DEVELOPMENT OF HIGH FREQUENCY SPEECH IDENTIFFICATION TEST IN MANIPURI LANGUAGE

Margaret Hmangte

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University of Mysore, Mysore.

ALL INDIA INSTITUTE OF SPEECH AND HEARING

NAIMISHAM CAMPUS, MANASAGANGOTHRI

MYSORE-570006

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Dedicated to my God, my Saviour, who made heaven and earth.

CERTIFICATE

This to certify that this dissertation entitled **"DEVELOPMENT OF HIGH FREQUENCY SPEECH IDENTIFFICATION TEST IN MANIPURI LANGUAGE"** is the bonafide work in part fulfilment for the degree of Masters in Science (Audiology) of the student **(Register No. 10AUD020).** 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 award of any other Diploma or Degree.

Mysore**Dr. S. R. Savithri**
May, 2012 **DIRECTOR**
All India Institute of Speech & Hearing
Manasagangothri,
Mysore -570006

CERTIFICATE

This is to certify that this dissertation entitled **"DEVELOPMENT OF HIGH FREQUENCY SPEECH IDENTIFFICATION TEST IN MANIPURI LANGUAGE"** has been prepared under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier to any other University for the award of any Diploma or Degree.

Mysore**Ms.Geetha. C**
May, 2012**GUIDE**
Lecturer in Audiology,
Department of Audiology
All India Institute of Speech & Hearing
Manasgangothri, Mysore – 570006

DECLARATION

This dissertation entitled **“DEVELOPMENT OF HIGH FREQUENCY SPEECH IDENTIFFICATION TEST IN MANIPURI LANGUAGE”** is the result of my own study under the guidance of Ms.Geetha. C, Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any university for any other Diploma or Degree.

Mysore **Reg. No. 10AUD020**

May, 2012

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Chapter 1

INTRODUCTION

Speech communication is so important that it is rightly considered to be the most characteristic feature of the human race (Plomp, 2002). Speech perception is defined as the process of decoding a message from a stream of sounds coming from the speaker (Borden &Harris, 1980).

A person with a hearing loss is bound to have difficulty in the perception of speech sounds. Depending on the pattern of audiogram, the speech perception ability of an individual varies. A most common audiogram configuration, which results in a poor speech perception, is high frequency sloping hearing loss.

Individuals with sloping high frequency hearing loss would have difficulty mainly in speech sounds having energy concentration in the high frequency region (Dean, 2000; Risberg& Margolis, 1972). Experiments have repeatedly shown that speech understanding cannot be predictedfrom pure tone thresholds, especially in these cases. Young and Gibbons (1962) noted that although there are some degrees of association between scores obtained from test of speech understanding and pure tone thresholds, the relationship was not strong enough to allow accurate prediction of speech understanding from pure tone audiogram.This is especially true for individuals whose hearing loss is not of flat pattern. Hence, carrying out speech audiometry for the assessment of auditory recognition or identification of words, nonsense syllables or phonemes, is a necessary part of clinical evaluations for individuals with hearing impairment.

Speech Identification Score (SIS), which is a part of speech audiometry, gives information on the speech identification ability of the person. For obtaining SIS, normally, a test which contains all consonants and vowels of the language is used. However, such a test would not give a correct picture about the identification ability of a person with a high frequency sloping hearing loss. This is because the person would perceive the low and mid frequency sounds relatively better and thus, would get clues from these frequencies. This will result in a better SIS than the person's actual speech identification in real life situations.

Hence, it is important to have the test material which contains only high frequency consonants and vowels present in that particular language, when assessing individuals with high frequency hearing loss.The first high frequency word list was developed by Gardner (1971) in English language. Gardner developed a word list that contained consonants of high frequency spectral energy and used it for testing speech discrimination in cases of high frequency hearing loss. It has also been found to be helpful in the application of hearing aid selection and auditory training. There are also other high frequency word lists available in English language. They are; Pascoe High Frequency Test (Pascoe, 1975); and California Consonant Test (Owens & Schubert, 1977).

It is a well-known fact that an individual's perception of speech is reported to be influenced by his/her mother tongue (Singh & Black, 1966). Most people consistently had better and optimum discrimination scores in their mother tongue as compared to other languages (De, 1973). Hence, speech materials have been developedin Indian languages for evaluating Indian population.

The Indian subcontinent consists of a number of separate linguistic communities each of which share a common language and culture. The people of India speak many languages and dialects. It is important to have speech materials developed in each of these languages. There are high frequency word lists developed and standardized in some of the Indian languages such as High Frequency-Kannada Speech Identification Tests (Kavitha&Yathiraj, 2002), High Frequency Speech Identification Test in Tamil (Sinthiya&Sandeep, 2009), and High Frequency Speech Identification Test in Telugu (Ratnakar&Mamatha, 2010).

Need for the study:

Manipuri is one of the official languages of India. It is spoken by over 56% of population in Manipur. Manipuri has several high frequency consonants (/t̪/, /t̪^{h}/, /s/, /ʤ/ /ʧ/, //ʧ^{h}/ and /ʃ/) and high frequency vowels (/i/, /e/ and/ei/). Further, the occurrence of these high frequency sounds is not uncommon in Manipuri language.

Speech materials to assess Speech Recognition Scores and Speech Identification Test developed by Tanuja(1985) are in Manipuri language. However, the Speech Identification Test contains all the sounds present in the language.

As mentioned earlier, Speech Identification Test containing all the sounds in the language have low, mid and high frequencies, which make the list redundant for a person with high frequency sloping hearing loss. Hence, it does not give true communication difficulties of persons with high frequency hearing loss.

Further, for the selection of appropriate hearing aids for individuals with sloping hearing loss, it is essential that a test that is sensitive to their problems be utilized. Therefore, speech identification scores obtained for a high frequency word list is a better means to assess the individual with high frequency hearing loss.

In addition, with increase in number of geriatrics, who most often exhibit sloping type of loss, there is an urgent need for developing High Frequency Speech materials in Manipuri language for assessing speech perception of the individuals who speak Manipuri language. Therefore, the present study attempts to develop a High Frequency Speech Identification Test in Manipuri Language.

