Development of norms for singing voice quality using singing power ratio for the female pre-pubertal trained and untrained classical singers, and non- singers

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CERTIFICATE

This is to certify that this dissertation entitled **"Development of norms for singing voice quality using singing power ratio for the female pre-pubertal trained and untrained classical singers, and non- singers"** is a bonafide work in part fulfillment for the degree of Master of Sciences (Speech-Language Pathology) of the student (Registration No. 13SLP031). 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.

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DECLARATION

This is to certify that this dissertation entitled **"Development of norms for singing voice quality using singing power ratio for the female pre-pubertal trained and untrained classical singers, and non- singers"** is the result of my own study under the guidance of Prof. Y. V. Geetha, Lecturer in Speech Sciences, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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Chapter 1

Introduction

Singing is the most versatile phenomenon which can be learnt by maintaining and balancing all the physical skills. Voicing is the primary important factor for singing and it requires control and coordination of all speech musculatures along with various speech subsystems. Singing is one of the ways to be more creative which could make individuals self expressive beings. Singing requires the voice mechanism to produce various musical modulations in a wide variety of ranges. A good singing voice quality can differ from a singing voice of a non-singer and various parameters can be quantified, that are perceptually recognizable by a trained experienced singer. Good singing voice quality includes an overall vocal performance where the aesthetic and technical quality of the singing voice is seen, such as, maintenance of the melody formulae as composed with a specific tune for that particular lyrics, follow of rhythm by maintaining the proper scale throughout, brilliance of tone which is called as ring in the voice that makes singer so special from the other group. Also, singing in tune with pitch accuracy, ability to sing freely throughout the pitch and dynamic range without inappropriate change in voice quality are the qualities of a good singing voice. Along with this certain aerodynamic parameters also vary and singers show more proficiency in controlling over the various speech subsystems than non singers. Trained and experienced singers will have more proficiency in breath management and control (Sundberg, 1990). Singers have special breathing habits in which pitch and loudness are coupled together for normal speech, both being dependent on subglottal pressure. Each and every note requires particular pressure

for singing in tune which is dependent on intended loudness and pitch for that particular song. Singers also differ in the production of their phonation and articulation (Sundberg, 1990).

Various western studies have documented the presence of singer's formant in talented singers (Watts, Murphy, & Barnes-Burroughs, 2003). In these studies, authors say that centre frequency of the singer's formant lies roughly between 2 and 4 kHz in power spectrum. Also, they have reported that there was an extra formant in sung vowels between the third and fourth formants of the spoken vowels and that this extra formant improved the ability of the vocal tract to transfer sound. In spite of many investigations, no uniform agreement of the definition of the singer's formant exists.

A talented singing is based on following the tune in voice quality, scale or pitch maintenance, loudness control along with the level of confidence. Apart from the natural ability, it is possible to train and achieve these qualities of talent to some extent. Even in untrained population there are people who are interested and good in singing and are termed as untrained talented singers. They have the ability of controlling pitch and production of pleasant timbre as that of the trained singers compared to untrained nontalented singers (Yarbrough, Green, Benson & Bowers, 1991). The ability to monitor vocal pitch has been identified as one variable related to singing talent (Goetze, Cooper, & Brown, 1990). Also, it has been suggested that the control of F0 is of paramount importance in singing (Titze, 1994). For talented singing, according to the experts, there are three most important variables to be considered and those are intonation, timbre, and musicality. The first two variables, intonation and timbre are related to physiological

singing abilities, i.e., pitch control and voice quality, respectively. Both factors can be measured objectively or experienced perceptually by a listener. Intonation is influenced by pitch control abilities. Timbre, or voice quality, is influenced by the supraglottal configuration of the vocal tract and its resonant effects on the voice source. It is possible to objectively investigate pitch control and voice quality in talented and nontalented persons via acoustic analyses of vocal productions. Study of these variables may provide evidence toward understanding the physiological capabilities that distinguish one group from the other.

The singing power ratio (SPR) is one such objective measure which quantifies the resonant quality of singers. The SPR indicates the quality of resonant tuning in the vocal tract, and represents the acoustic characteristics of singing voice quality. It is the ratio of the highest peak intensity between 2-4 kHz and 0-2 kHz frequency bands which can be analyzed by a sustained phonation or a singing sample (Omori, Kacker, Caroll, Riley & Blaugrund, 1995).

Singing is defined as the fundamental ability to express thoughts and emotions right from childhood and this facilitates the overall improvement and performance of social integration, language development and many other aspects. (Fuchs, Meuret, Geister, Pfohl, Thiel, Dietz, & Gelbrich, 2008). Many researchers have shown that there is a difference between singing voice quality when compared to children and adults. Perceptually children's voice has been described as being clearer, purer, echoey and non-fuzzy characteristics along with having lightness and clarity; beauty of tone and a clean white tone by the listeners (Howard, Williams, & Herbst, 2013). So, it is necessary to

know if before the pubertal changes occur in individuals, what will be the quality of their voice? How it differs from adults? Can they be advised to sing in future? and is it possible to judge whether a child can belong to a talented or non-talented category? Is there any objective tool that exists to quantify the voice quality of pre pubertal voices? These are some questions that need to be addressed by the researchers to provide the necessary advice to the parents or caregivers of the children who are interested in training their children to learn music.

Only few qualitative and quantitative researches are available which answers questions regarding singers in pre pubertal age range. Both the musical abilities and usage of vocal apparatus are influenced qualitatively by interaction of various psychosocial, organic and functional factors. Improvement in vocal performance and voice quality can be expected irrespective of age and gender through regular practice of singing from preschool age to young adulthood.

India is the place of birth for classical and Hindustani music, and also is the home for many popular singers and composers of classical music like Thyagarajamutt, Muttuswamy Dikshith, Vasudevachaarya, Hariprasad Chourasiya and Balamurali Krishna. Indian classical music has a long history and great pioneers and till date their compositions are included in the syllabus and sung right from young budding singers to experienced singers.

1.1. Need for the study

There are limited data base of published studies regarding SPR in the Indian context of classical music. The Carnatic music is one of the types of music which has its origins in the southern states of India; although it has global reach both in terms of trained musicians as well as the music lovers. The rendering styles of music vary widely with respect to different types of music such as Carnatic, Hindusthani, western classical and the non-classical varieties. Most of the studies are on adult singers which cannot be generalized to the children population although many talented young children have adult-like quality of rendering. Further, parents in their enthusiasm to develop talents in their young children, could force or pressurize children to learn music when they are not well equipped or have the necessary talent or skills for the same. The failure to learn on par with those who have the skill could frustrate them and jeopardize their ego. Hence, it is necessary to investigate to know if there are any qualitative and/or quantitative differences in terms of SPR in children compared to adults.

The present study was hence planned with the main aim to develop norms based on the Singer Power Ratio to classify pre-pubertal girls into female trained talented singers, untrained talented singers and untrained non talented singers. The specific objectives of the study are as follows:

Objectives of the study

- To investigate the differences if any in the SPR values among the three groups of prepubertal singers. i.e., trained talented singers, untrained talented singers and untrained non talented singers in singing
- To investigate the differences if any in the SPR values among the three groups of pre-pubertal female singers, i.e., trained talented singers, untrained talented singers and untrained non talented singers in phonation
- To develop normative SPR values for the classification of young voice samples under different categories

Chapter 2

Literature Review

"Speech is power: speech is to persuade, to convert, to compel. It is to bring another out of his bad sense into your good sense".

