High Frequency Speech Identification Test in Telugu

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Abstract

The present study aimed to develop the high frequency speech identification test in Telugu and also to test the utility of the developed test material. The study was conducted in three phases. Phase I involved the development of high frequency words in Telugu. In the present study three lists of 25 words each were developed. Two separate lists were prepared based on the number of syllables. In the phase II, the speech identification scores were obtained from individuals with normal hearing, who were native speakers of Telugu.. In the phase III the high frequency speech identification test in Telugu (HFSITT) was administered on individuals having high frequency sensorineural hearing loss to check the utility of the developed HFSITT. The results showed that majority of the normal hearing individuals obtained a mean score of more than 99 % in right as well as left ear for all the three lists. Comparison across the three lists showed that, any of the lists developed can be used to obtain speech identification scores. Individuals with high frequency hearing loss performed equally in all the lists and between the two ears. Individuals with sloping HFSNHL performed significantly poorer than the normal hearing individuals in all the three lists. The developed high frequency speech identification test thus will be useful to identify the speech perceptual deficits in individuals with high frequency sloping hearing loss who are native speakers of Telugu.

***Key words**: High frequency word, bisyllabic words, trisyllabic words.*

Hearing is one of the most desirous divine gifts for humans. An individual with a hearing loss is bound to have difficulty in the perception of speech depending on the degree & type of hearing loss and the configuration of the audiogram pattern (Lacroix & Harris 1979). Depending on the pattern of audiogram the speech perception ability of an individual varies. Individuals with sloping high frequency hearing loss would have difficulty mainly in hearing speech sounds having energy concentration in the high frequency region (Dean & Mc Dermott, 2000).

Speech audiometry is an important element in the audiometric test battery. An appropriate speech test can give 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 individuals with hearing impairment.

Furthermore speech identification performance on a High frequency word list shall be a better estimate of perception in the ambient noise conditions in individuals with high frequency sensori neural hearing loss (HFSNHL). The conventional speech identification tests done during routine audiological evaluation would overestimate the performance in individuals with high frequency hearing loss due to normal or near normal perception of the low frequency cues. Hence there is a need to develop high frequency speech identification test. The first high frequency word list was developed by Gardner (1971). Gardner developed a word list in English that contained consonants of high frequency spectral energy and used it for testing speech discrimination in cases of high frequency hearing loss.

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. On account of this, 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 of the languages. Although phonetically balanced speech identification tests have been developed in more than 7 Indian languages, there is lack of high frequency word lists in all these languages. High frequency speech identification tests are developed only in Hindi (Ramachandra, 2001), Kannada (Kavitha, 2002), English (Sudiptha, 2006), and Tamil (Sinthiya, 2009).

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 redundant information and hence not indicate the true nature of the communication problem of a person with a sloping HFSNHL. Also in order to select appropriate hearing aids for clients with a sloping hearing loss, it is essential that a test that is sensitive to their problems be utilized. It is highly possible that a person with a sloping HFSNHL may get maximum

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scores if a regular speech identification test is used. Hence, speech identification scores obtained for High frequency word list is a better estimate for such individuals. Telugu is the third most widely spoken language in India, after Hindi and Bengali. Because such a list is not available in Telugu language the study is attempting to develop the test material.

Aim of the present study was to develop speech identification material in Telugu for testing individuals with sloping high frequency hearing loss and to obtain normative for the newly developed material. The study also aimed to administer the test on a sample of adults with a high frequency sloping hearing loss to find its utility.

Method

The study was conducted in three different phases.

Phase I: The development of test material in Telugu which includes high frequency word list (bisyllabic & trisyllabic words).

Phase II: Standardization of the developed test material.

Phase III: Determining the utility of the developed test material.

Phase I: The development of high frequency word List in Telugu

The following steps were involved while preparing the high frequency test material in Telugu. (1) Selection of the high frequency words in Telugu. (2) Assessment of familiarity of the selected High Frequency words. (3) Administering Long-term average speech spectrum (LTASS) on the selected high frequency words. (4) Construction of word subtests. (5) Recording of the test material.