Aim of the study:

The aim of the study is to develop High Frequency Speech Identification Test in Manipuri language and to administerthe developed test on participants with normal hearing sensitivity.

Objective of the study:

The objectives of the present study are:

1. To develop high frequency word lists in Manipuri language to determine SIS in individuals with high frequency hearing loss.
2. To administerthe developed test on participants with normal hearing sensitivity who are native speakers of Manipuri, at three different input levels, i.e., 20 dB SL, 40dB SL and 60dB SL (Ref. SRT).

Chapter 2

REVIEW OF LITERATURE

Speech audiometry is an important component of diagnostic audiological evaluation battery for a variety of reasons. One of the basic and the earliest method to assess speech perception was speech audiometry. The basic speech audiometric tests include Speech Detection Threshold (SDT), Most Comfortable Level (MCL) and Uncomfortable Level (UCL).

The purpose of speech audiometry is three fold; first, it is a validation of pure tone air conduction thresholds (Carhart, 1952; Chaiklin&Ventry, 1964). Second, it provides an index of hearing sensitivity for speech. Third, it provides an estimate of suprathreshold speech perception (Hannley, 1986). SRT validates pure tone thresholds, whereas suprathreshold level speech recognition scores provide insight on the site of lesion and hence, the development of rehabilitative programs.

Though there is a correlation between SRT and PTA, speech perception ability of an individual cannot be predicted from puretone threshold alone. Young and Gibbons (1962) noted that the degree of association between scores obtained from speech understanding and pure tone thresholds, for subjects with hearing impairment. However, the relationship was not strong enough for accurate prediction of speech understanding from the audiogram.

Testing of speech should reflect the communication handicap created by the hearing loss and should differentiate the normal hearing individuals from those with sensorineural hearing impairment.

Listeners with cochlear hearing loss of lesser degree often do not manifest reduced word identification scores when performance is assed with commonly used monosyllabic word lists. This is also evident when word recognition ability is assessed in individuals with high frequency sensorineural hearing loss. Hence, the two major factors,degree of hearing loss and the configuration (sloping) of hearing loss influence the speech identification ability.

The high frequency hearing loss mostly is of sensory or cochlear hearing loss. Many people around the world with acquired sensory hearing loss have a high frequency hearing loss. Though this type of problem is not life threatening, it has become a major burden in social and professional life (Kemperman&Cremers, 2002).

2.1Perception of individuals with high frequency hearing loss.

Pascoe (1975) suggested that the critical range of frequencies which have a significant effect on word recognition, particularly in presence of noise are from 2500-6300 Hz. Hughes and Halle (1956) reported the resonance region for /s/ to be above 3000 Hz and /ʃ / to be 2000 Hz to 3000 Hz and above and for /f/ within 1500 Hz. Hence, the individuals with a high frequency sloping hearing loss have difficulty in the perception of speech sounds having high frequency energy.

Owens, Benedict and Schubert (1972) related the phonemic errors to pure tone configurations and to certain types of hearing impairment. They observed that /s/, /ʧ/, /ʤ/ and /ʧ/ and /θ/ were easily identified by patients with flat pure tone configurations, but were difficult for patients with sharply falling slopes of hearing loss from 500 Hz to 4000 Hz. Identification of the /s/ and initial /ʧ/ and /θ/ was highly dependent upon energy in the frequency range above 2000 Hz, whereas identification of the /ʧ/, /ʃ/, /ʤ/ was highly dependent on the range between 1000 Hz and 2000 Hz.

Further, the probability of error for individual phonemes was more closely related to pure tone configurations than to kinds of hearing impairment.

Sher and Owens (1974) studied the perception of consonants with energy above 2000 Hz in individuals with high frequency hearing loss. Group one included individuals with normal hearing up to 2000 Hz and high frequency loss beyond 2000 Hz, the degree of slope averaging 30 dB between 2000 Hz to 3000 Hz and 15 dB between 3000 Hz to 4000 Hz. The group two included normal hearing individuals, who heard the speech stimuli presented through a low-pass filter with a cut-off of 2040 Hz. The results indicated the phonemes contributing to this difficulty were primarily / p/, /b/, /t/, /k/, /s/, /θ/ in both initial and final positions, /ʧ/, /ʃ/, /f/, /ʤ/, /z/, /v/ in final position only. Hence, individuals with normal hearing up to 2000 Hz accompanied by a high frequency loss do have difficulty identifying a substantial number of phonemes.

Geetha, Ashly andYathiraj (2006) studied perception of high frequency filtered speech in normal hearing subjects to simulate gradual and sharply sloping hearing loss. The filtered words lists were presented at 45 dB HL. It was found that the gradual sloping results in higher identification scores than sharply sloping condition in word and phonemes scores. The place errors were; confuse between /d/ and /b/ followed by /d/ and /g/ and /p/ and /t/. Among the manner errors, fricatives /f/ was substituted with /h/ and /s/, and nasals /n/ and /m/ substituted with /l/. For the list representing gradual hearing loss, place errors were /d/ was substituted with /b/, and /p/ substituted with /b/. Among the manner errors, fricatives /f/ and /s/ were confused for each other, and in nasals /n/ substituted with /m/ or /l/. This gives the information of errors that are likely to be seen in individuals with high frequency hearing loss and also helps in planning rehabilitative programs.

A similar study done byPrawin and Yathiraj (2008) studied perception of speech by simulating different configurations of hearing loss. Phonetically balanced monosyllables were used. They noted that the gradually falling pattern had both manner and place errors whereas in sharply falling patterns only place errors were more evident.

2.2Role of speech tests in hearing aid selection.

Along the different purposes of speech audiometry which have already been discussed earlier in this chapter, it also has an important role in the selection of hearing aids. Dennison and Kelly (1978) carried out a study to check high frequency consonant word discrimination with hearing aids. Their results showed that in five of the nine subjects, the same hearing aid was selected using either the high frequency consonant test or the NU-6 test. However, in the remaining four subjects, while the NU-6 test indicated that the amplification was appropriate, the high frequency consonant scores indicated that the amplification was not appropriate. They concluded that the high frequency consonant scores should serve as a supplement to the NU-6 test scores and not as a replacement for NU-6.

