Original Research Article

Conventional speech identification test in Marathi for adults

S. B. Rathna Kumar[1]*, Panchanan Mohanty[2], Pranjali Anand Ujawane[1], Yash Rajeev Huzurbazar[1]

[1]Ali Yavar Jung National Institute for the Hearing Handicapped, Mumbai, India
[2]School of Humanities, Hyderabad Central University, Hyderabad, India

*Correspondence:
Dr. S. B. Rathna Kumar,
E-mail: sarathna@yahoo.co.in

ABSTRACT

Background: The present study aimed to develop conventional speech identification in Marathi for assessing adults by considering word frequency, familiarity, words in common use and phonemic balancing.

Methods: A total of four word lists were developed with each word list consisting of 25 words out of which 60% are monosyllabic words in CVC structure, and 40% are disyllabic words in CVCV structure. Equivalence analysis and performance-intensity function testing was carried out using four word lists on native speakers of Marathi belonging to different regions of Maharashtra (i.e. Vidarbha, Marathwada, Khandesh and Northern Maharashtra, Konkan and Pune) who were equally divided into five groups based on above mentioned regions.

Results: The results revealed that there was no statistically significant difference (p >0.05) in the speech identification performance between groups for each word list, and between word lists for each group. The performance-intensity (PI) function curve showed semi-linear function, and the groups' mean slope of the curve indicated an average slope of 4.5% increase in speech identification score per dB for four word lists. Although, there is no data available on speech identification tests for adults in Marathi, most of the findings of the study are in line with the findings of research reports on other Indian languages.

Conclusions: The four word lists developed were found to be equally difficult for all the groups and can be used interchangeably. Thus, the developed word lists were found to be reliable and valid materials for assessing speech identification performance of adults in Marathi.

Keywords: Speech identification performance, Phonemic balance, Equivalence analysis, Performance-intensity function testing, Reliability, Validity

INTRODUCTION

Speech audiometry is an essential component of the audiological test battery as it provides information pertaining to individual's sensitivity to speech stimuli and the understanding of speech at supra-threshold level.[1] There are two common speech audiometric measures used in the evaluation of speech identification or speech recognition performance for diagnostic purpose. The first is "speech recognition threshold" (SRT), i.e. the threshold for the identification of speech stimuli which provides an estimate of auditory sensitivity, as measured in pure-tone audiometry. The second is "speech identification score" (SIS) or "speech recognition score" (SRS), i.e. the maximum speech identification score obtained for speech stimuli presented at supra-threshold level under optimum listening conditions. The SIS testing has been used in every phase of audiology and the diagnostic value of identifying and differentiating auditory disorders is well documented.[2]

The SIS testing has been used in every phase of audiology, first, to describe the extent of hearing impairment in terms of how it affects individuals' ability

to understand to speech; secondly, to differentially diagnose auditory disorders by determining the anatomical site of lesion of auditory system; thirdly, to determine the needs for amplification devices and other forms of aural rehabilitation devices like cochlear implants; fourthly, to make comparisons between various hearing aids, hearing aid fitting approaches, and other forms of aural rehabilitation devices; fifthly, to verify the benefits of hearing aid usage and other forms of aural rehabilitation devices; and sixthly, to monitor individuals' performance over the time for either diagnostic or rehabilitative purposes.[2]

Speech audiometry has become a fundamental tool in audiological assessment, and speech identification performance must be evaluated routinely using valid and reliable clinical assessment procedures appropriate for different population. With regard to the history of materials for speech audiometry, different kinds of materials have been developed by several investigators in English and other languages. Several such attempts have also been made to develop and standardize materials for speech audiometry in Indian languages such as Hindi, Tamil, Gujarati, Kannada, Mizo, Rajasthani, Telugu etc.[3-9] Marathi is a southern Indo-Aryan language and is one of 23 official languages of India. Marathi is the official language of Maharashtra and Goa. Marathi is the 4th largest among the languages of India, and 14th largest among the languages of the world. With reference to Marathi, Waghmare et al.[10] developed speech recognition test for children between the age range 6 and 10 years. No such materials are available for assessing speech identification performance of adults in Marathi. Hence, the current study aimed to develop conventional speech identification tested in Marathi for adults.

METHODS

The study was conducted in the following five phases: 1) development of corpus of most familiar and commonly used monosyllabic and disyllabic words in Marathi, 2) calculation of frequency of occurrence of each phoneme from the developed corpus, 3) development of word lists for assessing speech identification performance, and 4) a formal study for carrying out equivalence analysis and performance-intensity (PI) function testing of developed word lists.

Development of corpus of most familiar and commonly used monosyllabic and disyllabic words in Marathi

The development of corpus of most familiar and commonly used monosyllabic and disyllabic words in Marathi was carried out in the following three sub-phases: 1) collection of monosyllabic and disyllabic words in Marathi, 2) familiarity assessment of collected words on native speakers of Marathi, and 3) validation of most familiar words by experts.

Collection of monosyllabic and disyllabic words in Marathi

The monosyllabic and disyllabic words were collected from the Marathi corpus available at language technology laboratory of center for applied linguistics and translation studies, university of Hyderabad. This corpus consists of a total of 1, 96, 904 words, and were arranged hierarchically according to their frequency of occurrence, i.e. from the most frequently occurring to the least frequently occurring words.

From the existing database, monosyllabic words having CVC structure and disyllabic words having CVCV structure with minimum occurrence of ten times among the first one hundred thousand words were extracted and arranged separately in a hierarchical manner, i.e. from the most frequently occurring to the least frequently occurring words.

