Otolaryngology online journal

ISSN: 2250-0359 Volume 5 Issue 3 2015

DO SINGERS MODULATE THEIR HARMONICS DIFFERENTIALLY DURING PHONATION AND SINGING?

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ABSTRACT

Objective: Singing has been used as a method to enhance the voice in singers. Singers have increased pitch range, high frequency in their voices when compared to untrained voice. Of late, the cepstral measures are gaining attention in the voice analysis as it is reported to be a strong predictor of vocal impairments. These measures signify the degree of harmonic organization in the voices.

It was interesting to investigate cepstral characteristics of voice during phonation and singing. The aim of this present study was to compare the cepstral peak prominence of singers during phonation and singing.

Method:

10 individuals who were trained in classical carnatic music participated in the study, they all were females. Speech tool uses Hillenbrand algorithm for the calculation of cepstral measures. CPP and CPPS were calculated according to the hillenbrands algorithm. Mean and standard deviation for all the cepstral measures were calculated.

Results: Results revealed no significant difference during phonation and singing, though there was an increased mean score for all the cepstral measure during singing. Conclusion: Further studies are warranted to investigate the same using larger sample size.

Introduction

Singing has been used as a method to enhance the voice in singers. Singers are frequently compared with athletes due to the demands and sophistication involved in using their phonatory apparatus. Singers use their voices in special ways to suit the requirements of music. This has promoted the researchers to investigate the acoustic and perceptual differences in voice if any between singers and non singers.

Brown, Rothman, and Sapienza reported that the presence of vibrato and formant of singers differentiated singers from non-singers [1]. Singers have increased pitch range, high frequency limit, area of high frequencies in their voices compared to untrained voices[2]. Omori, Kacker, Carroll, Rileyand and Blaugrund investigated acoustic measures between singers and non-singers and the findings revealed that singing power ratio can be differentiated among singing voices from non singing voices[3]. These studies have reported that singer and non singers are when it comes to acoustic measures. However, very few studies have investigated the singing voice in the Indian population. In india, there are two major types of singing which include carnatic and Hindusthani music. In the present study, carnatic singing was the focus.

Carnatic singing, the classical music of South India is a highly evolved form of art, which are often learned from their teachers (usually called gurus) through rigorous practice. It requires loud, open throated, predominantly low pitched singing and embedded with vocal nuances at higher pitches[4]. It is important in carnatic singing for the execution of long musical phrases/notes across varying octaves, tempos, and with discrete clear articulation of vowels and consonants. It is therefore necessary to characterize the singing voices using more robust acoustic measures.

Boominathan, et al found that lowering of first formants may also be attributed to the generalized low pitched singing noticed in trained Carnatic singers. This type of formant tuning characterizes trained Carnatic singers [5]. A study done by Prakup on acoustic measures on singers, displayed significantly less jitter and greater intensity than non-singers[6]. Shastry, Singh, Balasubramanium & Bhat investigated the cepstral peak prominence values in singers and non singers which revealed that there was significant difference between the means of singers and non singers indicating that cepstral peak prominence was higher among the singers in comparison with non singers[7]. In the similar line, we have used cepstral analysis to characterize their voice during singing and phonation in classical carnatic singers.

Aim of the Study:

The aim of this present study was to compare the cepstral peak prominence of singers during phonation and singing.

Method:

Participants: 10 individuals who were trained in classical carnatic music participated in the study. The participants were female singers. All these individuals had normal voice at the time of the study as evaluated through GRBAS voice rating scale. They did not have any history of vocal abuse/misuse, recent history of surgery to the oro-pharyngeal and laryngeal structures, smoking, hearing loss and neurological problems affecting the voice production.

Instrumentation: Speech tool (Hillenbrand, Western Michigan University, and Kalamazoo, MI) uses Hillenbrand algorithm for the calculation of cepstral measures. CPP and CPPS were calculated according to the algorithm used by the software.

Procedure:

Participants were seated comfortably on a chair. Microphone was maintained at a distance of 15cm from the participant's mouth to record the sample from singers.At first, each of the participants were asked to phonate vowel / a/at their comfortable pitch and loudness for three trails. Secondly the participants were asked to vary their pitch range from low to high and high to low using adhara shruthi for three trails. The task was demonstrated to each subject and instruction was repeated when required.

Data Analysis:

The software directly measures the following parameters using the Hillenbrand algorithm.

1. Cepstral peak prominence (CPP): The CPP is the difference in amplitude between the cepstral peak and the corresponding value on the regression line that is directly below the peak.

2. Smoothened cepstral peak prominence: CPPS is defined as the average of the individual cepstra over a given number of frames before extracting the cepstral peak and calculating the peak prominence.