However, Skinner (1980) and Skinner, Karstaedt and Miller (1982) used the Pascoe High Frequency word test for the selection of hearing aids in individuals with sensorineural hearing loss. It was found that Pascoe's High Frequency word test was better in selecting the appropriate hearing aid compared to regular speech identification test. They concluded that speech test plays an important role in selection of hearing aids for the hearing impaired individuals.

Kavitha (2002) also found that there was a significant difference between the aided and unaided scores on the word subtest of the High Frequency-Kannada Speech Identification Test developed when compared to the list developed by Mayadevi (1974). The latter was a regular speech identification test. She concluded that her test was sensitive to the perceptual problem of individuals with a sloping high frequency hearing loss. Hence, she recommended that the high frequency word test should be used in the fitting of hearing aids in the individuals with high frequency hearing loss.

A hearing aid test protocol for individuals with sloping high frequency hearing loss was developed by Krishnan (2003). In his study, 30 individuals, 11 gradually sloping, 13 steeply sloping and 6 precipitously sloping hearing loss individuals were tested. An analogue behind-the-ear was tested using High Frequency Kannada Speech Identification Test (HF-KSIT) developed by Kavitha (2002). Individuals were tested both in unaided and aided condition, of +5 dB and +10 dB SNR.

The results revealed that the significant difference existed between the unaided and the aided condition for both the word and sentence subtests across the audiometric slopes. Further, in unaided and aided condition, a significant difference was observed between the +5dB and +10dB SNR for the word subtest. There was no significant difference between the two SNRs for the sentence subtests for all the three audiogram slopes. Hence, the word or the sentence subtest in the presence of noise could be effective in selection of hearing aids for sloping high frequency hearing loss. In the gradual sloping, both word and sentence subtest could be used, but only at the +10 dB SNR.

It is clear from the above review that, individuals with high frequency hearing loss have difficulty in perception of high frequency speech sounds. Individuals with lesser slope have lesser problem than with greater problem with individuals with high frequency hearing loss. Hence, individuals with high frequency hearing loss usually complaint of difficulty in understanding or recognising speech in noisy background or conversational speech sounds. It can be deduced from this that a test with only high frequency sounds would be more sensitive to test these individuals.

2.3Speech identification test in various languages for individuals with high frequency hearing loss.

Researchers have developed high frequency speech identification tests for individuals with high frequency hearing loss in English and other different languages, in order to prevent misdiagnosis in individuals with a sloping high frequency hearing loss.

The following are the different high frequency speech identification test in different languages.

2.3.1High frequency speech test in English:

The various speech identification tests in English are as follows:

- Gardner High Frequency word Lists (Gardner, 1971)
- The Pascoe High Frequency Test (Pascoe, 1975)
- The California Consonant Test (Owens & Schubert, 1977)

2.3.1.aThe Garner High Frequency Word Lists.

Gardner (1971) compiled a list of words that contained consonants of high frequency spectral energy and used it for testing speech discrimination. He designed the high frequency word list which consists of seven voiceless consonants /p, t, k, s, f, θ, h/ in conjunction with the a single vowel /i/ these consonants have been known to be confusing in individuals with high frequency hearing loss. The fifty words were arranged in a random order and were assigned alternatively to two lists of twenty five words in each. It is specifically designed for application of hearing aid selection and also for auditory training as well.

The main drawback of the test developed by Gardner was that the lists were not standardised by the speech testing material under specified conditioned to determine if they are sensitive enough to provide the kind of information desired from the test.

2.3.1.bThe Pascoe High Frequency Test.

Pascoe (1975) developed a test to assess the speech perception abilities of those who are hearing impaired. The list included fifty monosyllable words. Only three vocalic nuclei were used /I/, /ai/ and /ou/ in order to increase the weight of the consonants in the correct identification of the vowels**.** Voicelessfricatives and plosives formed 63% of the number of consonants, the rest were nasals, laterals and voiced plosives. The words were divided into two lists.

In the first part, eight hearing impaired individuals were tested with binaural master hearing aids with five different frequency responses. In the second part, the Pascoe high frequency test was compared with the PB-word list in quiet and in the presence of noise.

The results indicated that the identification scores obtained using high frequency lists were more sensitive in detecting the deficits in communication. Pascoe high frequency test was alsofound to be useful as a standardised test. It was found to be useful for hearing aid evaluation as well as checking perception ability in the presence of noise.

2.3.1.cThe California Consonant Test.

Owens and Schubert (1977) developed the test to be used with hearing impaired subjects. It is a multiple choice test for consonant identification. It consists of 100 items. They believed that a clinical test should be developed which permitted phoneme variation in only one position in any given item which employed an easily manageable manner of foils.

The results revealed that the test was found to be sensitive to high frequency loss. Poor scores revealed that a fairly low correlation (-0.40) was found between the CCT and the degree of loss for 59 subjects with relatively flat configuration between 250 to 4 kHz.

One of the drawbacks, however, was that, in spite of having studied several of the variables, often associated with the development of a new word identification test, they did not determine performance-intensity functions for either normal or hearing listeners. Rather, the test was administered only at a most comfortable listening level typically at 40 dB SL.

Owens and Schubert (1977) also studied the reliability of the California Consonant Tests and found it to be highly sensitive and its range of difficulty is appropriate for separating patients with differing degrees of difficulty. Despite the test being designed specifically for detection of high frequency hearing loss,it contains only 38% of high frequency speech sounds.

2.3.2 High frequency speech test in Indian languages:

The Indian subcontinent consists of a number of separate linguistic communities each of which share a common language and culture. The people of India speak many languages and dialects. Singh and Black (1996) reported that an individual's perception of speech to be influenced by their mother tongue. De (1973) found that people consistently had better and optimum discrimination scores in their mother tongue as compared to other languages. Phonetically balanced speech information tests have been developed in some of the Indian languages. Administering the test in a subject's native language is considered ideal. Since India is a multilingual country, there is a need to develop the tests in each language.

