The Effect of Training on the Voice of Carnatic Classical Singers

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Abstract

There is a need to know the effect of training on the various parameters of voice in Carnatic singers. In this context, the present study was undertaken. The objective of the study was to compare the voice of trained Carnatic and beginning Carnatic singers. Two groups of subjects participated in the study. Group I consisted of 20 female trained singers and group II consisted of 20 female beginning singers. Subjects in group I had at least 10 years of training in Carnatic classical singing and subjects in group II had less than 2 years of training in Carnatic classical singing. The age range of subjects in group I was 12-40 years (mean = 16.46 years and SD = 7.93) and those in group II was 16-40 years (mean = 27.5 years and SD = 8.56). Specifically, the acoustic parameters maximum phonation duration, habitual frequency, frequency of the base note, frequency range in singing, speaking, and phonation, vibratos, presence / absence of singer's formant and voice projection (through measures of skewness and kurtosis) were measured. The results revealed a significant difference between the two groups for maximum phonation duration, difference between the habitual frequency and base note, range of frequencies in phonation, number of vibrato and Skewness and Kurtosis in singing and speech. This indicates that the trained singers did have an edge over the beginning singers over some acoustic features as a result of practice.

Key words: carnatic music, trained singers, beginning singers, skewness, kurtosis

Voice is a marvelous device, and the human voice that produces it is compared to a musical instrument. Because singing is a common musical outlet, the complexities of the vocal mechanism, the high degree of coordination and the amount of energy required for artistic performance are often overlooked, taken for granted, or not understood.

Singing is defined as a sensory motor phenomenon that requires particular balanced physical skills (Bunch, 1982). Sundberg (1994) stated, "the singer must gain control over all perceptually relevant voice parameters, so that they do not change by accident and signal an unintended boundary". Technical control of all voice parameters is a pre-requisite for artistic expression.

The primary difference between singers and non singers is not greater total lung capacity, but rather it is the use of greater proportion of air in his or her lungs, thus decreasing residual volume and increasing respiratory efficiency (Boominathan, 2008). Hirano (1981) reported MPD of 34.6 secs in normal adult males and 25.7 in normal adult females. Venugopal, Rajasudhakar and Savithri (2005) measured MPD in 80 normal children between 5 and 13 years. They found that the mean MPD for /a/ among girls between 5-5.11 years was 5.33 seconds, which increased to 14.8 seconds in the girls between 12-12.11 years. However, Sheela (1974) reported no significant difference in phonation time between the trained and untrained singers.

Chandra (2001) compared base pitch for singing of trained Carnatic singers with their habitual frequency for speaking/phonation. She found that subjects with more than six years of training had a lower base pitch than those who had training for less than six years.

The actual definition of singing range is the span from the lowest to the highest note a person can create with their voice. In speech, pitch slides up and down a restricted range of semitone covering a range of 6 or 8 notes, i.e. three or four notes above and below the middle note. In singing, however, pitch reaches one and a half octaves in untrained voices and two to two and half octaves in trained voices, i.e. on the 8^{th} or 10^{th} note above and below the middle note (Greene, 1972). Sheela (1974) studied frequency range in 30 (24 female and 6 male) trained and untrained singers between 19 and 57 years. They were asked to phonate their lowest and highest possible notes. She found the frequency range in trained singers to be 2.0 to 2.75 octaves, which was significantly higher than in untrained singers, which varied between 1.0 to 1.5 octaves. The average voice can master a variation from one and one and a half octaves to two octaves during speech (Karr, 1953).

Vibrato is a pulsation of pitch, usually accompanied by a synchronous pulsation of loudness and timbre. It is important as it gives pleasing

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flexibility, tenderness and richness of tone to good singing. Average rate of vibrato of a good singer is 6 to 7 c/s. Vibrato develops with training.

