

UGC MHRD ePG Pathshala

Subject: English

Principal Investigator: Prof. Tutun Mukherjee, University of Hyderabad

Paper 13: Introduction to Linguistics and Phonetics

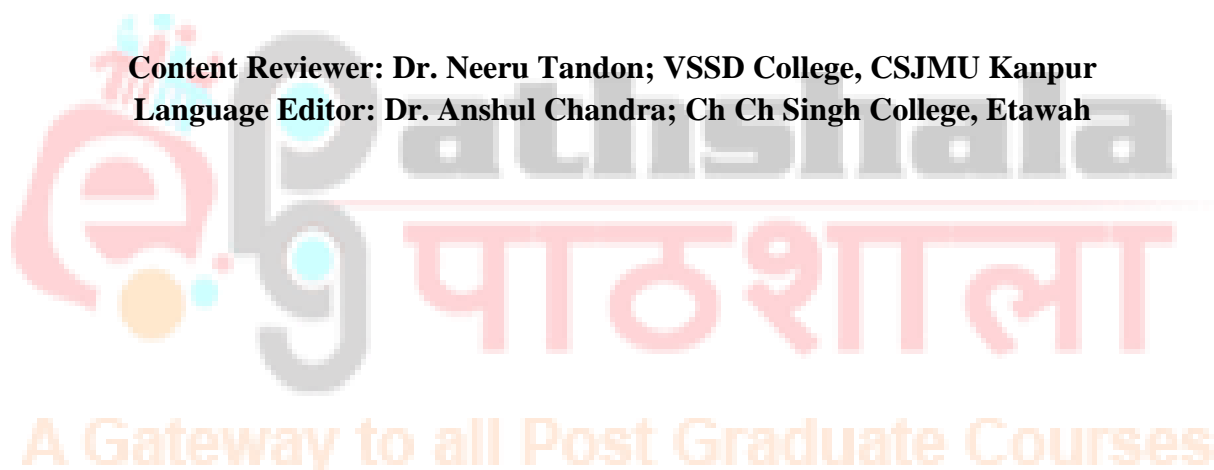
Paper Coordinator: Dr. Neeru Tandon; VSSD College, CSJMU Kanpur

Module No 06: Mechanism of Speech Production

Content writer: Dr. Namrata Rathore Mahanta, Mahila Mahavidyala, BHU

Content Reviewer: Dr. Neeru Tandon; VSSD College, CSJMU Kanpur

Language Editor: Dr. Anshul Chandra; Ch Ch Singh College, Etawah



Mechanism of Speech Production

6.0 Learning outcome:

This module shall introduce the learner to the various components and processes that are at work in the production of human speech. The learner will also be introduced to the application of speech mechanism in other domains such as medical sciences and technology. After reading the module the learner will be able to distinguish speech from other forms of human communication and will be able to describe in detail the stages and processes involved in the production of human speech.

6.1 Introduction: What is speech and why it an academic discipline?

Speech is such a common aspect of human existence that its complexity is often

overlooked in day to day life. Speech is the result of many interlinked intricate processes that need to be performed with precision. Speech production is an area of interest not only for language learners, language teachers, and linguists but also people working in varied domains of knowledge. The term ‘speech’ refers to the human ability to articulate thoughts in an audible form. It also refers to the formal one sided discourse delivered by an individual, on a particular topic to be heard by an audience.

The history of human existence and enterprise reveals that ‘speech’ was an empowering act. Heroes and heroines in history used ‘speech’ in clever ways to negotiate structures of power and overcome oppression. At times when the written word was an attribute of the elite and noble classes ‘speech’ was the vehicle which carried popular sentiments. In adverse times ‘speech’ was forbidden or regulated by authority. At such times poets and ordinary people sang their ‘speech’ in double meaning poems in defiance to authority. In present times the debate on an individual’s ‘right to free speech’ is often raised in varied contexts. As an academic discipline Speech Communication gained prominence in the 20th century and is taught in university departments across the globe. Departments of Speech Communication offer courses that engage with the speech interactions between people in public and private domain, in live as well as technologically mediated situations.