The various speech identification tests already developed in Indian languages are given below:

- The Speech Identification Test for Hindi and Urdu Speakers (Ramachandra, 2001)
- High Frequency – Kannada Speech Identification Test (Kavitha, 2002)
- Speech Identification Test for Indian English Speakers to Assess the Perceptual Problems of Individuals with HFHL (Sudipta, 2006)
- High Frequency Speech Identification Test in Tamil (Sinthiya, 2009)
- High Frequency Speech Identification Test in Telugu (Ratnakar, 2010)

2.3.2.aThe Speech Identification Test for Hindi and Urdu Speakers.

Ramachandra (2001) developed a high frequency speech identification test in India for Hindi and Urdu speakers. He developed two lists of randomized words rated for familiarity. The first list consisted of high frequency phonemes in the initial position and second category consisted of high frequency phonemes in the final position.

The test was done on 15 individuals with sloping high frequency hearing loss. It was found that the test was more sensitive to their perceptual problems compared to the common speech discrimination test for Indians developed by Mayadevi (1974). There were no significant differences between the groups of Hindi and Urdu speakers for the sensation levels from 0-40 dB at 0.05 dB level of significance.

It was also recommended that the test could be used for subjects speaking either Hindi or Urdu language. It was found to be useful for hearing aid evaluation as well as checking perception ability the individuals with high frequency hearing loss.

2.3.2.bHigh Frequency in Kannada Speech Identification Test.

Kavitha (2002) developed a speech identification test in Kannada for testing adults with high frequency hearing loss. The test consists of three word lists of different high frequency phonemes with equal distribution of high frequency sounds. It includes bisyllabic and trisyllabic words.

The test was administered randomly on 30 normal hearing individuals and 30 with high frequency loss individuals. The utility of this was also evaluated on five individuals with high frequency loss, with and without hearing aids. The results were compared with those obtained with the Common Speech Discrimination Test for Indians (Mayadevi, 1974).

It was found that there was no significant difference between the High Frequency Kannada Speech Identification Test and Common Speech Discrimination Test for Indians in normal hearing individuals.

The scores were poorer on individuals with high frequency hearing loss in word subtest compared to sentence subtest. The sentence subtest was unable to differentiate the subjects with high frequency hearing from the normal hearing subjects. It was suggested that the sentence subtest to be more sensitive if administered in the presence of noise.

Further, the individuals with high frequency hearing loss got poorer scores when the word scores were compared to phonemes scores. Thus, the word scoring procedure was recommended for individuals with high frequency hearing loss. The individuals with high frequency hearing loss were tested in both aided and unaided conditions.

The results of this showed that there was a significant difference in the performance of the subjects for the word and the sentence test in both the conditions. Hence, the test was considered to be useful for the selection of hearing aids and concluded that the HF-KSIT was a sensitive test for assessing sharply sloping high frequency hearing loss compared to individuals with sloping high frequency hearing loss group.

2.3.2.cSpeech Identification Test for Indian English Speakers to Assess the Perceptual Problems of Individuals withhigh frequency hearing loss.

This test was to assess the perceptual problems of Indian English speakers with high frequency hearing loss, developed by Sudipta (2006). The test includes four word lists and four sentence subtests.

This was administered on 30 normal hearing subjects and 10 sloping hearing loss subjects. The scores were compared with English monosyllabic word tests developed by Rout (1996). The results showed a significant difference between individuals with normal hearing and hearing impairment. Individuals with high frequency hearing loss got poorer scores on words than sentence subtest.

2.3.2.dHigh Frequency Speech Identification Test in Tamil.

This is yet another high frequency speech identification test, developed by Sinthiya (2009) in Tamil, for testing individuals with high frequency sloping hearing loss. The test consisted of three lists, two bisyllabic word lists and a trisiyllabic word list.

The test was administered on 100 normal hearing individuals. The results showed no significant difference between the two ears in their identification scores. All the three lists can be used to obtain high frequency speech identification. However, the test needs to be administered on individuals with high frequency hearing loss to test the clinical utility.

2.3.2.eHigh Frequency Speech Identification Test in Telugu.

Ratnakar (2010) developed speech identification materials in Telugu for testing individual with high frequency sloping hearing loss of Telugu speaking individuals. The test consisted of 50 bisyllabic words divided into two half lists, each list containing 25 words and one trisyllabic word list, containing 25 words.

The test was administered on 100 normal hearing individuals and on five individuals with high frequency hearing loss sensorineural, who were native speakers of Telugu. The test results showed no significant difference between the bisyllabic half word lists and trisyllabic word liststhere was a significant difference between the individuals with normal hearing and with individuals with high frequency hearing lossfound. Hence, the test was considered to be useful for the individual with sloping high frequency hearing loss in both diagnosis and selection of hearing aids.

2.4 Factors affecting speech audiometry:

There are various factors which need to be considered while developing speech materials.The details of each of them are given below.

2.4.1 Familiarization.

Recognition of the importance of familiarity with the speech stimulus is important. The purpose of familiarity is to ensure that the patient knows the test vocabulary and able to recognize each word auditorily, and the clinician can accurately interpret the patients response (ASHA, 1988). The studies done by Chaiklin and Ventry(1964) and Chaiklin, Dixon and Font(1967) reported thatfamiliarization with the spondee words prior to testing produced spondee thresholds with high test retest reliability and high correlations to the two- and three-frequency puretone average.

Tillman and Jerger (1959) investigated the use of familiarized and unfamiliarized spondees for determining spondee thresholds. They found familiarized spondee thresholds both initially lower in their mean sound pressure level (SPL) values and less variable upon repeated testing. Investigators have shown, therefore, that familiarization with the test spondees appears to be an important step in the determination of spondee thresholds.

2.4.2 Recorded versus monitored live- voice presentation.

It is a known fact that speech production varies from person to person (Brandy, 1966; Carhart, 1965). Further there can be variations in the same words spoken by the same person on different days. Hence, recorded presentation can be used because they ensure greater consistency across presentations (Brandy, 1966; Carhart, 1965). However, in audiology practice, many a times, live monitored voice is used than the recorded voice. However, there are results indicating that found no significant difference in test scores between recorded and monitored live voice presentations (Kruel, Bell & Nixon, 1969).

2.4.3 Level of presentation.

The most comfortable loudness is the most frequently used level (Martin & Slides, 1985) to determine word recognition scores.

