Indian Institute of Technology Madras
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NPTEL
NATIONAL PROGRAMME ON TECHNOLOGY ENHANCED LEARNING

Introduction to Modern Linguistics
Lecture-7
Production of Speech Sounds

Prof. Shreesh Chaudhary
Dept.of Humanities and Social Sciences
IIT Madras

Good morning are you all comfortable okay now in this part of the course we are going to begin the second unit of the course until yesterday we were looking at the design features of language what are those features of language that make it any language Telugu or English a tribal language or Latin or Sanskrit any language any natural language has all of these features and we call them design feature .

They are part of the design of the language if even one of them is not there it is not a natural language and these features all of them may not be unique to human language but some of them are and these some features make human language very versatile say for example we saw that human languages have a structure have a system ok they can be learned they can be taught they can be ambiguous meaning is not only the property of sound meaning is also the property of the way sounds are arranged .

Li T and T il we saw may have the same sounds but they do not mean the same thing John kicked Mary and Mary kicked John have the same words but they do not mean the same thing meaning also depends upon the way they are arranged that the way they are structured and we also saw that languages have dual structure not just one not just linear but you also vertically structure every time you speak every time .

I speak every time we speak we make choices should I take X or Y and if you take X then you have to take A if you take Y then you have to take B you know there are these constraints on the structure of language beginning today we will talk about the second unit of the course which is please write .

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Speech sounds okay not noise not non-speech sounds say this is also sound tapping the table is also sound clapping it is also sound okay or snapping your fingers can you do it these are all sounds we are not talking about them we are talking about speech sounds the sounds that we produce when we speak we will talk about the structure of speech sounds between now and next two weeks about not more than next two weeks quite some time about a dozen hours about how speech sounds are produced.

How organs of articulation are organized and how we get different kinds of sounds from within the same organs of articulation right are you okay are you with me say yes or no please are we together you will have to take notes please take out your pen and paper or pencil better beginning tomorrow for this class bring a pencil and eraser you will have to draw lots of diagrams and that sort of thing to be able to understand the way speech sounds flow right.

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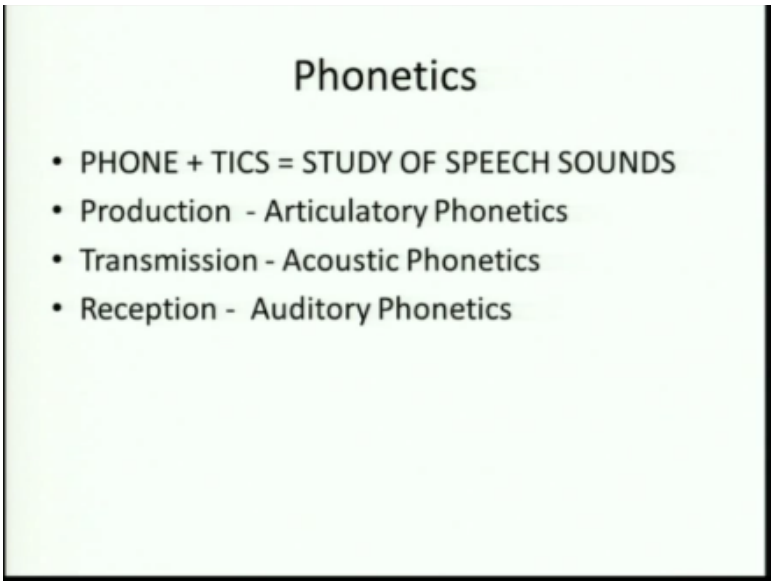

The branch of subject which studied which studies speech sounds is called please write phonetics you know in Greek phone means sound or a speech sound and tics is the science phonetics okay the science are for the study of speech sounds we can study speech sounds in any one of the three ways you know .

