Development of low frequency word lists in Malayalam

by Prashanth Prabhu

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ARF PROJECT PROPOSAL

Part A

1.0	**Title of the Project**	Development of low frequency word lists in Malayalam
	Area of research	Audiology
1.1	**Principal Investigator**	Mr. Prashanth Prabhu P Lecturer in Audiology AIISH, Mysuru prashanth.audio@gmail.com
1.2	**Co-Investigator**	Co-Investigator (1) Dr. Animesh Barman Professor of Audiology AIISH, Mysuru barmananimesh197@gmail.com Co-Investigator (2) Mr. Jithin Raj B Audiologist Grade II AIISH, Mysuru jithinrajb@gmail.com
1.3	**Collaborating Institution/ Organization**	Nil
1.4	**Total Grants required**	4, 93,000/-/- (Four lakh ninety three thousand only)
1.5	**Duration of the Project**	12 months

2.0 Project summary

The standard phonemically balanced word lists can give reasonably accurate prediction of speech understanding for flat configuration of hearing loss. Thus, it would be insensitive in identification of the speech perception difficulties of individuals with low frequency hearing loss. Thus, it is essential to have a speech test material having only low or high frequency speech sounds. There are high frequency speech word list developed in different languages. However, there are limited test materials which can be used to assess the communication ability of individuals with low frequency hearing loss. Malayalam is spoken by a large group of population across the world and it is essential to develop low frequency word list even in Malayalam. Thus, low frequency words would be carefully selected using familiarity assessment, analysis using PRAAT, FFT, k-mean clustering, LTASS and phonemic analysis. The word lists would be equalized using psychometric curves obtained at different sensation levels (SLs). The final word list would be standardized by administering them at 40 dB SL on 100 individuals with normal hearing. In addition, the effectiveness of the developed word list would be determined by administering it on individuals with low frequency hearing loss/simulating low frequency hearing loss. The developed word lists would be used clinically to assess communication ability in individuals with rising hearing loss. Similarly these word lists also has the potential to assess the performance after the amplification provided to the individuals with rising hearing loss.

3.0 Introduction

3.1 Definition of the problem

A person with a hearing loss will have difficulty in perception of speech. The kind and degree of perceptual difficulty depends on several factors. These include the degree of hearing loss, the type of hearing loss and the configuration of the audiogram (Jerger & Jerger, 1971; Gardner, 1971, Pascoe, 1975; Owens & Schubert, 1977; Lacroix & Harris, 1979). The speech spectrum shows that speech sounds such as stops (/p/, /b/, /d/, /m/, /n/, /g/), liquids (/l/, /r/) semivowels (/v/, /j/) and vowels (/i/, /u/,/a/) are in the low frequency (< 1KHz) and affricates and fricatives at mid to high frequencies. Individuals with low frequency hearing loss will have difficulty hearing sounds in the frequency range of 125 Hz to 1000 Hz. There are a number of acquired causes of hearing loss in low frequency range. It is frequently associated with Meniere's disease (Opheim & Flottrop, 1957), viral infections (Djupseland at al., 1979), and also with various retrocochlear lesions (Lundborg, 1955; Moller & Moller, 1983).

Hearing loss in the low frequency range of sounds may also be caused by congenital causes that include: poor cochlear development, congenital cholesteatoma (a destructive cyst in the middle ear), and delayed familial progressive causes (Konigsmark et al., 1971; Parving, 1984). A gene called WFS1 also has been identified that may be responsible for hearing loss in the low frequency range. Children who were born with a mutated copy of this gene were studied and were found to suffer from low frequency hearing loss. The perception of speech at low frequencies will be affected in individuals with rising type of hearing loss. However, there are limited speech materials only with frequencies to assess unaided and aided speech perception in individuals with low frequency hearing loss.

3.2 Importance of the proposed project in the context of current status

Speech is a stimulus of high redundancy because of the information in it is conveyed in several ways simultaneously (Martin, 1994). A hearing loss involving only the part of the frequency range may go undetected in a speech test which is not carefully controlled. A standard speech test can give reasonably accurate prediction of the best hearing threshold levels in the mid frequency region of the auditory range. However, the use of a regular speech identification test would be insensitive towards identification of the problem of a person with low frequency hearing loss. Thus, it is essential to have a speech test material having only low frequency speech sounds.

