A HIGH FREQUENCY - KANNADA SPEECH IDENTIFICATION TEST (HF-KSIT)

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Master's Dissertation as a part fulfilment of
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ALL INDIA INSTITUTE OF SPEECH AND HEARING,
MYSORE - 570 006

May, 2002

For you.....

My dearest Ammachie, Mamma, Dada and Naanu

With all my love

Certificate

*This is to certify that this Master's Dissertation entitled **"A HIGH FREQUENCY - KANNADA SPEECH IDENTIFICATION TEST (HF-KSIT)"** is the bonafide work in part fulfilment for the degree of Master of Science (Speech and Hearing) of the student with **Register No. M2K08.***

Mysore
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DECLARATION

*This is to certify that this Master's Dissertation entitled "**A HIGH FREQUENCY - KANNADA SPEECH IDENTIFICATION TEST (HF-KSIT)**" is the result of my own study under the guidance of* ***Dr. Asha Yathiraj,*** *Reader, Department of 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
May, 2002

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- *Ammachie- you're the best, Appa, Chechie, U. Jack, A. Asha, U. Tom and A Shyla and all my uncles and aunts – without all of you – 'family' has no meaning. Love you all.*
- *Nanulah … if I could wish for one thing… I'd wish … you were here right now. Miss you so….. much. You don't need a thank you, do you?*
- *Dodie, Tangu, Bobby, Karthik and the whole 'CLAN' – Let us always be the same. Love you all……… no thanks to you either.*
- *Memories never leave us….. they remain forever. Anjana, Hia, Shiva, Vathsan, Mukesh, Adz, Sharad, Ananthi, Shereen, Amala and Rakhee – you'll live in my heart forever.*
- *C-tha,Geeks, Nega, Pamo,Vidya, Nithyachi,Beuls,Bhumsie,and Samama – no one can take your place ….. come what may. Cheers to our friendship, love you all.*
- *Sabi and Bhumsie, a special note to tell you both you are more than special – you're a part of me – Thanking you would be… … insulting you.*
- *For the fun and laughter we all have shared and the sweet memories we've made – Thanks Kiddo and Jayen.*
- *Anu and Naresh, our friendship, like the tides will remain steadfast. We'll be friends forever.*
- *Mathew, Sai and Pressi dorling (your status hasn't changed) lets be friends forever. For all the love and affection we've shared, I want to say I love you three.*
- *For you…. my strength, my soul but most importantly my friend….. without you, I am incomplete…… I thank God for you.*

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INTRODUCTION

For over 100 years speech has been used in a systematic way to assess hearing ability. Feldman in 1960 (cited in Silman and Silverman, 1991) reported that Pfingsten in 1804 was probably the first investigator to report degree of hearing impairment based on speech tests. This pioneer divided speech sounds into three classes: vowels, voiced consonants and voiceless consonants. Within each class, sounds were ranked according to intensity Pfingsten characterized hearing disorders according to the speech sound understood by his patients.

Until the turn of the 20^{th} century, speech was considered as a major assessment tool, later puretones, noises warble tones were used to evaluate hearing sensitivity. Bunch (1934 cited in Penrod, 1994) reported that pure tones produce low percentage of responses and are not as effective as speech. Assessment of hearing using puretones provide information regarding the sensitivity but not on the receptive auditory ability (Elliot, 1963; Harris, 1965 and Marshall and Jesteadt, 1986).

Speech materials have become an indispensable tool in clinical evaluation for various reasons. Some of them include the following,

- They provide validating data for puretone thresholds (Carhart,1952, Chaiklin and Ventry, 1964).
- They also determine the extent to which a person has disruption in the perception of complex signals like speech (Wilson and Margolis,1983)
- At supra threshold levels, speech recognition scores contribute to decisions regarding site of lesion (Hannley, 1986).
- Speech materials are also being used in selection and prescription of amplification devices and in rehabilitation (Risberg and Martony, 1972 cited in Stark, 1979)

A person with a hearing loss is bound to have difficulty in perception of speech depending on several factors. A few include the degree of hearing loss, the type of hearing loss and the configuration of the audiogram pattern detecting the hearing loss (Jerger and Jerger, 1971).

Depending on the audiogram pattern the speech perception ability would vary. A person with a high frequency hearing loss would have difficulty mainly in hearing speech sounds having energy concentration in the high frequency region (Risberg dnd Margolis, 1972 cited in Stark, 1979). This perception would also probably vary depending on whether the person has a gradually sloping, sharply sloping or precipitously sloping audiogram (Martin 1987).

There are a variety of causes that results in a sloping high frequency hearing loss some of which are noise-induced hearing loss (Melnick, 1984 cited in Silman and Siverman, 1991), ototoxicity (Boettcher, Henderson, Grathan, Danielson and Bryne, 1987) and presbycusis (Schuknecht, 1955). Of these causes, aging and prolonged exposure to loud noise are the most common cause of high frequency hearing loss. The 1994 National Health Interview Survey statistics reveals that 15% of people between 55-64 years of age, 30% of people between 65-74 years of age and over 40% of people over 75 years of age having a hearing loss that affects communication (Adams and Marano, 1995 cited in Wiley, Cruickshank, Nondahl, Tweed, Klein and Klein, 2000).

Experiments have repeatedly shown that speech understanding cannot be predicted from pure tone threshold findings. Young and Gibbons (1962) noted that although there was some degree of association between scores obtained from tests of speech understanding presented at supra threshold levels and pure tone thresholds for hearing impaired subjects, the relationship was not strong enough to allow accurate prediction of speech understanding from pure tone audiogram.

Speech is a stimulus of high redundancy because the information in it is conveyed in several ways simultaneously (Martin, 1994). A hearing loss involving only part of the auditory frequency range may go undetected in an informal speech test, which is not carefully controlled. An appropriate speech test can give a reasonably accurate prediction of the best hearing threshold levels in the mid frequency region of the auditory range. Hence assessment of auditory recognition or identification of words, nonsense syllables or phonemes is a necessary part of clinical evaluation of hearing impairment and associated communication difficulties. The use of a regular identification test would be insensitive towards identifying the problems of a person with sloping high frequency hearing loss (SHFHL). The low frequency information may contribute redundant cues to the perceptual ability thus decreasing the sensitivity of the test in detecting their communication handicap.

Aims of the study

The aims of the study are:

1. To develop speech identification material for testing the adult population with SHFHL It would include word & sentence subtests.
2. To obtain normative data for the newly developed material.
3. To administer the test on a sample of the hearing impaired adults with SHFHL and to compare the score with a regular speech identification test.
4. To check the usefulness of the test in selecting hearing aids for the hearing impaired individuals with sloping hearing loss.

Need for the study

1. There is a need to determine the communication problems of a person having a hearing impairment. Pure tone audiometry does not allow for complete understanding of a persons communication deficit. Hence it is necessary to use a speech test.
2. Most speech identification tests have been developed to determine the communication problems of individuals having a flat frequency hearing loss. The speech tests normally used would provide information about all the speech sounds including low frequency speech sounds. Such a test will not give a true picture of the communication handicap of a person with a sloping HFHL.
3. In order to select appropriate hearing aids for cases with sloping hearing loss, it is essential that a test that is sensitive to their problem be utilized. It is highly possible that a person with SHFHL may get maximum scores unaided, if a regular speech identification test is used. Hence it will not be possible to check for an improvement in communication if such a test is used. It is unlikely that a hearing impaired person with SHFHL may get maximum scores unaided if tested with material that is specifically designed to detect his/her problem.

In order to note the availability of speech tests that are specially designed for individuals with a high frequency hearing loss, a review of literature is done in the following section.

REVIEW

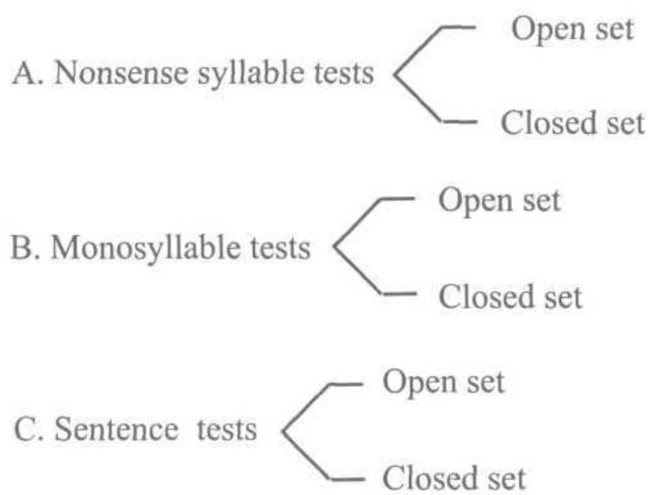
The review of literature has been divided into three categories as follows:

1. Speech identification testing- a glimpse into its metamorphosis
2. Tests of speech identification specifically for the Sloping High Frequency Hearing Loss (SHFHL)
3. Experiments and Studies conducted on the SHFHL with regard to speech identification

Speech identification testing- a glimpse in to its metamorphosis

It has been repeatedly demonstrated that speech understanding cannot be predicted from pure tone threshold findings. Young and Gibbons (1962) noted that although there was some degree of association between scores obtained from tests of speech understanding presented at supra threshold levels and pure tone thresholds for hearing impaired (HI) subjects, the relationship was not strong enough to allow accurate prediction of speech understanding from the pure tone audiogram. Similarly, attempts to relate speech-processing abilities of impaired auditory systems to deficiencies in frequency and temporal resolution capabilities have not been wholly successful. Hence, assessment of auditory recognition or identification of words, nonsense syllables or phonemes is a necessary part of clinical evaluation of hearing impairment and associated communication difficulties.

Bryant (1904, cited in Olsen and Matkin, 1979) used the phonograph (invented in 1877 by Edison) as part of a device he referred to as a phonographic acoumeter. These efforts were note worthy as one of the earliest attempts to exercise control over the test stimuli. The first materials designed for the measurement of auditory recognition or identification of speech sounds were developed at the Bell Telephone Laboratories in 1910(cited in Olsen and Matkin, 1979). In 1924, the first speech Audiometer was introduced (cited in Olsen and Matkin 1979). During this period, Jones and Knudsen included speech transmission system in their audio amplifier, which was used for audiometric purposes. Since then, there has been no abating in the development of tests to evaluate speech perception. These tests can be classified as :



Several methods have been advanced for measuring word recognition. These include testing with nonsense syllables digits, monosyllabic words and sentences (Martin, 1994). Procedures have included both open and closed, response message sets. In the open-set response format, the patient may select an answer from an infinite number of possible utterances. In a closed response system, however, the patient must choose the correct response from a group of words, sentences or pictures.