Selection of the high frequency words in Telugu: The bisyllabic and trisyllabic words with phonemes distributed in the frequency range from mid to high frequencies (i.e., above 1 KHz) were only used to develop the test material. Words with vowels /i/ & /e/ were preferred as the F2 and F3 of these vowels are higher than that of the other vowels (Cooper, Delattre Liebermann, Borst, & Gerstmann, 1952). Words with phonemes /k/, /g/, /h/, /s/, /p/, /ʈ͡ʂ/, /ʈ͡/, /tʃ/, and /ʃ/, were preferred in the selection of words or these phonemes have spectral energy distributed in the frequencies above 1 kHz (Hughes & Halle, 1956). Approximately 300 words were selected from different sources like text-books, dictionary, newspapers and magazines.

Assessment of familiarity of the selected high frequency words: The selected high frequency words were assessed for familiarity to ensure that selected words were well known to native speakers of Telugu and were commonly used by them. To assess the familiarity of the selected words, 20 adult native speakers of Telugu were included. A printed version of the 300 high frequency words (both bisyllabic & trisyllabic) written in Telugu were given to all the 20 individuals. They were instructed to rate the words on a 3 point rating scale of familiarity as most frequently used words, frequently used words, and seldom used words according to the frequency of occurrence of words in Telugu.

The words that occurs between 75 – 100% of the time in daily usage were rated as most frequently used words, words that occurs between 50 – 75% of the time in daily usage was rated as frequently used words and words that occurs less than 50% of the time in daily usage is considered as seldom used words. Only those words which were most familiar and frequently used by all the individuals were selected for the development of the test material. Totally 157 words were rated as most frequently used words out of the 300 selected words.

Administration of LTASS on the selected familiar words: To know if selected 'most familiar words' had high frequency spectral energy, LTASS was done on 157 words. This was required because the spectral information of the phonemes differs depending on the influence of the neighboring phoneme. These 157 words were spoken by an adult female who is a native speaker of Telugu and were recorded. The samples were stored into a computer. LTASS was derived using Computerized speech lab 4500 software and the spectral information was determined manually. The peak frequency of the spectra was taken as the target parameter. Out of 157 words, the words which had highest energy at and above 1000 Hz were selected. There were 100 such words having highest energy above 1000 Hz, which were considered for the construction of the high frequency word list. In the present study it was decided to use words with peak frequency above 1.5 kHz. There were 128 words with peak frequency above 1.5 kHz. Of these 125 words, 75 words were chosen randomly.

Construction of word subtest: The 75 most familiar words which had highest energy above 1.5 kHz were further categorized into a bisyllabic and trisyllabic list. There were 50 bisyllabic words which were divided into two half lists, each list containing 25 words. There was only one trisyllabic word list, containing 25 words. The frequency of occurrence of high frequency sounds was maintained same in the two half lists containing bisyllabic words. The bisyllabic (two half lists) & trisyllabic list is given in appendix (1, 2, 3).

Recording of the test material: The constructed word subtests were spoken by 3 adult females and 3

adult males, who were native speakers of Telugu and were recorded into a computer using 16 kHz sampling rate and 16 bit quantization using CSL 4500 software. These recorded materials were perceptually rated by 2 speech and language pathologists. The speaker who spoke with the best clarity was chosen for the audio recording of final test material. 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 12 bit analog to digital and digital to analog converter housed within a computer. The recorded material was then edited to carry out noise and hiss reduction. Amplitude normalization of the signals was done using the Adobe Audition (version 3.0) software to maintain the constant amplitude across the words. The inter stimulus interval between the two words was set to 3 seconds. A calibration tone of 1 kHz was inserted before beginning of the word list to adjust the VU meter at zero. The material was then copied onto an audio compact disc using a compact disc writer.

Phase II: Standardization of the test material

The developed test material was standardized by obtaining speech identification scores. The subjects were selected based on the following criteria. They were native speakers of Telugu who were in the age range 19 to 30 years. They had bilateral normal hearing sensitivity (<15 dB HL) at octave frequencies between 250 Hz and 8 kHz. No significant history of otological dysfunctioning and they had 'A' type tympanogram with ipsilateral and contralateral reflexes present at 500, 1000, 2000, and 4000 Hz.

