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## **Module 39: Speech and Language Science**

Being a speech and language therapist means you are an expert in all things related to speech and language, including the very scientific branches of the profession. This unit will discuss the topic of speech science in an easy to understand approach, introducing novice speech and language enthusiasts and future practitioners to the very important mechanisms of speech. From the internal workings of the brain, to the facial muscles responsible for movement, to the inner workers of the mouth, throat, ears, and respiratory gateways, you will explore how the human body is made up of all the necessary components for communication. We will introduce “must-know” terminology for aspiring speech and language therapists that will be used throughout our continued modules while exploring the anatomical and physiological components used to speak, listen, and comprehend in the world of communication.

What you’ll learn in this module:

39.1 What is speech science?

39.2 Anatomy and physiology of the face

39.3 Neuroanatomy

39.4 Acoustics

### **39.1 What is speech science?**

For speech and language therapists, the study of speech science aims to provide a basic understanding of the acoustics of speech production and speech perception, including the physics of sound, spectrographic analysis, the acoustic properties of voice, resonance of the vocal tract, and the acoustic and articulatory properties of vowels and consonants. To individuals just beginning a course of study in speech therapy and the sciences that relate, this wealth of information can seem like a daunting amount of information to grasp. However, in understanding the nuances in speech, voice, resonance, articulation, and acoustics, professionals in the field have the scientific background knowledge necessary to treat patients in a medical setting.

While speech pathologists working in a school might not often be paying attention to how sound waves affect the speech of their students, they still must understand the various ways that the human body has



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the ability to produce and respond to sound. From the interconnectedness of brain waves, nerve endings, and motor abilities, speech is able to become a physical sound that is produced with the help of the vocal cords responding to the various components of one's body.



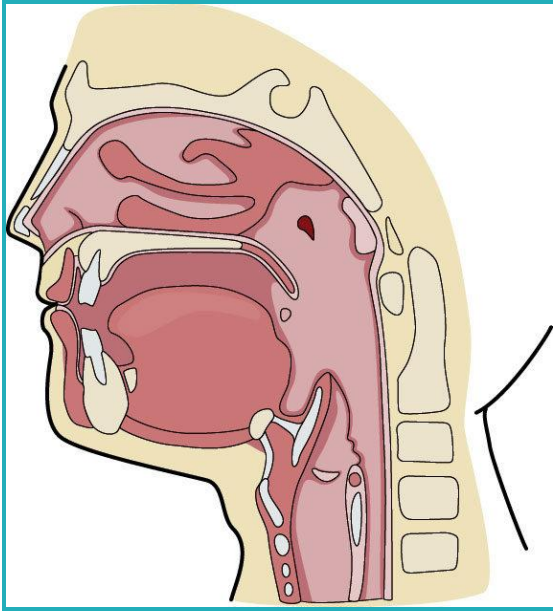
In relation to the topic of speech science, practitioners working in the profession of speech and language therapy must demonstrate:

- knowledge of biological sciences, physical sciences, mathematics, and social and behavioral sciences
- knowledge of basic human communication processes, including their biological, neurological, acoustic, psychological, developmental, linguistic and cultural bases
- knowledge of the nature of speech, language, hearing and communications disorders and differences including their etiologies, characteristics, anatomical/physiology



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## **39.2 Anatomy and physiology of the face**

Speech and language therapists are one of only a handful of professionals in the medical field who both diagnose and treat disorders associated with speech and swallowing. Keeping the company of dentists, primary physicians, and orthodontists, speech and language therapists are expected to be well-versed in the anatomical structures that affect and make up the face, neck, throat, and mouth.

Where anatomy deals with the physical structures of the human body themselves, physiology deals with the functioning of those structures.

### **39.2.1 Structures of the mouth, nose, and throat**

The main function of the **mouth, or oral cavity**, is both to eat and to speak. In addition to being called the “oral cavity” the mouth is often scientifically referred to in the speech and language and medical fields as the “**buccal cavity.**”

#### **The oral cavity**

The oral cavity is **made up** of structures within or around the mouth such as **the lips, the inner lining of the lips and cheeks, the teeth and gums, the vestibule, the hard and soft palates, and the salivary glands.**



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- lips – the mobile muscular structures that form the opening of the mouth.
- vestibule – the space between the lips and cheeks and the cheeks and gums made of soft tissue.
- gums – the dense tissue that hugs the teeth and protects the roots.
- hard palate – the bony roof of the mouth.
- soft palate – the membrane fold that hangs between the mouth and back of the throat.
- tongue – a fibrous muscle that allows us to speak, taste, and swallow. The structure of the tongue itself is divided into various portions of the tip, the blade, the front, the center, the back, and the throat or pharyngeal section.
- minor salivary glands – the clear enzymes, known as saliva, that help to break down food and keep the mouth moist.

