ACOUSTIC VOICE QUALITY INDEX (AVQI) IN HINDUSTANI SINGERS

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ALL INDIA INSTITUTE OF SPEECH AND HEARING,

MANASAGANGOTHRI,

MYSURU-570006

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CERTIFICATE

This is to certify that this dissertation entitled ***"Acoustic Voice Quality Index (AVQI) on Hindustani singers"*** is a bonafide work submitted in part fulfillment for degree of Master of Science (Speech- Language Pathology) of the student Registration Number: 18SLP024. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

Mysuru,
July, 2020

Dr. M. Pushpavathi
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CERTIFICATE

This is to certify that this dissertation entitled ***"Acoustic Voice Quality Index (AVQI) on Hindustani singers"*** is a bonafide work submitted in part fulfillment for degree of Master of Science (Speech- Language Pathology) of the student Registration Number: 18SLP024. This has been carried out under my supervision and guidance. It is also been certified that this dissertation has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled ***"Acoustic Voice Quality Index (AVQI) on Hindustani singers"*** is the result of my own study under the guidance of Dr. T. Jayakumar, HOD- Speech and Language Sciences, All India Institute of Speech and Hearing, Mysuru, and has not been submitted earlier o any other University for the reward of any other Diploma or Degree.

Mysuru **Registration No. 18SLP024**
July, 2020

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Chapter 1

Introduction

Voice acts as a source of speech through which we communicate with others. It makes each unique from each other. The term voice is “an auditory perception of the sound build by the larynx, which integrates domains such as loudness, quality, pitch and variability” (Aronson, 1928). Voice is an outcome of coordination between physiological activities such as respiration, phonation and resonance. Johnson et al. (1965) has listed certain criteria for normal voice such as pleasant quality, gender and age-appropriate pitch, loudness appropriate to communication environment, adequate pitch and loudness flexibility and sustainability.

Voice can be evaluated qualitatively as well as quantitatively. Objective multi-parametric assessment has gained its centre of attraction comparing to single parametric assessment in the present eras of voice evaluation. . Acoustic measurement of voice is proved as the utmost valid objective measure for evaluating the quality of voice such as Harmonic to Noise ratio, jitter, and shimmer. (Carding et al., 2009). Out of many multi-parametric approaches, the Dysphonia Severity of Index (DSI) (Wuyts et al., 2000) has been reported as a robust measure and been used widely and consistently as an outcome measure in various studies.

Dysphonia Severity Index (DSI):

DSI was introduced to give quantitative correlate of quality of voice. DSI includes Maximum Phonation Time (MPT), Highest frequency (F_0-High), Lowest Intensity (I-Low) and jitter. It is constructed as DSI= 0.13* MPT+ 0.0053*F_0High- 0.26* I-Low- 1.18* Jitter (%)+ 12.4 (Wuyts et al.,2000). Scoring of DSI is from +5 to -5, +5 indicating normal voice quality and -5 indicating severely dysphonic voice quality. DSI was found to be not influenced by gender (Hakkesteegt et.al., 2006). DSI is proved to be a promising tool to differentiate disorders

of voice. (Hakkesteegt et.al., 2008; Smits et.al., 2012) Effectiveness of therapy outcome are efficiently measured using DSI (Barsties, 2020; da Cunha Pereira et.al., 2018; Hakkesteegt et.al., 2010; Kandağan et.al., 2009; Rajasudhakar, 2016; Van Lierde et.al., 2004; Zhuge et.al.,2016) Thus, many of the perceptual and objective voice parameters of voice disorders and various categories of professional voice users are well correlated with DSI. It also correlated well perceptual measures of analysis of voice like GRBAS (Hakkesteegt et al., 2006) and CAPE-V (Neelanjana & Jayakumar, 2011). DSI studies are done on different professional voice users. Timmermans et al. (2002) analyzed the voice of occupational voice users (n=86) who were high school students of audiovisual communication and found that these students had worse DSI scores than non-professional voice users characterized with no vocal complaints. Timmermans et al. (2005) used DSI in future professional voice users to analyse the efficacy of voice training program and found significant DSI improvement following voice training of 9 months than after 18 months. DSI was also investigated on special educators by Yeshoda et al. (2013) and they found that their values were within normal limits. Benoy et al. (2014) compared DSI score of untrained choral singers and DSI score Non-singers from the literature and found that the DSI score was higher for untrained choral singers than non-singers. Ravibabu and Maruthy (2013) compared DSI of trained Carnatic singers and non-singers and they found better DSI scores on singers. Prasad and Geetha (2015) compared DSI of pre-pubertal female Carnatic singers and non-singers and found that the DSI value was higher for Carnatic singers.

Van Lierde et al. (2010a) assessed the voice quality and voice characteristics of female students (n=197) pertaining to Speech-Language Pathology using DSI throughout the course of 4 years. The analysis of variance between the master and the first bachelor year disclosed the absence of significant change in the objective vocal quality. Van Lierde et al. (2010b) studied the

voice quality of female teacher students during 3 years of study using DSI and found DSI% of 76 in Student teachers corresponding to normal perceptual and objective vocal quality.

Awan, S. N and Ensslen, A. J. (2010) compared the voice of trained and untrained vocalist using DSI on 30 trained singers and 6 untrained singers and found that the trained singers have higher DSI value (6.48) than untrained singers (4.00). Maruthy, S., and Ravibabu, P. (2015) compared the DSI between younger and older Carnatic singers and non-singers and found singers had higher DSI values and older singers had reduced DSI values.

Although DSI was widely used and validated across different variables of voice, Higher inter and intra-subject variability is found in DSI because of various procedural variations in obtaining vocal frequency and intensity limits (Gramming et al., 1991; Ma et al., 2007). As acoustic voice qualities of connected speech samples and sustained phonation varies there is a necessity to include connect speech sample in acoustic analysis so that the diagnose will be close to the individuals habitual speaking voice (Reynolds et al., 2012) With these disadvantages of DSI, to overcome the above-mentioned limitation of DSI, AVQI was introduced in the literature.

Traditionally for several reasons acoustic measures are measured from sustained mid-vowel samples and not from continuous speech samples. First, in sustained vowel stable phonation is found whereas fast and frequent glottal and supra-glottal changes are found in continuous speech. Second, Non-voiced phonemes, prosodic variations in F0 and amplitude and rapid voice on- and offsets are not included in sustained vowel segments. Third, sustained vowel are not influenced by vocal pauses, phonetic context ,speech rate and stress. Fourth, typical F0 or T0 perturbation and amplitude perturbation measures rely heavily on pitch detection and

extraction algorithms; and correspondingly, they become imprecise in continuous speech analysis, in which intonation patterns, voice onsets and offsets and unvoiced segments significan tly increase perturbation. Fifth, less effort is required for the production of sustained vowel and it is more consistent than continuous speech. Sixth, linguistics does not influence sustained vowel but the influence is found in continuous speech. (Askenfelt & Hammarberg, 1986; Maryn et al., 2009; Parsa &Jamieson, 2001; Zraick, Wendel, & Smith-Olinde, 2005).The rationale behind the inclusion of continuous speech as well as sustained vowels are as follows, First, vocal inconstancies are found in continuous speech but not in sustained vowels(e.g., prosodic modulations, voice onset/offset, voice breaks, etc.) (Hammarberg et al., 1980). Second, different types/degrees of vocal dysfunction when expressed in two different stimuli type, result in unlike perceptual ratings (Wolfe et al., 1995; Zraick et al., 2005). For example, relatively normal voice was observed during sustained vowels and severely disrupted voice was observed in continuous speech in case of adductor spasmodic dysphonia (Roy et al., 2005). Third, Symptoms of dysphonia typically take place in conversational speech rather than sustained vowels (except for singing voice) (Yiu et al., 2000). Therefore, recordings of the both tasks should be ideally measured for the measurement to be considered ecologically valid.

Acoustic Voice Quality Index (AVQI)

Maryn et al. (2010) introduced a tool to measure the overall dysphonia severity involving sustained phonation and connected speech which is Acoustic Voice Quality Index. The parameters included in AVQI have Smoothed Cepstral Peak Prominence (CPPS), Slope of the long-term average spectrum (slope), Harmonics-to-Noise ratio (HNR), Shimmer local dB (ShdB), Shimmer local (SL), and tilt of the line through the long-term average spectrum (tilt). AVQI is designed as AVQI=2.571*(3.295-0.111*CPPS-0.073*HNR-0.213*SL+ 2.789*shdB

+0.077* Tilt). Maryn and Weenink (2015) derived a beta version of AVQI which is AVQI= 9.072-0.245*CPPS-0.161*HNR-0.470*SL+6.158*ShdB-0.071*Slope+0.170*Tilt.

AVQI is found to be unwavering across different languages about different geographical regions. In Indian language, Malayalam and Kannada have AVQI value of 3.03 (Jose,2017), AVQI value for Kannada speaking children between 10 – 12 years was 3.74 (Seshashri, 2018), English has a value of 3.25(Maryn,2014), Tamil has a value of 2.76 (Vishali,2019), German has a value of 2.70 (Barsties & Maryn,2012), French has a value of 3.07 (Maryn et al., 2014), Dutch has a value of 2.80 (Barsties & Maryn, 2015) Lithuanian has a value of 2.97(Uloza et al.,2017), Japanese has a value of 3.12 (Hosokawa et al., 2017). Maryn et al. (2014) measured AVQI in different language speaking individuals including English, Dutch, French and German and confirmed good cross-linguistic validity and diagnostic accuracy.

Reynolds et al. (2012) assessed pediatric voice disorders (n=67) using AVQI and compared the objective result with GRBAS scale. Moderate level of correlation was found between AVQI and GRBAS. Núñez-Batalla et al. (2017) analyzed sustained vowel of 60 normal and 58 voice disorders using AVQI and compared it with overall perceived voice quality A significant correlation was found between them and thus the study demonstrated AVQI as clinically feasible to measure dysphonia severity.

Barsties et al., (2017) analysed the impact of gender and age on AVQI and DSI on vocally healthy adults (n=123) of age range 20 to 79 years including 68 females and 55 males and found that there is no effect of gender on both AVQI and DSI, and also significant correlation with age in DSI while AVQI didn't have a significant correlation with age.

