The speech Mechanism:

Types of Air Mechanism:

In speech production, two types of air stream are usually recognized:

1)Egressive air-stream(outgoing)or (pulmonic) in which the air stream is pushed out (when your lungs push air out) (or it can be iitiated in other parts of human body). All English sounds are normally produced in this way.

2)Ingressive Air-stream (ingoing) in which the air stream is sucked in. (atmosheric air is swallowed in).

Ladefoged(1993) mentions three types of air-stream mechanisms:

1-Pulmonic (air coming out of the lungs).

2-Glottic, when either of the following two actions occur:

a-upward movement of the closed glottis moves air out of the mouth.

b-downward movement of the closed glottis which causes air to be sucked into the mouth.

3-Velaric(movement of the body of air in the mouth).

Brosnahan and Malmberg(1970), for their part, list the following types as air mechanisms:

1)Pulmonic Mechanism: egressive air-stream through mouth. This is, they argue, the commonest of all types of air-stream and is used more frequently than any other in all known languages. With conversion of te kinetic energy of the air stream to acoustic energy only by the vibration of the vocal cords, and with general resonance in the supraglottal tract, we have one of the commonest and most widespread of types of speech sound, the voiced vocoids.

2)PulmonicMechanism::Ingressive air-stream throygh mouth: an ingressive air stream, produced by pulmonic mechanism, can be used, in theory, as a basis for the production of all types of sound, both of laryngeal and supralaryngeal conversion. In practice, however, such use of an ingressive air- stream to produce simple speech sounds appears to occur only as a personal or occasional varient of the egressive air stream.

3)Pulmonic Mechanism:Egressive air-stream through nose: if the velum is lowered, free access to the nasal cavities and the passage to the outer air through the nose is permitted to an egressive air stream from th lungs. If such access is added to a passage for the air through the mouth, Brosnahan and Malmberg (1970) consider it concomitant minoer articulation and term the resulting sounds nasalized, but if the passage through the nose is the only exit, because of blockage or closure in the buccal cavity, the resulting sounds are nasal contoids because the air stream has no free passage through the mouth- or simply nasals.

4)Pulmonic Mechanism:Ingressive air -stream through nose:this can be initiated by the pulmonic mechanism and may be used as a basis for the production of all types of nasal sounds, both of the laryngeal and supralaryngeal conversion. In practice, however, the use of such an ingessive air stram to produce normally occurig speech sounds is very rare, if, indeed, it occurs at all, and ingressive nasals seem to be confined to personal or occasional varients of the egressive nasals.

5)Pharyngeal Mechanism : Egressive air-stream through mouth: the methods of supralaryngeal conversion of the kinetic energy of pharyngeal egressive air in the oral tract are the interposition of a vibratile organ, the constriction of the air passage and the blockage and release of the air-stream having thereby ejective voiceless trills.

6)Pharyngeal Mechanism:Ingressive air-stream through mouth:In theory, this can be used as a basis for the production of all types of sounds. In practice, however, such use of the pharyngeal ingressive air strem to produce simple sounds is very rare indeed.

7)Pharyngeal Mechanism:Egressive air –stream through nose: here, the supraglottal nasal tract can be opened to the egressive air stream from the pharyngeal mechanism by lowering of the velum, and again a major factor in the determination of the transmittion characteristics of this tract is the position of the closure formed by the organs in the buccal cavity. Those sounds produced in the nasal tract result from conversion of kinetic energy at points above the larynx, and hence only voiceless types occur.

8)Pharyngeal Mechanism:Ingressive air-stream through nose: In theory, ingressive air –stream initiated by the pharyngeal mecanism can be used as a basis for all the sounds discussed in the above section, but i practice the use of such an air stream appears very rare, and injective nasals are unknown.

9)Oral Mechanism: Egressive air-stream through mouth: verbatile organs interposable in an oral egressive air stream are the tongue-tip and the lips. And control of the body of the tongue in its forward movement during the initiation of the air-stream, however, seems to inhabit tongue tip vibration, so that oral egressive apico- and lamino- alveolar and apico- and lamino dental trills hardly exist.

10)Oral Mechanism:Ingressive air-stream through mouth:It is the ingressive air-stream from the oral mechanism which ismore commonly used in languages than the egressive. All oral ingressive sounds actually occuring seem to be based on air-stream initiated by the release of ararefraction of the air i theforward part of the oral cavity. The common abrupt onset of sounds produced with such release is doubtless responsible for the generic term (clicks) for oral ingressive sounds.

