Development and Standardization of Speech Material in Rajasthani Language

Kholia L.[1] & Rajalakshmi K.[2]

Abstract

The purpose of the present study was to develop and to standardize the speech material (SRT & discrimination test material) in Rajasthani language. The methodology included collection of the polysyllabic and monosyllabic (CVC) words and familiarity, construction of lists of 'most familiar' polysyllabic and monosyllabic words and finally, standardizing the speech materials with the Rajasthani speaking adult subjects. Using this procedure, two monosyllabic word lists and three polysyllabic word-lists were developed. There was agreement between the SRT levels and PTA of the subjects. The speech identification scores increased with the increase in presentation levels and reached maximum at around 40dBSL. Thus, these lists can be used reliably on Rajasthani speaking population in speech audiometry.

Key words: *Speech audiometry, speech recognition threshold, speech identification threshold.*

Speech is one of the most important vehicles of human communication system. To be able to hear and comprehend speech it requires good auditory integrity. For the purpose of identification of auditory integrity, speech audiometry is essential.

There is nothing more essential in all existence than communication. It is the very essence of life and is basic to human existence. There are different means by which human beings communicate to each other. However, speech is the most important one due to its flexibility, efficiency, variety and its uniqueness. Human communication is the ability to speak with sufficient clarity to be understood by other people and the ability to hear and understand what other people say. When communication is impaired by speech, language and hearing disorders, the consequences may be devastating. For successful verbal communication, understanding speech is imperative and depends on many characteristics of the auditory system including hearing sensitivity. So the ability to understand speech should be considered as the most important measurable aspect of the human auditory function.

Speech audiometry reveals more information regarding auditory functions, when compared to pure tone audiometry. The advantages of speech audiometry are: (1) sensible to use the speech sounds to measure the threshold for speech intelligibility rather than to approximate that threshold by simply averaging pure tones (Hirsh, Davis, Reynolds, & Benson, 1952). (2) measurement of speech recognition threshold and discrimination score are useful in reading the qualitative estimate of the outcome of surgery or potential for hearing aid uses, of relative efficiency with different instruments and of phonemic perception in everyday life. (3) confirms pure tone thresholds (Carhart, & Porter, 1971) (4) facilitates the evaluation of auditory capabilities by proceeding from simple pure tones to more complex speech stimulus (Olsen, Matkin, 1979). Thus, Speech Audiometry offers a means whereby samples of speech are used to test both auditory reception and perception of speech in at least a quasi-systematic manner. Therefore the need for utilizing speech stimuli to assess an individual's performance in more difficult listening situation is stressed. Speech audiometry too, has limited diagnostic value but when combined with other battery of tests it gives much useful Information.

Speech audiometry if carried out properly with calibrated equipment and standardized speech materials can be useful for audiological diagnostic testing. Tests using speech materials are generally regarded as clinically more acceptable for identifying patient with poor auditory analytical capability and they have been found to be powerful tools for distinguishing patient with various types of auditory disorders.

Speech stimuli used in speech audiometry vary from consonants, phonetically balanced words, spondee words, digits, nonsense syllables, sentences and even continuous digit discourse. The most difficult material for the patient to understand is nonsense syllables, while the easiest ones are the sentence materials with monosyllabic words (Miller, 1951). Nonsense syllables tests were developed in an attempt to minimize contextual cues inherent in meaningful word while in sentence tests listener does not have to perceive the entire stimuli to respond correctly because contextual cues aid in auditory recognition. The two major components of speech audiometry are the measurement of hearing sensitivity for speech & threshold of speech recognition and suprathreshold measures of auditory function.

[1] e-mail: lovedeepkholia@gmail.com, [2] Reader in Audiology, AIISH; email: veenasrijaya@gmail.com

Speech audiometry incorporates both sensitivity and acuity measures (Ward, 1964). Sensitivity measures are threshold measures that typically are referred to as speech detection threshold (SDT) and speech recognition threshold. Acuity measures are suprathreshold measures that are referred to as speech recognition score or word discrimination score or speech identification Score (SRS/ WDS/SIS).

