Evaluating the Benefit of Hearing Aid Using Paired Words in Tamil

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Purpose: Subjective measurements, such as speech audiometry, are essential to determine the perception of speech as it provides insight regarding perceptual abilities. The present study aimed to develop paired word test stimuli in Tamil and evaluate their utility for assessing the benefits of a hearing aid. **Methods:** The stimuli were 30 paired words which were paired to rhythm containing almost all vowels and consonants of the Tamil language differing in one or more distinctive features, such as place, manner, voicing features of consonants, and height, duration, and rounding features of vowels. The paired words test was administered to 60 participants with normal hearing and 60 participants with hearing impairment. The correct identification scores and their percentage were computed to notice the benefit provided by their hearing aids. **Results:** The overall performance of individuals with normal hearing on the paired identification was high, suggesting that these paired word test materials could be used for individuals with hearing impairment to assess hearing aid benefit. A greater improvement in recognition scores for paired words was obtained after being fitted with a hearing aid in individuals with hearing impairment. It was noticed that due to hearing loss, the audibility of perception reduces, yielding lower scores in paired word identification. **Conclusion:** When the proper fitting was done, the percentage of identification scores was increased. Therefore, the present study concludes that speech perception abilities can be evaluated and quantified using these paired word tests.

Key Words: Hearing loss, Paired words, Speech perception, Tamil.

INTRODUCTION

Hearing impairment results in difficulty to interpret speech sounds, reduces the ability to communicate, causes a delay in the acquisition of language. Prevalence of sensorineural hearing loss are about 4.5% to 18.3% of in India (Verma et al., 2021). The most common management suggested for individuals with sensorineural hearing loss is use if hearing aids. The benefit of hearing aids has to be assessed post fitting as the primary need of hearing aid is to provide good speech perception and in-turn better communication (Perez & Edmonds, 2012). The use of speech audiometry is an important subjective test to assess the speech perception in individuals using hearing aids. Speech perception tests, provides information on word recognition abilities by the hearing aid users which helps to determine the benefit of the hearing aid for the individuals with hearing loss. The most commonly used speech test materials are monosyllabic words, spondees, monosyllabic words that are phonemically balanced, and sentences.

The Tamil language is a classical language that belongs to the family of Dravidian languages. The Tamil script has five vowels, 18 consonants and six extra consonants. The five vowels are classified into short and long and two diphthongs. The 18 consonants are categorized into three categories with six in each category: hard, soft or nasal and medium. The Tamil language has various meaningful sound combinations and their identification of the same in the ongoing speech is crucial for speech recognition

and comprehension. For native Tamil speakers, the Tamil spondees and phonetically balanced words (Samuel, 1976) are widely used for speech audiometry. The words in these lists have changes in familiarity and certain words in the list have become inappropriate usage words in the current Tamil linguistic scenario. Thus, a new word list is required for speech perception test in Tamil. There are minimal pair words developed in various Indian languages such as Tamil and Hindi (Sahoo & Nandurkar, 2020; Vijayakumar et al., 2021). The minimal pair words developed in Tamil is picture based and has been developed for children using cochlear implant. However, there is no existing paired Tamil word list for adults with hearing loss. This study will help us to understand the paired word perception.

While using paired words for speech perception assessment in individuals with hearing loss, their auditory discrimination ability along with the auditory identification skill can be better understood. As perception of minimally varying words will require good audibility and also repeating two words in single presentation will increase their cognitive load. These factors will support that paired words identification can be more difficult than the traditional monosyllable word identification.

Performance on paired words test may help the clinician to identify and provide realistic expectations of auditory performance under unaided and aided situations. In addition, for speech audiometry evaluations to be valid and accurate, individuals should be evaluated in their native language (Ramkissoon, 2001). Similarly, audiologists and other researchers also have suggested the importance of using linguistically appropriate vernacular diagnostic tools. Several enthusiasts have developed speech audiometry materials in several languages across the world. Therefore, in this study to address the need individuals with hearing loss, paired words were developed in Tamil language to evaluate their effectiveness in an individual with hearing impairment. The study aimed to develop and standardize paired words material in Tamil. To compare the paired word identification in individuals with hearing impairment under aided and unaided conditions in comparison with normal hearing individuals.