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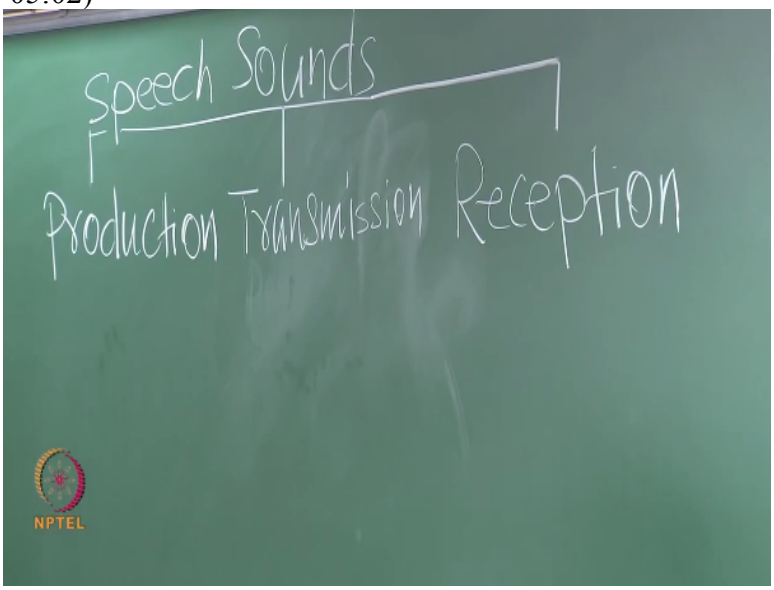

We can study the way it is produced production of speech sounds or the way it is transmitted it goes from me to you I produce the speech sounds it reaches you how does it travel what happens are there microphones are there wires between you and me what is the medium how do speech sounds travel okay and third reception of speech sounds how our speech sounds

received okay we know that we will hear through our ears but just as we produce different sounds in different ways .

When you say but both your lips come together but when you say your lips are far apart please say it but both your lips are together right but when you say your lips are far apart say are they not far apart yes or no so you know different speech sounds different speech sounds are produced differently are they also received differently is it that your ear bends when you speak pa and it rises when you say ha how do we receive them.

How are the you know primarily there may be many more you know science as somebody said has no limits because science is God science is nature it has no beginning it has no end okay it is all of it so from the little that we have understood we try to understand we say that the entire speech sounds can be studied from one of the three angles or all the three angles namely what are they can you please repeat production transmission of speech sounds and reception of speech sounds actually .

I made a mistake so production of his speech sounds transmission of speech sounds reception of his speech sounds okay each of these branches has a name for example you can see at the DVD screen.

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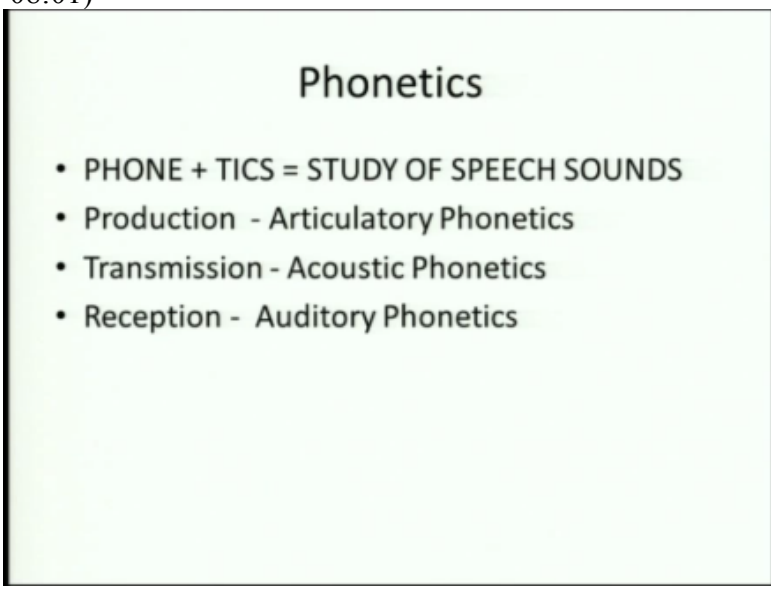

The production of speech sounds is studied under a branch of phonetics called articulatory phonetics please note articulatory phonetics production of his speech sounds what is it called

articulatory phonetics what is it called everybody please repeat after me articulatory phonetics yeah it is not phonetics it is phonetics what is it articulatory phonetics the science that studies production of speech sounds or you can look at the transmission of speech sounds and what is it called this branch of science acoustic .

What is it called acoustic phonetics study of the transmission of speech sounds it is known as acoustic phonetics what is it known as acoustic phonetics and then you have what is called the reception of speech sounds that is that branch of science is called auditory phonetics audition listening auditory phonetics we will not be looking at in any detail at the first two you know here on this course.

If you want to know more about some of these things more about sorry the second two more about acoustic phonetics and auditory phonetics you will have to do you should do higher courses here or elsewhere at this Institute or some other place but here on this course we will be talking mostly about articulatory phonetics not about acoustic phonetics neither about auditory phonetics .What are the problems you know I just give you an overview of those two subjects and then come back to it.