Procedure: The pure tone thresholds were obtained between 250 Hz and 8 kHz for air conduction and between 250 Hz and 4 kHz for bone conduction. Tympanogram and acoustic reflexes was done using GSI tympstar immittance meter. The speech recognition threshold were obtained using regular Telugu paired word list developed by Sreedhar (2008). The speech identification scores were obtained for high frequency word list developed in phase I. A calibrated two channel diagnostic audiometer (GSI- 61) was used to carry out pure tone and speech audiometry. Following this, using the same audiometer, the high frequency speech identification lists developed in the phase I was played through CD player at 40 dB SL (ref: SRT). All the participants were tested monaurally with all the three lists. To avoid order effect, the order of the lists was randomized during presentation of the stimulus. An open set response in the form of an oral response was obtained.

Phase III: Administration of the High Frequency Speech Identification Test in Telugu in individuals with high frequency sloping hearing loss

To test the utility of the developed test material, the test was administered on 5 hearing impaired individuals. The individuals considered in this group met the following criteria. They were native speakers of Telugu who were in the age range was from 15 – 35 years. All the individuals had acquired hearing loss with good language ability. They had bilateral high frequency sloping hearing loss with the audiogram pattern of gradually sloping, sharply sloping, or a precipitously sloping configuration (Lloyd & Kaplan 1978, cited in Silman & Silverman 1991). Ther was no significant psychological and neurological deficits.

The individuals clinically diagnosed as having bilateral high frequency sensorineural hearing loss fulfilling the stated criteria were considered for the administration of the high frequency test material. The developed test material was played through a CD player, which was routed through an audiometer (GSI 61). The speech material was delivered through the headphones. An open set response in the form of an oral response was obtained.

To evaluate the usefulness of the high frequency identification test in Telugu, the speech identification scores obtained in individuals with normal hearing were compared to the speech identification scores obtained in individuals with high frequency sloping hearing loss. The scores obtained from both the groups were subjected to statistical analysis.

Scoring: The responses of the subjects were marked either 0 or 1. Each correct response was given a score of 1 and an incorrect response was given a score of 0.The raw score was then converted to percentage as below:

$$\text{Total score (\%)} = \frac{\text{Total number of correct responses}}{\text{Total number of words presented.}} \times 100$$

Results and Discussion

Development of the high frequency word lists: A total of 300 words which includes both bisyllabic and trisyllabic words were collected from news papers, text books and dictionary for the development of the high frequency speech identification test. Out of 300 words, 157 words were rated as most familiar by 20 native speakers of Telugu. These 157 words were only considered for the development of the high frequency speech identification test in Telugu.

Results of LTASS for the familiar high frequency words: LTASS was done for all the 157 words to

validate the high frequency spectral information of the words and also to select the words to be included in the final test list. It was found that all 157 words had highest energy at and above 1 kHz and were selected. The 157 words were categorized based on the different cut off peak frequency (1.0, 1.5, 2.0, 2.5, & 3.0) as given in Table 1.

Table 1. Number of words with different cut off peak frequency

Cut off Frequency (kHz)	Number of Words
1.0	157
1.5	128
2.0	68
2.5	45
3.0	23

As shown in Table 1, there were 128 words with peak frequency above 1.5 kHz. In the present study, it was decided to use these words as they had adequate energy concentration above 1.5 kHz.

Construction of the word subtests: Out of 128 words, 75 words were randomly considered for the construction of word subtests. Based on the number of syllables, two separate lists were prepared. List 1 had 50 bisyllabic words, which was divided into two half lists (bisyllabic half list 1 and bisyllabic half list 2), each containing 25 words. While dividing the list, the frequency of occurrence of high frequency sounds in Telugu was maintained same in the two bisyllabic word lists. List 2 had 25 trisyllabic words.

Descriptive statistics was done to find out the mean and the standard deviation (SD) of the spectral peak of the 75 words selected in the final list. Table 2 shows the mean and standard deviation of spectral peak frequency from LTASS of the 3 word lists.

Oneway ANOVA was done to compare the 3 lists in terms of mean in peak frequency energy concentration. The results indicated that there was no significant difference across the lists [F (2, 72) = 0.674, $p > 0.05$] in terms of spectral peak frequency.. Hence the three word lists had similar high frequency energy concentration.

Development of normative for the High Frequency Speech Identification Test in Telugu (HFSITT): A total of 100 individuals with normal hearing, who were native speaker of Telugu were considered while developing the normative. The Speech identification scores were obtained for the two bisyllabic word lists and one trisyllabic word list separately for each ear. The Mean and Standard Deviation of speech identification scores obtained for the three lists are given in Table 3.