MATERIALS AND METHODS

The study design was case-control research where individuals with normal hearing are compared with individuals having a hearing impairment. This study was approved by the Scientific and Ethics Committee of our Institute. The committee declared that all processes contributing to this work comply with the ethical standards and the reference number of ethical clearance is 1295/IEC.

Participants

The study comprised total of 120 native Tamil-speaking participants enrolled through purposive convenient sampling. They are divided into two groups: group A contains 60 participants with normal hearing and group B contains 60 participants with hearing loss. In both groups, the participants were in the age range of 41 to 80 years and were categorized commonly as older adults with the age range between 41 to 60 years and geriatrics with the age range between 61 to 80 years. Each group had an equal number of older adults (n = 30) and geriatrics (n = 30). Similarly, the gender ratio for both groups was also equal (male = 30 and female = 30).

Inclusion criteria for individuals with normal hearing and hearing impairment

The subjects with the following criteria were included in the study: speakers with native Tamil language or having good proficiency in Tamil. For individuals with normal hearing, no complaints of decreased hearing sensitivity, and with pure tone average ≤ 20 dB hearing level (HL). Individuals with a hearing impairment must have acquired bilateral symmetrical moderate to severe sensorineural hearing loss. The audiometric configuration not varying > 20 dB HL across frequencies. Only binaural hearing aid fitting users were included and unilateral fitting was excluded.

Procedures

The Tamil language has various meaningful sound combinations of vowels and consonants and their identification of the same in the ongoing speech is crucial for speech recognition and comprehension. Therefore, the proposed study used a paired word list containing almost all

vowels and consonants of the Tamil language to assess the benefit of a hearing aid under unaided and aided conditions in individuals with hearing impairment.

Phase 1: Development of paired words test stimulus

Step 1: Selection of test stimuli

A total of 230 Tamil words that were used in day-to-day communication were taken from the manual remediation manual for phonological disorders (Indumathy & Lalitha, 2015). These 230 words Tamil words were subjected to familiarity rating by 50 native Tamil-speaking adults. Initially, 115 pairs of words were rated as most familiar and familiar. These words were paired with 50 sets of rhyming words. All vowels and consonants of the Tamil language were selected. Then, out of 115 pairs only 50 pairs were selected based on to form paired words and the acceptable contrasting distinctive features such as place, manner, voicing features of consonants, and height, duration, and rounding features of vowels. In the Tamil language constructing a word list with familiarity and having only one distinctive feature was difficult. Thus, paired words word list was considered where more than one feature varied. The list contained almost all vowels except /aʊ/ and consonants of the Tamil language. The targeted vowels and consonant are positioned such that it occurs in the initial word position of a pair and then in the medial word position of the following pair. In Tamil language, few consonants like /ŋ/, /ɲ/, /t/, /ɳ/, /ɻ/, /ɭ/, /r/, and /n/ have less or no words having these consonants in initial position and even if such words are found, appropriate contrasting couldn't be found based on similarity. Therefore, these consonants were included only in the medial position of the pair.

Step 2: Familiarity testing of paired words

The 50 paired words were then subjected to familiarity testing where it was given to 25 native Tamil speakers of age ranging from 20 to 60 years who were from different regions across Tamil Nadu. The judges were instructed to rate the pairs as most familiar, familiar and unfamiliar based on usage of words in day-to-day context. The final list for the study contained 30 paired words which were rated as the most familiar and familiar. The final word list is given in Appendix 1.

Step 3: Finalization of paired words

These 30 paired words were given to two linguistic experts for the content validity and the two experts agreed upon that the given words pairs are acceptable minimal and paired words in Tamil language. Hence, the final word list contained monosyllabic, bi-syllabic and one pair of tri-syllabic words containing almost all vowels and consonants in Tamil.

Step 4: Recording of paired words

Three native female Tamil speakers were instructed to read the paired words at a natural articulation rate with normal intonation pattern and with slight short pause between the pair and a longer pause between each paired words. The talkers were asked to produce each pair at least three times and the best production of the pair was used in the final recording. The test stimulus was recorded in a sound treated studio with an Apple Mac Book Pro equipped with Logic Pro X software (Apple Inc, Mumbai, India) and a RODE (voice condenser) microphone which was placed at 10 cm away from the speaker and was stored as a 32-bit wav file (44.1 kHz). Each recording took place for around 30 minutes as multiple trials were required. Each of the recorded pair were normalized for equal amplitude across the stimuli. Later, noise spectrum was eliminated by taking sample of the ambient noise.

