Development of High Frequency Speech Identification Test in Manipuri Language

[1]Margaret Hmangte & [2]Geetha C.

Abstract

The present study aimed at developing and administering high frequency speech identification test in Manipuri language. The study consisted of two stages. In stage I, monosyllabic words, which majorly contained /k/, $/k^h/$, /ʈ/, /s/, /p/, $/p^h/$, /t/, $/ʈ^h/$, /tʃ/ & /ʃ/ consonants and /i/, /e/ & /ei/ vowels, were selected from different sources. Long-term average speech spectrum was done on the selected words, to confirm that the selected words had high frequency spectral energy. Words with peak frequency of 2 kHz or above, and which had energy present even in the frequencies above the peak frequency were selected. After this, familiarity check was done. Only familiar and most familiar words were selected and two subtests of monosyllabic high frequency words were developed using those words. The developed materials were administered at three presentation levels [20, 40 and 60 dB SL (Ref: SRT)] to 20 normal hearing individuals at each level. SIS was obtained using both the subtests. The results showed a significant difference between the three levels, i.e., with increase in the levels, the SIS increased, with almost 100% at 40 dB SL. Comparison across the two subtests showed that any of the two subtests can be used to obtain high frequency speech identification scores. Thus, from the above findings, it may be concluded that this test has got normal performance-intensity function and has list equality. However, the clinical utility of the test has to be assessed by administering it on clinical population with different degrees of hearing impairment.

Keywords: *Speech Identification Scores, monosyllables, Long-Term-Average Speech Spectrum.*

Introduction

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

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

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

Hence, it is important to have the test material which contains only high frequency consonants and vowels present in that particular language, when assessing individuals with high frequency hearing loss.

The first high frequency word list was developed by Gardner (1971) in English language. Gardner developed a word list that contained consonants of high frequency spectral energy and used it for testing speech discrimination in cases of high frequency hearing loss. It has also been found to be helpful in the application of hearing aid selection and auditory training.

There are also other high frequency word lists available in English language. They are; Pascoe High Frequency Test (Pascoe, 1975); and California Consonant Test (Owens & Schubert, 1977).

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

[1]Email: hmangtemargaret@gmail.com,
[2]Lecturer in Audiology, Email: geethamysore.cs@gmail.com

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

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

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

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

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

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

Hence, the aim of the present study was to develop High Frequency Speech Identification Test in Manipuri language and to administer the developed test on participants with normal hearing sensitivity who are native speakers of Manipuri, at three different input levels, i.e., 20 dB SL, 40 dB SL and 60 dB SL (Ref. SRT).

Method

The objectives of the study were to develop High Frequency Speech Identification Test in Manipuri language, and to administer this on participants with normal hearing sensitivity at different input levels. The study was conducted in two stages. Stage 1 involved development of high frequency word subtests in Manipuri language. Stage 2 involved administering the developed test on participants with normal hearing sensitivity.

Stage 1: Development of the High Frequency Word Subtest in Manipuri Language

The following steps were involved, for preparing the high frequency test material in Manipuri language: Selection of words with high frequency sounds in Manipuri language; Recording of the selected words; Analyzing Long-term average speech spectrum (LTASS) of the selected words; Familiarity assessment; and Construction of subtests.

Selection of words with high frequency sounds in Manipuri language: Monosyllabic words, 230 in number, were selected from different sources like newspapers, dictionary, text books etc. The monosyllabic words, which majorly contained k/, /kʰ/, /h/, /s/, /p/, /pʰ/, /t/, /tʰ/, /tʃ/ and /ʃ/ consonants and /i/, /e/ and /ei/ vowels were chosen. In the literature, these phonemes have been reported to have energy at high frequencies and thus, results in confusion for individuals with high frequency hearing loss (Cooper, Liebermann, Delattre, Brost & Gerstmann, 1952; Gardner, 1971; Hughes & Halle, 1956).

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

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

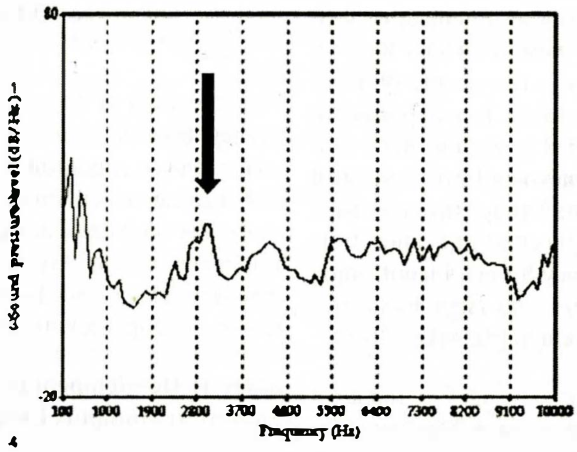

Figure 1: Spectrum of the word /siŋ/. Long Term Average Speech Spectrum showing peak frequency at 2800 Hz (indicated with an arrow mark) and the presence of energy even above 2800 Hz.

Long-Term Average Speech Spectrum (LTASS) of the selected words: LTASS was done on this 230 words, to confirm that the selected words have high frequency spectral energy. LTASS was derived using PRAAT (version 4.1) software and the spectral information was determined manually. The peak frequency of the spectrum was taken as the target parameter. Words with peak frequency of 2 kHz or above, and which had energy present even in the frequencies above the peak frequency were selected.