Familiarity assessment of collected words on native speakers of Marathi

The collected words were assessed for familiarity in order to ensure that these were known to native speakers of Marathi and were commonly used by people belonging to different regions of Maharashtra. For this purpose, a total of 300 subjects who are native speakers of Marathi in the age range between 18 and 35 years from different regions of Maharashtra (i.e. Vidarbha, Marathwada, Khandesh and Northern Maharashtra, Konkan and Pune) were included.

The subjects were further equally subdivided into five groups based on the above mentioned regions. A three-point rating scale was used for familiarity rating: most familiar, familiar and unfamiliar. The subjects were explained about the ratings as follows. Most familiar: A word should be rated as 'most familiar' if the subject knows the meaning of that word and he/she uses the same word to express in a day-to-day basis. Familiar: A word should be rated as 'familiar' if the subject knows the meaning of that word but he/she uses an alternative word to express in the daily activities. Unfamiliar: A word should be rated as 'unfamiliar' if the subject is not aware of it.

The responses of the subjects were scored based on three-point rating scale, i.e. the words which were rated as most familiar, familiar and unfamiliar were assigned a score of 2, 1 and 0 respectively. Based on the subjects' ratings, a word-wise total score was calculated and converted into percentage. The words with 90% score and more were selected and listed separately for each group. They were further assessed for homogeneity across groups in order to ensure that these words are most familiar and commonly used by all the groups. These words were considered for further assessment.

Validation of most familiar words by experts

Content validity was carried out in order to review how the essential test items, i.e. words can attribute to the test measures. For the purpose of carrying out the content validity, the most familiar and commonly used words developed by us were given to six experts working in the field of Speech Language Pathology, Audiology, and Linguistics. The experts were informed about the purpose of the test procedure and asked to respond whether the words selected would fulfil the purpose. Their responses were elicited under the categories of agree (i.e. use the word), disagree (i.e. do not use the word) and 'suggestions'. A word-wise validation of the materials was done by each expert. The words which were agreed by each expert were selected and listed separately. These words were further assessed for homogeneity across the responses of the experts. The words which were commonly agreed by all the experts were only considered and formed the "corpus of most familiar and commonly used monosyllabic and disyllabic words in Marathi". This corpus consists of 740 words which are arranged in a hierarchical order in terms of their frequency of occurrence, i.e. the most frequently occurring to the least frequently occurring words. This serves as foundation for developing speech identification test for adults in Marathi.

Calculation of frequency of occurrence of each phoneme from the developed corpus

The concept of phonemic balance played a major role in the development of many speech identification tests. The concept of 'phonemic balance' implies that phonemes in the word list occur with the same relative frequency as they do in a representative sample of speech.[11] Hence, the frequency of occurrence of each phoneme was calculated from the 'Corpus of most familiar and commonly used monosyllabic and disyllabic words in Marathi' developed in the present study as shown in appendix-I.

Development of word lists for assessing speech identification performance

A total of four word lists were constructed with each list consisting of 25 words. The phonemes upon which the test words were constructed in each word list were based on the frequency of occurrence of phonemes which was calculated in this study. Each word list consists of 25 words out of which approximately 60% are monosyllabic words having CVC structure, and 40% are disyllabic words having CVCV structure (see appendix-II). Each word list was randomized five times to form a total of 20 word lists. Each randomized word list was spoken by adult female native speaker of Marathi and recorded in a sound treated room. The inter stimulus interval between the two words was set to 5 seconds. A calibration tone of 1 KHz was inserted before beginning of the word list to adjust the vu meter at zero. The word lists were then copied onto an audio compact disc using a compact disc writer.

A formal study

A formal study was carried out for 1) equivalence analysis of word lists, and 2) performance-intensity function testing. The following method was carried out.

Participants

A total of 150 subjects in the age range between 18 and 35 years and mean age of 22.3 years with normal hearing and no speech disorders served as subjects. All the subjects were native speakers of Marathi belonging to different regions of Maharashtra, i.e. Vidarbha, Marathwada, Khandesh and Northern Maharashtra, Konkan and Pune. The subjects were further equally divided into five groups based on the above mentioned regions of Maharashtra.

Procedure

All the tests were conducted in a sound treated room where the ambient noise levels were within the permissible limits. The audiometric assessments including otoscopic examination, pure-tone audiometry and tympanometry were conducted in order to ensure that suitable subjects with normal hearing were selected for the experimental procedures. The speech identification score (SIS) testing was carried out on each subject with four word lists. The stimulus was played through a CD player, which was routed through diagnostic digital audiometer and delivered through the TDH 39 headphones. The stimulus was presented at five presentation levels, i.e. 5 dBSL, 15 dBSL, 25 dBSL, 35 dBSL and 45 dBSL with reference to PTA. At each presentation level a different randomized list was used and the order of list was also changed. All the subjects were tested monaurally and ear selection was done randomly. An open-set response in the form of an oral response was obtained. If the subject felt tired during the test, a short break was given. Each subject was given following instructions in Marathi "you will listen to the words presented one after another through headphones. Listen carefully and when you hear a word repeat the word in a loud voice". Initially ten practice items were presented in order to familiarize the subjects with the test procedure.

Scoring the responses

The responses of the subjects were assigned a score of either 0 or 1. Each correct response was assigned a score of 1 and an incorrect response was assigned a score of 0. The raw score was then converted to percentage which is known as SIS. The SIS was calculated for each subject for each word list separately at different presentation levels for further assessment.