Ralph Waldo Emerson (1803-1882)

Exchange of thoughts, feelings, emotions, expressions, ideas and facts between two or more persons form a communication. Whole world is living in a network of communication in many means. Language is one of the main tools for a means of communication. Language is composed of many components like semantics, syntax, pragmatics, etc, which is bound by its rules and regulations which vary across the languages. Means of communication can be of verbal or non verbal type. Non verbal communication includes facial expressions, body language, manual signs, etc. Verbal communication is through speech and main component for the expression of speech is voicing.

2.1. Speech production

Speech production is known to be a very complex phenomenon which is made possible by intricate coordinated act of respiratory, phonatory, resonatory and articulatory system with an overall control of the nervous system. There are many theories which explain production of speech and it can be classified based on the voicing and vocal tract

function. Few theories among them are Acoustic theory of speech production or source filter theory or the linear time invariant source-filter theory that was put forth by Fant in 1960, perturbation theory, and component tube theory. Also, there are theories of voice production such as Myoelastic Aerodynamic Theory, Neurochronaxic Theory, Cavity Tone Theory, and Harmonic Theory. To produce speech and to communicate with the communication partner voicing is very important. Using the organs of speech to produce sound is called voicing.

Speech production system is broken down into two major components, the sound source and the filter/resonator and hence called source-filter theory and this stemmed out from the experiments of Johannes Müller in 1848. The sound which is rich in harmonic structure is created by the source and these sources can be classified as voiced, voiceless, voice plus noise and no source/ silence. The filter selects a portion of the harmonic frequencies to be radiated out of the mouth. Vibration of the vocal folds due to differential air pressure in the supra glottis and sub glottic region is responsible for the voicing component. Therefore larynx plays a major role in the production of voice apart from its primary function that is airway protection.

2.2. Singing

Singing is an art of producing the musical tones with the help of the voice. Singing requires following of melody, tune and rhythm and it augments the regular

speech. One who sings can be mentioned as vocalist or singer and one who gets formal training in any particular music style can be called as a trained singer. Trained singers who build their career as a singing professional by continuous rigorous practice for many years with dedication in one specific music genre and who can project a good voice in their singing can be called as professional singers. Singing can be either formal or informal. Formal singing is bound by many rules based on the type of singing or singing style or genre. Major classification of music genre is classical and rock. Classical music varies according to the geographical region and topography. It is sung with and/or accompaniment of background instrumental music. Good singing needs years of formal training from a professional vocal teacher with lot of dedication and years of practice. Formal singing and its practice needs lot of adjustments and modification with respect to projection of voicing, breathe management, etc, for increasing the vocal range and to achieve the "ring" in the voice.

2.3. Similarities and differences between physiological, perceptual and acoustic characteristics in the voice of singers and non-singers

Controlled physiological functioning of various systems like respiratory, laryngeal, phonatory and articulatory systems constitute singing and along with the maintenance of pitch, tune, melody, etc., constitutes good singing. A good singing requires quality training and mastery over all the aspects of singing leading to a great talented singing. There are lot of differences in singers and non singers in terms of their

physiological functioning of all the subsystems. Singers will have supported singing voice and its characteristics can be described as manageability and quality production. In terms of quality, singers' voice will have good clarity, resonance, and ring in the voice. Manageability can be accounted for breath management in terms of deep inhalation and exhalation, regulation of breath pressure and/or airflow, increased vocal ranges, laryngeal or vocal tract involvement, posture and expanding ability of the ribcage (Griffin, Woo, Colton, Casper, & Brewer, 1995). The chest wall configuration varies greatly in trained singers in their best projection of singing voice resulting in the larger ribcage dimension. There will also be a greater activation of medial abdominal muscles resulting in the decrease in small lateral dimension (Thorpe, Cala, Chapman, & Davis, 2001).

There are a few controversies in the literature with regard to the differences in physiological aspects of trained singers in comparison to untrained singers. When questions were asked to singers regarding the gaining of excellent voice, few attributed to the teachers, years of practice and few considered it to be the inborn physiological aptitude or talent they have got. Some physiological studies have reported that trained singers use various physiological strategies in comparison with the untrained singers and they do exhibit this feature only with respect to the singing tasks, but not in speaking tasks (Allen, & Wilder, 1977). Hunt and Williams (1988) have reported that there is no significant difference between trained and untrained singers in terms of their ability to control and/or discriminate the breath pressure and they attribute this to the technical training they undergo and not because they are physiologically endowed with these features.

Trained singers can maintain high subglottal pressure for the loud production of singing and also for raising the pitch. Breathing pattern of trained singers is so special that they could vary the subglottal pressure based on the particular tune they sing, because each and every note in singing have their own intended loudness and pitch unlike normal speech. Therefore, failure to produce the required pressure would result in singing out of tune (Sundberg, 1990). In trained singers it is reported that stability in one subsystem can result in variability in another. For instance, trained singers with vocal fold static lengthening pattern had fewer years of singing experience, where they could sing in higher octaves more comfortably and exhibit higher vital capacity rate but it was the other way for dynamic vocal fold lengthening pattern (Lam Tang, Boliek, & Rieger, 2008).

Sathyanarayana (1979), based on perceptual study reported that technical requirements for a good singing voice would be bright, clear, lustrous, ringing phonation which can also be called as sonorant, producing a perfect intonation and steady tone. Also, according to the musical demand, maintaining the steady flow and continuous sound production over the full vocal range, along with the ability to flex the voice is very essential. Brown, Howard and Christine (2000), reported that singers and non singers can be identified using their singing sample with more precision (87%) than using their phonation or reading sample (57%). In the perceptual studies, expert listeners rely more on the quality of voice and singing. The parameters and different descriptors they consider for classifying the singers category are; ring/ resonance, focus/ clarity, warmth/ colour, and appropriate vibrato. All these factors attribute to the overall vocal quality

along with “open throat” technique with which a desired even and consistent, balanced and coordinated voice can be projected (Kenny & Mitchell, 2007). In classical singing this open throat singing technique is fundamental to singing training and researchers are positive regarding the sound quality they achieve in classical singing (Mitchell & Kenny, 2007).

Acoustic measures of voice include fundamental frequency, duration, percent jitter and shimmer, presence or absence of singer’s formant, vibrato, and noise to harmonic ratio. All these acoustic parameters of singing voice can be used to differentiate the voice of singers from non singers. Brown et al., (2000) studied these parameters in singing voice of singers and non singers. They reported that the most consistent significant differences were found between singers’ and non singers’ with respect to the presence and absence of singer’s formant and vibrato respectively. In rest of the parameters no much differences were found.

One of the acoustic measures, “vibrato”, refers to the even pulsation of a pitch/ timbre which is a very good parameter to classify the voice under singers, especially in western music. The acoustic truth is that no voice is really steady for any given tone, but it varies evenly about 6-7 cycles per second, the vibration taking on intensity, pitch and quality. In any music, too much of vibrato makes the voice unpleasant and/or unstable, and too little will make it rigid or brittle. So, vibrato/ timbre in the voice can be improved with the proper manipulation of laryngeal muscles, using resonating cavities and appropriate practicing with good breathing pattern/ technique (Sathyanarayana, 1979).

2.4. Voice related issues in singers

More longitudinal researches need to be done in the field of children's voice and singing due to the maturity they achieve, rapid growth and development in their physiological vocal apparatus, amount of glottis closure, etc., Due to growing competency, urge of learning, and mastering the music and singing at young age, the vocal demand is created more like the problems faced by singers at all ages. Major problems reported by Carnatic classical singers within the age range of 18 to 74 years are change in voice, reduced range of pitch and loudness, dryness in throat, difficulty reaching higher and lower pitch, difficulty sustaining voice for a longer duration, strain in voice, and vocal fatigue. Also, majority of the singers suffer from laryngo-pharyngeal reflux associated with muscle tension dysphonia and chronic laryngitis (Arunachalam, Boominathan, & Mahalingam, 2014). In children during pre-school age more vocal abuse happens due to shouting, playing, etc. Along with that if excessive and incorrect use of voice in singing is present, then it leads to functional and secondary organic impairments in them. In children due to high fundamental frequency, mechanical stress in phonation happens which causes more friction of vocal folds leading to vascular disturbances of its outer cover epithelium. This is one of the reasons for emerging vocal nodules in children (Fuchs et al., 2007).