11)Oral Mechanism:reverse egressive andingressive sounds:it ispossible with the oral mechanism to generate a potential air-stream if theforward end ofthe oral tract is closed. In this case, forward movement of the dorso-velar closure will compress the air in the forward part of the oral tract, and release of this closure will result in an egressive air stream flowing to the rear into the pharyngeal and, if the velum is open, nasal cavities. Similarly, backward movement of the dorso-velar closure will rarefy the air in the oral tract, and release of this closure will result in an ingressive air-stream flowing forward from the pharyngeal and, if the velum is open, nasal cavities.

12)Combinations of Mechansims: certain possibilities of simultaneous combination of air-stream mechanism exist. By converting kinetic energy in each of these air- streams into acoustic energy a number of combinations of sounds can be produced. Thus, for example, an air-stream may be initiated by the pulmonic mechanism. On the former air stream, an oral egressive bilabial trill may be articulated, and on the latter, a pulmonic egressive nasal voiced contoid, with dorso-velar closure.

In speech production, the source of energy for our vocal activity is provided by (pulmonic) lung air. Most sounds in natural languages entail (involve) lung air, but there exist sounds that are produced without the air of the lungs. They require the activity of a different initiator (the source that makes air to move).

Following Pike(1943), we can distinguish three major airstream mechanism. They are:1)Lung air-stream mechanism,2)Glottalic, 3)Velaric.

1)Lung air-stream mechanism(Pulmonic air-stream mechanism): the initiator is the two lungs, and the air set in motion (caused to move) is the air kept in them. In principle, air flowing either into or out of the lungs during the respiratory cycles may be used in generating speech sounds, and the nature of the sound produced will depend on what is happening in the vocal tract above the trachea, namely on the action of the larynx and on how the rest of the tract is constructed or modified in shape.

2)Glottalic air-stream mechanism(pharyngeal air-stram mechanism): the initiator is the larynx which is firmly closed. The air set in motion is the air in the pharynx and aove the pharynx,viz, the air above the glottis. Clark and Yallop(1995) state that the glottis is closed, and the larynx is moved up and down the pharynx, under the control of the exrtinsic (outside/outer) laryngeal muscles to initiate air flow.

Since the glottis is closed, subglootal (between the glottis) air is not involved and the larynx ,thus, acts rather like a plungeror piston in cylindar. I the larynx moves upwards in this way, it can generate an egressive air-stream; and moving downwards an ingressive glottalic air-stream is generated.

Ejectives are sounds normally produced by utilizing an egressive glottalic air-stream mechanism /pʾ,tʾ,kʾ/ (all voiceless); whereas implosives are produced by utilizing an ingressive glottalic air-stream mechanism /b̂̂̂͑҄҄ᵔ , dᵔ, gᵔ / (all voiced), e.g. in Igbo.

3)Velaric airstream mechanism(oral airstream mechanism): the initiator is the back part of the tongue, and the air it sets in motion is the air kept in the mouth cavity.Clark and Yallop(1995) comment that in velaric air-stream"the oral air flow is generated within mouth cavity, by raising the back of the tongue to make contact with the soft palate. Air in front of the tongue closure may then be sealed off by closing the lips or by pressing the sides and tip of the tongue against the roof of the mouth behind the teeth".

In his Fundamental Problems in Phonetics, Catford (1977) expounds that from the organiaerodynamic point of view the production of speech sounds involves (with trivial exceptions) two basic functional components:1)initiation and articulation. Iniiation is a bellows-like or piston-like movement of an organ (an initiator) that changes the volume of the vocal tract adjacent to it, thus compressing or dilating the air contained there and consequently (aninitiating an actual or potential flow of air. Articulation is a movement or posture of an organ (an articulator) that interrupts or modifies the air-flow in such a way asto give rise to a specific type of sound.