Uloza, V et al. (2018) compared the values of AVQI and DSI to evaluate and find differences between normal and dysphonic voices. /a/ phonation of 105 normal and 159 voice disorder voices where analyzed objectively using DSI and AVQI and perceptually using Grade and severity of dysphonia using Visual Analog Scale. The DSI threshold (i.e., DSI = 3.30) concerning G_{mean} attained equitable specificity of 83.4%and sensitivity of 85.8%. Concerned to VAS_{mean}, DSI showed excellent specificity of 93.9% and reasonable sensitivity of 70.3%. Also, the AVQI threshold (i.e., AVQI = 3.31) concerning to G_{mean} showed excellent specificity of 92.0% and reasonable sensitivity of 78.1%.Concerned to VAS_{mean}, an excellent sensitivity of 97.0% and specificity of 81.8% was found. As a correlate of auditory perceptual judgment AVQI yielded a higher level of accuracy proposing valid screening potential of AVQI.

DSI being well studied, it is validated for different disorders and different level of professional voice users. As studies have shown that AVQI acts better compared to DSI and as AVQI is not studied on different populations, there is a necessity to use AVQI in analyzing professional voice users. On professional voice users AVQI was measured in 26 Dutch theatre artists by Dhaeseleer, (2016) they analyzed their voice on sustained phonation and continuous speech prior and after the performance in *Praat* software and found their mean AVQI value to be 3.48 which corresponded to mild dysphonia. They concluded that this high AVQI value can be attributed to violent vocal behaviour and poor vocal hygiene.

Professional voice users are a group of the population for whom the voice is the primary tool of their occupation. The quality of their voice is the principal need. It includes teachers, singers, clergy, radio and television broadcasters, politicians, aerobics instructors, auctioneers, cheerleaders, actors and attorneys (Titze et al., 1997; Wingate et al.,2007). Koufman (1988) identified four levels of professional voice users based on professional demands and vocal load.

They are level 1: Elite vocal performer which includes singers, actors. Level 2: Professional voice user includes lecturers, teachers and clergy. Level 3: Non-vocal professionals include lawyers, businessmen, physicians and politicians. Level 4: Non-vocal non-professional includes clerks and other laborers. Singers fall into Elite vocal performer category. This level includes professionals for whom even a slight deviation in voice may have alarming consequences. .

Singing is described as pitched vocalizing (Banda F, 2000). Pitch is the highness or lowness of notes or musical sounds. Singing is also defined as a sensory-motor phenomenon that requires particular physical skills, which requires good coordination between respiration, phonation, resonance and articulation (Bunch, 1982). Singers are also known as "vocal athletes," as they have special and heavy demands on their voice. Indian classical singing includes Hindustani (North India) and Carnatic (South India). Hindustani singing is a North Indian style of singing which includes 7 Swara (sa,re,ga,ma,pa,dha,ni,sa) .The rhythmic patterns are called tala and melodic foundations are called ragas.

Sengupta (1990) studied singer formants of North Indian classical singing. He analyzed region of vowel definition (frequency up to 1.8 kHz) and singer's formant (2 - 4 kHz) in the spectrum. Fs was observed and its centre frequency increased with a rising pitch, which was found to be the same vowels sung in western music. The bandwidth was also found to increase with the increase in F0.

Devie (2003) studied the singer's formant in 20 Carnatic and 20 Hindustani singers. Their phonation of /a/ of 5 seconds was analyzed using LTAS. They found that in males, Hindustani singers showed a high value of F1 than Carnatic singers. In F2 both male and female Carnatic singers showed increased mean value than Hindustani singers Center frequency of Singers

formant was greater in Hindustani singers than in Carnatic singers but not significant. The mean value of bandwidth of Fs was significantly increased in Hindustani male singers than Carantic male singers. This was not observed in female singers. The intensity of Carnatic male singers was higher than Hindustani male singers but it was opposite in female singer.

From the above studies, it is clear that singers have a superior voice when compared to non-singers. Hence we need AVQI to be measured in professional voice users especially in Hindustani/ Carnatic singers. This current study is the analysis of AVQI in the voice of Hindustani singers.

Need for the Study

In present trend, AVQI is seen to be a promising tool in the evaluation of individuals wit dysphonic voices. Standard AVQI norms have been developed in different languages like Kannada, Malayalam, French, Dutch, German, English, Japanese, Lithuanian, English about different geometric areas of the world. As other acoustic metrics are not as informative and promising as AVQI, AVQI should be explored and validated in different disordered populations and in professional voice users like singers, actors, teachers.

Aim of the Study

The study aims to estimate AVQI data for Hindustani singers

Objectives

- To determine the AVQI scores of Hindustani singers
- To compare the AVQI score of Hindustani singers with non-singers.

Chapter 2

Review of Literature

"The human voice is extraordinary. It is adept of passing on not just the complex thoughts, but also elusive emotions. Within an instant, it can convey the terror of a scream or the beauty of song." This is the explanation of voice given by Sataloff (2005). Human voice is multi dimensional and it is judged by its loudness, pitch and quality.

Voice being an inseparable part of humans it becomes more crucial for professional voce users especially singers. Singers are referred to as "vocal athletes," because they impose special and intense demands on their voices. Several researchers have been done to discover the uniqueness of singers voice from non-singers and find the parameters which hold the reason for such variation. Researchers have also been done on different singing style and comparisons are made. Similarly voices of male singers and female singers are also compared. Voices are analyzed both perceptually and acoustically to yield reliable results.

Singer's Voice

Dysphonia Severity Index

Timmermans et al. (2002) assessed voice quality of 86 40 females and 46 males with age range between 18 to 27 years who were occupational voice users. There were of three groups future elite performers which includes stage actors, musical actors, future vocal professional which includes TV journalist, radio directors and future non-vocal professional which includes theatre directors. GRBAS scale was used for perceptual evaluation of their voice, a stroboscopic light source and90° Von Stuckradi rigid endoscope was used for Video laryngo-stroboscopy, DAT recorder Sony TCD-D100 was used to record the voice samples. MPT was calculated for aerodynamic measurement. To obtain overall voice quality DSI was measured, Psychosocial

impact of voice was assessed using VHI. Significant difference was not observed in GRBAS scale between the groups. Video laryngostroboscopy shows prevalence of few organic lesions and inflammatory afflictions in few subjects. Both the males and females in the control group had higher DSI values than elite vocal performers and vocal professionals. DSI of control group was significantly different non vocal professionals females which was not seen in males. No significant difference was seen between subgroups for females. For males there was a significant difference between controls, elite vocal professionals and vocal professionals. Significant difference was observed between subgroups of males for highest frequency and lowest intensity. In females, Fo-High and L-Int were better for control group than vocal professionals and non-vocal professionals. Female elite vocal performers had the worst LI than all subgroups. Significant difference was not found for VHI scores between all three groups. Questionnaire regarding their habits revealed late meal time, smoking, vocal abuse is observed in the subgroups.

Timmermans et al. (2005) analyzed the efficacy of voice training program on professional voice users who got vocal hygiene education for 1 year and voice training for 2 years (n=23). Their voice was analyzed in the European Laryngological Society protocol which contains DSI and VHI. Voices were analyzed during 9^{th} and 18^{th} week of voice training. DSI score was found to be improved better on 9^{th} week of training than 18^{th} week. In VHI good improvement was seen in 18^{th} week than 9^{th} week.

Shaheen et al. (2010) compared the voices of 30 trained (15 males and 15 females) and 36 (15 males and 21 females) untrained singers using Dysphonia Severity Index. The tasks were sustaining /a/ vowel after maximum inspiration, chanting 1, 2, 3, 4 sustaining /a/ at comfortable pitch quietly and sustaining /a/ at their maximum pitch level. The results showed a significant

difference in F0 high, jitter and I low between the groups. DSI score of trained singers are 6.48 and untrained singers are 4.00, indicating higher DSI score for trained singers than untrained singers.

Arunachalam et al. (2014) analyzed the voice of 45 Carnatic singers including 36 females and 9 males using GRBAS scale, Voice disorder outcome profile, Singing frequency range and DSI. Covering 3 octaves at three different speeds and three volume conditions participants were made to sing a basic scale ‘‘Ma:ya:ma:lavagoulai ragam’’ and also read standardized rainbow passage or general conversation at three different intensity levels. Singers reported to have difficulty in singing higher pitches and lower pitches, vocal fatigue, muscle tightness while singing. Poor vocal habits such as singing in loud voice for prolonged time, inadequate voice rest, practicing in extreme pitches, less intake of water, intake of oily/ spicy foods, improper meal time was reported. MPT was 10.2and 15.7 in females and males respectively which is less than the expected. Significant difference was not observed between genders in Singing Frequency Range. Singers with clinical diagnosis (vocal polyp, nodule, presbylarynges, edema) had less SFR than singers with LPR, MTD and chronic laryngitis. DSI score did not differ significantly between male and female singers and among different clinical diagnosis. 45 singers had DSI scores severely deviating from norm. Average VDOP score was 5.1 out of 10 indicating their overall severity of voice. These changes in voice of singers were due to inappropriate and excessive use of voice.

Maruthy and Ravibabu (2015) compared the DSI scores of 15 younger (below 50 years with mean training years of 19), 15 older Carnatic female singers (above 50 years with mean training years of 35.26) and 30 non singers. The tasks were to phonate vowel /a/ from their comfortable pitch to high pitch, soft to maximum loudness, sustain vowel /a/ for maximum time

to calculate MPT and sustain /a/ for 2 to 3 seconds o measure jitter. Comparing singers and non-singers, singers had long MPT, high phonation frequency and high DSI scores. On comparing younger and older Carnatic singers older singers had reduced MPT, DSI score and highest phonation frequency. Reduction in DSI values in older singers is attributed to lowering of Fo and reduced MPT.

Jitter, Shimmer, Harmonic to Noise Ratio

Brown et al. (2000) analysed the voice of 20 singers with experience of 7 o 30 years and 20 non singers acoustically and perceptually, which includes 10 males and 10 females in each group. The tasks were to sustain vowel /i/, read rainbow passage which had a modification i.e 3 lines where included from 'America the beautiful' song, sung sample of America the beautiful. On perceptual analysis the SLP's were able to identify singers and non singers 57% from their speaking utterance and 87% from in sung utterance. There was no significant difference in the speaking fundamental frequency of singers and non singers. Between female singers and non singers there was no significant difference in SD values of SFF while, male singers had greater variation than non singers. There was no durational difference between singers and non singers. In speaking, there was no significant difference between singers and non singers for shimmer and Noise to Harmonic ratio. Non-singers had greater jitter than singers. In singing, singers had less jitter than non singers however it was not significant. Female non singers had greater shimmer than singers. Male singers had significantly greater Noise to Harmonic ratio than non singers. All singers had their vibrato and singers formants.

