Lexical Neighbourhood Test (LNT) for Children in Kannada

[1]Apoorva H.M. & [2]Asha Yathiraj

Abstract

The aim of the present study was to develop a Lexical Neighbourhood Test in Kannada for children aged 6 to 8 year. The study also aimed to check the utility of the developed test on the target group and in children with hearing impairment using cochlear implants. The developed test material consisted of two word lists containing 40 words each which were constructed taking into account the lexical density as well as the frequency of occurrence of the words. Each list contained 20 lexically easy words and 20 lexically hard words. The developed test material was administered on both the groups. Results revealed that there was no significant difference between younger (6 to 6; 11 years) and older (7 to 8 years) normal hearing children. There was no significant difference between the two lists developed thus confirming inter-list equivalency. Both the groups performed better on the easy words and poorer on the hard words and thus there was a significant effect of lexical difficulty on both the groups. There was a significant difference between the performances of children with normal hearing and children with hearing impairment on both the lists for easy and hard words. The results demonstrated that the developed material represented different lexical difficulties. Hence, it can be used to tap the perceptual differences in children and can serve as a valid clinical tool in examining perceptual processes underlying spoken word recognition in Kannada.

Keywords: *Lexical density, easy words, hard words, speech identification*

Introduction

As early as 1952, Hirsh et al. noted that speech tests have diagnostic and prognostic values. Speech audiometry continues to be considered essential due to its inherent advantage over pure-tone audiometry. Speech stimuli have been found to aid in detecting perceptual difficulties that may go undetected if only pure-tones were used. Pathologies in the retro-cochlear region and higher auditory pathways have been reported to not manifest themselves if evaluated only using pure-tones. This occurs despite the presence of marked speech perception difficulties. Hence, speech has been considered the preferred test material for assessing higher cortical functions (Jerger & Hayes, 1971; Jerger & Jerger, 1974). It has also been used in assessing the success in otological surgery (Kasden & Robinson, 1970), in determining communication abilities (Berger, Keating & Rose, 1971) and for hearing aid evaluation (Markides, 1977). Further, speech audiometry has been noted to help in early detection of slight losses which are otherwise overlooked (Ritchie & Merklein, 1972). The need for speech audiometry has arisen mainly because speech is by far the most important class of sound that one hears.

Several speech identification tests have been developed for children (Ross & Lerman, 1970; Mayadevi, 1974; Elliot & Katz, 1980; Moog & Geers, 1990; Rout, 1996; Vandana, 1998; Prakash, 1999; Begum, 2000; Chowdary, 2003; Jijo & Yathiraj, 2008). However, such tests have been observed not to address difficulties faced by all children, especially those using cochlear implants (Cullington, 2000) as these children greatly vary in their spoken word recognition skills (Staller, Beiter, Brimacombe, Mecklenburg & Arndt, 1991). This variability depends in part on the age of onset and duration of their hearing loss (Fryauf-Bertschy, Tyler, Kelsay & Gantz, 1992), and on the length of cochlear implant use (Fryauf-Bertschy et al., 1992; Miyamoto et al., 1992; 1994). Thus, as children develop, there is a great need to have different levels of tests that increase in terms of their perceptual difficulty.

In order to assess the developing auditory skills in children as they grow, a number of speech perception measures have been developed. These speech perception tests range from very simple closed set tests like Pattern Perception Test (Moog & Geers, 1990), Word Intelligibility by Picture Identification test (Ross & Lerman, 1970), Northwestern University-Children's Perception of Speech (Elliot & Katz, 1980), Picture speech identification test for children in Tamil (Prakash, 1999) and in Hindi (Chowdry, 2003), Early Speech Perception test for Malayalam speaking children (Jijo & Yathiraj, 2008) to more complex open-set tests such as Phonetically balanced word lists-Kindergarten (Haskins, 1949), Bamford-Knowal-Bench sentence test (Bench, Kowal & Bamford, 1979), Common phrase test (Robbins, Renshaw & Osberger, 1995) . However, it has been reported by Mukari, Ling and Ghani (2007) that children with cochlear implants performed poorly on the PB-K. This has been attributed to the test containing words that are unfamiliar to young deaf children who typically have very limited vocabulary.

The Lexical Neighbourhood Test (LNT) was developed by Kirk, Pisoni and Osberger (1995) to assess spoken word recognition in order to reveal the perceptual processes employed by children, especially for those using cochlear implants. The LNT test items were formed

[1]Email: apoorvahm88@gmail.com,
[2]Professor of Audiology, Email:asha_yathiraj@rediffmail.com

based on the frequency of occurrence of word in the language (word frequency) and the number of phonetically similar words surrounding the word (lexical density). Words with many lexical neighbours were considered to have a 'dense' lexical neighbourhood, whereas those with only a few lexical neighbours were considered to have a 'sparse' neighbourhood. Based on word frequency and lexical density, 'lexically easy' and 'lexically hard' words were categorized. The lexically 'easy' words had more frequently occurring words with 'sparse' neighbourhood and lexically 'hard' words had less frequently occurring words with 'dense' neighbourhood.

The Lexical Neighbourhood Test is considered to be very useful for measuring word recognition in children with multichannel cochlear implants who exhibit varying speech perception abilities. Thus, it is reported to provide reliable estimates of spoken word recognition abilities in these children. The test is believed to allow the examination of the perceptual processes underlying spoken word recognition. Further, the test is used to gain further knowledge about the organization of sound patterns of words in young children's lexicons and the processes used to access these patterns in traditional speech identification tests (Kirk et al., 1995).