Spondee words are two syllable words with approximately equal stress on each syllable. The spondee words selected for detection of SRT should meet the following criteria: a) Familiarity b) Phonetic dissimilarity c) Normal sampling of English speech sound d) Homogeneity with respect to audibility.

To cite some of the spondee wordlists: - Central Institute for the Deaf Auditory test-1 (CID-1), CID-2, Psycho Acoustic Laboratory list-9 (PAL-9) and PAL-12 etc...For example- Baseball, Ice-cream, hotdog, airplane etc.

Fletcher (1950) has noted that the three frequency averages of pure tone air-conduction thresholds at 500Hz, 1 kHz; 2 kHz is a good prediction of the SRT in patient with a relatively flat hearing loss. It is generally agreed that if the SRT and the two- three frequencies pure tone average are within ± 6dB of each other, there is good agreement, if the score are between ± 7dB to ± 12dB, it is fair agreement but if it is more than ± 12dB, is a poor agreement.

Hudgins, Hawkins, Karlin, and Stevens (1947) reviewed the development of auditory test for determining SRT and noted that spondee words appeared to be the most appropriate for this purpose.

Suprathreshold measures: Many terms are used to refer speech recognition score such as Speech discrimination score (SDS), speech intelligibility score (SIS) or word recognition score (WRS). However, the term speech recognition score is widely used. SRS refers to a measure of the ability of an individual to recognize spoken speech. ISHA Battery, (1990) defined SRS as a procedure of establishing the percentage of correctly perceived phonetically balanced monosyllabic words or consonant vowel combination presented at a comfortable Suprathreshold level.

According to Egan, 1948, SIS is a method where the subject is presented with a series of stimuli (syllables, words, phrases etc), and is asked to identify what he has heard and results are reported in term of percentage on the basis of correctly repeated words presented to him.

The speech recognitions score approach may be further broken down into open set methods requiring the subject to repeat or write what was heard without prior knowledge of corpus of the test items (Egan, 1948, Hirsh, Davis, Reynolds, & Benson, 1952) and closed set method which the subject must choose.

Word recognition score is the measure with monosyllabic word lists, which are so constructed to include speech sounds in their appropriate frequency of occurrences in everyday speech.

Monosyllabic words are those which consist of single syllable. For example-pin, bin, one, knew, ill, cap, low, give, thing etc. According to Egan (1948), WRS test must include: monosyllabic structure, equal average difficulty of lists, equal range of difficulty of phonetic classes, equal composition representative of the language, words in common usage.

Speech Audiometry has emerged as an indispensable clinical tool for the audiologists on the basis of the concept of discrimination loss. The quantitative determination of a subject's ability to discriminate speech helps the clinician in determining: (1) the extent of difficulty in diagnosis of the site of lesion, (2) in evaluating social adequacy of effectiveness of communication (3) in determining candidacy and selection of appropriate amplification, in assessing central auditory function and (4) last but not the least in making a prognosis for the outcome of rehabilitative efforts (Penrod, 1975). However to achieve these tasks, one needs a meaningful & standardized test for hearing evaluation in particular language.

Role of speech audiometry is to assess basic communicative competence for aural language input, corroborative information in the identification of site(s) of lesion, assessment of language input competence in populations with linguistic limitations, measurement of effectiveness of personal amplification devices, identification of the possibly pseudohypoacusis listener, measurements on central auditory dysfunction with emphasis on identification of central lesion site, measurements on central auditory processing abilities, identification systems for locating the individual with auditory perceptual deficits, evaluating the effectiveness of aural therapeutic intervention, the quantification of the remedial approach, and for the recommendations for clinically appropriate speech protocols.

