

AN OBJECTIVE WAY OF LOCATING OPTIMUM PITCH

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Voice may be defined as a laryngeal tone which can be heard or measured. The normal voice should possess certain characteristics of pitch, loudness and quality which make meaning clear, arouse the proper emotional response and ensure a pleasant tonal effect upon the hearer (Berry and Eisenson, 1956). Normal voice may be related to cultural preferences, age and sex as well as social and economic status (Van Riper and Irwin, 1959).

It is accepted that each person in accordance with his unique physical vocal equipment, has a pitch level at which the greatest power and best resonance occur under conditions of greatest physioacoustic economy. This pitch level is known as the optimum or natural pitch level (Murphy, 1964).

There are several ways of finding the optimum pitch. But none of them has been found to be satisfactory and objective. The usual procedures of finding an optimum pitch level by a resonance reinforcement in a fixed region was not supported by Thurman's study (1958). But clinically it has been found to be useful to establish an optimum pitch level (Johnson et al, 1963).

A common factor of all the present definitions of optimum pitch is that, 'Optimum pitch level is the range where the maximum resonance occurs in the vocal tract of that person' and thus gives a voice with greatest loudness and good quality.

In the present study following definitions are used :

Resonance : "When a periodic force is applied to an elastic system, the system will tend to vibrate with the frequency of the applied force. The nearer the periodic force is to the natural frequency of the elastic system, the greater will be the resulting amplitude of vibration" (Gray and Wise, 1956) when this amplitude is at its maximum so that the sound is at its loudest, resonance is said to be occurred.

Pitch: "Pitch is a subjective auditory impression of the frequency, or the number of cycles per second of the oscillating waves of rarefaction". The frequency can be measured in the laboratory by different methods. In the present study "the optimum pitch level of a person is defined as the pitch range of vocal cords at which the maximum resonance occurs in the vocal tract of that particular individual.

In the study of the optimum pitch, pitch (in terms of frequency) and resonance (increase in intensity) are the only two measurable variables.

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Now, the problem is to find at which pitch (frequency of vocal cords) the maximum resonance, (intensity of voice measured in terms of SPL) occurs in the vocal tract of a particular individual.

The present study attempts to identify this pitch range objectively. An external sound source of variable frequency and constant intensity out-put will be used to stimulate the vocal tract. The response of the vocal tract will be measured by an SPL meter at each frequency level. It is expected that the intensity changes will be observed for different frequencies depending upon the natural resonance frequencies of the vocal tract: The range of frequencies receiving the maximum resonance may be considered as the optimum pitch level.

The sounds produced by the laryngeal vibrator do not themselves contribute voice. The laryngeal tone, cord tone or voice complex generated by this mechanism consists of a fundamental tone and a rich supply of overtones . . . only as it is influenced by the resonators below and above the rima glottidis and as its various paniais are resonated does it become, upon issuing from the mouth and nose, the human voice" (Judsbn and Weaver, 1966). Boone (1971) presents an interesting case history with reference to this. A patient with an open wo md immediately superior to his laryngeal cartilage was found producing a voice with a very low intensity and quality which was unhuman. This shows that the supraglottal resonators takes part in intensifying voice and also in giving the quality which is unique for each individual.

The resonance apparatus for the human voice, vocal tract, above the glottis (mainlyt-is a series of connected passages.

Different sections of the vocal tract may behave as tube resonators or cavity resonators under varying circumstances. The vocal tract acts as both sharp as well as broad response resonator. The result is strong intensification of certain overtones with damping out of siime others. Thus the variation in voice, both inter and intra-personal, can be explained. Resonance also affects the vocal cord vibration. Ineffective use of resonance may result in various disorders of voice (Rieber and Brubaker, 1966; Berry and Eisenson, 1956; Fisher, 1966; West et al, 1968; Murphy,

Good resonance is most easily developed at optimum pitch. According to Woolbert (1927). changes in pitch are mainly instrumental in expression of the logical aspect of meaning although they have some emotional significance as well, especially when extremely wide or narrow ranges are used. Lynch (1952) found by careful experimentation that both experienced and inexperienced speakers use the widest inflections for anger and the narrowest for grief. If the pitch usage is deviant, vocal dysfunction may result.

"For every person there is a general pitch level at which the voice will be most effective. This level will vary for different individuals and each person will find it

easily possible to make considerable variation from the general level. The approximate median of the range at which the voice functions most easily and most effectively is called the 'Optimum Pitch'. Thus optimum pitch is the best or most favourable pitch for speaking" (Gray and Wise, 1959).

"The prevailing notion now is that each person has an optimum pitch, an efficient pitch, at which the voice will be of a good quality and which will have maximum intensity with the least expense of energy". The optimum pitch is not a single pitch, rather it is a range (Van Riper and Irwin, 1959).

"In the gamut of pitch scale of each individual subject there is one level at least (and in adult males usually two) at which the chambers of mouth, throat and chest have relatively high potential for the resonance of laryngeal tone. That is, there is a pitch at which the individual phonates most efficiently and makes the loudest tone for the least expenditure of energy—a pitch at which the greatest amount of energy carried in the air column is transmitted into sound waves. Above and below this level of optimum resonance the speaker requires an inordinate amount of air pressure to produce an intensity equal to that produced easily at the optimum level" (West, 1968).

In most of the voice disorders it is found that the pitch is not appropriate for the person. That is, for the vocal cords or vocal tract (Williamson, 1945; Rieber and Brubaker, 1966; Van Riper and Irwin, 1959). "Fundamental to many procedures employed in vocal retraining is the belief that for each person there is an optimum or natural pitch level at which an human vocal apparatus operates with greatest efficiency" (Thurman, 1958). A review of literature on voice therapies also shows that the therapies are mainly relearning, that is finding an appropriate pitch or optimum pitch (which would include loudness and quality) for that particular person and making him use that pitch in his speech. Murphy (1964) presents an outline of those vocal techniques that are most frequently used in almost all types of voice problems, which also shows finding an optimum pitch as a most frequently used technique.