The term "singer's formant", was introduced by Sundberg (1974) who showed that the singer's formant could be interpreted articulatorily as a clustering of third, fourth and fifth formants, which may be an acoustic mismatch between the pharynx and the entrance of the larynx tube. Sengupta (1990) studied singer's formant in North Indian classical singing and singer's formant was observed. Chaya Devie (2003) compared Hindustani and Carnatic singers for presence of singer's formant. The results showed that singer's formant was present in Indian classical singers. Boominathan (2004) used LTAS module (FFT analysis) to determine if Carnatic singers demonstrate this peak energy contour. Contrary to the above studies, he did not find a singers' formant in Carnatic singers as such music is essentially homophonic and accompaniments usually shadow the singer and hence the singer would not require to project his/her voice over an orchestra.

Voice projection is the strength of speaking or singing whereby the voice is used loudly and clearly. Skewness and Kurtosis are used to infer projection.

The review of literature throws light on some aspects of acoustics of singing. However, it is insufficient to draw any conclusions. Further, it is known that training improves any skill and singing is not an exception. However, there is no empirical evidence to state that the acoustic measures in trained singers are different from untrained singers. In this context, the present study compared the voice of trained Carnatic with those of beginning Carnatic singers. The results of the study would throw light on how vocal training would affect the voice of these singers during singing and speech.

Method

Participants: Two groups of subjects participated in the study. Group I consisted of 20 female trained singers and group II consisted of 20 female beginning singers. Subjects in group I had at least 10 years of training in Carnatic classical singing and subjects in group II had less than 2 years of training in Carnatic classical singing. The age range of subjects in group I was 12-40 years (mean = 16.46 years and SD = 7.93) and those in group II was 16-40 years (mean = 27.5 years and SD = 8.56). Those with any other form of voice training (like Hindustani music) prior to or during the study period were excluded from the study. Those with a history of vocal pathology and ongoing pubertal or maturational voice changes, auditory problems and other respiratory or cardiac illness were also excluded.

Procedure: Phonation of vowel /a/, gliding from lowest to highest pitch, singing of gamaka, and singing and speaking of the song /kereja ni:ranu/ formed the material. All the voices were recorded in a quiet room on a Sony ICD-UX71 digital voice recorder at a sampling frequency of 441000 Hz. The following parameters were considered for the study: maximum phonation duration, habitual frequency, frequency of base note, singing frequency range, speaking frequency range, maximum frequency range in phonation, number of vibratos, singer's formant, skewness and kurtosis.

The researcher demonstrated each task before the participants' voice was recorded and three recordings were made for each parameter. The recorded phonation/ speech/ singing samples were transferred to the computer and saved on to the computer memory. PRAAT (Boersma & Weenink, 2006) software and LTAS of CSL 4500 (Kay Pentax, New Jersey) were used to extract the parameters. Number of vibratos/ gamaka was calculated.

The data was compiled and statistical analysis was done using commercially available SPSS 16.0 software. Mean and SD of the parameters were computed and MANOVA was done to find out the significant difference between groups on the 9 parameters investigated. Independent t-test was also used to confirm the results of MANOVA.

Results

MPD: Results of MANOVA showed a significant difference {F (1.38) = 22.63, $p<0.001$} between groups. Trained singers had longer MPD than beginning singers.

Habitual frequency: Results of independent t-test indicated no significant difference {t (38) = 1.720, $P > 0.05$} between groups. However, the mean habitual frequency and SD in group II was higher than those in group I.

Frequency of base note: Results of independent t-test indicated no significant difference {t (38) = -0.351, $P>0.05$} between groups on frequency of base note. However, subjects in group I had higher frequency of base note compared to those in group II.

Difference between habitual frequency and frequency of base note: Results of MANOVA indicated significant difference {F (1, 38) = 1.012, P<0.05) between groups. Subjects in group I had less difference compared to those in group II.

Singing frequency range: Results of MANOVA showed no significant difference {F (1, 38) = 2.224, P>0.05} between groups. However, group I had higher singing frequency range and SD compared to group II.

Speaking frequency range: Results of MANOVA showed no significant difference {F (1, 38) = 0.197, P>0.05} between groups. However, group I had higher speaking frequency range compared to group II.