Through the years a number of different expressions have been used to describe the measurement of speech discrimination. According to Hannely (1986) discrimination means making a judgment of "same" or "different" between a target stimulus and one or more comparison stimuli. It does not necessarily involve correct identification or even recognition. Konkle and Rintelmann, (1983, cited in Penrod l994) contend that the word "discrimination" in this context implies distinguishing among different stimuli, where as recognition suggests the report of a patient on what has been heard after the presentation of a single item. The expression "word recognition score" has appeared in the literature with increasing frequency in recent years and appears to be the current expression of choice.

There exists a lot of controversy between the terms identification and recognition, some authors believe recognition involves a report of the nature of the signal or message that can be matched to a set of target messages (closed set) while identification is that in which the set of alternatives is unspecified or open ended. Hannely (1986),Olsen and Matkin (1979) refer to recognition as the task in which the listener repeats the word without being given a specific set of test items from which to select a response. Identification according to them is the term applied to a closed response set in which the task of the listener is to select a response from a given set of items. However, more often than not, both the terms may be used interchangeably.

Monosyllable recognition or word recognition are the labels used to describe tests in which the listener repeats (or writes) the word following each presentation without being given a specific set of test items from which to select a response (Olsen and Matkin, 1979). If nonsense syllables are used, then the label becomes nonsense syllable recognition. The term phoneme, nonsense syllable, word or sentence precedes the label identification to describe whether the possible selections differ only in one phoneme, whole nonsense syllables, whole words or sentences respectively. The following section briefly describes a few of the speech identification tests that have been reported in the literature.

Nonsense Syllables : Open Response Sets

Edgerton and Danhauer, (1979, cited in Olsen and Matkin, 1979) described bisyllabic test materials using consonant-vowel-consonant-vowel (CVCV) nonsense syllables. Twenty consonants and ten vowels were used. The test lists consist of 25 CVCV items each, randomized 6 times and presented at 55 dB SL above the Speech Recognition Threshold.

A nonsense syllable test has been developed in India by Mayadevi(1974).It included 20 CV combinations and could be used as a common test for several Indian languages

Nonsense Syllables : Closed Response Sets

Lists of seven to nine CV and VC syllables presented in a closed response format were described by Resnick, Dubno, Hoffnung and Levitt (1976) and Levitt and Resnick (1978). Voiced consonants with the vowel /a/ were incorporated into 3 lists and unvoiced consonants followed by /a/ make up another list of the Nonsense Syllable Test (NST).

Another closed response nonsense syllable test, the Distinctive Feature Difference (DFD) Test was described by Feeny and Franks (1982). Thirteen consonants /p,b,t,d,k,f,v,9,s,/,t/,d,z / were inserted in nonsense syllables having the same intervocalic context.

Monosyllables: Open Response Sets

Although lists of 50 nonsense syllables (CV, VC and CVC items) were used to assess speech intelligibility in the early work at Bell Telephone Laboratories most tests that were subsequently developed to evaluate supra threshold speech intelligibility or speech understanding have employed monosyllabic words.

In 1939, Fry and Kerridge (cited in Olsen & Matkin, 1979) described 5 lists of 25 CVC words each called the Word Tests for Deaf People. It was advised that any persons whose score was less than 35% for the wordlist should be tested with a list from their sentences test to allow the listener the advantage of context.

Egan (1948) attempted to construct lists of monosyllables that were equal in average difficulty equal in range of difficulty and of equal phonetic composition employing English words in common usage. He developed 20 lists of phonetically balanced monosyllables, which came to be known as the Harvard PB-50 lists or the PAL PB-50 lists. Hirsh et al. (1952) modified the PB50 lists by reducing the vocabulary from 1000 words to 200 familiar words and incorporating them in to 4 lists of 50 words each. The lists were labeled the CID W-22 word lists and began to be widely used in clinical settings.

A different criteria, in the form of phonemic rather than phonetic balancing of word lists, was used by Lehiste and Peterson, (1959,cited in Olsen and Matkin, 1979) in their development of monosyllabic word lists. They contended that speech sounds are strongly influenced by the adjacent speech sounds and that, articulation of a speech sound is rarely physically identical to a previous utterance. They set out to develop word lists that were phonemically balanced more precisely and developed 10 lists with 50 different CNC words in each list. The 10 lists were reduced to 2 lists (Tillman, Carhart and Wilber, 1963 cited in Olsen and Matkin 1979) and subsequently expanded to four lists (Tillman and Carhart, 1966 cited in Olsen and Matkin 1979) in an effort to achieve lists of 50 CNC items that conformed more closely to the phonemic balance. These lists were labeled the North-Western University Auditory Test No. 6 (or NU-6).

Boothroyd (1968) described so-called isophonemic word lists with 10 words rather than 35 words per list. All of the test items were of the CVC type and the 15 lists were phonemically balanced with respect to one another.

For the Indian population several monosyllabic word tests have been developed / standardized on the Indian population. These include the work of Abrol, (1971) and Samuel, (1976), who developed PB word lists in Hindi and Tamil respectively. While the former test included 100 test items the latter had 25. Chandrashekhara, (1972) and Malini, (1981) standardised tests that were developed for the western population on Indians.

Monosyllables: Closed Response Sets

Fairbanks (1958) constructed 5 lists of rhyming monosyllables with 50 items per list known as the Fairbanks Rhyme test. Only the initial consonant differed in a set of 5 rhyming words, but the initial consonants were not given on the response sheet. Hence the response task of the listener was to write the initial consonant for the item provided on the answer sheet.

House, Williams, Hecker and Kryter (1965) developed the Modified Rhyme Test (MRT) by expanding the Fairbanks test into 6 lists and incorporating the differentiation of final and initial consonants. Each list included 50 items requiring identification of 25 initial and 25 final consonants. Rather than completing the word by adding the appropriate symbol, entire words were presented on the response sheets.

Griffiths refined the MRT further in 1967. In his test lists each word within a given set differed from another word in the same set in only one of the distinctive features characterizing speech sounds i.e., manner of articulation, place of articulation, or voicing. He labeled it the Rhyming Minimal Contrasts Test. It is made up of 250 monosyllables arranged in 5, 50 word lists.

McPherson and Pang Ching (1979) described their "Distinctive Feature Discrimination Test" (DFDT). It consisted of 4 lists of 50 CNC words in each list, 25 with the initial consonant as a variable and 25 with the final consonant as the variable phoneme. The Multiple Choice Discrimination Test (MCDT) (Schultz and Schubert, 1969) differs in that it includes foils allowing for confusion of either the initial consonant or final consonant in the same set.

A closed response test that includes vowel confusions as well as initial and final consonants was described by Pederson and Studebaker (1972) and was called the University of Oklahoma Closed Response Speech Test. It seems to be the only such test in which vowel and consonant confusions were considered.

A picture identification test for adults unable to respond orally or in writing was developed by Wilson and Antablin (1980). 200 CNC words with 3 rhyming alternates that could be illustrated were selected. Four lists of 50 words each were assembled to conform to the Lehiste and Peterson (1959, cited in Olsen and Matkin, 1979) criteria for phonemic balance.

Monosyllabic closed tests have also been developed in India. Rout, (1996) developed a test for English speaking Indian children. Other tests have also been developed in Indian languages but have included bisyllables instead of monosyllables because of the constraints of those languages.

Sentences: Open Response Sets

One of the criticisms of monosyllabic word tests for assessing speech understanding is that the test items are presented in a way that does not represent every day speech. The concern is that oral communication is conducted via phrases and sentences and not single words, hence the contention is that sentences should be used for determining an individual's ability to understand speech.

Fry and Kerridge in 1939, (cited in Olsen and Matkin, 1979) prepared sentence tests for patients who obtained scores of 35% or less on their word lists. These "Sentence Tests for Deaf People" consisted of 5 lists of 'short common place' sentences. There were 25 sentences per list with 4-7 words per sentence.

Watson and Knudsen (1940, cited in Olsen and Matkin, 1979) prepared phonograph records of 25 phrases such as "listen to......." "Try to hear....." and so forth followed by 3 monosyllables such as "bite, rim and let" or "bet, men, ring" and so on. The task of the listener was to write down the last three words. Only selected phonemes in each word were scored.

Use of lists of nonsense sentences such as "The River rolled over on its back" and "soft coal is hard to eat" was proposed by McFarlan in 1945.

Ten years later Silverman and Hirsh (1955) described their CID Everyday Sentences. They constructed 100 sentences of 2-12 words in length to represent "Everyday American Speech" Ten sentences are incorporated in each list of the 10 lists with 50 key words being considered as the test items in each list.

Fry, (1961 cited in Olsen and Matkin, 1979) developed 10 lists of 25 sentences each, with 100 words being scored in each list. Scoring can be either for each complete sentence or "main words" in each sentence.

A different approach in which only the last word of the meaningful sentence was considered as the test item was initiated by Kalikow, Stevens and Elliot (1977). Each of the 8 lists contained 50 sentences of 5-8 words (6-8 syllables) in length. The task of the listener was to repeat the last word of each sentence.

Another test labeled the Speech Perception In Noise (SPIN) was developed by Kalikow et al. (1977). In this test, tape recordings of high predictability sentences have been prepared with the sentences on one channel and the babble of 12 voices reading continuous text on the second channel. Thus, the user can use the test sentences and babble at various signal-to-babble ratios. The intention is that the babble serves as noise against which the sentences are heard thereby more closely simulating everyday listening conditions.

A different sentence test for patients having severe-to-profound hearing losses, and for cochlear implant patients was described recently by Danhauer, Beck, Lucks and Ghadialy (1988). Three lists of 10 sentences and 10 questions with a total of 140 syllables in each list have been recorded on videotape. The test can be administered as a test of visual, auditory or auditory and visual recognition.

Sentences: Closed Response Sets

Speaks and Jerger (1965) devised a method of assessing speech understanding using synthetic sentences. The sentences are synthetic in that words were selected at random from the 1000 most common words in the Thorndike and Lorge 1944 list (cited in Olsen and Matkin, 1979). In administering these test materials, the 10 sentences in a set are presented on a panel or answer sheet and the task of the listeners was to identify the sentence presented. This test was named the Synthetic Sentence Identification test (SSI).