There is a lot of disagreement among the authorities in the field of voice about the location of optimum pitch. Some consider it as one-fourth from the lowest pitch range that a person can produce, including falsetto (Fairbanks, 1960; Pronovost, 1942; Berry and Eisenson, 1956; Fischer, 1966). While others consider this as one-third from the lowest pitch of the pitch range that a person can produce, including falsetto (Berry and Eisenson, 1956). Some others consider this as one-fifth from the lowest pitch of the pitch range that a person can produce including falsetto (Brownstein and Jacoby, 1967). But some others consider this as the mode of the pitch range that a person can produce, while still some others consider this as median of the pitch range that a person can produce (Gray and Wise, 1959). West (1968) states that for male voices such an increase in loudness occurs at two different levels. But he does not refer to any experimental evidences in support of his statement.

There are several methods of finding optimum pitch, with different theoretical orientations. Pronovost (1942) described and experimented with nine methods. Wentworth (1940) in her study of fourteen texts found that there were eight different ways of finding optimum pitch. Among them were the following :

1. Finding the pitch at which increase in loudness occurs on the musical scale.
2. Finding the note one-third up from the basal tone.
3. Finding the note five tones up from the basal tone.
4. Finding the note at which the speaker experiences the greatest ease.
5. Humming the scale and locating the loudest note.
6. Considering the pitch at which the person coughs and laughs.

There are still other methods like ". . . stop the ears by pressing the tragus over the opening and then intone 'ah' at various points on the scale until you locate the tone which appears to you to reverberate loudest in your head. This may be your optimum pitch" Berry and Eisenson (1956); Murphy (1964) describes these methods of finding optimum pitch. "Grunt 'ah' or 'O' gradually prolonging the utterances until a passage is chanted at the original grunt pitch level". The hard-sigh technique : "Take a deep breath and intone 'ah' on expiration".

AH these methods are subjective, as in these methods the subject is asked to phonate and vary the pitch keeping the loudness/intensity constant. But there is no objective evidence to say that the subject has covered or phonated at all the pitch levels that he can and has phonated at a constant loudness/intensity level at all the pitch levels.

Thurman (1958) in his study of finding optimum pitch, recorded scales as sung or hummed on vowels (e) (a) and (u) by a group of subjects. He submitted these recordings to sound level measurements to determine the nature and location of sound level variations and played the records to a group of trained listeners who indicated the location of any swells in loudness. He found that neither the results of physical measurement nor the judgements of loudness variations by observers were consistent. He concluded that his study is not in support of this method of finding optimum pitch. Johnson et al (1963) says that "while Thurman's (1958) findings certainly suggest that we should not expect to establish an individual's natural pitch level by a simple technique. Clinical experience has amply demonstrated that cues for the establishment of an appropriate pitch level can frequently be obtained by hearing the individual speaking on a variety of pitch levels and observing the effects of his Voice".

The review of literature shows that there is no objective method of finding optimum pitch. Hence, here is an attempt to find an objective method of locating optimum pitch. In the present study the following assumptions are being made : The human body acts like a machine and it follows physical laws and hence it is possible to stimulate the vocal tract by an external stimuli (sound source). The

vocal tract acts as a resonator and at a particular frequency the resonance will be maximum and this frequency can be considered as the optimum pitch for that particular vocal tract or vocal cords.

Subjects: 30 males and 30 females with an age-range of 20-25 years, who are considered as good speakers by judges will be taken for the study. (This has no special reason except that if the group is homogenous in terms of age it will be better to draw conclusions.) The subjects must be free from oral deformities such as cleft lip or palate (even repaired) and must be able to understand instructions. These limitations are considered just to reduce the number of variables.

Instruments: Sound pressure level meter. Audiofrequency generator covering, at least a range, from 500 cycles/sec. to 5k cycles/sec., which can be varied 10 ~ steps, with a variable intensity controller. A probe speaker or receiver, should be small in size, as it is intended to place this in the oral cavity of the subject. Stroboscopic unit that can be used to measure the fundamental frequency of voice.

Study procedures : The subject will be asked to sit in a chair comfortably and the procedure will be explained. So that the subject would not be in a tensed state. The subject will be asked to phonate the vowel (a) (central vowel) and to observe carefully the positions of his tongue and lips. The subject will be asked to maintain that position without phonation. The receiver will be placed in the oral cavity (It is known that it is possible to stimulate the whole resonator by keeping the stimulus at any point within the resonator). The intensity of the output signal will be kept constant and the frequency will be increased starting from 500 cycles/sec at 10 cycles steps. The same procedure will be adopted with (e) and (u) vowels for each subject. This is to include different resonators for each subject.

Observations : The sound pressure level of the signal in front of the mouth (at a particular distance) will be measured at each frequency level in all the three vowel positions. This is plotted on a graph (frequency Vs intensity). Presumably there will be a peak (raise in intensity) because of maximum resonance at a particular frequency. That frequency can be considered as 'Optimum frequency of vocal tract'. This will be related to fundamental frequency of voice in case of good speakers, which can be measured using stroboscope. Thus the optimum pitch can be determined in an objective way.

- Limitations:*
1. The tension of the muscles of the vocal tract is not controlled.
 2. The size and shape of the vocal tract is not controlled.
 3. Whether this has included the infraglottal resonators is not known.

Usefulness of the study : If it is possible to find optimum pitch by this method objectively, then that pitch can be used in treating the voice problems, keeping that as a model. By further research it may become possible to develop norms and thus may help in diagnosing the voice problems objectively.

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