Frequency range in phonation: Results of MANOVA showed significant difference {F (1, 38) = 32.001, P<0.01} between groups. Group I had higher frequency range and SD compared to group II.

Number of vibratos / gamakas: Most of the beginning singers were not able to produce any gamakas, but for two participants who produced two gamakas each. On the other hand, the trained singers were able to produce a maximum of 5 gamakas (6 participants); others were able to produce 4 (4 participants), 3 (9 participants) and 2 (1 participant). Figure 2 shows the number of gamakas produced by the two groups of subjects.

Singers Formant (Fs): No singer's formant was noticed in any of the subjects in either group gamakas within one second.

Skewness and Kurtosis: Results indicated significant difference between groups on Skewness {F (1, 38) = 11.978, P<0.01} and Kurtosis {F (1, 38) = 25.075, P<0.01} in singing and speaking [skewness – {F (1, 38) = 61.383, P<0.01; kurtosis – {F (1, 38) = 162.299,

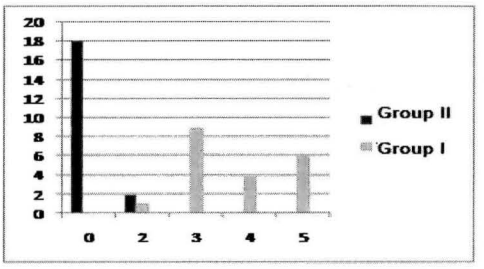

Figure 2. *Number of gamakas produced by the two groups of singers.*

P<0.01}]. Both groups had negative skewness indicating no projections in the voice. Figures 1 and 3 show an example from the sample of LTAS in singing and speaking, respectively. Table 1 shows the results of the present study.

Discussion

The results revealed several points of interest. First, a significant difference between groups on MPD was observed. *Subjects in group I (singers with > 10 years of experience) had longer MPD compared to those in group II (singers with < 2 years of experience).* First of all we shall observe whether the MPD in subjects of the present study was normal or not. Hirano (1981) reported MPD of 34.6 secs in normal adult males and 25.7 in normal adult females. Venugopal, Rajasudhakar and Savithri (2005) reported MPD of 5.33 secs in children between 5 and 5.11 years and 14.8 secs in girls between 12 and 12.11 years. The results of the present study are not in consonance with that of Hirano. There are differences in MPD between countries owing to the build of people. Therefore, it cannot be expected that Indian subjects will have the same MPD as reported by Hirano (1981). The MPDs obtained in the present study was 14.10 in subjects of group I and 10.30 in group II. However, there were 10 subjects in group II who had MPD below 10 seconds.

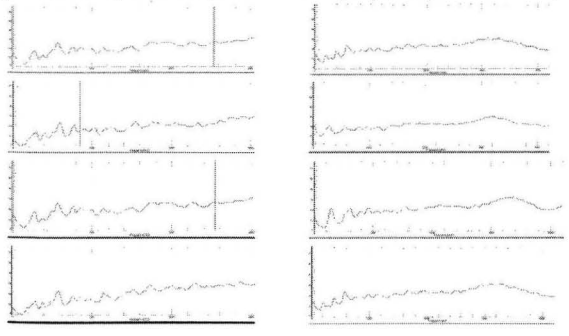

Figure 1. *LTAS in singing in group I (left) and group II (right) subjects in singing task..*