A descriptive cross sectional study done by Erickson (2012), collected data from artists, musicians and few non singers in the age ranges from younger than 20 years to 65 years through the administration of a 53 itemed questionnaire to study the vocal demand

and vocal health of traditional/ acoustic musicians. He reported that 41% of the artists did not have voice training, 34% had some formal vocal training, 41% had already experienced a tired voice, and 30% had experienced their top range or complete loss of voice at least once in their career span (Erickson, 2012).

2.5. Difference between trained, talented and nontalented singers

There have been many studies regarding classification of singers with respect to singer's formant and singing power ratio, where the empirical values and related evidence shows how singers are special in all aspects from others. Professional singers have the ability to project their voice with a high quality and what is known as "ring", which can be heard in spite of background music or orchestra without any amplification (Omori, Kacker, Carroll, Riley, & Blaugrund, 1996). Few researchers have mentioned this as singer's formant. Singer's formants are reported to be varying based on the voice type and the concentration of it towards its centre frequency also varies depending on the voice type. Since there is no uniform agreement regarding the definition of singer's formant, an objective tool was found called as singing power ratio (Omori et al., 1996**).** This tool defines and differentiates talented trained singing from non talented singing.

Training for singing is very important to improve many skills with respect to perceptual matching of tone, modulation of pitch and melody, and a few individuals will exhibit singing talent without any formal training. Various studies have been done to investigate and compare the perceptual and physiological variables for the singing voice

and often segregated the groups as singers v/s non singers, professionals v/s non professionals, talented v/s non talented, trained v/s untrained etc., Watts, Murphy, and Barnes-burroughs, (2003) conducted a study where they included 5 female volunteers in 3 groups each and those groups are trained singers, untrained talented and non talented singers. The authors tried to find out the pitch matching accuracy in these groups in conditions of varying feedback by giving external feedback. Untrained talented singers were equally accurate like trained singers in matching pitch in all measured conditions when compared to non talented singers. Interestingly, when they had to rely on internal feedback, untrained talented singers were more accurate in matching the pitch than trained singers. According to Goetze, et al, (1990), trained singers rely more on their proprioceptive feedback and their internal voice sensitivities such as vibratory and muscular effort available during singing rather than external feedback. They also say this can be achieved through constant practice and experience in singing.

2.6. Studies related to Singing Power Ratio (SPR)

The first study done on Singing Power Ratio was by Omori, et al, (1996). They studied power spectrum of sung and spoken vowel sound /a/ using Fast Fourier Transform of 37 adult singers (16 non-professional males, and 21 professional females) and 20 adult non singers (10 males, 10 females). They presented the parameter “singing power ratio” which objectively represents the singing voice quality by taking the power ratio of greatest harmonics peak between 2 and 4 kHz which is called as singing power

peak (SPP) with greatest harmonic peak between 0 and 2 kHz. They reported greater SPR in singers than non-singers in both males and females, but there was no significant difference between professional and non-professional singers in males and females. Also, SPR was found to be greater for sung vowel /a/ compared with spoken vowel. There was significant difference found in SPR with respect to singers who had less singing training and who had more than 4 years of training. These findings were supported by the reason that SPR is influenced by the shape of the vocal tract resonators and not directly influenced by vocal fold vibration. Also, the singer's formant has lower amplitude in female voices, particularly in sopranos (Hollien, 1983). The SPR of sung sample of soprano singers were significantly lower than that in other voice type singers. They also found no significant difference of SPR between professional and non professional singers, as well as male and female singers. With respect to adult untrained talented and non talented singers, the talented singers were found to have higher harmonic tuning of the source spectrum by the superior vocal tract (Omori et al., 1996).

Watts et al, (2006) investigated the voice quality differences objectively in 12 untrained talented and 22 untrained non-talented singers. These singers were all women in the age range of 20-35 years. They took the sample of sung voice from the participants. The participants were made to sing the first stanza of "America the beautiful" song in their best singing voice at comfortable pitch and loudness level. For finding the SPR measure, Fast Fourier Transform was used to calculate the power spectra from the selected vocalic segments in the recordings done with Computerized Speech Lab, model 4400. Their results showed a significant difference of SPR in talented and non-talented

singers, where the SPR was 8 dB lesser than that of non talented group. This study used formant difference method for the calculation of SPR; where the energy peaks were calculated between 0 and 4 kHz and then subtracting the highest partial found between 2 and 4 kHz from highest partial found between 0 and 2 kHz. The lesser values of SPR represents high energy in the higher harmonics i.e., above 2 kHz in ratio to the energy in the lower harmonics i.e., below 2 kHz. Therefore, the increase in the perceived vocal "ring" was indicated by the lower SPR in formant difference method (Watts, Barnes-burroughs, Estis, & Blanton, 2006).

Kenny and Mitchell, (2007) correlated the perceptual rankings with the acoustic measures in 15 female classical singers for optimal sung voice sample, i.e., open throat singing and sub optimal sung voice sample which is reduced open throat singing. They considered 2 acoustic measurements; Singing Power Ratio (Omori et al., 1996) and energy ratio (ER) (Thorpe et al., 2001) and correlation of these were done with the perceptual rankings. The perceptual rankings did not match with the rankings of SPR and ER. They concluded that these acoustic measurements are not sensitive enough to find the changes in the same voice across optimal and sub optimal conditions; instead they can distinguish across a wider range of vocal quality (Kenny & Mitchell, 2007).

One of the Indian studies showed statistically no difference between SPR values of trained Carnatic singers and untrained singers, and also the absence of the singer's formant (Ram Mohan & Rajasudhakar, 2007). This study had two groups of participants, one being experimental with 10 female Carnatic singers trained for minimum of 6 years,

and the other being control group of 10 female participants who did not receive training. The authors mentioned that SPR may not be helpful in evaluating the progress of a singer's training towards the development of a perceptually rich vocal quality in Carnatic singing. According to these authors, the greater emphasis is seen in 2-4 kHz harmonic band which is called as singer's formant, only in western singers because they have to project their voice beyond the background instrumental music. However, in Carnatic music, singers rely more on background music and they go along with that.

In another Indian study, Supritha, Swathi and Rajasudhakar, (2011) noted that the SPR values could differentiate three levels (junior, senior and vidwath level) of Carnatic singers. Here the samples of singing voice of pillari geethe Lambodara of Malahari raga Roopaka tala, with and without background music was extracted from karaoke software of the same song. Background music was played to participants through headphones in two conditions, one at their comfortable listening loudness level and another at slightly higher than their comfortable level.

Kate and Zenobi (2011), defined the term Modified Singing Power Ratio (MSPR) based on the work of three studies. The MSPR is defined as the ratio of the power between 2 and 4.6 kHz and the power between 0 and 2 kHz (Kate et al., 2011). These studies included the SPR by Omori, et al, 1996, the acoustic power ratio (the ratio of power in frequency bands between 2-4 kHz and 0-2 kHz) to indicate the vowel projection according to Thorpe, Cala, Chapman, Davis, (2001). Weiss, Brown and Morris, (2001) reported that upper boundary of the measurement was extended to 4.6 kHz to account for "ring" in soprano voices.