These two basic and essential functional components of speech production can easily be observed if one utters a prolonged "f- sound:[ffffff]. For this sound, the lungs operate as initiator, the act of initiation being there slow but continuous deflation :the lower lip and the upper teeth act as articulators, their conjunction creating an obstacle to air-flow, such that the flow past them becomes turbulent and generates a hiss-sound of the specific quality we

A third functional component of speech production is added by Catford(1977). This is phonation, i.e. the relevant activity in the larynx which is neither initiatory nor articulatory in function. Thus, the vocal cord vibration that is characteristic of [v], as in veer, and that distinguishes vee from fear is a variety of phonation. Phonatory activities are described chiefly in terms of postures and movements of the vocal cords. These may be widely separated , as for voiceless phonation (such as[f], [s], [p], or they may be brought together to form a narrow chink without actually vibrating, as for whisper- it is clear that phonation can occur only when we have a column of air passing through the larynx as is the case with pulmonic sounds; itis absolutely excluded with velaric sounds, which make use of air trapped in the mouth, and are thus phonationless.

Cummings et al. ( ) state that normal phonation requires that five conditions be satisfied :1)there should be adequate breath support to provide power, 2)the vibratory edges of the vocal folds should be aligned and se parated by an appropriately small gap, 3)the physical propertiesof the vocal fold should be conductive to vibration, and 4) its three-dimensional contour should be favourable and finally 5) a normal voice requires volitional control of glottic length, tension and shape.

 The process of phonation begins with inhalation of air, and then glottic closure, to position of the vocal folds near the midline. A sipmlified explanation of phonation is that exhalation causes subglottic pressure to increase until the vocal folds are displaced laterally, producing a sudden to the return of the vocal folds to the midline include this pressure decrease, elastic forces in the vocal fold. When the vocal folds return to the midline, pressure in the trachea buils again, and the cycle is repeated. Vocal fold structure determines whether the resulting vibration is periodic or chaotic.

Actual phonation

Is more complex than the previous model because the vocal fold is not a homogenousstructure and also because it vibrates in three dimentions. Moreover, the pattern of vibratin varies with pitch and vocal register. Catford (1988) expounds that there are three basic components (activities) usually exhibited (displaced, shown) when producing any speech sound:

1-An activity that initiates a flow of air. This activity is consequentlly called"initiation" (or air-stream mechanism) and the organs used for this purpose are called "initiators" (so the two lungs, the two vocal cords, the two lips can be called initiators) (for /t/ and/s/ the lungs can be initiators).

2-An activity that articulates the air-stream. This activity generates a specific type of sound; the process itself is called "articulation" and the organs used in articulations are termed "articulators".

3- An activity that modulates the quality of speech sounds in certain ways. This avtivity affects the function of the vocal folds,i.e.the set of the glottis and it is usually called "phonation". When the two vocal folds vibrate, we get a voiced sound and when they do not, the resulting sound is voiceless. Therefore "voice" and "voicelessness" are two patterns of phonation.

Coarticulation:

Peter Ladefoged (1993) defines coarticulation as "the overlapping of adjacent articulation" . He adds that English consonants often vary their place of articulation so that they become more like the next sound. /t,d/ are usually alveolar stops, but are pronounced with tongue contact on the teeth, so that they become [ ṱ ,ḓ ] when they occur before dental fricatives as in "eighth" [eIṱϴ] and "width" [wIḓϴ]. Another noticeable change in the place of articulation occurs in the pronunciation of /k,g/ before a front vowel as in the pronunciation of /k,g/ before a front vowel as in 'key, geese' / kI,gIz/as compared with a back vowel as in "gauze".

Catford (1977) , for his part, defines coarticulatin as " a simultaneous articulation in more than one articulatory area (oral or nasal) or in more than one articulatory zone (labial or velar).

Different classifications have been offered regarding types of coarticulation: 1)anticipatory coarticulation,i.e. the phenomenon where an articulator that is not necessarily involved in a given sound will nearly always start moving toward its position n the next sound in which it is the primary articulator, the [p] in "apt", for example,is unexploded because the closure for the [t] occurs beforethe lips come apart, 2)perseverative coarticulation,i.e. the case in which the actions involved in making one sound continue into the next, for example, when "it is" [It Is] is elided into "it's" [Its] , the voicelessness associated with the [t] persists into the next sound.

Catford (1977) claims that it is necessary to distinguish two kinds of coarticulation: co-ordinate and secondary. In co-ordinate coarticulation, the two articulations are of the same stricture –type, or the same strictural rank. O`Connor(1973) adds that it is a prerequisite for coarticulation that the two strictures (stop+stop) (kp), fricative+fricative (sf),open+open(the nasalized vowel of bon). Concerning secondary articulation, it is of lower strictural rank than the primary articulation, as Catford (1977) observes, saying that "strictural rank" means "relative degree of openness of stricture"; thus' basically, the rank order of stricture types is stop-trill, fricative-approximant and reonant. Here, the strictures are dealing with subordinating articulations, one of which is primary and the other secondary. An obvious example, given by O`Connor, is a s-sound said with close lip-rounding :the alveolar stricture is fricative and the lip position is open, therefore the alveolar stricture is primary and the lip stricture is secondary.

