Mizo High Frequency Speech Identification Test (MHF-SIT)

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Abstract

The aim of the present study was to develop a Mizo High Frequency Speech Identification Test (MHF-SIT) for the native speakers of Mizo having a high frequency hearing loss. The study also aimed to normalize and standardize the developed test on 100 adults with normal hearing ability. The developed test material consisted of Monosyllabic and Bisyllabic word lists which were further divided into 6 half lists containing 25 words each. Results revealed that there was no significant difference in speech identification scores between the 6 half lists. There was also no significant difference between the performances of male and female on the 6 half lists when the statistical test was carried out. The results demonstrated that the developed test material can be used to measure speech identification scores for persons having a high frequency hearing loss.

Keywords:*High Frequency word list, Sloping hearing loss, speech identification scores.*

Introduction

Hearing is the ability to perceive sounds by detecting vibrations through the organs of hearing. The basic mechanism for speech perception and effective communication precludes the ability to hear speech accurately. Speech perception involves the process by which the sounds of language are heard, interpreted and understood. The speech signal contains a number of acoustic cues like voice onset time, place of articulation or manner of articulation that are used in speech perception. These acoustic cues and other phonetic information are used for higher language processing and word recognition. An individual needs good hearing ability in order to decode a message from a stream of sounds coming from a speaker for effective communication (Borden & Harris, 1980) and it is a known fact that a person with hearing loss will have a communication problem.

In acoustic terms, vowels and consonants are described by their average pitch (frequency, measured in Hertz - Hz) and their average loudness (intensity, measured in decibels - dB) conversational speech level. The conversational speech has the most acoustic energy between 500 Hz and 3000 Hz. This frequency region is important for understanding meaningful speech (Pavlovic, 1987; Studebaker & Sherbecoe, 2002). A person needs to hear up to 1000Hz in order to hear all the vowels, but he/she needs to hear up to 3000 Hz in order to discriminate between the vowels and this helps us to discriminate between words that otherwise sound same.

However, the speech energy above 3000 Hz is also reported to offer listeners important linguistic information. Thus, one needs to have normal hearing sensitivity at high frequencies for good speech recognition. Any pathology that reduces hearing sensitivity at high frequencies will also affect speech recognition. Therefore, it is the essential duty of audiologists to identify, evaluate and rehabilitate aurally handicapped individuals.

Pure tone audiometry is a hearing test that involves the presentation of a series of sinusoidal tones (or beeps), to the listener, at specific frequencies to establish a person's hearing acuity. However, pure tone audiometry can only assess the auditory system's ability to "carry a simple stimulus" (Egan, 1979), and provides little information about the individual's ability to understand speech; speech audiometry is a type of audiological evaluation designed to better describe communication abilities and attempts to indicate how an individual may hear and understand spoken discourse by presenting words, instead of tones, during testing (Epstein, 1978). Also, because speech is a complex and continually varying signal requiring multiple auditory discrimination skills, it is not possible to accurately predict an individual's speech recognition from the pure-tone audiogram (Marshall & Bacon, 1981). Thus, pure tone audiometry provides little information about the individual's ability to understand speech.

Speech audiometry is routinely administered by audiologists as part of their audiologic evaluation battery. Basic speech audiometric tests include speech detection threshold (SDT), speech recognition threshold (SRT), speech identification scores (SIS), most comfortable level (MCL), and uncomfortable level (UCL). The purpose of these tests is to validate the pure tone air-conduction threshold and provide an index of hearing sensitivity for speech (Carhart, 1952; Chaiklin & Ventry, 1964). Speech audiometry materials were first developed in Standard American English but are now available in various other languages such as Hindi (Abrol, 1971; De, 1973), Spanish (Harris & Christensen, 1996), Italian (Turrini et al.,1993; Greer, 1997), Portuguese (Harris, Goffi, Pedalini, Merrill, & Gygi, 2001, Polish (Harris, Nielson, McPherson, & Skarzynski, 2004), Mandarin Chinese (Nissen, Harris, Jennings, Eggett, & Buck, 2005), Russian (Harris, Nissen, Pola, McPherson, Tavartkiladze & Eggett, 2007), Tongan (Seaver, 2008), etc. However, all these materials are conventional or regular speech audiometry materials

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which were developed and standardized on individuals who have mostly flat or nearly flat type of audiometric configuration. The use of these standard speech tests can give a prediction of the best hearing threshold levels in the mid frequency region of the auditory range.