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

Equivalence analysis of word lists

Equivalence analysis of word lists was carried out in order to ensure that the four word lists must be equally difficult so that the subject's speech identification performance obtained on one word list is similar to the performance of the same subject on other word list, and can be used interchangeably. Hence, the mean SIS obtained by the five groups for four word lists were calculated separately to carry out equivalence analysis of four word lists.

Performance-intensity function testing

Performance-intensity (PI) function is a graphical representation of the percentage of words correctly identified as a function of the intensity level of the words. The groups' mean SIS for each word list at different presentation levels were calculated and used to obtain the PI function curve for each word list.

Statistical analysis

The data were subjected to one-way ANOVA in order to find out significant difference in mean SIS of each group between four words lists, and mean SIS for each word list between five groups. Curve estimation and regression analysis were carried out in order to find out linearity function of the PI function curve and the average percentage (%) increase of SIS per dB

RESULTS

Equivalence analysis of words lists

The results indicated that with an increase in the presentation level, there was a corresponding increase in the mean SIS for four lists in five groups. The mean SISs obtained by five groups for four word lists were subjected to one-way ANOVA in order to find out significant difference in mean SIS between four word lists for each group, and between five groups for each word list. The results revealed that there was no statistically significant difference (p >0.05) in mean SIS of each group between four word lists.

In addition, the results indicated that there was no statistically significant difference (p >0.5) in the mean SIS for each word list between five groups. Hence, it can be concluded that the four word lists developed were equally difficult for all the groups and can be used interchangeably.

Table 1: Groups' mean SIS for four word lists at different presentation levels.

Presentation Level	Speech identification score (%)							
	List 1		List 2		List 3		List 4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
05 dBSL	36.85	13.30	36.98	13.16	36.82	13.13	37.04	12.99
15 dBSL	79.22	5.57	79.12	5.34	79.30	5.49	79.36	5.54
25 dBSL	95.70	3.11	95.57	3.28	95.57	3.18	95.68	2.98
35 dBSL	99.65	1.12	99.57	1.23	99.62	1.16	99.70	1.04
45 dBSL	99.68	1.08	99.60	1.20	99.62	1.00	99.66	1.00

Performance-intensity (PI) function testing

The PI function curve is a graphical representation of the groups' mean SIS obtained for each word list as a function of presentation level of words (5 dBSL, 15 dBSL, 25 dBSL, 35 dBSL and 45 dBSL with reference to PTA). The groups' mean SIS for each word list at different presentation levels are summarized in Table 1 and Figure 1 shows groups' mean PI function curve for the four word lists.

It was found that with an increase in the presentation level, there was a corresponding increase in the mean SIS for four word lists. The PI function curve showed semi-linear function with narrow standard deviation for high presentation levels while broad standard deviation for low presentation levels. The lower segments of the curves are more linear as compared to less linear higher segments. The subjects reached normal SIS (i.e. 90% and more) at 25 dBSL with reference to PTA. In addition the subjects obtained maximum SIS at 35 dBSL and remained almost unchanged thereafter at a higher intensity, i.e. 45 dBSL. The groups' mean slope of PI curve indicated an average slope of 4.5% in SIS per dB for four word lists.

DISCUSSION

Speech audiometry is generally regarded as clinically more acceptable than pure-tone audiometry for identifying individuals with poor auditory integrity. The SIS testing has been used in every phase of audiology and the diagnostic value of identifying and differentiating auditory disorders is well documented.[2] While the physic-

ological functioning of an individuals' auditory system is undoubtedly a major determinant of his or her hearing status, the linguistic and cultural differences should not be disregarded as they can affect every stage of audiological assessment. It is a well-established fact that