Furthermore, in naming and transcribing the two types of coarticulation, co-ordinate articulations are named by location labels separated by a hyphen, where no special symbol is available, by two letters linked by a ligature: thus, labial-velar stop [pk], post-alveolar-velar fricative [fx], and so on, whereas secondary articulation are named by placing an adjective in –ized before the locational term, and are transcribed with the help of diacritic marks added to the symbol for the primary articulation: thus, labialized lamino-alveolar fricative [sw], velarized apico-alveolar stop [t] and so on. (Catford,1977).

The rank order of stricture types, previously mentioned, ae traditionally deartured for several reasons:1)all sounds with simultaneous oral stop plus nasal approximant articulation [m,n], are simply called "nasals"- not "nasalized oral stops", as they would be if we rigorously followed strictural ranking, in which the relatively open nasal part of the articulation would be secondary to the complete oral closurs, 2) combination of non-occlusive oral articulation with nasal (approximant) articulation istermed " nasalized", even when the oral articulation is of lower strictural rank than the nasa one, as in the case of a wide resonant (such as[a]) accompanied by nasal approximant articulation [ã]. We call this a "nasalized vowel" rather than an "oralized nasal approximant", 3)any pharyngeal articulation accompanying a vowel is treated as secondary; thus an open [Ɛ ] vowel accompied by a pharyngeal approximant articulation is called a "pharyngealized vowel" rather than an "oralized pharyngeal approximant". The reason for this is that vowels cover a wide range of stricture types, going from narrow approximant [i]to wide resonant [a], 4) where we have a non-lateral co-articulation with a lateral,the lateral is regarded as primary (Catford, 1977).

Catford(1988:103) defines coarticulation as "a simultaneous articulation at two different locations". It is an essential feature of some sounds, such as [w], but it also occurs "accidentially" as it were in the close transition from one consonant to another. In the English word play , a little introspection will show that the tongue-tip makescontact with the alveolar ridge for the apico-alveolar lateral approximant [l] while the lips are still closed for the bilabial stop [p].There is thus a short period of overlapping articulation- and this is a period of transitory co-articulation.

Roach (2002:14) argues that "experimental Phonetics" studies coarticulation as a way of finding out how the brain controls the production of speech". When we speak, many muscles are active at the same time and someties the brain tries to make them do things that they are not caable of. For example, in the word "Mum" the vowel phoneme is one that is normally pronounced with the soft palate raised to prevent the escape of air through the nose, while the two /m/ phonemes must have the soft palate lowered. The soft palate when lowered gives a nasalized quality to the vowel. The nasalizatio is a coarticulation effect caused by the nasal consonat environent. Another example is the lip-rounding of a consonant in the environment of rounded vowels : in the phrase "you too", the /t/ occurs betwee two rounded vowels, and there is not enough time in normal speech for the lips to ove from rounded to unrounded and back again in a few hundredths of a second; consequently the /t/ is pronounced with lip-rounding.

Coarticulation is a phenomenon closely related to assimilation. The major difference is that assimilation is used as a name for the process whereby one sound becomes like another neighbouring sound, while coarticulation, though it refers to a similar process is concerned with articulatory explanations for why the assimilation occurs, and considers cases where the changes may occur over a number of segments.

Abercrombie (1967) states that the following four points belong to secondary articulation:

1)Labialization: consists of rounding the lips during the production of the segment, just as for a rounded vowel. Labialization: is a secondary articulation involving lip-rounding [ʷ] /t ʷ Ͻ : k/.

2-Palatalization: palatalized segments are important in many languages. English speakers pronounce the [l] at the beginning of the word little with some palatalization. Palatalization: [ʲ ] is a secondary articulation involving a movement of the tongue towards the hard palate. For instance, /t/ is alveolar and can be palatalized if during it’s articulation, the front part of the tongue moves towards the hard palate, as in tune /t ʲ j u: n/.

3-Pharyngalization: Arabic contains a number of pharyngalized segments in addition to the voiced labial nasal mentioned above; the [l] in the middle of the word (Allah) is an example of one of these.

