VOCAL EMOTION RECOGNITION IN GROUP OF INDIVIDUALS WITH NORMAL HEARING, SENSORINEURAL HEARING LOSS AND AUDITOTY DYS-SYNCHRONY

Register No: 09AUD026

A Dissertation Submitted in Part Fulfillment of Final Year

Master of Science (Audiology)

University of Mysore, Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING,

MANASANGOTHRI, MYSORE – 570006

June 2011

CERTIFICATE

This is to certify that this dissertation entitled ***"Vocal emotion recognition in group of individuals with normal hearing, sensorineural hearing loss and auditory dys-synchrony"*** is a bonafide work in part fulfilment for the degree of Master of Science (Audiology) of the student with Registration No: 09AUD026. 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.

Mysore
June, 2011

Prof. S. R. Savithri.

Director

All India Institute of speech and

Hearing, Manasagangothri,

Mysore, 570 006.

CERTIFICATE

This is to certify that this dissertation entitled ***"Vocal emotion recognition in group of individuals with normal hearing, sensorineural hearing loss and auditory dys-synchrony"*** has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysore
June, 2011

Guide.

Ms. N. Devi.

Lecturer in Audiology

(Department of Audiology)

All India Institute of Speech and Hearing, Manasagangothri,

Mysore - 570 006.

DECLARATION

This dissertation entitled **"*Vocal emotion recognition in group of individuals with normal hearing, sensorineural hearing loss and auditory dys-synchrony*"** is the result of my own study, and has not be submitted earlier to any other University for the award of any other Diploma or Degree.

Mysore,

June, 2011

Registration No: 09AUD026

|| shree ganeshay namah ||

Other things may change, but we

START & END with FAMILY!!!

Dedicated to

Mummy-Papa,

Bhai

Usha aunty &

My Cute Little "Bruzo"

Acknowledgment

"Grandparents make the world...a little softer, a little kinder, and a little warmer".

Peetajee, Badi mummy, Baapu, Maa, I know you are not there with us today, but I am sure that your hands are always there on us. Whatever I am today is just because of your blessings, and this dissertation is dedicated to you. Those few days of childhood which I had spend with you will always stay in my heart. Asking money from you to buy the candies, ice cream, chocolates, listening to your stories, your bhajans in your trembling voice is something which I miss the most, ...and I miss you all...thank you for being the best Grandparents.

"It takes a mother's patience, to bring a child up right, and her courage and her cheerfulness, to make a dark day bright."

Thank you mummy for always being there with me, for always understanding my silence, for being my first teacher, you showed me the right path, and help me out in selecting the better way to go. Every lesson you taught is something I can never get it from anyone. Thank you for believing in me and for all your blessings.... You the best mom in the entire world...... love you mummy!

"A daughter may outgrow from Father's lap, but she will never outgrow from his heart."

Papa for all those time I left it unsaid, THANK YOU. Thanks for being there for me, for being patient with me, even when I made it difficult for you.....for believing in me to dream, and for being such an inspiring presence in my life. Thanks for making me such a proud daughter. No doubt I am BLESSED by having you as my PAPA .. I have never told you before that you are my ideal, I follow you; just want to be like you. Whatever I am today is just because of your hard work. Love you BAAPU ..you are my "papa The GREAT"...!!

"To the outside world we all grow old. But not to brothers and sisters. We know each other as we always were. We know each other's hearts. We live outside the touch of time"

***Diplove**, dear Bhai, I would like to remember our time together, good times and the bad, I regret the times I yelled at you when you were only trying to help, but you know I only did it because you did it to me. Bhai sorry for all those fights we had, the time I didn't listen to you, didn't understand your feelings. You are the best brother one can ever get. I still remember the fights we had, just because of T.V remote??......it sounds funny now. I wish you lots of success and happiness in your life.*

***Shanky,** my dear younger brother, you are very special to me.... the time we had spend together during our childhood, playing Hide & Seek, Doctor-doctor, cricket was just something we can't bring back.....the only thing we can do is to remember & cherish those beautiful days.....thanks for always making me proud sister. Love you lots.*

"When God created teachers, He gave us special friends to help us understand His world and truly comprehend the beauty and the wonder of everything we see, and become a better person with each discovery".

*I sincerely thank, my guide, **Ms. Devi.N**, lecturer in Audiology, Department of Audiology, AIISH, for her constant support and guidance throughout this dissertation. I was really nice working with you ma'am & this dissertation is dedicated to you too.*

*A word of thanks is just not enough for all my knowledge I have and for all the support. I thanks, **Dr. Vijayalakshmi Basawaraj**, former Director, AIISH, Mysore, for permitting me to carry out this study. I also extend my gratitude to **Dr. P. Manjula**, HOD of Audiology, for permitting me to use the department for my study.*

*Deepest gratitude to all the lecturers at AIISH, without whose knowledge and assistance this study would not have been successful. Special thanks to **Asha ma'am, Sujeet sir, Mamtha ma'am, Prawin sir, Niraj sir, Rajalakshmi ma'am, Vinay sir, Geetha ma'am, Sandeep sir, Manohar sir, Ajish sir.** Special thanks to **Vasanthlakshmi ma'am** for helping me out in my statistics, thank you ma'am.*

*Special thanks to **Animesh sir**, for being the best teacher, great listener, & the coolest mentor. Sir we all enjoyed a lot in your classes.....thank you sir for always making studies enjoyable..... sir you are the BEST.*

*I would also like to thanks **Dhanlakshmi ma'am, Revathi ma'am, Baba sir, Ramadevi ma'am,** for making clinical postings enjoyable and memorable.*

*I would like to thanks all teachers and staff of **"Cambridge Foundation School"** for giving me the opportunity in each and every field and giving me the motivation. Special thanks to **Chawala ma'am, Ajit sir, Madhu ma'am.** I would also like to thank **Harsh sir,** tuition classes was really fun with you. I still remember that time. Thank you sir, for guiding me and sharing your knowledge.*

*Graduation time was fun too, I will always cherish those moments of my BSc period. **Anupriya ma'am, Vibha ma'am, Brajesh sir, Arti ma'am, Deepika ma'am, Sah sir, Narang ma'am, Neeraj sir, Rahul sir, Sayantanee ma'am,** thank you all for sharing you knowledge, and always listening to us in every situation. Its just because of your teaching I got into AIISH.*

*Special thanks to **Anupriya ma'am,** ma'am for many of you was the source of motivation, thank you ma'am for making our basics better...... Educational trip was something that was only possible just because of your effort,..... love you ma'am...you rocks..!!!!*

***Neeraj sir**, you was & you are my source of inspiration, doing a paper in speech was just because of your encouragement, the smile which you always gives is something more than a hand of praise. Thank you sir for changing the environment of AJY with filling love, knowledge, friendship, encouragement,& inspiration in each and every student ..!!! I would also like to thanks **Gupta sir** and **Prem sir** for always listening to us in our good & happy times.*

"Each friend represents a world in us, a world possibly not born until they arrive".

*Special thanks to my school friends, **Renuka, Tanmay, Shafali & Shivansh,** who have always been there for me....!!! You are preciously precious...!!!*

*My dear BSc friends, **Bhawna, Gunjan, Shivali, Neha, Subodh, Udayan, Madhuban, Nitika, Jiggi**, for all of you **"**ROSE IS A FLOWER, THAT STAYS FOR AN HOUR. BUT YOUR FRIENDSHIP HAS THE POWER THAT WILL STAYS FOR EVER ...".*

MSc batch (2009-11)...... *so as we are finishing our MSc, and we have to be explore the world in the different directions, last 2 years was the best days of my life. Eating, sleeping, playing in between the class is something which nobody can dare to do, but we did....because we are THE BEST in everything we do...!!!*

Prabhash*, Words are just not enough to thank you. You are special, you are the best, and you are my precious friend. A friend with whom I can share all my secrets, I can shout on you, fight with you and I know you will be there with me in all the ups and downs. I really don't understand how a person can be so polite, so true, so caring. Prabhash I have learned a lot from you, and want to be like you, hope one day I will. Thank you friend for being there with me always. Will miss the time we had spent together in library before the exams/class test (last moment reading was really fun), postings..... One wish, "smile ever, cry never". Stay the same...!!! You are the BEST..!!*

Anoopa *I will miss you the most 'Gadhae' if I will GO BACK TO DELHI..!!..lolz.......messaging in between the class was something which only you & me can do, no other work we had....!! Movies at sterling/skyline was the bestestttt thing that can ever happened to you...right? Idhar udhar ki baaten , waghara waghara...!!!! anyways thank you for being one of the good friend in my life.....& me kahe nahe jaati.....tu Manipur jaati....!!!!*

Bharath, Jyoti, Madhu, Praveen, Anisha, Prajnya, Pragati, Sonitha, Swathi (Bomb), Ranjeet, Anoop. O.T, Muksesh, Chaitra, Ashwani, Akash, Srikar *time which I had spend with you, whether in posting or in class or outside the campus was just not forgettable. I wish you all the success in your life....stay happy always.*

Bruzo, *My bestest friend, my cute little doggy...mera pyaar baccha.....love you Bruzo baby, I love the way he plays with me, with his tongue out ....he always want to win any situation........he is a FAMILY...his cute little eyes bring smile on my face.... When I am wrong, he is delighted to forgive, When I am angry he clowns to make me smile, When I am happy, he is joy unbounded. His head on my knee can heal my human hurts. His presence by my side is protection against my fears of dark and unknown things. Thank you for being in my life..thank you for always taking away my sorrows, and replacing it with a smile..you are the BEST... !!!! love you..!!*

"Senior-junior relationship.......sweet bond"

***Prashanth sir, Neerja di, Shreela chichi, Mohan sir,Vivek sir**, thank you all for making our posting time fun......& allowing us to go for canteen....and many a time saving us from the staff......thank you...you are the best seniors we can get...!!*

***Vijay sir,** this study is possible just because of you sir. Thank you for always helping me out with topic, articles, journals in all the possible ways. Sir this dissertation is dedicated to you too.*

***Vidit, Vikas, Archana, Sibi, Himanshu, Neha Singh, Amit Sharma, Amit Singh** you guyz were more than a seniors to me, I will always cherish the time I had spend with you. Thanks for your notes, and always helping us in clearing my doubts. Love you all.*

*And to my sweet & lovable juniors, **Neha sodhi, Sweta, Bhupi, Merlin, Anubhuti, Tarique, Ayesha,** thank you for the love you guys have given to me, keep rocking guys......!!!!*

***Archna, Priyanak di, swagatika di.....**i miss you the most, Hostel was just like home with you three.......in front of you, I just love to behave as a kid, its just like I am with my elder sisters...thanks for all for your love, your notes, and helping me out in my studies, and always giving right suggestion whenever I needed. And how can I forget to thank you for the yummy 'room' made food.....love you to core of my heart.*

***Priyanka (Bacchi),** mere pyaare guddiya......thanks for being a younger sister to me. Thanks for always listening to me, talking to you really makes me feel light....thanks for keeping my secrets and scolding me I whenever I don't study. You are the world's best sister. I will miss you more than anyone else....love you JHALLI.....!!!! Keep rocking, all the best for you studies....wish you lots n lots of happiness in life...keep smiling.*

***Garvita & Shailaja,** thank you for the love and respect you have given to me. Thanks for always encouraging me in everything I do..... love you both..!!*

*I would also like to thank **Sachi, Mahima, Sweta, Shabnam, Rishita, Riya, Preeti, Jitin, Seby, Rishi Pal**, for being such a sweet juniors. Good luck....*

***Divya, Tanvi, Vaishnavi, Pawan, Rashika, Shruti,** you are the wonderful juniors one can ever get....thank for your love........stay happy..!!!!!*

*I would also like to thanks my dear juniors at AIISH, **Vindhyashree and Akshtha,** without their help this study would not have been possible, thank you guys*

for helping me in finding out the sentences for my test battery..thanks a ton...God bless you both.