The use of speech materials in routine audiological evaluation began as a result of the work done at the Psycho Acoustic Laboratories of the Harvard University. The earliest application of Speech Audiometry stressed measurement of threshold sensitivity utilizing speech testing materials

developed to assess the efficiency of communication system. Penrod (1975) has given a review of the development and utility of material for speech audiometry.

Monosyllable words were first developed by W.H. Bristol in 1926 for children. In 1927, Fletcher produced an intelligibility test at Bell Labs, and was mainly used for hearing aid testing.

Earlier in the development of the test materials, frequency of words in conversational use and the phonetic balance of the words were not considered in the test development.

Test material: There were impeding question regarding as to the materials for the test of speech discrimination. Monosyllable words were most popular. They are presented under one of two response formats, open-or-closed-set. Open set tests includes the Harvard PB-50 list (Egan, 1948), CID word lists (Hirsh, Davis, Reynolds, & Benson, 1952) and NU auditory test No.6 lists (Tillman and Carhart, 1966). The PB list of Harvard were designed to be "phonetically balanced" in that the phonetic composition of the words in each test list was intended to be representative of the types of sounds found in sample of 100,000 words in news print. The CID W-22 word lists were more rigidly balanced using a different set of criteria.

Disyllabic words: During World War II, attention was given at an efficient communication system of the military. Harvard University carried on studies in this regard. At psychoacoustic lab, speech reception tests based on the concept of threshold of hearing was constructed. The first was test No.9 and the auditory test No. 14. Difference between the two was that test No.8, recorded at attenuated levels and test No.14 at a constant level. For both of these tests, same lists were used. Limitation of the lists used is that the vocabulary was too large for many clinical patients.

Hudson's (1947) selection of spondaic word was based on the following criteria: familiar to listener, dissimilar in phonetic construction, normal sampling of English, speech sounds and homogeneously audible.

To overcome the limitations of test No.9 and auditory test No.14, Hirsh et al (1954) modified by the Harvard lists at the Central Institute of Deaf (CID) and called it CID W-1 and W-2 test which are the recorded versions of auditory test No.14 and No.9 respectively. They tried to restrict the vocabulary, so that it suits the clinical population. The familiarity was determined, had originally 84 words and selected 36 familiar words, which then recorded into six different forms. The words which were too easy were reduced by 2dB and the most difficult words were increased by 2dB. The difference between the Harvard tests and CID W-1 and W-2 is that lower thresholds were obtained with the latter test. Threshold for the original spondee were on the order of 22dB while an average SRT of 14-15 dB was obtained for W-1 list. Also, different thresholds were obtained with the attenuated recording (W-2). The difference was on the order of 4dB (l8dB as compared to 14dB or 15dB for the W-1 test).

Monosyllabic words: The analytic units of speech are monosyllabic words and are more easily repeated than nonsense syllables. Attempts have been made to balance the sound in any one list according to their normal frequency of occurrence in normal conversational English.

Carhart (1965) recommends the use of monosyllabic words for discrimination test, since they are meaningful to the patient and are non-redundant.

Egan (1948) developed PB-word list, at Harvard University to assess the Intelligibility. The words were selected based on the following criteria: monosyllabic structure, equal average difficulty, composition representative of English speech and words in common usage.

SRT and pure tone averages: Most of the audiologists and authorities have found great positive correlation between PTA and SRT. Thus some authorities feel it's not necessary to determine SRT (Silverman and Hirsh, 1955). According to Martin (1958) if there is any discrepancy between PTA and SRT, then it's important to determine accuracy of both PTA & SRT.

For practical purposes, the average pure tone thresholds for 500kHz and 2kHz is considered for prediction of relationship between pure tone and speech thresholds (Hopkinson, 1978).

Studies conducted by Fletcher (1950), Carhart and Porter (1971) opine that the average of the two smallest threshold levels among the three speech frequencies, is also clinically useful. When the testing equipment is calibrated to ANSI reference levels and that audiometric contour is not taken into account, the following formula may predict the SRT from pure tone average (Carhart, 1971).