Prakup (2012) compared jitter, intensity, shimmer and fundamental frequency of 60 old amateur singers of age 65 to 80 years and 60 non singers 30 male and 30 female in each category using PRAAT software from their sustained vowel production and it was correlated

with perceptual listener judgments by 10 speech language graduate students. Results revealed that singers had less jitter and greater intensity than non singers. No significant difference was found between singers and non singers for shimmer or Fo. Both male and female singers were perceived to be younger than non singers. No significant difference was found in Fo and shimmer. There was no significant correlation between perceived intensity and age in male and female singers/ non singers. However partial negative correlation was found between age and intensity of female non singers. Moderate positive correlation of jitter in singers and non singers, significant correlation of jitter and age in female singers not in female non singers were observed.

Gunjawate et al. (2015) acoustically analyzed voices of Taar Saptak/Sthayi (TS) and Madhya Saptak/Sthayi (MS) using MDVP in trained 65 Indian classical (25 males and 40 females) who are trained minimum for 5 years. The singers were asked to phonate /a/ at TS and MS for 7 seconds in each. In MS and TS, females had higher group mean for mean Fhi, Flo, F0 and range of F0 than males. However, between males and females TS was found to have higher mean difference in these parameters as compared to MS. Females had higher jitt%, RAP, PPQ and SPPQ than males in TS and vice versa in MS. VF0 and NHR was decreased in TS for both males and females

Singing Power Ratio

Lundy et al. (2000) analyzed Singing Power Ratio and acoustic parameters in 14 males and 41 females who were singing students between their singing and speech using MDVP. Shimmer and NHR were higher in spoken tones. Between singing and speaking voice significant difference was absent for SPR and jitter

Mendes et al. (2003) studied the effectiveness of voice training in 14 voice majors. Tasks were singing 'America the Beautiful' and MPFR which contained frequencies lower in modal register to highest in falsetto register.Fo90 improved significantly in 3rd and 4th semester compared to 1st semester. As the number of semesters increased SPL of 90% level of MPFR increased significantly. There was no significant difference for vibrato due to vocal training. For the vowel /i/,/a/ 14,17 singer formats were identified. There was no difference in singer formants as a result of vocal training.

Voice Handicap Index:

John and Poduval (2015) studied the effect of vocal training in 50 professional voice users who didn't have proper prior voice training. VHI was measured for baseline prior to training and post training to see the impact. Vocal warm-ups by humming, breathing and jaw exercises were given. Minimal improvement was observed in VHI due to short training period however, it provided good vocal hygiene awareness among singers which was lacked before the vocal training.

North Indian classical singing:

In north Indian classical singers four male and female within the age range of 17 to 30 years who had musical training over 5 years Ranjan Sengupta (1990) analyzed Singer's formant. They sang /a/, /i/, /o/ twice a week, twice a day for 6 months over their full vocal range. AIWA stereo cassette recorder was used to record their voice. Two regions of the spectrum was concentrated (i) frequency upto 1.8KHz (region of vowel definition), (ii) 2-4KHz (region of singer's formant). Calculating the difference between the mean of two highest peaks in singer's formant and two peaks in vowel definition region resonance balance was measured. Centre frequency of singer's formant increases is found to be increasing with pitch and also increase of

Bandwidth with increase in fundamental frequency. Resonance balance is stable -4dB around fundamental frequency and decreases slowly as pitch increases. With increase in fundamental frequency spectral energy balance decreases slowly.

Johan Sundberg (1990) analyzed phonation, breathing and articulatory pattern during singing and compared it with speech pattern. In the analysis of breathing pattern increase in pitch and loudness is attributed to variation in subglottic pressure. For higher pitch vocal folds becomes stiffer and greater pressure is required to overcome the medial compression. They concluded that for singing a well controlled subglottic pressure is essential. For speech subglottic pressure focuses mainly on loudness control. During loud phonation differences was observed between singers and non singers. With increasing the fundamental frequency non-singers reduced their peak flow amplitude but singers maintained it high. Pressed phonation was produced by non-singers. Singers were interdependent on various parameters of phonation. They also observed the presence of singer's formant in singers. In speech, formant frequencies merely attribute to different vowels and consonants and higher formants depends on pitch which occurs due to change in position of larynx which changes air cavity volume at low pharynx.

Acoustic Voice Quality Index:

Maryn, DeBodt & Roy (2010) introduced a tool to measure the overall dysphonia severity involving sustained phonation and connected speech Acoustic Voice Quality Index. The parameters included in AVQI are Smoothed Cepstral Peak Prominence (CPPS), Shimmer local dB (ShdB), Harmonics-to-Noise ratio (HNR), Shimmer local (SL), Slope of long-term average spectrum (slope) and tilt of the line through the long-term average spectrum (tilt). AVQI is designed as AVQI=2.571*(3.295-0.111*CPPS-0.073*HNR-0.213*SL+2.789*ShdB-

0.032*Slope+0.077* Tilt). Maryn and Weenink (2015) derived a beta version of AVQI which is AVQI= 9.072-0.245*CPPS-0.161*HNR-0.470*SL+6.158*ShdB-0.071*Slope+0.170*Tilt.

Maryn et al. (2010) analyzed the treatment outcome using AVQI. In first experiment (external cross validation of AVQI) 6 vocally normal samples and voice samples of 33 (19 females and 14 males) voice disordered subjects were taken. In second experiment voice recordings of 33 voice disordered subjects pre and post therapy were taken (22 females and 11 males). Eclectic treatment program was received by all 33 subjects with combination of behavioral therapy which included both indirect and direct strategies. 6 patients were primarily treated with surgery. Patients underwent 1 to 49 sessions. Subjects phonated vowel /a/ for at least 5sec and read Dutch text which was phonetically balanced. The samples were recorded using CSL model4500 and saved in.wav format. Overall voice severity was rated by 5 experienced Speech Language Pathologist with an equal interval scale of 4 point. Test re-test reliability was checked by reanalyzing 20 samples. There was a strong concurrent validity; i.e AVQI estimated more than 60% of the variance of mean G. A ROC curve was constructed to check the ability of AVQI to distinguish normal from pathological voice and AVQI was found to have excellent discriminatory power. Standardized Change Score for G and AVQI was calculated which is the difference in the score between pre-therapy and post therapy. Higher values in SCS_{meanG} were proportionally associated with SCS_{AVQI}.

Reynolds et al. (2012) assessed voice disorders of pediatric (n=67) within the age range of 6 to 15 years using AVQI and compared objective result with GRBAS scale. The tasks were to phonate /a/ and to read “Level 1- Bird” for Neale analysis of reading ability. Middle 2 sentences of passage and middle 3 seconds of phonation is selected for analysis. Results showed a 80.4% of overall agreement between acoustic and perceptual measures. Within raters moderate

level of consistency was found. 0.794 is the correlation between mean G score and AVQI indicating a positive correlation and confirming strong concurrent validity. 3.46 is the best AVQI cut off score to discriminate normal from pathological voice which has a sensitivity of 82%, specificity of 92%, and accuracy of 84%. Previous study by Maryn et al has found a cut of score 2.95 in adult population which when implied in children had poor sensitivity and specificity. This difference is attributed to structural difference between children and adult larnges which changes the acoustic characteristics.

AVQI is found to be unwavering across different languages pertaining to different geographical regions. In Indian language, Malayalam and Kannada has a value of 3.03 (Jose,2017), AVQI value for Kannada speaking children between 10 – 12 years was 3.74 (Seshashri, 2018), English has a value of 3.25(Maryn,2014), German has a value of 2.70 (Barsties & Maryn,2012), French has a value of 3.07 (Maryn et al., 2014), Dutch has a value of 2.80 (Barsties & Maryn, 2015) Lithuanian has a value of 2.97(Uloza etal.,2017), Japanese has a value of 3.12 (Hosokawa et al., 2017). Maryn, Dobt, Roy and Barsties (2014) measured AVQI in different language speaking individuals including English, Dutch, French and German and confirmed good cross lingustic validity and diagnostic accuracy.

The effect of age and gender on AVQI and DSI was studied by Barsties et al.(2017). Voice samples of 123 vocally healthy including 68 females and 55 males between 20 to 79 years. The tasks were to phonate /a/ , read Lithuanian sentence, MPT, phonate /a/ at lowest and highest pitch and loudness. Significant correlation between age and AVQI was not found but was found in DSI. Gender did not have significant relationship with AVQI and DSI.

Núñez-Batalla et al. (2017) analyzed voices of 60 normal and 58 voice disorders using AVQI and compared it with overall perceived voice quality. The tasks were to phonate /e/ and to

read standardized passage. Perceptual analysis was done using GRBAS scale and CAPE-V. A correlation of 0.68 was found between AVQI and overall severity of dysphonia. 20 individuals from these sample underwent surgery for excision of polyp, cysts, nodule etc. Pre and post operative AVQI scores were compared and significant difference was found. A significant correlation was found between them and thus the study demonstrated AVQI as clinically feasible to measure dysphonia severity.

Two versions of AVQI were compared by Kim et al. (2018) for quantification of dysphonia severity. Voice samples of 2257 individuals across 14 diagnostic categories were analyzed using praat CPPS and two versions of the AVQI (v2 and v3). The difference between 2versions is

$$\begin{aligned}\text{AVQI v.2.02} &= 9.072 - (0.245 \times \text{CPPS}) - (0.161 \times \text{HNR}) \\ &\quad - (0.470 \times \text{SL}) + (6.158 \times \text{SL dB}) \\ &\quad - (0.071 \times \text{Slope}) + (0.170 \times \text{Tilt})\end{aligned}$$

$$\begin{aligned}\text{AVQI v.3.01} &= [4.152 - (0.177 \times \text{CPPS}) - (0.006 \times \text{HNR}) \\ &\quad - (0.037 \times \text{SL}) + (0.941 \times \text{SL dB}) \\ &\quad + (0.01 \times \text{Slope}) + (0.093 \times \text{Tilt})] \times 2.8902\end{aligned}$$

G (Likert scale) and OS(Visual analogue scale) were used for perceptual evaluation by 3 listeners. AVQIv2 had positive correlation with AVQIv3, G and OS and negative correlation with PraatCPPS. AVQIv3 had correlation with G, OS, PraatCPPS. Valid estimate of dysphonia severity was provided by PraatCPPS and was strongly correlated with the A-P ratings. Comparing the associations of the A-P ratings with the AVQIv2, AVQIv3 and CPPS significantly stronger was found with AVQIv2 than the AVQIv3 and PraatCPPS, suggesting outperformance of V2 than V3 and PraatCPPS.