It is also a known fact that a person with hearing loss is bound to have difficulty in perceiving speech. The kind and degree of perceptual difficulty depends on several factors, which include the degree of hearing loss, the type of hearing loss and the configuration of the audiogram (Gardner, 1971; Jerger & Jerger, 1971; Pascoe, 1975; Owens & Schubert, 1977; Lacroix & Harris, 1979). Depending on the audiometric configuration the speech perception ability would vary. A person with a high frequency hearing loss would have difficulty, mainly in hearing, speech sounds having an energy concentration in the high frequency regions (Stark, 1979; McDermontt & Dean, 2000). Martin (1987) concluded in his study by saying that speech perception would vary depending on whether the person had gradually sloping, sharply sloping or precipitously sloping audiograms. Another study by Mascarenhas (2002) also indicated that individuals with a sharply sloping high frequency hearing loss perform poorer than those with gradual and precipitous sloping high frequency hearing loss on High Frequency-Kannada Speech Identification Test (HF-KSIT).

Speech is a redundant stimulus as it contains information that is conveyed in various ways simultaneously (Martin, 1994). A hearing loss involving only part of the auditory frequency range may go undetected in a speech test if it is not carefully controlled. Thus, the use of a regular speech identification test would be insensitive towards identification of the problem of a person with a sloping high frequency hearing loss. In regular speech material, low frequency information may contribute redundant cues to the perceptual ability, thereby decreasing the sensitivity of the test in detecting their communication handicap (Schwartz & Surr, 1979; Kiukaanniemi & Maatta, 1980).

Owen & Schubert (1977) developed 100 multiple choice items for consonant identification in the California Consonant Test (CCT) to use with hearing impaired patients. A computer assisted analysis was obtained from the test responses of 550 patients with sensorineural hearing loss. They found that the test seems highly sensitive to configurations of high-tone loss, but were not sensitive to a regular speech test, i.e. CID W-22. They concluded that the two test measures different aspects of speech perception and the regular speech test does not assess the real communication problem of individuals with a high frequency loss. Similar results were obtained by Chung and Mack (1979) indicating that in quiet condition, both normal hearing participants and individuals with a high frequency hearing loss performed equally on a regular speech test (i.e. CID W-22). This indicated that the test was not sensitive to the communication problems of individuals with high frequency sensorineural hearing loss.

Also, selection of profitable hearing aids for elderly people or who have sloping high frequency hearing loss depends on utilizing a test which is sensitive to their problem (Sudipta, 2006). A significant improvement in speech identification scores was reported between the aided and unaided scores when High Frequency-Kannada Speech Identification Test (HF-KSIT) was administered instead of Common Speech Identification Test (CSDTI) developed by Mayadevi (1974) in individuals with high-tone loss (Mascarenhas, 2002). Thus, the use of speech identification test normally used may not determine their true communication handicap giving a maximum score unaided. It is unlikely that a person with sloping high frequency hearing loss will get maximum score unaided if a test material is used which are specially designed for their type of hearing loss.

Thus, it can be concluded that, regular speech identification tests are not sensitive to assess the perceptual problems of individuals with a sloping high frequency hearing loss. Hence, there is a need for special test to be developed and used while testing them. Such special tests have been developed in the past and they are called High Frequency Speech Identification Test. First high frequency word list was developed by Gardner in Standard American English (Gardner, 1971). The test contains consonants of high frequency spectral energy and is used for testing speech identification in cases of high frequency hearing loss. Currently, knowing its importance, these kind of tests are also developed in different Indian languages such as High frequency speech identification test in Hindi (Ramachandra, 2001), High frequency-Kannada speech identification tests (Mascarenhas, 2002), **High Frequency-English Speech Identification Test (HF-ESIT)** (Sudipta, 2006), High Frequency Speech Identification test in Tamil (Sinthiya, 2009), and High Frequency Speech Identification test in Telegu (Ratnakar, 2010). However, such materials are not currently available in the Mizo language. The purpose of this study was therefore to develop high frequency speech identification tests materials for native speakers of Mizo.

