowel then the steady state vowel will be rich.

So here if you see totally unvoiced totally is nothing no signal is there occlusion, then there is a burst then there is a dam gap g between the articulator opening and vocal cord closing. So, there is called VOT voice onset time. During this period vocal cord may produce an aspiration sound, then it is called aspirated sound. If it is aspiration is not there we call unaspirated VOT. So, VOT this VOT, VOT might be aspirated or maybe unaspirated. Should depending on the whether it is aspirated or unaspirated we can say we have a 4 Varieties of the velar sound k and kh then g and gh.

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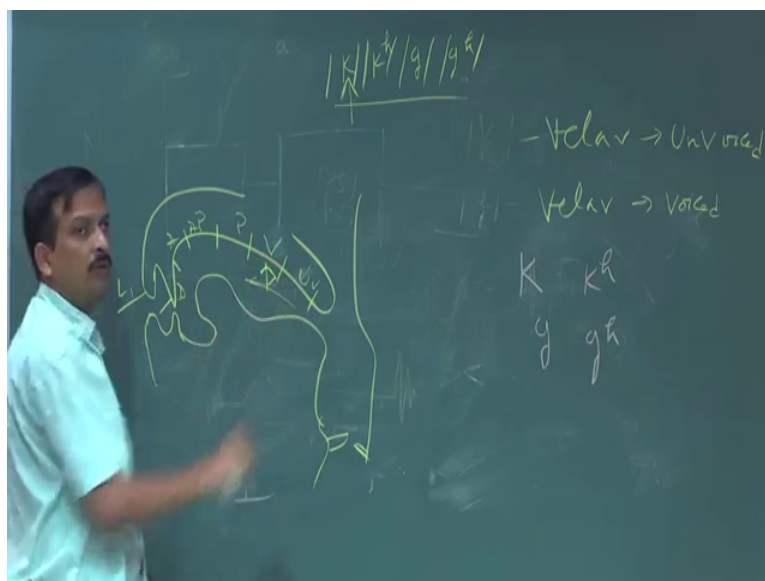


So, upper h this h is aspiration symbol for aspiration as per the IP notation.

If aspiration is voiced then we call voice expression if the expression is unvoiced than you call unvoiced aspiration. So, I have it velar sound 4 varieties ka aspiration ka kh ga and gh. All are plosive or stop plosive. Ka is velar, kh is velar, ga is velar, gh is velar. Only difference is the manner of articulation. If I say ka is unvoiced unaspirated. During the production of the ka the back of the tongue touches the velar position, but vocal cord is open.

So, there is no voicing during the occlusion that is why it is called unvoiced closer unvoiced velar unvoiced. Since VOT does not carry any aspiration then it is called unaspirated sound. So, unvoiced unaspirated velar plosive, this is the explanation of ka to write this way we put 2 slash line to produce 2 identify to identify the different sound this is a symbol for writing the vowels any consonant or any IP notation sound. So, if it is ka once I write ka then in there I know what it is property. What is the property? It is unvoiced unaspirated velar plosive, is it unvoiced unaspirated velar plosive. So, if I start if I start from this language in mainly in Indian language if I give the example.

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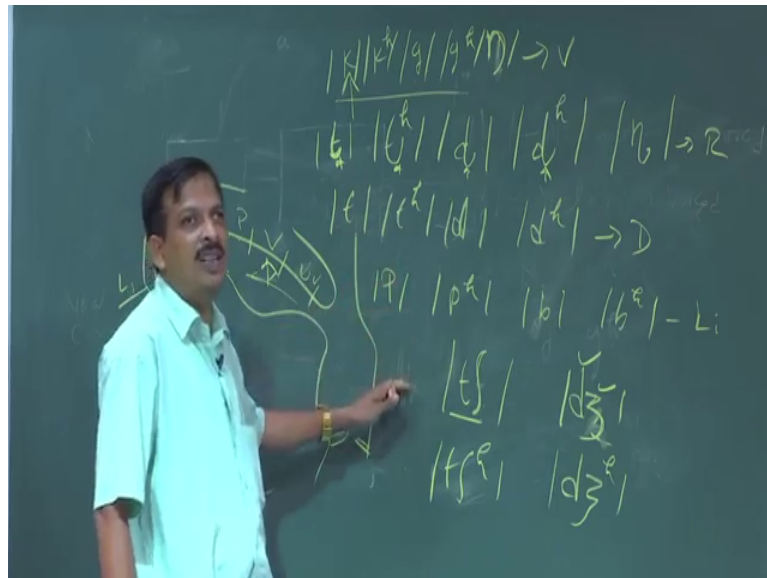