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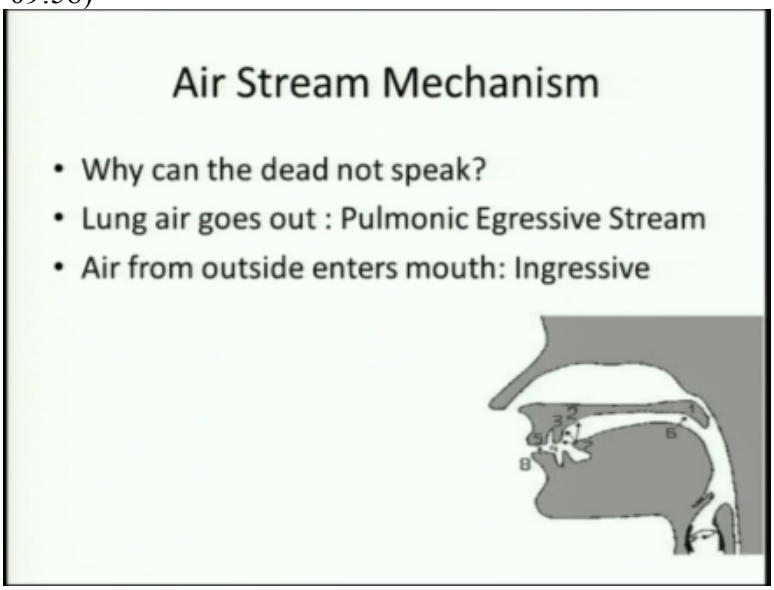

Okay I will give you an overview of those two sub branches or branches of the subject and before I come back to but let us first see what is primary to speech what is the most fundamental requirement for the production of speech sounds I you know you can close your eyes and

answer think about it for 10 seconds and then answer that question okay open your eyes and then answer the question the question is can dead people speak yes or no can dead people speak .

You do not seem to be sure okay can dead people speak Vishal Anurag where are you okay can dead people speak no say them formally say no can dead people no speak alright that is what we call a clear answer otherwise it looks you are not sure maybe my grandfather is could speak but my wife's grandfather could not okay no dead people can speak it is a universal rule why can't they speak close your eyes think for 10 seconds and tell me in the meanwhile I will write something else on the board .

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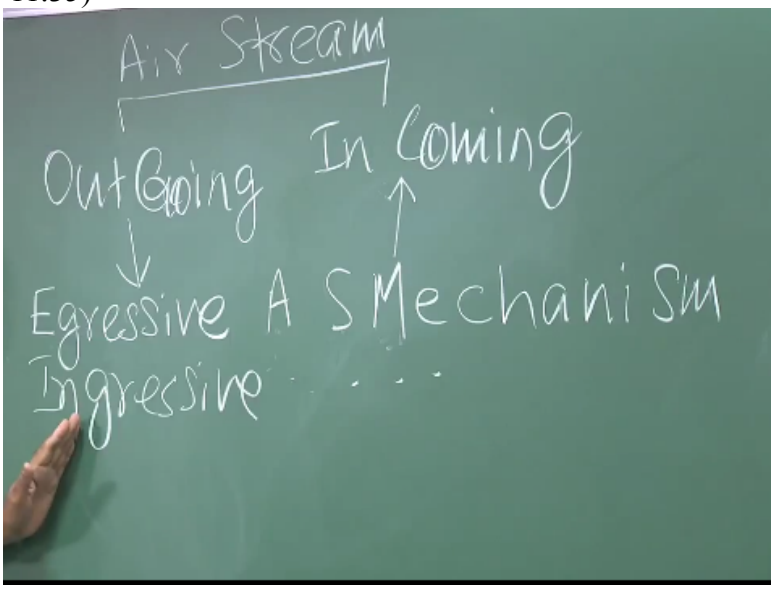

Okay open your eyes now why can't they speak they have the tongue they are the lips they have the lungs why can't they speak what is it they don't have a living people have living people have breath thank you very much who said that please my friends kindly capture my friend remove your hand for your face you know the please do not clap you know you are embarrassing me excellence is routine here right okay dead people cannot speak because dead people do not have breath.

Living people can speak because living people have breath dead people do not have breath or air is primary to speech you may have lungs you may have tongue you may have teeth you may have gums you may have X you may have Y no matter what you have if you don't have

air going into your mouth or coming out of your mouth you cannot speak every time you speak something it is either air coming in or going out keep your hand here .