I would also thank director, staff and the actors of ***RANGAYANA (KALA MANDIR****), all of them was so supportive, and helped me out for the recording of the stimuli. It was really nice working with you. Special thanks to Mimi Ramesh sir for being so nice and giving your precious time.*

"Last but not the least.....my source of inspiration".

Yes it's my ***GOD****.....thank you God for making this project successful..... "Thank you GOD for all the blessings and abundance in my life".*

*There is one more person, whom I admire....and I will admire her throughout of my life....she is not less than a God to me...that's my massi (***Usha Aunty).** *I believe that wherever you are, you are with me at each step of mine.....i admire the will power you had, the way with which you shaped you life...i had captured the last smile of yours in my eyes..i wish wherever you are, that smile stays on you face forever...May god bless your soul...and be with me always.....This dissertation is dedicated to you. Love and Miss you so much...!!!*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF GRAPHS

INTRODUCTION

Speech is a major form of communication; it conveys both linguistic and non-linguistic cues. The linguistic component of the speech includes the properties of the speech signal and word sequence and it deals more with what is being said, not how it is said. The non-linguistic component of speech deals more with talker attributes such as age, gender, dialect, and emotion. Cues to non-linguistic properties can also be provided in non-speech vocalizations, such as laughter or crying (Peters, 2006).

In a communication situation the true meaning of the communication is transferred not only by the linguistic content but also by how something is being said, how words are emphasized and by the speaker's mood and their outlook toward what is being said. Most, Weisel and Zaychik (1993) stated that the speaker's 'tone of voice' often provides a listener with as much information about the speaker's emotional state as does the semantic content of his/her utterances. According to Banse and Scherer (1996) for accurate understanding of emotional message the perception of emotion in the vocal expressions of others is essential.

According to Bachorowski (1999) in everyday experience, through the acoustic properties of speech, talker provide information about their emotional state, for example, many of us experienced talking in an unwittingly loud voice when feeling jovial, speaking in an unusually high pitched voice when greeting a sexually desirable person, or talking with marked voice tremor while giving a public speech. In turn listeners are seemingly skilled at marking accurate evaluations of emotional state even in the absence of visual cues, as routinely occur during telephone conversation.

According to Luo, Fu and Galvin (2007) imperative element of speech communication involves identification of a talker's emotional state, using only acoustic cues. Although facial expressions may be strong indicators of a talker's emotional state, vocal emotion recognition is an important component of auditory-only communication such as telephone conversation or listening to the radio.

Nonverbal behaviours can also assist in determining emotion. Information of speaker's intonation, facial expression, and gestures can add to or change the meaning of spoken discourse and these nonverbal actions are considered to have numerous functions, including the expression of emotion (Patterson, 1995; Feldman, Tomasian, & Coats, 1999; Bavelas & Chovil, 2000; Creusere, Alt, & Plante, 2004).

According to Most, Weisel and Zaychik (1993) visual information can undeniably help in determining a speaker's emotion in addition to auditory-only information. These authors also concluded that visual mode was always superior to auditory mode in identifying the different emotions in normal hearing individuals. The combined auditory-visual mode was also superior to auditory mode alone but not always significantly better.

Ear is the most essential part for the communication. Perception of any acoustic stimuli involves various steps, which includes conversion of an auditory stimulus into electrical signal at the receptor level, transmission of the electrical signal through the peripheral nerve, and processing and interpretation of the electrical signal in the central nervous system. Any breakdown in the process results in the major consequences in the perception. There is abundant literature on the perceptual consequences of both peripheral and central auditory disorders. For example, peripheral damage in the inner ear and auditory nerve leads to threshold elevation, abnormal loudness, pitch and temporal processing (Ryan & Dallos, 1975; Nienhuys & Clark, 1978; Prosen, Moody, Stebbins, & Hawkins, 1981; Fromby, 1986; Moore, 1996; Moore & Oxenham, 1998; Buss, Labadie, Brown, Gross, Grose, & Pillsbury, 2002; Oxenham & Bacon, 2003)whereas, central auditory disorders produces complex processing deficits in speech and sound object recognition (Levine et al., 1993; Wright, Lombardino, King, Puranik, Leonard & Merzenich, 1997; Cacace & McFarland, 1998; Gordon-Salant & Fitzgibbons 1999).

The most noticeable indication of cochlear hearing loss is a reduced ability to detect weak sounds. However cochlear hearing loss is also accompanied by a variety of other changes in the way that sound is perceived. According to Moore (1996) severe to profound cochlear hearing loss not only reduces the functional bandwidth of hearing but also reduces frequency selectivity, impaired intensity and temporal resolution, and also results in making detection of the subtle acoustic features contained in vocal emotion difficult.

Auditory dys-synchrony/neuropathy (AD) is a clinical syndrome which has disrupted auditory nerve activity with concurrently normal or near normal cochlear amplification function (Starr, Picton, Sininger, Hood, & Berlin, 1996). Clinically, the disrupted auditory nerve activity is reflected by highly distorted or absent auditory brainstem responses, whereas the normal cochlear amplification function is reflected by the presence of otoacoustic emission and/or cochlear microphonics (Starr et al., 1996; ; Rance et al., 1999; Hood,Berlin, Bordelon, & Rose, 2003)The other main characteristic of AD is a significantly impaired ability for temporal processing and difficulty in speech understanding, especially in noise, that is disproportionate to the degree of hearing loss measured by pure-tone thresholds (Zeng, Oba, Garde, Sininger, & Starr, 1999; Kraus, Bradlow, Cheatham, Cunningham, King, & Koch, 2000; Rance, Cone-Wesson, Wunderlich, & Dowell, 2002; Rance, McKay, & Grayden, 2004; Zeng, Kong, Michalewski, & Starr, 2005). The above mentioned difficulties in temporal processing and speech understanding may also result in difficulty in recognizing vocal emotions.

NEED FOR THE STUDY

In Indian scenario, incorporating assessment tool for the evaluation of speech perception abilities exists, findings of which can be utilised in the management of individuals with cochlear hearing loss as well as for those with auditory dys-synchrony/neuropathy. It is comparatively easy to measure speech intelligibility through metrics like the word recognition scores. Listeners are asked to identify spoken words under various conditions and their recognition score is taken as a measure of intelligibility. But we don’t have such straightforward method to assess “vocal emotion perception” in general especially in Indian scenario. Instead we can assess its constituent elements such as pitch, duration, and intensity.

Disruption in the perception of temporal cues has been demonstrated in both children and adults with auditory dys-synchrony/neuropathy (Starr et al., 1996; Zeng et al., 1999; Kraus et al., 2000; Rance, McKay, & Grayden, 2004; Michalewski, Starr, Nguyen, Kong, & Zeng, 2005) In addition to distortion of the spectral information that is seen in cochlear hearing impaired individuals, individuals with AD also possess distortion in temporal information (Zeng et al., 1999; Kraus et al., 2000; Rance et al., 2004). Hence the input signal in the auditory system is lot more distorted in individuals with AD compared to those with cochlear pathologies.

Reviewing the literature, the perception of segmental aspects of speech in AD had been proposed but researchers are lacking in the knowledge of vocal emotion perception in the hearing impaired group and AD population. As the features of suprasegmentals in terms of rhythm, stress, intonation, prosody, are included in acoustic feature of vocal emotion, an attempt is required to understand the recognition of different vocal emotion by normal hearing adults, hearing impaired individuals and individuals with AD.

AIM

The aims of the present study were:-

- To compile/construct vocal emotion perception battery in the context of Kannada language.
- To investigate the recognition of vocal emotions perception abilities of individuals with normal hearing.
- To investigate the vocal emotion perception abilities of individuals with minimal to mild sensorineural hearing loss.
- To investigate the vocal emotion perception abilities of individuals with auditory dys-synchrony (AD)/neuropathy.
- To compare the performance across the groups on the vocal emotion perception task.

REVIEW OF LITERATURE

Speech is the major form of communication; it not only conveys linguistic content but also indexical information about the talker's gender, age, identity, accent and their emotional state. Using only acoustic cues, the important dimension of speech communication involves recognition of a talker's emotional state. Although facial expressions may be strong indicators of a talker's emotional state, vocal emotion recognition is an important constituent of auditory-only communication such as telephone conversation or listening to the radio (Luo, Fu, & Galvin, 2007).

Reviewing the history, there are evidences of extensive research on the importance of emotional expression in speech communication and its influential impact on the listener. It has been reported that the strategic use of emotionally expressive speech, can be found in early Greek and Roman manuals on rhetoric in Western philosophy (Kennedy, 1972). In 19th century there was a renewed interest in the expression of emotion in face and voice by the emergence of modern evolutionary biology (Darwin, 1872). In the beginning of 20th century, researchers turned their view towards the effect of emotions on the voice, and psychiatrists trying to diagnose emotional disturbances through the newly developed methods of electroacoustic analysis (Scripture, 1921 ; Isserlin, 1925; Skinner, 1935).

Allport and Cantril (1934) have revealed that there is an increasing scientific concern with the communication of speaker attributes and states via vocal cues in speech with the discovery and rapid spreading of the telephone and radio. Systematic research programs were started in the 1960s when psychiatrists changed their interest in diagnosing affective states by means of vocal expression (Starkweather, 1956; Alpert et al., 1963; Ostwald, 1964; Hargreaves et al., 1965) During that period only non-verbal communication researchers explored the ability of different bodily channels to carry signals of emotion (Knapp, 1972; Harper et al., 1978; Scherer, 1982; Feldman & Rime, 1991) and emotion psychologists charted the expression of emotion in different modalities (Ekman, 1972), whereas linguists and phoneticians discovered the importance of pragmatic information in speech (Mahl & Schulze, 1964; Caffi & Janney, 1994), and to study the effects of emotion on the voice, engineers and phoneticians specializing in acoustic signal processing started to make use of ever more sophisticated technology (Lieberman & Michaels, 1962; Williams & Stevens, 1972).

Constituents of vocal emotions are different suprasegmentals features of a language, which are those properties of speech sounds that appear simultaneously with the phonetic (segmental) feature, but are not restricted to phonetic segment and instead are overlaid/superimposed on syllable, word, phrases or sentences. These suprasegmentals features may alter the meaning of an utterance by revealing speakers feeling and attributes in a manner that phonetic feature alone cannot achieve.

Different suprasegmentals features are:-

A. **Stress**, is an extra energy or effort used to emphasize a syllable or a word (Savithri, 1999). Stress is cued by acoustic parameters such as increased fundamental frequency, increased intensity, prolonged duration or change in vowel quality (Savithri, Rohini & Seema, 2004).
B. **Intonation**, refers to moment of the fundamental frequency in a sentence (Savithri, Rohini & Seema, 2004). It mainly involves changes in the fundamental frequency (Fo), so perceived as the pitch pattern of a phrase or sentence.