If you see if it is a vocal cords it look like this if you see that this is my upper cavity and this is my lower cavity, if this is my lower cavity and this is velum ok

If it is upper cavity upper cavity bilabial, dental, alveolar, post alveolar, palatal, velar, uvular, pharyngeal and girdle. Now if I come from this side velar let us uvular velar palatal postalveolar alveolar then dental then bilabial labial. Depending on that way if you see in most of the Bengali language Bengali Hindi most of the Indian language velar then we have [FL]. So, you start from here velar sound velar consonant [FL]. So, difference is unvoiced unaspirated unvoiced aspirated voice unaspirated voiced aspirated. [FL] then there is a nasal stop. So, that is velar nasal if that nasal is produced that is we call velar nasal ok.

So, then there will be nasal sound, which velar nasal I just forgot the symbol of the velar nasal, I can go to the IPA chart and find out the symbols for the velar nasal if I say the velar nasal it is look like not call back that it will be velar nasal not call back it will look like this, this is velar nasal. So, velar nasal then after the velar we have forget about the chow I will affricate I will come lateral this [FL] will come lateral. So, then we have retroflex is the postalveolar palatal region is the retroflex. So, tip of the tongue call back and touches the upper cavity that is called retroflex sound if I come to the animation, this is the retroflex sound and retroflex also have [FL].

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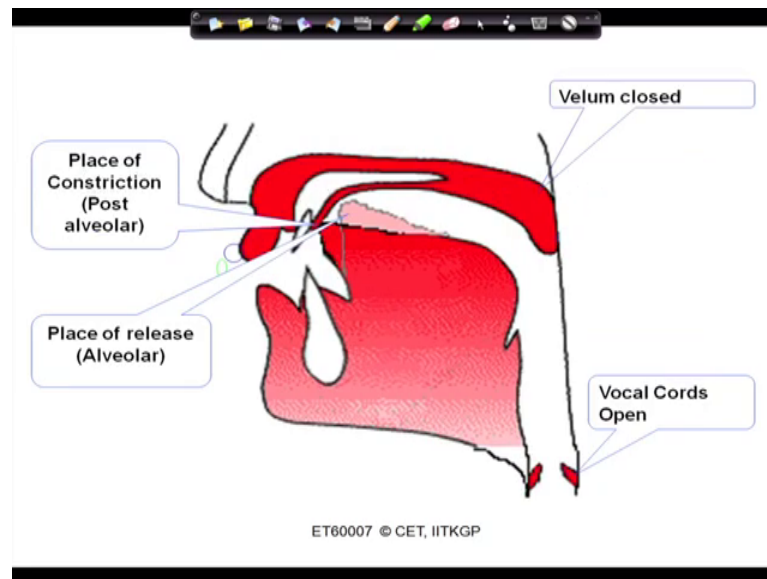


What is there retroflex sound are writing ta is ta, but it is called this bottom up this call back that is the symbol of retroflex symbol of retroflex. So, it is nothing but a ta unvoiced unaspirated retroflex, unvoiced aspirated retroflex, voiced unaspirated retroflex, voiced aspirated retroflex [FL]. So, depending on the place and manner I am writing the symbol.