And then start speaking now sing it here this way do not close your mouth keep your hand before your mouth and speak it now or any Sanskrit mantra or shloka or keep saying IIT is best IIT is best okay do you feel do you feel some air comes out every time you speak actually from some people's mouth bad air comes out but air does come out if there is no air there is no speech. Do not let any air come out now speak but do not let any air come out just keep your hand here but don't let air come out or go in no you cannot speak .

Air whether getting in you can also speak while getting in say for example when you say or for when you said do it you are sucking air in you are taking air in okay or when you throw air out as you say are you say a baa baa akka or ga whatever you say okay Airstream is important to the production of speech sounds dead people cannot speak because their lungs cannot take air in cannot throw air out okay they have everything else.

They have tongue they have teeth they have gums they have heart palate they have vocal cords everything is there yet no speech sound can come out because there is no air speech error is primary to speech right obviously you know we can have two kinds of air stream we can have air stream we can have air stream that is outgoing or we can have air stream that is incoming when you say you are taking air in when you say you are taking air in there are some languages like there is among Indian languages people say Sindhi.

Do you know where it is spoken Sindhi yeah in Sindh, now in Pakistan and there are Sindhi speakers all over India okay but primarily it is spoken in Karachi and adjoining areas in the Sindh province of Pakistan what is Pakistan today but you know what used to be all of India so Sindhi has some sounds where you take air in say for example they do not say baa they say but swell your cheek swell and puff it and now suck air in baa say it that is air going in so some sounds are also produced by incoming air .

You know air goes in but a large number of speech sounds nearly 99% of speech sounds are produced through air going out we call it please write egressive what is it called egressive airstream mechanism airstream mechanism and because this air comes from the lungs so we call it we call it pulmonic what is it called pulmonic pulmus in Greek will machine Latin is I

am not sure check please whether it is Latin or Greek Palmas is lungs are known as pulmus it I either Greek okay and because this air comes out of Palmas it is known as pulmonic please give me the complete name pulmonic air stream mechanism everybody together once again pulmonic aggressive air stream mechanism it looks like this fish market together one two three pulmonic aggressive air stream mechanism slowly please.

You in such a great hurry come again pulmonic aggressive air stream mechanism not mechanism please at least if you do not know mechanical engineering it does not matter but pronounce English correctly it is not mechanism its mechanism what is it mechanism okay pulmonic egressive airstream mechanism what will therefore incoming will be known as what is it known as pulmonic ingressive airstream mechanism what is the incoming air known as once again please pulmonic ingressive airstream mechanism .

All speech sounds are produced no matter what language you speak no matter you are a Latha Mangeshkar or chaudhary how sweet or how sour how noisy or how melodious all speech sounds are produced through either of these two mechanisms either it is through pulmonic egressive airstream mechanism or it is through pulmonic ingressive airstream mechanism okay because this is mostly and this is common we do not need to remember it we remember this egressive air stream or ingressive air stream again there are very few sounds which are produced through ingressive air stream.

Largely it is egressive airstream which produces mostly speech sounds in any language not just English not just Telugu not just Hindi any language you will find that most high speed sounds are produced through eggressive airstream mechanism look at that drawing the diagram.

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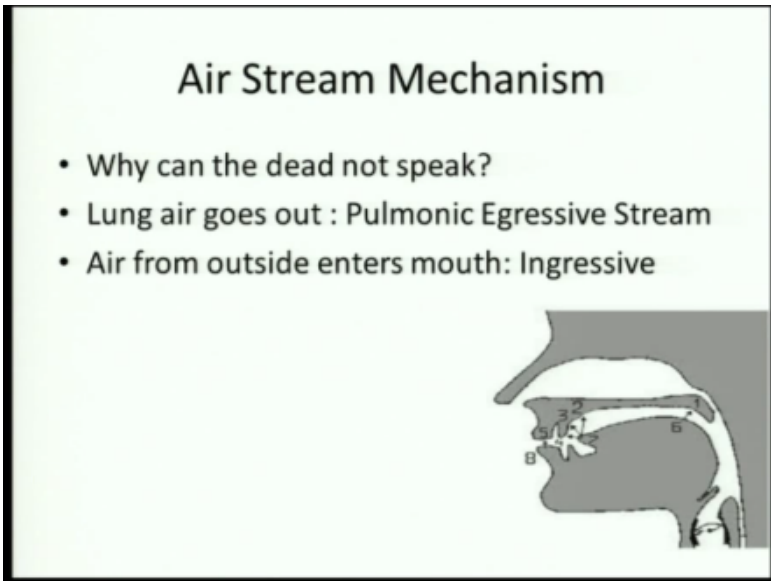

