# LEXICAL NEIGHBOURHOOD TEST FOR CHILDREN IN MALAYALAM

# (LNT- M)

Nayana P V

**Student Registration No.**

**16AUD016**

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**University of Mysore, Mysuru**

**ALL INDIA INSTITUTE OF SPEECH AND HEARING**

**Manasagangothri Mysuru – 570006**

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# CERTIFICATE

This is to certify that this dissertation entitled **'Lexical Neighbourhood Test for Children in Malayalam (LNT- M)'** is the bonafide work submitted as a part of fulfilment for the Degree of Master of Science (Audiology) of the student with Registration No: **16AUD016**. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru
April 2018

**Dr. S. R. Savithri**
**Director**
All India Institute of Speech and Hearing,
Manasagangothri, Mysuru- 570006.

## CERTIFICATE

This is to certify that this dissertation entitled **'Lexical Neighbourhood Test for Children in Malayalam (LNT- M)'** has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru
April 2018

**Dr. Asha Yathiraj**
**Guide**
Professor of Audiology,
Department of Audiology,
All India Institute of Speech and Hearing,
Manasagangothri, Mysuru- 570006.

## DECLARATION

This is to certify that this Master's dissertation entitled **'Lexical Neighbourhood Test for Children in Malayalam (LNT- M)'** is the result of my own study under the guidance of Dr. Asha Yathiraj, Professor of Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier in other University for the award of any Diploma or Degree.

Mysuru **Register No: 16AUD016**

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**Dedicated to**

**My Amma, Achan, Appu, Reshli**

**&**

**My Family members**

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# ABSTRACT

**Aim:** The aim of the study was to develop a Lexical Neighbourhood Test for children in Malayalam (LNT-M) and validate the same on typically developing children as well as children with hearing impairment using hearing aids and cochlear implants. The study also aimed to check the effect of type of words (easy & hard words), age, and the equivalency of two lists developed.

**Method:** The LNT-M was developed based on the frequency of occurrence of words and lexical density. Two lists were developed with 40 words in each having 20 lexically easy and 20 lexically hard words. The developed material was validated on 30 typically developing children aged 6 to 8 years, categorized into two age groups (≥ 6 years to < 7 years & ≥ 7 years to < 8 years). The LNT-M was also validated on children with hearing impairment, 10 using hearing aids and 6 using cochlear implants.

**Results:** Significantly higher scores were obtained for lexically easy words than lexically hard words in the typically developing children and in the two groups having hearing impairment. The two age groups within the typically developing children performed equally well in both lexically easy words and hard words for word scores and phoneme scores. Inter-list equivalency was also established between the two lists developed, both for word scores as well as for phoneme scores. Additionally, the comparison of typically developing children with children with hearing impairment (using hearing aids / cochlear implants) indicated that the former groups obtained significantly higher performance on the lexically easy words as well as hard words for word scores and phoneme scores. However, the performance of the children with hearing impairment using hearing aids did not differ significantly from children using cochlear implants.

**Conclusion:** The newly developed Lexical Neighborhood test in Malayalam allows investigation of the perceptual processes underlying spoken word recognition of lexically easy and hard words. Both the lists of the test can be used interchangeably to measure spoken word recognition in individuals above the age of 6 years.

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# INTRODUCTION

Speech audiometry is routinely carried out complementary to pure-tone audiometry to determine speech perception abilities. Speech audiometry has been considered to have the added advantage of providing information about everyday listening unlike pure-tones. Hence, measuring the ability to perceive speech is considered to gives a clinician a clearer picture of a patient's functional hearing ability. Speech audiometric tests have been mainly developed to establish the speech identification abilities of individuals for diagnostic purposes (Katz, 2002; Silman & Silverman, 1997). Additionally, speech identification tests have been used for selecting or establishing the utility of listening devices (Eisenberg, 2017; Geers & Moog, 1991; Geers, Nicholas, & Sedey, 2003).

It has been reported that speech perception material should be linguistically appropriate for children (Kirk, Gifford, & Uhler, 2017). It neither should be too easy nor too difficult. It is also suggested that a comprehensive speech perception test battery should be capable of evaluating hierarchal skills (Thibodeau, 2007; Tyler, 1994). A number of tests are available for speech audiometry in the selection of listening devices. The difficulty level of the tests has been designed to cater to children in different age groups or having different language levels. The Ling's 6-sound (Ling, 1989) has been recommended to be used in young children with hearing impairment as young as 2 years. The closed-set speech perception tests such as the 'Early speech perception test' (Geers & Moog, 1991) has been utilised in children with hearing impairment aged below 5 years of age with limited vocabulary. For children with relatively more vocabulary, higher level closed-set tests such as 'North-Western University Children's Perception of Speech' test (Elliot & Katz, 1980) and the ‘Word Intelligibility by Picture Identification’ test (Ross & Lerman, 1970) have been suggested. Open-set tests, that are void of visual based cues, are considered more difficult than closed-set tests due to the non-availability of additional cues thorough other modalities. One such open-set test used for children is the ‘Phonetically Balanced Kindergarten word test’ (Haskins, 1949). This test was reported to often yield poor scores as it demands large vocabulary in the children with hearing impairment (Staller, 1991). Sentences tests for children such as the Bamford-Kowal-Bench (Bench, Kowal, & Bamford, 1979), are reported to require much higher linguistic and spoken recognition abilities (Eisenberg, 2017).

The traditional open-set tests are known to provide descriptive information on spoken word recognition but give less information on the underlying perceptual process that support spoken word recognition. To overcome this problem, two tests were developed to provide such information. These included the Lexical neighbourhood test - LNT (Kirk, Pisoni, & Osberger, 1995) and the Multi syllable lexical neighbourhood test- MLNT (Kirk et al., 1995) with the theoretical support of ‘Neighbourhood Activation model' (Luce & Pisoni, 1998). The ‘Neighbourhood activation model’ describes the processes by which a stimulus word is identified in the context of phonetically similar words activated in memory. These tests were developed to asses spoken word recognition for children with hearing impairment using cochlear implants or hearing aids who exhibited varying speech perception abilities (Kirk, Eisenberg, Martinez, & McCutcheon, 1999). The tests were constructed based on word frequency of occurrence (number of times a word appears in a particular language) and lexical density (number of words that are phonetically similar to the target word). The words with more lexical neighbourhoods are termed as having a ‘dense lexical neighbourhood’ and words with less lexical neighbourhoods are termed as having a ‘sparse lexical neighbourhood’. Based on these two predominant aspects, words were categorized as ‘lexically easy’ (words with high frequency of occurrence having sparse lexical neighbourhood) and ‘lexically hard’ (words with low frequency of occurrence having less lexical neighbourhood) (Luce & Pisoni, 1998). This was considered to give information on organization of sound pattern of words in the lexicon of young children and the processes used to access the patterns in traditional speech identification tests (Kirk et al., 1995). Studies have shown that performance with LNT and MLNT have highly correlated with the other conventional measures of spoken word recognition and spoken language processing in children with cochlear implant. The tests were also found to provide reliable measures of spoken word recognition abilities of children with hearing impairment using cochlear implant (Geers et al., 2003; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000).

The Lexical neighbourhood test is available in various languages including Mandarin (Yang, Wu, Lin, & Lin, 2004), Cantonese (Yuen et al., 2008), and Chinese (Liu et al., 2011). This has also been developed in Indian English (Patro & Yathiraj, 2009- 10), Hindi (Singh, 2010), Kannada (Apoorva & Yathiraj, 2011-12) and Telugu (Chandekar & Yathiraj, 2015).

## 1.1 Need for the study

As speech is the most common and important signal that is used for communication, speech audiometry is considered as a part of routine audiometric evaluation. Speech identification tests are especially essential when selecting listening devices for individuals with hearing impairment. Such speech tests are also required while establishing the utility of selected listening devices over a period of time. This will enable manipulation of the parameters of the listening devices to maximise speech perception. While evaluating children, it is necessary to have a hierarchy of tests that can test the listening abilities of children with varying levels of speech and language functioning. Thus, speech identification tests useful for one age group may not be useful for another age group, especially those with different levels of language development. Hence, it is necessary to develop and validate material appropriate for children having different language levels. A test that is relatively more difficult than the typically used closed-set tests such North Western University Children's perception of Speech, Word Intelligibility by Picture Identification Test, but easier than open set tests such as Phonetically Balanced Kindergarten Word List would be useful for children who find the former group of tests easy but find the latter too difficult. Such a test would have a moderate level of difficulty (Wilson, 2008). The LNT for children developed by Kirk et al. (1995) is one such speech identification test that meets this requirement. This test is considered useful to evaluate the auditory perceptual difficulty of children with hearing impairment before administering a phonetically balanced word test that is considered as a relatively more difficult test (Gelfand, 2007).

Further, speech material developed in one language cannot be utilized in another language. Hence, having validated speech material in the native language of children is essential while doing speech audiometry. As India is a multilingual country, developing material in different Indian languages is necessary while administering speech audiometry. Although LNT is available in other Indian languages like Indian-English (Patro & Yathiraj, 2009-10), Hindi (Singh, 2010), Kannada (Apoorva & Yathiraj, 2011-12) and Telugu (Chandekar & Yathiraj, 2015), there is no such test in Malayalam. Kerala has active cochlear implant programs, both in the private and government sectors. LNT in Malayalam would be useful in assessing the outcome of these children. Therefore, there is a need to develop a test similar to the LNT given by Kirk et al. (1995), for children in Malayalam.

## 1.2 Aim of the study

The study aimed to develop a speech identification test in Malayalam for children aged 6 to 8 years, similar to the Lexical neighbourhood test developed by Kirk et al. (1995). The study also aimed to validate the developed test on typically developing children and children with hearing impairment using listening devices (hearing aids & cochlear implants).

## 1.3 Objectives of the study

The objectives of the study are as follows:

- Develop a speech identification test in Malayalam for children above the age of 6 years, similar to the Lexical neighbourhood test developed by Kirk et al. (1995).
- Validate the newly developed Lexical Neighbourhood test in Malayalam (LNT-M) on typically developing children aged ≥ 6 to < 7 years and ≥ 7 to 8 years who are exposed to Malayalam from early childhood.
- Study the effect of age of the participants on the test scores in typically developing children.
- To evaluate the equivalence of the different lists of LNT-M, separately for the easy words and hard words, in typically developing children.
- Validate the newly developed lexical neighbourhood test in Malayalam on children with hearing impairment (children using hearing aid and children using cochlear implant) who are exposed to Malayalam from early childhood.
- Compare the scores of the easy and hard words within each group (typically developing, children with hearing impairment using hearing aid & children with hearing impairment using cochlear implant).