C. **Rhythm** , a prosodic feature, refers to an event repeated regularly over a period of time (Savithri, Johnsirani & Ruchi, 2008).

According to Mili Marry and Jayashree (2010), Emotional prosody is considered as the ability to express emotions. Intonation is one parameter of prosody that gives information on the production aspect of emotions and they also stated that raising and falling contour perception are important in determining the type of emotion.

Yildirim et al. (2004) reported pitch, durations of phonemes or syllables, inter-word silence duration, voiced/unvoiced duration ratio in utterances, energy in the waveform envelope, the first three formant frequencies and spectral moment or balance are the commonly analyzed acoustic parameters for emotion in speech and he also stated that these parameters are associated to speech prosody, vowel articulation and spectral energy distribution. But the most reliable factors in indicating the speaker's emotional state were found to be the mean value of the fundamental frequency, the range of the fundamental frequency, and the rate of its changes. The duration of the production and changes in the intensity of the voice were also described as essential parameters as well (Williams & Stevens, 1972; Scherer, 1986; Most, Weisel & Zaychik, 1993). Oster and Risberg (1986) found that the most important factor in signaling the speaker's mood is the mean fundamental frequency and the range, along with the other factors.

According to Banse and Scherer (1996) listed are the various acoustic variable that are strongly involved in vocal emotion signaling: (a) the level, range, and contour of the fundamental frequency (it reflects the frequency of the vibration of the vocal folds and is perceived as pitch); (b) the vocal energy (or amplitude, perceived as intensity of the voice); (c) the distribution of the energy in the frequency spectrum (particularly the relative energy in the high vs. the low-frequency region, affecting the perception of voice quality or timbre); (d) the location of the formants (F1, F2…Fn, related to the perception of articulation); and (e) a variety of temporal phenomena, including tempo and pausing.

As reported by Murray and Arnott (1993) & Banse and Scherer (1996) acoustic cues that determine vocal emotion can be considered under 3 main types, speech prosody, voice quality and vowel articulation. Vocal emotion acoustic features have been analyzed in terms of, mean F0, variability of F0, duration (at sentence level, word level and phoneme level), intensity, first 3 formant frequencies and distribution of energy in the frequency spectrum.

According to Scherer (1986) basic emotions can be identified in the voice without depending on the verbal information, as can more abstract categories of language communication such as sarcasm (Bryant & Fox Tree, 2005). Prosodic features in speech such as pitch, loudness, duration, and spectral properties often form stereotyped configurations that are related to emotional categories in a systematic ways (Cosmides, 1983). To support these findings Scherer (1986) reported that vocalization which conveys happiness tend to be high in pitch, loud, high in pitch variability, and fast whereas, sad vocalizations tend to be low in pitch, soft, low in pitch variability, and slow. Many studies have described these distinctions through perceptual coding, acoustic analyses, and rating experiments. A study performed by Laukka (2005) showed that listeners judgments of stimuli were categorical even when a set of prototypical emotional vocal expressions were manipulated to create a continum, which further suggests that when inferring emotions from voice, listeners deduce discrete categories.

Conclusion of various studies have attempted to compare the acoustical properties of different emotions, that relative to neutral speech, anger and happy speech exhibits higher mean pitch, wider pitch range, greater intensity, faster speaking rate, whereas sad speech exhibits lower mean pitch, narrower pitch range, lower intensity, slow speaking rate. Normal hearing listeners using these acoustic cues can correctly identify 60% to 70% of target emotions (Petrushin, 2000; Scherer, 2003; Yildirim et al., 2004) but the perception of vocal emotion varies depending on their hearing acuity.

There is an abundant literature (Williams, & Stevens 1972; Murray, & Arnott 1993; Dellaert, Polize & Waibel, 1996; Pertushin, 2000; Scherer, 2003) on vocal emotion perception abilities of normal hearing listeners and many of these studies have used artificial intelligence systems. Emotional speech which is recorded in naturally occurring situations have poor recording quality and it also contains some difficulty in terms of defining the nature and number of the underlying emotion types (Williams & Stevens, 1972; Murray & Arnott, 1993; Dellaert, Polize & Waibe, 1996; Pertushin, 2000; Scherer, 2003). Scherer (2003) suggested that recording professional actors production of vocal emotion using standard verbal content is a more preferred experimental design, but the possible difficulty with these stimuli is that actors tries to overemphasise the production when compared with naturally produced vocal emotions. Before recording the target emotions the actors are usually instructed to imagine the real life situations to make the vocal emotion portrayals which should resemble natural emotional speech (Murray & Arnott 1993).

A speech perception difficulty as a consequence of hearing impairment is reported over and over again in the literature. In post linguistically deafened adults with sensorineural loss, a strong relationship exists between the behavioural audiogram and open set speech understanding and individuals with greater degrees of loss usually show poorer perception abilities (Yellin, Jerger, & Fifer, 1989). The exact cause(s) of these perceptual difficulties in these cases is still a matter of debate, but generally it is seen that speech understanding is restricted by signal audibility for losses up to about 60 dBHL and by a combination of audibility and cochlear distortion effects for greater degree of hearing losses (Moore, 1996).

Many individuals with severe to profound hearing loss have residual hearing in the low frequency region, some of them can detect and discriminate the time energy envelope of the signal whereas others can also discriminate Fo information (Erber & Witt, 1977). As stress is cued by duration, amplitude & Fo information, various researches have claimed that it should be available for many individuals with hearing impairment (Ling, 1976). For normal hearing individuals, the redundant acoustic cues for syllable stress enable facile identification of stressed Vs unstressed syllable, whereas individuals with hearing impairment have greater difficulty in perceiving lexical stress. Due to auditory perception deficiency in these individuals, the acoustic cues for the stress syllable might be less salient than it is normal hearing individuals. Especially for hearing impaired with greater degree of hearing loss, the acoustic which differentiate stressed Vs unstressed syllables could be un-discriminable.

According to Judith, Nancy and Karen (1986) individuals with hearing impairment are able to correctly identify stress only for the stimuli in which amplitude cue is available. Most (2000) studied the perception of stressed syllable by normal & hearing impaired children with a degree of sever to profound, and concluded that the average scores obtained by the hearing impaired children was 80.3% compared with 100% score achieved by normal hearing children.

Darrow (1984) reported that the overall rhythmic scores obtained by normal hearing children are higher when compared to their hearing impaired counterparts. Darrow (1984) also stated that there is a significant correlation found between specific rhythmic skills and the perception of suprasegmental aspects of speech.

In contrast, speech perception ability of individuals who were diagnosed with auditory neuropathy/dys-synchrony- type hearing loss shows no correlation with the pure-tone audiogram (Starr, Sininger & Pratt, 2000; Zeng, Oba & Starr, 2001), and in many of the cases, speech perception skills are significantly poorer than would have been expected for sensorineural losses of equivalent degree. Starr et al. (1996) reported the open-set speech perception task for 8 of the 10 subjects in their study, word recognition scores ranged from 0% to 92% and were significantly poorer in 12 of the 16 ears when compared with the norms given by Yellin, Jerger and Fifer (1989) for ears with sensorineural hearing loss. Similar findings of Sininger and Oba (2001) for speech discrimination scores on CID W-22 lists for 36 auditory neuropathy/ dys synchrony patients who are mostly adult, results revealed that 25 (69%) fell below the normative range of Yellin, Jerger and Fifer (1989). Various other authors have also given the similar findings of extreme speech perception difficulties in auditory neuropathy adults (Jerger, Ali, & Fong, 1992; Berlin, Hood, Cecola, Jackson & Szbo 1993; Sininger, Hood, Starr, Berlin, & Picton, 1995; Berlin, Hood, Hurley, & Wen, 1996; Starr, Sininger, &

Pratt, 2000; Zeng, Oba, & Starr, 2001; Starr, McPherson, Patterson, Don, & Gravel, 2003).

Kraus et al. (2000) presented findings of a single subject with an unremarkable medical history and normal hearing thresholds who had experienced difficulties in background noise throughout childhood. Result revealed perfect word recognition score on a CUNY-Sentence assessment in quiet, demonstrating that open-set speech perception can be achieved despite measurable neural disruption in the auditory brainstem. Whereas assessment in the presence of noise (multi-talker babble) at a+3 dB signal-to-noise showed abnormally miserable results (10% correct) whereas the mean score for a control group (normal hearing subjects) was 50%.

Limited behavioural data have been reported on the perceptual consequences of auditory neuropathy (Starr et al., 1991; Zeng et al., 1999; Kraus et al., 2000; Rance, McKay, & Grayden, 2004). A single case study each by Starr et al. (1991) and Kraus et al. (2000) in which the subject’s audiological, behavioural, and electrophysiological performance was systematically documented. Both of these authors found normal audiogram for the individual with AN but speech perception scores in noise were significant poorer. Zeng et al. (1999) found significant temporal processing impairment in 8 AN subjects and their temporal processing impairment correlates with the degrees of their speech perception deficits. Rance et al. (2004) in addition to temporal processing impairment, some of their 14 AN subjects showed additional frequency discrimination deficits.

Disruptions in the perception of temporal cues have been demonstrated in children as well as adults with AD (Starr et al., 1991; Zeng et al., 1999; Kraus et al., 2000; Rance et al., 2004; Michalewski et al., 2005). In addition to distortion of the spectral information that is seen in cochlear hearing impaired individuals, individuals with AD possess distortion in temporal information (Zeng et al., 1999; Kraus et al., 2000; Rance et al., 2004). Hence the input signal in the auditory system is lot more distorted in individuals with AD compared to those with cochlear pathologies.

Reviewing the literature, the perception of segmental aspects of speech in AD had been proposed but researchers are lacking in the knowledge of suprasegmental perception in the hearing impaired group and AD population. As the features of suprasegments in terms of rhythm, stress, intonation, prosody, are included in acoustic feature of vocal emotion, an attempt is required to understand the recognition of different vocal emotion by normal hearing adults, hearing impaired individuals and individuals with AD.

METHOD

The study was carried out in four phases. Phase I involved the generation of the stimulus battery, phase II involved the selection of the participants in different groups, phase III involved the administration of the vocal emotion perception battery, and in the end phase IV involved the reliability assessment of the test.

Phase I: Generation of stimulus (vocal emotion perception battery)

The test stimulus consisted of 5 sentences (Appendix A) each in 5 target emotions: happy, sad, angry, fear and neutral. Initially fifty 3-4 words sentences in Kannada language which were more appropriate to fit into all the five emotions were selected. Out of those fifty sentences; five 3-word sentences were selected for the study, which were further evaluated by the five Audiologist and Speech Language Pathologist (SLP) on the basis of their simplicity and appropriateness. Each target stimuli sentences (Kannada) were recorded in five different emotions. Hence total of 25 stimuli sentences was developed. Overall amplitude differences between the stimuli was either preserved or normalized.

The recording was done in the sound treated room where the noise level were as per the ANSI (1991) on a data acquisition system with a 16 bit analog to digital convertor at a sampling frequency of 44.1KHz. The material was edited and scaling was done using Audition version 3 software with a calibrated microphone. Interval of 10 seconds is added between the sentences to function as a response time. Professional stage actors of native Kannada language were taken for the recording of the stimulus. They were instructed to say the sentences with different emotion. Recording was done for 2 male and 2 female actors and then the 'goodness test' was performed by the 2 Audiologist and 2 Speech Language Pathologist to choose the best clarity voice for the final recording. Female voice was taken for the final recording of the stimulus. Randomly 2 sentences from the 25 sentences were taken as the 'trial' sentences. Hence the final battery consisted of 2 trial stimuli with 25 test stimuli. Recorded stimulus was then stored into the compact disk (CD) with a 30 second, 1KHZ calibration tone at the beginning at a level equal to the average intensity of the sentences.