Earlier studies have shown that the minimum level for maximum score (PB-Max) varies across pathological groups. The level of presentation also varies depending the degree and configuration of hearing loss Sometimes, if necessary, , the presentation level may be based on four frequencies pure tone average i.e. 500, 1 k, 2 k & 4 k Hz also instead of SRT. If the words are too loud for the patient the level is reduced to a more comfortable level.

2.4.4 Importance of testing at different levels.

Levin (1952) report of as the intensity increase, the score was increased until a maximum score is reached after which it will remain constant regardless of increase intensity. Articulation score for spondee and sentences was increase rapidly with an increase in intensity whereas the articulation scores for mono0syllabic words was increase more gradually. Inorder to get 20% to 60 % articulation score it is necessary to increase the intensity only 3.5 dB for spondee and 8.5 dB for monosyllabic.

2.4.5 Full list versus partial list.

Using full list is time consuming, due to these it may be necessary to have small list. Half list is generally prepared in which the frequency of occurrence of the phonemes are balanced between the two half lists. For example, Vandana(1998), showed no significant difference in the percentage of identification between full list and half lists.

2.4.6 Influence of non-nativelanguage.

An individual's perception of speech is reported to be influenced by his mother tongue (Singh & Black, 1966). De (1973) found that people consistently had better and optimum discrimination scores in their mother tongue as compared to other languages. So, administering the test in a subject's native language is considered ideal. Speech audiometry involves materials that are inherently linguistic in nature. The non-native speakers of the language typically obtain lower scores as compared with native speakers in speech identification and speech recognition tests (Gat & Keith, 1978). Hence, every patient is to be tested in his native language by an audiologist who is also a native speaker or fluent speaker of that language which will give a valid scores and appropriate responses.

2.4.7 Phonemic/Phonetic Balance.

Phonemically balancing of the speech material play a major role in the development of many speech recognition tests. However, phonemic balanced has been found to have little practical impact on the outcome of speech recognition tests, and its clinical relevance is questionable, (Tobias, 1964; Carhart, 1970; Bess, 1983), though, there are several tests available which are phonemically/phonetically balanced.

These are some of the factors which need to be considered while developing the speech material. Apart from these factors, even the equivalency between the sub tests and assessment of clinical utility of the developed tests are important.

Chapter 3

METHOD

The objectives of the study were to develop High Frequency Speech Identification Test in Manipuri language, and to administer this on participants with normal hearing sensitivity at different input levels. The study was conducted in two stages.

Stage 1: Development of high frequency word subtests in Manipuri language.

Stage 2: Administering the developed test on participants with normal hearing sensitivity.

3.1 Stage1: Development of the High Frequency word subtest in Manipuri Language:

The following steps were involved, for preparing the high frequency test material in Manipuri language.

1. Selection of words with high frequency sounds in Manipuri language,
2. Recording of the selected words,
3. Long-term average speech spectrum (LTASS) of the selected words,
4. Familiarity assessment, and
5. Construction of subtests.

3.1.aSelection of words with high frequency sounds in Manipuri language.

Monosyllabic words, 230 in number, were selected from different sources like newspapers, dictionary, text books etc.The monosyllabic words, which majorly contained k/, /k^h/, /h/, /s/, /p/, /p^h/, /t/, /t^h/, /ʧ/ & /ʃ/ consonants and /i/, /e/ & /ei/, were chosen.In the literature, these phonemes have been reported to have energy at high frequenciesand thus, results in confusion for individuals with high frequency hearing loss (Copper, Liebermann, Delattre, Brost&Gerstmann, 1952; Gardner, 1971; Hughes & Hall, 1956).

3.1.bRecording of the Test Material.

The recording of these 230 words were done in a sound treated double room set up. The monosyllabic words were spoken by an adult female who was native speaker of Manipuri language. This was recorded into a computer using 16 kHz sampling rate and 16 bit quantization using Computerized Speech Lab (CSL) 4500 software.

The speaker was instructed to say the words with flat tone and to keep the loudness constant across the words. The VU meter was monitored within optimum levels during the recording. The signal was digitized at a sampling rate of 16 kHz using the 12 bit analog to digital and digital to analog converter housed within a computer. Noise and hiss reduction was carried out on the recorded materials and amplitude normalization of the signals was done using the Adobe Audition (version 3.0) software to maintain constant amplitude across the words. The recorded materials were played to two adults who were native speakers of Manipuri language to ensure that the articulation and the clarity of the recorded material were good.

3.1.cLong-Term Average Speech Spectrum (LTASS) of the selected words:

Long-term average speech spectrum (LTASS) was done on this 230 words, to confirm that the selected words have high frequency spectral energy. Long Term

Average Speech Spectrum was derived using PRAAT (version 4.1) software and the spectral information was determined manually. The peak frequency of the spectrum was taken as the target parameter. Words with peak frequency of 2 kHz or above, and which had energy present even in the frequencies above the peak frequency were selected.

3.1.dFamiliarity Assessment:

Familiarity assessment of the words selected based the LTASS were assessed by five adults, two males and three females, who were native speakers of Manipuri language. They were instructed to rate for familiarity of each word on a three point scale; 1) most familiar (the words which were commonly used by the individual), 2) familiar (the words that are used occasionally) and 3) unfamiliar (the words which are not used). The words that were rated as most familiar and familiar were selected for the construction of the two subtests with one list each.

3.1.eConstruction of Word Subtest:

Two subtests with 25 words each were made after familiarization. The frequencies of occurrence of sounds were balanced as far as possible between the two subtests. These are given in Appendix.

The audio recorded files of these words were then copied to a compact disk. The inter stimulus interval between the words was set to 3 seconds. A calibration tone of 1 kHz was inserted before beginning of the high frequency word lists to adjust the VU meter at zero.

3.2 Stage 2: Administration of the test material on participants with normal hearing sensitivity:

3.2.aSelection of participants:

Inthis stage, the developed high frequency test materials were administered on 60 native speakers of Manipuri. For the selection of the participants for the study, routine audiological evaluation was carried out. The individuals were considered for the study based on the following inclusion criteria.