The MSPR quantifies the relationship between power measurements in two frequency ranges i.e., 2-4.6 kHz and 0-2 kHz. Kate, et al, (2011) studied the listening behaviour and aural modelling effectiveness in undergraduate level singers and it included the performances by both male and female singers of all voice types i.e., soprano, mezzo, tenor and baritone/Bass. MSPR was calculated from the audio samples collected from the participants of all voice types after the aural modelling. Aural model consisted of newly composed music and had 5 pitches; the total duration of it was 6 seconds. All the participants were asked to listen to it for 10 minutes each day for six days and then their audio samples were collected for the measurement of MSPR. MSPR compares the total power between 2 and 4.6 kHz to the total power between 0 and 2 kHz, rather than identifying specific peaks. The results revealed no significant difference in MSPR between the groups which indicated that MSPR did not change as a result of aural modelling in singers.

All these studies talk about adult singers and the centre frequency of singer's formant with respect to adults and between genders. Children's singing and speaking behaviour have been studied as different entities. Rinta and Welch (2009), studied 60 ten years old children, and using high quality MP3 recorder 5 tasks were recorded from all the participants. The tasks were a) reading a preselected passage, b) speaking spontaneously, c) sustain vowels like /a/ or /e/ or /i/, d) vocalizing the pitch glides, and e) singing a preselected song. All the samples were analyzed perceptually by 3 independent judges using a designed perceptual voice assessment protocol. The results revealed that children possess one voice for generating speaking and singing activity and authors

reported that both the activities are produced by the same physiological structures and the same voice and these two behaviours are perceptually connected (Rinta & Welch, 2009).

A number of physiological, acoustic and perceptual parameters of voice vary from infant to childhood to adolescent, and continues further. Vocal tract growth, maturity matters for these changes. The pattern of growth of vocal tract is not same for all individuals and it depends on growth spurts. Rapid development can be seen from birth to infancy followed by an interval of slow growth in middle and late childhood; thereafter again rapid growth is seen during puberty where the fundamental frequency shifts happen which surely differentiates the voice to its respective genders. Gender discrimination using perceived voice in children would be very difficult due to similar physiological structures. Rate of gender identification in children are less accurate compared to adults (Sergeant & Frederick, 2007).

Usha, Jyotsna and Rajasudhakar, (2014) studied prepubertal age range of 8 to 12 years and found the SPR difference with three groups, i.e., trained classical singers, untrained talented and non-talented singers with limited number of subjects in each group (N = 44; Group 1 with 14 trained singers, Group 2 with 12 talented untrained singers, and Group 3 with 18 untrained non talented singers). The results showed significant difference between the trained and untrained singers, untrained talented and non talented singers in SPR values. This study again followed the formant power difference method (Watts et al., 2006) for the calculation of SPR.

So for all the research work done on singers and non-singers, the researchers have to rely on experienced professional singers to classify the sung or spoken samples of the

subjects under study as trained, talented and non talented group. Since SPR gives the objective measure of singing voice quality the present study investigates the SPR values among three groups of pre-pubertal singers. (i.e., trained talented singers, untrained talented singers and untrained non talented singers) with more number of subjects in each group. Also, the development of normative values will be helpful for the future research purposes where the researcher may not have to rely on any experienced professional singers for the classification. Using this normative, it is possible to develop a software which can predict the given voice sample into one of the categories based on which again the researcher can proceed with the further study using that sample. It can also serve as a tool to identify children who could be trained in singing without unduly pressurizing the children to perform in singing training.

Chapter 3

Method

The main aim of the study was to develop norms based on the Singing Power Ratio to classify pre-pubertal girls into female trained singers, untrained talented singers and untrained non talented singers. The following procedure was adopted to investigate the study objectives.

3.1. Participants

Ninety six pre pubertal female participants were taken in the age range of 8 – 10 years, out of which, based on the study criterion, thirty participants were categorized under group 1, that is, trained Carnatic classical singers (TTS) with the minimum training period of 1.6 to 2 years. Group 2 consisted of thirty two children who were considered as untrained talented singers (UTS). Group 3 consisted of 34 children who were considered as untrained non-talented singers (UNTS). Children under Group 2 and 3 did not receive any formal training or singing practice.

3.2. Inclusion criterion

Girls within the age range of 8 to 10 years and who have not entered their puberty were considered for the study. Among these those having a minimum of 1.6 to 2 years of singing experience in Carnatic music were considered for the talented singing group, children without training but still interested in singing were included for untrained

talented group. The children without training and not interested in singing were considered for untrained non talented group.

3.3. Exclusion criterion

Children with any speech, hearing and communication disorders and upper respiratory tract infections, asthma, allergies were excluded from the study.

3.4. Instruments and materials

1. Recorded music "Lambodara lakumikara" song (Malahari raga) and roopaka thala.
2. Computerized Speech Lab (CSL) 4500 software (Keypentax, New Jersy, USA).
3. Modified rating scale developed for operatic singers (Oates et al., 2005) based on the major eight qualities/ parameters which a Carnatic classical singing voice should possess.
4. Checklist prepared for the judges' rating of voice samples (See Appendix A).
5. SPSS software package for data entry and analysis.

3.5. Procedure

3.5.1. Ethical Procedure

Participants' parents were briefed about the study and before collecting the voice samples from the participants, written consent was obtained from them.

Participants in all groups were assessed for general speech-language, oro-facial, voice related, breathing and medical problems by collecting demographic data using a questionnaire (See Appendix B). Also, information regarding the year of singing experience, number of practice hours per day, and singing exposure inside/ outside home were collected through the questionnaire which was filled by their parents.

All the participants were asked to sing "Lambodara lakumikara" song (Malahari raga and roopaka thala) which is known song for trained Carnatic singers. The untrained singers were provided the recorded sample of the song sung by a professional singer and were given sufficient time to practice the song with the lyrics before recording the same. Along with this, sample of sustained vowel /a/ was recorded from all the participants in three trials in their comfortable loudness and pitch after taking a deep breath. The task was demonstrated by the experimenter before recording the same.

3.5.2. Instructions: following instructions were given to the participants for 2 tasks.

Task 1: "maintain a distance of 5cms from your mouth to microphone (which was mounted to a stand already), do not move the microphone stand and when you are ready, take a deep breath and say the vowel /a/ at your comfortable loudness and pitch at least for 7 to 8 sec. And repeat the same thrice".

Task 2: "Sing Lambodara lakumikara song at your most comfortable loudness and pitch".

The recordings of the samples were done in a quiet sound treated room. Participants were made to maintain 5 cms distance from their mouth to microphone and recordings were done using Computerized Speech Lab (CSL) 4500 software (KeyPentax, New Jersey, USA).

After the recording were done, all 96 singing samples of participants were given to three professional singers as judges who had singing experience in Carnatic music with minimum of 15 years. The samples were given in a compact disk to reassure and assign the children into groups as trained classical singers (TTS), untrained talented (UTS) and untrained non-talented singers (UNTS). These judges were given an Auditory-Perceptual Rating Instrument for Singing Voice quality with Equal Appearing Interval (EAI) Scale Form (See Appendix A) to judge the samples and categorize them under different groups as mentioned.

This perceptual analysis was done based on a rating scale which was developed for operatic singers by Oates et al in 2005. Modification of this scale was done based on the major eight qualities/ parameters which a Carnatic classical singing voice should possess according to the three professional singers who were trained in Carnatic classical music and had singing experience of more than 15 years. After the unanimous consent from three judges these eight parameters were included and a rating scale was developed. The eight parameters were; 1. Overall vocal performance (an overall rating of the aesthetic and technical quality of singing voice), 2. Melodic formulae (maintenance of raga), 3. Rhythm follow (rhythmic scale/ thala), 4. Ring (brilliance of tone), 5. Pitch accuracy (singing in tune), 6. Breath management (efficient breath management), 7. Evenness throughout the range (ability to sing freely throughout the pitch and dynamic range without inappropriate change in voice quality), and 8. Strain (voice quality that gives impression of excessive vocal effort).