Phase II: Selection of participants under different groups

Participants

Three groups of participants were included in the study; the groups were named as Group-A, Group-B and Group-C. Participants in all the groups were native speaker of Kannada language within an age range of 15 to 40 years. 20 ears were included in Group-A whereas Group-B & Group-C consisted each of 10 ears.

Inclusion criteria for participants in Group-A

- Participants with hearing sensitivity within normal limits formed the group-A. Their hearing threshold were <15dB HL at octave intervals between 250Hz and 8000Hz for air conduction and between 250Hz to 4000Hz for bone conduction.
- Speech identification scores of all the 20 ears were above 90% in quite.
- All the ears had normal middle ear functioning with type 'A' tympanogram with normal ipsilateral as well as contralateral reflex threshold.
- All the ears had bilateral normal cochlear outer hair cell functioning with presence of transient evoked otoacoustic emissions (TEOAEs).

- Normal click evoked auditory brainstem responses (ABR) were obtained, with the occurrence of wave 'V' within the stimulus level of 30dBnHL for all the ears.
- The participants did not have any past or present history of otological abnormalities and/or neurological deficit.
- No physical illness was seen on the day of testing.

Inclusion criteria for participants in Group-B

- Participants with minimal to mild sensorineural hearing loss were included in group-B with the hearing thresholds ranged from 15dBHL to 40dBHL at octave intervals between 250Hz and 8000Hz for air conduction and between 250Hz to 4000Hz for bone conduction.
- Speech identification scores of all the 10 ears were proportionate to their pure tone average in quite.
- All the ears had normal middle ear functioning with type 'A' tympanogram with normal ipsilateral as well as contralateral reflex threshold.
- All the ears had normal cochlear outer hair cell functioning with presence of transient evoked otoacoustic emissions (TEOAEs).
- Wave 'V' of click evoked auditory brainstem responses was obtained till 50dBnHL for all the ears.
- They did not have any past or present history of otological abnormalities and/or neurological deficit.
- No physical illness was seen on the day of testing.

Inclusion criteria for participants in Group-C

- Ears with minimal to mild sensorineural hearing loss were included in group-B with the hearing thresholds ranged from 15dBHL to 40dBHL at octave intervals between 250Hz and 8000Hz for air conduction and between 250Hz to 4000Hz for bone conduction.
- Speech identification scores of all the 10 ears were not proportionate to their pure tone average scores in quite (poorer as compared to their pure tone average scores).
- All the ears had normal middle ear functioning with type 'A' tympanogram with absence of ipsilateral as well as contralateral reflexes.
- All the ears had normal cochlear outer hair cell functioning with presence of transient evoked otoacoustic emissions (TEOAEs).
- Abnormal/Absent click evoked auditory brainstem responses were obtained for all the ears.
- No physical illness was seen on the day of testing.

Test environment

Audiometric testing and administration of the test battery were carried out in sound treated room with the ambient noise levels within permissible limits (ANSI S 3.1-1991).

Instrumentation and test protocol

- A calibrated diagnostic audiometer, GSI-61 with TDH-39 earphones was used for estimating the air conduction thresholds. Radio ear B-71 bone vibrator was used for bone conduction testing.
- A calibrated diagnostic audiometer MAICO MA 53 with TDH 39 earphones was used to present the developed stimulus to administer vocal emotion perception battery.

- A calibrated middle ear analyzer GSI tympstar was used to record tympanogram with a probe tone frequency of 226 Hz and the acoustic reflexes thresholds were measured for 500 Hz, 1000 Hz, 2000Hz, and 4000Hz.
- Brainstem responses to click stimuli were recorded using Biologic Navigator Pro evoked potential systems. The site of electrode placement was prepared with skin preparation gel. Silver chloride electrodes were used with a conducting pate. Responses were differentially recorded from Ag-AgCl electrodes with each electrode impedance of < 5 kΩ. The following test protocol was used for the recording of auditory brainstem responses (ABR);

Table 1
Parameters used to acquire ABR

Stimulus parameters		*Acquisition parameters*	
Type of stimulus	Click	Low pass filter	100 Hz
Polarity	Rarefaction	High pass filter	3000 Hz
Intensity	Variable	Notch filter	On
Number of stimuli	1500	Artifact rejection	On
Repetition rate	11.1/sec & 90.1/sec	Time window	15msec
		Electrode montage	A1-Fz-A2

- ILO version 6.0 was used to record the transient evoked otoacoustic emissions (TEOAEs).
- The test stimulus was recorded on Adobe audition version 3 installed in a personal computer via a microphone (Ahuja, AUD-101XLR) placed at a distance of 10 cm from the lips of the speaker while recording.

Phase III: Assessment of vocal emotion perception battery

Subjects were made to be seated in a sound treated room (two room situation) and were made to listen to the stimuli. The vocal emotion perception battery from the laptop computer was routed via auxiliary input to the audiometer. The prepared stimulus was administered through headphone at most comfortable level (40dBSL) of the participants in each of the three groups. Before administering the vocal emotion perception battery, a response sheet was given to each of the participants along with an appropriate instruction.

A closed set, 5 alternative identification tasks was used to measure vocal emotion recognition. In each trail, a sentence was randomly selected (without replacement) from the stimulus set and presented to the participants. The participants were instructed to respond by ticking (√) on the 5 response choices (picture along with label- happy, sad, angry, fear and neutral) (Appendix B). In the commencement of test, two sentences were given as a trial. No feedback was provided. Response were collected and scored in terms of raw correct scores.

A scoring sheet was also developed which was used to score the responses given by the participants (Table 2). Scoring was done separately for each of the emotion. A score of ‘1’ was given for every correct response and ‘0’ for every incorrect response. The maximum score for each emotion was 5 and the maximum overall score was 25.

Summary of scores

Table 2
Scoring sheet

Various vocal emotions	*Scores obtained*	*Maximum scores*
Happy		*5*
Sad		*5*
Angry		*5*
Fear		*5*
Neutral		*5*
Total		*25*

Phase IV: Test-Retest reliability

Test to retest reliability of vocal emotion perception battery was checked by administering it to randomly selected one-half of the participants from all the three groups for a second time after duration of two weeks. The procedure for the carrying out test-retest reliability was same as it was done for the first time.

Statistical analysis

Descriptive statistical analysis of the scores in terms of mean, standard deviation, and other non-parametric tests such as Kruskal-Wallis test, Mann-Whitney test, Friedman Test, Wilcoxon Signed Rank test were performed using the SPSS (10.0 & 17.0) software. The results obtained are presented and discussed in the subsequent section.

RESULTS AND DISCUSSION

The participants were divided into three groups based on their hearing status and presence or absence of auditory dys-synchrony/neuropathy. Group-A consisted of 20 ears with normal hearing sensitivity, Group-B of 10 ears with minimal to mild sensorineural hearing loss and Group-C was formed by 10 ears with Auditory Dys-synchrony/neuropathy. The results are analyzed and discussed as follows:

I. Audiological findings of the participants of the study
   - Audiological findings of the participants in Group-A
   - Audiological findings of the participants in Group-B
   - Audiological findings of the participants in Group-C

II. Mean and standard deviation (SD) of different emotions among different groups.

III. Comparison of emotions among different Groups
   - Comparison of different emotions among Group-A and Group-B
   - Comparison of different emotions among Group-A and Group-C
   - Comparison of different emotions among Group-B and Group-C

IV. Within group comparison across different emotions.

V. Comparison among different emotions (with respect to responses and stimuli).

VI. Result of reliability assessment of the test.

I. Audiological findings of the participants.

Audiological assessment was carried out to divide the participants into Group-A, Group-B and Group-C. Different audiological tests such as pure tone audiometry (PTA), Speech audiometry (speech identification scores), Immittance evaluation (tympanogram, ipsilateral and contralateral acoustic reflexes), Transient evoked otoacoustic emissions (TEOAEs), auditory brainstem responses (ABR) were administered on each of the ears participated in the study. Before performing the audiological testing all the participants went under Otoscopic examination, which revealed no otological problem.

Audiological findings of participants in Group-A

Group-A included 20 ears with hearing sensitivity within normal limits.

Table 3
Audiological profile of participants in Group-A.

S.No of ears	PTA	Speech scores (SIS)	Immittance		TEOAEs	ABR (Wave 'V' present at the intensity level	Provisional diagnosis
			Tympanogram	Reflexes (I/C)			
1	10.5 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
2	9.8 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
3	11.0 dBHL	96%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
4	10.6 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
5	5.0 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
6	5.3 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
7	12.7 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
8	12.7 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
9	6.0 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
10	6.5 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
11	8.5 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
12	10 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
13	8 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
14	8 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
15	10.5 dBHL	96%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
16	10.5 dBHL	96%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
17	11 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
18	11 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
19	6.5 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity
20	6.5 dBHL	100%	Type 'A'	Present	Present	till 30dBnHL	Normal hearing sensitivity

Note: 'I/C'-'ipsilateral/contralateral'. 'PTA'- 'Pure tone average', 'TEOAEs'- 'Transient evoked otoacoustic emissions', 'ABR'-'auditory brainstem responses.

Table 3 depicts the audiological findings of participants in group-A. Test results revealed hearing sensitivity within normal limits in all the 20 ears, and their speech scores were proportionate to the pure tone audiometric thresholds with >90% scores in quite. On immittance evaluation, all the ears showed type 'A' tympanogram with presence of ipsilateral as well as and contralateral reflexes. Normal outer hair cell functioning is established in all the ears with presence of transient evoked otoacoustic emissions (TEOAEs). All the ears had normal click evoked ABR with presence of wave 'V' till the intensity level of 30 dBnHL.

The Audiological findings of Group-A is in congruence with the results obtained by Clark (1981) that pure tone average of three frequencies (500 Hz, 1KHz and 2 KHz) ranged from -10 to 15 dBHL indicates normal hearing sensitivity. According to Harris (1991) and Glattke (1991, 2002) otoacoustic emissions (OAEs) are the sounds of cochlear origin and Transient evoked OAEs are highly sensitive to cochlear pathology and in a frequency-specific way. TEOAE responses are typically absent at frequencies at which hearing thresholds exceed 20-30dBHL , therefore TEOAEs of all the ears included in the Group-A were present with thresholds' not exceeding beyond 20-30dBHL. In normal hearing listeners wave 'V' of ABR is the most visible peak at the lower intensity level of 25 to 30 dBnHL, which is an indication of normal auditory brainstem functioning. Wave 'V' was present within the intensity level of 30dBnHL in all the ears in Group-A. Jerger (1970); Jerger, Jerger & Mauldin (1972); and Liden, Harford, & Hallen (1974) classified various tympanogram according to their height and location of peaks, according to these authors type 'A' tympanogram shows normal peak height and is characteristic of normal middle ear functioning, similar findings of immittance evaluation was seen in Group-A. Jerger, Jerger & Mauldin (1972) stated that ARTs at the sensation level less than 60dBSL are consistent with cochlear hearing impairment where as ARTs more than 60dBSL are consistent with retrochochlear hearing impairment in sensorineural hearing impaired ears.