- Native Manipuri speakers within the age range of 18 to 30 years.
- Fluent speakers of Manipuri language.
- Normal hearing sensitivity (PTA less than or equal to 15 dB HL)from 250 Hz to 8000 Hz for air conduction and 250 Hz to 4000 Hz for bone conduction.
- Individuals with normal middle ear condition in both the ears, with ‘A’ or ‘As’ type of tympanogram with ipsilateral and contralateral reflexes present at 500, 1000 & 2000 Hz.
- No history of otological (ear disease, trauma, ototoxic drug intake or ear operation)or neurological dysfunction.
- Normal speech and language skills.

3.2.bTesting environment:

All the evaluations were carried out in an acoustically treated two-room situation. This set up had minimum noise levels.

3.2.cInstrumentation:

A calibrated dual channel GSI 61 audiometer coupled with acoustically matched TDH 39 headphones housed in MX-41AR ear cushions and B71 bone vibrator was utilized to estimate the pure tone threshold, speech recognition thresholds (SRT) and speech identification scores (SIS). Calibrated GSI Tympstar middle ear analyzer was used for obtaining tympanogram and acoustic reflex thresholds.

A computer was used to present the recorded speech test material. The output was routed through a computer connected to the auxiliary input of the calibrated GSI 61audiometer through TDH 39 headphones.

3.2.dTest procedure:

The pure tone thresholds were tracked for frequencies between 250 Hz to 8 kHz for air conduction and 250 Hz to 4 kHz for bone conduction using the modified Hughson and Westlake procedure (Carhart&Jerger, 1959). The speech recognition threshold and SIS were obtained using the existing SRT and SIS lists in Manipuri language developed by Tanuja (1985). A GSI Tymstar middle ear analyzer was used to find out the type of tympanogram and acoustic reflexes at 500 Hz, 1 kHz and2 kHz.

3.2.eAdministration of the test material:

Prior to testing, external input to the audiometer was calibrated to 0 VU, using a 1000 Hz calibration tone, for each subject. The high frequency speech identification lists developed were played through CD player at 20 dB SL, 40 dB SL and 60 dB SL (Ref. SRT).

The participants were asked to listen to the instructions first and to follow the instructions. Stimuli were presented through headphones and an open set response in the form of an oral response was obtained. All participants were tested monaurally using the developed lists. The tester recorded the responses in a scoring sheet.

3.2.fScoring:

Word scoring was done for both the lists. Scoring was done by giving a score of '1' for a correct repetition and '0' for a wrong repetition or missed words.

3.2.gStatistical Analysis:

The Statistical Package for the Social Sciences (version 17.0) software was used to carry out the statistical analysis. Repeated measures ANOVA, and Bonferroni pairwise comparison test were carried out for the analysis of the data.

Chapter 4

RESULTS AND DISCUSSION

The aim of the present study was to develop a High Frequency Speech Identification Test in Manipuri language and to administer this on participants with normal hearing sensitivity at three levels of presentation. The statistical analysis of the data was done using SPSS statistical package (version 17.0).

4.1 Development of the high frequency word lists:

As mentioned in the chapter 3, monosyllabic words with the phonemes (/h/, /s/, /p/, /p^h/, /t/, /t^h/, /ʧ/, /ʃ/, /k/ & /k^h/),230 in number, were selected from different sources like newspapers, dictionary, text books etc. These 230 words were recorded by two female adult native speakers of Manipuri. Recording was done in a sound treated room by using 16 kHz sampling rate and 16 bit quantization using Computerized Speech Lab (CSL) 4500 software. After recording, LTASS was done for these words to assess the spectrum.

4.2 Results of LTASS:

In order to confirm that these words have energy at high frequencies, LTASS was done using PRAAT (version 4.1) software. From the spectrum, the peak frequency and the pattern with which the energy spreads above the peak frequency were analyzed. The words which were found to have peak energy at 2 kHz or above, and with energy present even above the peak frequency were selected.

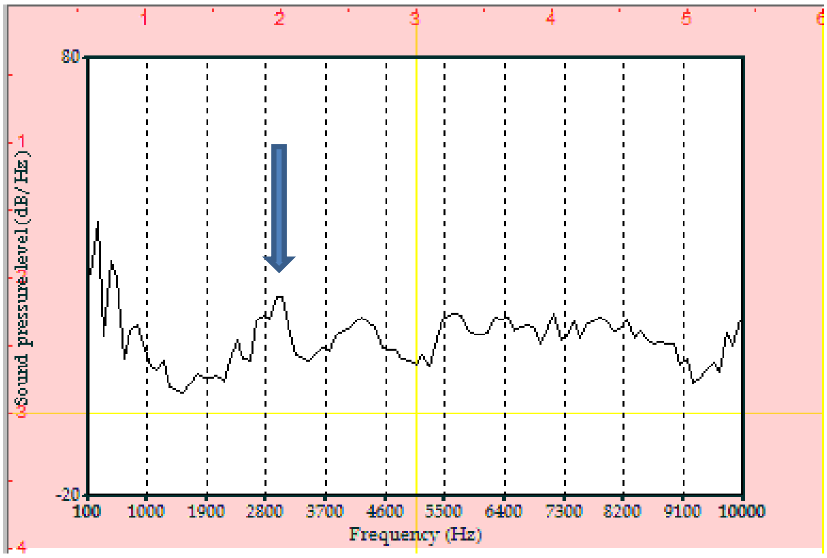

*Figure 4.2*Spectrum of the word /siŋ/. Long Term Average Speech Spectrum showing peak frequency at 2800 Hz(indicated with an arrow mark)and the presence of energy even above 2800 Hz.

Out of 230 words, 78 words met the above mentioned criteria. The list of these words and the frequency at which peak energy was present is given in the table 4.1. The selected words were then assessed for familiarity by five adult native speakers of Manipuri language.