Uloza et al. (2018) compared AVQI and DSI in finding the difference between normal and dyphonic voices. /a/ phonation of 105 normal and 159 voice disorder voices where analyzed

objectively using DSI and AVQI and perceptually using Grade and severity of dysphonia using Visual Analog Scale. The DSI threshold (i.e., DSI = 3.30) concerned to G_{mean} attained equitable specificity of 83.4% and sensitivity of 85.8%. Concerned to VAS_{mean}, DSI showed excellent specificity of 93.9% and reasonable sensitivity of 70.3%. Also, the AVQI threshold (i.e., AVQI = 3.31) concerning to G_{mean} showed excellent specificity of 92.0% and a sensitivity of 78.1%. Concerned to VAS_{mean}, excellent sensitivity of 97.0% and reasonable specificity of 81.8% was found. As a correlate of auditory perceptual judgment proposing AVQI yielded higher level of accuracy suggesting to be valid screening potential of AVQI.

Faham et al., (2019) investigate can AVQI be a screening tool along with auditory and perceptual perception of voice. Voice samples of 128 teaching students were analyzed. The tasks were to phonate /a/ and read standardized passage. Significant but weak correlations was found between Gmean and AVQI and its two parameters, harmonic-to-noise ratio and smoothed cepstral peak prominence (r = 0.27; _0.20, _0.24;, respectively; |P < 0.05); Between total VHI and AVQI score and cepstral peak prominence correlation were observed. Furthermore, AVQI scores differed significantly for the groups with a VHI total score <19 and ≥19.

Pebbili et al. (2019) assessed the diagnostic accuracy of AVQI. Voice samples of 71 individuals (18 females and 53 males) with voice disorders were analyzed using AVQI. Voices were perceptually evaluated by 3 experienced SLP's using GRBAS scale. The tasks were to read standardized kannada passage and phonate vowel /a/. Significant concurrent validity was found for AVQI. Score of AVQI was found to be increased with increase in dysphonia severity. AVQI was found to have more accuracy in discriminating slight versus moderate dysphonia severity, moderate versus severe dysphonia severity while, lesser accuracy was found in discriminating normal versus mild dysphonic voice.

On professional voice users AVQI was measured in 26 Dutch theatre artists by Dhaeseleer et al. (2016). They analyzed their sustained phonation and continuous speech prior and after performance in *Praat* software, voice samples were perceptually evaluated by GRBAS scale and they were also asked to fill questionnaire of vocal symptoms given by voice evaluation protocol of the European Laryngological Association. The mean AVQI value was found to be 3.48 which corresponded to mild dysphonia. They concluded that this high AVQI value can be attributed to violent vocal behavior and poor vocal hygiene. AVQI scores were not significantly different pre and post performance. There was a significant difference between overall grade between prior and after performance in perceptual evaluation.

It is evident from the review of literature that AVQI is a promising tool for assessment of voice. However, it is not still validated to be used for assessment of professional voice users like singers, teachers. Known that the voice quality of singers is better than non singers, it cannot be predicted that similar results of assessment will be observed in singers as non-singers. Thus this present study aims in estimate AVQI value for Hindustani singers and compare the values with AVQI values of non-singers.

Chapter 3

Method

The present study was conducted to check the validity of AVQI by measuring it in Hindustani singers. The method carried out is as follows:

Participants

A total of 60 individuals were included in the present study. Out of which 30 were Hindustani singers and 30 were non-singers with 20 females and 10 males in each group. Hindustani singers were further sub-grouped as singers with less than 10 years of experience and singers with more than 10 years of experience. Both the groups were age and gender-matched. The participants were within the age range of 18 to 40.

Exclusion Criteria

- Singers with experience less than 5 years (Hindustani singers).
- Participants with the report of vocal complaints
- Participants with the history of alcohol consumption, smoking
- Participants with the history of voice disorders or other pathologies of larynx.
- Participants with active upper or lower respiratory tract infections, asthma and other lung infections
- Participants with any neurological impairment or communication disorder.

Stimuli

Voice recordings of sustained phonation of vowel /a/ for a minimum duration of 8 seconds and a continuous speech sample of reading. Standardized reading passages were selected respective to participant's native language and proficiency like Kannada, Hindi, Tamil, and English.

Procedure

The aim and procedure of the study were explained to the participants of the study. Later, written informed consent was taken from the participants. They were seated in an erect position. To avoid breathing noise microphone was placed 15 cm away from the mouth of the participants. All the participants were asked to produce sustained phonation of vowel /a/ for a minimum 8 seconds and they were asked to read standardized reading passage respective to their language. Olympus LS 100 digital voice recorder was used for audio recording with a sampling frequency of 44.1 kHz and 16-bit resolution in .wav format in a quiet environment. Both sustained phonation and continuous speech were recorded using same recording setting. Two to three trials of each recording were done and for further analysis the best trial was selected.

Analysis

The procured audio recordings were subjected to analysis using *Praat (verion5.3)* to obtain AVQI score. The algorithm constructed by Maryn and Weenik (2015) for obtaining AVQI is AVQI= 9.072-0.245*CPPS-0.161*HNR-0.470*SL+6.158*ShdB-0.071*Slope+0.170*Tilt was used. The middle steady portion of 3 seconds was extracted and analyzed from the sustained vowel. Third to sixth sentences from the reading passage of the paragraph were analyzed for continuous speech. For sustained vowel the extracted sample in .wav format was renamed as

'SV'and Continuous speech as 'cs' and fed into AVQI version 2 script by Maryn et al.,(2010) and Maryn and Weenik (2015). Testing was again done for 10 % of the participants to check test re-test reliability. The reliability coefficient was 0.92. The AVQI output obtained for a Hindustani singer and a Non-singer is depicted in figure 3.1 and 3.2

Figure 3.1

An Example of Graphical Output of AVQI and its Constituents of Hindustani Singers.

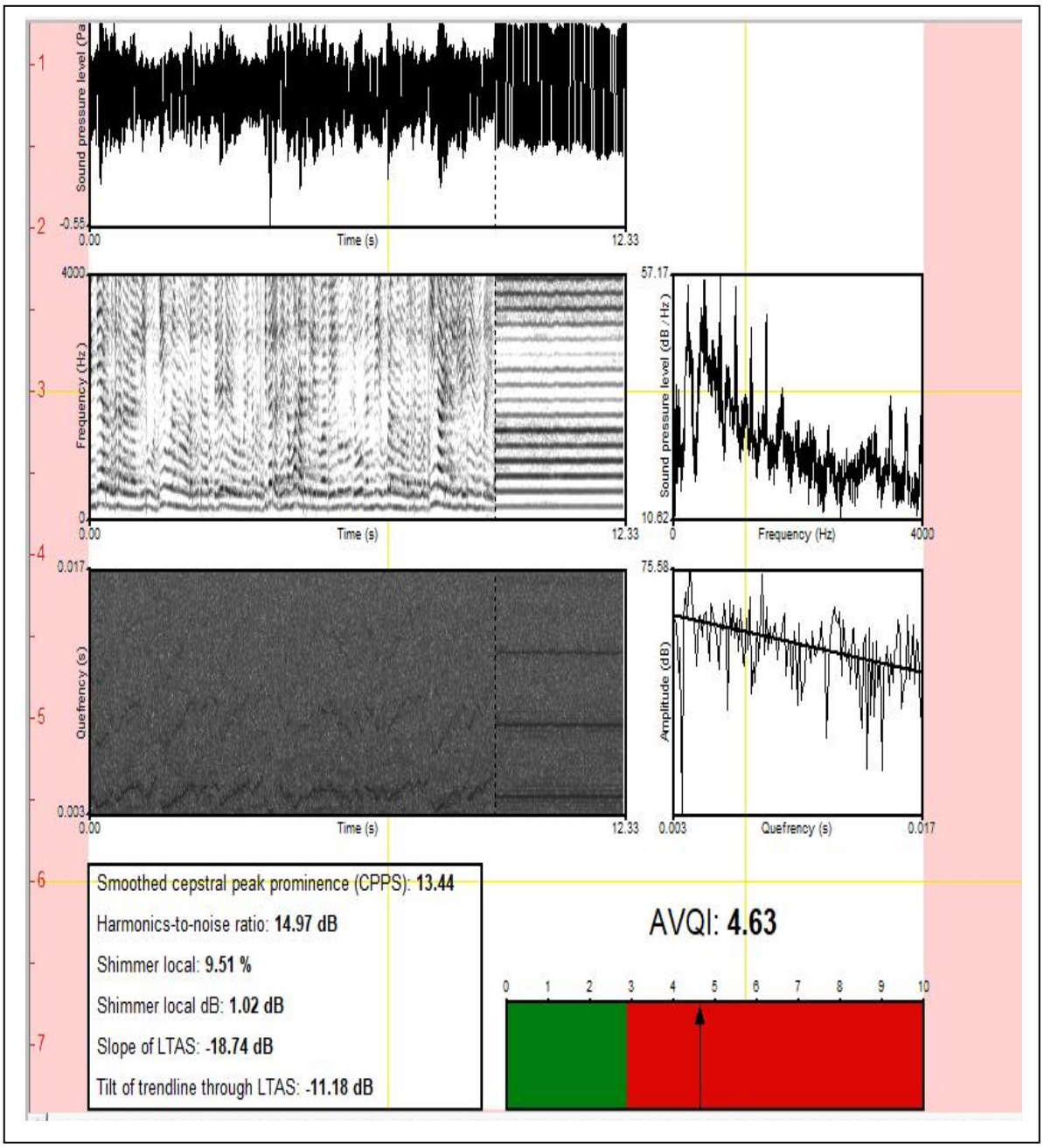
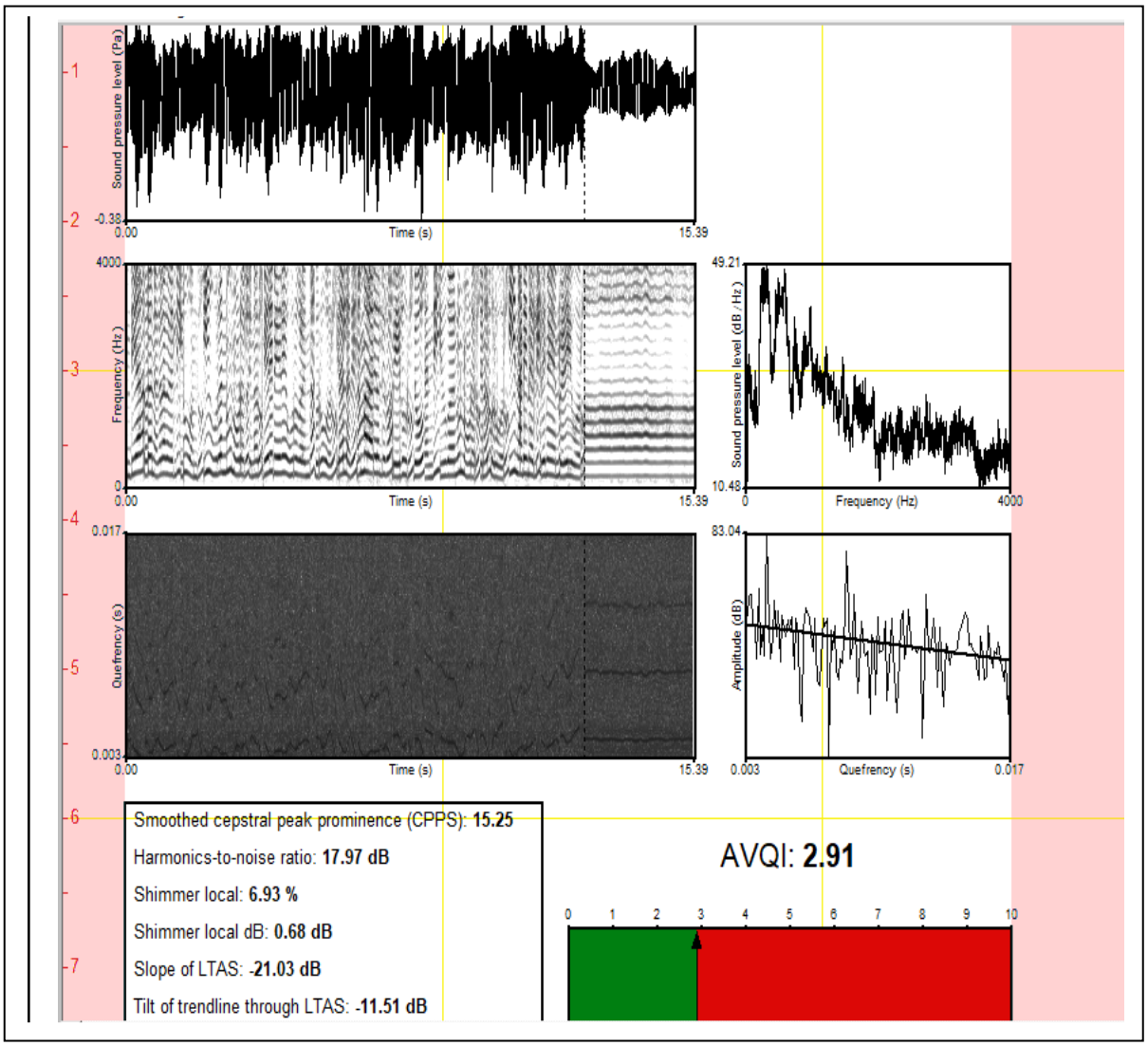