However, most speech identification tests developed in Malayalam by Mathew (1996), and Jain, Konadath, Vimal & Suresh (2014) have been developed to determine the communication problems of individuals with flat frequency hearing loss. In addition, there are high frequency speech identification tests developed by Ramachandra (2001) for Hindi and Urdu speakers, Mascarenhas (2002) in Kannada, Sudipta (2006) in English, Sinthiya (2009) in Tamil, Ratnakar (2010) in Telugu which can assess the communication ability of individuals with high frequency hearing loss. However, there is limited test material which can be used to assess the communication ability of individuals with low frequency hearing loss in Malayalam. Barman et al. (2016) developed and standardized low frequency word lists in Hindi and Kannada. Malayalam is spoken by a large group of population across the world and it is essential to develop low frequency word list even in Malayalam.

In order to select appropriate hearing aids for individuals with low frequency sensorineural hearing loss, it is essential to use a test which is sensitive to their problems. There is a high possibility that, if a regular PB word list is used in such individuals, the aided and the unaided scores may not be significantly different. Thus, it would be difficult to assess the benefit which one might get from the hearing aid. We can expect a significant difference in aided and unaided performance if a low frequency word list is used in individuals with rising hearing loss. Thus, it is essential to develop low frequency word list which would help in rehabilitation of Malayalam speaking individuals with low frequency hearing loss.

Objectives of the study:

- To develop low frequency word list in Malayalam to determine speech identification scores in individuals with predominantly low frequency hearing loss.
- To establish the normative data for the developed material in normal hearing adults who are native speakers of Malayalam.
- To check the equality of the different lists that is developed.
- To administer the test on a group of individuals with rising type of audiogram pattern/simulate low frequency hearing loss to check its utility.

4.0 Work plan

4.1 Method

The study would be carried out in three stages:

Stage 1: The development of the low frequency word list

Stage 2: Standardization of the test material

Stage 3: Determining the usefulness of the test material

Stage 1: Development of the low frequency word list would be carried out in following steps:

Selection of the words and familiarity rating

Bi-syllabic Malayalam words will be collected from different sources (common newspapers, magazines, & books). The words will be collected irrespective of the energy concentration of phonemes across frequencies. Those words will be verified for the presence of any script errors and correct categorization as bi-syllabic words. Further, corrected word list would be given to 10 adult native Malayalam language speakers to rate the words on a 5-point familiarity rating scale. The words rated familiar, more familiar or most familiar by 70% of the participants will be considered and rest of the words will be excluded from the list.

Recording of words and selection of best recorded words

The selected words will be recorded in a sound treated room. Each word will be recorded five times in clear and monotonous voice. Out of five recordings, first and the last recordings will be removed and only the middle three will be subjected to subjective and objective analysis to select the best recorded words. Praat software will be used for objective analysis. Firstly, words will be subjectively analyzed and rated by an experienced audiologist for the clarity of the utterance, presence of any intonation patterns and background audible noise. Out of three repetitions of each word, the best rated recordings, which were free of background noise, clear and monotonous will be considered. Further, among those recordings, one with visible pitch and formants observed using Pratt software will be finally selected during objective analysis. The selected words will be normalized for its intensity.

Separating words with dominant low frequency energy

Firstly, using MATLAB software, Fast Fourier Transform (FFT) will be carried out for all the words. Amplitude of energy below and above 1.5 kHz will be calculated for all the words individually. These amplitudes will be used to obtain amplitude ratios; the ratio of energy below 1.5 kHz to that of above 1.5 kHz. Further, considering these amplitude ratios, *k*-means clustering will be administered on all the words. During *k*-means clustering, total data will be divided into a number of clusters with its nearest mean. The words having dominant low frequency energy compared to rest of the words would be selected.

Further, long term average speech spectrum (LTASS) will be obtained for the clusters of low frequency words using MATLAB software. This would be done to further verify the correct categorization of words as low frequency dominant. To further ensure that the lists do not include words with more high frequency energy, the words will also be subjected to phonemic analysis. During this analysis, attempts will be made to eliminate the words having consonants considered as high frequency in Malayalam. Thus, the word list will be further shortlisted making sure the predominance of low frequency energy.