the reliability and validity of speech identification or recognition tests can be influenced by factors such as the word frequency, word familiarity, words in common use, phonemic balance, and type of stimulus used.[12]
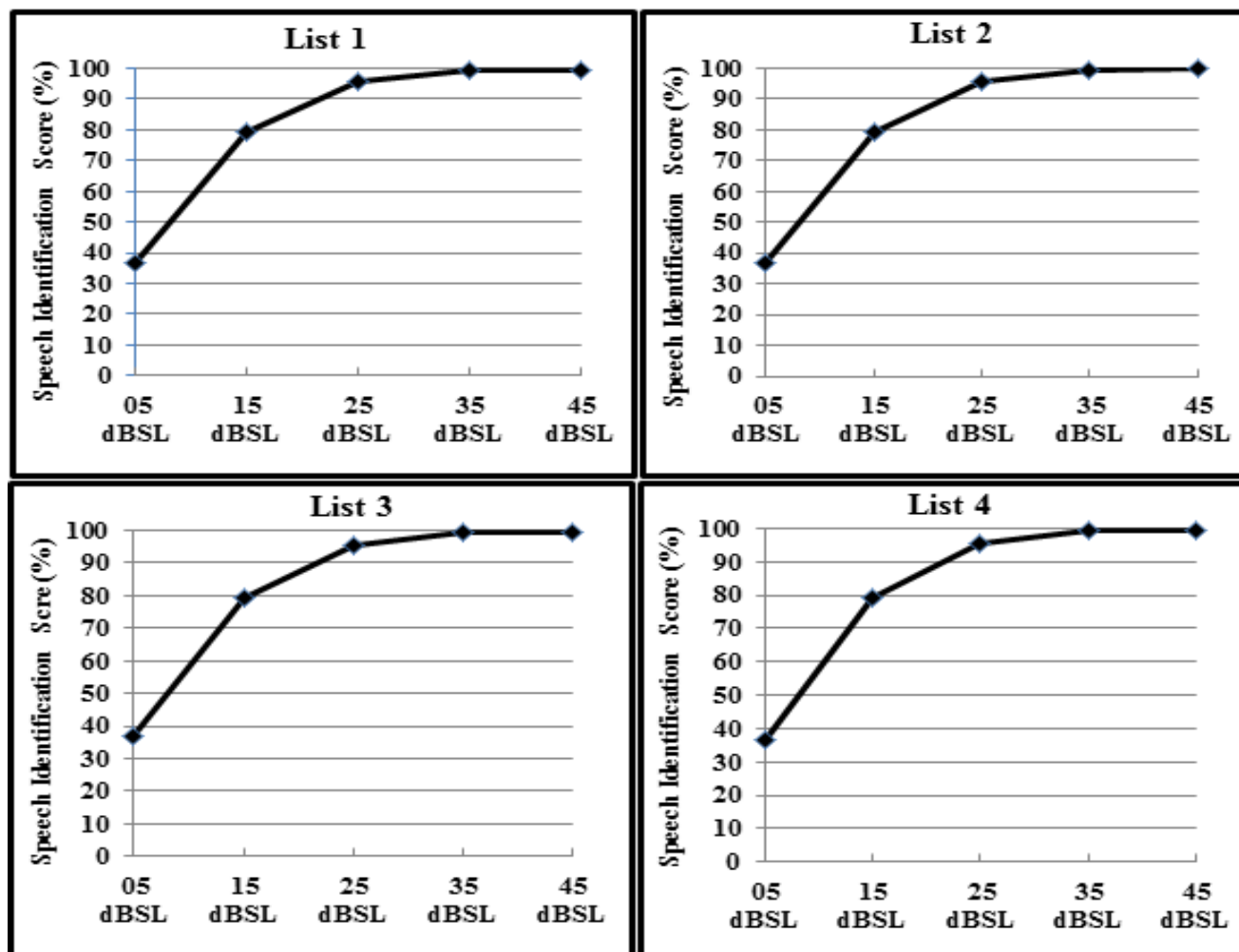

Figure 1: Groups' mean performance-intensity function curve for four word lists.

The concept of 'word frequency' is an important consideration while developing word lists for assessing speech recognition performance. In general, the word lists are developed by giving emphasis to word frequency as there is a well-established effect of word frequency on speech recognition performance. There is a significant bias favoring the recognition of words with higher frequency of occurrence compared to lower frequency of occurrence.[12,13] Considering this, Lehiste and Peterson developed ten word lists with each list containing 50 words in CNC structure from a total of 1263 monosyllabic words occurring with a minimal frequency of one per million according to the Thorndike and Lorge frequency count.[14,15] However, it was found that some of the words in the list were rare and literary words, and proper names. Hence, Lehiste and Peterson revised those word lists to give more uniform familiarity by

considering words occurring with a minimum frequency of five per million.[16] In the present study the words were selected from the "Corpus of most-familiar and commonly used monosyllabic and disyllabic words in Marathi" developed by us. As already mentioned, this corpus was developed from the main corpus of Marathi available at the language technology laboratory of centre for applied linguistics and translation studies, university of Hyderabad by considering monosyllabic words in CVC structure and disyllabic words in CVCV structure occurring with a minimum frequency of ten per hundred thousand words.

Although, 'word frequency' plays an important role, this is not the only consideration concerned while developing word lists for assessing speech identification performance especially in Indian languages. India has several states

and few Union territories. These states are further divided into regions, and as a result most of the main Indian languages have regional dialects and variations, sometimes very different from each other. Some of the frequently occurring words in one region may not be familiar to people belonging to other regions due to variations in regional dialects of same language. Therefore, the differences in the frequency of occurrence of a test word in two dialects might affect the word identification performance by representatives of the two different dialects. Moreover, the corpora available in most of the Indian languages are based on the words collected from written materials. The frequency of occurrence of words in a written language may not be same as words used in spoken language. Hence, in addition to 'word frequency', considerations such as 'word familiarity' and 'words in common use' might also show greater effect on speech recognition performance especially with reference to Indian languages.

It has also been stated that geographically, historically, and according to political sentiments, Maharashtra has five main regions known as Vidarbha, Marathwada, Khandesh and Northern Maharashtra, Konkan and Pune. Although, the mother tongue of majority of people of Maharashtra is Marathi, some of the frequently occurring words in one region may not be used by people belonging to other regions due to dialectal variations. Moreover, the main corpus of Marathi from which the words were selected is based on written materials. The frequency of occurrence of words in a written language may not be same as words used in spoken language. Hence, in addition to 'word frequency' we have given importance to 'word familiarity' and 'words in common use'. The intelligibility of speech stimuli increases when the subject's level of familiarity with the stimulus items is greater.[13] Hence, there is a need to carry out familiarity assessment of words in order to ensure that the test words are familiar to native speakers of particular language. We have also carried out familiarity assessment of words among native speakers of Marathi belonging to different regions of Maharashtra (discussed in detail in methodology).