Figure 3.2

An Example of Graphical output of AVQI of non-singers.



Statistical analysis

The procured AVQI value of the Hindustani singers and the Non-singers were subjected to statistical analysis using SPSS version 20 to derive

- The normality of the data.
- The comparison between AVQI and its constituents scores of Hindustani singers and Non-singers .
- The effect of gender on AVQI and its constituents.
- The effect of experience of singing on AVQI and its constituents.

Chapter 4

Results

This study was carried out to estimate the AVQI value of Hindustani singers and also to compare it with the AVQI scores of Non-singers. Voice samples of 30 Hindustani singers and 30 Non-singers were collected for two vocal tasks such as phonation of vowel /a/ for minimum 8 seconds and reading sample. AVQI values for both the group were calculated. Descriptive and inferential statistics were carried out using SPSS version 21 software. The results of the study are explained in the following titles:

- Normality check.
- Mean, Standard deviation and comparison of AVQI and its constituent parameters of Hindustani singers and Non-singers.
- Effect of gender on AVQI scores and its constituents.
- Effect of experience on AVQI scores and its constituents.

Normality check

The data collected for the study was checked for normality using Shapiro Wilk's test. By separating the data (Hindustani singer and Non-singer) all parameters other than the tilt of LTAS ($p=0.00$) followed a normal distribution with $p>0.05$.

Mean, Standard deviation and comparison of AVQI and its constituent parameters of Hindustani singers and Non-singers

AVQI value and its constituent's values were obtained for 30 Hindustani singers and 30 Non-singers. The mean and standard deviation of AVQI and its parameters are depicted in table 4.1. The mean AVQI value was found to be 4.86 for Hindustani singers and 3.87 for Non-singers. On observing the constituents of AVQI, CPPs, HNR and slope of LTAS were found to be lower in singers and shimmer local, shimmer dB and tilt of LTAS were found to be higher in singers. Multivariate Analysis of Variance (MANOVA) was carried out to compare the two groups. A significant difference is found between both the groups for AVQI and all its constituents ($P<0.05$) except slope of LTAS. Figure 4.1, depicts the comparison of Hindustani singers and Non-singers and Figure 4.2 and 4.3 depicts the comparison of Hindustani singers and Non-singers across genders..

Table 4.1

Mean, SD and Comparison between Hindustani Singers and Non-singers

Parameter	**Hindustani Singers**		**Non-singers**		**F-value**	***p*-value**
	Mean	**SD**	**Mean**	**SD**		
AVQI	4.86	0.70	3.87	0.55	29.7	0.00**
CPPS	12.32	0.96	13.68	1.16	22.2	0.00**
HNR	14.93	1.92	16.58	1.59	10.7	0.00**
Shimmer local	9.92	1.68	7.38	1.79	28.62	0.00**
Shimmer dB	0.97	0.13	0.77	0.09	38.9	0.00**
Slope of LTAS	-22.33	2.21	-19.09	8.57	2.87	0.09
Tilt LTAS	-9.62	3.86	-10.65	0.81	4.13	0.04*