LNT has been developed in various languages like Mandarin (Yang & Wu, 2005), Cantonese (Yuen et al., 2008), and Chinese (Liu et al., 2011). In India, it has been developed in Indian English by Patro and Yathiraj (2010) and in Hindi by Singh (2010).

Though there are several speech identification tests for children developed in India (Swarnalatha, 1972; Mayadevi, 1974; Vandana, 1998; Prakash, 1999; Chowdary, 2003; Jijo & Yathiraj, 2008), they have been developed taking into account only the familiarity of the stimuli. However, it is evident from literature (Kirk et al., 1995; Dirks, Takayana & Moshfegh, 2001; Krull, Choi, Kirk, Prusick & French, 2010) that despite words being familiar, word frequency and lexical density, also need to be considered. This would provide perceptual information of two different dimensions regarding the perception of speech. This would be especially useful in evaluating the subtle perceptual difficulties of children using listening devices such as hearing aids or cochlear implants. The results from the test would serve as guidelines regarding the usefulness of the devices. In addition, the test would help determine the progress made by children using these devices over time, with or without training. In India it is currently available only in Indian English (Patro & Yathiraj, 2010) and in Hindi (Singh, 2010).

When speech is used as stimuli for assessment, the regional language used for testing becomes an important variable (Alusi, Hinchcliffe, Ingham, Knight & North, 1974). An individual's perception of speech has been found to be influenced by his first language or mother tongue (Singh, 1966; Gat & Keith, 1978). India being a multilingual country, it is necessary to develop tests for the paediatric population in different Indian languages. Currently, LNT is not available in Kannada and hence there is a need to develop such a test in the language.

The aim of the present study was to develop a Lexical Neighbourhood test in Kannada for children aged 6-8 years. The study also aimed to check the utility of the developed test on the target group and in children with hearing impairment using cochlear implants.

Method

Participants

The study was carried out in two phases. The first phase involved the development of the Lexical Neighbourhood Test in Kannada for children aged 6 to 8 years. In the second phase, the developed material was administered on normal hearing children and children with hearing impairment using cochlear implants.

Participants

For the development of the material (Phase I of the study), 45 adults and 10 children were involved. All these participants were fluent speakers of Kannada. Among the adults, 3 were regular school teachers and 3 were special educators. The familiarity of the material was tested on the ten children who were exposed to Kannada from early childhood. These children were reported to be typically developing and had no history of speech and hearing problems. In Phase II of the study, data were collected from 30 typically developing children and 6 children with hearing impairment who used cochlear implants. All the children were exposed to Kannada from early childhood.

The typically developing children (Group I) were in the age range of 6 to 8 years and were exposed to Kannada from early childhood. Their AC and BC thresholds were within 15 dB HL in the frequencies from 250 Hz to 8000 Hz and 250 Hz to 4000 Hz respectively. Their speech identification scores were 90% or higher at 40 dB SL (ref: PTA) in both ears on the speech identification tests for Kannada speaking children (Vandana, 1998). They had bilateral A-type tympanograms with acoustic reflexes present at 90 dB HL in both ears at 500 Hz, 1000 Hz and 2000 Hz. In addition, it was ensured that they had no history of any speech, language or hearing problem as well as no otologic / neurologic problems. They had no illness on the day of testing.

The children using Nucleus cochlear implants (Group-II) were tested using their device in the prescribed settings for everyday use. Of them, 3 used CP 810 sound processor, 2 used Freedom sound processor and 1 used

Sprint processor. All the participants used their device regularly for at least one year. Their aided audiogram was within the speech spectrum. The children had a language age of at least 6 years, as evaluated using the Kannada Language Test (UNICEF funded project, 1990) with clear speech, with limited number of misarticulation.

Testing Environment

All the testing was carried in a sound-treated suite. The noise levels were maintained within permissible limits, as per ANSI S3.1- 1991.

Instrumentation:

A calibrated two channel diagnostic audiometer, ORBITER-922, version-2 coupled with headphones (TDH-39), bone vibrator (B-71) and sound-field speakers were used to estimate the pure-tone thresholds and speech identification abilities. A calibrated middle ear analyzer, GSI Tympstar version-2 was used to carry out immittance tests. A computer with Adobe Audition (version 1.5) software was utilized to record and present the speech tests.

Test Procedure

Phase I - Procedure for development of the material: The development of the material involved three steps. They included determining the familiarity of words that were considered to be in the vocabulary of 6 year old children; checking the lexical density of the familiar words; and determining the frequency of occurrence of the familiar words.

Initially, a list of words that were considered to be in the vocabulary of children aged 6 years was made. The words were selected from age appropriate print material. Additionally, 15 adults who were exposed to Kannada since early childhood were asked to make lists of words which they thought would be present in the vocabulary of children aged 6 years. The words from the print material and the 15 adults were pooled into a single list by omitting the common words. Thus, 550 words were obtained and the familiarity of these words was checked on 10 children aged 6 years. A word was considered highly familiar only if the children were able to describe its meaning. Words which could be described correctly by more than 80% of the children were included for further steps in the construction of the test. Of the 550 words, 230 words were found to be highly familiar.

