FUNDAMENTAL FREQUENCY IN SPEAKING, SINGING, READING AND PHONATION

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The importance of measurement of fundamental frequency of voice {habitual frequency) in the diagnosis and treatment of voice disorders is well known. Different types of speech samples have been considered by different investigators for this purpose. In the present study an attempt has been made to note the differences in fundamental frequency in speaking, singing, reading and phonation in 30 *males and* 30 *females, using a pitch analyzer. The results indicate that there are significant differences between each type of speech sample considered, in terms of fundamental frequency. The fundamental frequency used in phonation by these subjects has been found to be in the vicinity of optimum pitch.*

Voice, the underlying basis of speech, can be described in terms of pitch, loudness and quality.

Pitch is the psychophysical correlate of frequency. In complex tones, like voice, the pitch depends upon the frequency of its dominant component, *i.e.*, its fundamental frequency (Stevens and Davis, 1935). According to Plomp (1967) even in the absence of or a very weak fundamental frequency in a complex tone, the ear is capable of perceiving the fundamental frequency based on periodicity of pitch- Vocal cords are considered to be the ultimate determiners of the pitch and the pitch range that an individual can produce- Several factors, within the larynx, have been found to operate in varying the fundamental frequency of voice.

In speech the fundamental frequency of voice keeps changing depending upon several factors like, intonation, emotion expressed, *i.e.*, due to both linguistic and paralinguistic factors. However, the analysis of speech reveals that the speaker uses a fundamental frequency, more commonly than others. This fundamental frequency is termed as 'modal frequency' or 'habitual frequency'.

The measurement of habitual frequency plays an important role in the diagnosis and treatment of voice disorders (Nataraja, 1972; Shantha, 1973; Samuel, 1973; Nataraja and Jayaram, 1982).

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Many studies have been conducted to *note* the changes in fundamental frequency with age, sex and in different voice disorders. Different types of speech samples, *i.e.*, phonation, reading, speaking and singing, have been used in different studies. Often one finds comparison of results of different studies. But it will not be clear whether the same type of speech sample has been considered for such comparisons. And further it is not clear whether- all the speech samples are going to yield the same results. However, the clinical experience has shown that the subjects would use different fundamental frequencies under different Conditions. Therefore it was considered that it would be interesting and useful to study the fundamental frequency in different types of speech samples, *i.e.*, in phonation, spontaneous speech, reading and singing. Further it was also planned to determine whether the normals use then optimum in any of these conditions.

Methodology

30 males ranging from 18 35 years and 30 females in the age range of 17-36 years were taken as subjects for the study To obtain the speech samples the following procedure was used. None of the subjects had any speech and/ or hearing problem or formal training in singing.

(a) The subject was instructed to read a standard passage (for a duration of 30 sec) at comfortable loudness level.

(b) The subject was asked to phonate vowels /a/ /i/ and /u/ for a duration of 15 to 20 sec. at comfortable. loudness level.

(c) Spontaneous speech was elicited from each subject by asking the subject to describe an event or to talk about his job, or other matters for a duration of 60 sec approximately.

(d) Each subject was asked to sing a song or chant a prayer whichever the subject could do. The speech -sample- under this condition, was for about 15-20 sec. approximately.

All the speech samples were recorded using a stereo cassette deck (Philips), in a sound treated room.

For each subject the order of recording of speech samples, ie *(a)* to *(d)* were randomized.

For all the subjects optimum frequeucy was measured using an objective method of locating optimum frequency (Nataraja 1972).

Thus from all the subjects, samples of reading, speaking, singing and phonation were obtained and optimum frequency was also determined for each subject.

Analysis of samples

The recorded samples were fed to the pitch analyser PM 100 (Voice Identification Inc.) using line feeding system and the mean fundamental frequency for each sample was obtained. Thus the mean fundamental frequency in reading, speaking, singing and phonation was obtained.

Results and Discussion

The mean and standard deviation for both male and female groups of subjects were computed for each type of speech sample and optimum frequency obtained. Table I shows the results. Males have used lower pitch than females, under all the conditions consistently.