4-Nasalization: it isclassed among secondary articulation though it is of a rather different nature. The position of the velum form part of the definitions of stop and of nasal. is a secondary articulation involving the addition of nasality, [ ̃] “morning” /m Ͻ: ̃ n I ŋ/.

Other phoneticians agree that the following two points are also considered to belong to the process of secondary articulation.

5-Glottalisation: is a secondary articulation involving a simultaneous glottal constriction, especially a glottal stop, which is used in English to reinforce a voiceless plosive at the end of a word as in “what” /w ɒ t ɂ/.

6-Velarization: is a secondary articulation involving a movement of the back part of the tongue towards the velum[ɫ ] ,for example syllable-final /l/ as in “cooɫ “ is given a velar resonance as compared to syllable-initial /l/ as in'leap'.

Acoustic Phonetics:

It is the branch of Phonetics which studies the physical properties of speech sounds as transmitted between mouth and ear. Its importance to the phonetician is that acoustic analysis can provide a clear, objective datum for the investigation of speech- the physical "facts" of utterances. Sometimes, acoustic and auditory analyses of a sound conflict- for example, in intonation studies, one may hear a speech melody as rising, whereas the acoustic facts show the fundamental frequency of the sound to be steady. In such cases, it is for phoneticians to decide which evidence they will pay more attention to. ( Crystal, 1997).

The Nature of Sound:

Sound Wave:

Types os Sound Wave:

Despite the fact that air is considered the most common medium for the transmission of vibrations or oscillations (sound waves), yet sound waves may be transmitted through other media,i.e. through any medium which has mass and density.

Sound waves in air usually eminate (start) from a vibrating body, i.e. the source. The prongs of a tunning fork move outward, and inward continuously when they are being struck, i.e. when they are activated. When the prongs move outward, they compress the neighbouring molecules (particles) of air , and this compression is transmitted outward through further neighbouring molecules and so on. But when the prongs move inward the particles near them move outward over the same path as the preceding compression (until the energy dies, an inward movement causes transmission and rarefaction (an outward movement) until they vanish one after the other). A sound thus, consists of a series of alternate compressions and rarefaction in the air spreading sperically from the source. It is termed "a longitudinal progressive wave", for the movement of the air particles is a long the line of propagation.

A progressive wave is a wave in which the compressions and rarefactions travel outwards.

 There are two types of sound waves:1) sine waves and 2) complex waves. In a generated sound wave , we can measure the variations of pressure in the air with the lapse (cycle) of time as the compressions and rarefactions of the sound wave pass any point and moves to a rest point). The result is , then, a smooth curve with alternate peaks and hollows. For Brosnahan and Malmberg (1970) " a sound wave in which the pressure vibration (upward and downward movement) with time is represented by a sine curve called a "sine wave" or a "sinusoid".

It is evident from the above diagrams that as the sound wave passes, the pressure of the air rises from normal (rest point) A- to a peak or maximum (within the compression phase) at point B- the centre of the compression- then falls through normal c, to low point or minimum, D- the centre of the rarefaction- and rises again to normal A1 . From this point , the process begins again, exactly repeating itself. The sequence of events (from A to A1) represented by the line passing through ABCDA1 is known as a cycle , and the number of cycles in a given unit of time, usually a second, is the frequency of the wave.

The maximum extent of the change of pressure from the normal (starts at A) in any cycle is the pressure amplitude or simply amplitude (loudness in acouistic terms) of the wave. This is represented by the distances (B1-b) (compression), (D1-d)(rarefraction).

A Complex wave is any wave in which the compressions and rarefractions from two or more waves will mingle, and the pressure from moment to moment at the measuring point will be the resultant of the two or more pressures.

A Complex wave (non-sinusoidal)

A Sine Wave

A spectrogram (or sonogram) is a visual representation of an acoustic signal. In a spectrogram, we can see the following features:

1)Voice: is denoted as regular patterns of formants.

2)Formant: is a horizontal dark line, usually with vowels (whether pure or diphthong) (one vowel= one nucleus) and consonaants. We are interested with the second and third formants. Formant 1 shows the first resonating chamber, formant shows the second resonating chamber and so on. It shows tongue hight and movement. The closer the formants come togetherad the lower they go to the base line, this is a good indication that you have rounded vowel. The more far the formants, this is a god indication that we have a front vowel. Formant three is a good indication for the picture of the lips whther spread or rounded or it helps to understand the relation between F1 and F2.