Method

The study was conducted in the two phases; the first phase involved the development of high frequency word list and the second phase involved standardization of the developed test material.

Phase I -The Development of High Frequency Word List

Both monosyllabic and bisyllabic words with good redundant cues were selected for the construction of the test list. These words were collected from various sources like dictionaries, newspapers, articles, and books. Words having a phoneme /k/, /t̪/, /s/, /d̪/, /r/, /dʒ/, and /l/ were preferred for inclusion as these phonemes have spectral energy mostly distributed above 1000 Hz frequency (Hughes & Halle, 1956). From vowels, the vowels like /i/ and /e/ were preferred as these vowels show higher F2 and F3 formants (Copper, Liebermann, Delattre, Borst & Gerstmann, 1952). Totally, 445 words were collected from the various sources mentioned.

To assess the familiarity of the words selected, 10 adults (5male & 5female), who were native speakers of Mizo were chosen and instructed to rate the selected words according to their level of familiarity. A three point scale of familiarity was administered based on the frequency of occurrence: most familiar, familiar and unfamiliar. The operational definition of most familiar words are those words used commonly, familiar words are those words used occasionally and unfamiliar words are those words that are not used by the participants.

A printed version of words was given to the individuals for the assessment with instruction carefully written to follow while rating each word. Each participant was asked to tick the score suitable. Only those words that were rated as most familiar were selected for the construction of test lists. Thus, 378 words were selected out of 445 words.

After the assessment of familiarity, LTASS was done to determine if the most familiar words constitute spectral information predominantly in the higher frequencies. This was done to see if the selected word lists possess the required spectral information. It was a necessary procedure because the spectral information of the phonemes /k/, /t̪/, /s/, /d̪/, /r/, /dʒ/, and /l/ could differ depending on the context and hence the so called high frequency word may not be having high frequency spectral information. To do this, 378 words that were

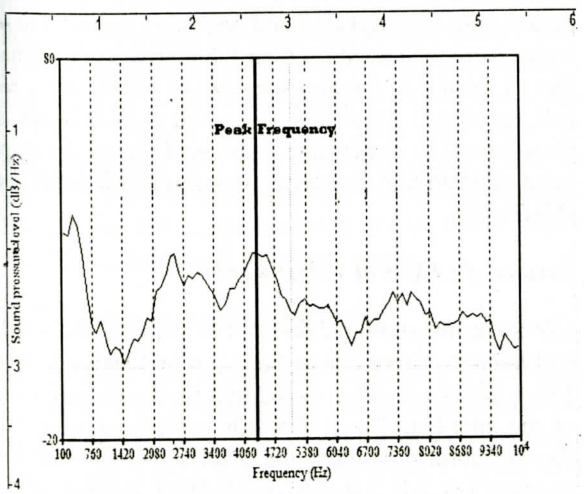

Figure 1: Spectrum derived from LTASS for a representative word (e.g. beisei).

rated as most familiar were assessed for the spectral information using LTASS. These words were recorded in a sound treated room using Computer software. They were spoken by adult female who was a native speaker of Mizo. The recording was done at 16 kHz sampling rate and 16 bit quantization using Adobe Audition software (version 3.0) and the samples were stored into a computer. LTASS was derived using the PRAAT software by feeding the audio samples one by one into it and the spectral information was determined manually. The peak frequency of the spectra which have a higher energy concentration was taken as the target parameter.

Peak frequency determined in LTASS showed that out of 378 words, there were 250 words having highest energy above 1000 Hz. These 250 words were further categorized based on different cutoff peak frequency (1.0, 1.5, 2.0, 2.5, & 3.0 kHz). In the present study it was decided to use words with peak frequency 2 kHz and above, to make it a more sensitive test. There were 186 such words with peak frequency of 2 kHz and above. Out of 186 words, 150 words were randomly selected for the construction of high frequency word list.