However, the student who peruses a study of ‘mechanism of speech production’ needs to focus primarily on the process of speech production. Therefore, the human brain and the physiological processes become the principal areas of investigation and research. Hence in this module ‘speech’ is delimited to the physiological processes which govern the production of different sounds. These include the brain, the respiratory organs, and the organs in our neck and mouth. A thorough understanding of the mechanism of speech production has helped correct speech disorders, simulate speech through machines, and develop devices for people with speech related needs. Needless to say, teachers of languages use this knowledge in the classroom in a variety of ways.


6.2 Speech and Language

In everyday parlance the terms ‘speech’ and ‘language’ are often used as synonyms. However, in academic use these two terms refer two very different things. Speech is the ‘spoken’ and ‘heard’ form of language. Language is a complex system of reception and expression of ideas and thoughts in verbal, non-verbal and written forms. Language can exist without speech but speech is meaningless without language. Language can exist in the mind in the form of a thought, on paper/screen in its orthographic form; it can exist in a gesture or

action in its non-verbal form, it can also exist in a certain way of looking, winking or nodding. Thus speech is only a part of the vast entity of language. It is the verbal form of language.

Over the years Linguists have engaged themselves with the way in which speech and language exists within the human beings. They have examined the processes by which language is acquired and learnt. The role of the individual human being, the role of the society/community/the genetic or physiological attributes of the human beings all been investigated from time to time.

Ferdinand de Saussure (Ferdinand de /sō'soor/), a Swiss linguist who laid the foundation for Structuralism declared that language is imbibed by the individual within in a society or community. His lectures delivered at the University of Geneva during 1906-1911 were later collected and published in 1916 as *Cours de linguistique générale*. Saussure studied the relationship between speech and the evolution of language. He described language as a system of signs which exists in a pattern or structure. Saussure described language using terms such as 'langue' 'parole' and 'langage'. These terms are complex and cannot be directly translated. It would be misleading to equate Saussure's 'langage' with 'language'. However at an introductory stage these terms can be described as follows:

 Stop and Think		
'langue' is the act of understanding and communicating	'parole' is the act of speaking	'langage' is the system or structure which underlies communication.
'langue' is an attribute of a group/community/society	'parole' is an act of the individual	

American linguist Avram Noam Chomsky argued that the human mind contains the innate source of language and declared that humans are born with a mind that is pre-programmed for language, i.e., humans are biologically programmed to use languages. Chomsky named this inherent human trait as 'Innate Language'. He introduced two other significant terms: 'Competence' and 'Performance'

'Competence' was described as the innate knowledge of language and 'Performance' as its actual use. Thus the concepts of 'Innate Language' 'Language Competence' and 'Language Performance' emerged and language came to be accepted as a cognitive attribute of humans

while speech came to be accepted as one of the many forms of language communication. These ideas can be summarized in the chart given below:

Speech	Language
Speech is the sound produced by any individual during verbal communication	Language is a complex system that operates between an idea or a thought and its meaning
Speech is a physiological activity	Language is a cognitive activity
Speech is concerned with the BRAIN and body organs	Language is concerned with the MIND and society/ community

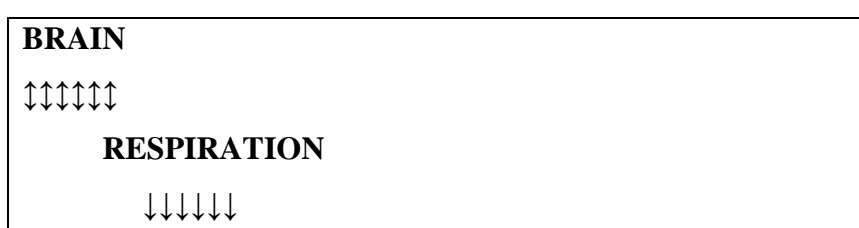
In the present times speech and language are seen as interdependent and complementary attributes of humans. Current research focuses on finding the inner connections between speech and language. Consequently, the term ‘Speech and Language’ is used in most application based areas.