- Compare the scores of the easy and hard words between the groups (typically developing vs. children with hearing impairment using hearing aids; typically developing children vs. children with hearing impairment using cochlear implant; & children with hearing impairment using hearing aids vs. children with hearing impairment using cochlear implants).

# Chapter 2

## REVIEW OF LITERATURE

Spoken word recognition scores are known to give valid information regarding listening skills (Eisenberg, Martinez, & Holowecky, 2002). The spoken word recognition tests used in clinical practice for children are either closed-set (Begum, 2000; Geers & Moog, 1991; Kant, 2003; Mathew, 1996; Prakash, 1999; Ross & Lerman, 1970; Vandana, 1998), or open-set (Apoorva & Yathiraj, 2011-12; Bench et al., 1979; Chandekar & Yathiraj, 2015; Haskins, 1949; Kirk et al., 1995; Patro & Yathiraj, 2009-10; Singh, 2010). Each of these categories of tests has been noted to have specific utility.

Closed-set tests have been observed to have the advantage of ease of administration, rapid and reliable scoring with limited trails (Gelfand, 2007). Further, closed-set tests have been recommended to be used on those who score less on open-set tests due to their limited vocabulary. However, closed-set responses are known to result in responses that may be due to a 'chance factor', unlike what happens in open-set responses. This is noted to occur as closed-set tests have fewer options and hence have less competition between alternatives. In contrast, open-set tests are reported to have a much larger lexical competition at the level of whole mental lexicon (Kirk et al., 1999). Clopper, Pisoni and Tierney (2006) found open-set responses of tests of speech perception to have a direct positive correlation with the lexical competition and the talker variability, unlike conventional closed-set tests. It was concluded that closed-set tests of spoken word recognition lacked validity because they do not truly assess the word recognition processes that they were designed to measure. Thus, despite closed-set tests having several advantages, open-set tests have been recommended to be used to obtain a true representation of an individual's speech perception.

One of the most extensively accepted open-set tests to measure spoken word recognition in children with hearing loss is the 'Phonetically Balanced Kindergarten word test' (PB-K) developed by Haskins (1949). Phonetic balancing was considered to be important, as it was assumed that a speech perception test should consist of all the speech sounds of the language (Kirk et al., 1999). However, earlier it has been suggested that phonetic balancing need not be a predominant factor in a spoken word recognition test (Carhart, 1965). Other non-auditory considerations such as age of the subject or language level have also been considered to influence the performance of spoken word recognition (Eisenberg et al., 2002; Kirk et al., 1995).

More recently, it has been found that children with hearing impairment using listening devices scored relatively poor on PB-K (Eisenberg et al., 2002). Staller (1991) found comparatively low scores (11%) on PB-K when administered on 28 children with two years of experience with cochlear implants. Similar findings were reported by Fryauf-Bertschy et al. (1997). They reported that 34 children with pre-lingually hearing impairment using cochlear implants obtained scores less than 20% on the PB-K, except one child who scored 35%. It was speculated that the reason why children with hearing impairment using listening devices scored poorly on the PB-K could be due to their limited vocabulary as the test only focuses on the phonetic balancing and not the familiarity of the words.

In order to overcome the above mentioned limitations of PB-K, the Lexical Neighbourhood Test (LNT) and the Multisyllabic Lexical Neighbourhood Test (MLNT) were developed to assess open-set speech perception in children using cochlear implants (Kirk et al., 1995). LNT and MLNT were constructed based on two main criteria i.e., lexical density and word frequency. The tests were developed based on the neighbourhood activation model.

### 2.1 Neighbourhood Activation Model

The Neighbourhood Activation Model (Luce & Pisoni, 1998) mainly accounts for how the spoken word recognition occurs through the sound pattern in memory. According to this model, whenever a stimulus is presented, a set of acoustic patterns similar to that of the presented word get activated in memory. The activation level of this particular process is reported to be directly proportional to the familiarity of the particular word to the listener. Soon after this activation stage, lexical selection is reported to occur. Under the lexical selection process, the chance of each word chosen is calculated and the process of word recognition occurs in the final stage (Luce & Pisoni, 1998).

According to the Neighbourhood Activation Model, higher the number of acoustic-phonetic patterns activation in memory by the stimulus input, slower will be the processing and reduction of identification accuracy. Further, word frequency was found to have a positive correlation on the nature and number of similar words activated in memory that is not intrinsic to the activation levels of the acoustic-phonetic patterns (Luce & Pisoni, 1998).

As per the Neighbourhood Activation Model, the lexical neighbourhood of a particular word is formed by deletion, omission or substitution of a phoneme from the given word (Luce & Pisoni, 1998). The process of lexical activation provides all possible syllables or phonemes from these lexical neighbourhoods for the target word. Luce and Pisoni (1998) have reported that those words with minimal lexical neighbourhood were recognized easier and faster in the lexical decision than the word with dense lexical neighbourhood. Similar lexical effects have been established in children with hearing impairment using listening device (Kirk et al., 1995).

The Neighbourhood Activation Model is also reported to provide information on word recognition and lexical access. This was noted to offer a clear picture about how children with hearing loss retrieve spoken words from their long term memory and not just the descriptive information on the outcome of listening devices (Kirk et al., 1995).

The Lexical neighbourhood test and Multisyllable Lexical Neighbourhood Test (Kirk et al., 1995) were developed under the principle of Neighbourhood Activation Model- NAM (Luce & Pisoni, 1998). The tests have been developed based on two parameters, frequency of occurrence of words and lexical density. All stimuli on the LNT and MLNT were taken from the vocabulary of children aged 3 to 5 years, thus reflects the early acquired vocabulary.

## 2.2 Lexical factors influencing spoken word recognition

Lexical factors have been considered to constitute several aspects that include word familiarity, phonological similarity, age of word acquisition and word occurrence frequency as the lexical factors affecting spoken word recognition (Goldinger, 1996). In the construction of the LNT and MNLT, besides word familiarity, the frequency of occurrence of words as well as the lexical density have been considered.

**2.2.1 Word Frequency effects.** The effect of word frequency on spoken word recognition has been found to be an important parameter as they assumed to influence the activation levels of acoustic phonetic representation in the mental lexicon (Kirk et al., 1999). Luce and Pisoni (1998) investigated the independent effect of word frequency on spoken word recognition in support with the

Neighbourhood activation model (NAM). Ninety native English-speaking young adults were recruited in the study for to check the effect of word familiarity. It was concluded that word frequency was one of the most powerful single predictors of word recognition performance. It was assumed that the number of words that must be discriminated among in memory would affect the accuracy and time-course of word recognition. It was also hypothesized that the frequencies of the words activated in memory would affect decision processes responsible for choosing among the activated words. Opined that the word frequency effect may be also be influenced by neighbourhood frequency and similarity, and not a simple direct function of the number of times the stimulus word was encountered.

Johns, Gruenenfeldera, Pisoni, and Jones (2012) evaluated the word frequency effect on 192 young adults in an open-set task. A significant correlation was established between spoken word recognition and word frequency in isolation. Less frequently occurring words were reported to be poor when compared to the performance on more frequently occurring words, when the words were tested in isolation.

Krull, Choi, Kirk, Prusick, and French (2011) evaluated the effect of frequency of occurrence of words on 24 typically developing children aged 5 to 12 years. They established a significant effect of word frequency on spoken word recognition in children. It was also found that in word isolation context, the high frequently occurring words were better identified than the less frequently occurring words. However, when it was evaluated in sentences, word frequency was not found to influence speech identification.

**2.2.2 Lexical Density Effects.** Lexical density is a predominant factor which is considered to influence spoken word recognition. It has been reported that 'density onset' plays a major role in the lexical density effect on spoken word recognition.

Thus, words that have less number of similar initial phonemes in comparison to the target words (sparse onset) are observed to be perceived better and with higher accuracy than the words with higher number of similar initial phonemes (dense onset) according to Jusczyk and Luce (1994).

It has also been reported that the accuracy and the speed of spoken word recognition depends upon the number of similar sounds activated during the process of spoken word recognition. The words with sparse neighbourhood were found to be recognised much easier than words with dense neighbourhoods (Kirk et al., 1999; Luce & Pisoni, 1998).

Vitevitch and Luce (1998) evaluated the effect of two types of words on 30 native English speaking adults. While one type of word had high probability phonotactic patterns with high neighbourhood density, the other type of words had low phonotactic patterns with low neighbourhood density. Both monosyllabic real words and non-words were used in the study. It was found that for monosyllabic real words with dense neighborhood, the participants responded more slowly than to words with in sparse neighborhoods, despite the fact that the stimuli occurring in dense neighborhoods were composed of high-probability segments and sequences of segments. However, the participants responded to monosyllabic non-words more quickly when they consisted of high-probability phonotactic patterns, despite the fact that they occurred in high-density neighborhoods.

With the aim of checking the effect of lexical effect on spoken word recognition on two test conditions (i.e., auditory shadowing and auditory lexical decision), Vitevitch (2008) studied 18 younger adults. It was found that words with few neighbours that shared the initial phoneme with the target word (i.e., sparse onset) were repeated more quickly than words with many neighbours that shared the initial phoneme with the target word (i.e., dense onset).

The neighbourhood-density effect on spoken word recognition was tested on 9 month old infants by Jusczyk and Luce (1994). They found the infants to demonstrate a listening preference for non-words, which had low phonotactic probabilities compared to the non–words, which had high phonotatctic probabilities. The low phonotactic non-words were considered to have sparse density, while words with high phonotactic probability were considered to have dense neighbourhoods.

Sommers and Danielson (1999) demonstrated the relation between the lexical neighbourhood density and the spoken word recognition in normal hearing elderly adults. Likewise, Kirk, Hay-McCutcheon, Sehgal, and Miyamoto (2000) found a similar relation between lexical neighbourhood density and spoken word recognition in children with hearing impairment who use cochlear implants.