The lexical density of the 230 words was calculated by determining the number of lexical neighbours for each word. This was done by determining the number of words that could be formed by adding, deleting, or substituting one phoneme at a time from the target word. To carry out this task, 12 adults who were educated in Kannada from early childhood and who spoke the language fluently were considered. They were instructed to construct as many lexical neighbours as possible for each of the 230 words by making use of the procedure to calculate the same. Later, the responses from the 12 participants were pooled into a single list by eliminating the words that were repeated by the different participants. The lexical neighbourhood density ranged from 0 to 15. Those words that had 3 and less neighbours were categorized to have a 'sparse neighbourhood' and those words which had more than 3 neighbours were considered to have a 'dense neighbourhood'. This cut-off value was selected since it approximated the value recommended by Kirk et al. (1995).

Further, the frequency of occurrence of the 230 words was determined by calculating the number of times each of the words occurred in text books / story books used by children in the age range of 6 to 8 years. The text material had as many as 507 pages and 24,980 words. The frequency of occurrence of each of the words in the text material was calculated manually. Since the word count was done manually it was calculated separately by two adults who read Kannada fluently. This was done to verify the accuracy of the word count. The frequency of occurrence was noted to range from 1 to 282. The words were then divided into two groups. Those words that occurred more than 6 times in the text material were classified as 'frequently occurring words' and those which occurred 6 or less were classified as 'infrequently occurring words'. Six was taken as the cut-off point as this value divided the words into half.

Based on the frequency of occurrence and lexical density, the words were categorized as 'lexically easy' and 'lexically hard' words. The lexically 'easy' words had 'more frequently occurring' words with 'sparse neighbourhood'. The lexically 'hard' words had 'less frequently occurring' words with 'dense neighbourhood'.

Thus, two word lists containing 40 words each were constructed taking into account the lexical density as well as the frequency of occurrence of the words. Each list consisted of equal number of 'hard' and 'easy' words, i.e., 20 easy words and 20 hard words which were randomized (Appendix).

Recording of developed word-lists: The developed word-lists were recorded by a fluent Kannada speaker. It was ensured that the fundamental frequency of the speaker was within normal limits as measured on the Vaghmi software. The recorded material was edited and scaled using Adobe Audition software to ensure that the intensity of all sounds were similar. The recording was done using a sampling rate of 44.1 kHz and 32-bit analogue-to-digital converter. A directional boom microphone, placed 6 cm from the mouth of the speaker and connected to a computer was used for the recording.

An inter-stimulus interval of 4 seconds was inserted between word pairs to obtain the response from the listeners. A 1 kHz calibration tone was inserted prior to each list. The developed material was subjected to a goodness test. This was done on 10 adults to ensure that the recording was clear. All the recorded words were found to be intelligible by 90% of these adults.

Phase II - Administration of the developed test material:

Administration on normal hearing children: The recorded stimuli were played using Adobe Audition (version 1.5) which was loaded on a computer. The output from the computer was routed to sound field speakers via a diagnostic audiometer. The loud speaker was placed at 0 ^{0}azimuth at 1 meter distance from the head of the listener. Prior to the presentation of the stimuli, the 1 kHz calibration tone was used to adjust the VU meter deflection of the audiometer to '0'. The stimuli were presented in a sound-field condition at 40 dB SL (ref PTA).

The participants were instructed to repeat what they heard. To ensure that they understood the instructions, they first listened to orally presented practice items that were not a part of the test items. Following this, they were presented the recorded test items. Half of the children were presented with list 1 first and the other half received list 2 first. This was done to eliminate the list order effect. The verbal outputs of the participants were noted by the tester on a response sheet which was later scored.

*Administration on children with hearing aids / cochlear implants:*The children with hearing impairment were tested with their cochlear implants using their preferred stable map. Children using Nucleus cochlear implants were tested using the 'everyday' pre-processing strategy. The procedure followed was similar to that used to evaluate the normal hearing children. The verbal output of the participants was audio recorded and also noted by the tester on a response sheet. The response of children who had misarticulations were scored correct if the stimulus and their verbal output corresponded with the findings of an articulation test that had earlier been administered on them.

Scoring

The responses of the participants were scored by the tester. Both word and phoneme scores were calculated. For calculating the word scores, a correctly identified word was assigned a score of 'one' and a wrong answer a score of 'zero'. Thus, the maximum word score was 40 for each list. Similarly, while calculating phoneme scores, every correctly identified phoneme was given a score of 'one' and a wrong phoneme a score of 'zero'. For list-1 the maximum phoneme score was 174 and for list-2 it was 168.

Statistical Analyses

The data obtained from the 30 typically developing children and 6 children with hearing impairment were analysed using Statistical Package for Social Sciences (SPSS) software version 18. Initially, mixed ANOVA was carried out to study the main effects and the interaction between the variables for group I (children with normal hearing). Further analysis using paired t-test or Wilcoxon signed rank test was done to study the effect of lexical difficulty (easy words vs. hard words) and effect of word lists (inter-list equivalency). The performance of the children with hearing impairment using cochlear implants was analysed using Wilcoxon signed rank test. Later, the performance of the two groups was compared and analysed using Mann-Whitney U test.

Results and Discussion

The responses of 30 normal hearing children aged 6 to 8 years and 6 children with hearing impairment using cochlear implants on the developed Lexical Neighbourhood Test in Kannada are discussed. The results of the two groups of participants are discussed separately.

Performance of Typically Developing Children (group I)

To study the main effects and the interaction between the variables 2-way repeated mixed ANOVA (2 lists x 2 word types x 2 age groups) was carried out. The results of the mixed ANOVA revealed a significant interaction between the list, word type and age [$F(1, 28) = 3.094$, $p < 0.05$] and also between the list and word type [$F(1, 28) = 0.674$, $p < 0.05$]. However, there was no significant interaction between type and age [$F(1, 28) = 1.674$, $p > 0.05$] and between list and age [$F(1, 28) = 0.916$, $p > 0.05$]. The results of the effect of age, list and word type are provided below.

