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# Spectral Analysis Of Voice Across Various Registers Of Singing In Classical Singers

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***Abstract:*** ***Even though researchers have documented the acoustic differences characteristic of the singer's voice, very less attention have been focused on examining the spectral characteristics across various registers in singers. Thus the present study aimed to document the spectral parameters, namely H1-H2, H1-A1, H1-A2 and H1- A3 in classical singers with the vidwath level of singing training across various registers of singing. Thus the voice was recorded from both singers and non singers on singing task and the recordings were analysed to extract spectral measures namely H1-H2, H1-A1, H1-A2 and H1- A3. The values of the H1-H2, H1-A1, H1-A2 and H1- A3 were further tabulated and statistically analysed using SPSS software. The results revealed that there was no significant difference between group 1 and group 2 on H1-H2, H1-A1, H1-A2 and H1- A3. The results also revealed, H1-A2 was the only spectral measure that was sensitive to note the changes in quality of voice among singers.***

***Keywords: Spectral analysis, Voice, Singers***



## I. INTRODUCTION

Carnatic music is a name for an art form or the style of singing that lays claim to a lineage stretching back over many centuries. Carnatic music has a very highly developed theoretical system. It is based upon a complex system of ragam (rag) and thalam (tal). These describe the intricacies of the melodic and rhythmic forms respectively. Carnatic music, mainly emphasizes on using the powerful voice with more prominence on using low-pitch and loud singing. Carnatic singing also emphasizes a precise shruthi or tonic pitch for singing with accurate breath pattern (Durga, 1997). Execution of long musical phrases/notes across different octaves, tempos, and clear articulation of vowels and consonants are crucial for Carnatic singing (Arunachalam, Boominathan, and Mahalingam, 2014). According to Radhakrisha and Scherer (2011), open-throated singing with forward placement of voice characterizes a good voice in Carnatic singers. Brown, Rothman & Sapienza (2000) reported that the presence of vibrato, singers formant and a lower jitter value among singers compared to that of non singers. Even though researchers have documented the acoustic differences characteristic of the singer's voice, very less attention have been focused on spectral characteristics of voice among Carnatic singers.

Literature review shows that the measurement of amplitude differences between harmonics and formant frequencies or the measures of spectral tilt provides a quantifiable acoustic guide of the quality of voice. Previous work done by Klatt & Klatt (1990), on the acoustic correlates of vocal quality has identified the amplitude of the first harmonic (H1), and the spectral tilt as the major features that predict perceptual ratings of breathiness, with varying degrees of success. According to Hanson (1999) vowel spectra are reliable, objective and powerful markers of the weak, hoarse, and breathy voice production. The measures of vowel spectra can be categorized into those which compare a low-range, mid-range, and high-range regions of the spectrum. Low-range measures like H1-H2 reflects the degree of vocal tension present amongvarious types of phonation (Holmberg, 1995; Sundberg, Andersson & Hultqvist, 1999). H1-A1, H1-A2, H1-A3, and A1-A3 are considered as the mid-range measures of spectral tilt. All these measures are derived by calculating the amplitude of the various formant frequencies. A1 refers to the amplitude of the most robust harmonic in the region of first

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formant frequency (F1), A2 refers to the amplitude of most robust harmonic in the region of second formant frequency (F2) and the strongest harmonic in the region of third formant frequency (F3) is referred to as A3. The H1 amplitude compared with A1 reveals the bandwidth of the first formant (bandwidth of the formant increases with the existence of a glottal gap, and is evident in breathy phonation) and the spectral tilt. This measure has been an alternative successful measure to distinguish the phonation types in many languages (Ladefoged 1983 & Kong 2001).

From the literature review it is evident that the measurement of amplitude differences between harmonics and formant frequencies provides a quantifiable acoustic guide of the degree of glottal closure (Blankenship 1997). Even though the measurement of harmonic amplitude differences has been proved as an effective, reliable and objective tool for assessment of voice quality, only a handful of data on the measurement limits the use of these measurements among singers. Furthermore, analysis of the voice source with respect to voice quality is essential to the understanding of the voice production system among singers.

## II. AIM OF THE STUDY

The present study aimed at documenting the harmonic amplitude differences between formally trained Carnatic singers and non singers. Additionally the study also aimed at addressing the differences in terms of H1-H2, H1-A1, H1-A2 and H1-A3 between singers and non singers.

## III. METHOD

### SUBJECTS

Two groups of subjects were recruited for the study. Group I subjects consisted of 30 female singers in the age range of 25 – 35 years. All these subjects were formally trained in Carnatic classical singing and had a vidwath degree in singing. Group II included 30 non singers who had no formal training in classical singing. A questionnaire in English, designed to obtain details of their profession, phonation habits, history of voice problems, regarding medical/surgical intervention or voice therapy and regarding the regular endocrine changes was administered. The responses from the questionnaire were also obtained and it was warranted that the none of the subjects had a history of vocal abuse or vocal misuse, exposure to fumes, respiratory tract infections or endocrine imbalances. Further, all the subjects of both group 1 and group 2 were explained about the purpose of the voice recording and the informed consent were obtained.