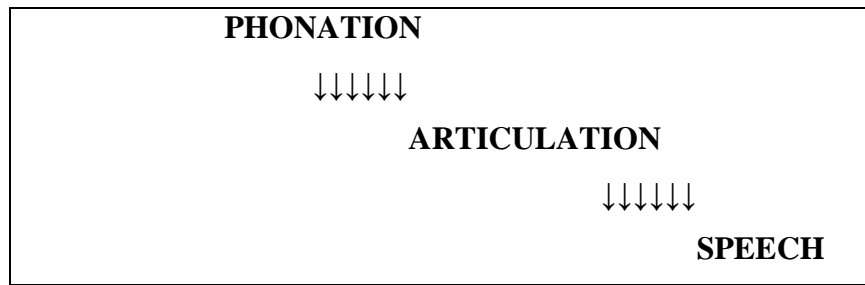
6.3 From Theory to Application

It is interesting to note that the knowledge of the intricacies of speech mechanism is used in many real life applications apart from Language and Linguistics. A vibrant area in Speech and Language application is ‘Speech and Language Processing’. It is used in Computational Linguistics, Natural Language Processing, Speech Therapy, Speech Recognition and many more areas. It is used to simulate speech in robots. Vocoder and Text to speech function (TTS) also makes use of speech mechanism. In Medical Sciences it is used to design therapy modules for different speech and language disorders, to develop advanced gadgets for persons with auditory needs. In Criminology it is used to recognize speech patterns of individuals and to identify manipulations in recorded speech patterns. Speech processing mechanism is also used in Music and Telecommunication in a major way.

6.4 What is Speech Mechanism?

Speech mechanism is a function which starts in the brain, moves through the biological processes of respiration, phonation and articulation to produce sounds. These sounds are received and perceived through biological and neurological processes. The lungs are the primary organs involved in the respiratory stage, the larynx is involved in the phonation stage and the organs in the mouth are involved in the articulatory stage.





6.5 The Brain

The brain plays a very important role in speech. Research on the human brain has led to identification of certain areas that are classically associated with speech. In 1861, French physician Pierre Paul Broca discovered that a particular portion of the frontal lobe governed speech production. This area has been named after him and is known as Broca's area. Injury to this area is known to cause speech loss. In 1874, German neuropsychiatrist Carl Wernicke discovered that a particular area in the brain was responsible for speech comprehension and remembrance of words and images. At a time when brain was considered to be a single organ, Wernicke demonstrated that the brain did not function as a single organ but as a multi pronged organ with distinctive functions interconnected with neural networks. His most important contribution was the discovery that brain function was dependent on these neural networks. Today it is widely accepted that areas of the brain that are associated with speech are linked to each other through complex network of neurons and this network is mostly established after birth, through life experience, over a period of time.

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Why do children below the age of 5 years display different patterns and levels of speech and language use even if they are of the same age? Why do adults display similar patterns irrespective of age? Why are children more adept at learning new languages than adults?

It has been observed that chronology and patterning of these neural networks differ from individual to individual and also within the same individual with the passage of time or life experience. The formation of new networks outside the classically identified areas of speech has also been observed in people who have suffered brain injury at birth or through life experience. Although extensive efforts are being made to replicate or simulate the plasticity and creativity of the human brain, complete replication has not been achieved. Consequently, complete simulation of human speech mechanism remains elusive.

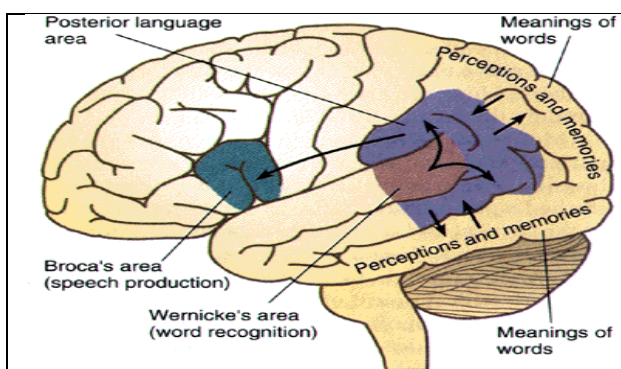


Figure 1: Areas of brain associated with Speech and Language

Image source:

http://www2.leeward.hawaii.edu/hurley/ling102web/mod5_learning/5mod5.2_disorders.htm