The spectrum derived from LTASS for a word is shown in the Figure 1. The 150 words that were selected based on LTASS results and having the highest energy above 2 kHz were further categorized into monosyllabic and bisyllabic words. There were 100 monosyllabic words and 50 bisyllabic words. The 100 monosyllabic words were divided into two lists, each of which were further divided into two half lists, each list containing 25 words. There were 50 bisyllabic words which were also divided into two half lists, each list containing 25 words. The frequency of occurrence of high frequency sounds was maintained same in each of the lists, containing both monosyllabic and bisyllabic words.

Recording of the test material (150 selected words) was done in a sound treated room as per ANSI guidelines (1999). Three adult females, who were native speakers of Mizo was selected for recording the tests words. The recording was done using Adobe Audition (version 3.0) software and the recorded materials were perceptually rated. The speaker who spoke with the best clarity and fluency was chosen for the audio recording of the final test list. The microphone was placed at a distance of 5 inches away from the mouth of the speaker. The VU meter was monitored within optimum levels during the recording. The speaker was instructed to say the words with her normal pitch and to keep the loudness constant across the words. The recording was done using 44.1 kHz sampling rate and 16 bit quantization in mono channel. The intensity of each word was edited as a single utterance using Adobe Audition software to obtain the same average RMS power as a 1000Hz calibration tone in an attempt to equate test word audibility (Harris et al., 2004; Wilson & Strouse, 1999). After editing, each word was saved individually as wave file.

The recorded material was also edited to carry out noise and hiss reduction. The inter stimulus interval between the two words was set to 5 seconds. The material was then copied onto an audio compact disc using a compact disc writer.

Phase II - Standardization of the Test Material

Participants:

The developed test MHF-SIT was normalized and standardized by obtaining speech identification scores on 100 native speakers of the Mizo language (50male & 50female). The participants were in the age range of 18 to 30 years. By self-report, all participants were native speakers of Mizo and considered Mizo to be their first language.

The participants of the study had normal hearing, as indicated by their four-frequency (500 Hz, 1000 Hz, 2000 Hz & 4000 Hz) pure-tone average threshold of ?15 dB HL, 'A' Type tympanogram with acoustic reflex thresholds in normal limits (90 dB at 1000 Hz). It was ascertained from a structured interview that none of these listeners had any difficulty in understanding speech in daily listening conditions and that they did not have any history of neurologic or otologic disorder.

Instrumentation:

All the evaluations were carried out in an acoustically treated two-room situation as per ANSI S3.1 (1991) using a calibrated single channel audiometer (Classic II) coupled with acoustically matched TDH-39 supra aural headphone and Radio ear B-71 bone vibrator was utilized to estimate pure tone threshold, speech recognition threshold and speech identification score. A calibrated immittance meter (Amplaid-760) was used for obtaining tympanometry and acoustic reflex. A Desktop Computer of Core 2 Duo processor with adobe audition (version 3.0) software was used to record and present the developed test material.

Procedure:

After the estimation of pure tone threshold, speech reception threshold (SRT) and speech identification scores (SIS), the high frequency word identification list developed in Phase 1 was played (through computer plugged to audiometer) at 40 dB SL (wrf: SRT), delivering the stimulus through headphones. An external output of the audiometer was calibrated prior to testing each participant to 0 VU, using a 1000 Hz calibration tone. All participants were tested monaurally using the developed lists. The order of the lists was randomized to avoid order effect and an open set response in the form of oral response was obtained. All participant responses were scored by a native Mizo interpreter throughout data collection. Responses were only marked correct if they matched the target stimuli in both pronunciation and lexical tone. Prior to the administration of word recognition test, each participant was given the following instructions in English or in Mizo: "You will hear lists of Mizo words a number of times at a specific level. One word will be followed by another word. The silent gap between each word will be about 5 seconds. Please listen carefully and loudly repeat out the word that you hear. If you are unsure of a word, you are encouraged to guess. If you have no guess say, *I don't know*, or wait silently for the next word. Do you have any questions?"