A different closed set sentence format is incorporated in the Kent State University Word Identification Test Devised by Berger (1969). Meaningful sentences are printed on answer sheets with 5 phonetically similar keywords given in the middle or at the end of the sentence. The listener's task was to determine which of the 5 words was used in a given sentence.

Sergeant, Atkinson and Lacroix (1979) have used Griffiths word list in the Naval Submarine Medical Research Laboratory Tri-word Test of Intelligibility (NSMRL TTI). The words were spoken in 3 word sets not as "discrete productions". Three lists of 50 sets were recorded. The task of the listener is to mark the 3 items heard, one mark in each column, in the 8-second silent interval between sets.

Each of the above class of test have their own inherent advantages and disadvantages. The choice of the appropriate test however would depend on the purpose for which it is being used.

A synthetic sentence identification test has also been developed in Kannada by Nagaraja, (1973).

Tests of speech identification specifically for Sloping High Frequency Hearing Loss (SHFHL)

A few speech perception tests have been designed specifically for individuals with high frequency sensorineural hearing loss. The impetus for the development of these tests arose from the fact that earlier tests of speech perception, such as traditional open set monosyllabic word tests, were found to be incapable of accurately assessing the speech perception abilities of this particular population of individuals. Although these individuals typically receive fairly high scores on traditional tests of monosyllabic word recognition, they frequently complain of having difficulty in understanding speech, particularly in noisy listening situations. These individuals often report difficulty in understanding women's and children voices or the softer sounds of speech. Thus, there has been a need for tests using stimuli with a high frequency emphasis, which might be more sensitive to the problem of these individuals (Mendel and Danhauer,1997).

Also, technological developments with hearing aids, including wide dynamic range compression (WDRC), digitally programmable circuits and deep or completely in-the-canal devices, now allow the audiologist to provide amplification in the high frequency region. Now because hearing aids have more high fidelity (some providing gain in the 12000 Hz to 16000 Hz region) it becomes a necessity to test hearing in the high frequencies (Mendel & Danhauer, 1997). Thus high frequency word lists should be maximally used. Some of the speech identification tests which have been designed to evaluate the high frequency speech sounds are :

- > The Gardener High Frequency Word Lists (Gardner, 1971)
- > The Pascoe High Frequency Test (Pascoe, 1975)
- > The California Consonant Test (Owens and Schubert, 1977)
- > The Speech Identification Test for Hindi and Urdu Speakers (Ramachandra, 2001).

The Gardner High Frequency Word Lists (Gardner, 1971)

Gardner (1971) compiled a list of words to meet the need for testing individuals having a high frequency hearing loss. According to him accurate measurements of the effects of modifications in tubing diameter, earmold design or acoustic filter placement, which results in the critical enhancement of high frequency information are essential. With improvement in technology and availability of instruments whose specification suggests their suitability for cases, there are few clinical methods for demonstrating the benefits of amplification. In order to test the subtle perceptual changes that the acoustical or electro acoustical modification brought about, he designed the high frequency word list.

It contained seven voiceless consonants / p, t, k, s, f, θ, h/ used in conjunction with the vowel /i/. These consonants have been known to result in confusion when identification is attempted by persons with HFHL. The 50 words were arranged in random order and assigned alternatively to two 25-word lists. The Gardner high frequency word lists were recommended for use in live voice presentation or with a tape recording of a female (or high pitched) talker. It was also recommended that the lists of stimuli provided be randomized for different list presentations, especially when performing hearing aid evaluations. Though the test was specially designed for application in hearing aid selection it may be used for auditory training as well.

The drawbacks of the Gardner Test was that no standardization information was reported for the different talkers presentation modes or randomized lists, therefore the sensitivity of this test is doubted. Also the stimulus must be tested under specified conditions to determine if they are sensitive enough to provide the kind of information desired from the test.

The Pascoe High Frequency Test (1975)

Pascoe developed this test to assess the speech perception abilities of individuals who are hearing impaired, using words with difficult phonemes. The list included 50 monosyllable words that emphasize phonemes that are difficult for hard of hearing subjects. Only 3 vocalic nuclei were used /I/, */ai/* and /ou/ in order to increase the weight of the consonants in the correct identification of words. Voiceless fricatives and plosives formed 63% of the number of consonants. The rest were nasals, laterals and voiced plosives. The words were recorded by a male and female talker

The experiment by Pascoe consisted of two parts, one in which eight hearing impaired subjects were tested with a binaural master hearing aid with five different frequency responses and the second part in which the Pascoe high frequency test was compared with a phonetically balanced word list in quiet and in noise. . The results indicated a high correlation between the subjects adjusted hearing levels, using a high frequency band and the identification scores in a non -PB list (i.e., the high frequency list). The Pascoe high frequency test was advantageous in that it provided standardization information on a male and female talker version of the test.

However, it is limited in that it uses two types of word lists, which differ in several dimensions. The high frequency lists were presented as a closed or known set, they are phonetically unbalanced in favor of high frequency phonemes and every list is identical to the others, except for differences in word order. On the other hand the PB lists besides being phonetically balanced, are an open set, with a different set of words in each list.

The California Consonant Test (1977)

The California Consonant Test (CCT), developed by Owens and Schubert (1977) consists of a 100 item, multiple-choice test for consonant identification. 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 number of foils. The results revealed that the test seemed sensitive to configuration of a high frequency loss. This was especially true for groups of subjects with high tone losses beginning at successively higher frequency as measured audiometrically. 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.

According to the authors the reliability of the CCT is high and its range of difficulty appropriate for separating patients with differing degrees of difficulty. The utility of the test in rehabilitation procedures and in hearing aid comparisons would be substantial if it can be used to identify consonant errors predominate in the speech reception of a given patient and if it is indeed highly sensitive to how much of the frequency range is being received by the patient.

One of the drawbacks however, was that inspite 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-impaired listeners. Rather the test was administered at a most comfortable listening level typically 40dB SL.

The Speech Identification Test for Hindi and Urdu Speakers (Ramachandra, 2001).

Ramachandra (2001) conducted a similar study on Indian population. She developed a high frequency speech identification test for Hindi and Urdu speakers. She developed two lists of randomized words rated for familiarity. The first list consisted of high frequency in the initial position and the second category consisted of high frequency phoneme in the final position.

The results revealed no significant difference between the two groups of Hindi and Urdu speakers for the sensation levels from 0-40 dB at the 0.05 level of significance. Test of significance for subjects with HFHL in this study, the California consonant test and Pascoe's high frequency word list showed no significant difference at 40 dBSL (re:SRT). Also, a high positive coefficient of correlation was found for high frequency speech identification scores in open set versus closed set condition, the speech identification scores for Common Speech Discrimination Test for Indians in open set versus closed set condition.

The limitations for the study were the number of subjects was rather small. Also test-retest reliability could not be carried out for the hearing impaired population.

Experiments and Studies conducted on the SHFHL with regard to speech identification.

It is a well known fact that a pre-requisite for speech perception is that a sufficient part of the speech signal is above the threshold of hearing. The extent to which this is the case, assuming reference speech power and spectral distribution at a certain distance to a human receiver, may be visualized by super imposing the spectral distribution of speech on a pure tone audiogram. An example is given in the figure which is given by Liden and Fant (1954, cited in Stark, 1979). The shaded frequency-intensity area is the reference distribution of speech power and is often referred to as the speech spectrum (Fig 1).

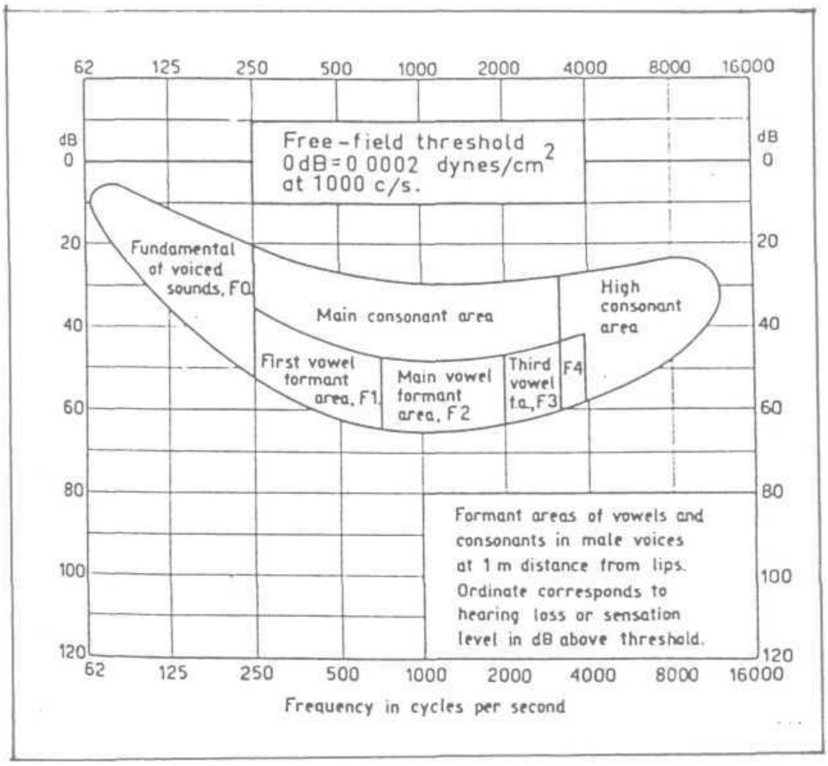


Figure - 1 : Speech Spectrum Data Schematized in terms of formant areas. From Fant (1959, cited in Stark, 1979).

The figure 1 represents sensation level above the standardized free field threshold at a distance of one metre and has been summarized to show regions occupied by voice fundamental frequency (FO) and the first, second, third and fourth formants. Also, shown are the main consonant area and the high frequency consonants region. Thus, high frequency hearing loss would result in misperception of high frequency vowels as well as consonants.

Phoneme recognition tests may include nonsense consonant-vowel or consonant-vowel-consonant materials or monosyllabic words (Stark, 1979). Results indicate that phoneme recognition is significantly correlated with pure tone average hearing loss (Smith, 1973, Jones and Studebaker, 1974, cited in Stark, 1979) with hearing at lOOOHz Smith (1973, cited in Stark, 1979) and with audiometric configuration Martony, Risberg (1972, cited in Stark, 1979). These findings are substantiated in fig. 2.