Audiological findings of participants in Group-B

To include the participants into Group-B, various audiological tests were performed such as PTA, Immittance evaluation, OAEs, ABR to confirm the sensorineural hearing impairment with a degree of minimal to mild. All the ears included in Group-B were diagnosed as minimal/mild sensorineural hearing loss depending upon their hearing thresholds.

Table 4
Audiological profile of participants in Group-B

S.No of ears	PTA	Speech scores (SIS)	Immittance		TEOAEs	ABR Presence of Wave 'V' (intensity level of the stimuli)	Provisional diagnosis
			Tympanogram	Reflexes (Ipsi/contra)			
1	26.6 dBHL	92%	Type 'A'	Present	Present	till 50dBnHL	Mild sensorineural hearing loss
2	26.6 dBHL	92%	Type 'A'	Present	Present	till 50dBnHL	Mild sensorineural hearing loss
3	21.6 dBHL	96%	Type 'A'	Present	Present	till 40dBnHL	Minimal sensorineural hearing loss
4	21.6 dBHL	100%	Type 'A'	Present	Present	till 40dBnHL	Minimal sensorineural hearing loss
5	28.3 dBHL	96%	Type 'A'	Present	Absent	till 50dBnHL	Mild sensorineural hearing loss
6	35 dBHL	90%	Type 'A'	Present	Absent	till 50dBnHL	Mild sensorineural hearing loss
7	16.6 dBHL	100%	Type 'A'	Present	Present	till 40dBnHL	Minimal sensorineural hearing loss
8	16.6 dBHL	100%	Type 'A'	Present	Present	till 40dBnHL	Minimal sensorineural hearing loss
9	33.3 dBHL	96%	Type 'A'	Present	Present	till 50dBnHL	Mild sensorineural hearing loss
10	35 dBHL	100%	Type 'A'	Present	Present	till 50dBnHL	Mild sensorineural hearing loss

Note: 'PTA' - 'Pure tone average', 'TEOAEs' - 'Transient evoked otoacoustic emissions', 'ABR'- 'auditory brainstem responses.

Table 4 depicts the findings of participants in Group-B. Pure tone thresholds (PTA) for all the ears ranged in between 15 dBHL to 40 dBHL with speech identification score proportionate to their pure tone average scores with not less than 90% in quite. Immittance evaluation revealed type ‘A’ tympanogram with present ipsilateral as well as contralateral reflexes for all the ears included in this group. OAEs result revealed normal cochlear outer hair cell functioning with the presence of transient evoked otoacoustic emissions (TEOAEs) in all the ears except the ear 5 and 6 where TEOAEs were absent indicating the cochlear outer hair cell damage. Wave ‘V’ of ABR was obtained till 50dBnHL for all the ears who were included in the Group-B.

The Audiological findings of Group-B is in congruence with the results obtained by Clark (1981) that pure tone average of minimal and mild sensorineural hearing loss ranges from 15 to 25 dBHL and 25 to 40 dBHL respectively. According to Harris (1991) and Glattke (1991, 2002), otoacoustic emissions (OAEs) are the sounds of cochlear origin and Transient evoked OAEs are highly sensitive to cochlear pathology and in a frequency-specific way. TEOAE responses are typically absent at frequencies at which hearing thresholds exceed 20-30dBHL, this results supports the findings of the present study with the absence of TEOAEs in the ear 5 and 6. In minimal to mild sensorineural hearing loss wave ‘V’ of ABR usually appears till the intensity level of 50dBnHL. Jerger (1970); Jerger, Jerger & Mauldin (1972) and Liden, Harford, & Hallen (1974) have described various tympanogram according to their height and location of peaks, according to these authors middle ear function is indicated by type ‘A’ tympanogram.

Audiological findings of the participants in Group-C

Ears which were considered in the Group-C were diagnosed with minimal or mild sensorineural hearing loss with auditory dys-synchrony(AD)/neuropathy based on their audiological findings of behavioural and electrophysiological tests.

Table 5

Audiological profile of participants in Group-C

S.No. of ears	PTA (dBHL)	Speech scores (SIS)	Immittance		TEOAEs	ABR	Provisional diagnosis
			Tympanogram	Reflexes (Ipsi/Contra)			
1	26.6 dBHL	45%	Type ‘A’	Absent	Present	Absent	Mild Sensorineural hearing loss with AD
2	28.3 dBHL	50%	Type ‘A’	Absent	Present	Absent	Mild Sensorineural hearing loss with AD
3	36.6 dBHL	72%	Type ‘A’	Absent	Present	Absent	Mild sensorineural hearing loss with AD
4	30 dBHL	68%	Type ‘A’	Absent	Present	Absent	Mild sensorineural hearing loss with AD
5	30 dBHL	92%	Type ‘A’	Absent	Present	Absent	Mild Sensorineural hearing loss with AD
6	26.6dBHL	92%	Type ‘A’	Absent	Present	Absent	Mild Sensorineural hearing loss with AD
7	38.3 dBHL	60%	Type ‘A’	Absent	Present	Absent	Mild Sensorineural hearing loss with AD
8	40.3dBHL	52%	Type ‘A’	Absent	Present	Absent	Mild Sensorineural hearing loss with AD
9	23.3dBHL	64%	Type ‘A’	Absent	Present	Absent	Minimal Sensorineural hearing loss with AD
10	21.6dBHL	56%	Type ‘A’	Absent	Present	Absent	Minimal Sensorineural hearing loss with AD

Note: ‘PTA’ -‘Pure tone average’, ‘TEOAEs’ -‘Transient evoked otoacoustic emissions’, ‘ABR’ -‘auditory brainstem responses.

Table 5 shows the findings of the results of behavioural and electrophysiological test performed on the participants. Ears which were selected under Group-C were diagnosed as minimal or mild sensorineural hearing loss with auditory dys-synchrony (AD)/ neuropathy. Speech identification score were not proportionate to their pure tone average with scores poorer than the expected score in quite condition, except for the ear 5 and 6 where the speech identification scores were proportionate to their pure tone average scores. Immittance evaluation results showed type 'A' tympanogram with absent ipsilateral as well as contralateral reflexes for all the ears. No click evoked auditory brainstem responses (ABR) were recorded for any of the ear included in Group-C.

The Audiological findings of Group-C is in congruence with the results obtained by Starr et al. (1991) that Auditory dys-synchrony/neuropathy is a clinical syndrome which has disrupted auditory nerve activity with concurrently normal or near normal cochlear amplification function . Clinically, the disrupted auditory nerve activity is reflected by highly distorted or absent auditory brainstem responses, whereas the normal cochlear amplification function is reflected by the presence of otoacoustic emission and/or cochlear microphonics (Starr, Picton, Sininger, Hood, & Berlin, 1996; Rance et al., 1999; Hood, Berlin, Bordelon, & Rose, 2003). The other main characteristic of AN is a significantly impaired ability for temporal processing and difficulty in speech understanding, mainly in noise, that is disproportionate to the degree of hearing loss measured by pure-tone thresholds (Zeng et al., 1999; Kraus et al., 2000; Rance, Cone-Wesson, Wunderlich, & Dowell, 2002; Rance, McKay, & Grayden, 2004; Zeng et al., 2005) Absent or severely abnormal ABR which does not correlate with audiometric thresholds and preserved otoacoustic emissions (Starr et al., 1991, Berlin et al., 1993, Starr et al., 1996).

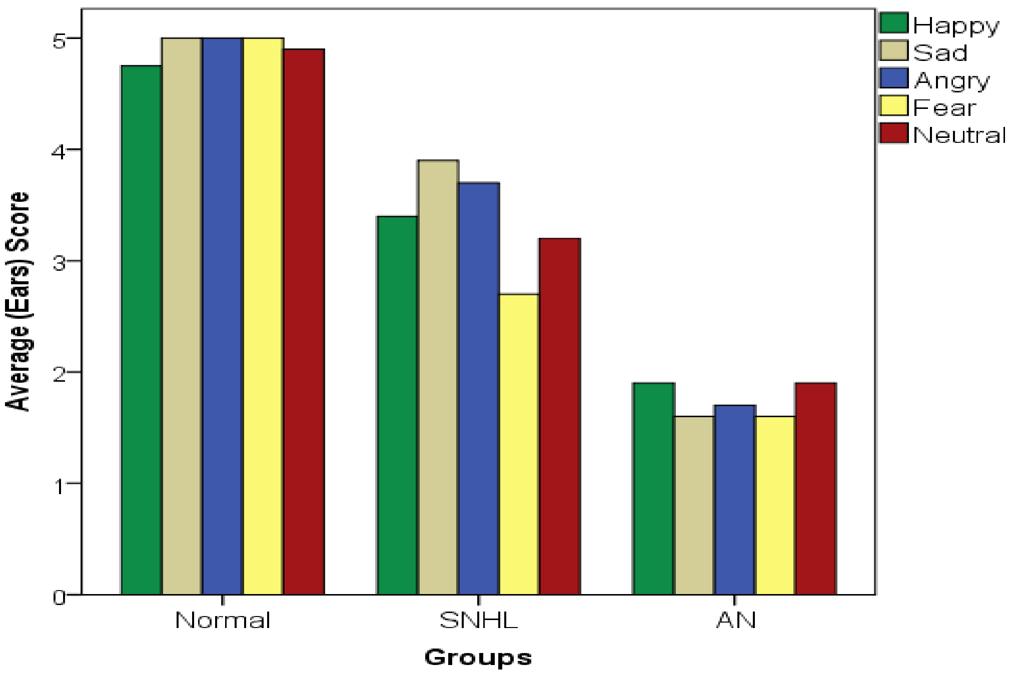
II. Mean and standard deviation (SD) of different emotions among different groups.

Vocal emotion perception battery was administered on all the ears included under three groups mentioned above to assess their vocal emotion recognition abilities. Assessment of the vocal emotion perception battery was done monaurally under headphone condition at the most comfortable level of the listeners.

Table 6
Mean and standard deviation (SD) of different emotions for different groups

Groups → / Emotions ↓	Group-A		Group-B		Group-C	
	Mean	SD	Mean	SD	Mean	SD
Happy	4.7500	0.4443	3.4000	1.3499	1.9000	1.2867
Sad	5.0000	0.0000	3.9000	0.9944	1.6000	1.2649
Anger	5.0000	0.0000	3.7000	1.3375	1.7000	1.4181
Fear	5.0000	0.0000	2.7000	2.2136	1.6000	1.7127
Neutral	4.9000	0.3078	3.2000	1.5492	1.9000	1.1972

Table 6 depicts the mean and standard deviation (SD) of scores obtained for different emotions (happy, sad, anger, fear and neutral) for different groups. There is a significant difference of $P<0.05$ between the different emotions and among all the three groups.



Graph 1. Comparison of different emotions among different groups.

As it can be seen in the graph 1 the scores obtained by the participants of Group-A were the highest as compared to the Group-B and Group-C. In Group-A, 100% scores were obtained for the emotion 'sad', 'anger' and 'fear' with a mean value of 5.00 each. For the emotion 'happy' and 'neutral' the mean scores were 4.75 and 4.90 respectively.

In Group-B, the highest mean score was seen for the emotion 'sad' with the value of 3.90 followed by the emotion 'anger' with the mean value of 3.70. The least mean value of 2.70 was seen for the emotion 'fear', whereas the emotions 'happy' and 'neutral' are intermediate with a mean score of 3.40 and 3.20 respectively.