### PROCEDURE

The recording took place in a room with relatively low ambient noise. Each subject was seated comfortably in a chair in front of the laptop computer screen during the recording. Subjects of group I were instructed to sing sapthaswarams in arohana style and the voice samples were recorded using a unidirectional microphone. Group II subjects were asked to sing a commonly known song "raghupathi raghava" at their comfortable loudness levels. The voice recordings of participants were collected with a high quality microphone onto the Praat software (version 5.3.23). The distance between the microphone and the participant's mouth was 15 cm. Voice recordings were digitized at a sampling frequency of 44.1 Hz and 16 bits/sample quantization. The sample of each participant was retrieved separately for the purpose of acoustic analysis. The acoustic analysis was carried to extract the spectral parameters namely H1-H2, H1-A1, H1-A2 and H1-A3.

## IV. RESULTS AND DISCUSSION

The values of H1-H2, H1-A1, H1-A2 and H1-A3 were further tabulated and statistically analysed using SPSS software. As a part of descriptive statistics, mean and standard deviation were calculated for all the parameters analysed across both the groups. .

| | | Group 1 | Group 2 |
|---|---|---|---|
| H1-H2 | Mean | -8.1583 | -6.6917 |
| | SD | 9.17670 | 6.94844 |
| H1- A1 | Mean | 0.6750 | -6.1083 |
| | SD | 17.24414 | 9.18323 |
| H1-A2 | Mean | 10.0167 | 10.7083 |
| | SD | 17.71311 | 18.39424 |
| H1- A3 | Mean | 19.9250 | 18.2333 |
| | SD | 9.44516 | 14.43445 |

*Table 1: mean and standard deviation (SD) values of H1-H2, H1-A1, H1-A2 and H1-A3 for both the groups*

The mean and SD values of H1-H2, H1-A1, H1-A2 and H1-A3 were given in the table 1. MANOVA was also carried out as a part of inferential statistics to compare the scores obtained across both the groups The results of MANOVA revealed that there was no significant difference between group 1 and group 2 on H1-H2 ($F=0.195$, $p>0.05$) , H1- A1 ($F=1.447$, $p> 0.05$), H1-A2 ($F=0.009$, $p> 0.05$) and H1-A23 ($F=0.115$, $p> 0.05$). Thus the subjects of group 1 not showed any difference compared to subjects of group 2.

*Table 2: showing mean and standard deviation (SD) values*

| | H1-H2 | | H1-A1 | | H1-A2 | | H1-A3 | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Sa | -8.1 | 9.17 | 0.67 | 17.24 | 10.01 | 17.71 | 19.92 | 9.44 |
| Re | -9.6 | 10.16 | -5.8 | 11.24 | 16.46 | 14.92 | 22.33 | 19.61 |
| Ga | -5.0 | 5.41 | -2.8 | 15.34 | 2.55 | 12.77 | 24.2 | 11.24 |
| Ma | -7.8 | 10.11 | -12.50 | 8.24 | -5.1 | 6.9 | 21.56 | 15.09 |
| Pa | -12.7 | 8.36 | -10.03 | 16.50 | -0.85 | 16.94 | 9.6 | 13.33 |
| Da | -9.4 | 14.73 | -8.85 | 17.09 | 6.14 | 16.73 | 13.22 | 21.13 |
| Ni | -8.8 | 20.19 | -6.4 | 21.46 | 10.05 | 10.93 | 13.41 | 23.39 |

*Across register for group 1*

MANOVA was also carried out as a part of inferential statistics to compare the scores obtained across both the groups and also within the group. The results showed that there was a significant effect of singing training on the spectral measures. Further, there was no significant difference between the registers across the spectral parameters H1-H2,

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H1-A1 and H1-A3. However, there was a significant difference seen in the spectral parameter H1-A2 ($F=2.9$, $p<0.05$). The highest mean value of H1-A2 was seen for swara Re with a mean of 16.4 and lowest H1-A2 value was seen for the Pa with a mean value of 0.8. As the measurement of H1-A2 are considered as the mid-range measures of spectral tilt, it can be inferred that swara Re showed the highest spectral tilt or the change in the quality of voice. Further, it was also inferred that out of all the measures, H1-A2 was the only spectral measure that was sensitive to note the changes in quality of voice among singers.

## V. SUMMARY AND CONCLUSION

Carnatic music is a name for an art form that lays claim to a lineage stretching back over many centuries. Carnatic music consists of various ragas and thaalas and with their combinations. Carnatic singing emphasizes a precise shruthi or tonic pitch for singing with accurate breath pattern. Execution of long musical phrases/notes across different octaves, tempos, and clear articulation of vowels and consonants are crucial for Carnatic singing. Even though researchers have documented the acoustic differences characteristic of the Carnatic classical singer's voice, very less attention have been focused on examining the spectral characteristics in singers across various singing registers. Thus the present study aimed at investigating the spectral parameters among classical singers across various registers of singing. Hence, voice recording was done from both singers and non singers on singing task and the recordings were analysed to extract spectral measures namely H1-H2, H1-A1, H1-A2 and H1-A3. The results revealed that there is no significant difference between group 1 and group 2.The present study results demonstrated H1-A2 to be a sensitive measure of change in voice quality in classic Carnatic singers. However, further studies on the correlation of the perception of the quality of voice and the spectral measures are warranted for a thorough understanding of voice control in singers.

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