Then if it is retroflex retroflex no I can write retroflex no in here which is nothing but a n, but call back. Retroflex no, then auto retroflex we have a dental sound [FL]. So, we have a [FL]. Bengali, Hindi all Indian language [FL]. Unvoiced unaspirated, unvoiced aspirated, voiced unaspirated, voiced aspirated, this is velar this is retroflex, this is dental or alveolar ok.

Then we have a [FL]. Invoiced unaspirated, unvoiced aspirated, voiced unaspirated, voiced aspirated this is bilabial labial. So, this is the stop consonant if you see in Bengali language or Hindi language all stop consonants are exist and all have 4 varieties in the most of the Indian languages the 4 varieties. 1 2 3 4 again there is a 1 2 3 4 in retroflex 1 2 3 4 in dental region 1 2 3 4 in labial region. Then there is a another sound in Indian language if you see that is called affricate. It is what is affricate sound we can say.

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If you see this one affricate sound means it is a combination of 2 sound. When I produce cha if you see when I am producing cha, then tip of the tongue touches the dental region and glide back to velar region to produce the friction sound.

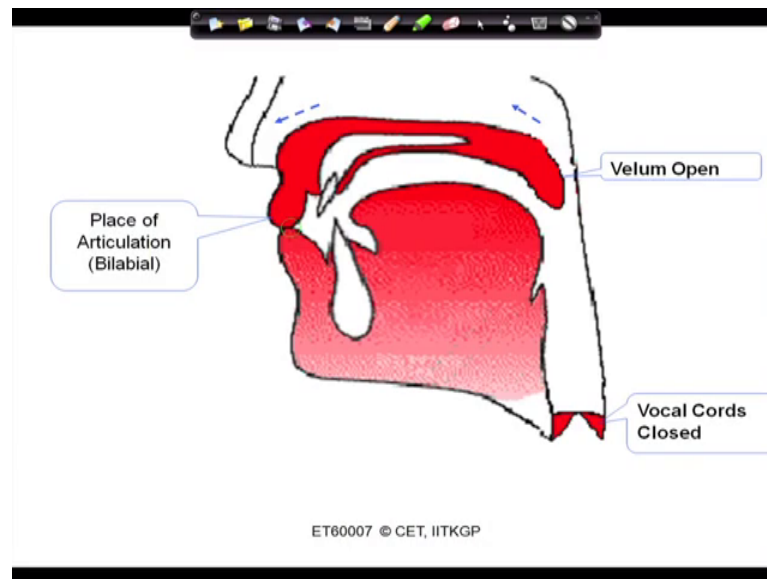
So tip of the tongue touches the dental region to produce the plosive part, and after the plosive tongue is called the tongue is push back and touches the post alveolar region to produce the friction. Then we can write the symbol ta is the position part. So, it is written by t and this saw is the fiction part which is written by the palatal or postalveolar. So, I can write postalveolar or palatal also I do not know what is the saw this. So, is palatal or postalveolar post alveolar. So, so if it is if it is unvoiced fiction, then I can write f this kind of see not f there is no gat this one. So, it is a plosion plus friction 2 kinds of sounds are there that is why it is written in 2 symbol [FL]. So, 2 symbols 2 sounds are there.

So, similarly if it is voiced then I can write da and I can write this one sorry, this one ok. So, the it is not retroflex. So, d and friction part this is voiced friction this is the voiced portion. Similarly this ca after the friction there may be a VOT which is aspirated or unaspirated. So, I can write either this symbol which is ca and chaw and [FL]. If it is a aspiration then it is ja. So, this way all the consonant can be described. It can be consists to 2 symbols or it can consists a signal symbol and with a diacritics marks which explained whether the aspiration is present or not, this aspiration if this h has 2 varieties.

If it is simple h then it is called unvoiced aspiration. If it is a voiced aspiration then I have to use the symbol of y is fricative.