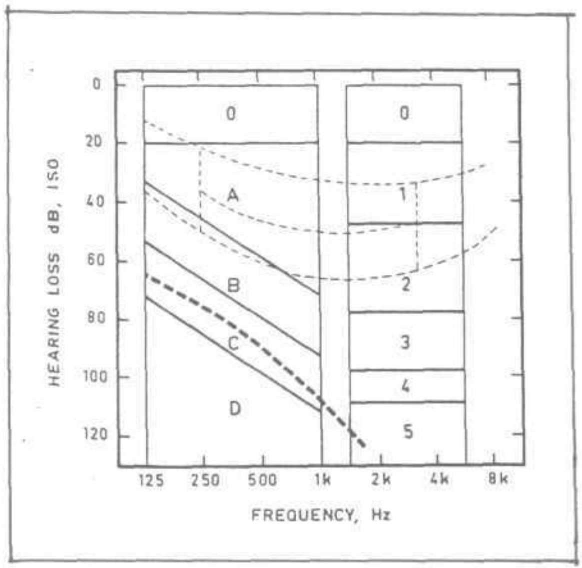


Figure - 2 : Subdividions of the low-frequency and high-frequency portions of the audiogram.

In the figure 2 the audiogram is divided into different frequency by intensity regions, according to area in which hearing loss may be found. Clearly someone with a A-5 partitioning of the audiogram will not be able to hear high frequency consonants. Cues to the place of articulation especially the third and second formant transitions are mainly concentrated in the high frequency region.

From these studies it is evident that various speech sounds have specific frequency characteristics. Depending on the audiogram configuration the perceptual problems would vary. Several studies have been carried out to show high frequency hearing loss would have difficulty perceiving a specific set of speech sounds.

Phoneme recognition by the high frequency hearing impaired.

Studies have confirmed the clinical observation that two major factors influence speech identification ability:

1. The degree of hearing loss
2. The configuration or slope of hearing loss

Lawrence and Byers (1969) investigated identification of voiceless fricatives in 5 subjects having steep hearing losses above lOOOHz. 16 consonant vowel test syllables were formed by combining each of the voiceless fricatives /s, J,f,0/ with the vowels /i, e, o, u/. The fricatives were identified correctly as follows / / 87%; /s/ 83%; /f/ 77% and / θ / 72%. Subjects showed idiosyncratic confusion patterns. There were no vowel confusions, however the fricatives were more often confused in association with the front vowels *I'll* and *Id,* than with the back vowels /u/ and /o/ Examination of the fricative syllable suggests that low frequency energy, intensity and duration of the fricative sounds, as well as formant transitions of vowels are available to these subjects to serve as possible cues for voiceless fricative identification.

In a study by Owens, Benedict and Schubert (1972) phonemic errors were observed as they relate to pure tone configurations and to certain types of hearing impairment. They observed that /s, , *t* , dz/ and the initial */t /, /* θ / were easily identified by patients with flat pure tone configurations, but were difficult for patients with sharply falling slopes, 500 to 4000 Hz. Identification of the /s/ and initial *It /* and /θ / was highly dependent upon energy in the frequency range above 2000 Hz, where as identification of the /t/, , dz / was highly dependent on the range between 1000 and 2000 Hz.

Also, probability of error for individual phonemes seemed to be more closely related to pure tone configurations than to kinds of hearing impairment. Slightly higher error probabilities occurred for /s, t , dz/ and initial /t / and initial /θ / for the noise-induced loss group, presumably because their pure tones slopes generally fell more sharply compared to the presbyacusic group. It was also observed that although the error response phonemes were usually the same as the stimulus phoneme in manner of production, it was not the same in place as the stimulus phoneme.

Consonant confusion matrices were obtained from 22 out patient listeners with sensorineural hearing loss for 4 sets of CV and VC nonsense syllables, presented monaurally at SRT + 40dB (Bilger and Wang, 1976). Four different syllable sets were used each consisted of 48 nonsense syllables formed by combining 16 consonants with 3 vowels /i,a,u/. If the consonant identification task was considered a test differentiating listeners interest of performance level, it seems clear that individual differences between subjects are highly reliable over time and over different sets of test materials although the level of performance may not be well predicted from audiometric data, it is clearly predictable from a limited sample of discrimination responses. The relative difficulty of individual consonants and the relative frequency of specific consonant confusions appear to be highly reliable. They also found inter-subject similarities in patterns of perceptual confusion are systematically related to the subject's audiometric configurations. The results also indicated in agreement with those of Owens et al., (1972), that listeners with HFHL had difficulty with sibilant consonants. Differences as revealed by feature analysis in this study suggest that there is a relationship between audiometric configuration and pattern of consonant confusion.

Syllable recognition ability and consonant confusion patterns were evaluated in 38 listeners with mild to moderate sensorineural hearing loss (Dubno, Dirks and Langhofer , 1982) using the closed set nonsense syllable test (Resnick, Dubno, Hoffnung and Levitt, 1975). The subjects were divided into three groups: flat, gradually sloping and steeply sloping. Interactions between syllable types and audiometric configuration revealed significantly poorer performance for the steeply sloping group for voiceless consonants versus voiced consonants where as the other two groups showed little difference between these consonant types. Similar interaction was found with vowel context syllable recognition for the steeply sloping varied widely as a function of the vowel. Syllable recognition with the vowel *Iil* and recognition of fricatives appears to be strongly related to reception of high frequency information. The authors conclude that the NST, in agreement with other findings show poorest syllable recognition performance for those listeners with steeply sloping audiometric configuration. Also, using the NST, subjects with gradually sloping configuration performed best followed by those with flat and steeply sloping audiograms thus suggesting that the nonsense syllable materials are sensitive to the effects of low frequency as well as high frequency hearing loss.

Dubno, Dirks and Ellison (1988) have tried to specify the contribution of certain frequency regions to consonant place perceptions for normal hearing listeners and listeners with HFHL. Stop-consonant recognition and error patterns were examined at various speech presentation levels and under conditions of low and high passing filtering. Subjects included 18 normal hearing listeners and a homogenous group of 10 young, hearing impaired individuals with HFHI of sensorineural type. Results revealed that performance for each consonant under filtered conditions was consistent with the presence of broadband spectrally based cues and additional vowel-dependant cues under low pass filtering. Stop consonant recognition and error patterns for normal hearing and hearing impaired listeners were equivalent for stimulus band widths that correspond to regions of normal hearing for both subject group. However differences between the normal hearing and hearing impaired listeners in recognition and error patterns were observed when the spectrum included regions of threshold elevation for the hearing impaired listeners

A study was carried out by Hogan and Turner, (1998) to investigate the effect of increasing audibility in high frequency regions for normal hearing and high frequency hearing impaired listeners on speech recognition scores. Five normal hearing-impaired listeners were asked to identify nonsense syllables that were low passed filtered at a number of cut-off frequency. They found that normal hearing listeners demonstrated an increase in recognition score as audibility increased. Listeners with mild HFHI performed similarly to the normal hearing listeners while those listeners with moderate HFHL performed poorer than the normal hearing or mildly impaired listeners. The listeners with severe HFHL performed worse than the three other groups. In particular it was observed that as hearing loss increased above approximately 55 dBHL, listeners were not6 as efficient as normal hearing listeners in using high frequency information to improve speech recognition performance. They concluded that eliminating amplification with in frequency regions that cause a decrease in performance score might help those listeners to improve their ability to recognize speech. He results suggest that clinicians should use some discretion in providing amplification above 4000 Hz when hearing loss in those regions is greater than 55 dB HL.

Yoshioka and Thornton (1980) have tried to develop a method for predicting a speech identification score from audiometric thresholds (SRT and pure tones) by investigating three prediction systems: a step wise multiple regression procedure, smear and sweep analysis and a clinical classification of the audiometric configuration.

Findings revealed by the clinical classification system was that speech identification was affected by changes in slope only when hearing loss was slight with mild hearing loss speech discrimination changed from Very good to Fair as the slope became steeper. For the moderate to severe hearing loss group all Speech Identification Scores were poor. As the degree of hearing loss became greater, slope had less influence on speech identification. Overall, they concluded that the trend towards increased variability in speech identification scores with increased hearing loss appeared to have an over riding effect on any of the prediction systems and reduced the effectiveness of the prediction system for individuals in the moderate to severe hearing loss categories. From the above studies it is evident that perception of speech sounds is dependent on the audiogram configuration and the degree of hearing loss. However, a few studies have reported otherwise.

In an experiment by Owens, Benedict and Schubert (1971) a list of 25 vowel test items employing a multiple choice response system was presented to 94 patients with hearing impairment and 10 with normal hearing listening through a low pass filter. No differences occurred in probability of error an individual phoneme among three types of hearing impairment (Meniere's disease, presbyacusis and noise induced loss). Multiple choice test items structured to permit confusion of one vowel with another do not appear to be sufficiently difficult to make good test items. The results make it appear unwise to consider a separate test composed of items for which the only difference in the foils offered is in the vowel sound. However the results should not be interpreted to mean that vowel sounds are not contributing to the testing of speech discrimination. The more reasonable interpretation is that in spite of the convenience of speaking as though we test the discrimination of individual sounds, the smallest unit operating except in rare circumstances, is a syllabic combination of sounds. Therefore in general multiple choice items structured to permit confusion of one vowel with another failed to show promise as good test items for speech discrimination.

In an experiment on specific frequency bands and their importance for perception, Plummer in 1943 said specific bands of the audio frequency range are dominantly important for recognition or discrimination between specific speech sounds. West (1937, cited in Plummer, 1943) says, for example, that all voiced sounds utilize the fundamental frequency or the band from 100 to 400 Hz, that the vowels, semivowels and nasal consonants utilize the resonant frequencies or the band from 400 to 2400 Hz and that the fricative stop and sibilant consonants utilize the high or friction frequencies or the band from about 2400 to 8000 Hz. If this theory were true, it should follow that either complete or partial deafness to a given frequency band should affect one's ability in a commensurate degree to recognize and to discriminate between the speech sounds said to utilize those bands. For example, if an individual cannot hear sounds in the high frequency range, he should have a corresponding difficulty in recognizing and discriminating the so called "high frequency sounds" of speech namely the stop, fricative and sibilant consonants.