On all the above mentioned parameters judges were asked to rate the given samples as poor (score 1), average (score 2), and good (score 3) for each of the parameter (highest score being 16 and lowest being 0) and rate the sample overall and categorize the same under TTS, UTS and UNTS. After receiving the ratings from the judges, best out of three ratings were considered for all the samples manually and 30 children came under TTS (Total score 13 to 16), 32 children under UTS (Total score 6 to 12) and 34 children under UNTS (Total score 0 to 5).

3.6. Analysis

All the samples were analyzed using Long Term Average Spectrum (LTAS) of CSL 4500 software to extract Singing Power Ratio. Out of three trials, last trial of phonated sample was taken with the time window of 5 seconds and for singing sample time window of 20 seconds, the middle portion was taken for the calculation of SPR. For both phonation and sung sample, LTAS was taken and highest amplitude was noted down manually in the frequency range of 0 to 2 kHz and 2 to 4 kHz. SPR was calculated by the formant difference method by subtracting the highest peak intensity between 2-4 kHz from 0-2 kHz frequency bands for both singing and phonation samples. Majority of the studies has taken formant difference method for the calculation of SPR, where lesser value indicates good singing. Also, the frequency measure corresponding to the highest amplitude was noted down and all the vales are tabulated. Then the SPR was tabulated for all three groups and compared across the groups for both kinds of samples i.e., singing and sustained vowel.

Later after a gap of 10 days, 16% of the samples from each group was taken and played randomly for the same three judges to rate the samples again for the reliability check.

3.6.1. Statistical Analysis

Statistical package for social sciences (SPSS) version 16.0 was used to analyze the data statistically. Test of normality was done to check for the normal distribution of the data set. Descriptive statistics was done to see the mean, and standard deviation. Parametric test, MANOVA was done to see the main, group and interaction effect across the groups. Spearmen's rho correlation coefficient was done to see the correlation of perceptual analysis and acoustic analysis of all groups group wise. Using descriptive statistics normative range was got for the classification of three groups.

Chapter 4

Results and Discussion

The objectives of the present study were to investigate the differences if any in the SPR values among the three groups of prepubertal singers i.e., trained talented singers (TTS), untrained talented singers (UTS) and untrained non talented singers (UNTS) in singing and phonation.

The results are discussed under the following subheadings:

1. Acoustic analysis of the samples
    a. Singing Power Ratio in phonation
    b. Singing Power Ratio in singing
2. Perceptual analysis of singing samples
3. Correlation of acoustic analysis and perceptual analysis
4. Normative for the SPR values for the classification of three groups

4.1. Acoustic analysis of the samples

4.1.1. Singing Power Ratio in phonation

The SPR was calculated in the study using the formant difference method, that is, SPR was calculated by subtracting the highest peak between 2 and 4 kHz from the level of the strongest peak between 0 and 2 kHz as reported by Watts, et al., (2006). In this method lesser SPR value indicates greater energy in the higher harmonics and it is seen in trained classical singers in this study. Table 4.1 provides mean and standard deviation of SPR for phonation across the three groups, namely the trained talented singers (Group 1),

untrained talented singers (Group 2) and untrained non talented singers (Group 3). Not many outliers were seen except for the four samples and standard deviations were not high. The test of normality was done for SPR values of phonation using Shapiro Wilk test of normality. Data followed normal distribution in all groups but for group 1 skewness of 0.068 was present. But data did not deviate much from normal distribution curve.

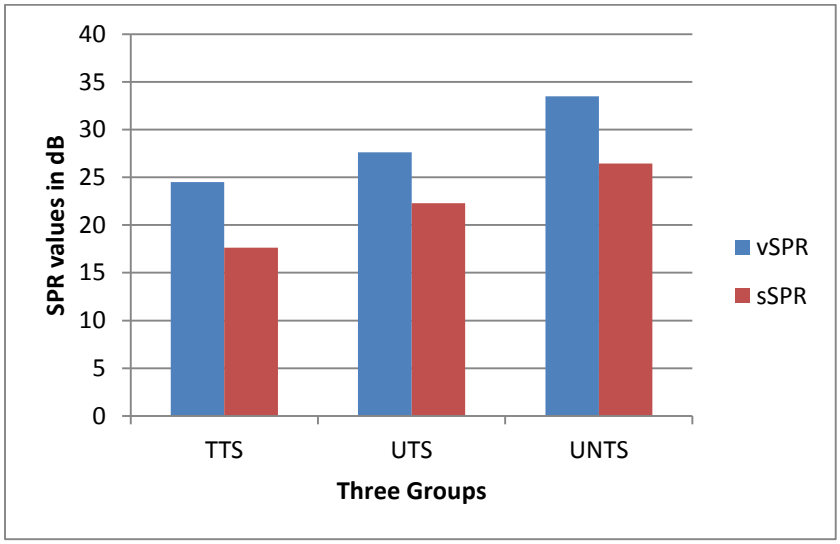
Table 4.1: *Mean (M) and standard deviation (SD) of SPR for phonation and singing across groups*

Groups	**Subjects**	**SPR for phonation (dB)**		**SPR for Singing (dB)**	
	N	**M**	**SD**	**M**	**SD**
Group 1	30	24.50	7.75	17.63	7.75
Group 2	30	27.63	4.90	22.29	5.62
Group 3	32	33.50	4.45	26.45	7.02

As seen in the table 4.1, the mean SPR is the lowest/least in trained classical singers (group 1) when compared to group 2 and group 3. Untrained non talented-singers (group 3) had the highest mean SPR value, among the three groups. Untrained talented singers (group 2) had mean SPR value in between group 1 and group 3 for phonation.

In formant ratio method as reported by Omori et al., (1996), higher SPR values indicates good singing. The reason for this is that singers have high harmonics in 2 to 4 kHz frequency range. Authors call it as centre frequency for singer's formant. This corresponds to the higher signal intensity between the third and fourth formant i.e., between 2 to 4 kHz in which the projection of voice quality will be good and makes the singer to be heard without amplification over background instrumental accompanying

music. So the higher peak values at this frequency range for singers is responsible for getting higher SPR values in formant ratio method (Omori et al., 1996), and lesser SPR values in Formant Difference Method (Watts et al., 2006). Therefore, the present study results for SPR of phonation are in consensus with the results of Omori et al., (1996).