Table 2. Mean and standard deviation (SD) of the spectral peak frequency on selected word lists

List	No of words	Mean Peak frequency (Hz)	SD	'F' value F(2,72)	Sig
List 1	25	2080	588	2.200	0.118
List 2	25	2200	573	0.954	0.390
List 3	25	2020	510	0.674	0.513

The scores obtained for the right and left ear are given separately for three lists. Majority of the normal hearing individuals obtained 100% speech identification scores in right as well as in left ear for all the three lists. The results are in agreement with earlier studies (Kavitha, 2002; Sudiptha, 2006), who has reported 100% speech identification scores in normal hearing individuals for high frequency word lists. The lowest speech identification scores obtained in the present study was 96%. Hence, it can be said that the specificity of the High Frequency Speech Identification Test in Telugu is good.

Table 3. Mean and standard deviation (SD) of high frequency speech identification scores in normal hearing individuals

Word Lists	Ears	Mean (%)	Range	SD
Bisyllabic word half List 1	Right	99.6	96-100	0.1000
	Left	99.8	96-100	0.1969
Bisyllabic word half List 2	Right	99.7	96-100	0.2387
	Left	99.8	96-100	0.1714
Trisyllabic word List 3	Right	99.9	96-100	0.1407
	Left	100	100	0.0000

Comparison of speech identification scores (SIS) between the ears: Two way repeated measure ANOVA was performed for the purpose of checking the effect of list, ear and the interaction between the two. Results of two way repeated measure ANOVA showed no significant difference in the identification scores obtained between the two ears [F (2, 198) = 1.406, $p > 0.05$]. For the normative data, the results were almost 100% and there was no significant difference between the scores for the 3 lists as most of the normal hearing individuals obtained near

perfect scores. Thus, it can be inferred that the specificity of the HFSITT is good.

Comparison of speech identification scores across the three word lists: The SIS obtained were compared across the three lists separately for each ear. Two way repeated measures ANOVA was also used to check whether there was a significant difference in the speech identification scores across the three lists, The results revealed a significant main effect of word list on speech identification scores [$F(2,198) = 3.343$, $p < 0.05$]. To confirm the significant difference in the identification scores across the three lists, Bonferroni test was done. Results showed that there was no significant difference between the two bisyllabic word lists [$p > 0.05$]. However, there was a significant difference between the bisyllabic half word list 1 and trisyllabic word list [$p < 0.05$], with the trisyllabic word list showing better results as compared to bisyllabic word lists. The improvement in performance of speech identification for the trisyllabic word list could be because of the redundancy of trisyllabic words, which are easier to identify than bisyllabic words. Although there was a statistical difference, the magnitude of the mean difference is small and will not have any clinical importance.

Administration of HFSITT in individuals with High frequency sensori neural hearing loss: The developed HFSITT wordlists was administered on 5 individuals with high frequency sensori neural hearing loss to check the utility of the developed HFSITT.

Wilcoxon signed rank test was performed for the purpose of checking the effect of list, ear and the interaction between the two among the group of individuals with high frequency sloping hearing loss. The results showed that there was no significant difference between any of the lists or ears at 5% level of significance. This indicates that the individuals with hearing impairment performed equally for all the lists and between the two ears.

The speech identification scores for each list were obtained for each ear separately. The mean and standard deviation of speech identification scores obtained for the three lists are given in Table 4.

Comparison of speech identification scores between normal hearing individuals and individuals with HFSHL on HFSITT: To check whether the difference in mean SIS between normal and high frequency sensorineural hearing loss is statistically significant independent t test was done. Table 4 shows the mean, standard deviation and z-values for the paired t-test administered.

The results revealed that there was a significant difference between the two groups [$p < 0.001$]. This indicates that the individuals with HFSNHL performed significantly poorer than the normal hearing individuals in all three lists. Similar findings have been reported by Gardner (1971), Pascoe (1975), Ramachandra (2001), Kavitha (2002), and Sudipta (2006), who have reported that word tests having frequency-specific sounds do differentiate the normal hearing individuals from the individuals with HFSHL.