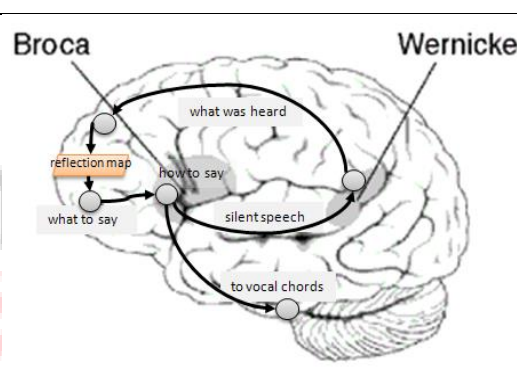


Figure 2: The neural networks in Speech and Language

Image

source :

<https://signsofmyrab.files.wordpress.com/2014/04/phonologicalloop.png>

6.6 The organs of speech

In order to understand speech mechanism one needs to identify the organs used to produce speech. It is interesting to note that each of these organs has a unique life-function to perform. Their presence in the human body is not for speech production but for other primary bodily functions. In addition to primary physiological functions, these organs participate in the production of speech. Hence speech is said to be the 'overlaid' function of these organs. The organs of speech can be classified according to their position and function.

- **The respiratory organs** consist of: The Lungs and trachea. The lungs compress air and push it up the trachea.

- **The phonatory organs** consist of the Larynx: The larynx contains two membrane-like structures called vocal cords or vocal folds. The vocal folds can come together or move apart.
- **The articulatory organs** consist of: lips, teeth, roof of mouth, tongue, oral and nasal cavities