[Note: TTS –Trained talented singers; UTS - Untrained talented singers; UNTS - Untrained non-talented singers]

Figure 4. 1: SPR *values of singing and phonation in the three groups*

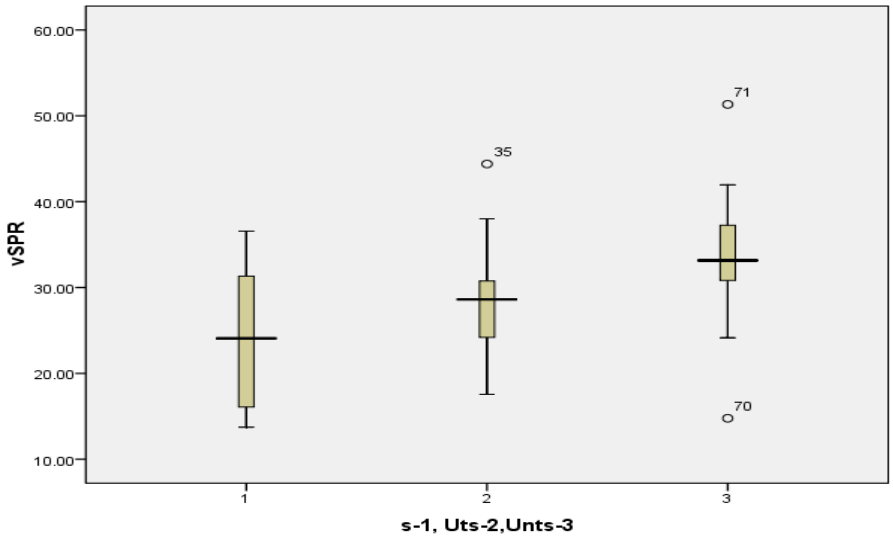


Figure 4. 2: *Box plot showing outliers in SPR of phonation in three groups*

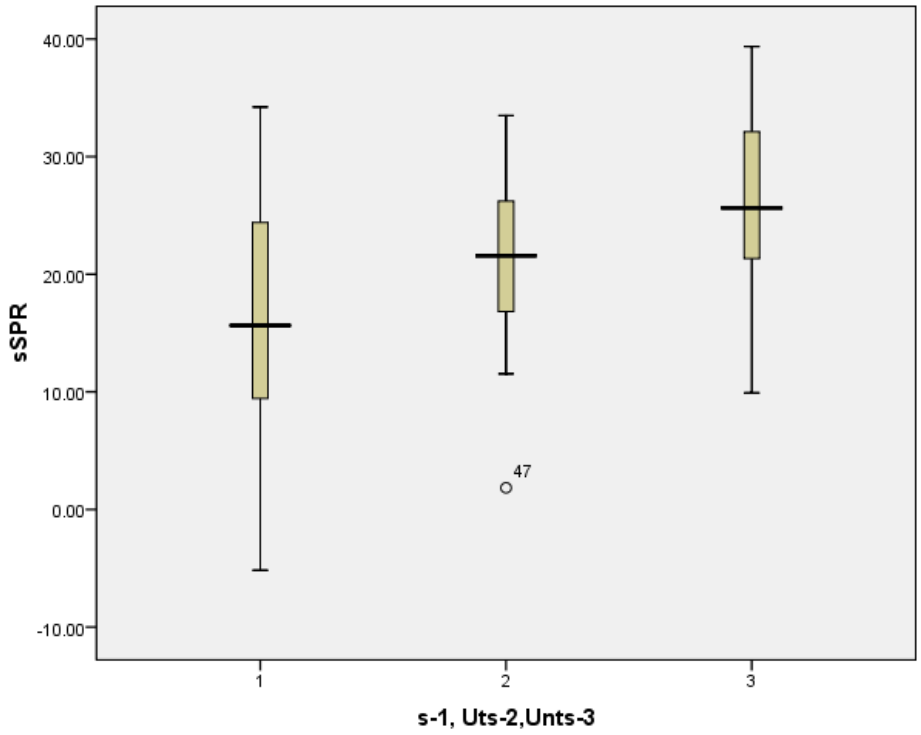


Figure 4. 3: *Box plot showing outliers in SPR of singing in three groups*

During the analysis 4 subjects' data (3 in SPR of phonation and 1 in SPR of singing) were removed because those data were found as outliers in box plots (Figures 4.2 & 4.3).

4.1.2. Singing Power Ratio in singing

Table 1 provides mean and standard deviation of SPR for singing across the three groups. After removing the outliers mean and standard deviation was calculated. Standard deviations did not cross the mean and it was not too high. The test of normality was done for SPR values of singing using Shapiro Wilk test of normality. Data followed

normal distribution for SPR values of singing for all three groups showing the p value > 0.05 for phonation.

As seen in figure 4.1, mean of the SPR for singing has followed the similar trend as seen for the SPR for phonation. But, the mean of phonation SPR was greater than singing SPR for all three groups. Here also the mean SPR was the lowest/least in trained classical singers (group 1) when compared to group 2 and group 3. Untrained non talented-singers (group 3) had the highest mean SPR value, among the three groups. Untrained talented singers (group 2) had mean SPR value in between group 1 and group 3 for singing.

Since data followed normal distribution, parametric test MANOVA was carried out to see the significant difference across the groups in each of the SPR. A significant difference was found for SPR values of phonation, [$F (2, 89) = 18.92$, $p < .05$] and singing, [$F (2, 89) = 12.76$, $p < .05$]. Since there was overall significant difference between all the groups across all the variables, Post Hoc Duncan tests were done to see the pair-wise comparison of SPR for phonation of vowels across groups. The results showed significant difference across all the three groups for both the SPRs for the alpha value 0.05.

Watts et al., (2003) have reported that untrained talented group can also possess similar qualities such as trained singers in tune following, pitch control, pitch matching and can present a pleasant timbre. But with the several years of rigorous practice under the proper guidance, singers can actually stand out with presence of “ring” in their voice. Greater energy in the spectral region has been argued to reflect on singing voice quality.

Also, there was a significant difference noticed in SPR value between the two groups. The lower SPR value for trained singers (group 1) reflects singing talent which indicates good quality of singing voice (Watts et al, 2006). Watts et al., (2006) studied two groups i.e., talented and non talented singers and calculated the SPR from the entire singing sample, where the talented group showed SPR of 8 dB lesser than the non talented group. The current findings also supported Usha et al., (2014) who had taken three groups similar to the present study with small sample size of pre pubertal classical singers. They reported lesser SPR values for trained singers, higher values for untrained non talented and in between values for the untrained talented group. Thus, the lower SPR indicates the singing talent in trained singers and consistently there is a higher value of SPR for non singers. In other words, untrained non talented group had always stood out as poor in singing and could be differentiated better from the other two groups whereas trained singers and untrained talented group showed almost similar SPR range.

In the present study, singers and non singers can be easily differentiated. Also, in untrained group, talented and non talented singers could be easily differentiated. The reasons might be because of the regular and more hours of singing practice. The present study has proved previous results with more number of participants compared to all the previous studies.

4.2. Perceptual analysis of singing samples

Perceptual analysis was done using the Auditory-Perceptual Rating Instrument for Singing Voice Quality. Three judges listened to the singing samples of all the participants

provided randomly and rated them on 8 parameters each being rated as minimum 0 and maximum 2. Final judgement was given through rankings as 1 for TTS (total score 0 to 5), 2 for UTS (total score 6 to 12), and 3 for UNTS (total score 13 to 16). Later, best two out of three rankings were taken manually for all the participants and they were assigned to respective three groups as seen in the table 4.2. Further, intra and inter-judge reliability was checked using statistical tool.

Table 4. 2: *Average scores of ratings done by three judges of all samples for three groups*

N	TTS	UTS	UNTS
1	15.5	7.5	2.5
2	14	7	1
3	16	9.5	0.5
4	14.5	6.5	1
5	13.5	6.5	1
6	16	6.5	1
7	15	7	1
8	16	8	1
9	15	6	0.5
10	16	8	1.5
11	16	6	0
12	13	7.5	0.5
13	15.5	6.5	0
14	15.5	7	0
15	14	7.5	0.5
16	16	7	1.5
17	16	10	0
18	15	7	1
19	14.5	8	2.5
20	15	7.5	1.5
21	15	7.5	1.5
22	15	8	1
23	16	7	1

24	16	6.5	1
25	14	6.5	1.5
26	15.5	7.5	1.5
27	14	7	1
28	14.5	8	1
29	14	7.5	0.5
30	15.5	8	1.5
31		7.5	0.5
32		6.5	0.5
33			1.5
34			1

4.2.1. Inter judge reliability

To verify the reliability of perceptual ratings by 3 judges, inter judge reliability test was performed for obtained ratings. For inter judge reliability, Kappa analysis was done because the final remarks of the ratings of the judgement were ranked. Reliability between judge 1 and judge 2 was found out to be 0.707, between judge 1 and judge 3 was 0.648 and between judge 2 and judge 3 was found out to be 0.756, with the p value, 0.05 for all the conditions. Since, the value is >6, it can be considered as good reliability and the ratings done by 3 judges are reliable.