The next step after familiarity assessment was selection of 'words in common use' by native speakers of Marathi belonging to different regions of Maharashtra. Therefore, the words rated as 'most familiar' were listed for each group of native speakers of Marathi (region) separately and these words were further assessed for homogeneity across the groups in order to ensure that selected words were known to and were commonly used by them. These words were further subjected to content validity in order to review how essential these words can attribute to the test measures (discussed in detail in methodology). This is how we have developed the "Corpus of most-familiar and commonly used monosyllabic and disyllabic words in Marathi". This corpus consisted of 740 words, and served as foundation for constructing final word lists for

assessing speech identification performance by adults in Marathi.

The concept of phonemic balance played a major role in the development of many speech identification tests, and phonemically balanced word lists are a long established tool in the study of speech intelligibility. Although initially the concept of phonemic balance was termed as phonetically balanced, Lehiste and Peterson pointed out that true phonetically balance word lists were impossible, and modified the concept to phonemic balance since speech recognition is accomplished on a phonemic rather than phonetic basis.[14] The phonemes are actually groups of speech sounds (each of which is a phonetic element) that are classified as being the same by native speakers of the language. Hence, all phonetic differences are not phonemically relevant. For example, the allophones, i.e. phonetically different variants of phoneme /p/ are identified as /p/ even though they vary in terms of their phonetic characteristics in different speech sound context or position of the word and from production to production.[2]

The concept of phonemic balancing implies that the phonemes in the word list occur with the same relative frequency as they do occur in a representative sample of speech of particular language.[11] Considering this, Lehiste and Peterson developed phonemically balanced CNC word lists from 1263 monosyllabic words drawn from the Thorndike and Lorge frequency counts.[14,15] They have considered the first order of phonemic balancing in which each initial consonant, vowel, and each final consonant appear in the same frequency of occurrence in the word list.[17] Although phonemically balanced word lists are a long established tool in the study of speech intelligibility, phonemic balance has been found to have limited practical impact on the outcome measures of speech recognition tests, and its clinical relevance is also questionable. Martin et al reported that speech recognition performance of individuals with hearing impairment or normal hearing did not seem to be affected by whether the word list had phonemic balance or not.[12] Hence, in terms of its relevance to speech recognition testing, the issue of phonemic balance is still an area of dispute.[18]

Although phonemic balance have limited practical impact on the outcome measures of speech recognition tests, in order to avoid the bias of distribution of phonemes and have a reasonable degree of distribution of phonemes in each word list, we have calculated the overall frequency of occurrence of each consonantal phoneme from the "Corpus of most familiar and commonly used monosyllabic and disyllabic words in Marathi" developed in the present study. Although we have not followed the first order phonemic balance, the phonemes upon which the final word lists were constructed were based on the overall frequency (combined initial and final occurrence) calculation of each consonantal phoneme. The phonemes

with a minimum overall frequency of occurrence (combined initial and final consonant frequency) value of 0.5 calculated for 25 words list (i.e. among 50 consonantal phonemes in a word list) were only considered for constructing the word lists.

Although [c] i.e. 'च' in Marathi represents [ʧ] and [ts], and the [j] i.e. 'ज' represents [dʒ] and [dz], there are no separate letters for [ʧ], [ts], [dʒ] and [dz] in Marathi. The phonemes [ʧ] and [ts], and [dʒ] and [dz] are represented by letters 'च' and 'ज' respectively in Marathi. Hence, the frequency of occurrence value of 'च' and 'ज' includes the combined frequency of occurrence value of [ʧ] and [ts], and [dʒ] and [dz] respectively. The phonemes such as /ch/, /jh/, /th/ and /ʂ/ i.e. 'छ' 'झ' 'थ' and 'ष' respectively were not included in the word lists as their frequency of occurrence value was less than 0.5 for a 25 words list (i.e. calculated for 50 consonantal phonemes in each word lists). However, it was ensured that all the four lists have equal distribution of remaining consonantal phonemes of Marathi as in Appendix-I.

We have not followed the vowel aspects of phonemic balance in the present study. Vowels are produced without any obstruction to the airflow and relatively perceived better than consonants because they are voiced and relatively high in intensity. Vowels are produced with relatively open vocal tract with prominent resonance. The first two formant frequencies (F1 and F2) are essential for the discrimination of vowels. Vowels are more accessible to auditory analysis as they are longer in duration and may hold longer duration in the auditory memory.[19] On the other hand; consonants are produced with the obstruction to the airflow. So consonants are classified according to whether they are voiced or voiceless, their manner of articulation (e.g. stops, fricatives, nasals, etc.) and their place of articulation (e.g. labial, alveolar, palatal, etc.). Although, most of the consonants contain much less power than vowels, these consonants are the ones which play a major role in speech intelligibility. The identification of consonants is more dependent upon the ability to receive the higher frequency components which are frequently missed by individuals with sensorineural hearing loss. If this information inadequate, the place of articulation of consonants cannot be determined, thus precluding recognition. They are affected by loss of intensity more rapidly than vowels. Hence, consonants are less accessible to auditory analysis due to their brevity and relatively low intensity, and held briefly in auditory memory.[19]

In view of above, Kumar and Mohanty, have also argued that consonantal aspect of phonemic balance is important as the perception of consonants is much more complex than vowel perception due to their low intensity, more susceptible to degradation and varied classifications.[9,20]

Hence, they developed word lists in Telugu by considering only the consonantal aspects of phonemic balance. This makes the consonantal aspect of phonemic balance a priority in the development of word lists for assessing speech recognition performance, and hence, we also considered this aspect of phonemic balance is reasonable in the present study.