In Group-C, the overall scores for all the different emotions were comparatively less from the Group-A and Group-B. The emotion 'happy' and 'neutral' shared same mean scores of 1.90, for ‘anger’ the mean score was 1.70, whereas for ‘sad’ and ‘fear’ the mean score was least of 1.60 each.

III. Comparison of emotions among different Groups

Comparison across different emotions was carried out using Kruskal-Wallis test (non-parametric tests). Non-parametric test was applied due to large variability of the sample size among the groups. Results of Kruskal-Wallis test showed the significant difference ($P<0.05$) between all the five emotions.

Table 7
Comparison across different emotions

	Happy	Sad	Anger	Fear	Neutral
Chi-Square	23.927	32.013	29.391	25.242	26.804
Df	2	2	2	2	2
Asymp. Sig.	.000	.000	.000	.000	.000

Comparison of emotions between Group-A and Group-B

Mann-Whitney Test (non-parametric test) was applied for the comparison of different vocal emotions among Group-A and Group-B. Non-parametric test was applied due to the large variability in the sample size between the Group-A and Group-B.

Table 8
Comparison of different emotions between Group-A and Group-B.

	Group-B					
Group-A		Happy	Sad	Anger	Fear	Neutral
	Happy	SD	SD	SD	SD	SD
	Sad	SD	SD	SD	SD	SD
	Anger	SD	SD	SD	SD	SD
	Fear	SD	SD	SD	SD	SD
	Neutral	SD	SD	SD	SD	SD

Note: ‘SD’ indicates ‘significant difference’.

Table 8 summarises the statistical results of comparison of different emotions between Group-A and Group-B. Findings reveals significant difference ($P<0.05$) among Group-A and Group-B across all the five emotions, which indicates that the vocal emotion perception by individuals with normal hearing is different from those individuals with minimal to mild sensorineural hearing loss.

Comparison of different emotions between Group-A and Group-C

Mann-Whitney Test (Non-parametric test) was applied for the comparison of emotions between Group-A and Group-C.

Table 9
Comparison of different emotions between Group-A and Group-C

	Group-C					
Group-A		Happy	Sad	Anger	Fear	Neutral
	Happy	SD	SD	SD	SD	SD
	Sad	SD	SD	SD	SD	SD
	Anger	SD	SD	SD	SD	SD
	Fear	SD	SD	SD	SD	SD
	Neutral	SD	SD	SD	SD	SD

Note: ‘SD’ indicates ‘significant difference’.

Table 9 revealed a significant difference of $P<0.05$ between both the groups across all the five emotions, which indicates that the vocal emotion perception by normal hearing listeners is different from those individuals with minimal or mild sensorineural hearing loss with auditory dys-synchrony(AD)/neuropathy.

Comparison of emotions among Group-B and Group-C

Group-B and Group-C were also compared across different emotions using Mann-Whitney Test.

Table 10
Comparison of different emotions between Group-B and Group-C

	Group-C					
Group-B		Happy	Sad	Anger	Fear	Neutral
	Happy	SD	SD	SD	SD	SD
	Sad	SD	SD	SD	SD	SD
	Anger	SD	SD	SD	SD	SD
	Fear	SD	SD	SD	SD	SD
	Neutral	SD	SD	SD	SD	SD

Note: 'SD' indicates 'significant difference'.

Table 10 shows the findings of statistical analysis applied to Group-B and Group-C for the comparison of different vocal emotions. Results showed a significant difference of $P<0.05$ among both the groups across all the five emotions except the emotion 'fear'. The emotions 'happy', 'sad', 'anger' and 'neutral' were significantly different between the two groups indicated that the perception of these four emotions were different in individuals with minimal to mild sensorineural hearing loss from those with auditory dys-synchrony (AD)/neuropathy.

For the emotion 'fear' the perception was not significantly different between the Group-B and Group-C, which indicates that perception ability of participants in both the group in perceiving the emotion 'fear' is similar. The acoustic parameters of the 'fear' stimuli are, pitch of 300.61Hz, F1 of 885.8Hz, intensity of 76.8dB with duration of 2.1sec, which infers that in both groups it is affected in a similar way.

IV. Within group comparison across different emotions.

Friedman test (non-parametric test) was applied as a statistical tool for the analysis of within group comparisons across different emotions.

Table 11
Within group comparison across emotions.

	Group-A	Group-B	Group-C
Chi-Square	13.714	1.246	4.946
Df	4	4	4
Asymp.sig.	.008	.871	.293

Table 11 summarises the different emotions across groups separately. In Group-A some difference is seen among the emotions whereas for Group-B and Group-C, no difference is seen among all the emotions.

V. Comparison among different emotions

Comparison of different emotions was done with respect to the responses obtained by the participants in all the three groups as well as based on the acoustic analysis of the stimuli used in the vocal emotion perception battery.

Table 12
Comparison among different emotions (based on the responses)

	Z	Asymp. Sig. (2-tailed)
SAD-HAPPY	-2.236	.025
ANGER- HAPPY	-2.236	.025
FEAR-HAPPY	-2.236	.025
NEUTRAL-HAPPY	-1.134	.257
ANGER-SAD	.000	1.000
FEAR-SAD	.000	1.000
NEUTRAL-SAD	-1.414	.157
FEAR-ANGER	.000	1.000
NEUTRAL-ANGER	-1.414	.157
NEUTRAL-FEAR	-1.414	.157

Wilcoxon Signed Rank Test was applied for the comparisons among different emotions. Table 12 reveals that the results of various pair wise comparison across different emotions such as sad with happy, anger with happy, fear with happy, neutral with happy, anger with sad, fear with sad, neutral with sad, fear with anger, neutral with anger and neutral with fear. Difference is seen among all the pairs listed above. These findings were supported by the findings of the acoustical analysis of the stimuli which is discussed further in the following subsection.

Table 13
Comparison among different emotion (based on their acoustic characteristics).

	Happy	*Sad*	*Anger*	*Fear*	*Neutral*
Pitch (Hz)	*395.65*	*257.81*	*324.01*	*300.61*	*238.73*
F1	*856.89*	*776.80*	*861.91*	*885.80*	*781.83*
F2	*1927.46*	*1869.65*	*1994.45*	*1963.6*	*1949.07*
F3	*2985.17*	*3033.95*	*3181.91*	*3099.15*	*3106.95*
F4	*3852.63*	*4012.27*	*3974.20*	*4022.41*	*4054.35*
Intensity (dB)	*78.66*	*77.6*	*79*	*76.80*	*73.92*
Duration (sec)	*1.7*	*1.8*	*1.55*	*2.1*	*1.53*

Table 13 shows the findings of the acoustic analysis of the stimuli used in the vocal emotion perception battery. Difference in pitch values (Hz) was seen in all the emotions. The target emotions were ordered in terms of their pitch values (from high to low) as ‘happy’, ‘anger’, ‘fear’, ‘sad’ and ‘neutral’ with a pitch values of 395.65Hz, 324.01Hz, 300.61Hz, 257.81Hz and 238.73Hz respectively. Intensity difference was also seen among the emotions the target emotions were ordered in terms of their intensity values (from high to low) as ‘anger’, ‘happy’, ‘sad’, ‘fear’ and ‘neutral’ with the a values of 79dB, 78.66dbB, 77.6dB, 76.80dB, and 73.92dB respectively. These findings are in congruence with the findings of Petrushin (2000), Scherer (2003) and Yildirim et al. (2004) that relative to neutral speech, anger and happy speech exhibits higher mean pitch, wider pitch range, greater intensity, faster speaking rate, whereas sad speech exhibits lower mean pitch, narrower pitch range, lower intensity, slow speaking rate.

The target emotions were ordered in terms of their F1 values (from high to low) as 'fear', 'anger', 'happy', 'neutral' and 'sad' with a values of F1 as 885.80Hz, 861.91Hz, 856.89Hz, 781.83Hz and 776.80Hz respectively. Luo et al. (2007) found the similar findings for male talker with mean F1 values (from high to low) as 'anger', 'anxious', 'happy', 'neutral' and 'sad'.

According to Williams and Stevens (1972) when the speaker is anger the basic opening and closing articulatory gestures characteristic of the vowel-consonant alteration in speech appeared to be more extreme, the vowels tended to be produced with more open vocal tract and hence have higher first-formant frequencies, and the consonants were generated with a more clearly defined closure. In the present study also higher first formant frequency was found for the emotion 'anger' as compared to other emotions. The vowel and consonants produced in a fear situation were often more precisely articulated than they were in neutral situation and the average Fo for fear was found to be lower than that observed for anger and for some voices it was found to be close to that of the utterance spoken in the neutral situation. The finding of Fo of fear in the present study correlates with the findings of Williams and Stevens (1972). These authors also concluded that the average fundamental frequency for the utterances spoken in the sorrow situation was considerably lower than that for neutral situations and the range of Fo was usually found to be quite narrower. In the present study Fo for the emotion 'sad' was found to be higher than the emotion 'neutral'.

In the present study, acoustic characteristic in terms of the duration of the stimuli was also taken into consideration. The target emotions were ordered in terms of their duration values (from high to low) as 'fear', 'sad', 'happy', 'anger', and 'neutral'. Williams and

Stevens (1972) also summarised the duration parameters associated with various parameters. They concluded that the duration of utterances spoken in ‘anger’ were usually longer, but this effect was not great and was not always consistent in all voices. Whereas the duration of an utterance in fear situation tended to be longer than in the case of ‘anger’ or ‘neutral’ situation. Increased duration of the stimulus is also seen for the emotion ‘sad’ which resulted from longer vowels and consonants and from pauses that were often inserted in a sentence.

Therefore it can be concluded for the findings given in Table 12 and Table 13 that all the emotions differ from each other in terms of their acoustic properties as well as the responses given by the participants of the present study.

VI. Result of reliability assessment of the test

Test to retest reliability of the vocal emotion perception battery was checked by administering it to randomly selected one-half of the participants from all the three groups for a second time after duration of two weeks. The number of correct responses given by each participant in each of the group for the test was noted. The results were compared with the respective participant’s results obtained during the first test.

Alpha coefficient was used for the reliability assessment. For Group-A the alpha values were 0.7, for Group-B it was 0.98, where as for Group-C it was 0.90. The results showed the good test-retest reliability.

SUMMARY AND CONCLUSION

The present study aimed at developing emotion perception battery in Kannada language and assessing the vocal emotion recognition abilities of group of individuals with normal hearing, sensorineural hearing loss and auditory dys-synchrony/neuropathy.

The test material was developed in Kannada language. 5 sentences each in 5 different emotions (happy, sad, anger, fear and neutral) were recorded in the sound treated room by the professional stage actor who was a native speaker of Kannada language. Before recording of the stimulus, the sentences were evaluated by five Audiologist and five Speech Language Pathologists. Initially recording was done for 2 male and 2 female actors after which the 'goodness' test was performed by 2 Audiologist and 2 Speech Language Pathologist to choose the best clarity voice for the final recording. Overall amplitude difference between the stimuli was either preserved or normalised. The final recorded vocal emotion perception battery consisted of 2 trail sentences and 25 test sentences. Recorded stimulus was then stored into the compact disk (CD).

The other aim of the study was to assess the vocal emotion perception abilities across the group of participants. The groups included, Group-A having ears with normal hearing sensitivity (N=20), Group-B having ears with minimal to mild sensorineural hearing loss (N=10), Group-C having ears with minimal/mild sensorineural hearing loss with auditory dys-synchrony/neuropathy (N=10).