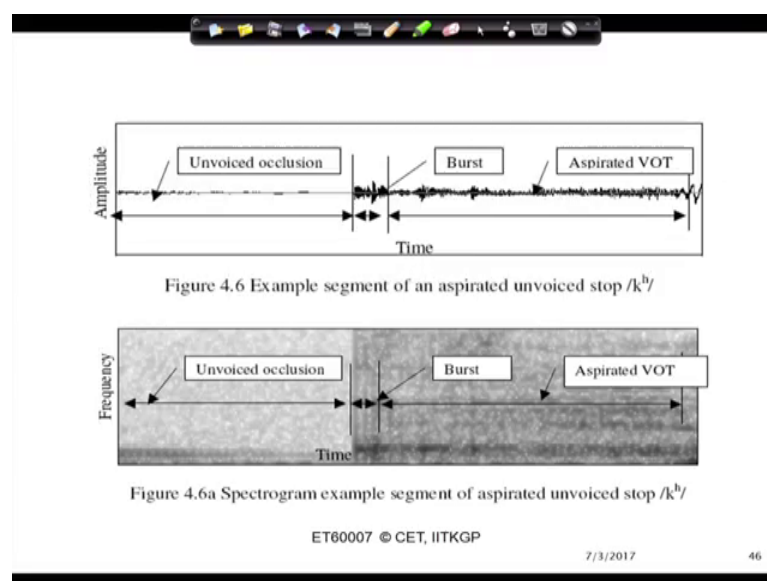
So that all are described in here now I will show you some picture.

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So, somebody if I Give me this picture and told me which sound probably this is. I can say this is nothing but a voiced stop voiced bilabial stop. So, if it is a voiced bilabial stop; that means, either it can have a ba or it can have bha. That it can be have aspirated voiced bilabial stop or it can have a unaspirated voiced bilabial stop. Now if I see the picture after recording if I see the spectrogram and the picture if you see this is ka.

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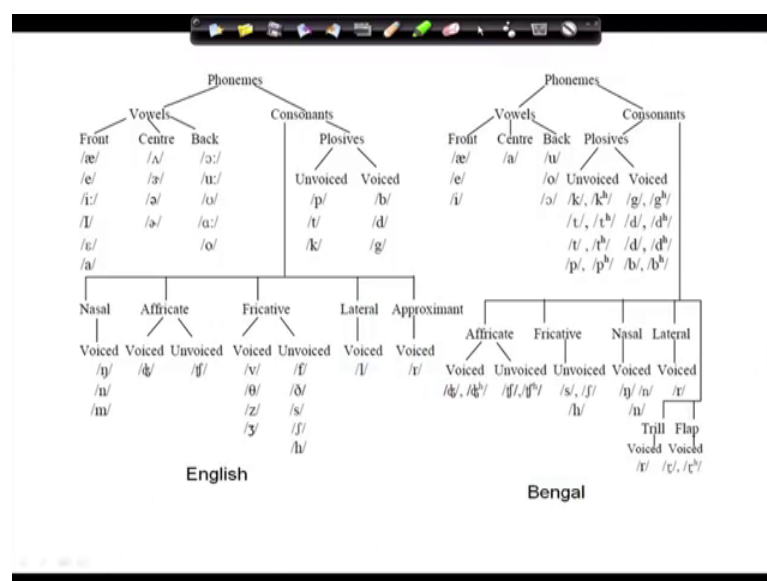


You see here this is kha, burst then VOT is aspirated and VOT is longer. All aspirated consonant VOT is longer. So, occlusion burst aspirated, if it is voiced during the occlusion period vocal cord is closed. So, there is a voice bar kind of sound that is why it is called voiced also occlusion is voiced. So, it is voiced stop ga go.

Then if it is gha then there will be aspiration aspirated VOT, all are the same then it is ka. Similarly if I say affricate occlusion part unvoiced. Then friction then VOT. So, if it is occlusion in unvoiced friction is present VOT is unaspirated then it is ca. So, if it is VOT is aspirated then it is cha. If it is occlusion is if this portion is voiced I can say this is voiced. So, it is ja jha. So, I can show you after the next class that I open a spectrogram and I classify which kind of sound it is. If it is a fricative that look like this if it is a vowel then it will be a periodic sound, it is a periodic sound.