These three audio recordings were played to five audiologists and were asked to judge the audibility, naturalness and the clarity of pairs. The first female talker list was the judged to be more natural and clear and thus it was chosen for administration to the subjects. The audio recorded 30 paired words (list 1) were used as test stimulus for individuals with normal hearing and with hearing impairment (unaided testing). Then the same 30 paired words were randomized using Logic Pro X software to create list 2 and used for individuals with hearing impairment (aided testing).

Phase 2: Administration of behavioral testing to the subjects with normal hearing and subjects with hearing impairment

Before the testing, all the participants were educated regarding the study and appropriate written consent was obtained from the participants.

Otoscopic examination and acoustic immittance were conducted for all the participants included in the study

to confirm no middle ear pathology. The pure tone air conduction threshold was ≤ 20 dB HL for normal hearing individuals at all octave frequencies (500 Hz, 1,000 Hz and 2,000 Hz & 4,000 Hz). The speech recognition threshold also correlated with pure tone average (± 12 dB HL) and their speech identification scores were ≥ 80% in speech audiometry in both ears (Tamil spondees and phonemically balanced words; Samuel, 1976). Similarly, for subjects with hearing impairment, the pure tone air conduction threshold ranged between 41 to 90 dB HL with the audiogram configuration variation ≤ 20 dB HL across all octave frequencies. Moreover, speech recognition threshold correlated with pure tone average and the speech identification scores were ≥ 60% in both ears.

Phase 3: Administration of paired words test material to the subjects with normal hearing and subjects with hearing impairment

The testing was conducted in a sound treated booth with ambient noise level within ANSI specifications (Acoustical Society of America, 1999), the patients were seated comfortably one meter apart from the loudspeakers. The recorded test stimulus was routed from the external laptop to the calibrated audiometer with ANSI S3.6-1996 (Acoustic Society of America, 1996) standards and therefore to the participants via loud speaker placed at zero-degree azimuth. The test stimuli were presented at 60 dB HL for all the participants regardless of degree of hearing loss and all the participants were instructed to listen carefully and repeat back the words heard.

Before the testing, real ear measurements were done to make sure that the given hearing aids have adequate gain, if required re-programming and tuning were done for individuals with hearing impairment. Test trial was done for all the participants using five paired words apart from the list to make the subjects understand the testing procedure. Following the trial, the list 1 paired words were presented in free field for individuals with normal hearing and with hearing impairment (unaided). Then the list 2 randomized paired words were presented to the same individuals with hearing impairment after fitting with hearing aids bilaterally. The list 2 was used to avoid potential learning and order effects of the test stimulus.

Voice recorder was used to record the participant's verbal responses and was analyzed for number of correct paired words identification. A score of one was assigned if the participants were able to correctly repeat the paired words and a score of zero was given if the participant were unable to repeat the pair or incorrect.

Statistical analysis

The collected data were analyzed using SPSS software version 22 (International Business Machine Corporation, New York, NY, USA). All numerical data were analyzed by calculating mean and standard deviation. Comparison between two groups and across groups were carried out using independent t test and analysis of variance (ANOVA). A p value, less than 0.05 was considered as significant result. For each of the participants of normal hearing and hearing impairment, correct identification of paired words (n = 30) and the percentage of scores were analyzed.

RESULTS

The study comprised of two group A and B where group A consist of 60 participants with normal hearing and group B consist of 60 participants with hearing impairment. These two groups were broadly classified based on age (older adults and geriatrics) and gender (male and female). For participants with normal hearing, the mean age of older adults and geriatrics are 50.5 and 69.67 years of age respectively. Similarly, for participants with hearing impairment, the mean age of older adults and geriatrics are 46.6 and 70.4 years of age respectively. For each group, there were equal number of male (n = 30) and female participants (n = 30). In addition, the individuals with hearing impairment were categorized into three groups concerning degree of hearing loss: moderate (mean pure tone average [PTA] = 47.63 dB HL), moderately severe (mean PTA = 63.05 dB HL), and severe (mean PTA = 81.02 dB HL).