The speech sound discrimination test used by Plummer involved the eight voiceless consonants /p/, /t/, /k/, /f/, /s/, /θ/, /ʃ/, and affricate / tʃ / and the eight voiced consonants /b/, /d/, /g/, /v/, /z/, /ð/, /ʒ/ and the affricate /dʒ/. Results indicated that of the 52 subjects tested nine had mild to severe cases of high frequency deafness. Examination of their discrimination test errors revealed that these nine cases had no appreciable difficulty in discriminating between the consonants which have been known to be dependent highly upon sensitivity of the higher frequency. It also appears that no given consonant sound is dominantly dependent for its discrimination upon any specific frequency along the range, said to be used in speech.

These findings are contrary to studies carried out later on individuals with HFHL. A possible reason for the difference in their findings was to do with the slope of the audiogram. Individuals with lesser slope are known to have lesser problems in perceiving high frequency sounds.

Experiments with tests specifically designed for the HFHL group

Some experiments, which have been conducted, have involved testing the HFHL group with a test specifically designed for that population. Comparisons have also been studied between the use of tests specifically for the HFHL and other regular speech identification tests.

Schwartz and Surr (1979) conducted three experiments using the California Consonant Test (CCT). They determined the performance intensity function of the CCT, they compared performance scores on the CCT with those on the NU-6 lists and examined internal consistency and split half reliability of forms 1 and 2 of the CCT.

According to them speech testing ideally should reflect the communication handicap created by the hearing loss and should differentiate the normal hearing individuals from those with sensorineural hearing impairment. Unfortunately, however, many listeners with cochlear hearing losses often do not manifest reduced word identification scores when performance is assessed with many of the more commonly used monosyllabic word lists despite reports of hearing handicap. This is particularly evident when word recognition ability is assessed in persons with high frequency sensorineural hearing loss.

The results of Schwartz and Surr (1979) support that of Owens and Schubert (1977) and suggest that the CCT is sensitive to phoneme recognition difficulties experienced by listeners with HF SNHL. The performance intensity function for both normal hearing individuals and those with cochlear hearing loss indicate that the test should be administered at a sensation level of 50 dB for maximum speech discrimination at a fixed intensity level. The result of the second experiment revealed that in the comparative distribution of scores for the NU-6 lists and the CCT the hearing impaired listeners often attain relatively high scores on the NU-6 materials despite significant high frequency losses. Conversely the results from CCT demonstrated markedly reduced word identification scores. Such findings seem consistent with the communication difficulties reported by these individuals. In their concluding remarks the authors report that the CCT has considerable implication for selecting appropriate amplification and determining progress in auditory rehabilitation for persons with HFHL.

Maroonroge and Diefendorf (1984) presented to two groups of listeners the Northwestern University Auditory test No. 6 (NU6), the California Consonant Test (CCT) and Pascoe High Frequency Test. One group consisted of 12 individuals with normal hearing up to 2 kHz accompanied by a high frequency loss and second group consisted of 12 persons with normal hearing. The authors opine that persons who sustain HFHL encounter varying degrees of difficulty in perceiving and distinguishing between similar sounds. They undertook the study to investigate the importance of frequency above 2000 Hz for understanding speech.

They found that the CCT and Pascoe's Test did not differ significantly on the overall speech identification scores. However, for the NU 6, scores were significantly higher than the other two tests. An analysis of variance between the two groups however revealed no significant difference when the performance of the two groups was analyzed together. The findings suggest that the NU 6 identification test is the least sensitive and may not be appropriate for identification difficulties in individuals with HFHL. The high NU 6 test scores among individuals with sharp slopes may be attributed to the perceptual cues provided by low frequency elements. These cues may have facilitated word discrimination in quiet as suggested by Goetzinger (1972) and Hopkinson (1972).

These studies highlight the importance of using appropriate tests while evaluating individuals with a HFHL. Tests that are not sensitive to their problem will not identify their perceptual difficulty.

Speech recognition by the high frequency hearing impaired in the presence of noise

Cohen and Keith (1976) attempted to determine whether word recognition scores obtained in noise were more sensitive to the presence of a hearing loss than recognition scores obtained in quiet subjects with normal hearing high frequency cochlear loss and flat cochlear hearing loss were tested in quiet and in the presence of a 500Hz low-pass noise in 2 signal-to-noise conditions of -4dB and -12dB. The results indicated that, while the word recognition scores of groups were similar in quiet, however, the more negative the signal-to-noise ratio, poorer the recognition scores of the hearing impaired subjects as compared with that of the normal hearing subjects.

Liden (1965, cited in Cohen and Keith, 1976) suggested that the use of a 500Hz low-pass noise presented simultaneously with the word lists would make word recognition test results more diagnostic. Liden published data indicating that word recognition of listeners with high frequency cochlear hearing loss was

60-70% poorer than that of listeners with normal hearing when tested in the presence of a 500Hz low pass noise even though their word recognition scores in quiet were similar. Based on their results, the authors have interpreted that a low-pass 500Hz noise can effectively separated normal hearing listeners from those with flat and high frequency cochlear hearing losses. This speech-in-noise test is, therefore, more sensitive in differentiating groups of listeners with different threshold curves than PB words presented in quiet.

Psychophysical tuning curves in speech identification in the high frequency hearing loss

Studies have also been conducted on the hearing impaired with regard to speech identification ability and the shape of psychophysical tuning curves (PTC) Bonding (1979) reported a general finding of decreased word intelligibility with broadened PTC's . Thornton and Abbas (1980) found that word intelligibility performance was generally related to the shape of PTC's. Subjects with higher word intelligibility scores also had narrower, well-defined PTC's. These findings suggest direct relations between PTC characteristics and speech intelligibility performance.

The relation between frequency and selectivity and consonant intelligibility were investigated in subjects with sensorineural hearing loss in an attempt to derive predictive indices by Preminger and Wiley (1985). According to the authors subjects with the same degree and configuration of SNHL may demonstrate substantially different abilities to perceive speech and subsequently may receive different degrees of benefit from amplification. In order to study this aspect they took. Six subjects who were separated into three matched pairs. Each subject pair had different audiometric configurations: high frequency hearing loss, flat hearing loss, low frequency hearing loss. One, member of each pair had a good word intelligibility score and one member had a reduced score. Results

METHODOLOGY

The aim of the present study is to develop speech identification material in Kannada for testing adults with sloping high frequency hearing loss. The study also aims at checking the usefulness of the material on a sample of hearing impaired adults with sloping high frequency hearing loss (SHFHL). The study was done in three stages.

Stage I: The development of the test material for the High Frequency-Kannada Speech Identification Test (HF-KSIT)

Stage II: Administration of the speech identification tests on normal hearing individuals. This included administration of the Common Speech Discrimination Test for Indians (CSDTI) (Mayadevi, 1974) and the HF-KSIT.

Stage III: Administration of the speech identification tests on hearing impaired individuals. That includes:

a. Administration of the Common Speech Discrimination Test for Indians (Mayadevi, 1974) and the HF-KSIT on the pathological population.
b. Administration of the HF-KSIT on the pathological population without and with a suitable hearing aid.

for the subject pair with HFHL revealed that the 500 PTC's were broadened and elevated, but they evidenced a relatively normal V shaped configuration. PTC's at 4 KHz were clearly abnormal for both subjects, however, the PTC characteristics were clearly different for the 2 subjects with good speech intelligibility score was quiet shallow but it retained a V-shaped configuration. In contrast the 4000 Hz PTC for the poor scores subjects was basically flat in configuration with no tip region evident. The mean percent- correct data (CV's) for this pair exhibited consistently better performance for low frequency CV's as compared to high frequency CV's in both vowel contexts. This was particularly evident for high frequency vowel *I'll* context. Thus shape of the PTC did have a correlation with speech identification scores.

From the review it is evident that there have been several tests developed to evaluate speech identification abilities in the hearing impaired. However, the number of tests specifically designed for individuals with high frequency hearing impairment is relatively few. Research has shown that regularly used tests are unable to identify the specific perceptual problems in these individuals. Hence it is essential that a speech identification test be designed for this population.

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b. Administration of the HF-KSIT on the pathological population without and with a suitable hearing aid.

Stage I: Development of the test material

Formulation of the test material:

The material for the study was obtained from a book compiled by Ranganath (1982), which contains a list of the frequently occurring words in Kannada. Only bisyllabic, and tri-syllabic words with phonemes distributed in the frequency range from mid towards high frequencies (i.e., above 1 kHz) were chosen. However the vowels were not restricted to only high frequencies. The low frequency vowels also had to be included since words having only high frequency consonant and vowels were not among the most commonly used words in Kannada. A minimum of 100-150 words was selected. The phonemes used for the test items are listed in table 1. The phonemes were selected because the primary cues for the perception of these phonemes falls in the high frequency region (i.e. above 1kHz).

Table 1: A list of the phonemes used for construction of the HF-KSIT

Phoneme class	**Phoneme**
Vowels	\a\, \i\, \e\, \o\, \u\
Semivowels	\j\, \r\, \1\, \1\
Stops	\t\, \9\, \k\
Fricatives	\s\, \ʃ\, \ \
Affricates	\t \

Evaluation of familiarity of test items

In order to confirm the familiarity of the test items, 15 native adult Kannada speakers from all walks of life, which included to housewives, doctors, teachers, students, shopkeepers, lawyers, were chosen. They were instructed to classify the words according to familiarity and frequency of occurrence in daily conversation. The words were classified as follows:

a) Most frequently used words (words that occur between 75-100 % of the time in daily usage).
b) Frequently used words (words that occur between 50-75% of the time in daily usage).
c) Seldom used words (words that occur less than 50% of the time in daily usage).

Construction of the word subtest

From the material collected, all the words rated as "most frequently used" and twelve "frequently used" words were chosen. They were compiled to form three subtests of words. Each subtest contained 25 words, with all the three subtests having equal distribution of the high frequency consonants as mentioned in table 1.

Construction of the sentence subtest

Each sentence contained one key word, which was used in the word subtest. Three sets of sentences were constructed with each having nine sentences. It was ensured that all the high frequency phonemes occurred in each of the sets. All the sentences were in the assertive case, with an average length of 7 ± 2 syllables. The same 15 subjects who judged the familiarity of the words also evaluated the sentences for their familiarity and grammatical correctness. Any modification suggested by them was incorporated.

Three lists were thus constructed (List I, List II and List III). Each list included a word subtest and a sentence subtest (Appendix).

Recording of test material

A female speaker, whose mother tongue was Kannada, spoke the words and sentences. Her fundamental frequency was 220 Hz, as recorded on the

Vaghmi Computer Software. The words and sentences were recorded in a computer. The recorded material was then edited using the "Creative Mixer Sound Blaster 16" software. Scaling of the signals was done using the "Audio Lab" software to ensure that the intensity of all sounds was brought to the same level. A 1 kHz calibration tone was recorded prior to each list. The material was then copied onto an audio compact disc using a compact disc writer.