Scoring:

After the estimation of MHF-SIT the responses were scored. Each correct response was given a score of 1. Each incorrect response was given a score of 0. The raw score was converted to percentage as below:

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

Statistical Analysis:

Statistical Package for the Social Sciences (version 16) software was used to carry out the statistical analysis. Descriptive statistics to find out the Mean and Standard Deviation, Independent *t*-test to compare the Mean scores of variables, one way ANOVA, repeated measure ANOVA and Bonferroni post hoc test were the statistical test used.

Results and Discussion

The results of the present study are described and reported under the following sub-headings.

Development of the High Frequency Word List/s

Selection of the words and their familiarity:

Initially a total of 445 words were collected which included both monosyllabic and bisyllabic words. These words were then rated for their familiarity using 10 native (5 female & 5 male) speakers of Mizo. As a result, out of 445 words 378 were rated as most familiar. Only these 378 words were considered for the development of Mizo high frequency speech identification test (MHF-SIT).

Results of LTASS of Target words:

LTASS results showed that out of 378 words, 250 words had highest energy concentration at and above 1 kHz. These 250 words were considered for the development of the final list. The 250 words considered were further categorized based on the different cut off peak frequency (1.0, 1.5, 2.0, 2.5, & 3.0 kHz) as given in the Table 1.

Table 1: Cut off frequency of selected 250 words

Cut off Frequency(kHz)	Number of words
1.0	250
1.5	213
2.0	186
2.5	124
3.0	68

Table 2: Mean and Standard Deviation (SD) of spectral peak frequency on selected word list.

List	Number of words	Mean Peak frequency (Hz)	SD
List 1: Half list 1	25	2937.68	421.96
List 1: Half list 2	25	2920.44	374.92
List 2: Half list 1	25	2926.36	450.45
List 2:Half list 2	25	2928.72	568.13
List 3: Half list 1	25	2946.60	587.99
List 3: Half list 2	25	2948.64	546.70
Total	150	2934.74	489.83

From the data given in Table 1, it is clear that 250 words had predominant spectral information above 1 kHz. It is also evident that as the cut-off frequency increased, the number of words decreased.

Although all 250 words showed spectral information higher than 1 kHz, in the present study only those words that have cut off frequency at and above 2 kHz were included for the final construction of the list. Sinthiya (2009) statistically compared spectral peak frequency between regular standardized phonetically balanced speech identification test and High frequency Speech Identification Test in Tamil. Results indicated that words with predominant spectral information above 2 kHz were more sensitive in detecting speech perception deficits in individuals with high frequency hearing loss, compared to words with energy above 1 kHz. Hence, the decision to use words with cut-off frequency above 2 kHz as inclusion criteria for the construction of final word lists is justified. Thus, there were 186 words available with peak frequency above 2 kHz, of which 150 words were randomly selected for the final list. These 150 words consisted of 100 monosyllabic and 50 bisyllabic high frequency words.

Construction of the Word subtests:

Word subtest was constructed from selected 150 words consisted of 100 monosyllabic and 50 bisyllabic words. Thus, based on this, three separate lists were prepared; List 1 and List 2 had 50 monosyllabic words each while the List 3 had 50 bisyllabic words. This was done because the redundancy in bisyllabic words could be more than that of monosyllabic words which could affect speech identification scores (Hirsh, Silverman, Reynolds, Eldert & Benson, 1952). It was also presumed that depending on the level of word difficulty in these lists speech identification scores could differ and a normative developed combining these words within the same list may be erroneous. Hence, separate monosyllabic and bisyllabic list were prepared.

Further, 50 monosyllabic words in both List 1 and List 2 were divided into two half list with 25 words each, thus, there were 4 half list of 25 words each. Similarly, List 3was also divided into two half list with 25 words each. This was done to provide a shorter version of the test which could be useful when the complete list cannot be administered due to time constraints. While dividing the lists, attempt was made to keep the frequency of high frequency sounds similar in all the half lists.

Descriptive statistics was done to find out the Mean and Standard Deviation (SD) of the spectral peak of 150 words selected for the final list. Table2 shows the Mean and Standard Deviation of spectral peak frequency obtained from LTASS of all the 6 lists.