### Teeth

In humans, like in any animal, teeth are the organs made and used for chewing or “mastication.” Our teeth will grind, tear, and cut down food within the mouth, allowing it to be mixed in with saliva and transformed into a bulbous ball that can be ingested down the swallowing structures, **through the esophagus**, and into the stomach for digestion.



While we often consider teeth to be important for this primary function of eating, teeth are also very important to understanding speech and speech disorders. For instance, the placement of the teeth can



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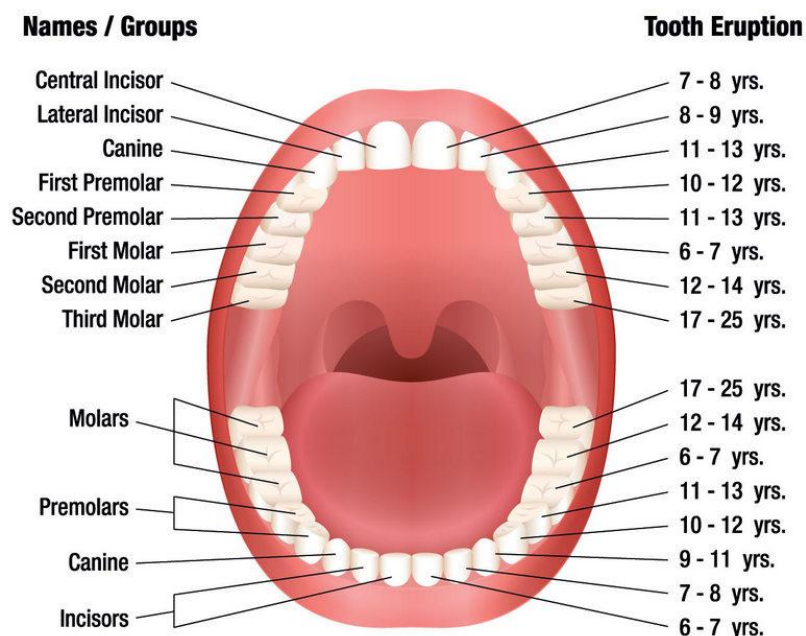
contribute toward speech impediments and mouth discomforts that affect speech. Our teeth work alongside the tongue, lips, and soft and hard palates to produce speech sounds that communicate.

A simple practice of producing speech sounds will indicate the importance of teeth and their placement. Try articulating the isolated sounds of the letters “f” and “v” and pay attention to the placement of the teeth in relation to the lips and entire oral structure. Next try “s” and “z” followed by “i” and “j.” Thanks to our teeth we are able to produce the small intricate differences among each of these speech sounds in order to create eventual words.

If the teeth are severely crooked, missing, or have any number of defects, speech pronunciation and articulation can be affected. Stuttering, lisps, and teeth whistling are just a few disorders that can result from crooked teeth, misaligned teeth, missing teeth or severe over or under bites. In addition to seeking help from orthodontists to correct teeth problems, speech and language therapists are consulted in order to provide therapy approaches to retraining an individual how to speak. Activities and exercises utilizing the facial and oral muscles can be learned in order to work around the challenge associated with difficult communication caused by issues with dental structures.

For speech and language therapists, understanding the human mouth, including the roles of the types of teeth, are essential to treating disorders of speech pronunciation and communication.

## Permanent Teeth Chart





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### The types of teeth in the human mouth are:

- incisors – the 8 teeth (4 on top, 4 on bottom) in the front and center of the mouth whose primary usage is for breaking down food.
- canines – the 4 teeth found on each side of the incisors on the top and bottom of each side of the mouth. Canines are the sharpest teeth in our mouths and are responsible for tearing and ripping apart food.
- Premolars and molars – used for grinding food, these appear on the sides of the mouth on the upper and lower teeth.
- wisdom teeth – the last teeth to develop along the inner sides of the jaw closest to the cheeks. Not all people develop wisdom teeth or “third-molars” as they are often called. Most people who do acquire wisdom teeth will be advised to have them removed, because their presence tends to push the teeth inward, crowding the mouth and resulting in pain, crooked appearance, and possible speech and communication difficulties.