Paired words identification in individuals with normal hearing and hearing loss

The correct identification scores on 30 paired words were obtained in individuals with normal hearing and hearing loss where a descriptive statistic was used to quantify the

results. The mean score of correct paired words identification for individuals with normal hearing, hearing loss in unaided and aided conditions were mean (M) = 25.73, M = 6.6, M = 19.82, respectively. The overall percentage of correct identification score 86%, 22% and 66% for individuals with normal hearing, hearing loss in unaided and aided conditions respectively. Independent t test p value ($p < 0.05$) indicated statistically significant difference between unaided and aided conditions. There was statistically significant difference between normal hearing and individuals with hearing impairment under aided conditions with a p value indicating ($p < 0.05$) (Table 1).

Paired words identification across degree of hearing impairment

Descriptive statistics was done to observe the difference in mean correct identification scores and percentage across degree of hearing loss in both conditions. ANOVA was done to measure the identification scores of correct paired words across degree of hearing loss; moderate, moderately severe and severe under aided and unaided conditions. The overall mean scores were for individuals with moderate degree, moderately severe and severe were M = 23.05, M = 20.15, M = 16.25. Their percentage of correct identification scores were moderate degree = 78.33%, moderately severe = 67.17%

and severe = 54.17% under aided conditions. Moreover, ANOVA (F = 4.831 and p = 0.010) shows a statistical difference across degree of hearing loss under aided conditions in the identification of correct pairs (Table 2, 3).

Paired words identification in normal hearing and individuals with hearing impairment across age

The mean scores for paired words identification across age are depicted in Table 4. Table 4 illustrates that mean values are higher for older adults in individuals with normal hearing (M = 27.27) as well as in individuals with hearing impairment (M = 20.30) compared to geriatrics with normal hearing (M = 24.20) and with hearing impairment (M = 13.33). Similarly, the percentage of correct identification scores for older adults (91%) in individuals with normal hearing and older adult (68%) in individuals with hearing impairment are on the higher side compared to geriatrics whose percentage of scores is 81% in normal hearing and 64% in individuals with hearing impairment.

Paired words identification in normal hearing and individuals with hearing impairment across gender

As shown in Table 5, the mean scores were found to be similar for both male (M = 25.57) and female (M = 25.90) in normal hearing subject also in individuals with hearing

Table 1. Identification of correct paired words in individuals with normal hearing (n = 60) and hearing impairment (n = 60)

	Mean	SD	% of correct identification
Normal	25.74	2.63	85.77
Unaided	6.6	4.75	22.00
Aided	19.82	3.86	66.06

SD: standard deviation

Table 3. One way analysis of variance across of degree of hearing impairment under aided condition (n = 60)

Variables	df	F	p-value
Across degree of hearing loss	2	104.629	0.00
Identification under aided condition	1	789.646	0.00
Across degree under aided condition	2	4.831	0.01

Table 2. Comparison of correct paired words identification across degrees of hearing impairment under unaided and aided conditions (n = 20)

Degree of HL	Fitting condition	Mean	SD	% of correct identification
Moderate	Unaided	11.90	3.45	39.67
	Aided	23.05	2.42	78.33
Moderately severe	Unaided	5.85	1.95	19.50
	Aided	20.15	3.05	67.17
Severe	Unaided	2.05	1.50	6.83
	Aided	16.25	2.59	54.17

HL: hearing loss, SD: standard deviation

impairment (male = 20.13, female = 19.50) under aided condition, in paired words identification. Similarly, the percentage of correct identification also showed minimal difference between male and female (85% and 86%) in normal hearing individuals and also in individuals with hearing impairment (67% and 65%).

DISCUSSION

The study aims to develop, standardize a list of 30 paired words in Tamil which can be used to assess the benefit of hearing aid in individuals with hearing impairment by comparing the percentage of correct identification scores under unaided and aided conditions.

At first, the study established the performance in identification of paired words for individuals with normal hearing where the statistical results showed a greater performance in them. These results suggested that normal hearing listeners can understand paired words in quiet environment as long as the pairs are clear and audible. Therefore, this implies that the same paired words can be used to investigate contrast perception ability in individuals with hearing impairment as hearing loss reduces their audibility of speech heard and leads to distortion (Souza, 2016).