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

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

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

Stage 2: Administration of the Test Material on Participants with Normal Hearing Sensitivity

Selection of Participants: In this stage, the developed high frequency test materials were administered on 60 native speakers of Manipuri. For the selection of the participants for the study, routine audiological evaluation was carried out. The individual was considered for the study if the person was a native Manipuri speaker within the age range of 18 to 30 years. The person had to have normal hearing sensitivity (PTA less than or equal to 15 dB HL) from 250 Hz to 8000 Hz for air conduction and 250 Hz to 4000 Hz for bone conduction. They had normal middle ear condition in both the ears, with 'A' or 'As' type of tympanogram with ipsilateral and contralateral reflexes present at 500, 1000 and 2000 Hz. The person no history of otological (ear disease, trauma, ototoxic drug intake or ear operation) or neurological dysfunction and had normal speech and language skills.

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

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

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

Test Procedure: The pure tone thresholds were tracked for frequencies between 250 Hz to 8 kHz for air conduction and 250 Hz to 4 kHz for bone conduction using the modified Hughson and Westlake procedure (Carhart & Jerger, 1959). The speech recognition threshold and SIS were obtained using the existing SRT and SIS lists

Table 1: List of 78 words with their peak frequency

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

in Manipuri language developed by Tanuja (1985). A GSI Tymstar middle ear analyzer was used to find out the type of tympanogram and acoustic reflexes at 500 Hz, 1 kHz and 2 kHz.

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

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

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

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

Results and Discussion

The aim of the present study was to develop a High Frequency Speech Identification Test in Manipuri language and to administer this on participants with normal hearing sensitivity at three levels of presentation.

Development of the high frequency word lists

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

Results of LTASS

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

Out of 230 words, 78 words met the above mentioned criteria. The list of these words and the frequency at which peak energy was present is given in the Table 1. The selected words were then assessed for familiarity by five adult native speakers of Manipuri language.

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

Further, LTASS has been successfully used in the present study to ensure that the energy in low frequencies is not dominating and confirm the high frequency energy spread of the selected words. This has also been used in several other studies for the development of speech materials (Kavitha, 2002; Sudipta, 2006; Sinthyia, 2009; Ratnakar, 2010). Out of these 78 words, 60 words were rated as most familiar and familiar, and thus, were selected for preparing the lists. These words were not sufficient to make three lists of 25 words each, and hence, 50 words with highest peak frequency were selected for preparation of two subtests with 25 words each. These 50 words are highlighted in the Table 1 and the two subtests are given in appendix.

Comparison of SIS across levels within and between the lists

Two subtest with 25 words each were administered on 60 normal individuals at three levels i.e. 20 dB SL, 40 dB SL and 60 dB SL on 20 subjects at each levels. Hence, there were three groups of participants. Since the number of sample was lesser in each group, to ensure normal distribution of the sample, One-sample Kolmogorov - Smirnov test was carried out. The result of this test is given in the Table 2. The test results showed that the standard level is minimal for all the three groups. Hence, the sample tested is normally distributed.

Table 2: Results of one sample test (maximum score=25)

	Mean(Number of correctly identified words)	SD	Z score	p- value
20 dB SL	21.6	1.79	1.19	0.11
40 dB SL	24.6	0.77	2.91	0.00
60 dB SL	25.0	0.00	-	-

Table 3: Mean and Standard Deviation for SIS for two subtests across three presentation levels

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

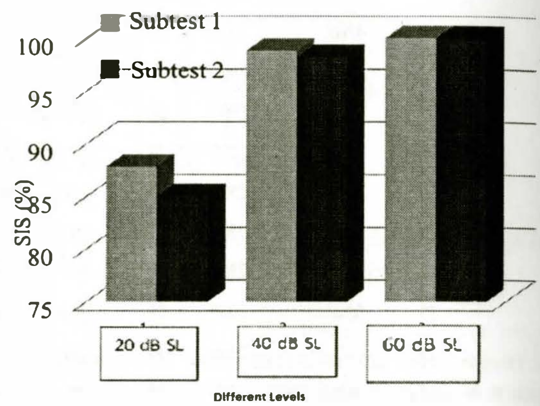

Figure 2: Figure 2: Comparison of SIS across levels for both the subtests.

Comparison between the SIS obtained at three different levels for both the subtests were made. The mean and SD of SIS at different levels for the two subtests are given in the Table 3. It can be observed that the SIS at 20 dB SL is at around 92%, at 40 dB SL, it is around 99%, and 100% at the highest level of presentation, i.e., 60 dB SL. In order to see if there is a statistically significant difference across two subtests and three different levels repeated measures ANOVA was carried out. Results of repeated measures ANOVA revealed that there was a significant difference between the SIS at three different levels [$F(2, 76) = 127.901$, $p < 0.05$].

As there was a significant difference between the SIS obtained at three levels, Bonferoni pair-wise comparison of SIS was done across different presentation levels.

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

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

Comparison of SIS between the two subtests was also done (given in the table 3). It can be observed that there is not much of difference in the scores between the two subtests. Results of repeated measures ANOVA showed no significant difference between the SIS obtained for the two subtests [$F(1, 38) = 1.494$, $p > 0.05$], and there was no significant interaction effect found between the subtests and the different presentation levels [$F(2, 76) = 1.250$, $p > 0.05$]. This indicates that performance obtained from the two subtests will yield similar results. Hence, it can be said that the two subtests developed in the present study have good equality.

Conclusions

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

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