### The nasal cavity

The human nose is more than just an organ used to experience scents; in fact, its primary function is to warn and protect the body against dangers. The nasal structures filter the airway and rid the body of infection and other particles that could threaten the immune system. The two nasal cavities, or nostrils, condition the air that is projected into the respiratory tract, made of the larynx and pharynx and trachea, bronchi, and lungs.

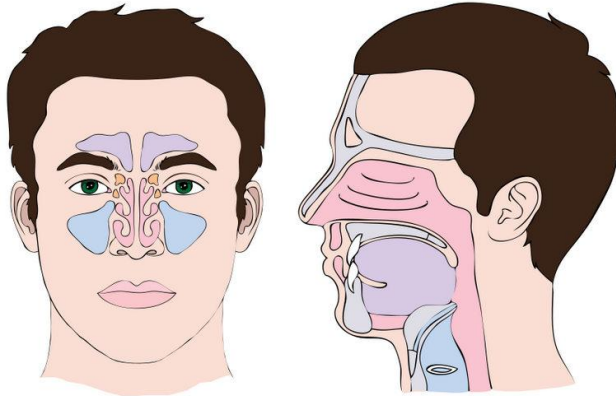
The nasal structure is one of the speech producing structures of the body. Individuals who have ever suffered a cold or sickness that affected their nasal passageway can consider how this disruption affected their speech at that time. Some people who have severe nasal issues like allergies, infections, or disorders or disease associated with the nasal passage, as well as sinus pressure and other nasal issues, will often experience resonance and articulation and speech sound difficulties.

Pharynx and larynx



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The pharynx is a fibromuscular tube that extends from the base of the human skull and becomes the esophagus, connecting the throat to the stomach and where food passes from the mouth to the stomach for digestion. The pharynx is made up primarily of three muscular structures known as “constrictors.” These constricting muscles perform the ability to take chewed food that has been transformed by the teeth into a bolus and ingest and transfer it into the esophagus.

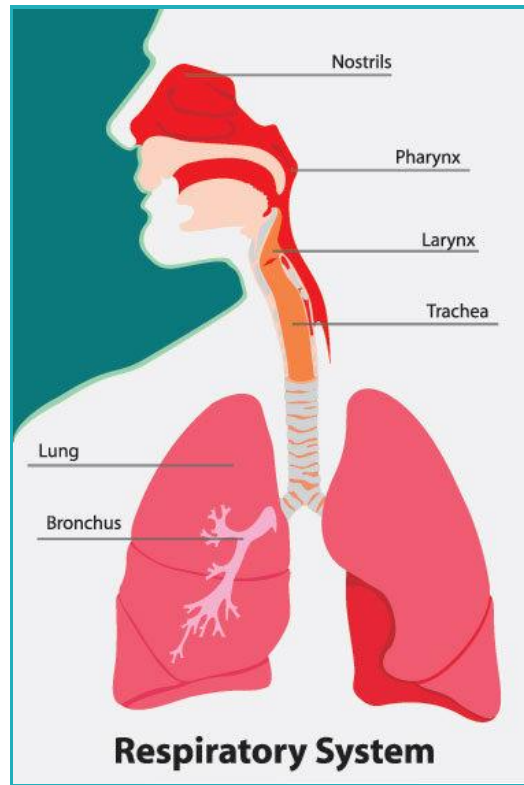
The larynx is made up of a combination of cartilage, ligaments, muscles, and mucous membrane which guard the respiratory passages (trachea, bronchi, lungs). The larynx is the home to the vocal cords, which affects speech production.

Individuals who seek the help of speech pathologists for swallowing disorders will undergo exercises, treatment plans, and potential surgery by a board certified surgeon to structures that affect the pharynx and/or larynx. During therapy, speech and language therapists will often perform vocal exercises, feeding, chewing, and swallowing practice, and other techniques to help treat disorders associated with the inner workings of the throat.



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### The vocal folds and respiration

We will discuss the dynamics of respiration and voice in our next module of study within this course, however, some key terminology relevant to the physiology of speech production is useful in the study of speech science for use by speech and language therapists.