Effect of Age: The effect of age was determined by comparing the word scores of the two age sub-groups (6 to 6; 11 years and 7 to 8 years) on the easy and hard words for the two lists. Table 1 gives the mean, minimum, maximum and standard deviation (SD) values for the two age groups. As can be seen from the table, the scores were slightly higher for the older age group compared to the younger group for both easy and hard words on the two lists. However, the mixed ANOVA indicated there was no significant difference between the two age groups [$F(1, 28) = 2.754$, $p > 0.05$].

The effect of age was also determined by comparing the phoneme scores of the two age sub-groups on the easy and hard words. Table 2 gives the mean, minimum, maximum and SD values for the two age groups. To see if there was difference between the two age groups for the phoneme scores, Mann Whitney U test was administered. This non-parametric test was administered since

Table 1: Mean and Standard Deviation (SD) of the word scores (easy words, hard words and the total word scores) for the two age groups

Age groups		List 1			List 2		
		*Easy	*Hard	#Total	*Easy	*Hard	#Total
6-6;11 yrs N = 15	Mean	19.27	17.33	36.6	19.47	18.27	37.73
	Min	17	15	34	18	15	35
	Max	20	20	40	20	20	40
	SD	0.88	1.45	1.96	0.74	1.34	1.67
7-8 yrs N = 15	Mean	19.40	18.47	37.87	19.73	18.53	38.27
	Min	17	15	34	19	15	34
	Max	20	20	40	20	20	40
	SD	0.83	1.46	2.03	0.46	1.36	1.58

*Note: *Maximum scores for easy and hard words = 20; #Maximum Total score = 40*

Table 2: Mean and Standard Deviation (SD) of the percentage phoneme scores (easy words, hard words and the total word scores) for the two age groups

Age groups		List 1			List 2		
		Easy	Hard	Total	Easy	Hard	Total
6-6;11 yrs N = 15	Mean	98.85	96.46	97.78	99.20	97.99	98.46
	Min	94.55	93.83	94.83	95.18	94.19	95.86
	Max	100.00	100.00	100.00	100.00	100.00	100.00
	SD	1.70	1.86	1.45	1.34	1.55	1.16
7-8 yrs N = 15	Mean	99.14	97.72	98.47	99.52	98.30	98.90
	Min	96.77	92.89	95.98	97.59	94.19	96.45
	Max	100.00	100.00	100.00	100.00	100.00	100.00
	SD	1.09	2.33	1.51	0.76	1.58	1.00

the scores had to be converted to percentage scores due to the unequal raw phoneme scores across the two lists / word-type. The analysis revealed that there was no significant difference for phoneme scores between the two age groups for easy words ($Z = 0.269$, $p > 0.05$), hard words ($Z = 1.788$, $p > 0.05$) as well as total scores ($Z = 1.101$, $p > 0.05$).

The finding of the present study regarding the performance of the two age groups was similar to that of Liu et al. (2011). They studied the effect of age using the standardized Chinese version of LNT on children aged 5.0 to 5;10 years and 6.0 to 6;11. The finding of the present study and that of Liu et al. indicated that speech identification abilities of children for stimuli such as the LNT reached its peak value by a younger age. Due to a ceiling effect, with increase in age there was no further improvement in speech recognition. This probably occurred in the both the studies since the test stimuli were derived from speech materials meant for children in the younger age. While in the present study the stimuli were derived from material for the younger age group (6 to 6;11 years), in the study by Liu et al. it was derived from children younger (3 to 5 years) than their youngest age group (5.0 to 5;10 years). This could have lead to the lack of statistically significant differences between the age groups. Thus, for the Kannada LNT, children as young as 6 years can be expected to perform similar to older children.

Table 3: Mean and SD of word scores (easy words, hard words and the total word scores) for 30 normal hearing individuals

List	Word type	Mean	SD	Range Min	Range Max
List 1	*Easy	19.33	0.84	17	20
	*Hard	17.90	1.54	15	20
	#Total	37.23	2.06	34	40
List 2	*Easy	19.60	0.62	18	20
	*Hard	18.40	1.33	15	20
	#Total	38.00	1.62	34	40

*Note: *Maximum scores for easy and hard words = 20; #Maximum Total score = 40*

Table 4: Mean and SD of percentage phoneme scores (easy words, hard words and the total word scores) for 30 normal hearing individuals

List	Word type	Mean	SD	Range Min	Range Max
List 1	Easy	99.00	1.41	93.55	100
	Hard	97.09	1.67	92.89	100
	Total	98.12	1.50	94.83	100
List 2	Easy	99.36	1.08	95.18	100
	Hard	98.14	1.55	94.19	100
	Total	98.68	1.09	95.86	100

Table 5: Mean and Standard Deviation (SD) of the word scores (easy words, hard words and the total word scores) for 6 children with hearing impairment

List	Word type	Mean	SD	Range Min	Range Max
List 1	*Easy	15.83	0.98	14	17
	*Hard	12.50	1.51	10	14
	#Total	28.33	2.42	24	31
List 2	*Easy	15.83	1.17	14	17
	*Hard	12.33	1.63	11	15
	#Total	28.17	2.48	25	32

*Note: *Maximum scores for easy and hard words = 20; #Maximum Total score = 40*

Table 6: Mean and Standard Deviation (SD) of the percentage phoneme scores (easy words, hard words and the total word scores) for 6 children with hearing impairment

List	Word type	Mean	SD	Range Min	Range Max
List 1	Easy	90.32	3.85	83.87	94.62
	Hard	87.65	4.06	80.25	91.36
	Total	89.08	3.86	82.18	93.10
List 2	Easy	91.57	2.80	86.75	93.98
	Hard	87.02	3.07	83.74	90.70
	Total	88.76	2.97	85.21	92.30

*Note: *Maximum scores for easy and hard words = 20; #Maximum Total score = 40*

Since the mixed ANOVA results for word scores and Mann Whitney U test for phoneme scores revealed no significant age effect, the data obtained for the two age groups were combined for further analysis. This was done while determining the effect of inter-list equivalency and lexical difficulty.