**2.2.3 Combined effect of word frequency and lexical density.** It is reported that the lexical density effects are distinct from the effects of frequency on spoken word recognition. However the interaction between the word frequency and lexical density are assumed to have a significant influence on spoken word recognition which supports the Neighbourhood Activation model (Luce & Pisoni, 1998). They made this conclusion based on earlier studies (Jusczyk & Luce, 1994; Kirk et al., 1995; Vitevitch & Luce, 1998).

Kirk et al. (1995) examined the effect of both lexical density and word frequency on spoken word recognition in sentence context for children. The results found were in support with the Neighbourhood Activation model i.e., both lexical factors had a major influence on spoken word recognition in typically developing children.

The combined effect of frequency of occurrence of words and the lexical density have been investigated to check how individuals perform on 'easy' and 'hard' words. Luce and Pisoni (1998) described 'easy' words as those that occurred frequently and had sparse density, while ‘hard’ words as those that did not occur frequently and had dense density.

Using such words, a significant correlation was found between spoken word recognition for isolated word stimuli as well as sentences with the effect of lexical density and the frequency of occurrence of words by Krull et al. (2011). They investigated the independent effect of word frequency and lexical density on 24 typically developing children aged 5 to 12 years. It was ensured during the evaluation that that the key words within a sentence belonged to one of the four following lexical categories: (1) high-frequency sparse, (2) low-frequency dense, (3) high-frequency dense and (4) low-frequency sparse. They found that there were significant main effects of word frequency and lexical density as well as a significant interaction between the two lexical factors. In isolation, high-frequency words were recognized more accurately than low-frequency words. However, the sparse density words obtained higher scores in spoken word recognition irrespective of the word frequency presented both in isolation and sentence context.

Several studies have concluded that the combined effect of word frequency and lexical effect has a significant effect on the performance of spoken word recognition than the independent impact of the same (Kirk et al., 2017; Krull et al., 2011; Liu et al., 2011; Luce & Pisoni, 1998). The combined effect of word frequency and lexical density are capable of explaining the role of lexically easy and lexically hard words. These lexical components (lexically easy and hard words) are assumed to have an impact on spoken word recognition which accounts for Neighbourhood activation model (Luce & Pisoni, 1998).

**2.2.4 Age of participants.** Word frequency and neighborhood density are reported to exert significant influences on spoken word recognition. The age of the participant is found to serve as a co-variant on the impact on spoken word recognition

(Liu et al., 2011). It has been reported that the older children are likely to obtain higher scores than the younger children. This was attributed to the larger vocabulary present in older children who were capable of distinguishing the target word easily from the competitors at the activation level. In contrast, the younger children with limited vocabulary were found to use the broad phonetic categories to differentiate between the target words from the competitor making the task difficult for them (Eisenberg et al., 2002; Kirk et al., 1995).

Liu et al. (2011) validated the standardised Lexical neighbourhood test on 96 typically developing children aged 4 to 7 years grouped into three (4 to 4.11 years, 5 to 5.11 years, & 6 to 6.11 years) with the aim of checking the age effect on spoken word recognition. It was noted that all the 3 groups did not differ significantly with effect of age. They attributed this to the ceiling effect in children and the procedural difference in developing the Chinese lexical neighbourhood test material, as they chose the words from the vocabulary of children aged 3 to 5 years.

Further, the effect of lexical factors and age on spoken word recognition was investigated on 213 normal hearing children aged 3 to 6 years by Ren et al. (2015). The children, grouped into three age groups (3 to 3.11 years, 4 to 4.11 years & 5 to 6 years), were tested in quiet and in the presence of noise using a Chinese version of LNT (Liu et al., 2011). The children were evaluated using the four categories of the test (dissyllabic easy, dissyllabic hard, monosyllable easy & monosyllabic hard). Higher scores were obtained for the disyllabic words than the monosyllabic words. Additionally, the scores were higher for easy words when compared to the hard words across all the lists. Also, the scores obtained by children in the quiet condition was higher for disyllabic easy words (85.4%), followed by the disyllabic hard words (65.9%), monosyllabic easy (71.7%) words and monosyllabic hard (54.2%) words. They reported of an age effect on the spoken word recognition, especially in the presence of noise. The younger children obtained significantly poorer scores when compared to the older children. This was attributed to the limited vocabulary of the younger age group.

In an Indian study by Patro & Yathiraj (2009-10), LNT developed in Indian-English was administered on 30 typically developing children grouped into two age groups (6 to 6.11 & 7 to 8 years). Significantly better scores were obtained by the older children than the younger children. They established a positive correlation between the age and the performance in spoken word recognition.

Unlike the earlier studies, Apoorva & Yathiraj (2011-12) found that their 30 typically developing children, grouped into two age groups (6 to 6.11 years & 7 to 8 years) demonstrated no age effect on the LNT in Kannada. Both the age groups yielded similar results for lexically easy and hard words. The authors attributed this to a ceiling effect as the vocabulary was that of the younger age group.

From the above, it can be seen that the majority of the studies indicate that age of the participants is an important factor in deciding the spoken word recognition performance. Lexical density and the word frequency are reported to be directly correlating with age. However, it was also noted in a few studies that ceiling effect of lexical skills could also could occur where there is no improvement in performance with increase in age.

## 2.3 Performance of typically developing children vs. children with hearing impairment on LNT

Lexical characteristics on the spoken word recognition performances are reported to be different in individuals with hearing impairment. This has been demonstrated in many studies done over the years to check the interaction between the lexical factors in children with hearing impairment and compare them with typically developing children (Apoorva & Yathiraj, 2011-12; Eisenberg et al., 2002; Kirk et al., 1995; Patro & Yathiraj, 2009-10; Singh, 2010).

Kirk et al. (1995) investigated spoken word recognition in children with hearing impairment using cochlear implant (who demonstrated some amount of open word speech recognition) using the open-set and closed-set responses. They reported that high performances were obtained for open-set word recognition with lexically easy words compared to lexically hard words. On the other hand, closed-set responses did not elicit the effect of lexical difficulty. It was also noted that word recognition was better for multisyllabic than for monosyllabic stimuli. Thus, they concluded that pediatric cochlear implant user is sensitive to the acoustic-phonetic similarities among words, that they organize words into similarity neighborhoods in long-term memory, and that they use this structural information in recognizing isolated words. Therefore, they recommended the use of open-set responses when testing with of speech perception reported to be the comprehensive tool to assess the perceptual operations.

Eisenberg et al. (2002) investigated the effect of spoken word recognition on 48 typically developing children aged 5 to 14 years. Among them 12 were typically developing children and 12 were children with hearing impairment using cochlear implants. The words were presented in isolation and in a sentence context. The sentence context material contained two sentence lists constructed on the principles of neighbourhood activation model, with one list being lexically easy and the other being lexically hard. They found that the lexically easy words were identified quickly with better accuracy than the lexically hard words. This was attributed to the strong positive correlation of word frequency to the acoustic phonetic properties of other words. The typically developing children and nine high-performing children with cochlea implant performed better with sentences compared to words, whereas the three low performing children with cochlear implant performed better on the word task compared to sentence task. There was also a significant correlation between the language age of the children and the performance scores.

A comparison was done between 30 typically developing children and five children with hearing impairment using hearing aid using the LNT in Indian-English (Patro & Yathiraj, 2009-10). A significant difference in the performance on both the list for easy and hard words was found although the language ages of the two groups were matched. The typically developing children obtained significantly better scores than the children with hearing impairment using hearing aid. The poorer performance of the children with hearing impairment when compared to the typically developing children was ascribed to the limited utility of the listening devices worn by the former group.

Similarly, Apoorva & Yathiraj (2011-12) evaluated the performance of 30 typically developing children with 6 children with hearing impairment wearing cochlear implants using the Kannada LNT. They too observed results that were consistent with the previous studies which compared the spoken word recognition scores between typically developing children with the children with hearing impairment.

### 2.4 LNT developed in other languages

Apart from the Lexical neighbourhood Test and Multi syllabic lexical neighbourhood test developed by Kirk et al (1995), several other authors have developed tests based on the principle of the neighbourhood activation model (Apoorva & Yathiraj, 2011-12; Chandekar & Yathiraj, 2015; Liu et al., 2011; Patro & Yathiraj, 2009-10; Singh, 2010; Yang & Kirk, 2016; Yuen et al., 2008). These tests have been described below.

The Mandarin LNT was developed to have eight lists with 25 monosyllable words in each. The developed test material contained four lists with lexically easy and the other four with were lexically hard words. The developed test material was also validated on 80 typically developing children and 24 children with hearing impairment using cochlear implant. They have also noted that the Mandarin speaking children with hearing impairment using cochlear implant were sensitive to the acoustic phonetic similarities among lexical words and could organize words into similarity neighbourhoods in long term memory (Yang et al., 2004).

Later, LNT in Cantonese was developed based on the Neighbourhood Activation model. Six monosyllabic and disyllabic word lists were constructed with equal number of lexically easy and hard word. The developed test material consisted of 25 words.  Higher performance was obtained with disyllabic words with lexically easy words compared to the lexically hard disyllables words, a consistent with the findings of other studies. However the monosyllabic words did not exhibit a difference in scores between the easy and hard words, which did not correlate with the Neighbourhood activation model and previous studies (Yuen et al., 2008).

Liu et al. (2011) developed the LNT in Chinese to have six lists of monosyllabic and disyllabic words. Each list had equal number of lexically hard and lexically easy words, with the total number of words per list being 20.  The developed test was validated on 96 children aged 3 to 5 years. The noted a lexical effect in support with the Neighbourhood activation model. The children were reported to have better performed with the disyllabic words than the monosyllabic words. The authors attributed this to the larger redundant cues present in the disyllabic stimuli than in the monosyllabic stimuli.

LNT has also developed and validated in Indian languages such as  Indian-English (Patro & Yathiraj, 2009-10), Hindi (Singh, 2010), Kannada (Apoorva &

Yathiraj, 2011-12) and Telugu (Chandekar & Yathiraj, 2015). Patro & Yathiraj (2009-10) developed two lists of LNT in Indian-English, each having 20 hard words and 20 easy words. The recorded test material was administered on 30 typically developing children aged 6 to 8 years and five children with hearing impairment using digital hearing aids. They evaluated the effect of age on spoken word recognition by grouping the participants into two (6 to 6.11 years & 7 to 8 years). They noted a developmental trend with reference to the performance on easy and hard lexical words, with the older group performing better than the younger group. The authors have concluded that there was a significant effect of lexical properties on individuals with normal hearing. The lexically easy words were reported to be better perceived than lexically hard words. The inter-list equivalency was also checked and reported to similar for both typically developing children and children with hearing impairment.