Speech relies on air to be produced by the lungs within the respiratory, or breathing, system of the body. The lungs themselves are two cone-shaped bags stored within the chest cavity. The chest cavity is enclosed and protected by the rib cage and diaphragm. When a person inhales (known as inhalation) the diaphragm contracts and upon an exhale (exhalation) the diaphragm relaxes. The process of inhalation and exhalation creates pressure and air flow within the body that affects speech production.

During speech we reach a state titled “phonic respiration.” During phonic respiration, the quality of sound and breath depends heavily on the airflow within the respiration process. Speech and language therapists are well-versed in the entire respiration cycle as a means to assess, evaluate, and treat patients with speech disorders.

## 39.2.2 Facial muscles





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There are 43 muscles of the face that are controlled by the seventh cranial nerve, also known as the facial nerve. This nerve exits the cerebral cortex, or outer layer of the brain, emerging from the skull right in front of the ears. The facial muscles controlled by this part of the brain and nerve system is categorized into five branches: temporal, zygomatic, buccal, mandibular, and cervical.

As a speech and language therapist, professionals can aid clients into performing a range of exercises and motions to strengthen the facial muscles that affect speech articulation.

However, depending on nerve endings and signals that have experienced difficulty in movement, speech professionals can utilize data from patient evaluations to diagnose various speech disorders.



- temporal muscles – the thin, fan-shaped muscles at the side of the skull in front of the ears is the “temporalis” muscle of mastication. This muscle works with the masseter muscle to elevate and retract the mandible, or lower jaw. Head, face, eyebrow, teeth, and jaw pain can all result from this muscle area. TMJ syndrome is often the result of irritation to this region.
- zygomatic muscles– starting at the cheekbone and extending to the lower mouth, the zygomatic muscle is responsible for the control of facial expression in moving the mouth both up and outward. This is the major muscle and groups of muscles responsible for producing a smile or a frown. Many conditions affect the control of the zygomatic major muscle, for instance, Bell’s Palsy, neuromuscular diseases, lacerations, contusions, myositis (inflammation of muscle tissue), and myopathy (disease of muscle tissue) are all in effect with this muscle region.
- buccal muscles –the group of muscles affecting the lips and the cheeks on each side of the face. This region of muscles affects the ability to fill one’s mouth with air in their cheeks, purse the lips to whistle or blow a kiss, and to move chewed food within the oral cavity due to movement of the cheeks.



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- mandibular muscles– muscles of mastication (chewing) and movement of the jaw. In connection with the temporal muscle, all functions of the jaw are affected in coordination of these muscle motions.
- cervical muscles– these muscles of the head and neck aid in pulling the skull and jaw toward the shoulders for motor movements. These, along with other muscle groups, manage to affect the facial movements associated with speech.