Inter-list equivalency: To compare the performance of the normal hearing children across the two lists developed, the mean and the SD of both easy and hard words were analysed. In both list 1 and list 2, the mean word scores were similar for the easy words (19.33 & 19.60 respectively), hard words (17.90 & 18.40 respectively) and total scores (37.23 & 38.00 respectively) as evident in Table 3. Similar to the word scores, the mean phoneme scores were similar for the easy words (99.00 & 99.36 respectively), hard words (97.09 & 98.14 respectively) and total scores (98.12 & 98.68 respectively) as seen in Table 4.

Mixed ANOVA results revealed that there was no significant main effect for list [$F (1, 28) = 4.003$, $p > 0.05$]. Further, to confirm if the two lists were equivalent statistically for easy words, hard words and for total word scores, paired-t test was carried out. This analysis also revealed that there was no significant difference between the two lists for easy words ($t = 1.161$, $p > 0.05$), hard words ($t = 1.675$, $p > 0.05$) and also for the total scores ($t = 2.004$, $p > 0.05$). Similarly, to confirm list equivalency for the phoneme scores, Wilcoxon Signed Rank test was carried out. Once again, the results revealed that there was no significant difference between two lists for the easy words ($Z = 1.085$, $p > 0.05$), hard words ($Z = 2.585$, $p > 0.05$) as well as the total scores ($Z = 1.590$, $p > 0.05$).

As the two lists were found to be equivalent, it is recommended that they can be used alternatively during any assessment in order to avoid any word familiarity effect. The lists can be used interchangeably irrespective of whether word or phoneme scores are being calculated.

Effect of lexical difficulty on speech identification scores: The effect of lexical difficulty was analyzed by comparing the scores obtained for lexically easy and lexically hard words. From the mean and SD values of the word scores for easy and hard words (Table 3) it is evident that the mean scores for the latter were lesser than that of the former. Mixed ANOVA results revealed a significant main effect for word type [$F (1, 28) = 46.43$, $p < 0.001$] with lists combined. To check the effect of lexical density for each of the lists, paired-t test was done. It was found that there was a significant difference between easy and hard words for both list 1 ($t = 5.68$, $p < 0.001$) and list 2 ($t = 5.07$, $p < 0.001$).

Similarly, Table 4 shows the mean and SD values of the phoneme scores for easy and hard words for the two lists. It can be seen from the table that the mean scores for hard words were lesser than that of easy words. Wilcoxon signed rank test revealed that there was a statistically significant difference between the scores obtained for the easy and hard words. This was evident in both list 1 ($Z = 3.69$, $p < 0.001$) and in list 2 ($Z = 3.18$, $p < 0.001$).

Earlier reported studies had also observed that easy words were easier to perceive than hard words. Thus, the finding of the current study are consistent with what has been found in the English LNT (Kirk et al., 1995; Dirks et al., 2001) and in LNT of other languages (Yang

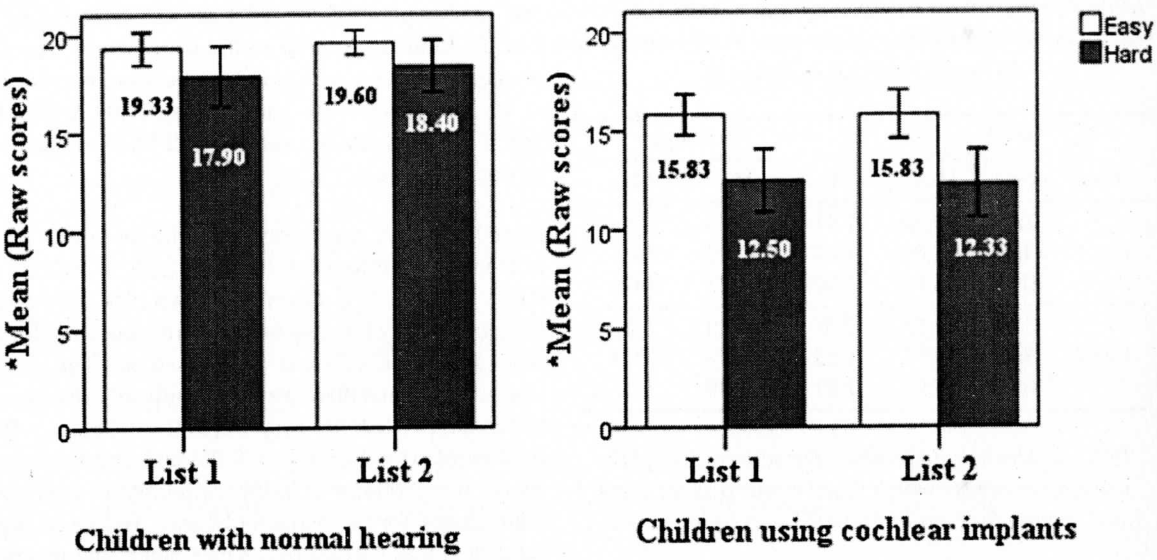

Figure 1: Mean easy and hard word scores for children with normal hearing and for children with hearing impairment using cochlear implants.