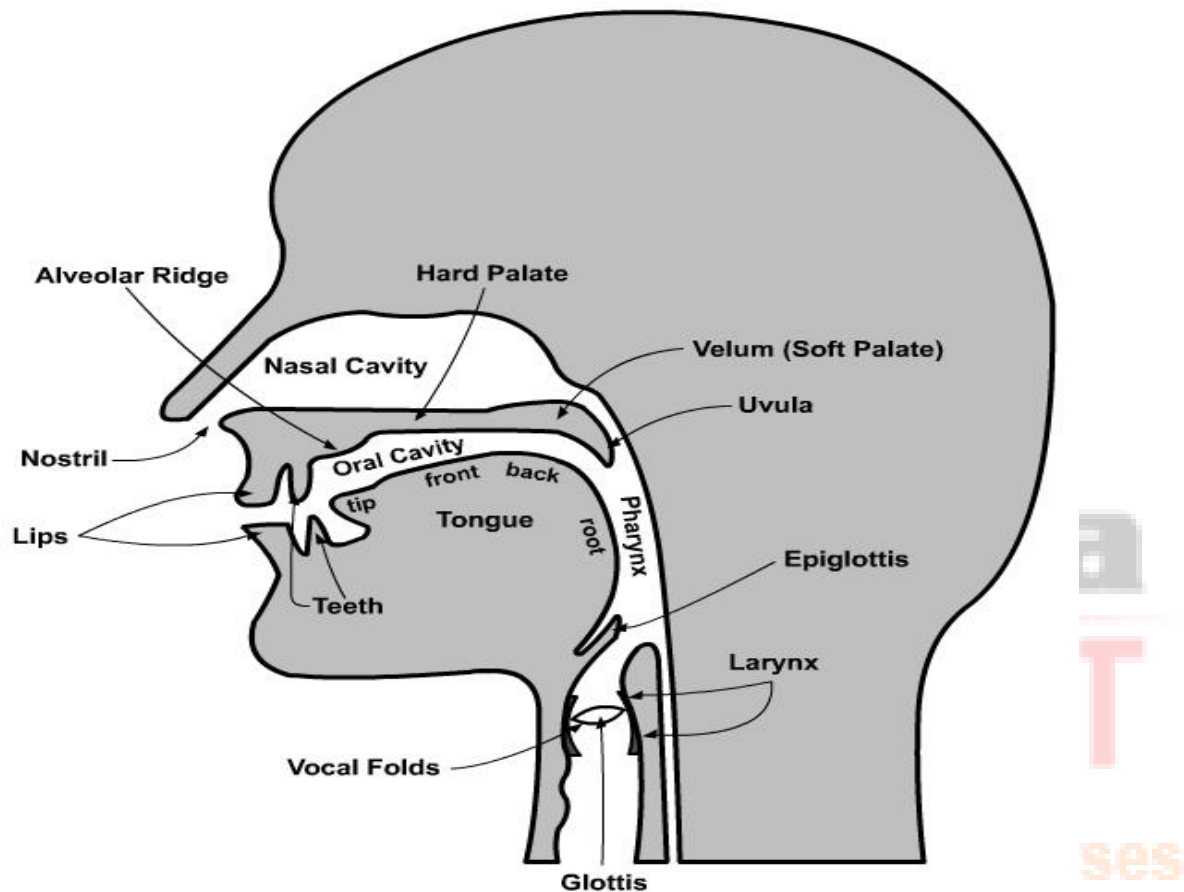
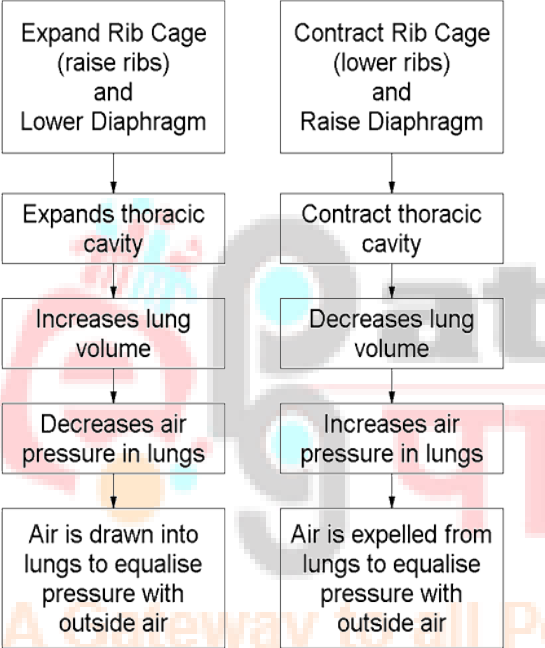
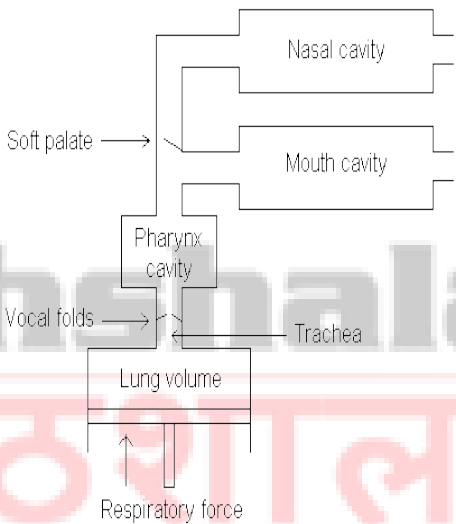


Figure 3: Organs of Speech

Image source: <http://www.madbeppo.com/french-language/the-organs-of-speech-from-the-neck-up>

6.6.1 The respiratory process involves the movement of air. Through muscle action of the lungs the air is compressed and pushed up to pass through the respiratory tract- trachea, larynx, pharynx, oral cavity, nasal cavity or both. While breathing in, the rib cage is expanded, the thoracic capacity is enlarged and lung volume is increased. Consequently, the air pressure in lungs drops down and the air is drawn into the lungs. While breathing out, the rib cage is contracted, the thoracic capacity is diminished and lung volume is decreased. Consequently, the air pressure in the lungs exceeds the outside pressure and air is released from the lungs to equalize it. Robert Mannel has explained the process through flowcharts and diagrammatic representations given below:

 <pre> graph TD subgraph In A[Expand Rib Cage (raise ribs) and Lower Diaphragm] --> B[Expands thoracic cavity] B --> C[Increases lung volume] C --> D[Decreases air pressure in lungs] D --> E[Air is drawn into lungs to equalise pressure with outside air] end subgraph Out F[Contract Rib Cage (lower ribs) and Raise Diaphragm] --> G[Contract thoracic cavity] G --> H[Decreases lung volume] H --> I[Increases air pressure in lungs] I --> J[Air is expelled from lungs to equalise pressure with outside air] end </pre>	 <pre> graph TD SoftPalate[Soft palate] --- NasalCavity[Nasal cavity] SoftPalate --- MouthCavity[Mouth cavity] MouthCavity --- PharynxCavity[Pharynx cavity] PharynxCavity --- VocalFolds[Vocal folds] VocalFolds --- Trachea[Trachea] Trachea --- LungVolume[Lung volume] RespiratoryForce[Respiratory force] --> LungVolume </pre>
Figure 4: Breathing in and Breathing out	Figure 5 : A simplified diagram of the vocal tract
Image source: http://clas.mq.edu.au/speech/phonetics/phonetics/introduction/respiration.html	Image source: http://clas.mq.edu.au/speech/phonetics/phonetics/introduction/vocaltract_diagram.html

Once the air enters the pharynx, it can be expelled either through the oral passage, or through the nasal passage or through both depending upon the position of soft movable part of the roof of the mouth known as soft palate or velum.

Egressive and Ingressive Airstream:

If the direction of the airstream is inward, it is termed as ‘Ingressive airstream’. If the direction of the airstream is outward, it is ‘Egressive airstream’. Most languages of the world

make use of Pulmonic Egressive airstream. Ingressive airstream is associated with Scandinavian languages of Northern Europe. However, no language can claim to use exclusively Ingressive or Egressive airstreams. While most languages of the world use predominantly Egressive airstreams, they are also known to use Ingressive airstreams in different situations. For extended list of use of ingressive mechanism you may visit Robert Eklund's Ingressive Phonation and Speech page at www.ingressive.info .



Egressive process involves outward expulsion of air.

Ingressive process involves inward intake of air.

Egressive and Ingressive airstreams can be pulmonic (involving lungs) or non-pulmonic (involving other organs).

Non Pulmonic Airstreams: There are many languages which make use of non pulmonic airstream. In these cases the air expelled from the lungs is manipulated either in the pharyngeal cavity, or in the vocal tract, or in the oral cavity. Three major non pulmonic airstreams are:

- Ejective
- Implosive
- Clicks

In Ejectives, the air is trapped and compressed in the pharyngeal cavity by an obstruction in the mouth with simultaneous closure of the glottis. The larynx makes an upward movement which coincides with the removal of the obstruction causing the air to be released.

In Implosives, the air is trapped and compressed in the pharyngeal cavity by an obstruction in the mouth with simultaneous closure of the glottis. The larynx makes a downward movement which coincides with the removal of the obstruction causing the air to be sucked into the vocal tract.

In Clicks, the air is trapped and compressed in the oral cavity by lowering of the soft palate or velum and simultaneous closure of the mouth. Sudden opening causes air to be sucked in making a clicking sound. For a list of languages which use these airstream mechanisms you may visit

<https://community.dur.ac.uk/daniel.newman/phon10.pdf>

While the process of phonation occurs before the airstream enters the oral or nasal cavity, the quality of speech is also determined by the state of the pharynx. Any irregularity in the pharynx leads to modification in speech quality.

6.6.2 The Phonatory Process: Inside the larynx are two membrane-like structures or folds called the vocal cords. The space between these is called the glottis. The vocal folds can be moved to varied distance. Robert Mannel has described five main positions of the vocal folds:

Voiceless: In this position the vocal folds are drawn far apart so that the air stream passes without any interference.

Breathy: Vocal folds are drawn loosely apart. The air passes making whisper like sound

Voiced: Vocal folds are drawn close and are stretched. The air passes making vibrating sound.

Creaky: The vocal folds are drawn close & vibrate with maximum tension. Air passes making rough creaky sound. This sound is called ‘vocal fry’ and its use is on the rise amongst urban young women. However its sustained and habitual use is harmful.