3)Each straition represents a vibration of the vocal folds.

4)Silence is shown in complete space in the spectrogram.

5)Noises mean fricatives shown in messy lines in the higher places of the spectrogram.

6)Voice is shown in regular straitations in the spectrogram.

7)The fricatives seem like messy waves in higher places in the spectrogram since they are noisey.

8)Vowel transmission: the movement of one sound to a vowel, in accordance with the context and the speaker`s voice.

It is noteworthy to mention that there are two types of spectrogram:

1-Narrowband Spectrogram: reveals individual harmonics (component frequencies) shown in a long window resolving frequency at the expense of time. It shows the time.

2- Wideband Spectrogram: a small analysis window with adjacent harmonics are smeared together, but with better time resolution, in which individual pitch periods appear as vertical lines (or striations), with formant structure. Wideband spectrograms are used to give more information about what`s going on in the vocal tract, showing the formants (darker bands) changing rapidly. It shows frequency.

Some Useful Definitions:

Pitch:is that auditory property that enables a listener to place it on a scale going from high to low without considering its acoustic properties.

Loudness:is that auditory property o a sound that enables a lstener to placeit on a scale going from soft to loud withoutconsidering its acoustic properties.

Intensity: is the amount of acoustic energy in a sound, measured in decibles (dB).

Stress:is the use of extra respiratory energy during a syllable.

Amplitude:is the amount of deviation of the oscillating molecules from thr rest position. It is the positive or negative pressure attained by a sound wave.

Frequency: is the number of complete repitions (cycles) of variations in pressure occuring in a second and measured by Hertz (HZ).

Fundamental Frequency:(F0, F zero or F nought): is the frequency with which the complex pattern of these combined variations is repeated. Changes in F0 are what we perceive as changes in pitch.

Harmonics: the sinusoidal component which is the repeated sequences of F0. The frequency of harmonic 2, being twice of that of the fundamental.

Periodic sounds: sounds whose period remains the same for cycle after cycle are known as periodic sounds.

Aperiodic sounds: a mechanism constructed to reinforce certain frequencies of a complex sound while weakening others is a filter in Acoustics.

Resonance: every vibration tends to set in motion the elastic bodies that are in the path of the sound wave. If the peculiar frequency of the body i question is the same asthat of the vibration, this body begins to vibrate also. This is the phenomenon called resonance, one of the fundamental concepts of Phonetics. A resonator then is any vibrating unit that intensifies an already existing sound.

Acoustic classification of vowels:According to results obtained by modern electro-acoustics, it is possible to classify vowels into acoustic types depending on whether the two main formants are in the middle of the spectrum (as for [a]), or at each of the two extremities, clearly separated from one another, it is possible to speak of a compact type and of a diffuse type. If the vowels [i], [e], [a] are pronounced one after the other, the two formants approach each other successively. If , on the other hand, we pronounce the series [i], [y], [u], the low formant remains invariable, while the high formant falls respectively from 2,500 to 1,800 and to 800. The vowels [i] and [y] have a clear or acute timbre, while [u] has a dark or grave timbre. The compact type [a] occupies an intermediate (neutral) position.

Acoustics of Consonants:

The noises utilized in human languge are produced by different modifications of the air-stream coming from the lungs. The air-stream is either constricted so as to produce friction, or else stopped momentarily and then suddenly released (explosion). It is known that if we disturb the air contained in a cavity by means of an air current -in our case the pulmonary air current- this cavity emits a sound. This phenomenon is utilized when we pronounce the so-called fricative consonants, whose timbre is due to the shape and volume of the passage through which the air-stream has to pass. The smaller (shorter, narrower) this passage is, the greater will be the predominance of high frequencies, and the sharper will be the souns emitted. The noise characteristic of the consonant [s] contains the highest frequencies of all (up to 8,000- 9,000 c/s). The consonant [t], [d] is contrasted with [p] [b] as [i] is with [u]. The consonant [k] is intermediate (neutral) in this contrast.

Sounds (vibrations) may vary as regards:

1-Their frequency: that is the number of cycles per unit of time (second). (the frequency of F0 determines the pitch of the tone).

2-Their amplitude:which determines in principle the intensity of the sound (provided, however, that the frequency is constant).

3-Their timbre:which is due to the number and audibility of the harmonics.