To test the null hypothesis, the identification of paired words was investigated in individuals with hearing

impairment under unaided and aided conditions. A good improvement in the identification scores were obtained after fitting with hearing aid suggesting enhanced speech perception with appropriate fitting of hearing aid as supported by various literature studies. Munro and Lutman(2003) and Walden et al.(2001) found significant hearing aid benefit in the identification of consonants under unaided and aided conditions. Similarly, McRackan et al.(2016) observed substantial improvement in the recognition of words between unaided and aided conditions. However, Levitt(2001) found that hearing aid fitting results in improvement of audibility but not in intelligibility for many hearing aid users with hearing impairment because of their limited dynamic range which yields limited benefit with hearing aids. The statistical test checked the overall significance of the data and values ($p < 0.05$) gave evidence supporting alternate hypothesis concluding that there is significant difference in the identification of paired words after fitted with hearing aid.

The performance of paired words recognition between normal hearing and individuals with hearing impairment after fitted with hearing aid was also compared. The results showed that even with the presence of hearing aid, the individuals with hearing impairment performed slightly poorer than normal hearing individuals suggesting decreased perception ability due to broadened auditory filter causing difficulty to detect changes in pitch, frequency

Table 4. Comparison of older adults and geriatrics in the identification of correct paired words in normal hearing and individuals with hearing impairment under aided condition (n = 30)

	Normal			Hearing impaired (A)		
	Mean	SD	% of correct identification	Mean	SD	% of correct identification
Older adult	27.27	1.01	90.9	20.30	3.65	67.67
Geriatrics	24.20	2.86	80.67	13.33	4.07	64.43

SD: standard deviation

Table 5. Comparison of male and female in the identification of correct paired words in normal hearing population and individuals with hearing impairment under aided condition (n = 30)

	Normal			Hearing impaired (A)		
	Mean	SD	% of correct identification	Mean	SD	% of correct identification
Male	25.57	2.64	85.22	20.13	3.87	67.1
Female	25.90	2.66	86.33	19.50	3.9	65.0

SD: standard deviation

and amplitude of speech sounds. The results obtained are consistent with studies conducted on western population where even after fitting with hearing aid; the sensorineural subjects have difficulty in perception of speech unlike normal hearing individuals. Studies by Schultz(1964) and Dubno et al.(1982) investigated on word recognition scores and found infrequent phonemic confusions and consonant confusions in sensorineural hearing loss subjects. Therefore, the obtained statistical results suggest that there is a significant difference in performance between normal hearing and individuals with hearing impairment under aided condition thereby accepting alternative hypothesis.

The paired words correct identifications scores across degree of hearing loss; moderate, moderately severe and severe, across age groups and gender were compared between individuals with normal hearing and with hearing impairment to observe for any difference in the speech perception ability.

The statistical result for correct identification of paired words across degree of hearing indicated greater improvement in the perception of pairs with hearing aid. The scores were higher for individuals with moderate degree of hearing loss suggesting lesser the degree of loss greater the improvement. However, within degree comparison between unaided and aided conditions, the results implied that the greatest benefit was observed for individuals with severe degree of hearing loss followed by individuals with moderately severe degree then by individuals with moderate degree of hearing loss. The reason may be attributed to the audibility enhancement when fitted with hearing aid. Generally, the perception of speech itself is difficult in severe and moderately severe degree of hearing loss due to higher audiometric thresholds but they are least affected by noise and other factors. Whereas for individuals with moderate degree of hearing loss, perception of paired words may be distorted due to the perception of external and internal noise or other factors. This finding was consistent with the study by Shanks et al.(2002) where they found overall good improvement in speech recognition between unaided and aided conditions across degree and configuration of symmetrical sensorineural hearing loss. The authors observed benefit of hearing aids in subjects with severe degree of hearing loss and decrease in performance was noticed when presentation level increased from 52 to

74 dB sound pressure level (SPL) especially for individuals with mild degree of hearing loss under aided conditions. Boothroyd(1984) also investigated the perception of speech contrast with different degree of sensorineural hearing loss and had found higher the degree of loss, lesser the access to perception of contrast. Similarly, Bilger & Wang(1976) found that pattern of consonant confusion varies with respect to degree and configuration of sensorineural hearing loss.