Later, one way ANOVA was done to compare the equality in peak frequency energy concentration across 6 lists. The results indicated that there was no significant difference between the spectral peak frequencies of the words in the lists [$F (5, 144) = 0. 013$, $p>0.05$] indicating that all 6 lists had similar high frequency energy concentration.

Development of the Normative for the Mizo High Frequency Speech Identification Test (MHF-SIT)

Normative was established for the developed test on 100 normal hearing individuals (50 Females & 50 Males) who were native speakers of Mizo. Speech identification scores were obtained for all 6 half lists for each ear separately. Words were presented randomly to both ears. The Mean and standard deviation of speech identification scores obtained for six lists are given in the Table3.

Comparison between the Ears:

Speech identification scores obtained for the left and right ear was compared for all the six lists (Table 3). It was observed that the majority of the normal hearing individuals obtained almost 100% speech identification scores in the left as well as right ear. Later, one way ANOVA (Table 4) was performed for the purpose of checking the effect of list, ear and interaction between the two. Results of one way ANOVA showed no significant difference between the speech identification scores obtained in two ears. Hence, the data from left and right ear were combined for further statistical analysis.

The present result showed that normal hearing individuals obtain almost 100% speech identification score on

Table 3: Mean and Standard Deviation (SD) of MHF-SIT scores in normal hearing individuals

Lists	Ears	Mean (%)	Range	1 SD
List-1 Half list 1	Right	99.5	100 - 96	1.25
	Left	99.5	100 - 96	1.30
	Total	99.5	100 -96	1.27
List-1 Half list 2	Right	99.6	100 - 96	1.10
	Left	99.6	100 - 96	1.20
	Total	99.6	100 - 96	1.17
List-2 Half list 1	Right	99.7	100 - 96	1.09
	Left	99.6	100 - 96	1.15
	Total	99.6	100 - 96	1.11
List-2 Half list 2	Right	99.5	100 - 96	1.13
	Left	99.6	100 - 96	1.20
	Total	99.5	100 - 96	1.25
List-3 Half list 1	Right	99.8	100 - 96	0.685
	Left	99.9	100 - 96	0.562
	Total	99.9	100 - 98	0.626
List-3 Half list 2	Right	99.8	100 - 96	0.876
	Left	99.8	100 - 92	0.971
	Total	99.8	100 - 92	0.922

Table 4: One-way ANOVA results across lists

List	F	p
Word-List-1 Half list 1	0.049	0.826
Word-List-1 Half list 2	0.058	0.881
Word-List-2 Half list 1	0.064	0.801
Word-List-2 Half list 2	0.202	0.653
Word-List-3 Half list 1	0.203	0.653
Word-list-3 Half list 2	0.093	0.760

high frequency words. This finding is in agreement with several earlier studies (Schwartz & Surr, 1979; Mascarenhas, 2002; Sudipta, 2006; Sinthiya, 2009; Ratnakar, 2010). The lowest score obtained among the 100 participants was 92%. Thus, it can be inferred that the specificity of the Mizo High Frequency Speech Identification Test (MHF-SIT) is good. Earlier studies (Schwartz &Surr, 1979; Mascarenhas, 2002; Sudipta, 2006; Ratnakar, 2010) have checked for the sensitivity with high frequency sensorineural hearing loss. However, due to time constraints that was not among the objectives of the present study.

Comparison between Males and Females

The speech identification scores were also compared across the 6 lists for males and females (50 males & 50 females). One way ANOVA was performed to see whether there was a significant difference in the speech identification scores between male and female participants. To do this, speech identification scores of both ears (right and left ears) obtained from males were compared with that of females separately for each of the 6 lists. The results revealed that there was no significant difference between the speech identification scores obtained between males and females in all the 6 lists as depicted in Table 5. This finding was in agreement with earlier studies (Kruger, 2010) where comparison was

Table 5: One way ANOVA for Speech Identification Scores between male and female participants