*Table 4.2*List of 78 words with their peak frequency

SL. No.	Words	LTASS	Sl. No.	Words	LTASS	SL. No.	Words	LTASS	SL. No	Words	LTASS
1.	/ki/	2000	21.	/cæŋ/	2800	41.	/t̪ʰɛt/	2500	61.	/sɛp/	2800
2.	/ke/	2800	22.	/cɛt̪/	2900	42.	/t̪ʰem/	2800	62.	/sɛm/	2800
3.	/ken/	2800	23.	/cen/	2900	43.	/t̪ʰəi/	2800	63.	/sku:l/	3700
4.	/kəi/	2800	24.	/cep/	2900	44.	/pi/	2000	64.	/sɤit/	2500
5.	/kʰi/	3500	25.	/cəi/	2900	45.	/pik/	2800	65.	/slet̪/	2000
6.	/kʰik/	2500	26.	/ṭik/	2000	46.	/pin/	2800	66.	/svəi/	2000
7.	/kʰiŋ/	2500	27.	/ṭiŋ/	2800	47.	/pɛk/	2000	67.	/svi/	2200
8.	kʰin/	2500	28.	/t̪in/	2000	48.	/pəi/	2000	68.	/hi/	2000
9.	/kʰɛɤ/	2200	29.	/t̪e/	2000	49.	/pʰi/	2000	69.	/hik/	2000
10.	/kʰe/	2500	30.	/t̪ɛk/	2000	50.	/pʰəi/	2000	70.	/hiŋ/	2500
11.	/kʰɛk/	2500	31.	/t̪ɛŋ/	2000	51.	/si/	2800	71.	/hip/	2500
12.	/kʰɛt/	2500	32.	/t̪en/	2000	52.	/sik/	2800	72.	/hui/	2000
13.	/kʰəi/	2000	33.	/t̪ɛm/	2000	53.	/sit/	2800	73.	/hɛn/	2000
14.	/ci/	2500	34.	/t̪əi/	2000	54.	/siŋ/	2800	74.	/hɛk/	2000
15.	/cik/	2500	35.	/tʰi/	2800	55.	/sin/	2800	75.	/həi/	2000
16.	/ciŋ/	2000	36.	/t̪ʰiŋ/	2800	56.	/sɛ/	2300	76.	/dzoːi/	2800
17.	/cit/	3000	37.	/t̪ʰit/	2800	57.	/sɛk/	2000	77.	/Zip/	2000
18.	/cin/	2000	38.	/t̪ʰin/	2800	58.	/sɛŋ/	2800	78.	/dzəil/	2800
19.	/cɛ/	2200	39.	/t̪ʰɛk/	2200	59.	/sɛt/	2800			
20.	/cɛk/	2900	40.	/t̪ʰɛŋ/	2000	60.	/sɛn/	2800			

According to Gardner (1971), consonants /p/, /t/, /k/, /s/, /f/, /θ/, /h/) result in confusion for individuals with high frequency hearing loss. In addition, even the fricative /ʃ/ had energy above 2000 to 3000 Hz frequency (Hughes & Halle, 1956) and the affricate /ʧ/ is also included in the high frequency consonants. Hence, it is important to include all these consonants along with vowels which have higher f2 and f3 formants (Copper, Liebermann, Delattre, Brost&Gertmann, 1952).

Further, LTASS has been successfully used in the present study to ensure that the energy in low frequencies is not dominating and confirm the high frequency energy spread of the selected words. This has also been used in several other studies for the development of speech materials (Kavitha, 2002; Sudipta, 2006; Sinthyia, 2009;Ratnakar, 2010).

Out of these 78 words, 60 words were rated as most familiar and familiar, and thus, were selected for preparing the lists. These words were not sufficient to make three lists of 25 words each, and hence, 50 words with highest peak frequency were selected for preparation of two subtests with 25 words each. These 50 words are highlighted in the table 4.1 and the two subtests are given in appendix.

4.3 Comparison of SIS across levels within and between the lists:

Two subtest with 25 words each were administered on 60 normal individuals at three levels i.e. 20 dB SL, 40 dB SL and 60 dB SL on 20 subjects at each levels. Hence, there were three groups of participants. Since the number of sample was lesser in each group, to ensure normal distribution of the sample, One- sample Kolmogorov – Smirnov test was carried out. The result of this test is given in the table 4.3.a.

Table 4.3.a Results of one sample test

	Mean	SD	Z score	p- value
20 dB SL	21.6	1.79	1.19	0.11
40 dB SL	24.6	0.77	2.91	0.0
60 dB SL	25.0	0.0	-	-

The test results showed that the standard level is minimal for all the three groups. Hence, the sample tested is normally distributed.

Comparison between the SIS obtained at three different levels for both the subtests were made. The mean and SD of SIS at different levels for the two subtests are given in the table 4.3.b

Table 4.3.b Mean and Standard Deviation of SIS for two subtests across three presentation levels

Subtests	20 dB SL Mean (SD)	40 dB SL Mean (SD)	60 dB SL Mean (SD)
Subtest 1	21.95 (1.93)	24.70 (0.57)	25.00 (0.00)
Subtest 2	21.25 (1.61)	24.55 (0.94)	25.00 (0.00)

It can be observed that the SIS at 20 dB SL is at around 92%, at 40 dB SL, it is around 99%, and 100% response at the highest level of presentation, i.e., 60 dB SL. In order to see if there is a statistically significant difference across two subtests and three different levels repeated measures ANOVA was carried out. Results of repeated measures ANOVA revealed that there was a significant difference between the SIS at three different levels ($F (2, 76) = 127.901$, $P < 0.05$).

As there was a significant difference between the SIS obtained at three levels, Bonferroni pair-wise comparison of SIS was done for the following pairs.