** $p<0.01$,* $p<0.05$

Figure 4.1

Comparison between Hindustani Singers and Non-singers

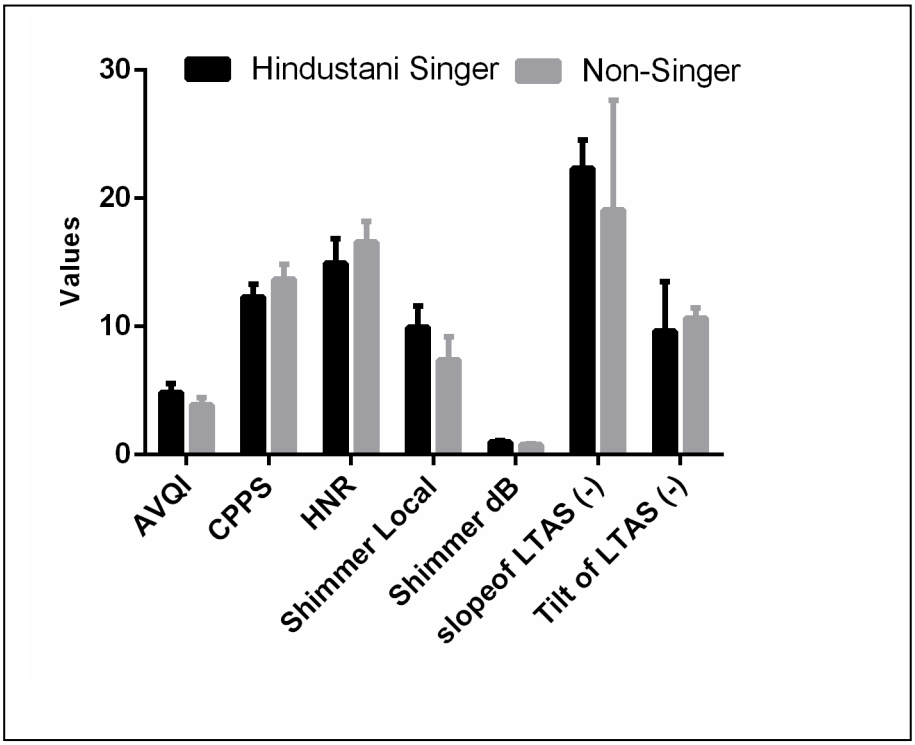


Figure 4.2

Comparison between Female Singer and Non-singer

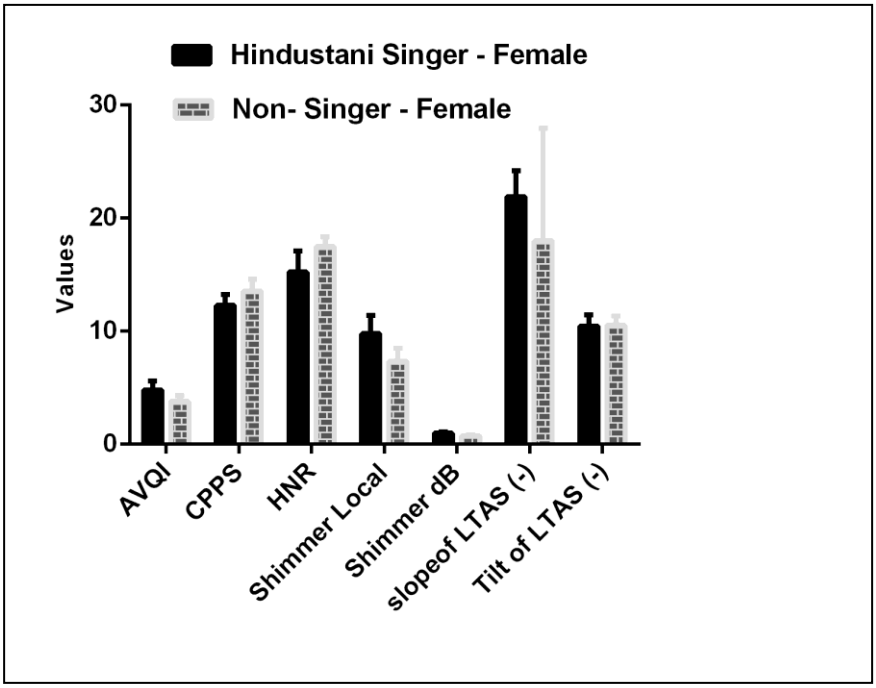
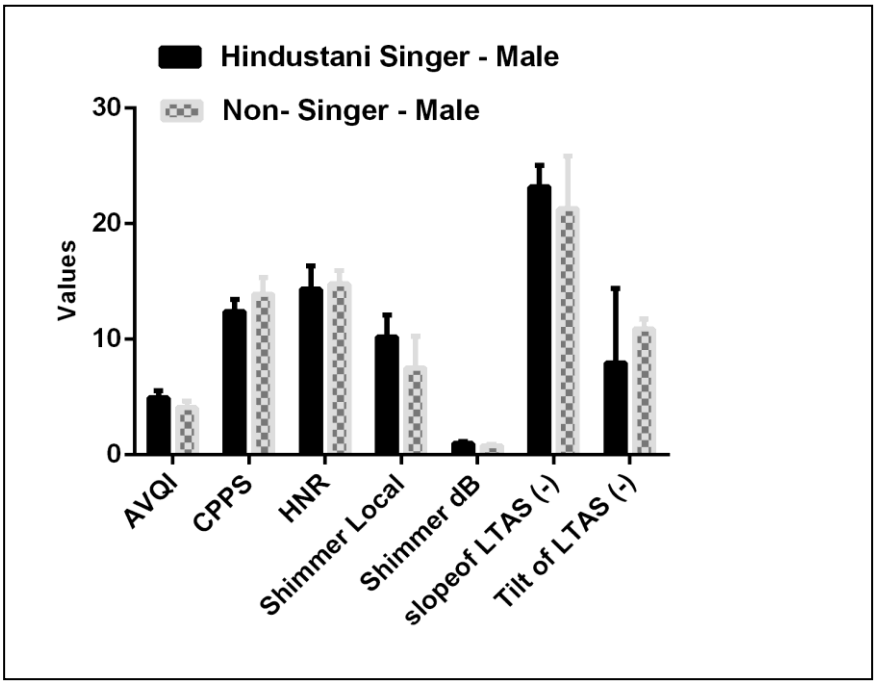


Figure 4.3

Comparison between Male Singer and Non-singer



Effect of gender on AVQI scores and its constituent's scores

Multivariate Analysis of Variance (MANOVA) was carried out to find the effect gender on AVQI and its constituents. The values are depicted in table 4.2. Results revealed that there is no effect of gender on AVQI and its constituents except for HNR. When AVQI and its constituents is compared between male and female singers significant difference is not observed except in tilt of LTAS. The values are depicted in table 4.3. A significant difference is found for HNR and shimmer dB when AVQI and its constituents is compared between male and female Non-singers. The values are depicted in table 4.4.

Table 4.2

Mean, SD and Gender Comparison of AVQI and its Constituents.

Parameter	**Male**		**Female**		**F- value**	***p*-value**
	Mean	**SD**	**Mean**	**SD**		
AVQI	4.51	0.71	4.29	0.84	1.56	0.21
CPPS	13.15	1.43	12.92	1.18	0.59	0.44
HNR	14.56	1.60	16.36	1.82	19.05	0.00**
Shimmer local	8.85	2.67	8.55	1.86	0.38	0.53
Shimmer dB	0.90	0.14	0.86	0.15	1.81	0.18
Slope of LTAS	-22.23	3.52	-19.94	7.38	1.78	0.18
Tilt LTAS	-9.4	4.71	-10.50	0.88	2.08	0.14

** $p<0.01$

Table 4.3

Mean, SD and Gender Comparison between Non-singers.

Parameter	**Male Non-singer**		**Female Non-singer**		**F-value**	***p*- value**
	Mean	**SD**	**Mean**	**SD**		
AVQI	4.08	0.54	3.77	0.75	2.1	0.15
CPPS	13.90	1.42	13.57	0.95	0.55	0.46
HNR	14.79	1.13	16.5	1.86	53.1	0.00**
Shimmer local	7.50	2.72	7.38	11.61	0.05	0.81
Shimmer dB	0.82	0.08	0.77	0.12	4.56	0.04*
Slope of LTAS	-21.29	9.93	-19.09	2.29	0.98	0.33
Tilt LTAS	-10.89	0.79	-10.65	0.99	1.26	0.27

** $p<0.01$,* $p<0.05$

Table 4.4

Mean, SD and Gender Comparison between Hindustani Singers

Parameter	**Male Non-singer**		**Female Non-singer**		**F-value**	***p*- value**
	Mean	**SD**	**Mean**	**SD**		
AVQI	4.94	0.61	4.81	0.75	0.21	0.64
CPPS	12.40	1.02	12.28	0.95	0.10	0.75
HNR	14.32	2.00	15.24	1.86	1.54	0.22
Shimmer local	10.21	1.87	9.78	11.61	0.42	0.52
Shimmer dB	0.98	0.14	0.97	0.12	0.04	0.83
Slope of LTAS	-23.18	1.85	-21.9	2.29	2.33	0.13
Tilt LTAS	-7.96	6.43	-10.45	0.99	2.96	0.09

Effect of experience on AVQI scores and its constituents:

One-way ANOVA was carried out to find the effect of experience on AVQI between two groups of Hindustani singers the values are depicted in table 4.5. No significant difference was found for AVQI and its constituents between the groups. Figure 4.4 depicts the graph comparing the two groups of singers.

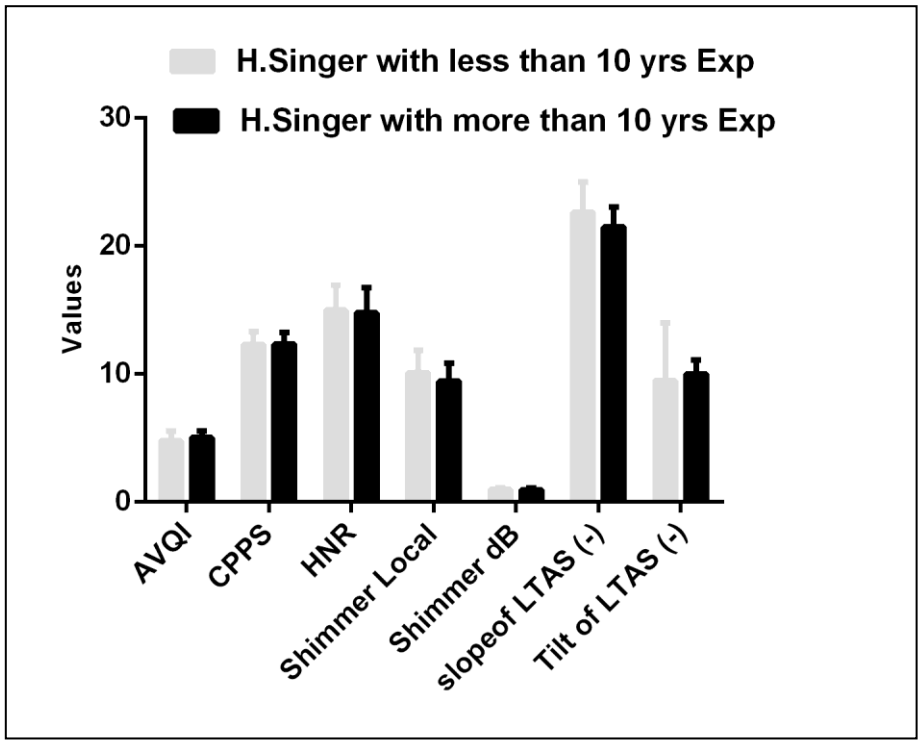
Table 4.5

Mean and Comparison between Two Groups of Singers

Parameters	**Mean Experience >10 years (n= 8)**	**Mean Experience < 10 years (n=22)**	**F-value**	***p*-value**
AVQI	5.03	4.79	0.64	0.43
CPPS	12.34	12.31	0.09	0.92
HNR	14.79	14.98	0.56	0.81
Shimmer local	9.43	10.11	0.95	0.33
Shimmer dB	0.97	0.98	0.57	0.81
Slope of LTAS	-21.48	-22.64	1.63	0.21
Tilt LTAS	-10.01	-9.4	0.10	0.74

Figure 4.4

Mean and Comparison between Two Group of Singers



Chapter 5

Discussion

Assessment of voice, including the voice quality and severity of dysphonia, was not found to be satisfactory with single parameter measurement, which led to the recommendation of multi-parametric approaches. Among the various multi-parametric approaches AVQI framed by Maryn et al., (2010) is a tool which assesses voice quality using both sustained phonation and continuous speech. Voice quality of singers has been analysed using many tools, and it has been found to be better than non-singers. AVQI being found to a promising tool for measuring the voice quality invariant across gender (Barsties et al., 2017; Jayakumar et al.,2020) and languages and a lack of measurement in professional voice users, this study aimed to find the AVQI value for Hindustani singers and to find how it varies from Non- Singers. AVQI was measured for age and gender-matched 30 Hindustani singers and Non-Singers between 18 to 40 years.

Comparison of AVQI and its constituents between Hindustani singers and Non-Singers:

The procured mean AVQI value of Hindustani singers was 4.86, which was poorer than the AVQI values procured by Non-Singers which was 3.87. These values were slightly higher than the normal AVQI values reported in the literature, e.g., 3.03 in Kannada and 3.00 in Malayalam (Benoy, 2017); 2.76 in Tamil (Vishali,2019); 3.07 in French (Maryn et al.,2017); 2.70 in German (Barsties & Maryn, 2012); 3.12 in Japanese (Hosokawa et al.,2017); 2.97 in Lithuanian (Uloza et al.,2017); 2.80 in Dutch (Barsties & Maryn, 2015); 3.25 in English (Maryn,2014) revealing the need the of perceptual evaluation before measurement of AVQI. AVQI value for singers is not available till date in the literature. Present study shows poor voice quality in Hindustani singers. It can be attributed to improper vocal warm-ups, poor vocal

hygiene and vocal abuse. Timmermans, 2005 reported that singers will have poor voice quality if the vocal hygiene behaviors such as warm-up exercises, hydration, vocal rest, and medical considerations such for allergies, reflux, infections and environmental irritants, medication are not taken in consideration.