So, these are different how Bengali vowel shape you can cut see the other vowel shape also then I can show you there is there is a phonetic chart for English language and Bengali language, you can see that there is a phoneme in English and phoneme in Bengali. So, all the phonemes I have tabilized in English all the phonemes in Bengali. So, there is a thesis also we have studied that similarity between the American English and Bengali English. So, there we have taken those things and find out the similarity non similarity all those things, but here if you see that the 2 phonemic chart.

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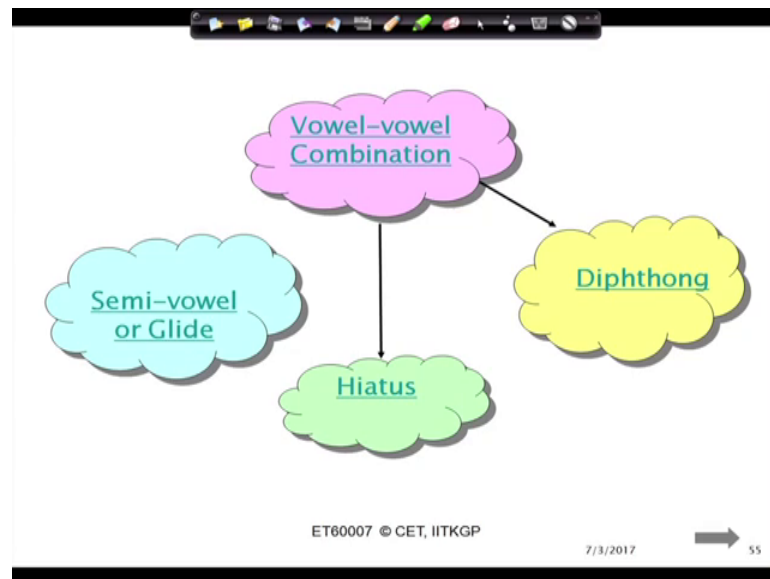


In English if you see we have only English plosive has only p t k b d g, but in Indian language let us Bengali it has [FL]. So, 4 into 4 into 4 into 4 ok.

But we have only 7 vowel in Bengali, but here if you see there are lot of vowels in English how many 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15. Then if I say we have affricate affricate voice unvoiced fricative then nasal lateral (Refer Time: 24:49) trill and flap there is a nasal affricate fricative lateral approximant all kinds of sounds are. So, there is a similar sound dissimilar sound all those things are there. So, you can go through that, but how to write that once I know the symbols, I can describe the place and manner of articulation and if I know the place and manner of articulation the place of articulation and manner of articulation, I can write down the symbol. So, both way it has to be practiced. That if you want the if I say that a consonant a plosive unvoiced unaspirated velar plosive then and there I have to write k. If I say k then and there I know it is unaspirated unvoiced velar plosive ok.

So, this is the sound description and this is how the place and manner of articulation are described in acoustics phonetics. So, then instead of vowel and consonant there may be other sound also like that approximant or there this is the a vowel vowel combination Semi vowel or glides diphthong hiatus all kinds of sounds will be there.