	Gender	Ear	Mean (%)	SD	p
List-1: Halflist-1	Female	Right	99.6	1.21	0.75
		Left	99.3	1.48	0.22
	Male	Right	99.5	1.31	0.75
		Left	99.6	1.09	0.22
List-1: Halflist-2	Female	Right	99.6	1.09	0.73
		Left	99.7	0.95	0.18
	Male	Right	99.6	1.21	0.73
		Left	99.4	1.40	0.18
List-2: Halflist-1	Female	Right	99.5	1.31	0.14
		Left	99.5	1.31	0.29
	Male	Right	99.8	0.79	0.14
		Left	99.7	0.95	0.29
List-2: Halflist-2	Female	Right	99.4	1.40	0.54
		Left	99.4	1.40	0.18
	Male	Right	99.6	1.21	0.54
		Left	99.7	0.95	0.18
List-3: Halflist-1	Female	Right	99.8	0.79	0.56
		Left	99.8	0.79	0.15
	Male	*Right*	99.9	0.56	0.56
		Left	100	0.00	0.15
List-3: Halflist-2	Female	Right	99.7	0.95	0.65
		Left	99.8	0.79	1.00
	Male	Right	99.8	0.79	0.65
		Left	99.8	1.13	1.00

Table 6: Results of Boneferroni's post hoc test showing the pair wise comparison across the word subtests

Lists	List-1 Half list 1	List-1 Half list 2	List-2 Half list 1	List-2 Half list 2	List-3 Half list 1	List-3 Half list 2
List-1Half list 1	-	NS	NS	NS	S	NS
List-1Half list 2	NS	-	NS	NS	S	NS
List-2Half list 1	NS	NS	-	NS	NS	NS
List-2Half list 2	NS	NS	NS	-	S	NS
List-3Half list 1	S	S	NS	S	-	NS
List-3Half list 2	NS	NS	NS	NS	NS	-

done to determine to see the presence of any significant statistical differences between males and females on word recognition scores in native speakers of Samoan and results showed no significant difference.

Comparison of Speech Identification Scores across lists to check the equality of different lists

To verify whether there is any significant difference in the speech identification scores across the 6 lists, repeated measures ANOVA was done. The results of repeated measure ANOVA indicated that there was a significant main effect of word list on speech identification scores [$F(5, 995) = 4.106$, $p < 0.01$]. To obtain a pair wise comparison across the 6 lists, Boneferroni's post hoc analysis was carried out. The results of Boneferroni's test are shown in the Table 6.

Results showed no significant difference in speech identification scores between 4 monosyllabic half lists, and between 2 bisyllabic half lists. Also, there was no significant difference between monosyllabic word (wordlist-2) half list 1 and the bisyllabic word lists in terms of speech identification scores. However, significant difference was seen between bisyllabic word lists (Halflist-1 of List-3) [$p < 0.05$] and other word lists, with bisyllabic word lists showing better speech identification scores as compared to monosyllabic word lists. This improvement in speech identification scores for bisyllabic word list could be because of the redundancy of the bisyllabic words, which is easier to identify as compared to monosyllabic words. A similar result was also found in earlier studies done by Hirsh et al. (1952).

Thus, although the results revealed that there was statistical difference, inspection of the mean speech identification scores obtained for the monosyllabic word lists and the bisyllabic word lists was above 99%. This indicates that the magnitude of the mean difference is very small and will not have any clinical importance. Hence, it can be concluded that any of the 6 word subtests can be used to assess the high frequency speech identification.

Conclusions

The results showed that the normal hearing participants obtained a mean score of more than 99% for all the 6 lists. No significant difference across the ear and gender was observed in speech identification scores across the lists. Further, pair wise comparison across the 6 half lists showed that any of the lists are equally comparable and can be used to obtain high frequency speech identification scores. However, the utility of test needs to be checked on individuals with high frequency hearing loss.

The Mizo High frequency Speech Identification Test (MHF-SIT) will be useful to identify and evaluate speech perceptual deficits in individuals with high frequency hearing loss. Speech perception abilities obtain using this test will give a better estimate of the communication handicap that these individuals possess as compared to regular speech test. This could also be useful in the selection of appropriate amplification devices for individuals with high frequency hearing loss and auditory training of high frequency words.

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