SRT= 0.5 X (pure tone threshold at 500 Hz + pure tone threshold at 1000 Hz)-2dB (2dB is minor correct constant).

Method

Purpose of the present study was (1) to develop speech material in Rajasthani language. (2) to standardize the speech material (SRT and discrimination test material in Rajasthani language), using Rajasthani speakers as subjects.

To facilitate the purpose of the study, the methodology had the following proceedings. (1) Collection of the polysyllabic and monosyllabic (CVC) words and familiarizing them. (2) Construction of lists of 'most familiar' polysyllabic and monosyllabic words. (3) Standardizing the speech materials with the Rajasthani speaking adult subjects.

Procedure

Polysyllabic and monosyllabic words were collected from periodicals, journals, phonetic books, and spontaneous speech. This resulted in an accumulation of about 150 polysyllabic and 125 monosyllabic words. These words were sent to persons residing in the various districts of Rajasthan for the purpose of familiarity. They were instructed to rate the familiarity using the three point scale i.e. highly familiar, familiar and unfamiliar.

From the list, the words which were most familiar, were chosen and as such 90 polysyllabic and 50 monosyllabic were rated to be most familiar. Of this, 60 polysyllabic and 50 monosyllabic words were taken randomly. Thus the lists, which aims at assessing SRT consists of 60 polysyllabic word chosen randomly from a list of most familiar polysyllabic words. The material, which aims at assessing speech discrimination ability, consists of 50 monosyllabic words, chosen from a list of most familiar words (these are shown in Appendix-I and II)

Recording: Recording was done through CSL software through a Windows enabled computer (Pentium IV), in a sound treated room (according to ANSI S3.1, 1991).

Subjects: Subjects satisfying the following criteria were selected for the present study: Rajasthani as the native language/ mother tongue/ first language. With bilateral normal hearing sensitivity with pure tone average equal or less than 15 dBHL. Within the age range of 15-35 years. Number of subjects: 100 (38 females and 62 males). Otologically normal with no history of ear discharge, prolonged noise exposure or ototoxicity. All the subjects were evaluated for the following before starting the study: (1) Otoscopy examination for normal and clean ear canal. (2) Pure tone audiogram (AC and BC) across test frequencies from 250 Hz to 8000 Hz for AC and 250 Hz to 4000 Hz for BC respectively.

Instrumentation: A two channel diagnostic audiometer Orbiter-922, which was calibrated in accordance with the ANSI standards was used. A computer with CD ROM and media player was used to feed the speech material. The recorded words were played by computer and were fed to the CD/TAPE input of the audiometer which in turn fed to earphones (TDH-49) coupled with MX-41/AR ear cushion.

Test environment: Study was conducted in sound treated two room situation. One of the rooms was used as control room and the other as testing room. The noise level of the test room was regularly checked using a sound level meter. It was ensured that noise level of the audiometric room was within permissible limits.

Procedure: All the subjects were subjected to routine audiological testing. Pure tone thresholds at 500, 1000 and 2000 Hz were obtained for each subject, using 10 down and 5 up method of threshold measurement, (David S. Green).

Standardization of SRT test material: The most familiar words, obtained, were divided into three lists randomly. Each list thus obtained was again randomized six times forming six different lists. This was done to eliminate practice effect. Thus the 3 lists had 18 randomized lists. Each list was presented at six different intensity levels at an interval of 5 dB, such as 0dB, 5 dB, 10dB, 15 dB, 20 dB and 25 dBHL (ref. to 0dBHL = 20dB SPL). Each one of the eighteen lists was presented only at one intensity level. The subjects were instructed to respond. The responses were converted into percentage. The level at which subjects repeats correctly 50% of the test items, was taken as SRT levels

Standardization of speech discrimination test material: The 50 monosyllabic words which were most familiar as collected were divided into two lists consisting of 25 words. Each list was again randomized into four lists and was presented at five different intensity levels such as 5, 10, 20, 30, 40dB above subjects established SRT levels were noted down in the similar manner like polysyllabic words. Scores were then converted into percentage.