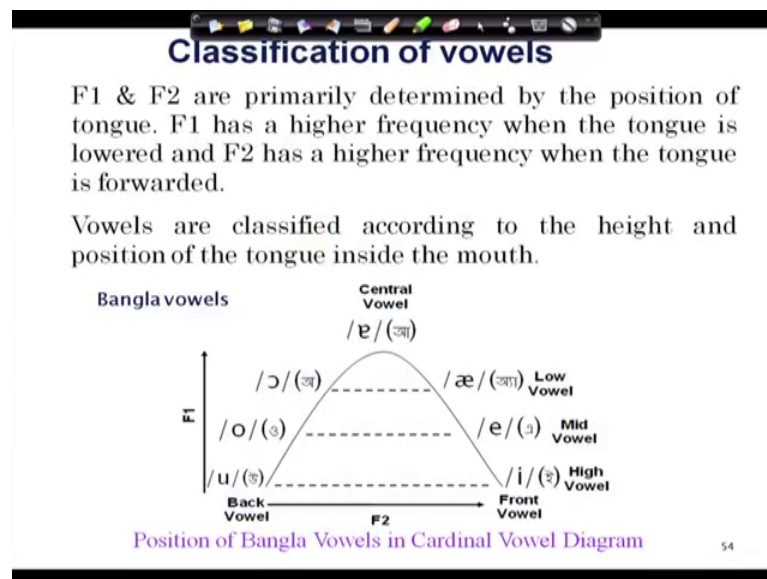
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As an engineer you should know what is the signal wise difference between a semi vowel and a glide hiatus and diphthong that we should know. Not that what is the definition of hiatus what is the definition of diphthong there may be linguistic definition all those things.

But as an engineer I should know if there is a diphthong and if there is a semi vowel somebody is going. So, what is the difference between because I have to recognize it from the signal. So, what is the signal look like this. So, I will show you the signal for Bengali example Bengali, but there are other important things.

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I said that vowel or f1 f2 plain all the cardinal this is called cardinal diagram. So, cardinal vowel diagram, it is called vowel can be placed. If I placed a Bengali vowel it will look like this. Back and front is f2 height is defined by f1 closed or open is defined by f1. So, it is f1 and f2 plane. So, I can see that different vowel depending on their production mechanism production of tongue position and tongue height they are described and that can be mapped in the f1 and f2 plane.

So when I describe the engineering model I have use these thing. So, if I see I want to classify let us I given example, if I say I am to classify between u and e if the distance is much. One is front vowel one is back vowel. So, in that case f2 value one is very low and another is will be very high. So, f2 value be different f1 value will be different. So, depending on the f1 f2 value. So, I can place the vowel and I can immediately understand which vowels can be classified in better accuracy from which. So, that a cardinal vowel diagram or if I say plot the cardinal vowel diagram of English you can construct the f1 f2; however, f1 f2 of different sample and then plot it in f1 f2 plane and find out the where it is clustered where, who is there? What do you mean by central vowel? How it is changing? So, all kind of clustered position you can analyze. So, that is also important.

Now if I said that diphthong hiatus I am not going through the slides because you can read this slide this is the definition linguistic definition. There is a some example I have given from the bangoli.

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Hiatus

➤ When two vowels coming together without any contraction or elision are pronounced separately as distinct from Diphthongs they are termed as **hiatus**.

➤ Hiatus may be of two types:

- 1) **Internal Hiatus** → which occurs within a word.

Example: **Bangla Word** : **/peik/** (পাইক)

- 2) **External Hiatus** → which refers to the break between two successive words. In this situation the first word ends with a vowel and the second word starts with a vowel.

Example: **Bangla Sentence** : **/emi ilif k^hebo/** (আমি ইলিশ খাব)

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If you want I can give you the English example also the English example also Is there.

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Semi-vowel after a vowel

Vowel-semivowel combination (V-j) consists of transitional duration with semivowel along with the preceding vowel's steady state duration.

/k/ (ক) /ɔj/ (অয) /l/ (ল) /e/ (এ)

Spectrographic View of Bangla Word /kɔjle/ (কল)
with V-j combination /ɔj/ (অয)

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So, if you see the signal this red line green line, blue line and yellow line are the formant line, formant movement line. If you see that the movement of the formant is different for is the for different vowel after vowel combination. And that produce a hiatus diphthong all kinds of things will be there. This is the phonetic chart for Bengali, I have prepared it for that things.

Then next class what I will discuss I will open a speech signal in this spectrogram and time domain speech signal, then try to find out what kind of signal it is. Whether it is ta, whether it is da, whether it is dha, whether it is a pha, whether it is a wa, we want to classify it.

So thank you.