Age comparison was also evaluated in subjects with normal hearing and subjects with hearing impairment where they found that the mean scores were better for older adults in comparison to geriatrics suggesting speech perception decreases with advancing age for both individuals with normal and in individuals with hearing impairment. Generally, auditory and cognitive functions like working memory capacity, speed of processing and attention abilities decline with advancing age and may have negative impact on speech recognition whereas age related hearing loss results in difficulty with speech recognition and may be poorly compensated by conventional hearing aid. Pittman and Stelmachowicz(2000) found that ageing affects hearing sensitivity especially at higher frequencies resulting in loss of phonetic details where discrimination between consonants becomes difficult. Another study by Dubno et al.(1984), also found that elderly individuals have difficulty in speech processing despite similar audiograms as younger adults.

Similarly, in individuals with normal hearing and with hearing impairment, the paired words identification scores were examined for gender differences. The average values of raw data for males and females depict small difference across genders for correct pair identification in both groups. This finding was supported by a prevalence study observed for age and sex differences in age related hearing loss (Homans et al., 2017). It was found that older adults are more prone to age related hearing loss and small significant differences were obtained between genders. A contrast study found that word recognition scores in quiet and competing message were observed to be poorer for males compared to females across all age groups (Wiley et al., 1998).

Subjective measurements such as speech audiometry are essential to determine the perception of speech as it provides insight regarding the perceptual abilities. It also plays a major role during the hearing aid fitting, tuning and helps to

predict the aided outcome based on the percentage of correct identification scores with the use of amplification devices in individuals with hearing impairment. Therefore, in the present study, paired words test stimuli were developed, standardized and final test stimuli comprised of totally 30 paired words containing almost all vowels and consonants of Tamil language differing in distinctive features such as place, manner, voicing features of consonants and height, duration, rounding features of vowel. The paired words test was administered in 60 participants with normal hearing and in 60 participants with hearing impairment and subjects was asked to repeat back the paired words heard through loudspeaker placed at zero-degree azimuths. Later, the correct identification scores and their percentage were computed to notice the benefit provided by that particular hearing aid.

The overall performance of normal hearing individuals on paired words identification were high suggesting that these paired words test material can be used for individuals with hearing impairment to assess hearing aid benefit. A greater improvement in recognition scores for paired words was obtained after fitted with hearing aid in individuals with hearing impairment. Despite hearing aid fitting, the individuals with hearing impairment performed slightly poorer in comparison to normal hearing individuals. Moreover, individuals with hearing impairment were evaluated across degree of loss, in which individuals with moderate degree of hearing impairment yielded higher identification scores compared to individuals with moderately severe and severe degree of hearing impairment indicating greater the loss, lesser the perception ability. However, within each degree comparison between unaided and aided conditions, the greatest benefit with hearing aid was achieved by individuals with severe degree of hearing loss as they are least affected by noise and other factors. Demographic variables such as age and gender were also assessed. Across age, older adults performed better than geriatrics in both individuals with normal hearing and in individuals with hearing impairment implying decline in speech processing with advancing age. Across gender comparison, a small gender difference was observed in both normal hearing and individuals with hearing impairment concluding both male and female performs similar.

Moreover, identification of first word or a word in a pair was observed to be better than double correct identification in paired words in individuals with hearing impairment. This provides evidence that paired words are more difficult to identify compared to single word identification. The difficulty in identifying can be attributed to difficulty in discriminating the acoustically minimally varying words, cognitive loading required for attending both the words.

Based on the results drawn from the study, we can conclude that the paired words test was able to provide the correct identification and percentage of scores in individuals with normal hearing and individuals with hearing impairment across degree of hearing loss. It was noticed that the audibility and ability to discriminate between the paired words is poor thus, yielding lower scores in the paired words identification in individuals with hearing loss. When appropriate fitting was done, the percentage of identification scores was increased in aided conditions. Therefore, the present study concludes that speech perception and discrimination abilities can be evaluated and quantified using these paired words test.

This test was able to provide a realistic position of an individual with hearing impairment in perception of speech compared to normal hearing individuals. This tool can be used in the hearing aid trial and based on the performance of subjects in pair identification, the audiologist can point out the extent of benefit, a hearing aid provides for that particular patient. Based on the scores, tuning becomes plausible and counseling can be done regarding the different features of hearing aids which can be used to overcome the deficit in perception ability.

The limitations of this study are only subjects with sensorineural hearing loss were included and individuals with mixed and medically untreatable conductive loss subjects were excluded. Similarly, this study was not performed on verbal children with hearing loss. Distinctive feature analysis was not performed for the correct identification and only overall identification of contrast was evaluated.