Stage II: Administration of the speech identification tests on normal hearing individuals.

In this stage, the Common Speech Discrimination Test for Indians (Mayadevi, 1974) and the HF-KSIT were administered on 30 normal hearing adults. The subject selection criteria was as follows:

1. The subjects were above 15 years of age
2. They were fluent speakers of Kannada.
3. The pure tone thresholds of all the subjects were within 15dBHL
4. They had no significant otological deficit. This was ruled out through an immittance evaluation.

Instrumentation

A Philips CD player (AZ2160V) was used to present the recorded speech test. The output was routed through an audiometer Madsen OB822, which was calibrated according to ANSI 1989 (cited in Silman and Silverman, 1991) standards. Headphones TDH39, housed in ear cushions were used as transducers.

Test Environment

The testing was done in a sound treated double room, with the ambient noise levels within permissible limits as recommended by ANSI (1989).

Procedure

After the estimation of pure tone thresholds, the speech recognition threshold (SRT) was obtained using the Kannada paired word list (Rajashekar, 1976 cited is ISHA Battery, 1990). The Common Speech Discrimination Test

(Mayadevi,1974) was then administered at 40 dBSL with reference to the SRT.

Following this, the HF-KSIT was then administered at the same level. All the subjects were tested with the three lists, which were presented randomly. Half the subjects were tested in the right ear and half in the left ear. An open-set response in the form of an oral response was obtained. For the sentence subtests, the subject had to repeat the entire sentence.

Scoring

Word and phoneme scoring was used for the words in the word subtests and for the keywords in the sentence subtests. For the word scores, even for a single phoneme that was wrong, the entire word was marked wrong. Each correct word got a score of one. However for the phoneme scores the words were marked for the consonants and vowels separately. Therefore for a single phoneme that was wrong in a word, the response was scored wrong only for that particular phoneme and the remaining phonemes were marked correct. Each correct phoneme got a score of one.

Stage III: Administration of the speech identification tests on hearing impaired individuals.

a. Administration of the Common Speech Discrimination Test and the HF-KSIT on the pathological population.

Subjects

The test material was administered on 30 hearing impaired adults. These subjects met the following criteria:

1. They were above 15 years of age with a bilateral sloping high frequency hearing loss. The audiogram pattern depicted a gradually sloping, sharply sloping or precipitously sloping configuration (Lloyd and Kaplan, 1978 cited in Silman and Siverman, 1991).

2 All subjects were fluent speakers of Kannada

3. The subjects had a history of acquired loss with good language ability.

4. They had no significant neurological deficit

Procedure

Initially pure tone thresholds were obtained. As with the normal hearing subjects, the speech recognition thresholds were obtained using the standard paired words.

The Common Speech Discrimination Test for Indians (Mayadevi, 1974) was then administered at 40 dBSL with reference to the SRT. For six cases the presentation level was at 30 dBSL (four due to audiometric constraints and two due to lowered uncomfortable loudness levels). Following this the HF-KSIT was administered at the same levels. The responses were scored in a similar manner as was done with the normal hearing subjects.

b. Administration of the HF-KSIT on the pathological population without and with a suitable hearing aid.

To evaluate the usefulness of the HF-KSIT in hearing aid selection, five subjects were randomly selected. The unaided responses was obtained at 40dBHL, using one list of the HF-KSIT.

A suitable hearing aid was selected for each patient based on the insertion gain results, using the POGO II formula. This was done using the FONIX 6500C hearing aid test system. The aided response was then obtained, with the case using the selected hearing aid in the position that matched the target curve the best. A different list of the HF-KSIT was presented at 40dBHL. The unaided and the aided responses were noted and scored as mentioned earlier.

The scores obtained from the normal hearing and the hearing impaired individuals were then subjected to statistical analysis.

RESULTS AND DISCUSSION

The data obtained from the normal and hearing impaired population was subjected to a statistical analysis using the SPSS statistical software.

Analysis was carried out for the following :

I. Analysis of normative data for the High Frequency - Kannada Speech Identification Test (HF-KSIT)

A. Test of significance for :

(a) Within list variation

(b) Word subtest versus sentence subtest

(c) Word score versus phoneme score

B. HF-KSIT versus CSDTI in normal hearing subjects

II. Analysis of data obtained from the pathological group.

A. Test of significance for HF-KSIT between

(a) Word subtest versus sentence subtest

(b) Word score versus phoneme score

B. HF-KSIT versus CSDTI on pathological groups.

C. Correlation between slope of the audiogram and the identification scores for HF-KSIT and CSDTI.

III. Comparison between the normal and pathological (path) group for HF-KSIT.

IV. Comparison between the aided versus unaided using the HF-KSIT.

I. ANALYSIS OF NORMATIVE DATA

a) Within list variation

To check for variation between the three lists of the HF-KSIT, the mean, standard deviation (SD) and 't' test was carried. This was done for both the word subtest and sentence subtest (Table-2).

Table-2 : Mean and SD for word and sentence subtests across lists

Subtest	Values	I	II	III
Word	Mean	97.86	97.93	97.80
	SD	4.03	3.80	4.52
Sentence	Mean	99.9	99.85	99.82
	SD	0.38	0.45	0.46

As can be seen from table 2, there is a minimal difference between the means and SD's for the three lists. This is observed for both the word and sentence subtests.

Table-3 : Significance of difference between lists for the word and sentence subtests

Lists	t-value	
	Word subtest	Sentence subtest
I Vs II	-0.066*	0.460*
II Vs III	0.123*	0.195*
I Vs III	0.060*	0.666*

*Not significant at the 0.05 level

From the results of the 't' test it can be noted that there is no significant difference between the three lists for both the subtests. Hence it can be concluded that any of the three lists may be used while evaluating the subjects.

b) Word subtest versus sentence subtest

As there, was no difference obtained between the lists (Table-2) the mean of the three lists were averaged to obtain a single score using the word and sentence subtests. The SD for these scores was also calculated. The t-test was computed between the word subtest and the sentence subtest of the HF-KSIT for the normal group for both the word score and score and phoneme score procedure (Table-4).

Table-4 : Mean, SD and t-values for the word and sentence subtest using word phoneme scores

Score procedure	Subtest for HFKSIT	Mean	SD	t-value
Word	Word	99.73	1.01	-0.842*
	Sentence	99.90	0.38	
Phoneme	Word	98.80	2.89	1.775*
	Sentence	99.75	0.61	

* Not significant at 0.05 levels

The results revealed that there was no significance of difference between the word subtest and the sentence subtest even at the 0.05 level. In both these subtests most of the normal hearing subjects obtained maximum scores, thus resulting in no difference.

c) Word scoring versus phoneme scoring

The word scoring procedure for the word and sentence subtests was tested for significance against the phoneme scoring procedure (Table-5).

Table-5 : Mean SD and t-value for the word scoring versus the phoneme scoring in the word subtest and the sentence subtest

Subtest	Scoring for HF-KSIT	Mean	SD	t-value
Word	Word	97.86	4.03	1.037*
	Phoneme	98.80	2.89	
Sentence	Word	98.37	4.11	-1.815*
	Phoneme	99.75	0.61	

* Not significant at 0.05 levels

The t-tests revealed that there was no significance of difference between means when the scores were analysed in terms of words or phonemes. This is because majority of the normals hearing subjects obtained 100% scores on the tests.

d) HF-KSIT versus CSDTI in normal hearing subjects

To compare the scores between the HF-KSIT and CSDTI, in the normal hearing subjects, the mean and SD were obtained for each of the tests. For the HF-KSIT the mean and SD was obtained for both the subtests (word and sentence) of the lists. This was done for the two scoring procedures that were utilized, i.e., the word score and the phoneme score (Table-6).

Table-6 : Mean, standard deviation and t-value for the two subtests in the HF-KSIT and CSDTI using word and phoneme scores

Subtest	Scoring	Mean	SD	t-value
Word	HFKSIT (word score)	97.86	4.03	-1.533*
	HF-KSIT (Phoneme Score)	98.80	2.89	-0.532*
Sentence	HF-KSIT (word score)	98.37	4.11	-1.815*
	HF-KSIT (Phoneme score)	99.90	0.61	-1.719*
-	CSDTI	99.16	2.30	-

* Not significant at 0.01 and 0.05 levels

As can be seen from Table-6 the mean scores for the normal hearing group was not very different, irrespective of the scoring procedure. This was true for both the word and sentence subtests of the HF-KSIT. These results were observed as a majority of the subjects obtained 100% scores for both the subtests.

The t-test of significance reveals no significant differences, for both scores, between the HF-KSIT (word subtest and sentence subtest) and CSDTI at the 99% and 95% levels of confidence. The scoring procedure did not seem to make any difference to the significance either .

This indicates that the normals are able to get maximum scores on both the speech identification tests and that their performance was similar irrespective of the scoring procedure used. These scores were obtained when the stimuli were presented at 40 dBSL (re : SRT)

These results are in accordance with other studies. Maroonroge and Diefendorf (1984) in their study also obtained similar results. A comparison between 12 normal subjects and 12 pathological subjects for the NU-6, California Consonant Test and the Pascoe High Frequency Tests revealed 100% scores for the normal hearing group at 40 dBSL. Similar results were also obtained at 30 dBSL.

Schwartz and SUIT (1979) obtained 100% scores in their 12 normal hearing subjects on the California Consonant Test. However their recommended level of presentation was 50 dBSL (re. SRT).

II. ANALYSIS OF DATA OBTAINED FROM THE PATHOLOGICAL GROUP

A. Test of significance for HF-KSIT between

(a) Word-subtest versus sentence sub-test

The data obtained for the word subtest and sentence subtest was subjected to statistical analysis, using the t-test to check for the significance of difference in the subjects with high frequency hearing loss. This was calculated for both the scoring procedures (Table-7).

Table-7 : Mean, SD and t-value for the word versus sentence subtest of the HF-KSIT using word and phoneme scores

Scoring procedure	Subtest of HF-KSIT	Mean	SD	t-value
Word	Word	77.85	14.39	-7.507*
	Sentence	98.37	4.11	
Phoneme	Word	84.98	14.67	-5.508*
	Sentence	99.75	0.58	

* Significant at the 0.01 and 0.05 levels

The results revealed that for both the scoring procedures, the word subtest and sentence subtest are significantly different at the 0.05 and 0.01 levels. For the word and phoneme scoring procedures, the subjects obtained significantly higher scores on the sentence subtest.