Recording of responses: For scoring and noting subject's response, talk back system was used. The subjects repeated the word and the examiner recorded the correct responses. The number of correct responses obtained was converted into percentage at every intensity level. For each correct response, the subject was awarded the score of 4%. Therefore, if the subject responds correctly for whole list, then he will be given the score of 100%.

Results and Discussion

The main aim of the present study was to develop the speech material (both for speech recognition threshold and for speech intelligibility score) in the Rajasthani language and to evaluate its performance on subjects with normal hearing sensitivity. Test was carried out on 100 subjects with normal hearing sensitivity that accounts to 200 ears. Table 1 shows the description of the audiometric results done before carrying out the study. All subjects were having 'A' type tympanogram suggestive of no middle ear pathology in both the ears.

Table 1. Description of the subjects (n=100)

No. of subjects	Sex	Average age (in years)	Average Hearing level in dBHL (for both ears)			PTA in dBHL	Mean S.R.T. (Hindi)	S.I.S (Hindi)
			500Hz	1kHz	2kHz			
38	Females	27.37	5.39	5.34	6.38	5.71	12.76 dBHL	100%
62	Males	29.03	10.15	8.56	12.28	10.33	13.35 dBHL	100%

In the study, the spondee word lists were presented in 5 dB steps starting from 5dBSL to 25dBSL for each subject for each ear. The subjects were asked to repeat the words presented to them and the responses were recorded as correct or incorrect. On the basis of this, speech recognition thresholds were calculated for each ear for each subject. The level at which subjects repeats correctly 50% of the test items, was taken as SRT levels.

Articulation gain function curve for the three polysyllabic word lists are shown (in Figure 1-3). From the tables and the figures it is evident that percentage of correct response (intelligibility) increases with increase in sensation level. Figure 4 shows the articulation gain function curves for list S_{1s} S_2 & S_3 (combined) for polysyllabic words. Table 2 shows the mean percentage of correct response at various intensity levels.

In this study, the mean SRT level was attained at 11.5 dBHL (ref. 0 dBHL= 20 dBSPL). The average pure tone average of the subjects taken for the study was 8.02 dBHL. The difference between PTA and SRT for the polysyllable word list is thus 3.48 dBHL which shows that all these three lists yield almost equivalent scores at different hearing levels.

Taking SRT as the reference, the Phonetically Balanced (PB) word lists were administered in 10 dB steps from 10 dBSL to 40 dBSL for each subject and each ear. The subjects were asked to repeat the words presented to them and the responses were recorded as correct or incorrect. For each correct response, the subject was awarded the score of 4%. Therefore, if the subject responds correctly for whole list, then he will be given the score of 100%. On the basis of this, Speech Identification Scores (SIS) was calculated for each ear for each subject. Mean and Standard Deviations were obtained for each list at each presentation level.

Table 2. Mean and standard deviation for speech identification scores at different sensation level for the lists P1 and P2

Sensation Level ref. SRT (dBHL)	P_1		P_2	
	Mean	SD	Mean	SD
5	13%	3.8	14%	2.6
10	29%	7.2	32%	6.6
20	69%	5.3	69%	6.5
30	87%	3.0	89%	2
40	100%	0	100%	0

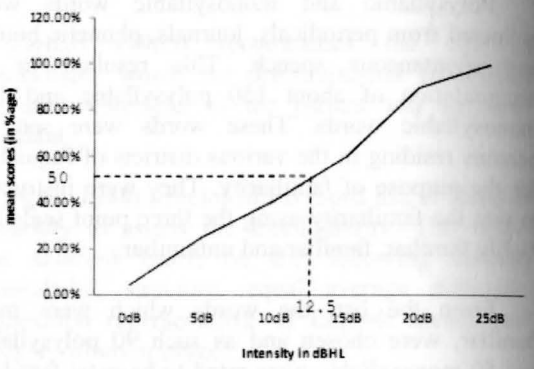

Figure 1. Articulation gain function curve for the list S1.