Singh (2010) has constructed LNT in Hindi with two lists of 40 words in each list. One list included easy words and the other list included hard words. They validated the developed material lists on 30 typically developing children and seven children with mild to moderate hearing loss using hearing aids. A significantly higher score was reported for typically developing children in lexically easy and lexically hard words when compared to the children with hearing impairment using hearing aid.

LNT has been developed in Kannada with two lists of bisyllabic words with 20 easy and 20 hard words in a random order. The developed material was administered on 30 typically developing children and six children with hearing impairment using cochlear implant. There was no statistical significant difference found in two age groups in lexically easy and hard words on both word scores and phoneme scores. However, a significant effect of lexical difficulty was found on spoken word recognition between the typically developing children and children with hearing impairment using cochlear implant (Apoorva & Yathiraj, 2011-12).

Chandekar & Yathiraj (2015) developed lexical neighbourhood test in Telugu with two list of words each consisting of 40 words with 20 easy and 20 hard words. The test was validated on 30 typically developing children aged 6 to 8 years who spoke Telugu fluently from the early childhood. They also established inter-list equivalency between the two lists. The results indicated that the there was a significant better performance with the easy words than with the hard words in both the lists. Both word scoring and phoneme scoring was done during the validation of the developed material. It was found that the overall word recognition scores were poorer than the phoneme scores. The authors attributed this finding to the difference in scoring procedure (as the single phoneme error present in a particular word resulted in $1/4^{th}$ or $1/3^{rd}$ of the phoneme being scored wrong. On the other hand, a whole was marked wrong with just one phoneme error. However, there was a positive correlation established between the word scoring and the phoneme scoring.

From the review of literature, it can be seen that the Lexical neighbourhood test has been used by several authors an open-set spoken recognition test. The test has been used to compare the performance of children with hearing impairment using listening devices with typically developing children. The tests developed in different languages have majorly utilized monosyllabic words, with a few tests being developed with disyllabic words. In all the tests developed, lexical density and word frequency were reported to influence spoken word recognition, supporting the Neighbourhood activation model.

# Chapter 3

# METHODS

The study was undertaken in two phases. In the first phase, the 'Lexical neighbourhood test in Malayalam' (LNT-M) was developed for children in the age range of 6 to 8 years. In the second phase, the developed test material was validated on typically developing children as well as two groups of children with hearing impairment, one using hearing aids and the other using cochlear implants.

## 3.1 Participants

To develop the test material, five normal hearing adults were selected, who were exposed to Malayalam from the early childhood and spoke the language fluently. Among these adults, one was a regular school teacher, two were special educators and two were parents of typically developing young children. These adults were required to prepare a list of words that they considered in the vocabulary and were familiar to children aged 6 years. These adults were also employed in part of the construction of the test (listing out the lexical neighbours). Additionally, ten typically developing children aged 6 years, who were exposed to and spoke Malayalam from early childhood, were employed to check the familiarity of the material. Five adults, fluent in Malayalam, who were not included in the initial part of the development of the material, were utilised to carry out a goodness test of the recorded material.

The developed test material was validated on 30 typically developing children who were aged ≥ 6 years to < 8 years. The typically developing children was grouped into two ages (≥ 6 to 7 years & ≥ 7 to < 8 years), with each age group having 15 participants. Additionally, 16 children with hearing impairment were also used to validate the material, ten using hearing aid and 6 using cochlear implant. All the participants taken in this study were exposed to Malayalam from early childhood.

The typically developing children had air conduction and bone conduction thresholds within 15 dB HL across the frequencies 250 Hz to 8 kHz and 250 Hz to 4 kHz respectively. Their speech identification scores were greater than 90% at 40 dB SL (Ref. PTA) in both ears on the 'Picture perception of speech perception in Malayalam for children' (Mathew, 1996). They had A-type tympanogram with ipsilateral acoustic reflexes present at frequencies 500 Hz, 1 kHz and 2 kHz in both ears. They also had no history of any speech, language, hearing, neurological, or psychological problems. To rule out the presence of an auditory processing problem, the children were required to pass the 'Screening checklist for Central Auditory Processing' (Yathiraj & Mascarenhas, 2004).

The children with hearing impairment had bilateral severe to profound sensorineural hearing loss with the minimum language age of 6 years. It was also ensured that they had used listening devices, prescribed by audiologists, for at least 2 years with their aided warble thresholds being within the speech spectrum. Only those participants who either wore binaural digital hearing aids or bimodal cochlear implants with stable maps were selected. All the participants were required to have minimal or no misarticulation, based on their performance on the Malayalam Articulation test (Maya, 1989).

### 3.2 Instrumentation

A calibrated dual channel diagnostic audiometer (Maico 53) with headphones (TDH 39 with MX 41/AR ear cushion), bone conduction vibrator (Radio ear B 71), and sound field speakers were used to select the participants and to administer the newly developed test. An immittance meter (Grason Stadler Tympstar) was used to rule out the presence of any middle ear problem. A personal computer having Adobe audition (version 3.0) software installed with Motu Microbook II external sound card interface and Behringer B-2 Pro dual diaphragm condenser microphone were used to record and to carry out the speech tests.

### 3.3 Test environment

The familiarity of the material was checked in quiet rooms, free from visual distractions. All the other audiological tests were carried out in a sound treated double room with recommended signal to level ratio maintained as per ANSI S3.1-1999-R2013 (American National Standard Institute, 1999).

### 3.4 Procedure

The procedure for the study involved the development of the LNT-M and validation of the same. The procedure for validation for each of the participant groups (typically developing & children with hearing impairment using hearing aid & cochlear implant) was done separately.

**3.4.1 Procedure for the development of the LNT-M.** To develop the material, initially 400 bisyllabic words were selected from story books and school text books meant of children aged 6 to 8 years. Bisyllabic words were chosen as very few monosyllabic words were in the vocabulary of children. Words were also obtained from caregivers of children in the above age range.

The *familiarity of the material* was checked on ten children aged 6 years. The children were instructed to describe the meaning of each word either orally or through actions. Words that were described meaningfully by at least 80% of the participants were shortlisted as being highly familiar. Additionally, five adults who were exposed to Malayalam from early childhood and spoke it fluently were instructed to shortlist the words that they thought would be present in the vocabulary of children aged 6 years. Of the initially selected 400 words, 326 were categorized as highly familiar words.

The *frequency of occurrence of words* were calculated by determining the number of times each of the 326 familiar words occurred in text books and story books meant for children aged 6 to 8 years. The selected books had 504 pages containing approximately 28499 words, with equal number of pages from story books (252 pages) and text books (252 pages). Among the 326 words, 163 words were found to have a frequency of occurrence of 21 and more and the other 163 words had a frequency of occurrence of less than 21. Thus, words that had a frequency of occurrence of ≥ 21 were categorized as 'frequently occurring' and those that had a frequency of occurrence of less than 21 were grouped as 'not frequently occurring'.

The *lexical density* of the 326 familiar words, classified as 'frequently occurring' and 'not frequently occurring', were checked. This was done by estimating the number of words that could be formed by adding, omitting, substituting one phoneme at a time from the target word. This was under taken by giving the task to five adults who were exposed to Malayalam from early childhood and spoke it fluently. Each adult was instructed to make as many lexical neighbours as possible for each familiar word. The responses of all the adults were pooled to classify the words as having sparse and dense neighbourhood. Words with less than 8 lexical neighbours were grouped as 'sparse' and those with more than 8 lexical neighbours were grouped as 'dense'. The familiar words were classified as 'lexically easy' and 'lexically hard' words based on the frequency of occurrence and lexical density. The 'lexically easy words' had more frequently occurring words with sparse neighbourhood and lexically hard words were those with less frequently occurring words with dense neighbourhood.

Finally, two bisyllabic word lists with 40 words in each list were developed. Each list had equal number of hard and easy words that were highly familiar to children aged 6 years. It was also ensured that List 1 and List 2 consisted of equal number of phonemes (164) with the easy words in each list having 85 phonemes and hard words having 79 phonemes. The hard and easy words were randomised within each list.

*Recording of LNT-M* was done by a fluent Malayalam speaker who has clear speech. The words were recorded by using Adobe audition (version 3.0) software installed in a personal computer with i7 processor connected to a Motu Microbook II external sound card interface. The recording was carried out with a condenser microphone (Behringer B-2 Pro) placed 15 cm (6 inches) from the mouth of the talker, using a sampling rate of 44.1 kHz and 16-bit resolution. The recorded material was edited and scaled to make sure that the average amplitude of all the words were similar. An inter-stimulus interval of 4 seconds was maintained between the words. The clarity of the recording was checked on 5 adults, who rated the words as being clear. A 1 kHz calibration tone was recorded before each of the word-lists.

**3.4.2 Procedure for the validation of LNT-M on typically developing children**. The 30 typically developing children who met the inclusion criteria were tested in a sound field set-up. The recorded LNT-M was played using Adobe audition (version 3) software installed in a computer. The output was routed through a dual channel diagnostic audiometer (Maico 53). The 1 kHz calibration tone, recorded prior to each list, was used to adjust the VU meter deflection of the audiometer to zero. The stimuli were presented through a loud speaker that was placed at $0^o$ azimuths and at 1 meter distance from the head of the listener. The stimuli were presented at 40 dB SL (Ref. PTA). The participants were asked to repeat the words. All participants were made to hear both lists, with half hearing the 1st list first and the other half hearing the 2nd list first, to avoid a list order effect. The responses were noted down and scored.

**3.4.3 Procedure for the validation of LNT-M onchildren with hearing loss using listening devices (Hearing aids / Cochlear implant).** The procedure to evaluate the children with hearing impairment was similar to that used to test the typically developing children. The children with hearing impairment who met the inclusion criteria were tested with them wearing their personal listening device/s. Those using cochlear implants were tested with the device set to the recommended map and with them wearing their recommended hearing aid programming in the non-implanted ear. Children using hearing aids were tested with them wearing binaural hearing aids at the recommended setting. The oral responses of the participants were noted down and scored. The misarticulation noted in the Malayalam Articulation Test was taken into consideration while scoring their responses.