4.2.2. Intra judge reliability

Perceptual judgement of 16% of the samples (5 samples) from each group was done and ratings of three judges were compared. Raw scores of the judges were almost same and the final remarks made by all judges were 100% reliable.

4.3. Correlation of acoustic analysis and perceptual analysis

After assigning the participants to groups based on the judges' ratings, SPR for both phonation and singing were tabulated. Spearman's rho correlation coefficient was done to see the correlation between the perceptual ratings and SPR of phonation and singing. The results revealed perfect positive correlation of 1 with $r = 0.432$, $p < 0.05$ for SPR of singing and $r = 0.515$, < 0.05 for SPR of phonation. Hence, we can surely say that the relationship between SPR and singers is good to make judgements about quality of voice in singers and non singers based on their phonation as well as singing samples. Professional singers can be easily differentiated from non singers by the listeners when they hear the singing sample (87%) than by listening to their speaking sample (57%) (Brown, Jr., Howard & Rothman, 2000).

4.4. Normative for the SPR values for the classification of three groups

Till now for all the research work done on singers and non-singers, the researchers had to rely on experienced professional singers to classify the sung or spoken samples of the subjects under study as trained, talented and non talented group. Since SPR gives the objective measure of singing voice quality, the present study investigated the SPR values among three groups of pre-pubertal singers with more number of participants in each group. The development of normative values will be helpful for the future research purposes where the researcher may not have to rely on any experienced professional singers for the classification. Using descriptive statistics at 95% confidence

interval of mean, lower bound and upper bound of statistic was found for both phonation and singing SPR values.

Table 4. 3: *Normative for the SPR values of phonation for three groups*

	Normative range	
	Lower limit (dB)	Upper limit (dB)
Group 1 (TTS)	21.6114	27.4066
Group 2 (UTS)	25.8049	29.4644
Group 3 (UNTS)	31.9004	35.1115

As seen in table 4.3, trained and untrained talented groups can be clearly distinguished from untrained non talented group. There is a large overlap in the upper limit of group 1 and lower limit of group 2, which makes it difficult to categorize the phonation sample under these two categories.

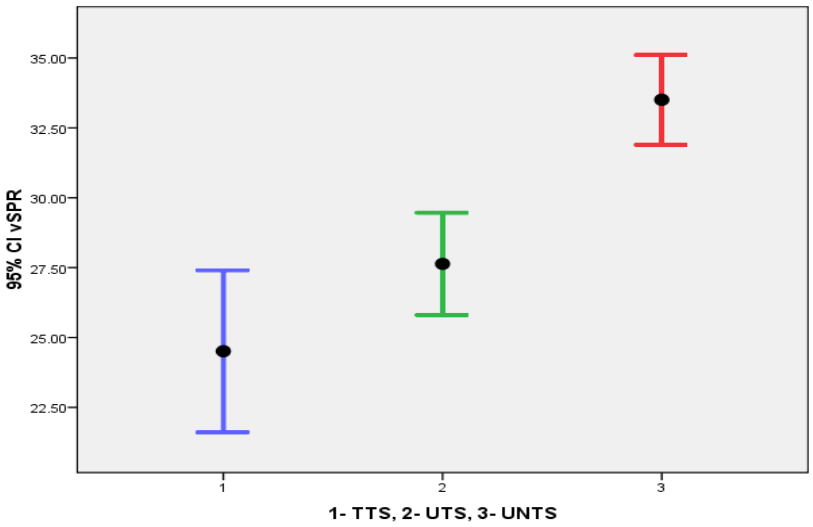


Figure 4.4: *Normative range for the SPR values of phonation for the classification of three groups*

Table 4.4: *Normative for the SPR values of singing for three groups*

	Normative range	
	Lower limit (dB)	Upper limit (dB)
Group 1 (TTS)	14.7413	20.5360
Group 2 (UTS)	20.1984	24.3956
Group 3 (UNTS)	23.9183	28.9836

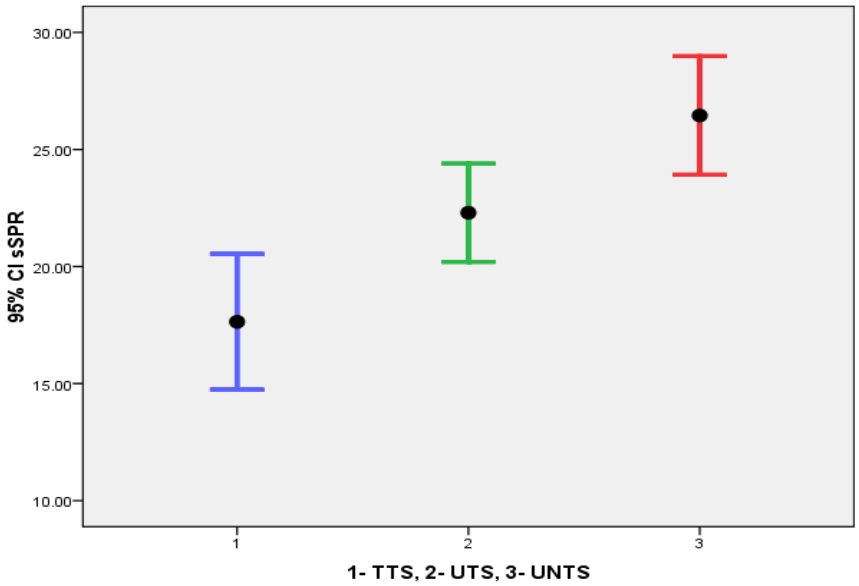


Figure 4.5: *Normative range for the SPR values of singing for the classification of three groups*

As mentioned in table 4.4, the normative values of SPR for singing, upper and lower limit values could clearly separate the SPR values for all three groups. As seen in figure 4.5, an overlap is present between the upper limit of group 1 and lower limit of

group 2 with the difference of 0.3376, also overlap between upper limit of group 2 and lower limit of group 3 with the difference of 0.4773. But the overlapped values are very.

These differences in both normative of phonation and singing may be overcome if more number of subjects is taken for the study in future research work. Also, the differentiation of talented and non talented singers should be made even more crucial by improvising or by adding more parameters for the rating scale for the better categorization of these two groups by the judges to create a clear gap between them in the normative range.

Using this normative, it is possible to classify the singing samples by calculating the SPR to see whether the voice sample belongs to a trained or an untrained singers' category. And in untrained category also, experimenter can come to conclusion whether the sample belongs to talented or non talented if the values of SPR does not come in the overlapping region that is 23 to 24 dB.

Further, it is possible to develop a software which can predict the given voice sample into one of the categories. Based on this the researcher can proceed with the further study using that sample. It can also serve as a tool to identify children who could be trained in singing without unduly pressurizing them to perform in singing training.