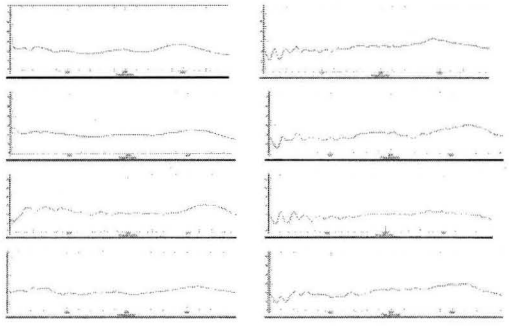

Figure 3. *LTAS of speaking in group I (right) and group II (left).*

Table 1. *Results of the present study*

Parameters	I (trained)	II (beginning)
MPD (sec)	14.10 (1.87)	10.30 (3.04)
Habitual frequency (Hz)	205.59 (17.40)	222.94 (41.63)
Frequency of base note (Hz)	205.59 (17.40)	202.84 (30.45)
Habitual frequency ~ frequency of base note (Hz)	10.47 (15.75)	20.11 (39.82)
Singing frequency range (Hz)	226.62 (54.96)	205.25 (28.83)
Speaking frequency range (Hz)	105.89 (19.41)	103.40 (15.69)
Frequency range in phonation	301.40 (70.47)	191.39 (50.95)
Singer's formant	Absent	Absent
Skewness (singing)	-1.93	-1.22
Skewness (speaking)	-1.23	-0.47
Kurtosis (singing)	3.84	2.03
Kurtosis (speaking)	1.75	-1.15

These results are in contrast to those of Sheela (1974), who found no significant difference in phonation time between trained and untrained singers. Also, Carnatic vocal practice consists of singing many notes or long verses in a single breath and in various tempos. Such training starts early in the syllabus of Carnatic music. The experienced singers might have greater practice using their respiratory apparatus to maintain singing longer utterances. Hence, their phonation time also increases with practice. Therefore, the results can be interpreted that the trained singers had greater respiratory efficiency i.e. their laryngeal mechanism uses the air supply effectively.

Second, the results showed no significant difference between groups on habitual frequency, frequency of base note, frequency range of singing and speaking. The first result that there was no significant difference in habitual frequency is expected, as habitual frequencies need not be different just because a group of subjects are trained singers. Many a time the music teachers do not select an appropriate base pitch as relevant to the physique of the student. Therefore, it cannot be expected that the frequency of base note will be different in two groups of subjects. This result does not correlate with the study by Chandra (2001) who found that subjects with more than six years of training had a lower base pitch than those who had trained for less than six years. However, many of the beginning singers' production of a:dha:ra sr.ti did not match that of sr.ti box, and hence their production of the pitch was sharp. But the trained singers were successful in matching their pitch with the sr.ti box. The lack of significance between the trained and beginning singers on frequency range in singing could be because of the song selected. Both the groups of singers were asked to sing the same song, which restricted their singing frequency range as they had to stick to the notes of the song. Hence, this task does not elicit the wide singing range in group I subjects. However, it was noticed that subjects in group I had wider range of frequency compared to those in group II. This result reflects the fact that in spite of the same song, the subjects in group I was able to use ornamentation in singing which reflected in wider range.

Third, the difference between habitual frequency and that of base note was significantly different in the two groups with group I subjects' habitual frequency closer to the frequency of base note. Though there was no significant difference between groups on habitual frequency and frequency of base note, the difference between the two was significant. While subjects in group I had lower habitual frequency than frequency of base note, those in group II had higher habitual frequency than frequency of base note.

Fourth, subjects in group I had significantly wider range of frequency in phonation than those in group II. The frequency range in group I was 301.4 Hz, while that in group II was 191.39 Hz. This study is in agreement with Sheela (1974) who found a greater range of pitch in trained singers than in untrained singers. She found the frequency range in trained singers to be 2.0 to 2.75 octaves, which was significantly higher than in untrained singers, which varied between 1.0 to 1.5 octaves. The results could be interpreted as the wider range in group I resulting from practice.

Fifth, subjects, in group II (except two of them) were not able to produce gamaka/vibrato. This may be because of the curriculum in Carnatic music. The initial part of the curriculum focuses more on ta:la, tempo and rhythm and gamakas are not taught. Therefore, subjects in group II, in spite of a demonstration might not be able to produce gamaka. Also, production of Gamakas requires great control of respiratory and laryngeal

mechanism. The physiologic tremors in the cricoarytenoid and thyroarytenoid muscles are a result of practice and training which might not be achieved by singers with singing experience of < 2 years.