From the literature it is known that singers are more sensitive to early symptoms of voice problems compared to that of non-singers (Rosen & Murry, 2000).Similarly AVQI was measured in 26 Dutch theatre artists by Dhaeseleer et al. (2016). The mean AVQI value was found to be 3.48 which corresponded to mild dysphonia. They concluded that this high AVQI value can be attributed to violent vocal behavior and poor vocal hygiene. In concern with this two professional voice users, poor voice quality is observed in them compared to the non-professional voice users using AVQI value. Professional voice users were observed to have poor voice quality when compared to non-professional voice users due to poorly balanced vocal coaching (Timmermans et al., 2005). 59% of the singers were reported to have voice problems due to their abusive vocal habits and poor vocal hygiene (Boominathan et al.,2005). Knowledge of vocal hygiene when compared between Carnatic and Hindustani singers showed better knowledge for Carnatic singers than Hindustani singers and also Carnatic singers were found to take more preventive measures for voice problem than Hindustani singers (Supraja, 2007).This literature suggest poor vocal hygiene awareness in Hindustani singers.

But several studies on the voice of singers have revealed better voice quality in singers compared to Non-singers which is in contradiction with results of this study. A study by Bandhopadhyay et.al., (2019) on comparing the phonetogram parameters of Hindustani trained singers, untrained singers and non-singers found significant difference between the three groups in speech range profile and voice range profile with greater frequency range, higher intensity

range and greater phonetogram area in trained singers concluding greater vocal dynamics in them due to increased respiratory lung capacity, increase lung and ribcage volume and usage of different respiratory posture. Hindustani singers were found to have higher singing power ratio and higher amplitude of singer's formant which explains the resonant ability of voice, compared to non-singers due to their wide pharyngeal opening revealing better quality of voice in them (Joshi & Raju, 2016). Hindustani singers were reported to have lesser mean pitch, lesser frequency perturbation, lesser intensity perturbation, higher HNR compared to Carnatic singers (Thomas & Patil,2014). Awan and Ensslen (2010), Maruthy & Ravibabu, (2015) found higher DSI scores in trained singers compared to Non- singers with lesser jitter in trained singers representing better voice quality in singers. Gunjawate et al. (2018) reviewed 26 studies on acoustic analysis of the voice of singers. Different acoustic measures fundamental frequency, perturbation, cepstral, spectral, dysphonia severity index, singing power ratio etc. were measured and were found to be better for singers (Awan & Ensslen, 2010; Arunachalam et al., 2014; Balasubramanium et al., 2015; Brown et al., 1993; Brown et al., 2000; Cesari et al., 2012; de Almeida Bezerra et al., 2009; Delviniotis,2013; Dong et al., 2014; Echternach & Richter, 2012; Gunjawate et al., 2015; Guzman et al., 2013; Hakes et al., 1988; Hamdam et al., 2008; Hanayama et al., 2009; Hoffman-Ruddy et al., 2001; Larrouy-Maestri et al., 2014;Lundy et al., 2000; Maruthy & Ravibabu, 2015; Mendes et al., 2013Omori et al., 1996; ; Peppard et al., 1988; Prakup, 2012; Rehder & Behlau, 2008; Rothman et al., 2001; Sataloff et al., 2012)

Smoothened Cepstral Peak Prominence of Hindustani singers were less than Non-singers which is in negation with the literature revealing higher CPPs in Carnatic singers than Non-Singers (Balasubramanium et al., 2015). A significant difference was found for HNR between Hindustani singers and Non-singers with higher HNR in Non-singers this is supported by the

study carried out by (Yoo et.al., 2002) which compared the voice characteristic of classical singing students and other college students. This study showed higher shimmer in singers than non-singers which is contradicted by the study done by Pakrup (2012) which observed no significant difference between singers and Non-singers for Shimmer. Barrichelo et al. (2001) found a significant difference between the LTAS of singers and non-singers. Male singers were found to have more energy at 3000Hz compared to non-singers, and female singers were found to have more energy at 2480, 3000, 3480 and 4000Hz than non-singers. The better voice quality of singers compared to non-singers was explained due to their better coordination of respiratory, articulatory and phonatory system, increased breath support and vocal hygiene behaviours.

Effect of gender on AVQI and its constituents:

AVQI values between males and females didn't not show significant difference in this study, which aligns with the study done by Barsties et al. (2017) on 123 vocally healthy adults including 55 males and 68 females of 20 to 79 years to find the impact of gender and age on AVQI and its constituents and also with the study done by Jayakumar et al. (2020) which studied the effect of gender on 200 participants which included 100 adults, 50 older adults and 50 pediatrics.

A significant effect of gender was found only in HNR of the constituents of AVQI. Other constituents did not show any significant impact of gender. Males were found to have lower HNR values compared to females. This result is in accord with the study carried out by Goy et al. (2013) which concluded that lower HNR values in males than females was due to the anatomical and physical variations found across the genders. Heffernan (2004) on comparing the voice of males and females of Canadian English and Japnese also found lower HNR in males compared to females in both the group. Teixeira and Fernandes (2014) analysed jitter, Shimmer and

harmonic to noise ratio parameters of voice in 34 females and 7 males. HNR and Shimmer local, shimmer dB were seen to be higher in females when compared to males, but a significant difference was not observed.

In this present study, between males and females Shimmer local and Shimmer dB were not significantly different. Sorensen and Horii (1983) on comparing the frequency and amplitude perturbation of males and females voice found significant lower shimmer values for females than males. Brockmann et al. (2008) analysing voices of 28 women and 29 men found lesser Shimmer in male compared to female on soft and medium phonation task. On considering CPPs, Significant difference is not found in this study. However, literatures reveal higher CPPs for males compared to females (Choi & Choi, 2016; Balasubramanium et.al., 2011) which is due to the fact that 80% of the females have posterior phonatory gap which leads to softer- less intense voice in them. A significant difference was not found between males and females for slope and tilt of LTAS. Yüksel and Gündüz (2018) analysed LTAS of 20 Turkish males and 20 females. Statistical difference was found for alpha values between the genders. Sergeant and Welch (2009) reported significant difference between girls and boys within the range of 4-11years in LTAS of singing voice which did not accord to the result of the present study.

Effect of singing experience on AVQI and its constituents:

A significant difference in AVQI and its constituents were not observed between the two groups of singers (experience <10 years & >10 years) in this study. This may be due to sampling inequalency between the two groups. In <10 years experience group, 22 participants and >10years experience group 8 participants were included. This result is in disagreement with the literature which reveals better voice quality in experienced singers than beginners.

Comparing the amplitude of singer's formant and singing power ratio among 3 groups i.e., non-singers, singers with less than 5 years of training and singers with 5-10 years of experience it is found that amplitude of singer's formant and singing power ration increased as years of experience increased (Joshi & Raju, 2016). Mendes et al.,(2003) reported a decrease in jitter and Shimmer and increase in speaking fundamental frequency within each semester in voice students indicating better voice quality with training. Hazlett, Duffy and Moorhead (2011) reviewed ten studies (Broaddus-Lawrence,2000; Bovo et al.,2007; Chan,1994; Duffey & Hazlett,2004; Illomaki et al., 2008; Lehto et al.,2003; Lehto et al., 2005; Pasa et al., 2007; stemle et al., 1994; Timmermans et al., 2004) to find the impact of voice training in voice quality of professional voice users. All the studies showed a significant difference in at least one of the voice parameters indicating better voice quality in individuals undergoing voice training, and the rationale was better respiratory and phonatory coordination, better knowledge and practice of vocal hygiene and vocal warm-ups.

Chapter 6

Summary and Conclusions

Assessment of voice quality is an inevitable part in diagnosing and managing various voice disorders, and it is in continuous revision in the literature starting from single parametric measurement to multi-parametric measurement approach. Though DSI was found to have good reliability due to its little limitation, another multi-parametric measurement tool was put forth by Maryn et al., (2010) which is Acoustic Voice Quality Index (AVQI). AVQI is being measured, and norms are being estimated for different languages and population, and it is found to a reliable tool. Since no literature available on AVQI values on singers, this study was taken up for estimating the AVQI value for Hindustani singers who belong to elite professional voice users.

The study included 30 Hindustani singers (20 females and 10 males) within the age range of 18 -40 years with minimum experience of 5 years in singing. Age and gender-matched Non-singers were included as the control group. Tasks such as sustained phonation of the vowel /a/ for a minimum 8 seconds and reading standardised passage sample were obtained from the participants. The collected data were analysed using AVQI version 2 script in praat software. Further, AVQI and the values of its constituents obtained were statistically analysed using SPSS version 21.

The results showed better AVQI scores for Non-singers compared to Hindustani singers revealing poor voice quality in Hindustani singers. However, the mean AVQI value obtained by the singers (4.86±0.7) and Non-singers (3.87±0.5) were slightly higher than the normative value found in the literature for Indian population, also across different languages. The poor voice

quality of singers is attributed to poor vocal hygiene, improper vocal warm-ups, and vocal abuse. Gender and years of experience in singing did not have an impact on AVQI value and all its constituents except HNR, which is found to be significantly lower in male compared to female.

Implications of the study:

- The obtained AVQI value for the Hindustani singers can be used in the assessment and management of Hindustani singers with voice disorders.
- The present study gave the reference value of AVQI and its constituents for Hindustani singers giving more knowledge about the unique voice characteristics pertaining to Hindustani singers, which can be compared with other related studies on the voice characteristics of Hindustani singers.

Limitation of the study:

- The distribution of the number of singers based on experience was unequal.
- Administration of any vocal hygiene questionnaire along with the testing would have given a better clarity on the results.
- More extensive demographic details inclusive of practice hours should have been included.
- Perceptual evaluation of voice should have been done on the participants before they took part in the study.
- Voice samples could have been better if they were recorded in sound treated rooms.

Future directions:

- Impact of experience of singing on Hindustani singers can be studied further with equal distribution of the number of singers in each group.
- Vocal hygiene and vocal behaviors of Hindustani singers can be studied in detail.
- Voice quality of Hindustani singers can be measured with other multi-paramteric approaches to check the reliability of the findings.
- AVQI normative can be estimated for other groups of singers and other professional voice users.