The mouth the speech air goes in this way through the oral passage through the pharynx into the lungs air or it arises in the lungs you know a storm of muscles press lungs that is why you will find you know many teachers going to canteen after the class because there are lungs their vocal cords are tired they want a cup of tea students go to the class because they are tired of listening okay but it is a muscular effort that produces speech okay stomach muscles press lungs , lungs press air out and air comes through the mouth this passage okay.

We will talk about that in some detail the airstream mechanism the production of speech sounds in some detail a little later let us look at something else.

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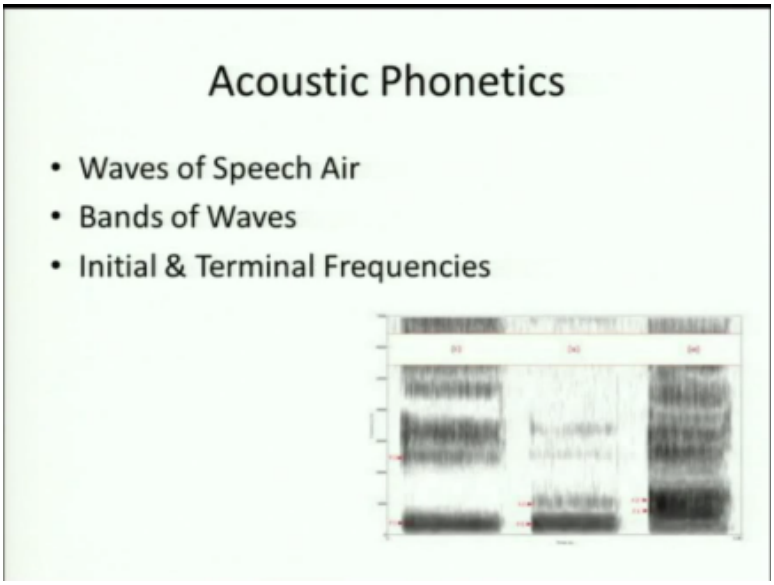

Let us look at you know we will not be talking about acoustic phonetics at any length I am just trying to give you an overview you know what is an overview can somebody tell me what is an overview say for example you want to see the entire IIT campus and you have only 2 minutes now what can you do you can take a helicopter go up above and from there you see the entire campus on your left is Hindu on your right is sharavathi etc okay or go to the ad block on the top of a tall building stand there look around and you see ya similarly you know from a greater distance if you go to the moon you can see the entire half of the earth hemisphere okay.

So I am giving you an overview not details you will just see peaks and valleys okay how do we speech air how does the speech air travel in acoustic phonetics talks about transmission of speech sounds how do we speech sounds travel speech sounds travel in waves why do the travel in waves because lungs have to contract and to expand you know it's like this contract and expand so air comes out the way we stopped comes out again where you stopped again so it goes out in waves okay and because it goes out it goes out in waves you remember your basic physics it has a crest okay all waves have a crest have you been to the beach go to the beach again sometime in this you know holidays that are coming Independence Day and other things go there and check again you will see that all waves have a trough they go as low as they can and all waves have a what is the opposite of trough crest .

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So you know speech air speech error travels in waves and because it travels in waves necessarily have troughs what is a trough the lowest the valley you know this is the UC crest trough crest trough crest trough crest trough it always goes this way okay that is how speech air flows it in waves and waves have crests and troughs waves also have other characteristics they are called frequency characteristics.

What was the pressure with which you threw air out into the lungs anything you know anything thrown is thrown with a pressure you can throw the ball such that it reaches only the batsman in cricket you can throw the ball such that it reaches the fielder far away the fielder returns the ball good fielders return the ball such that it hits the wicket without the wicket keeper having to bother about it .

So you know you throw anything with a particular amount of force so waves are also thrown with force so waves can have written crests here okay so waves are also produced with a kind of force there can be a force which says maximum it will go there and there will be a force which says it will start here let us write starting force of the wave you know you can start it at 2 kilograms per inch or you can start it at the level of 2 tonnes per inch okay now2 kilograms per inch will go maybe 20 meters or 2 tonnes per inch will perhaps go to America okay.