The better performance in the sentences subtest may be attributed to the availability of redundant, semantic, syntactic and phonetic cues. Additionally the predictability of the key words in the sentences was quite high, thereby improving the scores in this subtest.

Hence, this implies that the word subtest is more sensitive to identify the speech perceptual problems found in individuals with HFHL when compared to the sentence subtest. Therefore it is recommended that the word subtest be used rather than the sentence subtest while evaluating individuals with high frequency hearing loss.

These findings are in agreement with the results obtained with many authors. Speaks and Jerger and Trammel (1965) obtained performance scores for PB word lists and synthetic sentences on 60 hearing impaired patients. Their results indicated that, for the sloping losses, as the slope increases, the performance on PB word tests became progressively worse while performance on synthetic sentences was not substantially altered.

In addition Speaks, Jerger and Jerger (1966) noted that a higher percentage of sentences, rather than PB words or spondees, are identified in a performance - intensity function. This difference has been attributed to the different kinds of linguistic units that were used.

These findings of the present study are further supported by Speaks (1967), Speaks, Jerger and Jerger (1966), Egan (1948), Miller, Heise and Lichten (1951).

Giolas, Cooker and Duffy (1970) report about the factor of predictability and note that key words that were easy to predict in sentences increased the scores achieved whereas difficult to predict keywords decreased the scores.

Infact Kalikow et al. (1977) recommended that for sentence tests, the tests may be mixed with speech babble at various signal to babble ratios to improve its sensitivity and to simulate, more closely everyday listening conditions.

Hence it is recommended that for the sentence subtest of the HF-KSIT also, speech noise be used at various signal-to-noise ratios, to improve its sensitivity.

(b) Word scores versus phoneme scores

The t-test of significance was carried out to find out the significance of difference for the word versus phoneme score for the HF-KSIT on the hearing impaired group. The analysis was carried out for both the word and sentence subtest at the 0.01 and 0.05 levels of confidence (Table-8).

Table-8 : Mean, SD and t-value for the word and phoneme scores for the HF-KSIT in the word and sentence subtest

Subtest	Scoring procedure for HF-KSIT	Mean	SD	t-value
Word	Word	77.85	14.39	1.899*
	Phoneme	84.98	14.67	
Sentence	Word	99.75	0.61	0.043**
	Phoneme	99.75	0.58	

•Significant at the 0.01 and 0.05 levels
** Not significant at the 0.05 levels

From the table 8 it can be observed that there is a significant difference for the scores of the word and sentence subtests, depending on the scoring procedure used. The decreased performance for the word subtest reveals that the word score is more sensitive to detecting the speech perception difficulty faced by the HI individual. The subjects tended to have improved speech identification scores when the phoneme scores were used. Thus it is recommend that word scoring be used instead of phoneme scoring. This is in agreement with Boothroyd (1968) who reported that phoneme scores are 20-30% higher than whole word score. This finding has also been substantiated by Dillon and Ching (1935).

However, these differences were not significant for the sentence tests. This was because, for the sentence tests, as discussed earlier, the pathological group performed well, irrespective of the scoring procedure being used.

B. HF-KSIT versus CSDTI on pathological group

The mean and standard deviation was obtained for the HF-KSIT and CSDTI in the pathological population. These values were obtained for both the word and sentence subtests and included the word and phonemic scores for HF-KSIT. The results are tabulated in Table-9.

Table-9 : Mean, Standard deviation and t-value (for the word and sentence subtest) for HF-KSIT versus CSDTI in the hearing impaired.

Subtest	Scoring	Mean	SD	t-value
Word	HF-KSIT (word score)	77.85	14.39	-0.629**
	HFKSIT (phoneme score)	84.00	14.67	1.445**
Sentence	HF-KSIT (word score)	98.37	4.11	-7.999*
	HF-KSIT (phoneme score)	99.75	0.61	- 9.089*
	CSDTI	80.00	11.89	-

* Significant at the 0.01 level
** Not significant at 0.01 and 0.05 levels

From table 9, it is evident that for the word scores the mean values for the HF-KSIT was relatively lower when compared to the CSDTI for individuals with sloping high frequency hearing loss (SHFHL). The variability was also more for the former test. This indicates that the subjects performed poorer on the HF-KSIT. However, the difference between these two tests was not significant even at 0.05 level.

Contrary to the expected finding the subjects with HFHL obtained slightly higher mean values for the HF-KSIT when the phoneme scoring was used. However, the variability was comparable to that obtained with word scores. The t-test was not significant at the 0.05 level for the phoneme scoring of the word subtest versus the CSDTI.

The t-tests between the CSDTI and the sentence subtest, for word and phoneme scores, however, revealed a significance of difference at the 0.01 level.

The subjects obtained an almost perfect scores on the sentence subtets, indicating that it was not sensitive to their problem. This could account for the significance of difference between means of the sentence subtest and the CSDTI.

The word scores and phoneme scores for the word subtest, was then subjected to further analysis.

C. Correlation between slope of the audiogram and the identification scores for HF-KSIT

The slope in dB per octave was calculated from the puretone audiogram of the subjects. The correlation between the slope and the identification scores on the HF-KSIT was calculated for the word subtest.

This was done for both scoring procedures i.e. word and phoneme scores. The Karl Pearson's formulae for bivariate correlation was used (Table-10). The correlation for the sentence subtest was not carried out as it was not sensitive to their problem. The correlation was also checked between the slope and the scores on the CSDTI.

Table-10 : Mean, standard deviation and coefficient of correlation for the slope and the speech identification, scores for the HFKSIT word subtest.

Variables	Mean	SD	Coefficient of correlation
Slope dB/octave	10.37	1.98	
HF-KSIT (word score)	77.85	14.39	-0.379*
HF-KSIT (Phoneme score)	84.98	14.67	-0.271 **
CSDTI	80.00	11.89	-.253**

* Significant at 0.05 level
** Not significant at 0.05 level.

The results reveal a negative correlation for the two scoring procedures. As the slope of the audiogram increased, the speech identification scores decreased.

The correlation was significant at the 0.05 level for the word score. The phoneme score however revealed no significance of difference even at the 0.05 level. This may be attributed to the improvement of scores for the phoneme scoring, thereby decreasing its sensitivity in detecting the speech perceptual difficulty of the person with a high frequency hearing loss (HFHL).

A correlation between the slope of the audiogram and the scores for the CSDTI revealed a negative correlation which was not significant even at the 0.05 level. This implies that the HF-KSIT word scores are sensitive in identifying the perceptional problems of individuals with sharply sloping audiograms, while the CSDTI, which is a regular speech identification test, is not.

A study by Yoshioka and Thornton (1980) is in concurrence with the finding in the present study. In their study subjects with hearing losses at 4000 Hz and essentially normal hearing at 2000 Hz obtained excellent speech identification scores in quiet. The changes in speech identification scores was affected by changes in slope when hearing loss was slight. With mild hearing loss speech identification changed from "Very Good" to "Fair" as the slope became steeper. For the moderate-to-severe hearing loss group all speech identification scores were poor. As the degree of hearing loss became greater, slope had less influence on speech identification.

Similar findings have been reported by Boothroyd (1968), Goetzinger (1972), Hopkinson (1972) and Maroonroge and Diefendorf (1984).

Ill COMPARISON BETWEEN THE NORMAL AND PATHOLOGICAL GROUP FOR HF-KSIT

The significance of difference was calculated for the HF-KSIT in the normal hearing and the pathological population. The results were computed for the word and phoneme scores for the word and sentence subtests at the 0.01 and 0.05 levels (Table 11).

Table-11 : Mean, SD and t-value for the speech identification scores in the normal hearing versus the hearing impaired population using the word and phoneme scores

Subtest	HF-KSIT		Mean	SD	t-value
	Group	Scoring			
Word	Normal	Word	97.86	4.03	-7.332 *
	Pathological		77.85	14.39	
	Normal	Phoneme	98.80	2.89	-5.063*
	Pathological		84.98	14.67	
Sentence	Normal	Word	99.73	0.58	0.078**
	Pathological		99.75	1.01	
	Normal	Phoneme	99.75	0.61	-1.080**
	Pathological		99.90	0.38	

* Significant at the 0.01
** Not significant at 0.05 level

The results reveal that there was a significant difference in the word subtest, irrespective of the scoring procedure used, between the normal hearing individuals and the HFHI individuals at both levels (0.05 and 0.01).

However, for the sentence subtest the results indicate that the HF-KSIT was not significant between the two groups. Thus, the sentence subtest does not differentiate a normal hearing individual from that of a HFHI individual.

Similar findings have been reported by Gardner (1971) Pascoe (1975), Owens and Schubert (1977), Ramachandra (2001) who report that word tests having frequency specific sounds do differentiate the normals from individuals with HFHL.

IV COMPARISON BETWEEN THE AIDED VERSUS THE UNAIDED FOR THE HF-KSIT

The statistical analysis for selection of hearing aid was restricted to five subjects. A nonparametric t-test was used to find out the significance of the HF-KSIT for the word and sentence subtest in the aided versus the unaided condition. The word scoring was used, as it was found to be more sensitive to detect the perceptual handicap (Table-12).

Table-12 : Mean, SD and t-value for the HF-KSIT in the aided versus unaided condition for the word and sentence subtest using word scores

Subtest	Group	Mean	SD	t-value
Word	Unaided	37.6	18.67	-4.838*
	Aided	89.6	15.12	
Sentence	Unaided	55.5	11.1	-8.964*
	Aided	100.00	0.00	

* Significant at the 0.01 and 0.05 levels

From the table 11 it can be inferred that there was a significant difference in the performance for the unaided versus aided condition at both the 0.01 and 0.05 levels. This indicates that the HF-KSIT may be used effectively for selection of HA.

As in the present study, tests developed specifically for HFHL by Gardner (1971), Owens and Schubert (1977) and Pascoe (1975) have been reported to be useful in selecting amplification devices for individuals with HF hearing loss.

From the above analysis it may be concluded that:

- The HF-KSIT may be used with the high frequency hearing impaired population, especially those with a sharp slope and a higher degree of hearing loss.
- The word subtest scored using the word scoring procedure is more appropriate and sensitive.
- The sentence subtest may be used with a background competition of speech noise.
- For hearing aid selection also, the word and sentence subtests of the HF-HSIT may be used.