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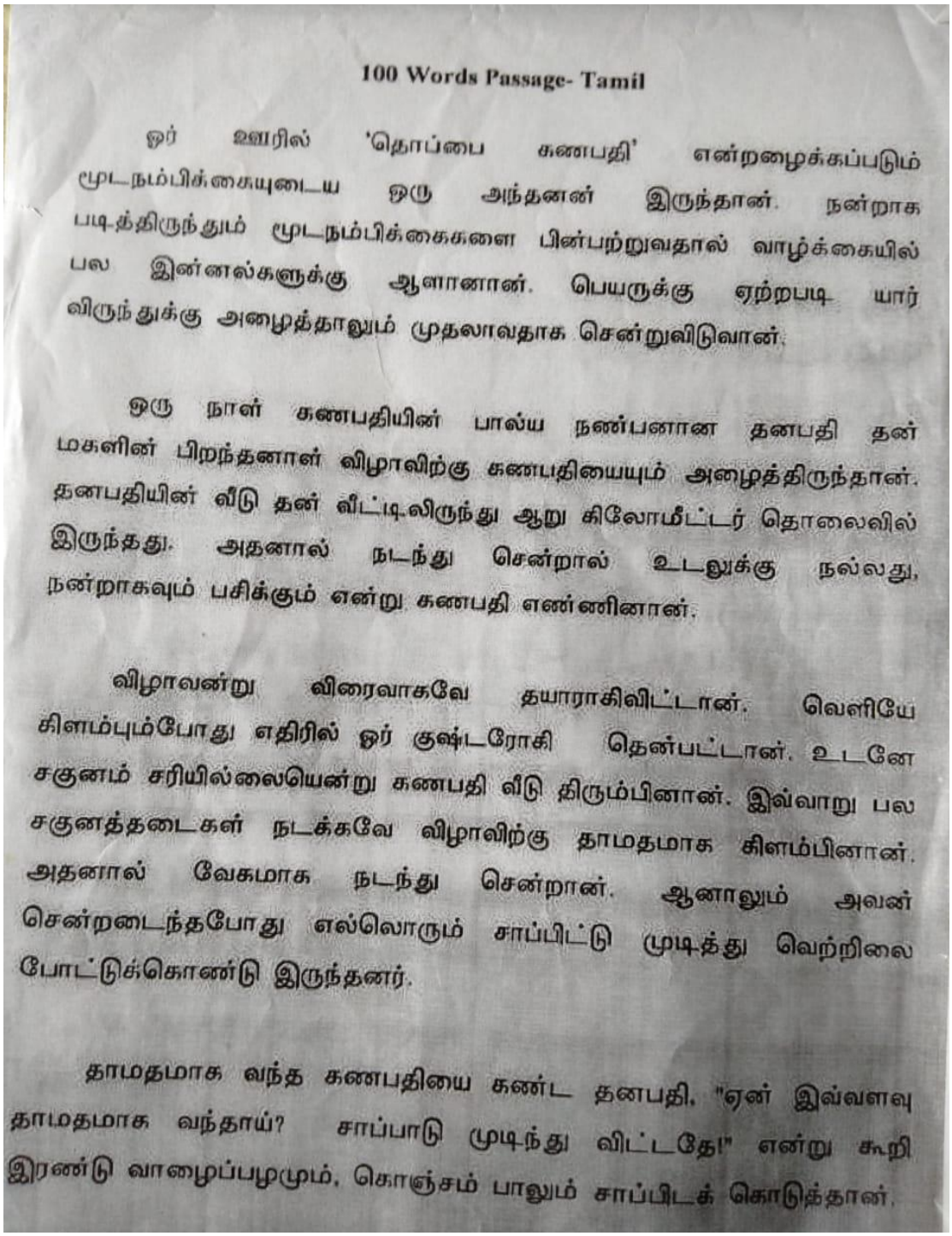
APPENDIX

Reading passages in Tamil, Kannada, Hindi and English



100 Words Passage- Tamil

ஓர் ஊரில் 'தொப்பை கணபதி' என்றழைக்கப்படும் மூடநம்பிக்கையுடைய ஒரு அந்தனன் இருந்தான். நன்றாக படித்திருந்தும் மூடநம்பிக்கைகளை பின்பற்றுவதால் வாழ்க்கையில் பல இன்னல்களுக்கு ஆளானான். பெயருக்கு ஏற்றபடி யார் விருந்துக்கு அழைத்தாலும் முதலாவதாக சென்றுவிடுவான்.

ஒரு நாள் கணபதியின் பால்ய நண்பனான தனபதி தன் மகளின் பிறந்தனாள் விழாவிற்கு கணபதியையும் அழைத்திருந்தான். தனபதியின் வீடு தன் வீட்டிலிருந்து ஆறு கிலோமீட்டர் தொலைவில் இருந்தது. அதனால் நடந்து சென்றால் உடலுக்கு நல்லது, நன்றாகவும் பசிக்கும் என்று கணபதி எண்ணினான்.

விழாவன்று விரைவாகவே தயாராகிவிட்டான். வெளியே கிளம்பும்போது எதிரில் ஓர் குஷ்டரோகி தென்பட்டான். உடனே சகுனம் சரியில்லையென்று கணபதி வீடு திரும்பினான். இவ்வாறு பல சகுனத்தடைகள் நடக்கவே விழாவிற்கு தாமதமாக கிளம்பினான். அதனால் வேகமாக நடந்து சென்றான். ஆனாலும் அவன் சென்றடைந்தபோது எல்லொரும் சாப்பிட்டு முடித்து வெற்றிலை போட்டுக்கொண்டு இருந்தனர்.

தாமதமாக வந்த கணபதியை கண்ட தனபதி, "ஏன் இவ்வளவு தாமதமாக வந்தாய்? சாப்பாடு முடிந்து விட்டதே!" என்று கூறி இரண்டு வாழைப்பழமும், கொஞ்சம் பாலும் சாப்பிடக் கொடுத்தான்.

HINDI PASSAGE

नारियल का पेड़ अधिकतर दक्षिण भारत में पाया जाता है। यह पेड़ हर एक घर में पाया जाता है। नारियल के पेड़ का हर भाग पत्तों से लेकर जड़ तक किसी न किसी काम में उपयोग में लाया जाता है। नारियल के पत्तो से घर की छत बनाई जाती है। और झाड़ भी बनाया जाता है। नारियल बहुत प्रकार के होते हैं। कोई गोल और कोई चौड़े। कई फल तो हरे भी रहते हैं और कोई पीले रंग के हो जाते हैं। नारियल बाहर से तगड़ा होता है पर अन्दर से मुलायम। इससे हमारी प्यास भी बुझती है और यह हमारे देह के लिए अच्छा माना जाता है। नारियल की तार से रस्सी बनाई जा सकती है; और इसे गद्दियाँ भरने में भी इस्तमाल करते हैं।

no. of words = 126

KANNADA PASSAGE

ಬೆಂಗಳೂರು ನಮ್ಮ ರಾಜ್ಯದ ಒಂದು ದೊಡ್ಡ ಊರು. ಈ ಊರನ್ನು ನಮ್ಮ ರಾಜ್ಯದ "ಬೊಂಬಾಯಿ" ಎನ್ನುವರು. ಇಂಡಿಯಾದ ದೊಡ್ಡ ನಗರಗಳಲ್ಲಿ ಇದೂ ಒಂದು. ಈ ಊರನ್ನು ನೋಡಲು ಜನರು ಬೇರೆ ಬೇರೆ ಊರುಗಳಿಂದ ಬರುವರು. ಇದಲ್ಲದೆ ನಮ್ಮ ರಾಜ್ಯದಲ್ಲಿರುವ ಬೇಲೂರು, ಜೋಗ್, ನಂದಿ, ಇವುಗಳನ್ನು ನೋಡಲು ಜನರು ಬರುವರು. ಈ ನಾಡಿನಲ್ಲಿ ರೇಷ್ಮೆಯನ್ನು ಬೆಳೆಯುವರು.

ಕೃಷ್ಣಾ ನದಿಯು ಸಹ್ಯಾದ್ರಿ ಪರ್ವತಗಳಲ್ಲಿ ಮಹಾಬಲೇಶ್ವರದ ಹತ್ತಿರ ಹುಟ್ಟುತ್ತದೆ. ಈ ಪ್ರದೇಶವು ರಮಣೀಯವಾದ ಸ್ಥಾನ. ಇದು ಮಹಾರಾಷ್ಟ್ರ, ಕರ್ನಾಟಕ ಮತ್ತು ಆಂಧ್ರಪ್ರದೇಶಗಳಲ್ಲಿ ಹರಿದು ಬಂಗಾಳ ಕೊಲ್ಲಿಯನ್ನು ಸೇರುತ್ತದೆ. ಇದಕ್ಕೆ ಉಪನದಿಗಳು ಹಲವು. ಕೊಯಿನಾ, ತುಂಗಭದ್ರಾ, ಘಟಪ್ರಭಾ, ಭೀಮಾ, ಮಲಪ್ರಭಾ– ಅವುಗಳಲ್ಲಿ ಕೆಲವು. ಕೊಯಿನಾ ನದಿಗೆ ಅಣೆಕಟ್ಟನ್ನು ಕಟ್ಟಿ ವಿದ್ಯುತ್ತನ್ನು ಉತ್ಪಾದನೆ ಮಾಡುತ್ತಾರೆ.

THE RAINBOW PASSAGE

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach, his friends say he is looking for the pot of gold at the end of the rainbow.

Throughout the centuries men have explained the rainbow in various ways. Some have accepted it as a miracle without physical explanation. To the Hebrews it was a token that there would be no more universal floods. The Greeks used to imagine that it was a sign from the Gods to foretell war or heavy rain. The Norsemen considered the rainbow as a bridge over which the Gods passed from earth to their home in the sky. Other men have tried to explain the phenomenon physically. Aristotle thought that the rainbow was caused by reflection of the sun's rays by the rain. Since then physicists have found that it is not reflection, but refraction by the raindrops which causes the rainbow. Many complicated ideas about the rainbow have been formed. The difference in the rainbow depends considerably upon the size of the water drops, and the width of the colored band increases as the size of the drops increases. The actual primary rainbow observed is said to be the effect of superposition of a number of bows. If the red of the second bow falls upon the green of the first, the result is to give a bow with an abnormally wide yellow band, since red and green lights when mixed form yellow. This is a very common type of bow, one showing mainly red and yellow, with little or no green or blue.