So all waves have 2 kinds of frequencies number one please write fundamental frequency the frequency at which it started fundamental frequency the frequency at which the wave started

okay and the terminal it cannot go beyond it has reached its crest now it has to decline it has to fall so let us call it terminating force or in the language of physics call it formant frequency can you take it okay so you know all waves are produced through you know both fundamental frequency in book and literature you will find it abbreviated at (f 0) and formant frequency (ff) fundamental frequency and formant frequency or initial and terminal frequencies.

Because we do not produce each sound with the same kind of initial and terminal frequencies their waves differ and that is why our ears catch these waves differently look at the picture I have given you this is called a spectrogram this a spectrogram gives you the pictures of some sounds this is e the vowel E as in cheese in English or this is ah this is ooh one kind of vowel yet another kind of one kind of sound another kind of sound another kind three different kinds of sounds you will see have three different kinds of waves okay .

In the case of one we have lot more air coming out okay we have different kinds of fundamental and formant frequency we have different kinds of band structures we have different kinds of perception we have different kinds of reception because we have different kinds of production so in acoustic phonetics we study transmission of speech sounds where we study the following how speech sounds are formed fundamental frequency formant frequency transmission characteristics relative differences .

What is the difference between pa and ba that your ear can you know you and I otherwise require when somebody says write the phone number and write the name then you say VV GE and you ask V as in Bangalore know V as in victory okay you and I need Clues but routinely face to face your ear catches all of these frequencies very appropriately so that you understand one another without having to ask your speaker to repeat himself or herself.

How does that happens because each speech sound has different fundamental and formant characteristics please write their fundamental and formant characteristics their fundamental frequency and formant frequencies differ that is why we are able to perceive different sounds you can do a lot of engineering in his speech you know processes you can design a machine which can listen like human beings which can answer like human beings but if you design that machine your machine will have to have the ability to recognize the different wave characteristics okay .

Only if you can recognize the difference between wave characteristic of ah and wave characteristics of ooh can your machine perceive that now we are talking about car or we are talking about cut okay these wave characteristics differ for each sound actually some people say that no two sounds are produced alike some people go further and say if in the same sound is not produced alike on two occasions okay that is the dynamics of nature you know we are always changing constantly changing constantly in flux that is why there has been a great philosopher a Greek philosopher senior to Plato by about 300 years .

Somebody called Heraclitus please write you know it may not be important now but before you are 40 before you think of buying another car or buying a plane okay think of reading it okay and people like you know if this is also there in Sanskrit in the Indian tradition that you know Heraclitus said we swim and do not swim in the same river twice because by the time you approach the river yesterdays water has gone away and yet you go to the same spot so you know it is the same thing on no two occasions any speech sound is produced the same way.

If you take the spectrogram and today's computers have it by default almost or if you like you can go to the speech laboratory of the computer science and engineering department ask colleagues there I want to see the photograph of my own voice and they will let you speak into the microphone and the computer will produce a picture of your voice and you will see speak the same thing twice and you will find it is not exactly the same okay .

Are you with me are we together all I am trying to get you to understand is not these details just now but the fact that production transmission reception of his speech is a highly complex engineering okay but Nature has gifted us with apparatus with mechanism which helps us understand things easily almost effortlessly we do not even say that look I am going to now switch on by turning my listening machine. It happens automatically it happens in the middle of noise it happens in the middle of quarrel .

You can take a phone talk to somebody else you can also pretend to listen to a third person actually there are people who can take two dictation at the same time just as there are people who can do two paintings at the same time okay they are the freaks of nature but by and large speaking is a natural ability similarly listening is also a natural ability how does that happen that happens because all speech sounds come with different formant and fundamental

frequencies different wave characteristics they strike our ears differently and our ears know how to recognize them and that is how they are recognized okay .

Any problem are you with me no only three people ears or are you with me lovely great okay how do we listen.