Analysis was accomplished by carrying out descriptive statistics, and Mann-Whitney Test, Friedman test and Wilcoxon Signed Rank test, utilizing social science (SPSS) version 10.0 & 17.0 software.

Mean and standard deviation of scores obtained for different emotions shows a significant difference among all the three groups. Comparison of performance across the three groups on vocal emotion perception recognition revealed that there was a significant difference across all the five emotions. Comparing the performance of the participants in Group-A and Group-B, it was noted that, that both the groups were significantly different across all the five emotions. Similar findings were obtained when Group-A and Group-C were compared. Therefore it can be concluded that perception abilities of normal hearing listeners is different from those with minimal/mild sensorineural hearing loss and with those with auditory dys-synchrony. Whereas when the performance of Group-B and Group-C were compared on vocal emotion perception assessment, revealed a significantly different across all the emotions except the emotion 'fear'. Hence it can be concluded that the perception of the emotion 'happy', 'sad', 'anger' and 'neutral' were different in individuals with minimal to mild sensorineural hearing loss from those with auditory dys-synchrony (AD)/neuropathy. For the emotion 'fear' the perception was not significantly different between the Group-B and Group-C, which indicates that perception ability of the participants in both the groups were similar in perceiving 'fear', which could be because of the underlying acoustic parameters of the stimuli.

It was observed for within Group comparison, Group-A showed some difference among the emotions whereas for Group-B and Group-C, no difference was seen among the emotions.

Results obtained from comparison among different emotions with respect to both responses obtained from the participants and the acoustic characteristic of the stimulus reveals that the difference is seen among all the various pair wise comparison across different emotions such as sad with happy, anger with happy, fear with happy, neutral with happy, anger with sad, fear with sad, neutral with sad, fear with anger, neutral with anger and neutral with fear.

Comparison of the acoustic characteristics of the stimulus reveals the difference in the pitch, intensity and duration values of all the five emotions. The target emotions were ordered (from high to low) in terms of their,

- Pitch (Hz) values as 'happy', 'anger', 'fear', 'sad' and 'neutral'.
- Intensity (dB) values as 'anger', 'happy', 'sad', 'fear' and 'neutral'.
- Duration (sec) values as 'fear', 'sad', 'happy', 'anger', and 'neutral'.
- F1(Hz) values as 'fear', 'anger', 'happy', 'neutral' and 'sad'.

Test to retest reliability of the vocal emotion perception battery was checked by administering it to randomly selected one-half of the participants from all the three groups for a second time after duration of two weeks. Alpha coefficient was used for the reliability assessment. The results showed the good test-retest reliability.

Hence the vocal emotion perception battery developed as a part of this study is a useful is assessing the vocal emotion perception abilities of individuals with normal hearing, sensorineural hearing loss and auditory dys-synchrony/neuropathy.

Implications of the study

- To understand better about the vocal emotion recognition abilities of individuals with sensorineural hearing loss and auditory dys-synchrony/neuropathy.
- It will be useful in the therapeutic management of individuals with hearing impairment and auditory dys-synchrony.

Future research

The vocal emotion perception battery can be administered on more number of participants with minimal/mild sensorineural hearing loss and individuals with minimal/mild sensorineural hearing loss with auditory dys-synchrony.

Vocal emotion perception abilities can also be assessed on individuals with various degree of sensorineural hearing impairment with and without auditory dys-synchrony to measure the effect of severity of hearing impairment on the perception of vocal emotions.

More detailed analysis of acoustic parameters of stimuli and recognition of the responses will fine taper the understanding of recognition abilities of individuals with sensorineural hearing loss with and without auditory dys-synchrony.

REFERENCES

American National Standard Institute (1991). *Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms.* ANSI S 3.1 – (1991). New York. Ambient National Standard Institute.

American National Standard Institute (1996). *"Specifications for Audiometers".* ANSI S3.6 – (1996). New York. Ambient National Standard Institute.

Alpert, M., Kurtzberg, R.L., & Friedhoff, A.J. (1963). Transient voice changes associated with emotional stimuli. *Archives of General Psychiatry, 8,* 362–365.

Allport, G.W., & Cantril, H. (1934). Judging personality from voice. *The Journal of Social Psychology, 5,* 37–55.

Bachorowski, J. (1999). "Vocal expression and perception of emotion". *Current directions in Psychological Science", 8(2),* 53-57.

Banse, R., & Scherer, K.R. (1996). "Acoustic Profiles in Vocal Emotion Expression." *Journal of Personality and Social Psychology, 70,* 614-636.

Bavelas, J.B., & Chovil, N. (2000). Visible Acts of Meaning: An Integrated Message Model of Language in Face-to-Face Dialogue. *Journal of Language and Social Psychology, 19,* 163-194.

Berlin, C.I., Hood, L. J., Cecola, R.P., Jackson, D.F., & Szabo, P.P. (1993). Does type II afferent neuron dysfunction reveals itself through lack of efferent suppression. *Hearing Research, 65,* 40-50.

Berlin, C.I., Hood, L.J., Hurley, M.S., & Wen, H. (1996). Hearing aids: only for hearing impaired patients with abnormal otoacoustic emissions. In Berlin, C.I. (Eds), *Hair Cells and Hearing Aids* (pp. 99-111). San Diego: Singular Publishing Group.

Bryant, G. A., & Fox Tree, J. E. (2005). "Is there an ironic tone of voice?". *Language and Speech, 48*(3), 257-277.

Buss, E., Labadie, R.F., Brown, C., Gross, A.J., Grose, J.H., & Pillsbury, H.C. (2002). Outcome of cochlear implantation in pediatric auditory neuropathy. *Otology Neurotology, 23,* 328-332.

Cacace, A.T., & McFarland, D.J. (1998). Central auditory processing disorder in school-aged children: a critical review. *Journal of Speech Language and Hearing Research, 41*, 355-373.

Caffi, C., & Janney, R.W. (1994). Toward a pragmatics of emotive communication. *Journal of Pragmatics, 22,* 325–373.

Clark, J. G. (1981). Uses and abuses of hearing loss classification. *Asha, 23,* 493–500

Creusere, M., Alt, M., & Plante, E. (2004). Recognition of Vocal and Facial Cues to Affect in Language-Impaired and Normally Developing Preschoolers. *Journal of Communication Disorders*, *37,* 5-20.

Cosmides, L. (1983). Invariances in the acoustic expression of emotion during speech. *Journal of Experimental Psychology: Human Perception and Performance, 9,* 864-881.

Darrow, A. (1984). A comparison of rhythmic responsiveness in normal and hearing impaired children & an investigation of relationship of rhythmic responsiveness to suprasegmental aspect of speech. *Journal of Music Therapy, 21(2),* 48-66.

Darwin, C. (1872). The Expression of Emotions in Man and Animals. In: Murray, J., & Ekman, P. (Eds.1998). London: Harper Collins.

Dellaert, F., Polzin, T.H., & Waibel, A. (1996). Recognizing emotions in speech. *Proceedings of the International Conference of Spoken Language Processing (1996)*, Philadelphia, USA.

Erber, N.P., & Witt, L.H. (1977). Effect of stimulus intensity on speech perception by deaf children. *Journal of Speech and Hearing Disorders, 42(2),* 271-278.

Ekman, P. (1972). Universals and cultural differences in facial expression of emotion. In: Cole, J.R. (Ed. 1971), *Nebraska Symposium on Motivation* (pp. 207–283). University of Nebraska Press, Lincoln.

Feldman, R.S., & Rime, B. (1991). Fundamentals of Nonverbal Behavior (Eds.). Cambridge University Press, New York.

Feldman, R.S., Tomasian, J.C., & Coats, E.J. (1999). Nonverbal Deception Abilities and Adolescents' Social Competence: Adolescents with Higher Social Skills are Better Liars. *Journal of Nonverbal Behaviour, 23*, 237-250.

Fromby, C. (1986). Modulation detection by patients with eighth-nerve tumors. *Journal of Speech and Hearing Research, 29*, 413-419.

Glattke, T. (1991). Otoacoustic Emissions – Clinical Applications, results with respect to pure tone audiogram. *Ear and Hearing, 12,* 399-405.

Glattke, T.J., & Robinette, M.S. (2002). Transient evoked otoacoustic emissions. In: Robinette, R.M., & Glattke, T. (eds). *Otoacoustic Emissions – Clinical Applications* (2nd edn.) Thieme publications, New York.

Gordon-Salant, S., & Fitzgibbons, P.J. (1999). Profile of auditory temporal processing in older listeners. *Journal of Speech Language and Hearing Research, 42,* 300-311.

Hargreaves, W.A., Starkweather, J.A., & Blacker, K.H. (1965). Voice quality in depression. *Journal of Abnormal Psychology, 70*, 218–220.

Harper, R.G., Wiens, A.N., & Matarazzo, J.D., (1978). Nonverbal Communication: The State of the Art. Wiley, New York.

Harris, F.P., & Probst, R. (1991). Reporting click-evoked and distortion-product otoacoustic emission results with respect to the pure tone audiogram. *Ear and Hearing, 12,* 399–405.

Herzog, A., (1933). Voice and personality. *Journal of Psychology,* 130, 300–379.

Hood, L. J., Berlin, C. I., Bordelon, J., & Rose, K. (2003). Patients with auditory neuropathy/dys-synchrony lack efferent suppression of transient evoked otoacoustic emissions. *Journal of the American Academy of Audiology*, *14*, 302–313.

Isserlin, M., (1925). Psychological-phonetic studies. Second communication. *Z. Gesamte Neurol. Psychiatr. 94,* 437–448.

Jerger, J. (1970). Clinical experience with impedance audiometry. *Archives of Otolaryngology, 92,* 311-324.

Jerger, J.F., Ali, A., Fong, K., & Tseng, E. (1992). Otoacoustic emissions, audiometric sensitivity loss, and speech understanding: A case study. *Journal of American Academy of Audiology, 3,* 283-286.

Jerger, J., Jerger, S., & Mauldin, L. (1972). Studies in impedance audiometry: In Normal and sensorineural ears. *Archives of Otolaryngology, 96,* 523-531.

Judith, R.S., Nancy, S.M., & Karen, Y. (1986). Perception of stress contrast by hearing impaired. *Journal of Acoustic Society of America, 79,* S5.

Kennedy, G. (1972). The Art of Rhetoric in the Roman World. 300 BC–AD 300. Princeton University Press, Princeton, NJ.

Knapp, M.L. (1972). Nonverbal Communication in Human Interaction. *Holt, Rinehart and Winston*, New York.

Kraus, N., Bradlow, A. R., Cheatham, J., Cunningham, C. D., King, D.B., kouch, T. G., Nicol, T. J., McGee, L. K., Stein, L. K., & Wright, B. A (2000). Consequences of neural asynchrony: a case study of auditory neuropathy. *Journal of the Association for Research in Otolaryngology, 1,* 33-45.

Laukka, P. (2005). Categorical perception of vocal emotion expressions. *Emotion*, *5*(3), 277-295.

Levine, R.A., Gardner, J.C., Fullerton, B.C., Stufflebeam, S.M., Carlisle, E.W., Furst, M., Rosen, B.R., & Kiang, N.Y. (1993). Effect of multiple sclerosis brainstem lesions on sound lateralization and brainstem auditory evoked potentials. *Hearing Research*, *68*, 73-88.