### 3.5 Scoring

Both phoneme and word scores were calculated for each child. While calculating phoneme scores, every correctly identified phoneme was awarded a score of 'one' and every wrong phoneme a score of 'zero'. Likewise, for the word scores, each correctly identified words were given a score of 'one' and each incorrect response were scored 'zero'.

### 3.6 Statistical Analyses

The data obtained from the typically developing children, and children with hearing impairment using hearing aid and cochlear implants were analysed using Statistical Package for Social Sciences (Version 20.0). The Shapiro Wilks test indicated that the data were not normally distributed. Therefore, non-parametric tests were carried out. Descriptive and inferential statistics were done.

# Chapter 4

# RESULTS

The data obtained from the three groups of children (30 typically developing children, 10 hearing aid users, & 6 cochlear implant users) were subjected to within group analysis and between group analysis. The data obtained from the typically developing children were analyzed to establish the effect of age using a Mann-Whitney U test and the equivalence of lists was determined using Wilcoxon signed rank test. The differences between the three groups were analyzed using Kruskal-Wallis, followed by Mann-Whitney U test. All comparisons were done separately for the easy words, hard words and total word scores for each list using word scores as well as phoneme scores.

## 4.1 Comparison of scores across the age groups in the typically developing children

From the descriptive statistics given in Table 4.1 it can be seen that the mean and median *word scores* of the younger children (≥ 6 years to < 7 years) were only marginally poorer than the older children (≥ 7 to < 8 years). This was observed for the easy, hard and total scores for each of the lists. Similar results were also observed for the *phoneme scores*, as can be seen in Table 4.2.

To confirm whether these scores across the two age groups were significantly different, Mann-Whitney U test was performed. For the *word scores*, the output of the Mann-Whitney U test indicted that the two age groups did not differ significantly in List 1 for the easy word scores ($U$ = 97.50, $p > .05$, $r'$ = 0.14), hard word scores ($U$ = 94.50, $p > .05$, $r'$ = 0.15), and total word scores ($U$ = 94.5, $p > .05$, $r'$ = 0.15). Similarly, in List 2, the two age groups did not differ for the easy word scores ($U$ =

104, $p > .05$, $r' = 0.08$), hard word scores ($U = 105$, $p > .05$, $r' = 0.06$), and total word scores ($U = 90.50$, $p > .05$, $r' = 0.18$).

Table 4.1

*Mean, Median and Standard deviation (SD), Minimum (Min) and Maximum (Max) word scores (easy, hard, & total word scores) for the two age groups (separately & combined) among the typically developing children*

| **Age groups** | | **List 1** | | | **List 2** | | | **Lists 1+2** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **^Easy** | **^Hard** | **#Total** | **^Easy** | **^Hard** | **#Total** | **^Easy** | **^Hard** | **#Total** |
| ≥ 6 to 7 yrs N = 15 | Mean | 19.66 | 19.26 | 38.93 | 19.60 | 19.33 | 38.66 | 39.26 | 38.66 | 77.86 |
| | SD | 0.48 | 0.88 | 1.33 | 0.73 | 0.97 | 1.75 | 1.16 | 1.75 | 2.89 |
| | Median | 20 | 20 | 40 | 20 | 20 | 40 | 40 | 39 | 79 |
| | Min | 19 | 18 | 37 | 18 | 17 | 35 | 37 | 35 | 72 |
| | Max | 20 | 20 | 40 | 20 | 20 | 40 | 40 | 40 | 80 |
| ≥ 7 to < 8 yrs N = 15 | Mean | 19.80 | 19.53 | 39.33 | 19.73 | 19.46 | 39.20 | 39.53 | 39 | 78.53 |
| | SD | 0.41 | 0.74 | 1.11 | 0.59 | 0.83 | 1.32 | 0.91 | 1.51 | 2.35 |
| | Median | 20 | 20 | 40 | 20 | 20 | 40 | 40 | 40 | 80 |
| | Min | 19 | 18 | 37 | 18 | 18 | 36 | 37 | 36 | 73 |
| | Max | 20 | 20 | 40 | 20 | 20 | 40 | 40 | 40 | 80 |
| ≥ 6 to < 8 yrs N = 30 | Mean | 19.73 | 19.40 | 39.13 | 19.66 | 19.40 | 39.06 | 39.4 | 38.83 | 78.2 |
| | SD | 0.44 | 0.81 | 1.22 | 0.66 | 0.89 | 1.48 | 1.03 | 1.62 | 2.61 |
| | Median | 20 | 20 | 20 | 20 | 20 | 20 | 40 | 40 | 80 |
| | Min | 19 | 18 | 37 | 18 | 17 | 35 | 37 | 35 | 72 |
| | Max | 20 | 20 | 40 | 20 | 20 | 40 | 40 | 40 | 80 |

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

Similarly, for the *phoneme scor*es (Table 4.2) the Mann-Whitney U test indicated that no significant difference existed between the two age groups in List 1 for the easy ($U = 109.50$, $p > .05$, $r' = 0.02$), hard ($U = 93.5$, $p > .05$, $r' = 0.16$) and total phoneme scores ($U = 107$, $p > .05$, $r' = 0.04$). In List 2 also, the phoneme scores did not differ significantly for the easy ($U = 99$, $p > .05$, $r' = 0.14$), hard ($U = 102$, $p > .05$, $r' = 0.09$), and total phoneme score ($U = 102$, $p > .05$, $r' = 0.09$).

Table 4.2

*Mean Median and Standard deviation (SD), Minimum (Min) and Maximum (Max) phoneme scores (easy, hard & total phoneme scores) for the two age groups (separately & combined) among the typically developing children*

| **Age groups** | | **List 1** | | | **List 2** | | | **Lists 1+2** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **^Easy** | **^Hard** | **#Total** | **^Easy** | **^Hard** | **#Total** | **^Easy** | **^Hard** | **#Total** |
| ≥ 6 to 7 yrs N = 15 | Mean | 84.60 | 78.20 | 162.86 | 84.66 | 78.20 | 162.86 | 169.26 | 156.46 | 325.73 |
| | SD | 0.63 | 1.01 | 1.45 | 0.61 | 1.20 | 1.72 | 1.22 | 1.99 | 3.05 |
| | Median | 85 | 79 | 164 | 85 | 79 | 164 | 170 | 157 | 327 |
| | Min | 83 | 76 | 160 | 83 | 76 | 160 | 166 | 152 | 320 |
| | Max | 85 | 79 | 164 | 85 | 79 | 164 | 170 | 158 | 328 |
| ≥ 7 to < 8 yrs N = 15 | Mean | 84.40 | 78.53 | 162.93 | 84.73 | 78.46 | 163.26 | 169.20 | 157 | 326.2 |
| | SD | 0.74 | 1.12 | 1.53 | 0.79 | 0.99 | 1.43 | 1.42 | 1.60 | 2.65 |
| | Median | 85 | 79 | 164 | 85 | 79 | 164 | 170. | 158 | 328 |
| | Min | 81 | 77 | 160 | 82 | 76 | 160 | 166 | 160 | 320 |
| | Max | 85 | 79 | 164 | 85 | 79 | 164 | 170 | 164 | 328 |
| ≥ 6 to < 8 yrs N = 30 | Mean | 84.50 | 78.20 | 162.90 | 85.00 | 78.23 | 163.0 | 169.23 | 156.73 | 325.96 |
| | SD | 0.90 | 1.37 | 1.47 | 0.96 | 1.27 | 1.57 | 1.30 | 1.79 | 2.08 |
| | Median | 85 | 79 | 164 | 85 | 79 | 164 | 170 | 158 | 327 |
| | Min | 81 | 73 | 160 | 81 | 75 | 160 | 166 | 152 | 320 |
| | Max | 85 | 79 | 164 | 85 | 79 | 164 | 170 | 158 | 328 |

*Note.* *^Maximum score for easy words = 85; Maximum score for hard words = 79; # Total phoneme score =164*

As the data obtained from the typically developing children aged ≥ 6 to 7 years and ≥ 7 to < 8 years were not significantly different from each other, further analyses were done with scores of the two age groups pooled together. This was done to compare the difference between the two lists as well as compare scores between the three participant groups.

## 4.2 Comparison of scores within and across the lists in the typically developing children

*Comparison of scores within lists* was done to check the difference between the easy and hard words. The word scores (Tables 4.1 & Figures 4.1) and phoneme scores (Tables 4.2 & Figures 4.1) of the easy and hard words scores obtained by the typically developing children was markedly poorer in the former than the latter. This can be seen in both lists. Further, a Wilcoxon signed rank test revealed that within each list the word scores of the lexically hard word scores were significantly different from the lexically easy words in List 1 ($Z = 3.16$, $p < .01$) and in List 2 ($Z = 2.53$, $p < .01$). The *phoneme scores* were also statistically significant in List 1 ($Z = 4.99$, $p < .001$) and in List 2 ($Z = 5.02$, $p < .001$).

*Comparison of scores across the lists* (List 1 & List 2), as evident from Tables 4.1 and 4.2 as well as Figures 4.1, indicates that the mean, median, and variability of scores were similar for the easy words, hard words and the words grouped together (easy + hard words).

A Wilcoxon signed rank test confirmed that the mean *word scores* across the two lists were not significantly different for the lexically easy words ($Z = 0.81$, $p > .05$), lexically hard words ($Z = 0.00$, $p > .05$). Similarly, the total word scores were also not significant ($Z = 0.50$, $p > .05$). As was seen with the word scores, the *phoneme scores* were also not significantly different between the two lists for the easy words ($Z = 0.35$, $p > .50$), hard words ($Z = 0.00$, $p > .50$) and for the phonemes grouped together ($Z = 0.64$, $p > .05$).