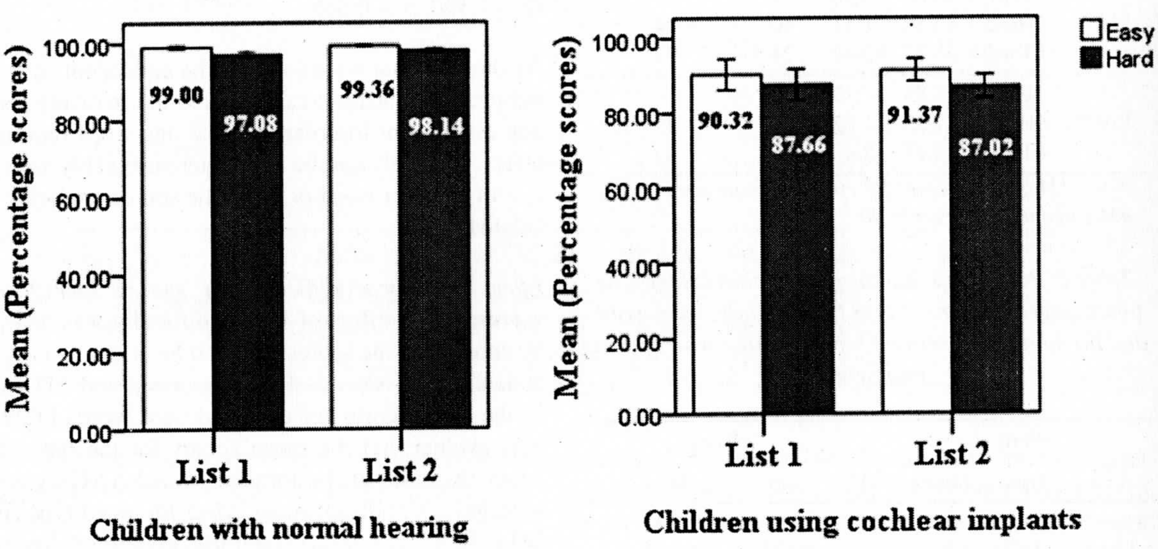

Figure 2: Mean percentage phoneme scores (for easy and hard words) for children with normal hearing and for children with hearing impairment using cochlear implants.

& Wu, 2005; Patro & Yathiraj, 2010; Singh, 2010; Liu et al., 2011). As seen in the other studies, the children in the present study found more frequently occurring words with sparse neighbourhoods to be easier to identify. Liu et al. (2011) opined that repeated stimulations with frequently occurring words might have strengthened their memory of the words and consolidate the words in the lexicon compared to the less frequently occurring words. Furthermore, the sparser neighbourhood density might have facilitated retrieval of the 'easy' words as a result of a 'top-down' process. Therefore, children have better mastery of the 'easy' words than the 'hard' words as observed by Liu et al. (2011).

The finding of the present study indicates that the developed material does represent different lexical difficulties. Hence, it can be used to tap the perceptual differences in children and can be used as a valid clinical tool in examining perceptual processes underlying spoken word recognition in Kannada language.

Performance of Children with Hearing Impairment using Cochlear Implants (group II)

The mean and the SD values for the easy and hard words for the 6 participants with hearing impairment using cochlear implants are given in Table 5 for the word scores and Table 6 for the phoneme scores. Similar to the performance of normal hearing group, the children with hearing impairment also performed better on the easy words compared to the hard words. This was observed for both the lists.

Further, Wilcoxon Signed Rank test was done for both word scores and phoneme scores to see if the difference between the easy and the hard words were statistically significant. It was found that there was a significant difference between easy and hard words for list 1 ($Z = 2.232$, $p < 0.05$) and for list 2 ($Z = 2.236$, $p < 0.05$) for word scores. Similarly, for phoneme scores it was found that there was a significant difference between easy and hard words for list 1 ($Z = 2.201$, $p < 0.05$) and for list 2 ($Z = 2.201$, $p < 0.05$).

In addition, Wilcoxon Signed Rank test was also done for both word scores and phoneme scores to see whether there was any difference between the scores obtained across the two lists. The results showed that there was no significant difference between the two lists for the easy words ($Z = 0.04$, $p > 0.05$), hard words ($Z = 0.447$, $p > 0.05$) and the total scores ($Z = 0.378$, $p > 0.05$) for word scores. Likewise, with the phoneme scores there was no significant difference between the two lists for the easy words ($Z = 0.526$, $p > 0.05$), hard words ($Z = 0.949$, $p > 0.05$) and the total scores ($Z = 0.524$, $p > 0.05$). Similar performance across the lists suggests that the two lists developed are equivalent even when used with children using cochlear implant.