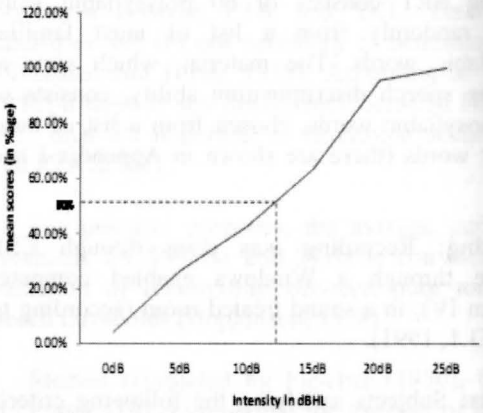

Figure 2. Articulation gain function curve for the list S2.

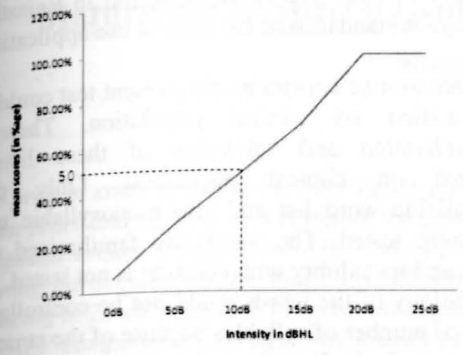

Figure 3. Articulation gain function curve for the list S3.

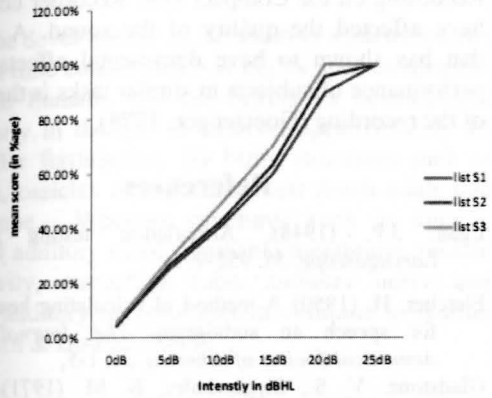

Figure 4. Articulation gain function curve for the list S1 to S3 combined.

Inter-list equivalency was analyzed by keeping a record of each subjects score on each list at each presentation level. It has been found that with increase in presentation level, there was a corresponding increase in SIS. The obtained data then plotted on Performance Intensity Phonetically Balanced Function Curve (PIPB) (Jerger & Jerger, 1971).

The mean values are represented in graphical form in Figure 5 and 6. All the curves in the figure represent a semi-linear function. The lower segments of the curves are linear with the average growth rise of approximately 3.7% per dB in the single presentation of list P_1 and P_2 respectively.

As shown in the graph, the Performance Intensity function follows a curvilinear progression where score increases gradually with gradual increase in signal strength for 90% and above score when presentation level reached the maximum level at 40 dBSL.

Thus, there is a gradual increase in percentage score in recognition ability for both word lists. This is similar to the findings reported by various authors as shown in Table 3.

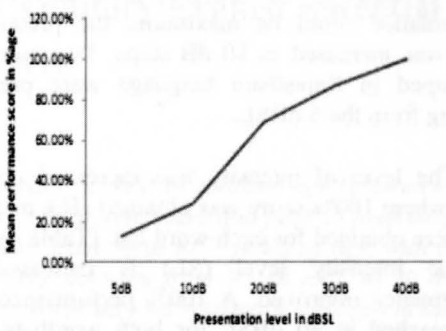

Figure 5. Mean perforamance intensity function in percentage (PIPB) for P1.