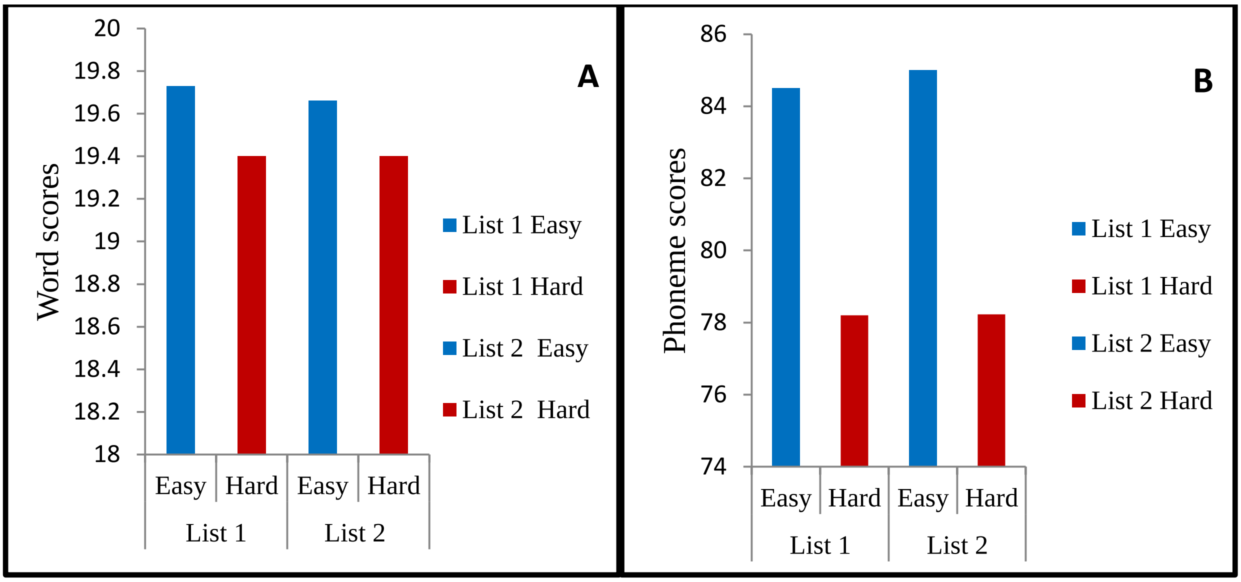



*Figure 4.1.* Mean word scores for easy and hard words in List 1 and List 2 (Panel A) and mean phoneme scores for easy and hard words in List 1 and List 2 (Panel B).

### 4.3 Comparison of scores within lists in children with hearing impairment (hearing aid & cochlear implant users)

*Comparison of scores within lists* was carried out to check the difference between the scores obtained for easy and hard words in children with hearing impairment. This was done separately for those using hearing aids and those using cochlear implants. The mean word scores (Tables 4.3 & Figures 4.2) and phoneme scores (Tables 4.4 & Figures 4.2) obtained by both the groups of children with hearing impairment were better in for the lexically easy words compared to lexically hard words. This can be seen in List 1 as well as List 2.

Further, a Wilcoxon signed rank test revealed that within each list the *word scores* of the lexically hard words were significantly poorer than the lexically easy words in List 1 ($Z$ = 2.58, $p$ < .01) and in List 2 ($Z$ = 2.40, $p$ < .01) for the children with hearing impairment using hearing aid. The *phoneme scores* were also statistically significant in List 1 ($Z$ = 2.81, $p$ < .01) and in List 2 ($Z$ = 2.81, $p$ < .01), with it being poorer in the hard words. In a similar line, the children with hearing impairment using cochlear implant also obtained significantly higher scores for lexically easy words when compared to the lexically hard words in List 1 ($Z = 2.25$, $p < .05$) and in List 2 ($Z = 2.33$, $p < .05$). The *phoneme scores* were also significantly poorer in the hard words compared to the easy words in List 1($Z = 2.23$, $p < .05$) and in List 2 ($Z = 2.26$, $p < .05$).

Table 4.3

*Mean, Median and Standard deviation of word scores (easy, hard and total word scores) for children with hearing impairment using hearing aid and cochlear implant*

| **Groups** | | **List 1** | | | **List 2** | | | **Lists 1+2** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **^Easy** | **^Hard** | **#Total** | **^Easy** | **^Hard** | **#Total** | **^Easy** | **^Hard** | **#Total** |
| Hearing aid users N = 10 | Mean | 17.8 | 16.6 | 34.4 | 17.6 | 16.6 | 34.2 | 35.4 | 33.2 | 68.6 |
| | SD | 0.78 | 0.84 | 1.42 | 0.96 | 0.84 | 1.31 | 1.42 | 1.39 | 2.50 |
| | Median | 18 | 17 | 34 | 17 | 16 | 34 | 35 | 33 | 69 |
| | Min | 17 | 15 | 32 | 16 | 16 | 32 | 33 | 31 | 65 |
| | Max | 19 | 18 | 37 | 19 | 18 | 36 | 38 | 36 | 73 |
| Cochlear implant users N = 6 | Mean | 17.66 | 16.83 | 34.5 | 17.5 | 16.6 | 34.16 | 35.16 | 33.5 | 68.66 |
| | SD | 0.51 | 1.32 | 1.51 | 0.83 | 1.03 | 1.72 | 1.16 | 1.87 | 3.01 |
| | Median | 18 | 17 | 34.5 | 18 | 17 | 34 | 35.5 | 34 | 69.5 |
| | Min | 17 | 15 | 32 | 16 | 15 | 31 | 33 | 30 | 63 |
| | Max | 18 | 18 | 36 | 18 | 18 | 36 | 36 | 35 | 71 |

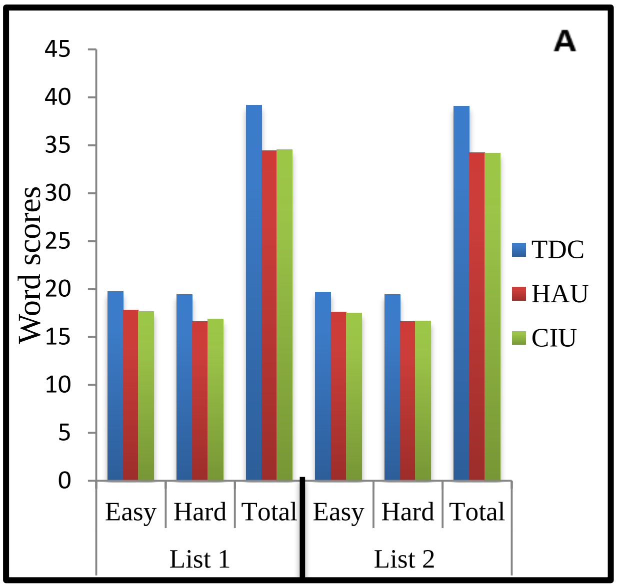
Note: ^*Maximum scores for easy and hard words = 20; #Maximum Total score = 40*

Table 4.4

*Mean, Median, Standard deviation (SD), Minimum (Min) and Maximum (Max) phoneme scores (easy, hard, & total word scores) for children with hearing impairment using hearing aids and cochlear implants*

| **Groups** | | **List 1** | | | **List 2** | | | **Lists 1+2** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **^Easy** | **^Hard** | **#Total** | **^Easy** | **^Hard** | **#Total** | **^Easy** | **^Hard** | **#Total** |
| Hearing aid users N = 10 | Mean | 81.40 | 73.0 | 154.40 | 79.4 | 73.2 | 152.6 | 160.80 | 146.20 | 307 |
| | SD | 2.06 | 1.82 | 3.40 | 2.01 | 2.04 | 3.71 | 3.64 | 2.57 | 6.07 |
| | Median | 82 | 73 | 154 | 79 | 73.5 | 153 | 161 | 146 | 307 |
| | Min | 77 | 71 | 149 | 77 | 70 | 147 | 154 | 142 | 296 |
| | Max | 84 | 77 | 161 | 82 | 76 | 157 | 165 | 150 | 315 |
| Cochlear implant users N = 6 | Mean | 81.33 | 74.66 | 155.66 | 81.5 | 74.6 | 156.16 | 162.83 | 149.33 | 313.83 |
| | SD | 1.36 | 1.21 | 1.63 | 1.87 | 2.58 | 4.11 | 3.12 | 3.07 | 8.40 |
| | Median | 81.5 | 74.5 | 156 | 82 | 75 | 158 | 163 | 150 | 314 |
| | Min | 79 | 73 | 153 | 78 | 70 | 148 | 157 | 144 | 301 |
| | Max | 83 | 76 | 157 | 83 | 77 | 159 | 166 | 153 | 327 |

*Note.* *^Maximum score for easy words = 85; Maximum score for hard words = 79; # Total phoneme score =164*



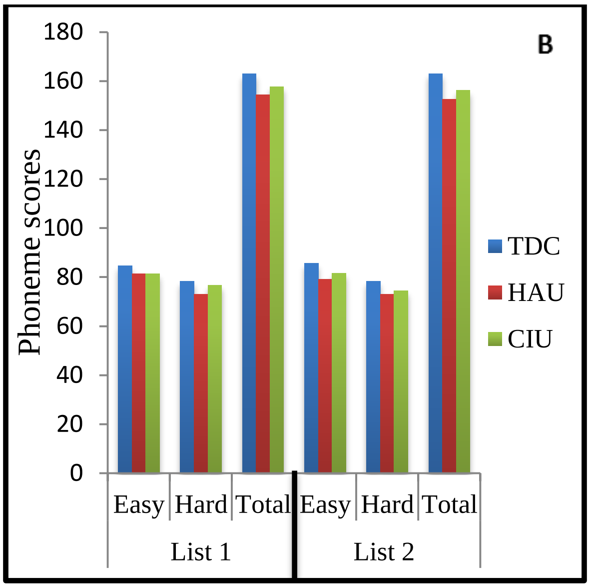




*Figure 4.2.* Comparison between typically developing children, hearing aid users and cochlear implant users on mean word scores (A) and Phoneme score (B) for easy, hard and total scores for List 1 and List 2 (TDC = Typically developing children; HAU = Hearing aid users; CIU = Cochlear implant users).

### 4.4 Comparison of participant groups

The mean, median and variability in the *word scores* of the typically developing children (Table 4.1) and children with hearing impairment (Table 4.3) indicate the difference in performance between the groups. From the two tables it can be seen that the former group performed better than the latter groups. The latter groups included those using hearing aids and those using cochlear implants. Both the groups with hearing impairment obtained similar scores. Likewise, the *phoneme scores* are provided for the typically developing children (Table 4.2) and children with hearing impairment (Table 4.4). The trend seen for the phoneme scores was similar to what was seen with the word scores, with the typically developing children performing better than the children with hearing impairment and the two groups with hearing impairment performing similarly. This difference in performance between the three groups is also evident in Figure 4.2, where information is provided for the two lists for easy, hard and total word and phoneme scores.