SUMMARY AND CONCLUSION

Speech being a stimulus of high redundancy, a hearing loss involving only part of the auditory frequency range may go undetected unless tests that are specially designed to detect the individual's problem are utilized. The use of a regular identification test would be insensitive towards identifying the problems of a person with sloping high frequency hearing loss (Mendel and 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 and Diefendorf, 1984).

The present study was undertaken to develop a speech identification test to evaluate adult population having a sloping high frequency hearing loss (SHFHL). The developed material was administered on 30 normal hearing and 30 hearing impaired individuals. The study also aimed at checking the usefulness of the tests in hearing aid selection.

The study was done in 3 stages. In the first stage the material was developed consisting of familiar words and sentences mainly having high frequency phonemes. Three lists, each consisting of a word subtest and a sentence subtest, were complied.

The three lists were then randomly administered to 30 normal hearing and 30 hearing impaired individuals. The results obtained were also compared with those obtained with the Common Speech Descrimination Test for Indians (CSDTI) (Mayadevi, 1974).

Analysis of the data revealed the following :

a) All three tests yielded similar scores on the normal hearing subjects.

b) There was no significant difference between the word subtest and the sentence subtest in the normal hearing group.

c) There was no significant difference between the word scores of phoneme scores in the normals.

d) There was no significant difference between the HF-KSIT and CSDTI in the normal hearing population.

e) The HFHL group obtained poorer scores on the word subtest compared to the sentence subtest, indicating that the former was more sensitive to detect their problem.

f) The HFHL group got poorer scores when the word scores were used compared to when the phoneme scores were used. Thus, the word scoring procedure is recommended for individuals with HFHL.

g) A significant negative correlation was obtained between the slope of the audiogram and the word identification scores for HF-KSIT. This was observed when the word scoring procedures was used. This correlation was not observed with the CSDTI.

h) There was a significant difference in the performance of the subjects for the word and sentence subtests in the unaided versus the aided condition for selection of hearing aids.

Thus, it may be concluded that the HF-KSIT is a sensitive test for sharply sloping HFHL. It may be used as a part of the diagnostic test battery as well as a fitting procedure during selection of hearing aids.

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APPENDIX

WORD SUBTEST I

1. ಕೇಳು |ke:ḷu|
2. ಇಲ್ಲೆ |ille|
3. ರಸ |rasa|
4. ಇಷ್ಟ |iʃṭa|
5. ಇಟ್ಟ |iṭṭa|
6. ಇಲಿ |ili|
7. ಸೇರಿಸಿ |se:risi|
8. ಹೊಟ್ಟೆ |hoṭṭe|
9. ವಿಚಾರ |vitʃara|
10. ಚಿಕ್ಕಿ |tʃikki|
11. ಸಿಟ್ಟು |siṭṭu|
12. ಚಕ್ರ |tʃakara|
13. ಹಸಿವು |hasivu|
14. ಸಿಕ್ಕು |sikku|
15. ಚಿಟ್ಟೆ |tʃiṭṭe|
16. ತಲೆ |tale|
17. ಕೋತಿ |koṭi|
18. ಕುಳ್ಳಿ |kuḷḷi|
19. ಚಮಚ |tʃamatʃa|
20. ಶಿಲೆ |ʃile|
21. ಸರಿಯೆ |sariye|
22. ಸಾಲು |sa:lu|
23. ಇರಲಿ |irali|
24. ಇರುವೆ |iruve|
25. ಕಟ್ಟೆ |kaṭṭe|

SENTENCE SUBTEST I.

1. ಎಲೆ ಹಸಿರು ಬಣ್ಣ.
2. ಚಿಕ್ಕ ಚಮಚ ಬೇಕು.
3. ಇದು ನನ್ನ ಸರ
4. ನಾನು ಚಿಟ್ಟೆ ನೋಡಿದೆ.
5. ನನಗೆ ಇಡ್ಲಿ ಇಷ್ಟ.
6. ನನ್ನ ಮಾತು ಕೇಳು.
7. ನನಗೆ ಹೊಟ್ಟೆ ಹಸಿವು.
8. ಇದು ದೊಡ್ಡ ಕಿಟಕಿ.
9. ರಾತ್ರಿ ಸೂರ್ಯ ಇರಲ್ಲ.

SENTENCE SUBTEST I

1. /yele hasiru baṇṇa/
2. /tʃikka tʃamatʃa be:ku/
3. /id̪u nanna sara/
4. /naanu tʃiṭṭe no:ḍid̪e/
5. /nanage idli iʃṭa/
6. /nanna ma:t̪u ke:ḷi/
7. /nanage hoṭṭe hasivu/
8. /id̪u d̪oḍḍa kitiki/
9. /rat̪ri surya iralla/

WORD SUBTEST II

1. ರೊಟ್ಟಿ /roṭṭi/
2. ಕೊಕ್ಕು /kokku/
3. ಕುಟ್ಟು /kuṭṭu/
4. ಚರ್ಚಿಸು /tʃartʃisu/
5. ಇರ್ಲಿ /irli/
6. ಕೆಲವು /kelavu/
7. ತಾಳಿ /t̪a:ḷi/
8. ಯೋಚಿಸು /yotʃisu/
9. ತೋಟ /t̪oṭa/
10. ಉಯ್ಯಾಲೆ /uyya:le/
11. ಕೋಸು /ko:su/
12. ಇಳಿಸಿ /iḷisi/
13. ಚರ್ಚೆ /tʃartʃe/
14. ಸಲಹೆ /salahe/
15. ಸಂಕೋಚ /saŋko:tʃa/
16. ಹಿಟ್ಟು /hiṭṭu/
17. ಹುಚ್ಚು /hutʃtʃu/
18. ಇಷ್ಟೆ /iʃṭe/
19. ಇರಿ /iri/
20. ಸೇರಿ /se:ri/
21. ಇಳಿ /iḷi/
22. ತಳ್ಳು /t̪aḷḷu/
23. ಸುಲಿ /suli/
24. ಕೋಟಿ /ko:ṭi/
25. ಅಳು /aḷu/

SENTENCE SUBTEST II

1. ಮನೇಲಿ ಇರುಳ್ಳಿ ಇದೆ.
2. ನಾನು ಊಟ ಸರಿಯಾಗಿ ಮಾಡಿದೆ.
3. ಯಾತ್ರೆ . ಸುಖವಾಗಿತ್ತು.
4. ಕೆಂಪು ಚಿಟಿ ಕೊಡಿ.
5. ಅಲ್ಲಿ ಹಾವು ಇತ್ತು.
6. ನನ್ನ ಕೆಲಸ ಆಯ್ತು.
7. ಕಾಫಿಯಲ್ಲಿ ಸಕ್ಕರೆ ಜಾಸ್ತಿ ಇದೆ.
8. ನಾಯಿ ಕಚ್ಚುತದೆ.
9. ನೂರು ರುಪಾಯಿಗೆ ಚಿಲ್ಲರೆ ಕೊಡಿ.

SENTENCE SUBTEST II

1. /mane:li iruḷḷi id̪e/
2. /avaḷu u:ṭa se:riyage maḍid̪aḷu/
3. /yat̪re sukʰavagit̪t̪u/
4. /kempu tʃiṭi koḍi/
5. /alli ha:vu it̪t̪u/
6. /nanna kelasa ait̪u/
7. /coffee yalli sakkare jasti ide/
8. /nai katʃtʃu tad̪e/
9. /nu:rupayige tʃillare koḍi/

WORD SUBTEST III

1.	ಸೂಚಿಸಿ	/su:tʃisi/
2.	ಕಿವಿ	/kivi/
3.	ಲೀಚೆ	/li:tʃe/
4.	ಚಿಕ್ಕ	/tʃikka/
5.	ಹಚ್ಚು	/hatʃtʃu/
6.	ರುಚಿ	/rutʃi/
7.	ಕುಳ್ಳ	/kuḷḷa/
8.	ಕೊಳೆ	/koḷe/
9.	ಸೊಸೆ	/soṣe/
10.	ಸುಖ	/sukʰa/
11.	ತಟ್ಟೆ	/t̪aṭṭe/
12.	ಕೋಟೆ	/k̚o:ṭe/
13.	ಕೆಲಸ	/kelasa/
14.	ಈರುಳ್ಳಿ	/iruḷḷi/
15.	ಅವಳು	/avaḷu/
16.	ಇಟ್ಟೆ	/iṭṭe/
17.	ಅಳತೆ	/aḷat̪e/
18.	ಕಾಲು	/ka:lu/
19.	ಏಳು	/ye:ḷu/
20.	ಶಾಲೆ	/ʃa:le/
21.	ಸರಿ	/sari/
22.	ಅಷ್ಟು	/aʂṭu/
23.	ಅಚ್ಚು	/atʃtʃu/
24.	ಚಿಲ್ಲರೆ	/tʃillare/
25.	ಕಾಳು	/avaḷu/

SENTENCE SUBTEST III

1. ಕಸ ಗುಡಿಸಿ ಆಯ್ತು.
2. ನನಗೆ ನಡೆಯೋದು ಕಷ್ಟ.
3. ಆಕಾಶದಲ್ಲಿ ಹಕ್ಕಿ ಹಾರುತ್ತೆ.
4. ನಾವು ಸೇರಿ ಆಡೋಣ.
5. ಇದು ರಾಗಿ ಹಿಟ್ಟು.
6. ಹುಡುಗ ಚೇಷ್ಟೆ ಮಾಡ್ತಾನೆ.

* 7. ಹೂವಿನ ತೋಟ ಚೆನ್ನಾಗಿದೆ.

8. ಮಾಡಿಯಿಂದ ಇಳಿ ಬೇಕು.
9. ಅಮ್ಮ ರೊಟ್ಟಿ ಮಾಡಿದರು.

SENTENCE SUBTEST III

1. | Kasa guḍiṣi aiṭ̪u |
2. | nanage naḍiyod̪u kaʃṭa |
3. | Aaka:ʃad̪alli hakki harat̪e |
4. | Avaru se:ri ha:ḍid̪aru |
5. | Idu ragi hiṭṭu |
6. | Huḍuga tʃeʃṭe maḍutane |
7. | Huvina t̪o:ṭa tʃanaag id̪e |
8. | Ma:ḍi ind̪a iliyabeku |
9. | amma roṭṭi ma:ḍid̪aru |