Table 4. Mean and standard deviation (SD) scores on HFSITT in individuals with HFSHL

Word Lists	Ears	Mean (%)	SD
Bisyllabic half word List 1	Right	47.2	1.3038
	Left	49.6	0.5477
Bisyllabic half word List 2	Right	49.6	1.1402
	Left	50.4	0.5477
Trisyllabic word List 3	Right	52.8	0.8367
	Left	48.8	0.4472

Table 5. Mean SD and z-value for score of HFSITT in normal hearing individuals and individuals with HFSNHL

Lists	Group	Mean	SD	/z/-value
Bisyllabic half word List 1	Normal	24.99	0.77	13.81*
	HFSHL	12.10	0.99	
Bisyllabic half word List 2	Normal	24.97	o.17	11.59*
	HFSHL	12.50	0.84	
Trisyllabic word List 3	Normal	24.95	0.20	10.71*
	HFSHL	12.70	0.82	

*Significance at 0.05 levels

Conclusions

The high frequency word identification test developed in the present study has 2 bisyllabic half lists and one trisyllabic test of 25 words each. The test has good specificity as well as sensitivity. It is an open- end test and one can obtain either oral or written respone. The developed high frequency speech identification test will be useful to identify the speech perceptual deficits in individuals with high frequency sloping hearing loss who are native speakers of Telugu. This shall give a better estimate of the speech identification in communicative handicap that these individuals possess compared to regular phonetically balanced word test. This could

also be useful in the selection of amplification devices for individuals with HFSNHL and auditory training of high frequency words.

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Appendix 1

Bisyllabic half word list 1

చేప	/tʃe:pa/
సూది	/su:ɖi/
గీత	/gi:ʈa/
తోట	/ʈo:ʈa/
పొగ	/poga/
సంత	/sanʈa/
కోతి	/ko:ʈi/
చాప	/tʃa:pa/
సీసా	/si:sa:/
కొంగ	/koŋga/
శిల	/ʃila/
గంప	/gampa/
కోడి	/ko:di/
చాకు	/tʃa:ku/
పాత	/pa:ʈa/
కోపం	/ko:pam/
సాకు	/sa:ku/
తీగ	/ʈi:ga/
చంక	/tʃaŋka/
హాంస	/hamsa/
పూస	/pu:sa/
సొంటి	/soɳṭi/
చలి	/tʃali/
సీసం	/si:sam/
పాక	/pa:ka/

Appendix 2

Bisyllabic half word list 2

పాట	/pa:ʈa/
కాకి	/ka:ki/
పైస	/paisa/
చాట	/tʃa:ʈa/
సేవ	/se:va/
గంట	/gaɳṭa/
తోక	/ʈo:ka/
చెవి	/tʃevi/
ఆట	/a:ʈa/
సింహాం	/simham/
తీపి	/ʈi:pi/
పంట	/paɳṭa/
సంచి	/saɲtʃi/
టోపి	/ʈo:pi/
చీమ	/tʃi:ma/
తూకం	/ʈu:kam/
కేక	/ke:ka/
పాము	/pa:mu/
వంట	/vaɳṭa/
సొంతం	/soɳʈam/
కోటి	/ko:ṭi/
కసి	/kasi/
చీల	/tʃi:la/
ఈక	/i:ka/
విషం	/višam/

Apendix 3

Trisyllabic word list 3

కొడుకు	/koɖuku/
టమాట	/ʈama:ʈa/
కిటికి	/kiṭiki/
చినుకు	/tʃinuku/
తులసి	/ʈulasi/
ఆకాశం	/a:ka:ʃam/
తెలుగు	/ʈelugu/
పలక	/palaka/
సపొట	/sapo:ʈa/
పెరుగు	/perugu/
కానుక	/ka:nuka/
తుపాకి	/ʈupa:ki/
చెమట	/tʃemaṭa/
పసుపు	/pasupu/
గుడిసె	/guɖise/
చాకలి	/tʃa:kali/
గెలుపు	/gelupu/
ఒకటి	/okaṭi/
కొడుకు	/sa:hasam/
టమాట	/ʈalupu/
కిటికి	/tʃiluka/
చినుకు	/po:li:su/
తులసి	/ka:ʈuka/
ఆకాశం	/golusu/
తెలుగు	/parupu/