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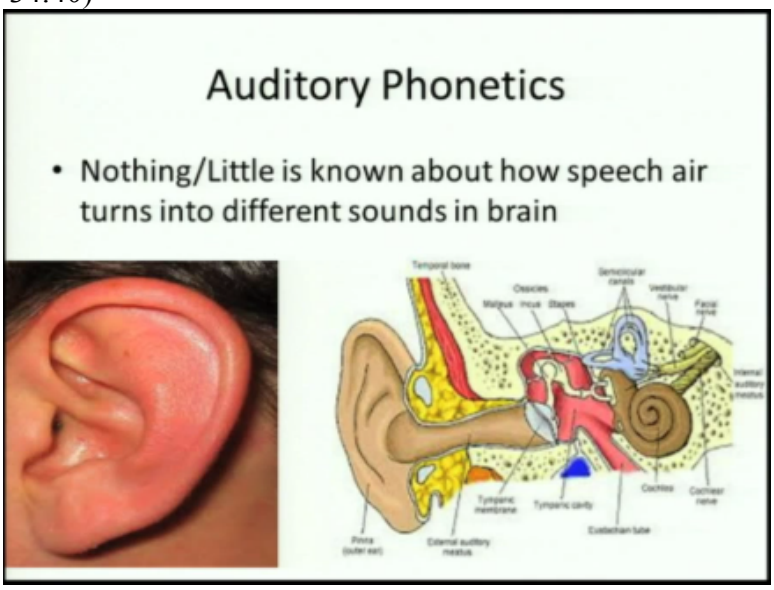

Look at the picture of you touch your ear please if it is dirty touch it with a handkerchief okay why do we have grooves in the air here why do our ears are the bones or flesh or what cartilage why cartilage why not bones you know or some people say I will have ears of diamond you know rich people could have had ears of diamond slum dwellers could have had years of paper disposable throw it tomorrow okay why do we have ears like this any guesses look at your two ears you know go today and take a tape ask your friend to measure it.

They are not exactly the same height okay measure it from the crest of your head okay there is minute difference they are not exactly symmetrically aligned there is there is a you know there is a slight difference one is a little higher than the other why do we have two years why are the ears designed this way and then why do years have these grooves they should have been once something flat keep it clean you know maybe they were designed so that we could have jewelry okay .

The reason is we need two years because it is the mean of that angle no matter where the sound comes from okay it hits right ear and left ear and they make a certain kind of angle and

your brain the processing mechanism finds the mean of that angle and knows this is the source those who go weak in one year have difficulty recognizing the source of the sound it happens when you get aged it happens when people age the ability physical ability starts weakening their eyes become weak their ears become weak .

Then you know they have difficulty saying who called from where you may be calling them from Ganga hostel but they go answering to sharavathi hostel okay they have difficulty listening they have difficulty answering but ideally nature has given us two eyes two ears so that we can locate exactly taking the average where the sounds come from these groups because it is with to these groups that speech air wave strikes they catch those waves and then you know waves are directed inside through the inner ear .

And inner ear is a very complex thing look at the drawing of the inner air inner ear who can do the drawing of the inner ear in 30 seconds can you at least the outlines try I will give you 30 seconds let us see or one minute full one minute can you do the drawing of the inner ear first do the outer ear does not matter is it an Indian ear or an American ear do not know cannot say I took it from Google okay come on quick one minute only please do the outer ear first just do the outer ear do not worry about inner ear is very difficult very complex phenomenon and you can find it on the net okay.

It is anyway there you know that I am only trying to draw your attention to the groups we know hardly enough about it we do not know much we only know that there is a tunnel inside this tunnel okay his pitcher comes here and then here this thing you know the cochlea the tiny here more than are close to 40,000 tiny hair cells here so the speech sounds strike these hair cells and at the strike of the hair cell at the strike of these waves and they regain their normal position.

They regain their normal position okay so depending upon you see longer hair makes a bigger arch it goes down in a long distance comes back in a long distance so the distance traveled the time taken the entire thing all these mechanisms perhaps this is a very big word an important word perhaps we know nothing about how speech sounds are produced how speech sounds are processed between cochlea the inner ear hair cell in the brain.

How those signals are transmitted we do not know we have human beings today people say no as much only about these things as they know about they knew about the solar system in the time of Galileo which means we know very little right let us continue another so we know hardly enough about how speech sounds are processed we only know that is speech sounds a strike the hair cells in the inner ear is a certain force and they produced electrical impulses which travel to brain and brain interprets them in various ways .

We do not have any algorithm which tells us that A is produced in perceived in this way and B is produced in this way we do not know enough.