Table I. Showing the mean optimum frequency, mean fundamental frequency and S.D. in males and females in Speaking, Reading, Phonation and Singing

Group	Optimum frequency in Hz	Speaking f.f. in Hz	Phonation f.f. in Hz	Reading f.f. in Hz	Singing f.f. in Hz
Males M	127.91	166.00	141.49	192.25	211.17
σ	8.48	33.84	29.72	43.27	60.64
Females M	241.13	266.26	237.03	272.91	304.04
σ	18.39	53.7	29.30	44.48	55.89

Table II. Showing significance of differencet present (P) or absent (A) between each condition in males

	phonation f.f.	Singing f.f.	Reading f.f.	Speaking f.f.
Optimum frequency	A	P	P	P
Speaking f.f.	P	P	A	
Reading f.f.	P	P		
Singing f.f.	P			

The inspection of Table I shows that males, use a fundamental frequency for phonation which is slightly higher than the optimum frequency, *i.e.*, 141.49 Hz and 127-91 Hz respectively. The variability within the group on the optimum frequency is very less (8-48). The same group has shown a greater variability on the measurement of fundamental frequency with maximum variability in singing (60-64) and minimum in phonation (29-72). The subjects have shown a tendency to use a higher fundamental frequency for speaking than for phonation and much higher fundamental frequency in reading and singing than in speaking, *i.e.*, they have used the highest fundamental frequency in singing (211-7 Hz), than in other conditions which, deviates from optimum frequency by 84 Hz.

Table III. Significance of difference present (P.) or absent (A) between each condition in females

	Phonation f.f.	Singing f.f.	Reading f.f.	Speaking f.f.
Optimum frequency	A		P	P
Speaking f.f.	P		P	
Reading f.f.	P	A		
Singing f.f.	P			

Further statistical analysis using Wilcoxon Matched Pairs signed ranks test (Results of which are shown in Table 11) also shows no significant difference between the mean fundamental frequency used in phonation and optimum frequency, both at 0-01 and 0.05 level of significance. The mean fundamental frequencies used for speaking, reading and singing differ significantly from the optimum frequency both at 0.01 and 0 05 levels of significance This confirms the observations, that the normals uo not use their optimum for speaking (Samuel, 1973, Gopal, 1980) and further that they use a higher fundamental frequency for reading and singing. The study of Table II further indicates that the fundamental frequency in spontaneous speech is significantly different from phonation and singing. Similarly the fundamental frequency in reading is significantly different from singing. The fundamental frequency in phonation is significantly different from fundamental frequency in spontaneous speech, reading and singing in case of males. The mean fundamental frequency used for speaking is not significantly different from mean fundamental frequency used for reading. However, it is significantly different in other 2 conditions.

The study of Table I with reference to female group reveals that females also show a similar trend both in terms of mean fundamental frequency and variability in mean fundamental frequency. However, females use a lower fundamental frequency for phonation than their optimum frequency But, just

like males, females also use higher mean fundamental frequency for speaking, reading and singing when compared with their optimum frequency. Again, in female group, the highest mean fundamental frequency of 304-04 Hz has been used for singing and a mean fundamental frequency of 266-26 Hz has been used for speaking, which is also higher than the optimum. The subjects have shown maximum variability under singing conditions in terms of mean fundamental frequency and a minimum variation is seen in phonation. Thus the increase in variabilty in mean fundamental frequency is seen from phonation to singing condition.

The statistical analysis of the results shown in Table III further confirm the observations that eventhough the mean fundamental frequency used for phonation is slightly lower than the optimum frequency, it is not significaintly different statistically at both the levels of significance. The mean fundamental frequency used for speakng, reading and singing differ significantly from the optimum frequency and they are higher than the optimum frequency. Inspection of Table **III,** indicates a similar trend as in the case of males, *i.e.,* the fundamental frequency in phonation is significantly different from other conditions. Fundamental frequency in spontaneous speech is significantly different from other two conditions. The fundamental frequency in reading is not significantly different from the fundamental frequency in singing. Thus the results of the present study cautions about the sample to be considered while evaluating the voice, *i.e.,* it may not be enough if one considers one condition to determine the mean fundamental frequency used for evaluation of voice.

This also indicates the need for training the normals to use their optimum frequency while speaking, reading and singing, *i.e.,* the normals do not use their optimum for speaking. These results confirm the findings of Samuel (1973) and Gopal (1980).

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