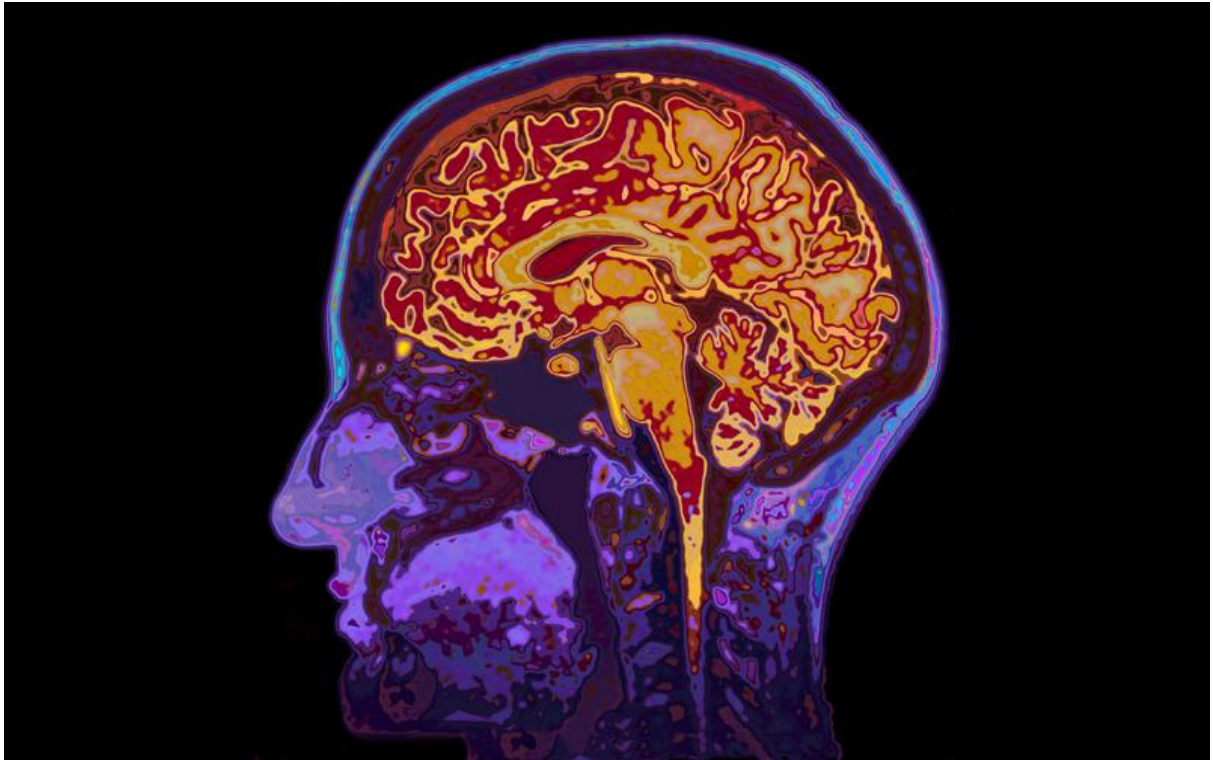




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### 39.3 Neuroanatomy



Students, assistants, and working professionals in the speech and language therapy sciences should have a broad understanding of the various centers of the brain and how they each might relate to speech and communication.

While all primary physicians and medical doctors must know about every muscle, bone, nerve, and tissue structure in the human body, speech therapists are more specifically focused on that of the brain, head, neck, and facial structures.

**The four main structures of the human brain are:**

- the cerebrum
- the cerebellum
- the limbic system
- the brain stem

#### 39.3.1 Parts of the brain



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### The cerebrum

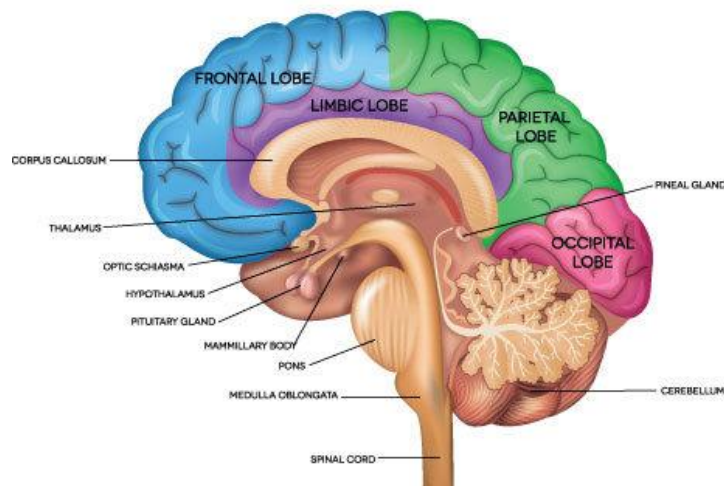
The cerebral cortex is the largest part of the human brain and is associated with thought and action. The cerebrum is home to the four lobes of the brain, each specifically centered toward various functioning of the mind and body.

- frontal lobe – associated with reasoning, planning, parts of speech, movement, emotions, and problem solving.
- parietal lobe – associated with movement, orientation, recognition, and perception of stimuli.
- occipital lobe – associated with visual processing.
- temporal lobe – associated with perception and recognition of auditory stimulus, memory, and speech.

Each of the cerebral lobes are in some way connected to communication and affect the various disorder types that SLP interact with.

### The cerebellum

#### ANATOMY OF THE BRAIN



Referred to as the “little brain” and is split into a right and left hemisphere, just like its larger counterpart, the cerebrum. Movement, balance, and coordination are regulated within the cerebellum.