Further, to check for a significance of difference between the three different groups (typically developing children, children with hearing impairment & children with cochlear implant) for *word scores* as well as *phoneme scores,* Kruskal-Wallis test was carried out. The test revealed that there was a significant difference between the three participant groups for the word scores ($H$ = 31.56, $p < .001$) and for the phoneme scores ($H$ = 29.37, $p < .001$). To establish which of the groups differed from each other, Mann-Whitney U test was administered. This was checked with the lists grouped as they did not differ for the easy, hard, and total word scores and phoneme scores.

The Mann-Whitney U test revealed that there was a significant difference between the *typically developing children and children using hearing aid* for the easy ($U$ = 6, $p < .001$, $r'$ = 0.77), hard ($U$ = 3, $p < .001$, $r'$ = 0.74), and total word scores ($U$

= 2, $p < .001$, $r' = 0 .75$). Similarly, they performed significantly different between the easy ($U = 0$, $p < .001$, $r' = 0.79$), hard ($U = 0$, $p < .001$, $r' = 0.76$), and total phoneme scores ($U = 0$, $p < .001$, $r' = 0.76$).

A comparison of the *typically developing children and children using cochlear implants* also highlighted that a significant difference occurred for the easy ($U = 0$, $p < .001$, $r' = 0.71$), hard ($U = 1$, $p < .001$, $r' = 0.66$), and total word scores ($U = 0$, $p < .001$, $r' = 0.66$). Similarly, they performed significantly different between the easy ($U = 1$, $p < .001$, $r' = 0 .68$), hard ($U = 1.5$, $p <. 001$, $r' = 0.66$), and total phoneme scores ($U = 13$, $p < .001$, $r' = 0.56$).

The Mann-Whitney U test carried out to compare the *children using hearing aid and the children using cochlear implants* indicated that they did not differ significantly for the easy ($U = 29.5$, $p >.05$, $r' = 0.01$), hard ($U = 22.5$, $p > .05$, $r' = 0.20$), and total word scores $U = 26.5$, $p >.05$, $r' = 0.09$). Similarly, they did not differ significantly between the easy ($U = 20$, $p > .05$, $r' = 0.27$), hard ($U = 12$, $p > .05$, $r' = 0.49$), and total phoneme scores ($U = 13.5$, $p > .05$, $r' = 0.44$).

The result reveal that there is no significant effect of age on the scores obtained for easy and hard words when administered on typically developing children aged ≥ 6 years to < 7 years and ≥ 7 to < 8 years separately. The two lists developed can be used interchangeably as the inter-list equivalency was established between the List 1 and List 2. The current study also shows that the scores obtained for lexically easy words are better in three participant groups when compared with lexically hard words. The scores obtained by the typically developing children for the word scores and phoneme scores were significantly higher than the scores obtained for the children with hearing impairment. However, there was no significant difference between the scores obtained by the children with hearing impairment using hearing aid and children with hearing impairment using cochlear implant on the word scores and phoneme scores.

# Chapter 5

# DISCUSSION

The results obtained from the 30 typically developing children, 10 children with hearing impairment using hearing aid and 6 children with hearing impairment using cochlear implant on newly developed Lexical neighbourhood test in Malayalam are discussed. The effect of type of words and age on spoken word recognition, inter-list equivalency, and the comparison of performance between the typically developing children with the children with hearing impairment using hearing aids / cochlear implants are provided.

In the present study, the word and phoneme scores of the *lexically easy words* (words with high frequency of occurrence having sparse neighbourhood) were significantly higher than the *lexically hard words* (words with low frequency of occurrence having dense neighbourhood). This was obtained in the typically developing children, as well as both groups of children with hearing impairment. In all three participant groups, both word scores and phoneme scores were significantly higher for the lexically easy words when compared to the lexically hard words. This indicated that the newly developed test, Lexical Neighbourhood Test in Malayalam' (LNT-M) meets the requirement of a lexical neighbouthood test, as noted by Kirk et al. (1995).

This finding is consistent with previous studies (Apoorva & Yathiraj, 2011-12; Chandekar & Yathiraj, 2015; Kirk et al., 1999; Liu et al., 2011; Patro & Yathiraj, 2009-10; Yang et al., 2004), where lexical easy words were reported to yield better scores than lexical hard words. The better scores of the lexical easy words can be attributed to the frequent of occurrence of the easy words, enabling them being rapidly and accurately retrieved from long term memory. Additionally, the sparser neighbourhood density would have led to less confusion, as the number of confusable words were less when compared to the dense words that had relatively more confusable words.

Comparison of scores across the age groups (≥ 6 years to < 7 years & ≥ 7 years to < 8 years) revealed that there was no statistically significant difference between the two groups. This probably occurred as the bisyllabic words were chosen from the vocabulary of younger children aged 6 years during the development of the test material. Additionally, while constructing the test, children aged 6 years were tested to confirm that the words were familiar to them, thereby ensuring that no words that were unfamiliar to this age group was included in the test. Similar findings were also noted in earlier studies where there was no significant difference was observed between the age groups studied. They too attributed this to the vocabulary of the test material being that of the younger age group evaluated by them (Apoorva & Yathiraj, 2011-12; Liu et al., 2011).

However, unlike the current study and that of other studies reported in literature (Apoorva & Yathiraj, 2011-12; Liu et al., 2011), Patro & Yathiraj (2009-10) reported of a significant difference in the age groups studied by them when tested using the LNT in Indian-English. The improvement in scores with increase in age noted by Patro & Yathiraj (2009-10) could have occurred as the children were evaluated in a language that was not their native language, unlike the other studies that evaluated the children in their native language. Thus, it can be inferred that if children are tested with a lexical neighbourhood test in their native language, age related changes are not likely to be present, if the vocabulary is familiar to the younger age group. Hence, it can be stated that the Lexical Neighbourhood test developed in Malayalam can be used on individuals aged 6 years and above, without considerable change in scores with increase in age.

The *inter-list equivalency* was established between the two lists developed in the present study for word scores as well as phoneme scores. The equivalency was observed for the lexically easy and the lexically hard words. This indicates that the two lists (List 1 & List 2) can be used interchangeably as a useful clinical tool. This would prevent the effect of word familiarity affecting test results when children are evaluated repeatedly in situations such as selection of listening devices.

Comparison of performances between the *typically developing children* and *children with hearing impairment using listening devices* (hearing aids & cochlear implants) yielded significantly better performance by the former group compared to the latter group. Despite matching the language age of the typically developing children with children with hearing impairment using listening devices, the children with hearing impairment performed significantly poorer. This indicates that the listening devices / training provided did not compensate adequately for their hearing impairment. This had been noted in earlier studies also (Apoorva & Yathiraj, 2011-12; Patro & Yathiraj, 2009-10).

Additionally, the comparison between the *two groups of children with hearing impairment (hearing aids & cochlear implants)* indicated no significant difference between them. This can be attributed to the participant selection criteria followed during the validation of developed LNT-M. All the participants with hearing impairment, recruited in the present study, had a language age of > 6 years and had used their listening devices (hearing aid / cochlear implants) for at least a minimum period of 2 years. Further, it was ensured that both groups had aided audiograms within the speech spectrum. Perhaps, as these criteria were matched between the two groups of participants, the scores obtained by them were comparable. Thus, it can be construed that the newly constructed LNT-M is able to detect similarities in performance in participants who have comparable listening abilities.

In conclusion, the results of the present study provide support for the NAM theory (Luce & Pisoni, 1998). The newly developed Lexical Neighborhood test in Malayalam can be used to measure spoken word recognition in children, including those with hearing impairment using listening devices who exhibit varying speech perception abilities. The distinct difference in performance between the easy and hard words in all three participant groups indicates that the construction of the test material was appropriate and can be used to assess the difference in performance of individuals on these types of words. Further, it can be noted that the LNT-M is sensitive to the spoken word recognition difficulties in children with hearing impairment. Additionally, the test can be used to understand the perceptual problems of speech sound patterns of words in the lexicon of children and the processes used to access these patterns in traditional speech identification tests, as was reported by Kirk, Pisoni, and Osberger (2012).

# Chapter 6

## SUMMARY AND CONCLUSIONS

The importance of using a hierarchy of speech perception tests when evaluating children has been stressed in literature (Thibodeau, 2007; Tyler, 1994). This is recommended as with increase in vocabulary and overall language abilities of children, more difficult tests are required to prevent a ceiling effect. Thus, with increase in language levels, the use of open-set tests has been recommended. Among the open-set tests reported in the literature, the Lexical Neighbourhood Test (LNT), and the Multisyllabic Lexical Neighbourhood Test (MLNT) by Kirk et al. (1995) have been recommended to be used in children with hearing impairment. These tests are considered to be relatively easier than phonetically balanced word tests. Hence, they have been recommended to be used on children who find tests such as the Phonetically Balanced Kindergarten Word List difficult (Gelfand, 2007).

The LNT and MNLT were developed with the theoretical support of Neighbourhood activation Model (Luce & Pisoni, 1998). The tests were constructed keeping in mind the frequency of occurrence of words (number of times a word appears in a particular language) and the lexical density (number of words that are phonetically similar to the target word). Words having more lexical neighbours were considered to have 'dense lexical neighbourhood' and words having less lexical neighbours were considered to have 'sparse lexical neighbourhood'. Based on the frequency of occurrence and lexical density, words were categorized as 'lexically easy' (words with high frequency of occurrence with sparse lexical neighbourhood) and 'lexically hard' (words with low frequency of occurrence with dense lexical neighbourhood).

Tests, similar to LNT have been developed in language such as Mandarin (Yang et al., 2004), Cantonese (Yuen et al., 2008), and Chinese (Liu et al., 2011).

Similar tests have also been developed for the Indian population in Indian-English (Patro & Yathiraj, 2009-10), Hindi (Singh, 2010), Kannada (Apoorva & Yathiraj, 2011-12) and Telugu (Chandekar & Yathiraj, 2015). However, there is no such test in Malayalam. As Kerala has active cochlear implant programs, LNT in Malayalam would be useful in assessing the outcome of these children. Therefore, there is a need to develop a test similar to the LNT given by Kirk et al. (1995) for children in Malayalam.

The aim of the study was to develop Lexical Neighbourhood Test for children in Malayalam (LNT-M) and validate the same on typically developing children and children with hearing impairment using hearing aids and cochlear implants. Additionally, the study also aimed to check the effect of type of words, age, and equivalency of the lists of the test.