Another important aspect in the development of word lists for assessing speech recognition performance is the type of stimuli. Monosyllabic words with consonant-nucleus-consonant (CNC) structure are generally used and have been widely accepted for assessing word recognition performance. This is mainly due to the fact that these are minimum meaningful units, non-redundant and common in languages like English and most of the Indian languages. But in language like Italian, disyllabic words are used for developing materials for assessing speech recognition performance.[21] This is because Italian is a vowel ending language and there are very few monosyllabic words in Italian, and most of them are function words.[22] For this reason, Turrini et al developed materials using disyllabic words for assessing speech recognition performance.[21]

Similarly, some Indian languages are vowel ending and the occurrence of monosyllabic words is minimal in them. In such languages it is difficult to construct phonemically balanced monosyllabic word lists because of the scarcity of their occurrence. Considering this, Yathiraj and Vijayalakshmi developed word lists for assessing speech recognition performance using disyllabic words in Kannada, a South Dravidian language which is vowel ending language.[6] Similarly, Kumar and Mohanty have also faced difficulty in collecting meaningful monosyllabic words for preparing materials for assessing speech recognition performance in Telugu, a South Central Dravidian language with very few monosyllabic words.[9] This could be attributed to the reason that Telugu is another vowel ending language like Italian and Kannada. Hence, Kumar and Mohanty developed word lists by considering disyllabic words having CVCV structure for assessing speech recognition performance.[9]

In view of above, Kumar and Mohanty summarized that speech identification or recognition score testing is a procedure of establishing the percentage of correctly identified or recognized monosyllabic words presented at comfortable supra-threshold level, provided the particular language contains adequate number of meaningful monosyllabic words.[20] However, languages which end in vowels may not contain plenty of meaningful monosyllabic words and hence, disyllabic words can be used for this purpose in such languages. Thus, they concluded that "speech identification or recognition score is the percentage (%) of correctly identified or recognized test words which are minimum meaningful units of a language and presented at comfortable supra-threshold level".

The authors in the present study also faced difficulty in collecting adequate monosyllabic words in CVC structure for constructing word lists. It was observed that Marathi has limited number of monosyllabic words in CVC structure. Hence, in addition to monosyllabic words, we have also included disyllabic words in the final word lists. We have developed a total of four word lists with each list consisting of approximately 60% monosyllabic words in CVC structure and remaining disyllabic words in CVCV structure As mentioned earlier, since there are no separate letters in Marathi to represent [ʧ] and [ts], and [dʒ] and [dz], they are always represented as 'च' and 'ज'in the word lists as in Appendix-II.

Any measurement used to assess one's behavioral performance should be subjected to thorough standards with regard to its development to ensure that the measure accurately reflects the behavior of interest. The speech identification performance must be assessed routinely using reliable and valid materials suitable for native speakers of the concerned language. Reliability is a psychometric principle that plays an important role in the development of any speech identification test. Reliability refers to the extent to which measurements are repeatable by the same individual using the same measures of a particular attribute, by the same individual using different measures of the attribute, or by different people using the same measure of the attribute without the interference of error. There are four different methods commonly used to determine the reliability of speech recognition tests, including test-retest reliability, inter-list equivalence, split-half method and inter-item consistency reliability.[23]

In the present study, the equivalence analysis of four word lists was carried out. The equivalence analysis of word lists was carried out in order to ensure that the four word lists must be equally difficult so that the subjects' speech identification performance obtained on one word list is similar to the performance of the same group of subjects on other word list, and on the other hand, to ensure that the subjects of different groups obtain similar speech identification performance on same word list. It was found that there was no statistically significant difference in speech identification performance between four word lists for each group, and no significant difference between five groups for each word list.

Hence, the four word lists were found to have equal difficulty and these word lists can be used interchangeably for any group of subjects in clinical practice.

The extent to which a test instrument appears to measure what it is supposed to measure constitutes validity. There are three categories of methods commonly used to determine the validity of speech identification tests, including construct validity, criterion related validity and content validity. The degree of validity is measured as the correlation between test instrument scores and criterion-related variables, and generally, the higher the correlation, the greater the degree of validity. Thus, validity is a matter of degree, rather than an all-or-none property, and therefore, such measures should be ongoing so that appropriate modifications of existing tests can be made as necessary.[23]

In the present study, the PI function testing, which is the percentage of SIS as a function of intensity level of stimulus, was carried out. The results revealed a narrow standard deviation for high presentation levels while broad standard deviation for low and mid presentation levels. This indicates that at high presentation levels the subjects' performance showed less variance and at low and high presentation levels the subjects' performance became more variant. This is expected because, as the presentation level increases, the relevant phonetic cues become more consistently audible. On the other hand, as the presentation level decreases, the phonetic cues become less consistently audible and responses mainly depend upon guessing the words.[24]

Clinically the most commonly used presentation level for assessing speech identification performance is 25 to 40 dBSL with reference to SRT. The normal hearing subjects obtain the beginning of plateau at 25 dBSL at which they obtain 90% or better SIS, and 30 to 40 dBSL with reference to SRT represents a reasonably comfortable listening level at which normal hearing subjects obtain maximum SIS.[25,26] Similarly the subjects in the present study reached the beginning of the plateau at 25 dBSL with reference to PTA at which they obtained more than 90% SIS.