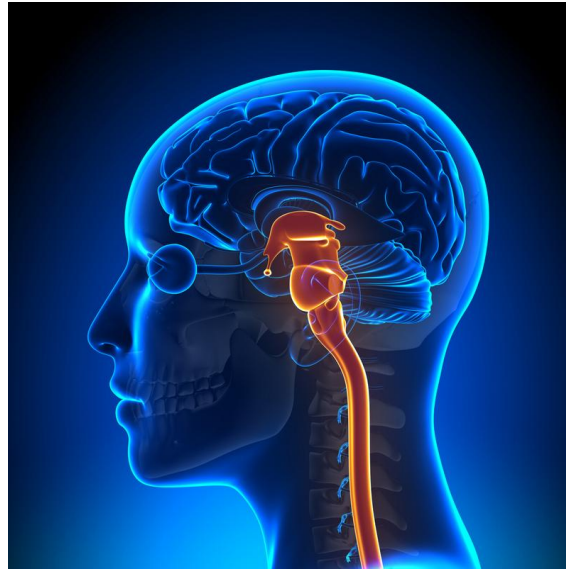
### The limbic system



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The “emotional brain” or limbic system, is found within the cerebrum. It is composed of four important structures: the thalamus, hypothalamus, amygdala, hippocampus.



- thalamus – a structure of sensory and motor functions.
- hypothalamus – involved in functions like thirst, hunger, emotion, and control of the automatic nervous system.
- amygdala – deals with memory, emotion, and fear.
- hippocampus – an important structure for learning, memory, and spatial interpretation and understanding.

### **The brain stem**

The highly important structure responsible for keeping humans alive and well, the brain stem is responsible for the vital life functions of breathing, heartbeat, and blood pressure. The brain stem is made up of three parts: the midbrain, the pons, and the medulla.

- the midbrain – involved in eye movement, vision, hearing, and body movement.
- the pons – motor control and sensory analysis rely on the pons, as does the processes of consciousness and sleep.
- the medulla – directly responsible for the vital life functions of the heart, breath, and blood



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### 39.3.2 Anatomy of speech and language

There are some specific areas of the brain that play a critical role in speech and language. When these areas have deficits, speech and language disorders are present.

- Broca's Area – located in the left hemisphere of the cerebrum, Broca's Area is associated with speech production and articulation. Someone's ability to articulate ideas through both oral and written expression is attributed to this area of the brain.
- Wernicke's Area – located in the temporal lobe, Wernicke's Area is the result of comprehension across the board, whether through reading, writing, or general understanding as well as speech and language processing.
- Angular Gyrus – it is thanks to this section of the brain that people are able to process various and many types of language based information, be it auditory, visual, or sensory. This area of our brains allows us all to have word and image association as well as sensations related to these aspects of life and a generation of ideas.

### 39.4 Acoustics



Acoustics is the science that deals with how sound is transmitted and received, thanks to sound waves, speech sounds, speech production, frequency and analysis. In the world of speech, language, and hearing therapy, it is the role of the audiologist to test the hearing and sound wave perception of



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individuals with speech and hearing difficulties. However, in the pursuit of the study of speech science, even speech and language therapists must have a basic and general grasp of the various components of sound.

In understanding components of speech and hearing, speech and language therapists and audiologists alike **learn about the following through their graduate studies:**

- acoustic cues used to determine the direction of sound sources
- acoustic and mechanical mechanisms involved in production of speech sounds
- acoustic and mechanical mechanisms used to transduce and analyze sounds in the ear
- the anatomy and physiology of the inner, mid, and outer ear structures

**Further acoustic studies in speech, language, and hearing deal with:**

- evaluating the source of sounds from the vocal cords and vocal folds and the eventual production of sound waves
- voiced and unvoiced pronunciation of vowels, consonants, and fricatives in language. In other words, the amount of air and aspiration and exhalation that is produced when different speech sounds are produced. The study of this in individuals with speech impediments can identify the specific areas where therapy must occur.
- frequency levels from whispers to shouts and how sound is articulated from the larynx
- registers in pitch production, such as strained voice or reverberation of the vocal folds



The continued connectivity among speech, language, and hearing is a core area of focus in speech science studies. In addition to anatomical and physiological structural sources functioning properly, individuals searching for a place in the speech and language professional community will



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continuously explore the areas of the human body that affect communication. Throughout future modules of this course of study, we will look more in depth to the disorders of communication that are affected by defects in the brain, hearing, and facial and breathing structures of the human form.

**EXAM LINK**