These paired words material can be used to assess the benefit of hearing aid or cochlear implant on children with hearing loss. Background noise can be added to this test material and can be tested with different signal to noise ratios

to observe the performance of individuals with hearing impairment across the degree of hearing loss as adding of noise represents the realistic setting of the person with hearing impairment and the processing of speech with noise can be quantified.

Author Contributions

Conceptualization: Jayakumar Praveen, Priya VCS. Data curation: Priya VCS. Formal analysis: Jayakumar Praveen, Priya VCS. Writing—original draft: Jayakumar Praveen, Priya VCS. Writing—review & editing: Jayakumar Praveen, Priya VCS. Approval of final manuscript: all authors.

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☐ **APPENDIX** ☐

Appendix 1. Paired word list in Tamil

Name: Date:
Age/sex: Type & degree of hearing loss:

S. No.	List 1	Scoring 1	List 2	Scoring 2
1	/ kuɖai / - / koɖai /		/ toɖɨ / - / to:ɖɨ /	
2	/ naɡɑi / - / paɡɑi /		/ ɡaŋɡɑi /- / maŋɡɑi /	
3	/ ɡaŋɡɑi /- / maŋɡɑi /		/ kendʑɨ / - / kondʑɨ /	
4	/ sa:mbʌ̣ / - / so:mbʌ̣ /		/ su:ɖɨ / - / ku: ɖɨ /	
5	/ ve:səm /- / ne:səm /		/ sa:mbʌ̣ / - / so:mbʌ̣ /	
6	/ kendʑɨ / - / kondʑɨ /		/ naɡɑi / - / paɡɑi /	
7	/ su:ɖɨ / - / ku: ɖɨ /		/ nil / - / nɛl /	
8	/ kaɳɳi:r / - / ʈaɳɳi:r /		/ kaɳɳam / - / vaɳɳam /	
9	/ kaɳɳam / - / vaɳɳam /		/ ve:səm / - / ne:səm /	
10	/ toɖɨ / - / to:ɖɨ /		/ ɡi:tɑi / - / si:tɑi /	
11	/ ɡi:tɑi / - / si:tɑi /		/ pa:mbɨ / - / ka:mbɨ /	
12	/ nil / - / nɛl /		/ nandi / - / pandi /	
13	/ nandi / - / pandi /		/ ʋɑ:nəm / - / mɑ:nəm /	
14	/ pasi / - / paɖɨ /		/ ja:ɡəm / - / jo:ɡəm /	
15	/ pa:mbɨ / - / ka:mbɨ /		/ maʈʈɑi / - / muʈʈɑi /	
16	/ maʈʈɑi / - / muʈʈɑi /		/ si:mɑi / - / ti:mɑi /	
17	/ si:mɑi / - / ti:mɑi /		/ pasi / - / paɖɨ /	
18	/ ja:ɡəm / - / jo:ɡəm /		/ ʋel / - / ʋe:l /	
19	/ kɑ:jəm / - / sɑ:jəm /		/ velli / - / kolli /	
20	/ radəm / - / rasəm /		/ marəm / - / varəm /	
21	/ marəm / - / varəm /		/ ja:nɑi / - / pa:nɑi /	
22	/ landʒəm / - / laʧʧʃəm /		/ pirəppɨ / - / sirəppɨ /	
23	/ talɑi / - / kalɑi /		/ landʒəm / - / laʧʧʃəm /	
24	/ ʋel / - / ʋe:l /		/ aʋan / - / iʋan /	
25	/ aʋan / - / iʋan /		/ maɻɑi / - / taɻɑi /	
26	/ maɻɑi / - / taɻɑi /		/ kuɖai / - / koɖai /	
27	/ velli / - / kolli /		/ kɑ:jəm / - / sɑ:jəm /	
28	/ pirəppɨ / - / sirəppɨ /		/ radəm / - / rasəm /	
29	/ ja:nɑi / - /pa:nɑi /		/ talɑi / - / kalɑi /	
30	/ ʋɑ:nəm / - / mɑ:nəm /		/ kaɳɳi:r / - / ʈaɳɳi:r /	

List 1 (normal hearing/unaided condition)	List 2 (aided condition)
Total no of correct identification =	Total no of correct identification =
Percentage of correct pairs =	Percentage of correct pairs =