Sixth, none of the subjects in the present study exhibited singer's formant. This is in contrast with the results of Sundberg (1974), Sengupta (1990) and Chaya Devie (2003). However, it is in consonance with that of Boominathan (2004) who stated that in Carnatic singing, music is essentially homophonic and accompaniments usually shadow the singer and hence the singer would not require projecting his/her voice over an orchestra.

Seventh, a significant difference between groups on Skewness and Kurtosis in singing and speaking was noticed. Subjects in group I had lower skewness and higher kurtosis compared to those in group II. The data on skewness and kurtosis indicated absence of voice projection. This is in consonance with the results of Devvuru & Savithri (2006) who reported no one to one correspondence between acoustic and perceptual correlates of projection. Voice rated as having good projection did not have low skewness and high kurtosis. The LTAS in the present study needs some description. They were unusual with the spectra spread over all frequencies and most of the time tilting upwards in group I. The reason for this is not known. Initially it was thought that the result was related to the recording procedure. Hence, a singer sang and spoke the song in to the microphone of CSL 4500. However, the results were the same with LTAS tilting upwards in high frequency. The results are interesting as it is known that LTAS is predominant in low frequencies and has lower energy at high frequencies. A software scientist was consulted and he also was of the opinion that the recordings were good (did not clip or was not recorded on multiple channels and was free from any other distortions that could affect the analysis). Hence the unusual LTAS in the present study still remains unsolved.

Conclusions

The results of the present study have thrown light on the acoustic parameters in beginning and trained singers. The results are encouraging in that some of the acoustic parameters were significantly different in two groups of subjects. However, the results of the present study are restricted to Carnatic singing. In the present study the same song was used in two groups of subjects for comparison. This was not able to reflect the frequency range used by two groups of subjects. Future studies on various glottal parameters and extension of the present study for frequency range of singing using various songs are warranted.

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References

Boominathan, P. (2004). *Do carnatic singers have singer's formant*? Proceedings of Frontiers of Research in Speech and Music.

Boominathan, P. (2008). *Assessment of professional voice.* Proceedings of Seminar on Voice: Assessment and Management, All India Institute of Speech & Hearing, Mysore.

Boersma, P., & Weenink, D. (2006). *PRAAT v 4.5.01.* Institute of Phonetic Science, University of Amsterdam.

Bunch, M. (1982). *Dynamics of the singing voice.* New York: Springer, Verlag.

Chandra, A. (2001). *Relationship between fundamental frequency of voice and 'a:dhara shruthi' in Carnatic vocal music.* Students research at AIISH: Articles based on Dissertation, Vol IV.

Chaya Devie, N. (2003). *Singer's formant in Indian classical singers – Carnatic vs. Hindustani.* Students research at AIISH: Articles based on Dissertation, Vol I.

Devvuru, S., & Savithri, S. R. (2006). *Acoustic and perceptual attributes of vocal projection in Carnatic classical singers.* Proceedings of PAS3 06, London.

Greene, M. C. L. (1972). *The voice and its disorders.* Pittman Medical Publishing Co., III Edn., London.

Hirano, M. (1981). *Clinical disorders of voice, Disorders of Human Communication*, 5, Springer Weain.

Karr, J. M. (1953). *Developing your speaking voice.* Harper and Row Publishers, New York.

Sengupta, R. (1990). Study on some aspects of the "Singer's Formant" in North Indian classical singing. *Journal of Voice*, 4(2), 129-134.

Sheela, E. V. (1974). A comparative study of vocal parameters of trained and untrained singers. Students research at AIISH: Articles based on Dissertation, Vol I.

Sundberg, J. (1974). Articulatory interpretation of the "singing formant". *Journal of the Acoustic Society of America*, 55, 838-844.

Sundberg, J. (1994). Perceptual aspects of singing. *Journal of Voice*, 8(2), 106-122.

Venugopal, M. B., Rajasudhakar, R., & Savithri, S. R. (2005). Maximum phonation duration and s/z ratio in Dravidian children. *Journal of the Indian Speech and Hearing Association*, 19, 47-51.