For more details on laryngeal positions you may visit Robert Mannel’s page-
http://clas.mq.edu.au/speech/phonetics/phonetics/airstream_laryngeal/laryngeal.html

You may see a small clip on the vocal fry by visiting the link –
<http://www.upworthy.com/what-is-vocal-fry-and-why-doesnt-anyone-care-when-men-talk-like-that>

6.6.3 The Mouth

The mouth is the major site for articulatory processes of speech production. It contains active articulators that can move and take different positions such as the tongue, the lips, the soft palate. There are passive articulators that cannot move but combine with the active articulators to produce speech. The teeth, the teeth ridge or the alveolar ridge, and the hard palate are the passive articulators



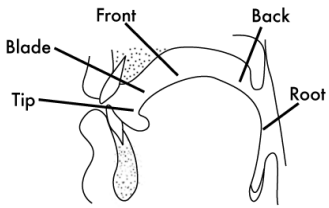
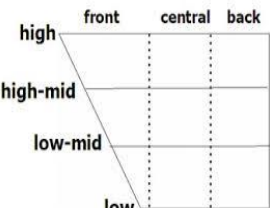
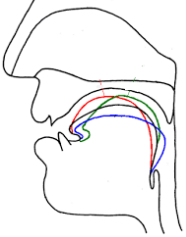
The vocal folds are the active articulators in the Larynx

Amongst the active articulators, the tongue can take the maximum number of positions and combinations to. Being an active muscle, its parts can be lowered or raised. The tongue is a major articulator in the production of vowel sounds. Position of the tongue determines the acoustics in the oral cavity during articulation of vowel sounds. For the purpose of identifying and describing articulatory processes, the tongue has been classified on two parameters.

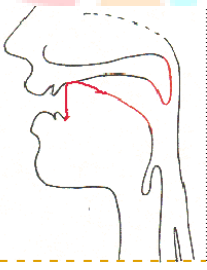
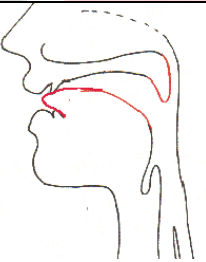
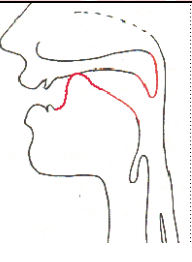
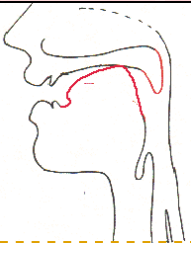
- a. The part of the tongue that is raised during the articulation process. There are four markers to classify the height to which the tongue is raised
 - Maximum height
 - Minimum height
 - Two third of maximum height
 - One third of maximum height
- b. The height to which the tongue is raised during the articulation process. Three main parts of the tongue are identified as Front, Back, and Center.

For the purpose of description the positions of the tongue are diagrammatically represented through the tongue quadrilateral.

- **Close:** The Maximum height is called the high position or the close position. This is because the gap between the tongue and the roof of mouth is nearly closed.
- **High-Mid or Half Close:** Two third of maximum is called high- mid position or half – close position
- **Low-Mid or Half Open:** One third of maximum is called low – mid position or half-open position
- **Low or Open:** The Minimum height is called the Low or the Open position. This permits the maximum gap between the tongue and the roof of mouth.

		
Fig. 6a Parts of Tongue	Fig. 6b The Tongue Quadrilateral	Fig 6c Heights of elevation
<p>Image source:</p> <p>6a. https://www.studyblue.com/notes/note/n/muscles-of-the-tongue/deck/5700718</p> <p>6b. http://www.azlifa.com/pp-lecture-7/</p> <p>6c. http://clas.mq.edu.au/speech/phonetics/phonetics/vowelartic/</p>		

The tongue also acts as an active articulator on the roof of the mouth to create obstruction in the oral cavity. Few prominent positions of the tongue are shown below

<p>Figure 6c</p> 			
Against the Alveolar Ridge	In between the teeth	Against the Hard Palate	Against the Soft Palate
<p>Image source:</p> <p>https://www2.leeward.hawaii.edu/hurley/Ling102web/mod3_speaking/3mod3.5.2_place.htm</p>			

Lips: The lips are two strong muscles. In speech production the movement of the upper lip is less than that of the lower lip. The lips take different shapes: Rounded, Neutral or Spread

Teeth: The Upper Teeth are Passive Articulators.