This finding of difference in the performance of easy and hard words in cochlear implant users is in consonance with previous studies (Kirk et al., 1995; Kirk, Eisenberg, Martinez & McCutcheon, 1998; Dirks et al., 2001; Yang & Wu, 2005; Yuen et al., 2008; Wang, Wu & Kirk, 2010 & Liu et al., 2011). It suggests that cochlear implant users also utilised their lexical knowledge in word recognition tasks. Kirk et al. (1995) reported that despite a hearing loss and with the degraded sensory input provided via the cochlear implant, their subjects were sensitive to the acoustic-phonetic similarity among the test words. Kirk also reported that though these children have limited vocabularies, they appear to organize words into similarity neighbourhoods in long-term memory, and use this structural information in recognizing isolated words. In a similar manner, the children using cochlear implants in the present study were also able to utilise strategies in a comparable way as that of normal hearing children. This could have lead to them perceive easy and hard words differently.

Comparison of Performance of Children with Normal Hearing and Children with Hearing Impairment using Cochlear Implants

The mean and SD for the word scores and phoneme scores are provided in Figure 1 and Figure 2 respectively. The figures present information of the normal hearing individuals as well as of those with hearing impairment. For both the groups, the mean scores for children with normal hearing were greater than for the children with hearing impairment using cochlear implants.

Mann Whitney U test was used to test the significance of difference between group I and group II for word scores. The results showed that for both the lists there was significant difference between the two groups. This was observed for both easy ($Z = 4.006$, $p < 0.001$) and hard words ($Z= 3.885$, $p < 0.001$) in list 1. Similar findings were obtained in list 2 for the easy ($Z = 4.225$, $p < 0.001$) and hard words ($Z = 3.854$, $p < 0.001$).

To compare the performance of 2 groups on easy and hard words for phoneme scores, Mann Whitney U test was administered which also revealed significant difference between group I and group II. This was observed for both easy ($Z = 3.947$, $p < 0.001$) and hard words ($Z = 3.858$, $p < 0.001$) for list 1. Similar findings were obtained for list 2 for the easy ($Z = 4.163$, $p < 0.001$) and hard words ($Z = 3.884$, $p < 0.001$).

The above finding is in consonance with previous research by Wang, Wu, and Kirk (2010) who studied cochlear implant users and by Patro and Yathiraj (2010) who studied hearing aid users. In both the studies, children with hearing impairment performed significantly poorer than that of normal hearing children on both easy and hard words. Patro and Yathiraj (2010) reported that this poor performance may be because the listening device worn by them was not able to compensate totally for their hearing deficit.

Conclusions

The results indicated a significant effect of lexical difficulty in both the groups (children with normal hearing and for children with hearing impairment using cochlear implants). Both groups performed better on the lexical easy words and poorer on the lexical hard words. There was no significant difference in the performance of children with normal hearing between the two age groups considered. Also, there was no significant difference between the two lists developed thus confirming the inter-list equivalency. The performance of the normal hearing participants was significantly better than that of the cochlear implant users. Similar trend of findings were seen in the performance for both the word scores and phoneme scores for both the groups and for all the parameters.

The material developed in the present study can be used as a valid clinical tool for assessing the speech perception abilities in children. The test can be administered on those children who perform well on simple closed set tests but perform poorly on open set PB word tests, as the difficulty of the test lies in between these two extremes of perceptual difficulty. Also, the test developed can be helpful in selection of appropriate listening devices and may provide guidelines in planning the therapy effectively and also to monitor the progress over time.

References

Alusi, H. A., Hinchcliffe, R., Ingham, B., Knight, J. J., & North, C. (1974). Arabic speech audiometry. *Audiology, 13*(3), 212-220.

American National Standards Institute. (1991). *American National Standard maximum permissible ambient noise levels for Audiometric Test rooms.* (ANSI S3.1 - 1991). New York: American National Standards Institute.

Begum, A. (2000). *A speech perception test for English speaking hearing impaired Indian preschoolers.* Unpublished Independent project, University of Mysore, Mysore.

Bench, J., Kowal, A., & Bamford, J. M. (1979). The BKB (Bamford Kowal Bench) sentence list for partially hearing children. *British Journal of Audiology, 13,* 108-112.

Berger, K. N., Keating, L. W., & Rose, D. E. (1971). An evaluation of the Kent State University speech discrimination test on subjects with sensorineural loss. *Journal of Auditory Research, 11,* 140-143.

Chowdary, B. K. (2003). *Picture speech Identification test for Hindi speaking children.* Unpublished Master's Dissertation, University of Mysore, Mysore.

Cullington, H. E. (2000). Book review of: Cochlear implant rehabilitation in children and adults by Diane J. Allum. *British Society of Audiology News, 21,* 13.

Dirks, D. D., Takayana, S., & Moshfegh, A. (2001). Effects of lexical factors on word recognition among normal-hearing and hearing-impaired listeners. *Journal of American Academy of Audiology, 12*(5), 233-44.

Elliot, L. L., and Katz, D. (1980). Development of a new children's test of speech discrimination. In F.Martin (Eds.), Hearing disorders in children (pp. 265). Austin, Texas: Prof. Ed. Inc.

Fryauf-Bertschy, H., Tyler, R. S., Kelsay, D. M., & Gantz, B. J. (1992). Performance over time of congenitally deaf and postlingually deafened children using a multichannel cochlear implant. *Journal of Speech and Hearing Research, 35,* 892-902.

Gat, I. B., & Keith, R. W. (1978). An effect of linguistic experience: Auditory word recognition by native and non-native speakers of English. *Audiology, 17,* 339-345.

Haskins, H. (1949). A phonetically balanced test of speech discrimination for children. Unpublished master's thesis, Northwestern University, Evanston, IL.

Hirsh, I. J., Davis, H., Silverman, S. R., Reynolds, E. G., Eldert, E., & Benson, R. W. (1952). Development of materials for speech audiometry. *Journal of Speech and Hearing Disorder, 17,* 321-337.