20 - 40 dB SL

20 - 40 dB SL

40 - 60 dB SL

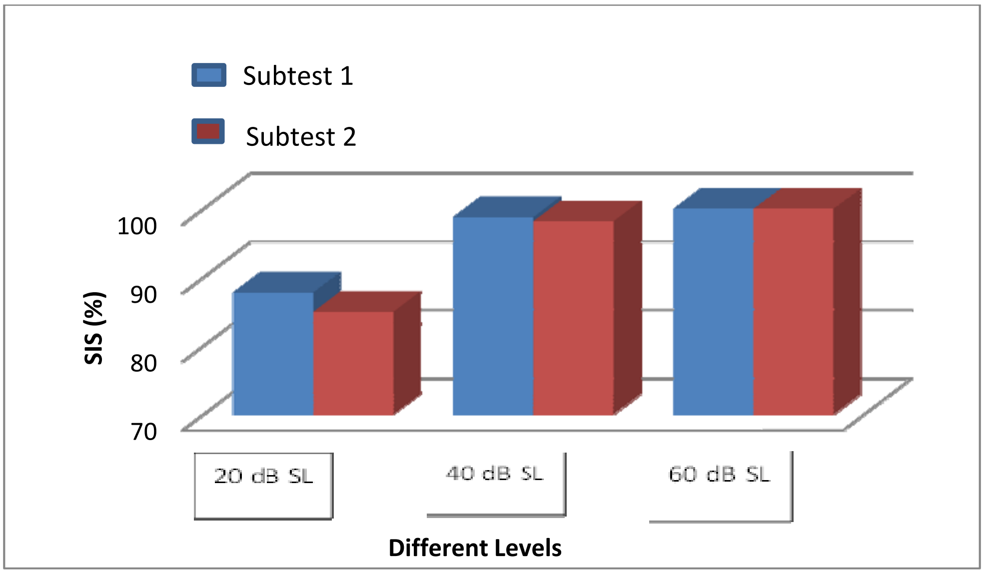

*Figure 4.3*Comparison of SIS across levels for both the subtests

The results showed a significant difference across three levels ($p < 0.01$). That is, the scores at 20 dB SL were poorer and were significantly different from the SIS obtained at 40 dB SL and 60 dB SL. The scores at 40 dB SL were a little lesser and were significantly different from the SIS obtained at 60 dB SL, i.e., as the level of presentation increased the scores also increased.

The result of the present study is consistent with the results of Turner and Cummings (1999). They studied the SIS across different input levels, i.e., performance-intensity function, in the normal participants of 20 – 27 years of age. They found that with the increase in intensity the scores improved, and also reported that the scores were near 100% at the level of 50 dB SPL in normal hearing participants. In the present study, also, there was near 100% performance (as can be seen in Figure 4.3) for both the subtests, at 40 dB SL (which is around 70 dB SPL).Which is higher than that was reported in the above study. There could be two explanations for this. One could be that the testing was not done at 30 dB SL which would be almost 60 dB SPL. The second reason for this could be that, in the above study, the task was closed set easier task. In the present study, it was an open set task, which is relatively difficult. Further, Sinthiya (2009) also found near 100% responses at 40 dB SL (ref. SRT) in normal hearing subjects.

Comparison of SIS between the two subtests was also done (given in the table 4.3). It can be observed that there is not much of difference in the scores between the two subtests. Results of repeated measures ANOVA showed no significant difference between the SIS obtained for the two subtests ($F(1, 38) = 1.494$, $p > 0.05$), and there was no significant interaction effect found between the subtests and the different presentation levels ($F(2, 76) = 1.250$, $p > 0.05$). This indicates that performance obtained from the two subtests will yield similar results. Hence, it can be said that the two subtests developed in the present study have good equality.

Chapter 5

SUMMARY AND CONCLUSION

High frequency hearing loss individuals have difficulty in perception of high frequency sounds depending on the type, degree and configuration of hearing loss (Gardner 1971; Jerger&Jerger, 1971; Pascoe 1975). The use of a regular identification test would be insensitive towards identifying the problems of a person with sloping high frequency hearing loss (Mendel &Danhauer, 1997). The low frequency information may contribute redundant cues to the perceptual ability, thus, decreasing the sensitivity of the test in detecting their handicap (Maroonroge&Diefendorf, 1984). Hence, a test with only high frequency information would be sensitive to evaluate the perceptual difficulties of Individuals with sloping high frequency hearing loss.

The present study aimed to develop such a test to evaluate adult individuals with high frequency hearing loss. The study was conducted in two stages. In the first stage, two the high frequency word lists in Manipuri language were developed. This was done by collecting monosyllabic words (230 in number) which contained high frequency sounds.LTASS was done on these 230 words to validate the high frequency spectral information of the words and also to select the words for construction of the subtests. The words which were found to have peak energy at 2 kHz or above, and with good energy present at frequencies even above the peak frequency were selected. 78 words met these criteria.

Out of these 78 words, 60 words were rated as most familiar and familiar, and thus, were selected for preparing the subtests. 50 words with highest peak frequency were selected for preparation of two subtests with 25 words each.In the present study, LTASS has been useful to ensure that the energy in low frequencies is not dominating and confirm the high frequency energy spread of the selected words.

In the second stage, the developed materials were administered at three presentation levels (20, 40 and 60 dB SL (Re: SRT)) to 20 normal hearing individuals each. SISwere obtained using both the subtests.

The results showed a significant difference between the three levels, i.e., with increase in the levels, the SIS increased, with almost 100% at 40 dB SL (Re: SPL). The result of the present study is consistent with the results of Turner and Cummings (1999) and Sinthiya (2009).

Further, there was no significant difference between the SIS obtained forthe two subtests and no significant interaction effect found between the subtests and the different presentation levels which reflects the list equality at all the presentation levels.

Thus, from the above findings, it may be concluded that this test has got normal performance-intensity function and has list equality. However, the clinical utility of the test has to be assessed by administering it on clinical population with different degrees of hearing impairment.

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Appendix

High Frequency Speech Identification Test in Manipuri Language

Subtest 1	Subtest2
/cəi/	/sɛ/
/si/	/ki/
/dzo:i/	/sin/
/pi/	/cɛ/
/cen/	/kʰik/
/kəi/	/t̪ʰɛk/
/cæŋ/	/ciŋ/
/cik/	/t̪ʰəi/
/t̪əi/	/cɛt̪/
/t̪ʰiŋ/	/t̪ʰit/
/cit/	/t̪ʰɛŋ/
/hui/	/həi/
/t̪ʰin/	/cin/
/pik/	/pʰi/
/kʰiŋ/	/pəi/
/pʰəi/	/sɛn/
/sɛŋ/	/kʰəi/
/sɛt/	/sit/
/kʰi/	/kʰɛt/
/sik/	/siŋ/
/ke/	/sɛm/
/hip/	/hi/
/t̪ʰɛt/	/t̪ʰem/
/hɛn/	/hɛk/
/hik/	/hiŋ/