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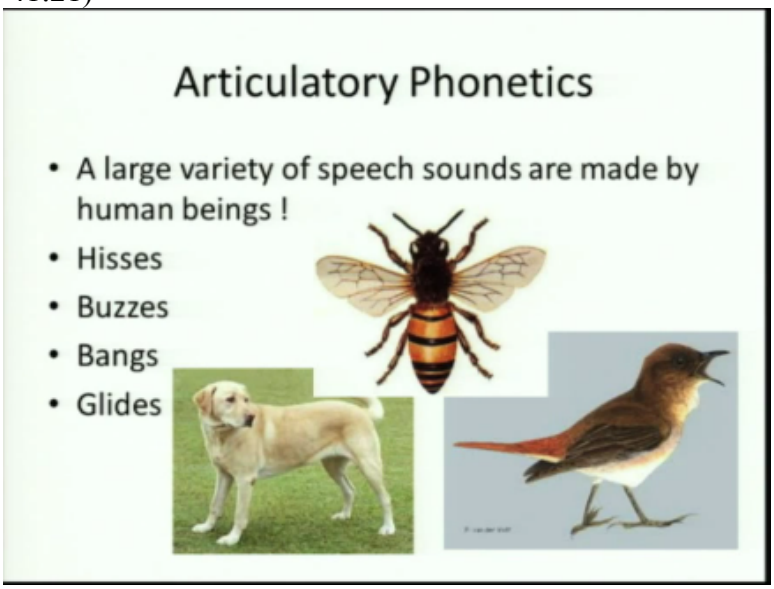

But finally the most important thing we will be talking about on this course is articulatory phonetics how speech sounds are produced human beings have a very large capacity human beings are versatile they have the capacity to produce all kinds of sounds they can speak like bees they can speak like flies they can speak like birds they can speak like other animals other mammals other four-footed animals actually in animal world only four kinds of sounds are produced.

People say we can either produce hissing sounds like reptiles you know like snakes and crocodiles they produce sounds like the hissing sound or we can produce buzzing sounds like flies or we can talk like birds you know birds can whistle they can say can you do it okay yeah

all right you know so birds can do that kind of sound they can produce you know gliding sounds whistles or like dogs or lions you can produce roaring sounds.

You can say who a okay so you know if you look at the entire animal world only four kinds of sounds are possible people say you can either produce hisses or buzzes or bangs or glides human beings can produce all the four different kinds of sounds they can produce hissing sounds such as when we say as in set or as in sing origin so origin in all different kinds of as in as in sharp or yeah R as in chivalrous okay .

They can produce buzzing sounds as in is was Zee, Zee TV okay or you know all kinds of other buzzing sounds that we have or they can produce sounds like glides you know say for example when you say or when you say when you say or yeah or sounds that are produced with a great explosion like pot but oh so you know human beings can produce all the four or five different kinds of sounds that is because how is that possible what is it that flies cannot do bees cannot do lions and elephants and dogs cannot do birds cannot do but human beings can the idea is the reason is human beings have a very versatile apparatus of speech organs of articulation.

They have a tongue they have vocal cords they have teeth their jaws there are lips which manipulate sounds in many different ways and then we produce all kinds of different sounds a beginning tomorrow we will talk about organs of articulation and we will talk about production of speech sounds you may refer to the books I have already listed in the course outline all of these books are known as some kind of phonetics you know either articulatory phonetics or introduction to phonetics a number of things .

Look up any book on phonetics and you will have it very easy time understanding the subject if you have difficulties or doubts please ask me please look at the references are given and you will sure enjoy and understand this is where the next frontier of challenge for engineering lies can you design a machine which can speak and listen like human beings which can ask and answer questions like human beings can if you want to do that your machine will have to understand some of these mechanisms .

We will talk about the production of speech sounds for the next two to three weeks okay, thank you do you have any questions thank you have a good day .

Online Video Editing /Post Production

K.R.Mahendra Babu

Soju Francis
S. Pradeepa

S. Subash
Camera

Selvam
Robert Joseph
Karthikeyan
Ramkumar
Ramganesh
Sathiaraj

Studio Assistants

Krishnakumar
Linuselvan

Saranraj

Animations

Anushree Santhosh
Pradeep Valan .S.L

NPTEL Web & Faculty Assistance Team

Allen Jacob Dinesh
Bharathi Balaji
Deepa Venkatraman

Dianis Bertin
Gayathri
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Malarvizhi
Manikandasivam
Mohana Sundari

Muthu Kumaran
Naveen Kumar

Palani
Salomi
Senthil
Sridharan
Suriyakumari

Administrative Assistant

Janakiraman .K.S

Video Producers

K.R Ravindranath

Kannan Krishnamurty

IIT Madras Production

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