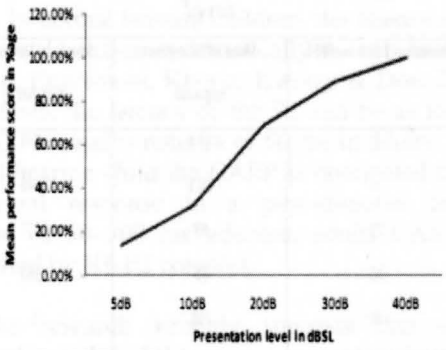

Figure 6. Mean perforamance intensity function in percentage (PIPB) for P2.

Table 3. Findings reported by various authors for various word lists

Details of Authors with years	Name of PB word list with language	Percentage(%) increase per dB increment
Tillman & Carhart, 1966	NU 6 (English)	5.6 %
Dayalan, 1966	Tamil PB word lists (Tamil)	3.0%
Wilson et al., (1976)	NU 6 (English)	3.6%
Beattie et al., (1977)	W 22 (English)	4.6%
Tanuza Devi, (1987)	Manipuri PB word lists (Manipuri)	5.4%
Present researcher, 2009-2010	Rajasthani PB word lists	3.7%

The present study has revealed a narrow standard deviation for the extreme presentation levels while broad for the mid presentation levels which is similar to the findings reported by Beattie, Edgerton & Svihorek, (1977), Tillman & Carhart (1966) & Wilson, Coley, Haenel & Browning (1977) as shown in the above Table 3.

Various researchers like Jerger state the performance of the subjects vary with the level of intensity of presentation of stimuli. Therefore, in

order to find out the intensity level at which the performance could be maximum, the presentation level was increased in 10 dB steps. Two word lists developed in Rajasthani language were presented starting from the 5 dBSL.

The level of intensity was increased upto the level where 100% score was obtained. The mean and SD were obtained for each word list. (Table 4). Thus as the intensity level (SL) is increased, the performance improved. A 100% performance score was reached at 40 dBSL for both wordlists in all subjects and remained unchanged thereafter at higher intensities.

Table 4. Mean percentage and standard deviation percentage in correct response at each sensation level

Sensation Level in dBSL	Mean of % correct response	Standard Deviation (Ref. SRT)
5	13.5	1.893
10	30.5	2.646
20	69	4.272
30	88	2.363
40	100	0

Thus, there is not much variation in the word recognition scores obtained for both word lists with per dB increment of approximately 3.7% for each list. However, the percentage increment is about 3.1% per dB at lower sensation levels (5dB- 10dB). Thus, it can be inferred that both lists are essentially equivalent in all the criteria of test development like familiarity, test equivalency, presentation level etc. Hence it is possible to use these word lists interchangeably in clinical practice.

Conclusions

The established difference between SRT and PTA is 3.48 dBHL. The performance of the subjects on the developed Phonetically Balanced monosyllabic word lists directly depends on the presentation levels. As the presentation level increases, the performance improves upto a certain level and reaches maximum, after that saturation is reached. Established 100% score was obtained at 40dBSL (ref. SRT) for both the monosyllables word lists. Both the lists were found to be essentially equivalent and can be used interchangeably because for all the four word lists, a maximum score of 100% word recognition score was obtained at 40 dBSL. Hence, the developed speech material in Rajasthani language is standardized for clinical use/application.

Due to time constraint, the present test could not be verified on clinical population. Therefore standardization and validation of these lists is required on clinical population. Only three polysyllabic word list and two monosyllabic word lists were tested. The words are familiarized with adults and its validity with children is not tested. The morphology of the words could not be controlled in terms of number of syllables because of the structure of the words in Rajasthani language. The subjects were Rajasthani speakers residing in Karnataka, so there may influence of Kannada on the results. Recording on the Compact Disc Recorder could also have affected the quality of the sound. A variable that has shown to have detrimental effects on the performance of subjects in similar tasks is the quality of the recording (Goetzenger, 1978).

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