Generating word lists with equal difficulty

All the low frequency words will be then presented to 25 adult native Malayalam speakers (5 participants for each SL) with normal hearing at 5 different sensation levels (ref: PTA). Sensation levels (SLs) of +0, +4, +8, +12 and +16 dB will be considered. The signal will be routed through a personal computer to calibrated audiometer and presented through headphones, Sennheiser HDA-200. All the low frequency words will be presented at one sensation level (SL) for each participant and at each SL, data will be collected from 5 participants for each SL. Further, speech identification (SI) scores will be calculated using the following formula:

$$\text{SIS} = \frac{\text{Obtained number of responses}}{\text{Total number of responses}} * 100$$

The speech identification scores obtained from the participants at each SL will be averaged and tabulated. Based on the averaged scores at all SLs, psychometric functions will be derived for all the words using MATLAB software. Mean sensation level where 50% SI scores occurred and mean slope of the psychometric functions will be obtained. Words falling within ±1.5 standard deviation from overall mean and slope will be accepted. These words will be used to make the final word lists of 25 words each. For constructing equalized list, firstly 25 words will be randomly selected from the available word pool. For each list, mean SL where 50% scores occurred and mean slope will be found out. This mean SL and slope will be compared with the overall mean SL and slope of the low frequency word pool obtained initially. If the mean value was within ±1.5 standard deviation, then the list considered will be selected. If not, then another set of 25 words will be randomly selected and this procedure will be repeated. The word lists developed will be recorded on a CD-R using a personal computer at 16 bits and 44.1 kHz sampling frequency.

Stage 2: Standardization of Test material

The developed test material will be standardized by obtaining the speech identification scores for 100 adult native speakers of Malayalam. All the participants should be literate with an education level of at least 7^{th} standard or 10^{th} Standard who know to write Malayalam. The participants in the age range of 18 to 30 years, with normal hearing sensitivity (< 15 dB HL thresholds at all octave frequencies from 250 Hz to 8 KHz) will be selected. They should have no history of any otological problems and should have normal middle ear functioning based on immittance findings. Speech perception in Noise (SPIN) test would be administered to rule out Auditory Processing Disorder (APD) and all the participants should have speech identification scores greater than 60% at 0 dB SNR (Orchik & Burgess, 1977).

Procedure

A calibrated dual channel audiometer would be used to determine pure tone and speech audiometry. After estimation of pure tone thresholds, the speech recognition threshold (SRT) will be determined. The speech identification scores (SIS) will be determined at 40 dB SL (ref SRT) with the word list developed in Phase I. All the participants will be tested only one ear with all the lists developed to avoid practice effect. To avoid ear effect, 50 individuals will be tested in right ear and the other 50 in left ear. The speech material recorded for the study will be played using Adobe Audition (Version 3.0) software. The signal will be routed through a computer to the tape and auxiliary input of an audiometer and presented through headphones. The intensity of the presentation level would be controlled from the audiometer. An open set

response in the form of written response will be taken from all the participants. The speech identification scores (SIS) will be calculated using the following formula:

$$SIS = \frac{\text{Obtained number of responses}}{\text{Total number of responses}} * 100$$

The following criteria will be considered to conclude that the list is standardized:

- The speech identification scores obtained using each list should be more than 90 %.
- There should be no significant difference between the scores obtained between the lists to conclude that all the lists are equally intelligible or equally difficult.

Stage 3: Determining the usefulness of the test material

After standardization of the test, at least 5 adults with rising low frequency, preferably cochlear hearing loss will be considered to determine the utility of the test material. If these individuals are not available then hearing loss would be simulated using NIOSH Hearing Loss Simulator software (version 3.0.12151). The classification of rising type will be based on the classification given by Lloyd and Kaplan (1978, cited in Silman & Silverman, 1991). All the participants of the study will be tested with low frequency word list developed. The scores obtained by individuals with rising hearing loss were compared with individuals with normal hearing. In addition, scores obtained for PB word list in Malayalam and developed low frequency word list will be compared. The data obtained will be analyzed using SPSS software for significant differences, if any.

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