The roof of the mouth:

The roof of the mouth has a hard portion and a soft portion which are fused seamlessly. The hard portion comprises of the Alveolar Ridge and the Hard Palate. The soft portion comprises

of the Velum and the Uvula. The anterior part of the roof of the mouth is hard and unmovable. It begins from the irregular surface called alveolar ridge which lies behind the upper teeth. The alveolar ridge is followed by the hard palate which extends up to the centre of the tongue. The posterior part of the roof of the mouth is soft and movable. It lies after the hard palate and extends up to the small structure called the uvula.

The soft palate: It is movable and can take different positions during speech production.

- **Raised position:** In raised position the soft palate rests against the back of the mouth. The nasal passage is fully blocked and air passes through the mouth
- **Lowered Position:** In lowered position the soft palate rests against the back part of tongue in such a way that the oral passage is fully blocked and air passes through the nasal passage.
- **Partially lowered Position:** In partially lowered position, the oral as well as the nasal passages are partially open. Pulmonic air passes through the mouth as well as the nose to create 'nasalized' sounds.

The hard palate lies between the alveolar ridge and velum. It is a hard and unmovable part of the roof of the mouth. It lies opposite to the centre of the tongue and acts as a passive articulator against the tongue to produce sounds. Sounds produced with the involvement of the hard palate are called palatal sounds.

The alveolar ridge is the wavy part that lies just behind the teeth ridge opposite to the front of the tongue. It acts as a passive articulator against the tongue to produce sounds. Sounds produced with the involvement of the Alveolar ridge are called Alveolar sounds. Some sounds are created with the involvement of the posterior region of the Alveolar ridge. These sounds are called post alveolar sounds. Sometimes sounds are created with the involvement of the hindmost part of the alveolar ridge and the foremost part of the hard palate. Such sounds are called palato alveolar sounds.

6.7 Air stream mechanisms involved in speech production

The flow of air or the airstream is manipulated in a number of ways during production of speech. This is done with the movement of the active articulators in the oral cavity or the larynx. In this process the air stream plays a major role in the production of speech sound. Air stream works on the concept of air pressure. If the air pressure inside the mouth is greater than the pressure in the atmosphere, air will escape outward to create a balance. If the air pressure inside the mouth is lower than the pressure outside because of expansion of the oral or pharyngeal cavity, the air will move inward into the mouth to create balance. On the basis

of the nature of the obstruction and manner of release, the following classification has been made:

Plosive: In this process there is full closure of the passage followed by sudden release of air. The air is compressed and when the articulators are suddenly removed the air in the mouth escapes with an explosive sound.

Affricate: In this process there is full closure of the passage followed by slow release of air.

Fricative: In this process the closure is not complete. The articulators come together to create a narrow passage. Air is compressed to pass through this narrow stricture so that air escapes with audible friction.

Nasal: The soft palate is lowered so that the oral cavity is closed. Air passes through the nasal passage creating nasal sounds. If the soft palate is partially lowered air passes simultaneously through the oral and nasal passages creating the 'nasalized' version of sounds.

Lateral: The obstruction in the mouth is such that the air is free to pass on both sides of the obstruction.

Glide: The position of the articulators undergoes change during the articulation process. It begins with the articulators taking one position and then smoothly moving to another position.

6.8 Summary

Speech mechanism is a complex process unique to humans. It involves the brain, the neural network, the respiratory organs, the larynx, the oral cavity, the nasal cavity and the organs in the mouth. Through speech production humans engage in verbal communication. Since earliest times efforts have been made to comprehend the mechanism of speech. In 1791 Wolfgang von Kempelen made the first speech synthesizer. In the first few decades of the twentieth century scientific inventions such as x-ray, spectrograph, and voice recorders provided new tools for the study of speech mechanism. In the later part of the twentieth century electronic innovations were followed by the digital revolution in technology. These developments have made new revelations and have given new direction to the knowledge of human speech mechanism. In the digital world an understanding of speech mechanism has led to new applications in speech synthesis. Speech mechanism studies in present times are divided into areas of super specialization which focus intensively on any specialized attribute of speech mechanism.

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