The subjects obtained maximum SIS at 35 dBSL and remained almost unchanged thereafter at a higher presentation level, i.e. 45 dBSL. The groups' mean slope of the PI function curve for Marathi word lists showed 4.5% increase in SIS per dB for four word lists. In other Indian languages, Dayalan, Kholia, Kumar and Mohanty, and Devi reported a mean slop of 3.0%, 3.7%, 4.6% and 5.4% per dB for Tamil, Rajasthani, Telugu and Manipuri word lists respectively on adult population.[4,8,9,27] Although, there is no data available on SIS tests for adults in Marathi, most of the findings of the study are in line with the findings of research reports on other Indian languages.

CONCLUSION

Speech audiometry is an essential component of the audiological test battery and speech perception skills must be assessed routinely using valid and reliable clinical assessment methods suitable for native speakers of the concerned language. The present study developed conventional speech identification test in Marathi. This test consists of four word lists. They were found to be equally difficult, reliable and valid test materials. These test materials can be administered on hearing impaired population and other clinical population to check their

applicability. However, these conventional word lists would be effective in identification the true nature of communication difficulties caused by flat frequency heating loss but not effective in identifying the true nature of communication difficulties caused by sloping high frequency hearing loss. The conventional speech identification tests are constructed with almost all the phonemes (both voiced and voice less) of Marathi. When they are administered during routine audiological evaluation would provide redundant information and overestimate the performance of individuals with sloping high frequency hearing loss due to normal or near normal perception of the low-frequency speech cues. Hence, there is a need to utilize speech identification tests that are specifically designed to ideally reflect the perceptual difficulties of individuals with sloping high frequency hearing loss. Hence, the word lists constructed with voiceless phonemes would be ideal in assessing the true nature of communication difficulties caused by sloping high frequency hearing loss as these phonemes have spectral energy distributed predominantly in the higher frequency region.

REFERENCES

1. Mendel LL. Considerations in Pediatric Audiology. International Journal of Audiology. 2008;47:546-53.
2. Gelfand SA. Essentials of Audiology, 2nd Ed, New York: Thieme Medical Publishers; 2007.
3. De NS. Hindi PB List for Speech Audiometry and Discrimination Test. Indian Journal of Otolaryngology. 1973;25:64-75.
4. Dayalan S. Development and Standardization of Phonetically Balanced Test Materials in Tamil Language. Unpublished Master's Dissertation, Mysore: University of Mysore; 1976.
5. Mallikarjuna. Phonetically balanced words in Gujarati: In Kacker, S.K. and Basavaraj, V. Indian Speech, Language and Hearing Test: The ISHA Battery, Mysore: ISHA; 1984.
6. Yathiraj A, Vijayalakshmi CS. Phonemically Balanced Word List in Kannada: Developed in Department of Audiology. Mysore: AIISH; 2005.
7. Mangaiahi L. Development and Standardization of Spondee and Phonetically Balanced (PB) Word List in Mizo Language. Unpublished Master's Dissertation, Mysore: University of Mysore; 2009.
8. Kholia L. Development and Standardization of Speech Material in Rajasthani Language. Unpublished Master's Dissertation, Mysore: University of Mysore; 2010.
9. Kumar SBR, Mohanty P. Speech Recognition Performance by Adults: A Proposal for a Battery for Telugu. Theory and Practice in Language Studies. 2012;2(2):193-204.
10. Waghmare P, Mohite J, Gore G. Development of Marathi Speech Recognition Test (Pediatric): A Preliminary Report. Journal of Indian Speech and Hearing Association. 2011;25(1):59-64.
11. Hirsh IJ, Davis H, Silverman SR, Reynolds EG, Eldert E, Benson RW. Development of materials for speech audiometry. Journal Speech and Hearing Research. 1952;17:321-37.
12. Martin FN, Champlin CA, Perez DD. The Question of Phonetic Balance in Word Recognition Testing. Journal of American Academy of Audiology. 2000;11:489-93.
13. Luce PA, Pisoni DB. Recognizing Spoken Words: The Neighborhood Activation Model. Ear and Hearing. 1998;19:1-36.
14. Lehiste I, Peterson GE. Linguistic Considerations in the Study of Speech Intelligibility. Journal of Acoustic Society of America. 1959;31:280-7.
15. Thorndike DL, Lorge I. The Teachers Word Book of 30,000 Words. New York: Colombia University Press; 1944.
16. Lehiste I, Peterson GE. Revised CNC Lists for Auditory Tests. Journal of Speech and Hearing Disorders. 1962;27:62-70.
17. Causey GD, Hood LJ, Hermanson CL, Bowling LS. The Maryland CNC Test: Normative Studies. Audiology. 1984;23:552-68.
18. Nissen SL, Harris RW, Jennings L, Eggett DL, Buck H. Psychometrically Equivalent Mandarin Disyllabic Speech Discrimination Materials Spoken by Male and Female Talkers. International Journal of Audiology. 2005;44:379-90.
19. Stevens KN. Toward a Model for Lexical Access Based on Acoustic Landmarks. Journal of Acoustic Society of America. 2002;111(4):1872-91.
20. Kumar SBR, Mohanty P. Speech Recognition Performance by Children: A Battery for Telugu. Journal of the Linguistic Society of India. 2012;73:101-15.
21. Turrini M, Cutugno F, Maturi P, Prosser S, Leoni FA, Arslan E. Bisyllabic Words for Speech Audiometry: A New Italian Material. Acta Otorhinolaryngologica Italica. 1993;13:63–77.
22. Pagliuca G, Monaghan P. Discovering Large Grain-Sizes in a Transparent Orthography: Insights from a Connectionist Model of Reading for Italian. Journal of Cognitive Psychology. 2010;22(5):813-25.