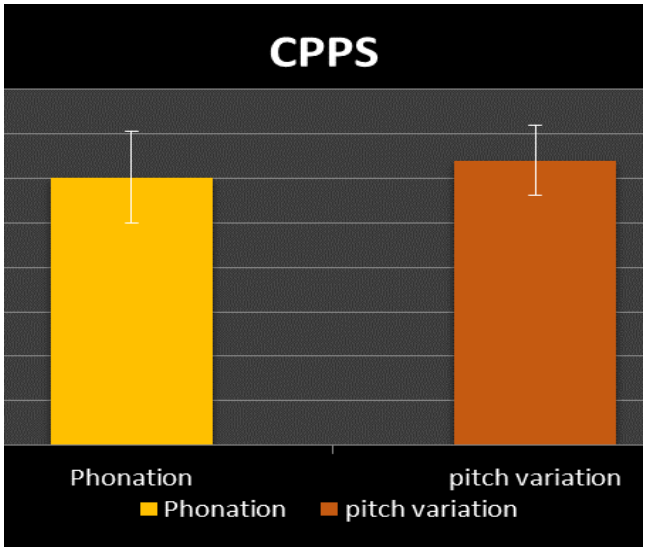
Both CPP and the CPPS have been shown to correlate with perceptions of breathiness, with CPPS being the better predictor of vocal impairments8.

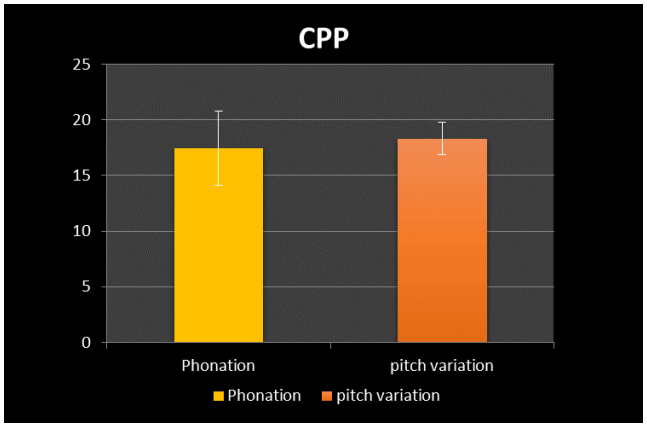
Statistical analysis:

Mean and standard deviation for all the cepstral measures were calculated for each participant. Paired sample t-test was administered to compare the significant difference between the means across phonation and singing.

Results:

Descriptive statistics was employed to find out the mean and standard deviation for the cepstral peak prominence of singers during phonation and singing which is shown in the graph below.





Results of paired T-test revealed no significant differences during phonation and singing, though there was an increased cepstral peak values during singing was observed at $p>0.05$.

Discussion:

Degree of harmonic organization was reported to be more in classical carnatic singers in comparison to non singers[7]. However, singing and the habitual voice of classical carnatic singers have not been compared so far using cepstral measures. Cepstral measures were considered as it was reported to be reliable and a predictor of degree of harmonic organization in the voices of normal and pathological conditions and hence the present study was planned to investigate the cepstral measures in singers during phonation and singing. The results revealed that there was no significant difference in cepstral measures during singing and phonation. But there was an increased mean score for all the cepstral measures during singing, though not statistically significant.

The increased cepstral measures during singing could be due to the presence of more number of harmonics in the voice spectrum of singers[7]. Apart from the number of harmonics, amplitude of harmonics are boosted and further contributes to the increased degree of harmonic organization[2-3]. It can also be said that noise level during singing is lesser than during phonation which might have also contributed to the increased harmonic organization during singing. The trained singers use all formants with greater precision and accuracy while singing which in turn could have augmented the degree of harmonic organization during singing.

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All of this suggests that singers modulate their voice to create a greater degree of harmonic organization during singing in comparison. Small adjustment made to the vocal tract can change the overall tone quality of the singing by changing the relationship of the formant frequency to the fundamental frequency. This is further augmented by the fact that the number of years of training and experience that singers have in the use of voice probably could have increased the harmonic organization during singing[7].

Though the number of years of training varied among the participants, singing voices had slightly higher cepstral values in comparison to their habitual phonation.

It is also possible that the degree of harmonic organization is similar during phonation and singing. However, it is difficult to draw such conclusion due to the lesser number of participants in the present study. Further studies are required to be carried out with larger sample size to elucidate such relationship. Similar studies are warranted even for Hindustani singers in the Indian context.

Conclusion:

The present study investigates the cepstral peak prominence values in singers during phonation and singing. Results revealed no significant difference during phonation and singing, though there was an increased mean score for all the cepstral measure during singing was observed. Increased cepstral measures could be due to the differences in the vocal modulation during singing and phonation, thereby increasing the harmonic organization during singing. Further studies are warranted to investigate the same using larger sample size.

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