Liden, G., Harford, E., & Hallen, O. (1974). Tympanometry for the diagnosis of ossicular disruption. *Archives of Otolaryngology*, *99,* 23-29

Lieberman, P., & Michaels, S.B. (1962). “Some Aspects of Fundamental Frequency and Envelope Amplitude as Related to the Emotional Content of Speech”. *Journal of Acoustic Society of* America, *34,* 922-927.

Ling, D. (1976). Speech and the hearing impaired child: Theory and Practice. Washington, D.C. The Alexander Graham Bell Association for the Deaf.

Luo, X., Fu, Q.J., & Galvin, J.J. (2007). Vocal emotion recognition by normal-hearing listeners and cochlear implant users. *Trends in Amplification*, *11,* 301-315.

Mahl, G.F., & Schulze, G., (1964). Psychological research in the extralinguistic area. In: Sebeok, T.A., Hayes, A.S., & Bateson, M.C. (Eds.), *Approaches to Semiotics* (pp. 51–124). The Hague, Mouton.

Michalewski, H. J., Starr, A., Nguyen, T. T., Kong, Y. Y., & Zeng, F. G. (2005). Auditory temporal processing in normal – hearing individuals and in patients with auditory neuropathy. *Clinical Neurophysiology, 116,* 669-680.

Milli Marry, M. & Jayashree, S.B. (2010). Nature of Sentence Intonation in Kannada, Tulu and Konkani. *Language in India, 10*, 15-25.

Moore. B.C. (1996). Perceptual consequences of cochlear hearing loss and their implications for the design of hearing aids. *Ear and Hearing*. *17,* 133-161.

Moore, B.C. & Oxenham, A.J. (1998). Psychoacoustic consequences of compression in the peripheral auditory system. *Psychology Review*, *105*, 108-124.

Most, T., Weisel, A., & Zaychik, A. (1993). "Auditory, Visual, and Auditory-Visual Identification of Emotions by Hearing and Hearing-Impaired Adolescents". *British Journal of Audiology, 27*, 247-253.

Most, T. (2000). Production and perception of syllable stress by children with normal hearing and children with hearing impairment. *Volta Review, 101(2),* 51–70.

Murray, I.R., & Arnott, J.L. (1993). Toward a simulation of emotion in synthetic speech: A review of the literature on human vocal emotion. *Journal of Acoustic Society of America, 93,* 1097– 1108.

Nienhuys, T.G. & Clark, G.M. (1978). Frequency discrimination following the selective destruction of cochlear inner and outer hair cells. *Science*, *199*, 1356-1357

Ostwald, P.F. (1964). Acoustic manifestations of emotional disturbances. In: *Disorders of Communication*, *42,* 450–465. Research Publications.

Oster, A., & Risberg, A. (1986). "The Identification of the Mood of a speaker by Hearing Impaired Listeners". In the *Speech Transmission Laboratory, Quarterly Progress and Status Report 4,* (pp. 79-90).

Oxenham, A.J. & Bacon, S.P. (2003). Cochlear compression: perceptual measures and implication for normal and impaired hearing. *Ear and Hearing, 24*, 352-366.

Patterson, M.L. (1995). Invited article: A Parallel Process Model of Nonverbal Communication. *Journal of Nonverbal Behavior, 19*, 3-29.

Peters, K.P. (2006). "Emotion perception in speech: Discrimination, identification, and the effects of talker and sentence variability". *Independent Studies and Capstones. Paper 121*. Program in Audiology and Communication Sciences, Washington University School of Medicine.

Petrushin, V.A. (2000). Emotion recognition in speech signal: experimental study, development, and application. In: *Proceedings of the International Conference on Spoken Language Processing, 2,* 222-225.

Prosen, C.A., Moody, D.B., Stebbins, W.C., & Hawkins, J.E. (1981). Auditory intensity discrimination after selective loss of cochlear outer hair cells. *Science*, *212*, 1286-1288.

Rance, G., Beer, D. E., Cone-Wesson, B., Shepherd, R. K., Dowell, R. C., King, A. M., Rickards, F.W., & Clark, G.M. (1999). Clinical findings for a group of infants and young children with auditory neuropathy. *Ear and Hearing*, *20*, 238–252.

Rance, G., Cone-Wesson, B., Wunderlich, J., & Dowell, R. (2002). Speech perception and cortical event related potentials in children with auditory neuropathy. *Ear and Hearing, 23,* 239–253.

Rance, G., McKay, C., & Grayden, D. (2004). Perceptual characteristic of children with auditory neuropathy. *Ear and Hearing, 25,* 34-46.

Ryan, A. & Dallos, P. (1975). Effect of absence of cochlear outer hair cells on behavioural auditory threshold. *Nature, 253,* 44-46.

Savithiri, S.R. (1999). "Perceptual cues of words stress in Kannada". *The Journal of the Acoustical society of India, 25,* 1-4.

Savithri, S.R., Johnsirani, R., & Ruchi, A. (2008). Speech Rhythm in Hearing-impaired children. *AIISH Research Fund Project.*

Savithri, S.R., Rohini, H., & Seema, M. (2004). "Perception of Word Stress in Kannada". *Journal of the Indian Speech and Hearing Association, 19,* 41-44.

Scherer, K.R. (1982). Methods of research on vocal communication: Paradigms and parameters. In: Scherer, K.R., & Ekman, P. (Eds.), *Handbook of Methods in Nonverbal Behavior Research* (pp. 136–198). Cambridge University Press, Cambridge, UK.

Scherer, K.R. (1986). Vocal affect expression: A review and model for future research. *Psychological Bulletin, 99*, 143-165

Scherer, K.R. (2003). Vocal communication of emotion: A review of research paradigms. *Speech Communication, 40*, 227-256

Scripture, E.W., (1921). A study of emotions by speech transcription. *Vox, 31,* 179–183.

Sininger, Y.S., Hood, L.J., Starr, A., Berlin, C.I., & Picton, T.W. (1995). Hearing loss due to Auditory neuropathy. *Audiology Today, 7, 10-13.*

Skinner, E.R. (1935). A calibrated recording and analysis of the pitch, force and quality of vocal tones expressing happiness and sadness. *Speech Monographs, 2,* 81–137.

Starr, A., McPherson, D., Patterson, J., Don, R.I., & Gravel, J. (2003). ''Auditory neuropathy'': Physiologic and pathologic evidence calls for more diagnostic specificity. *International Journal of Pediatric Otorhinolaryngology, 67,* 707–728.

Starr, A., McPherson, D., Patterson, J., Don, M., Luxford, W., Shannon, R., Sininger, Y., Tonakawa, L., & Waring, M. (1991). Absence of both auditory evoked potentials and auditory percepts dependent on timing cues. *Brain, 114,* 1157-1180.

Starr, A., Picton, T.W., Sininger, Y., Hood, L.J., & Berlin, C.I. (1996). Auditory neuropathy. *Brain, 119 (3),* 741–753.

Starr, A., Sininger, Y.S., & Pratt, H. (2000). The varieties of auditory neuropathy. *Journal of Basic and Clinical Pharmacology*, *11*, 215-230.

Starkweather, J.A. (1956). Content-free speech as a source of information about the speaker. *Journal of Personality and Social Psychology, 35*, 345–350.

Williams, C.E., & Stevens, K.N. (1972). Emotions and Speech: Some Acoustical Correlates. *Journal of the Acoustical Society of America*, *52,* 1238-1250.

Wright, B.A., Lombardino, L.J., King, W.M., Puranik, C.S., Leonard, C.M., & Merzenich, M.M. (1997). Deficit in auditory temporal and spectral resolution in language-impaired children. *Nature, 387*, 176-178.

Yellin, M.W., Jerger, J., & Fifer, R.C. (1989). Norms for disproportionate loss in speech intelligibility. *Ear and Hearing*, *10(4)*, 231-234.

Yildirim, S., Bulut, M., Lee, C., Kazemzadeh, A., Busso, C., Deng, Z., Lee, S., & Narayanan, S. (2004). An acoustic study of emotions expressed in speech. In: Proceedings of the International Conference on Spoken Language Processing (pp. 2193-2196). Jeju Island, Korea.

Zeng, F.G., Kong, Y.Y., Michalewski, H.J., & Starr, A. (2005). Perceptual consequences of disrupted auditory nerve activity. *Journal of Neurophysiology*, *93,* 3050–3063.

Zeng, F. G., Oba, S., Garde, S., Sininger, Y., & Starr, A. (1999). Temporal and speech processing deficits in auditory neuropathy. *Neuroreport*, *10*, 3429–3435.

Zeng, F.G., Oba, S., & Starr, A. (2001). Suprathreshold processing deficit due to desynchronous neural activities in auditory neuropathy. In Breebaart, D.J., Houstma, A.J.M., Kohlrausch, A., Prijis, V.F., & Schoonhoven, R. (Eds.): *Physiological and Psychological Bases of Auditory Function* (pp. 365-372). The Neetherlands: Shaker Publishing.

Appendix-A

Sentences used in vocal emotion perception battery

S. No.	IPA
Sentence 1 Sentence 2	/ivəţu skul illa/ /nənge mədve gothagide/
Sentence 3	/avarəlla urige bərudilla/
Sentence 4	/navu bæ͡glurge hogbeku/
Sentence 5	/illi məļe ide/

Order of the sentences in the vocal emotion perception battery

(Answer key)

Trial sentences

1	/ivəʈu skul illa/	Happy
2	/avarəlla urige bərudilla/	Fear

Test sentences

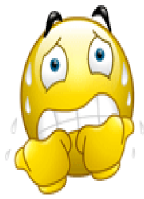
1	/ivəʈu skul illa/	Happy
2	/avarəlla urige bərudilla	Fear
3	/illi məḷe ide/	Sad
4	/nənge mədve gothagide/	Neutral
5	/illi məḷe ide/	Angry
6	/nənge mədve gothagide/	Fear
7	/avarəlla urige bərudilla/	Neutral
8	/ivəʈu skul illa/	Sad
9	/nənge mədve gothagide/	Happy
10	/navu bæ̃glurge hogbeku/	Fear
11	/ivəʈu skul illa/	Angry
12	/navu bæ̃glurge hogbeku/	Angry
13	/nənge mədve gothagide/	Sad
14	/illi məḷe ide/	Neutral
15	/navu bæ̃glurge hogbeku/	Sad
16	/illi məḷe ide/	Happy
17	/avarəlla urige bərudilla	Sad
18	/ivəʈu skul illa/	Neutral
19	/navu bæ̃glurge hogbeku/	Happy
20	/illi məḷe ide/	Fear
21	/avarəlla urige bərudilla/	Happy
22	/ivəʈu skul illa/	Fear
23	/navu bæ̃glurge hogbeku/	Neutral
24	/avarəlla urige bərudilla	Angry
25	/nənge mədve gothagide/	Angry

Appendix-B

Response sheet for vocal emotion perception battery

Instructions for identification of various vocal emotions

You will be hearing 25 sentences randomly in 5 different emotions, one at a time with equal interval of gap between them. After listening to it, you will have to identify the appropriate emotion of that particular sentence. You will be given a response sheet, wherein you will have to put a tick mark (√) below the most appropriate response for each of the stimuli. There are 25 sentences, two practice items and 25 test items.

	HAPPY 	SAD 	ANGRY 	FEAR 	NEUTRAL 
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Client's signature