Initially, LNT-M was developed for children in the age range of 6 to 8 years. The developed test material consisted of 2 lists having bisyllabic Malayalam words, with each list having 20 easy words and 20 hard words. The developed LNT-M was validated on 30 typically developing children, 10 children with hearing impairment using hearing aids and 6 children with hearing impairment using cochlear implants.

The data obtained from the typically developing children were analyzed to establish the effect of age using a Mann-Whitney U test. The comparisons between lexically easy and hard words as well as between lists were determined using Wilcoxon signed rank test. The differences between the three participant groups were analyzed using Kruskal-Wallis, followed by Mann-Whitney U test. All comparisons were done separately for the easy words, hard words and total words for each list using word scores as well as phoneme scores.

Comparison of scores across the age group (≥ 6 years to < 7 years & ≥ 7 years to < 8 years) revealed no statistical significant difference. Further, all three participant groups obtained significantly better scores on the lexically easy words compared to the lexically hard words. This was seen for the word scores as well as the phoneme scores. The two list of LNT-M were not found to be statistically different and can be used interchangeably. Significantly higher performance was seen in the typically developing children compared to both groups of children with hearing impairment (hearing aid users & cochlear implant users). This difference was seen for the lexically easy, lexically hard, and total words when word as well as phoneme scores were calculated. However, the children with hearing impairment using hearing aids did not differ significantly from children with hearing impairment using cochlear implants.

The findings of the current study indicate that the newly developed Lexical Neighborhood test in Malayalam can be used to measure spoken word recognition in children, including those with hearing impairment using listening devices. The distinct difference in performance between the easy and hard words in all three participant groups indicates that the construction of the test material was appropriate.

**Implication of the present study**

- The developed test can be used to assess speech perception abilities for Malayalam speaking children using hearing aids / cochlear implants.
- The test can be used in the selection of appropriate listening devices.
- It can be used to monitor the effectiveness of auditory rehabilitation and setting goals and activities for therapy.
- It can be used to check if there is any need for reprogramming hearing aids or re-mapping of cochlear implant.
- It will be useful for children who are unable to carryout open-set speech identification tests using phonemically balanced word tests.

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## APPENDIX 1a

## Lexical Neighbourhood Test in Malayalam (LNT-M)

## LIST 1

| Sl. No. | Words | | Easy/ Hard | Sl. No. | Words | | Easy/ Hard |
|---|---|---|---|---|---|---|---|
| | Malayalam | IPA | | | Malayalam | IPA | |
| 1 | കയർ | /kajar/ | Hard | 21 | തറ | /t̪ara/ | Hard |
| 2 | എന്റെ | /ente/ | Easy | 22 | കാര്യം | /ka:rjam/ | Easy |
| 3 | ആന | /a:na/ | Easy | 23 | കുളം | /kuɭam/ | Hard |
| 4 | കുയിൽ | /kujilə˞/ | Hard | 24 | ജനൽ | /ɟanal/ | Easy |
| 5 | പേര് | /pe:ɾə˞/ | Easy | 25 | മാല | /ma:la/ | Hard |
| 6 | മുറ്റം | /muttam/ | Hard | 26 | നാളെ | /n̪a:ɭe/ | Hard |
| 7 | വീട് | /vi:də˞/ | Easy | 27 | പുഴ | /puɻa/ | Easy |
| 8 | പട്ടം | /paʈʈam/ | Hard | 28 | നീല | /n̪i:la/ | Hard |
| 9 | അവൾ | /avaɭ/ | Easy | 29 | പേന | /pe:na/ | Hard |
| 10 | വെള്ളം | /veɭɭam/ | Easy | 30 | മുറി | /Muri/ | Easy |
| 11 | അമ്മ | /amma/ | Easy | 31 | ഭൂമി | /b^hu:mi/ | Hard |
| 12 | വാല് | /va:lə˞/ | Hard | 32 | ചുമ | /Cuma/ | Hard |
| 13 | തെങ്ങ് | /t̪eŋə˞/ | Easy | 33 | കിളി | /kiɭi/ | Easy |
| 14 | പാല് | /pa:lə˞/ | Hard | 34 | തുണി | /t̪uɳi/ | Hard |
| 15 | വാങ്ങി | /va:ŋi/ | Easy | 35 | ഉപ്പ് | /uppə˞/ | Easy |
| 16 | പൂവ് | /pu:və˞/ | Easy | 36 | താളം | /t̪a:ɭam/ | Hard |
| 17 | മൂക്ക് | /mu:kkə˞/ | Hard | 37 | പുലി | /Puli/ | Hard |
| 18 | വഴി | /vaɻi/ | Easy | 38 | മാനം | /ma:nam/ | Easy |
| 19 | ചായ | /ca:ja/ | Hard | 39 | ഈച്ച | /i:cca/ | Hard |
| 20 | എത്ര | /et̪ra/ | Easy | 40 | എണ്ണ | /eɳɳa/ | Easy |

**Lexical Neighbourhood Test in Malayalam (LNT-M)**

**LIST 2**

| Sl. No. | Words | | Easy/ Hard | Sl. No. | Words | | Easy/ Hard |
|---|---|---|---|---|---|---|---|
| | Malayalam | IPA | | | Malayalam | IPA | |
| 1 | ഓർമ്മ | /o:rma/ | Easy | 21 | സ്വന്തം | /swant̪am/ | Easy |
| 2 | മുട്ട | /muʈʈa/ | Hard | 22 | ചട്ടി | /chaʈʈi/ | Hard |
| 3 | രസം | /rasam/ | Easy | 23 | കോഴി | /ko:ẓi/ | Easy |
| 4 | കുട | /kuɖa/ | Hard | 24 | പല്ല് | /pallɚ/ | Hard |
| 5 | വൃത്തി | /vrɚt̪t̪i/ | Easy | 25 | ഭയം | /bʰajam/ | Easy |
| 6 | ആദ്യം | /a:djam/ | Hard | 26 | മാങ്ങ | /ma:ŋa/ | Hard |
| 7 | കൃഷി | /krɚʃi/ | Easy | 27 | ഉള്ളി | /uɭɭi/ | Hard |
| 8 | മുടി | /muɖi/ | Hard | 28 | ആമ | /a:ma/ | Hard |
| 9 | കാട് | /ka:ɖɚ/ | Easy | 29 | തല | /t̪ala/ | Easy |
| 10 | മാവ് | /ma:vɚ/ | Hard | 30 | നിലം | /Nilam/ | Hard |
| 11 | ഭാരം | /bʰa:ram/ | Easy | 31 | ചിത്രം | /cit̪ram/ | Easy |
| 12 | കഷ്ടം | /kaʃʈam/ | Hard | 32 | മടി | /maɖi/ | Hard |
| 13 | ഉച്ച | /ucca/ | Easy | 33 | നായ | /na:ja/ | Easy |
| 14 | മതിൽ | /mat̪ilɚ/ | Hard | 34 | മുഖം | /mukʰam/ | Easy |
| 15 | നോക്കി | /no:kki/ | Easy | 35 | മണം | /maɳam/ | Easy |
| 16 | കരി | /kaɾi/ | Hard | 36 | തട്ട് | /t̪aʈʈɚ/ | Hard |
| 17 | നെറ്റി | /netti/ | Easy | 37 | കഥ | /kadʰa/ | Easy |
| 18 | പത | /pat̪a/ | Hard | 38 | പൂഴി | /pu:ẓi/ | Hard |
| 19 | ഏത് | /e:t̪ɚ/ | Easy | 39 | ചെടി | /ceɖi/ | Easy |
| 20 | ചാക്ക് | /ca:kkɚ/ | Hard | 40 | കഞ്ഞി | /kaɲi/ | Hard |

**APPENDIX 1b**

**Lexical Neighbourhood Test in Malayalam (LNT-M)**

**SCORING SHEET**

Name: Case number:

Age/ Gender: Date:

Contact number: Class:

*(Note the response of the child in the space provided and indicate the word scores and phoneme scores for the lists in the space provided)*

**LIST 1**

| Sl. No. | Response | Word score | Phoneme score | Sl. No. | Response | Word score | Phoneme score |
|---|---|---|---|---|---|---|---|
| 1 | | | | 21 | | | |
| 2 | | | | 22 | | | |
| 3 | | | | 23 | | | |
| 4 | | | | 24 | | | |
| 5 | | | | 25 | | | |
| 6 | | | | 26 | | | |
| 7 | | | | 27 | | | |
| 8 | | | | 28 | | | |
| 9 | | | | 29 | | | |
| 10 | | | | 30 | | | |
| 11 | | | | 31 | | | |
| 12 | | | | 32 | | | |
| 13 | | | | 33 | | | |
| 14 | | | | 34 | | | |
| 15 | | | | 35 | | | |
| 16 | | | | 36 | | | |
| 17 | | | | 37 | | | |
| 18 | | | | 38 | | | |
| 19 | | | | 39 | | | |
| 20 | | | | 40 | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Total Easy Word Score** | **/20** | **Total Easy Phoneme Score** | **/85** | **Grand Total Word score** | **/40** |
| **Total Hard Word Score** | **/20** | **Total Hard Phoneme Score** | **/79** | **Grand Total Phoneme score** | **/164** |

**Lexical Neighbourhood Test in Malayalam (LNT-M)**

**LIST 2**

| Sl. No. | Response | Word score | Phoneme score | Sl. No. | Response | Word score | Phoneme score |
|---|---|---|---|---|---|---|---|
| 1 | | | | 21 | | | |
| 2 | | | | 22 | | | |
| 3 | | | | 23 | | | |
| 4 | | | | 24 | | | |
| 5 | | | | 25 | | | |
| 6 | | | | 26 | | | |
| 7 | | | | 27 | | | |
| 8 | | | | 28 | | | |
| 9 | | | | 29 | | | |
| 10 | | | | 30 | | | |
| 11 | | | | 31 | | | |
| 12 | | | | 32 | | | |
| 13 | | | | 33 | | | |
| 14 | | | | 34 | | | |
| 15 | | | | 35 | | | |
| 16 | | | | 36 | | | |
| 17 | | | | 37 | | | |
| 18 | | | | 38 | | | |
| 19 | | | | 39 | | | |
| 20 | | | | 40 | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Total Easy Word Score** | **/20** | **Total Easy Phoneme Score** | **/85** | **Grand Total Word score** | **/40** |
| **Total Hard Word Score** | **/20** | **Total Hard Phoneme Score** | **/79** | **Grand Total Phoneme score** | **/164** |