23. Mendel LL, Danhauer JL. Audiologic Evaluation and Management and Speech Perception Assessment. San Diego: Singular Publishing Company; 1997

24. Wang S, Mannell R, Newall P, Zhang H, Han D. Development and Evaluation of Mandarin Disyllabic Materials for Speech Audiometry in China. International Journal of Audiology. 2007;46(12):719-31.

25. Gold S, Lubinsky R, Shahar A. Speech Discrimination Scores at Low Sensation Levels as Possible Index of Malingering. Journal of Audiological Research. 1981;21:137-41.

26. Silman S, Silverman CA. Auditory Diagnosis, New York: Academic Press; 1991.

27. Devi ET. Development and Standardization of Speech Test Material in Manipuri Language. Unpublished Master's Dissertation, Mysore: University of Mysore; 1985.

Appendix 1: Phonemes upon which the words are constructed and their frequency of occurrence in each word list.

Marathi Letter	Phonetic Symbol	Phoneme Frequency	Marathi Letter	Phonetic Symbol	Phoneme Frequency
क	k	3	ध	$d̪^h$	1
ख	k^h	1	न	n	2
ग	g	2	प	p	3
घ	g^h	1	फ	p^h	1
च	ʧ/ts	1	ब	b	1
# छ	$ʧ^h/ts^h$	0	भ	b^h	1
ज	dʒ/dz	2	म	m	2
# झ	$dʒ^h/dz^h$	0	य	j	1
ट	ʈ	2	र	r	4
ठ	$ʈ^h$	1	ल	l	2
ड	ɖ	3	व	ʋ	3
ढ	$ɖ^h$	1	श	ʃ	1
ण	ɳ	1	स	s	0
त	t̪	3	# ष	ʂ	2
# थ	$t̪^h$	0	ह	h	1
द	d̪	2	ळ	ɭ	2

Phonemes such as 'छ' 'झ' 'थ' and 'ष' respectively are not included in the word lists as their frequency of occurrence value was less than 0.5 for a 25 words list (i.e. calculated for 50 consonantal phonemes in each word lists). However, it was ensured that all the four lists have equal distribution of remaining consonantal phonemes of Marathi.

Appendix 2: Word lists for assessing speech identification performance in Marathi.

List 1		List 2		List 3		List 4	
गाडी	gaɖi	घर	gʰə:r	पाणी	paɳi	घोडा	gʰoɖa
तेल	t̪e:l	फूल	pʰu:l	दात	d̪at̪	चार	ʧar
काळा	ka:ɭa	भाजी	bʰa:dʒi	शिरा	ʃIra	कोण	koɳ
पाठ	pa:ʈʰ	ताक	t̪a:k	काम	ka:m	मीठ	mi:ʈʰ
मध	mə:d̪ʰ	गेट	ge:ʈ	पाटी	paʈi	शाळा	ʃaɭa
सुरी	sUri	डावा	ɖava	वाघ	va:gʰ	धूर	d̪ʰur
डोळे	ɖoɭe	वेणी	veɳi	दोन	d̪o:n	केस	ke:s
फोन	pʰo:n	पोट	poʈ	काय	ka:j	तवा	t̪əva
राग	ra:g	दूर	d̪ur	पेढा	ped̪ʰa	पान	pa:n
मिशी	mIʃi	कधी	kəd̪ʰi	कुठे	kUʈʰe	टोपी	ʈopi
घाट	gʰaʈ	मोठा	mot̪ʰa	भात	bʰat̪	बाळ	ba:ɭ
भूक	bʰu:k	तास	t̪as	चहा	ʧəha	फुगा	pʰUga
वाटी	vaʈi	खेळ	kʰeɭ	नीट	ni:ʈ	खीर	kʰir
तीन	t̪i:n	कडू	kəɖu	वास	va:s	गाय	ga:j
डबा	ɖəba	पाय	pa:j	गोड	go:ɖ	तुला	t̪Ula
काजू	kadzu	चोर	tsor	तार	t̪ar	कमी	kəmi
वय	və:j	जुना	dzUna	मला	məla	देव	dev
दही	d̪əhi	पाल	pal	फळ	pʰəɭ	पुडी	pUɖi
ताप	t̪a:p	नवा	nəva	खाली	kʰali	दोरा	d̪ora
रोज	ro:dz	माशी	maʃi	राजा	radʒa	नाव	na:v
सण	sə:ɳ	बस	bə:s	धूळ	d̪ʰuɭ	ढोल	d̪ʰol
पुढे	pUɖʰe	गोरा	gora	बरा	bəra	जीभ	dʒibʰ
दार	d̪a:r	डाळ	ɖa:ɭ	जड	dzə:ɖ	सही	səhi
चव	tsə:v	हात	ha:t̪	डास	ɖas	ताट	t̪aʈ
खोली	kʰoli	दाढी	d̪ad̪ʰi	गाव	ga:v	जोडी	dzoɖi

In Marathi the letter 'च' represents [ʧ] and [ts], and the letter 'ज' represents [dʒ] and [dz]. However, there are no separate letters for [ʧ], [ts], [dʒ] and [dz] in Marathi. The phonemes [ʧ] and [ts] are represented by the letter 'च' and the phonemes [dʒ] and [dz] are represented by the letter 'ज'. Hence, they are represented as 'च' and 'ज' in the word lists.