Jerger, J., & Hayes, D. (1971). Audiological manifestations of lesions in the auditory nervous system. *Laryngoscope, 70,* 417-425.

Jerger, J., & Jerger, S. (1974). Auditory findings in brainstem disorders. *Archives of Otolaryngology, 99,* 324-354.

Jijo, P.M., & Yathiraj. A. (2008). *Early speech perception test in Malayalam children.* Published Master's Dissertation, University of Mysore, Mysore.

Kasden, S. D., & Robinson, M. (1970). Otologic-audiologic Hearing Aid Evaluation. *Archives of Otolaryngology, 93*(1), 34-36.

Kirk, K. I., Eiesenberg, L. S., Martinez, A. S. & McCutcheon, M. H. (1998). *The lexical neighbourhood test: Test-retest reliability and interlist equivalency.* Research on spoken language processing, progress report no. 22. Bloomington, IN: Speech Research Laboratory, Indiana University.

Kirk, K. I., Pisoni, D. B., & Osberger M. J. (1995). Lexical effects on spoken word recognition by pediatric cochlear implant users. *Ear and Hearing, 16,* 470-481.

Krull. V., Choi, S., Kirk, K. I., Prusick L., & French, B. (2010). Lexical effects on spoken word recognition in children with normal hearing. *Ear and Hearing, 31*(1), 102-114.

Liu, C., Liu, S., Zhang, N., Yang, Y., Kong, Y., & Zhang, L. (2011). *International Journal of Pediatric Otorhinolaryngology, 75,* 774-781.

Markides, A. (1977). *Binaural hearing aids.* London: Academic Press Inc.

Mayadevi, (1974). *Development and standardization of a common speech discrimination test for Indians.* Unpublished Master's Dissertition, University of Mysore, Mysore.

Miyamoto, R. T., Osberger, M. J., Robbins, A. M., Myres, W. A., Kessler, K., & Pope, M. L. (1992). Longitudinal evaluation of communication skills of children with single- or multichannel cochlear implants. *American Journal of Otology, 13,* 215-222.

Miyamoto, R. T., Osberger, M. J., Todd, S. L., Robbins, A. M., Stroer, B. S., Zimmerman-Phillips, S., & Carney, A. E. (1994). Variables affecting implant performance in children. *Laryngoscope, 104,* 1120-1124.

Moog, J. S., & Geers, A. E. (1990). *Early speech perception test for profoundly hearing impaired* *children.* St. Louis: Central institute for the deaf.

Mukari, S. Z., Ling, L. N., & Ghani, H. A. (2007). Educational performance of pediatric cochlear implant recipients in mainstream classes. *International Journal of pediatrics Otorhinolaryngology, 71,* 231-240.

Patro, C., & Yathiraj, A. (2010). *Lexical Neighbourhood Test: An Indian English version for children.* Published Master's Dissertation, University of Mysore, Mysore.

Prakash, B. (1999). *A picture speech identification test for children in Tamil.* Unpublished Master's Dissertition, University of Mysore, Mysore.

Ritchie, B., and Merklein, R. (1972). An evaluation of the efficiency of the verbal auditory screening for children (VASC). *Journal of Speech and Hearing Research, 15,* 280-286.

Robbins, A. M., Renshaw, J. J., & Osberger, M. J. (1995). *Common phrase test.* Indianapolis, IN: Indiana University School of Medicine.

Ross, M., and Lerman, J. W. (1970). A picture identification test for hearing impaired children. *Journal of speech and hearing Research, 13,* 44-53.

Rout, A. (1996). *Perception of monosyllabic words in Indian children.* Unpublished Master's Dissertation, University of Mysore, Mysore.

Singh, S. (1966). Cross language study of perceptual confusion of plosives in two conditions of distortion. *Journal of the Acoustical Society of America, 40,* 635-656.

Singh, D. K. (2010). *Development of multi-syllabic lexical neighbourhood test in Hindi.* Unpublished Master's dissertation, University of Bangalore, Bangalore.

Staller, S. J., Beiter, A. L., Brimacombe, J. A., Mecklenburg, D. J., & Arndt, P. (1991). Pediatric performance with the Nucleus 22-channel cochlear implant system. *American Journal of Otology, 12,* 126-136.

Swarnalatha, C. K. (1972). *Development and Standardization of speech test material in English for Indians.* Unpublished Master's Dissertation, University of Mysore, Mysore.

UNICEF Research project by RRTC and AYJNIHH. (1990). *Development and standardization of language and articulation tests in seven different languages.*

Vandana, S. (1998). *Speech identification test For Kannada speaking children.* Unpublished Independent project, University of Mysore, Mysore.

Wang, N. M., Wu, C. M., & Kirk, K. I. (2010). Lexical effects on spoken word recognition performance among Mandarin speaking children with normal hearing and cochlear implants. *International Journal of Pediatric Otorhinolaryngology, 74,* 883-890.

Yang, H. M., & Wu, J. L. (2005). Mandarin Lexical Neighborhood Test (M-LNT) for pre-school children: development of test and its validation, *Journal of Taiwan Otolaryngology-Head and Neck Surgery, 40*(1), 1-12.

Yuen, K. C., Ng, I. H., Luk, B. P., Chan, S. K., Chan, S. C., Kwok, I. C., Yu, H.C. et al. (2008). The development of Cantonese Lexical Neighborhood Test - a pilot study. *International Journal of Pediatric Otorhinolaryngology, 72,* 1121-1129.