Chapter 5

Summary and Conclusion

Singing being an extraordinary art needs lot of dedication and practice over years to project a good singing. The knowledge of music and interest in this field is increasing eventually, also young budding singers due to their interest and/ or demands from the parents are stepping into the field. Due to all these reasons many researches are being done in the field of music and singing. For the analysis of the sung or spoken sample researchers always rely on an experienced listener or a professional singer which is always perceptual and subjective. Therefore, there is a need to have an objective tool which can classify the sample as trained singing or untrained singing voice. There is one such objective tool called Singing Power ratio which can distinguish the trained singer's voice from untrained singer's voice. There is no normative to classify a given sample under these categories either for children or for adults. Therefore, this study was undertaken to obtain an objective tool based on the Singing Power Ratio (SPR) for the classification of the singing sample into different categories like trained singing (TTS), untrained talented (UTS) and untrained non talented singing (UNTS). Also, it was aimed to check whether there is any difference in SPR values across these three groups for phonation and singing sample. Pre pubertal age range (8 to 10 years) was selected and 94 female participants were taken for the study, where 30 were singers who had minimum of 1.6 to 2 years of singing experience in Carnatic classical music and rest 64 children who were not interested in singing. All the participants were asked to phonate /a/ and to sing "Lambodara lakumikara" song of Malahari raga, which is a well known song in Carnatic

classical music. Enough practice trials were given along with the lyrics for all the participants before the actual recording.

All these samples were given in a compact disk to three judges who had minimum of 15 years of singing experience in Carnatic classical music, to assign the samples under three groups using an Auditory-Perceptual Rating Instrument for Singing Voice quality with Equal Appearing Interval (EAI) Scale Form. This form had eight parameters which a Carnatic singer should possess, such as 1. Overall vocal performance, 2. Melodic formulae, 3. Rhythm follow, 4. Ring, 5. Pitch accuracy, 6. Breath management, 7. Evenness throughout the range, and 8. Strain. Based on these eight parameters, all the samples were assigned to different groups like TTS, UTS, and UNTS. Later all the samples were analyzed using Long Term Average Spectrum (LTAS) of CSL 4500 software to extract Singing Power Ratio. Highest amplitude was noted down manually in the frequency range of 0 to 2 kHz and 2 to 4 kHz and SPR was calculated by the formant difference method by subtracting the highest peak intensity between 2-4 kHz from 0-2 kHz frequency bands for both singing and phonation samples. Then again after a gap of 10 days, 16% of the randomly selected samples from each group was taken and played randomly to the same three judges to rate the samples again for the reliability check. Statistical analysis was carried out using SPSS 16.0. Based on the analyses following conclusions were drawn from the study results.

- The SPR values were high for singers and low for untrained non talented group and in between value for the untrained talented group for both phonation and singing task which implies that singers have higher harmonics and greater

emphasis at 2 – 4 kHz frequencies. This gives good projection and ring in their voice which is not there in untrained singers due to lack of practice. These results were in consensus with the previous studies.

- Significant differences across all three groups were found with the p value < 0.05 using parametric tests for both phonation and singing.
- There was a complete positive correlation found between the acoustic measure SPR and perceptual rating done by the judges. Reliability check showed 100% reliable values by the same judges.
- Using descriptive statistics at 95% confidence interval normative range was found for SPR for all three groups where the range could clearly differentiate singers from non singers. But there was slight overlap in the upper limit of UTS and lower limit of UNTS which was very negligible.

In conclusion it can be stated that singers always stand out due to their good singing ability, projection in voice because of the training and differences in their physiological aspects compared to nonsingers. All these years, for all the research work, the voice samples needed to be classified under different categories like singers and non singers only on perceptual judgement basis by the experienced listener or singer. But this study tried to develop a normative to carry out the same activity without depending on a perceptual judgement. Now, one can categorize as to whether the singing voice sample belongs to singers or non singers category without the help of a professional singer, by calculating the SPR and then comparing it with the normative given by this study. But because of the slight overlap in untrained singers, the examiner should carefully decide to

which category the voice should belong by considering the perceptual judgement also, if the SPR falls under that overlapping range.

5.1. Limitations of the study

Presence of overlap of values in the normative range is more in SPR of phonation where there will be confusion in categorizing if the SPR values fall under the overlapped range. Only distinction between talented and non talented singing groups can be done using the normative of SPR of phonation.

There is also overlap of values in the normative range of SPR for singing in all groups' upper limit values with the consecutive group's lower limit values. This makes the examiner to see the other aspects of singing part like whether the participant is trained or untrained, years of singing experience, etc to categorize the sample under different groups along with the objective measure of SPR value.

5.2. Implications of the study

This study was the first attempt to find out the normative value for an objective tool SPR in pre pubertal aged female participants. Using this normative it is possible to develop a software which can predict the given voice sample into one of the categories based on which again the researcher can proceed with the further study using that sample. It can also serve as a tool to identify children who could be trained in singing without unduly pressurizing the children to perform in singing training.

5.3. Future directions

Further research can be done by taking a large sample size with even more years of experienced singing to eliminate the overlap which was seen in this study. Similar study can be done for male participants also and older age range for both the genders.

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Appendix A: Auditory-Perceptual Rating Instrument for Singing Voice quality: EAI Scale Form

Name: Age: Gender: Date:

Please rate the singer on the following parameters as:
0 – Poor; 1 – Average; 2 - Good

Sl. No	Particulars	0	1	2
1.	**Overall vocal performance** (an overall rating of the aesthetic and technical quality of singing voice)			
2.	**Melodic formulae** (maintenance of raga)			
3.	**Rhythm follow** (rhythmic scale/ thala)			
4.	**Ring** (brilliance of tone)			
5.	**Pitch accuracy** (singing in tune)			
6.	**Breathe management** (efficient breath management)			
7.	**Evenness throughout the range** (ability to sing freely throughout the pitch and dynamic range without inappropriate change in voice quality)			
8.	**Strain** (voice quality that gives impression of excessive vocal effort)			

Please categorize the singer based on the overall ratings by ticking in the appropriate column:

I	**UNTS (untrained non talented singers)**	
II	**UTS (untrained talented singers)**	
III	**TTS (trained talented singers)**	

Remarks:

Appendix B: Questionnaire

Participant's name: Age:
Date of Birth: Education:
Father's name: Mother's name:
Complete address & phone no:

General Speech-language-hearing, oro-facial, voice, breathing and medical history

Sl. No	Questions	Yes	No
G1	Does your child have any speech, language or hearing problems?		
G2	Does anyone in family have any speech, language or hearing problems?		
G3	Does your child have any voice/ breathing problem?		
G4	Is the child on any medication? If so, what and what for?		
G5	Has your child undergone any surgery related to ENT? If yes, specify		
G6	Has your child attained puberty?		
G7	Are there any oro-facial defects? If yes, specify		
G8	Are there any singers in the family?		
G9	Does your child go to formal singing training in Carnatic music?		
G10	Are there any formal/informal singing training at home or school?		

For singers

Sl. No	Questions
S1	How long is your child taking formal training in Carnatic music? 1- <1year; 2 – 1 to 2years 3 – 2 to 3years 4 - >3years
S2	Does your child enjoy listening to music? 0 – No; 1 -Yes
S3	Does your child enjoy singing? 0 – No; 1 -Yes
S4	How many hours of practice will be done per day? 1- <1 hour; 2 – 1 to 2 hours; 3 – 2 to 3 hours 4 - 3 to 4 hours > 4 hours
S5	Any exposure to music at home/outside 0 – No; 1 -Yes
S6	Do you think your child sings well? 0 – No; 1 -Yes

For Non-singers

Sl. No	Questions
NS1	Does your child enjoy listening to music? 0 – No; 1 -Yes
NS2	Does your child enjoy singing? 0 – No; 1 -Yes
NS3	How many hours of singing will be done per day? <1 hour; 2 – 1 to 2 hours; 3 – 2 to 3 hours 4 - 3 to 4 hours > 4 hours
NS4	Any exposure to music at home/outside 0 – No; 1 -Yes
NS5	Do you think your child can sing well? 0 – No; 1 -Yes
NS6	Do you think your child imitate the songs well? 0 – No; 1 -Yes

Remarks:
Parent: Investigator:
Date: Date: