LEXICAL NEIGHBOURHOOD TEST IN TELUGU

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CERTIFICATE

This is to certify that this dissertation entitled "**Lexical Neighbourhood Test (LNT) in Telugu**" is the bonafide work submitted in part fulfilment for the degree of Master of Science (Audiology) of the student with Registration No. 11AUD019). 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.

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This is to certify that this dissertation entitled "**Lexical Neighbourhood Test (LNT) in Telugu**" 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.

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DECLARATION

This dissertation entitled "**Lexical Neighbourhood Test in Telugu**" is the result of my own study under the guidance of Prof. Asha Yathiraj, Professor of Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier in any other University for the award of any Diploma or Degree.

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CHAPTER I

INTRODUCTION

In order to detect the perceptual problems in individuals with hearing impairment, it is essential to use appropriate tests. It is especially important that appropriate tests be used to determine the problems individuals have in the perception of speech. Several speech perception tests are available and they range from very simple closed-set tests to complex open-set tests. A few of the closed sets test that are available abroad and in India are 'Early Speech Perception Test' (Moog & Geers, 1990), 'Early Speech Perception test for Malayalam speaking children' (Jijo & Yathiraj, 2008), 'Word Intelligibility by Picture Identification test' (Ross & Lerman, 1979), 'Northwestern University-Children's Perception of Speech' (Elliot & Katz, 1980), 'Picture speech identification test for children in Tamil' (Prakash & Yathiraj, 1999) and in Hindi (Chowdry & Yathiraj, 2003).

As children develop their auditory skills, it is preferred that open-set tests be carried out as they give a more realistic idea of their actual speech perception. A few of the open-set tests that are available are 'Phonetically balanced word lists-Kindergarten' (Haskins, 1949), 'Monosyllable, Bisyllable and Trisyllable Word Identification Test for Children in Indian English' (Prawin & Yathiraj, 2009), 'Spondee and PB word list in Hindi' (De, 1973), and 'Speech Discrimination Test in English for Indians' (Swarnalatha & Rathna, 1972).

Among the various types of speech perception tests developed for the children using cochlear implants, the open-set tasks are the most challenging ones. One of the most popular tests for open-set spoken word recognition is 'The Phonetically Balanced Kindergarten' (PB-K) word list which was developed by Haskins in 1949.

The PB-K was also used to assess pre and post operative word recognition abilities in cochlear implantees. Studies have reported that children with cochlear implants perform poorly on this open-set test (Staller, Beiter, Brimacombe, Mecklenburg, & Arndt, 1991; Fryauf-Bertschy, Tyler, Kelsay, & Gantz, 1992; Miyamoto, Osberger, Robbin, Myers & Kessler, 1993). It has also been reported in literature that to assess the perceptual abilities of the individual it is not necessary to have wordlists which are phonetically balanced (Tobias, 1964; Carhart, 1965 and Hood & Poole, 1980). To overcome the disadvantages of the PB-K list, The Lexical Neighbourhood Test (LNT) was developed at the Indiana University School of Medicine (Kirk, Pisoni, & Osberger, 1995) to assess the open-set speech perception performance of children with hearing loss using a cochlear implant or other sensory aids. The LNT considers two aspects that are known to affect the identification of words. These aspects include the frequency of occurrence of words in the language and the lexical neighbours (i.e. the number of words that differed from the target word by one phoneme).

Companies manufacturing cochlear implants or hearing aid claim that that advances in technology result in enhancement in speech perception. In order to evaluate these perceptual changes, it is necessary that speech perception tests be available that can evaluate changes in speech perception, without the test being too difficult for the individual to carry out. LNT has been found to be a very efficient test to measure the perceptual abilities in children using cochlear implant or hearing aids (Kirk et al., 1995; Kirk, Eiesenberg, Martinez, & McCutcheon, 1998; Patro & Yathiraj, 2010, Apoorva & Yathiraj, 2012).

Need for the study:

India being a multilingual country, it is essential to have regional language-specific speech perception tests. Several speech perception tests have been developed in different Indian languages (Haskins, 1949; Lerman, Ross, & Mc Lauchlin, 1965, Ross & Lerman; 1979; Elliot & Katz, 1980; Rout & Yathiraj, 1996; Vandana & Yathiraj, 1998; Prakash & Yathiraj, 1999; Begum & Yathiraj, 2000; Chowdary & Yathiraj, 2003). These tests include familiar phonemically balanced words. Though these tests have been designed as closed set tests, they have been used as open set tests as it gives a more realistic picture of the perceptual abilities of an individual. It has been established that children using cochlear implants have poor performance on the open-set tasks having phonetically balanced wordlists (Staller et al., 1991; Fryauf-Bertschy et al., 1992; Miyamoto et al., 1993). In contrast, they are able to carry out with greater ease open-set speech identification tests that consider word frequency of occurrence and lexical density (Kirk et al., 1995). The LNT is one such test that keeps in mind these factors that are also essential in assessing speech perception skills.

It is essential that speech perception abilities of children be tested in the regional language that they are familiar with. The influence of regional language on speech perception has been confirmed by Alusi, Hinchcliffe, Ingham, Knight & North in 1974. Thus, there is a necessity to develop test in different languages. Lexical Neighbourhood test has been developed in Indian-English (Patro & Yathiraj, 2010), Hindi (Singh, 2010) and Kannada (Apoorva & Yathiraj, 2012). Such a test is not available in Telugu. Hence, there is a need to develop the Lexical Neighbourhood test in Telugu to enable testing children using hearing aids and cochlear implants who speak the language. The test can also be used for assessing the development in

listening skills over a period of time and thus, would also be useful for rehabilitative purposes. Hence, there is a necessity to develop a Telugu version of the LNT test.

Aim of the study:

The aim of the study is to develop and test the Lexical Neighbourhood Test on typically developing Telugu speaking children.

Objective of the present study:

- To develop Lexical Neighbourhood Test for children speaking Telugu.
- To administer and test the developed test material on a group of typically developing children.

CHAPTER II

REVIEW OF LITERATURE

Speech perception abilities have been assessed using several tests that have been developed over the years. In the course of time, these tests have undergone many modifications in order to get a good representation of the individual's perceptual abilities. For children who have a fair amount of language, open-set speech identification tests have been recommended (Osberger et al., 1991; Tyler, 1993; Dowell, Blamey & Clark 1995). The primary feature considered in the construction of these tests was use of age appropriate vocabulary, depending on the age groups for which the tests were designed. Some of the open-set speech identification tests that have phonemic / phonetic balance and have been used with children using cochlear implants include the Phonetically Balanced Kindergarten Test (Haskins, 1949), CID Auditory Test W-22 wordlists (Hirsh et al., 1952), North-western University Auditory test No. 6 (Peterson & Lehiste, 1962), Speech Discrimination Test in English for Indians (Swarnalatha & Rathna, 1972), PB word list in Hindi (De, 1973), City University of New York Nonsense Syllable Test, (Resnick, Dubno, Hoffnung, & Levitt, 1975).

The Phonetically Balanced Kindergarten word lists (PB-K) is one of the earliest speech recognition tests developed by Haskins in 1949. This open-set test is widely used to assess the perceptual abilities of children. However, Osberger et al. 1991; Staller, et al., 1991; Fryauf-Bertschy, et al., 1992; Miyamoto, et al., 1993, found that children using a cochlear implant performed poorly on this open-set recognition test.

Children using cochlear implants, for durations of 1 to 2 years, have been found to have scores as low as 9% to 11% on the PB-K test (Osberger et al., 1991; Staller et al., 1991). It was also noted that children who performed poorly on the PB-K test actually performed well in their day-to-day activities and that the test did not distinguish children with varying device experience due to a floor effect (Kirk, et al., 1995). The words used in the test were found not to be in the vocabulary of these children, leading to a poor performance (Dale, 1974; Lach, Ling & Ling, 1970; Quigley & Paul, 1984).

Studies have reported that phonetic balancing includes all the speech sounds of the language and it was required to establish homogeneity among the word-lists (Hirsh et al., 1952). However, a few authors (Tobias, 1964; Carhart, 1965; Hood & Poole, 1980) report that phonetic balancing of word-lists was not an essential. Therefore, to combat these issues, the Lexical Neighbourhood Test (LNT) was developed in 1995 by Kirk et al. to assess the perceptual abilities in children with cochlear implants. The LNT was developed based on the Neighbourhood Activation Model (NAM) of spoken word recognition given by Luce and Pisoni (1998). The NAM, as postulated by Luce and Pisoni (1998), results in an acoustic stimulus activating numerous acoustic-phonetic patterns in the mental lexicon. This stage, referred to as 'phonetic processing', in turn was hypothesised to activate a word decision unit that makes decisions as to which stored acoustic pattern best matches with the target stimulus. The information from the higher-level lexicon, which was considered to tell about the frequency of the target word, was hypothesised to contribute in the decision making, a process labelled as 'lexical selection'. The combined effect of the 'phonetic processing' and the 'lexical selection' were considered important to arrive at the final word recognition. Luce (1986) used the

term ‘lexical density’ to calculate the lexical neighbours (words that are phonetically similar to the target word), which was defined as the number of phonemically similar words the target word could have.

Additionally, based on reports of earlier studies on the frequency of occurrence of words, another domain was considered in the construction of the LNT material test material. This was besides the information based on the NAM given by Luce and Pisoni (1998). In earlier studies (Soloman, & Postman, 1952; Howes, 1957; Newbigging, 1961; Savin, 1963), the frequency of occurrence of a word has been referred to as the number of times a word appears in a particular language.

It has been reported that the recognition of a word in an individual is affected by word frequency and lexical density. These two domains were considered by Kirk et al. (1995), Yang and Wu, (2005), Yuen et al. (2008), Patro and Yathiraj (2010), Singh (2010), Liu et al., (2011) and Apoorva and Yathiraj (2012) in the considered in the construction of the LNT.

Kirk, et al., 1995, based on the assumptions of the NAM and the supporting research done to establishing the factors effecting word recognition, developed ‘The Lexical Neighbourhood Test’ and ‘The Multisyllabic Lexical Neighbourhood Test (MLNT)’. The LNT developed by them included two lists of 50 monosyllabic words. Each word list consisted of equal number of ‘lexically easy’ and ’lexically hard’ words. These words were selected from the Child Language Data Exchange System (CHILDES) database (Mac-Whinney & Snow, 1985). Logan in 1992 had determined the lexical properties of these words. From this database Kirk et al. (1995) selected the lexically easy and hard words and constructed the LNT in English.

2.1 Word frequency and lexical density effects on spoken word recognition

The structural organization of words in the mental lexicon is known to be influenced by the frequency of occurrence of words and the phonetic similarity it has with the other words. As mentioned earlier, word frequency of a word denotes the number of times a word occurs in a particular language. The lexical neighbour of a given word has been defined as all of the words differing from the target word by one phoneme by substitution, deletion, or insertion (Greenburg & Jenkins, 1964; Landauer & Streeter, 1973). Based on the lexical neighbours, words have been classified as having 'dense neighbours' or 'sparse neighbours'. Those words that have many lexical neighbours have been said to have a 'dense' lexical neighbourhood, and those with only a few lexical neighbours are considered to have a 'sparse' neighbourhood.

2.2 Effect of frequency of occurrence of speech stimuli / lexical neighbours on speech perception

The influence of frequency of occurrence of stimuli on speech perception has been studied since several decades. Soloman and Postman conducted a study in 1952, where they presented nonsense words using a tachitoscope and noted the recognition thresholds. They found that as the frequency of presentation increased, the thresholds became better. Similar results were reported by Howes (1954, 1957) and Newbigging (1961).

Savin in 1963 considered words of different syllable length and presented them in different signal to noise ratio conditions. The results showed that the words which had higher frequency of occurrence were identified better in worse SNRs. Similar results were observed by Howes (1957). However, Hood and Poole in 1980 presented words in white noise. Their findings contraindicated the findings of

previous studies. Their results did not show a good correlation between recognition of words that were frequently occurring and their intelligibility scores.

Havens and Foote (1963) used a visual word recognition task while controlling the number of neighbourhoods to study the word frequency effects. The results suggested that the effect of frequency of occurrence of words was dependent up on the neighbourhoods it had within the lexicon.

Anderson (1962) found that the neighbourhood density and frequency had an effect on the spoken word intelligibility. From the findings of the study, it was concluded that target words with more density were less intelligible than words with lesser neighbourhood density.

2.3 Outcome of tests based on frequency of occurrence of speech stimuli / lexical neighbours

Kirk et al. (1995) compared the performance of 28 children using cochlear implants on the PB-K, LNT, and MLNT word lists. The best performance was noted in MLNT followed by LNT and worst performance on PB-K test. Good performance in MLNT was attributed to linguistic redundancy of the stimuli. Overall, better performance was noted for the lexically easy words than hard words and multisyllabic words than monosyllabic words resembling the performance of normal hearing listener. Like normal listeners, the listeners with hearing impairment tended to categorize words with similar neighbourhoods in the long-term memory and retrieve it from there during the word recognition process.

Dirks, Takayana & Moshfegh (2001) studied the performance-intensity functions in normal hearing children and children with hearing impairment. They administered two lists of words containing both the lexically easy and hard words.

The results of their study indicated that the group with hearing impairment had shallower performance-intensity functions than the normal listening group. However, both the groups performed according to the assumptions of the NAM.

A recent study carried out in 2010, by Krull, Choi, Kirk, Prusick and French was done on children between 5 to 12 years of age. For the test, 100 sentences were constructed, consisting of 300 key words. Of these 100 sentences, 25 had high frequency and sparse neighbourhood sentences and 25 had low frequency and dense neighbourhood sentences. The remaining 50 sentences were used as control with 25 low frequency - sparse neighbourhoods and 25 high frequency - dense neighbourhood sentences. The children had to identify the key words in isolation first and when embedded in the sentence. They were asked to recognise easy and hard words in the presence of noise to avoid ceiling effects. The results indicated some amount of interaction between the density of lexical items and the frequency of occurrence of words, which posed a difficulty while interpreting the results. Also, children accurately identified words with sparse neighbourhood than words with dense neighbourhood, independent of the frequency of occurrence of words. Similar findings had been reported earlier by Triesman (1978a, 1978b).

In relation to the research done till date, it is clear that the performance on LNT is affected by certain variables. These can be subject related variable such as age, age of implantation and hearing impairment. The performance can also be affected due to procedural variations such as type of stimulus used, type of task involved and scoring patterns.

2.4 Subjective variables affecting the perception of lexically easy and hard words:

2.4.1 Age of the participant

A study carried out by Sommers in 1996, compared the performance in older and younger individuals using lexically easy and lexically hard words. The results of the study showed that older individuals had a poorer performance on the lexically hard words. This was attributed to the fact that with increasing age the processing difficulties increase and reduced ability to remember.

Liu et al. (2011) administered the Standard-Chinese LNT on 96 normal hearing native Chinese speakers. The participants were divided into three groups based on their age, i.e. between 4;0 to 4;11 years, 5;0 to 5.10 and 6;0 to 6;11 years. The results showed that the mean scores increased with increase in age for both easy and hard words (93.5%, 96.1%, & 97.9% and 86.41%, 88.48%, & 92.92%, respectively). There was a significant difference in scores between the 6 year old and the 4 year old children. However, this difference was not significant between 5 and 6 year olds. They concluded that language development in children may be static up to certain age and then increases suddenly. Another conclusion made was that the test material that was used was meant for children in the age range of 3 to 5 years. Therefore, they concluded that the performance of 6 year olds might have reached a ceiling effect.

The literature presented above suggests that the age of the individual acts as a contributing factor for the outcome measures. Therefore, appropriate material for the development of the test and proper norms should be established before assessing the perceptual abilities of the child.

2.4.2 Performance of children with hearing impairment on the LNT

Kirk et al. (1995) studied the effect of lexical difficulty in English in 28 cochlear implant users and found that individuals with hearing impairment performed more accurately on easy words than on hard words. Thus, Kirk reported that even individuals with hearing impairment do use their lexical knowledge in word recognition tasks.

Further, Kirk, (1996) conducted a study with 16 children using cochlear implants on the LNT and MLNT. Of these 16 children, five had congenital hearing loss and the remaining 11 had their onset of hearing loss between 0.75 to 6 years. Oral form of communication was used by 13 of them and total communication by three of them. Children who used oral communication were asked to repeat the words heard and those who used total communication were asked to sign as well as speak the words. The results revealed that word recognition performance on the LNT were better for easy words than hard words. The phoneme scores for easy and hard words did not show a statistical difference. Further, they found that there was a high positive correlation between the phoneme and word scores. This was observed for both the easy and hard words. The children who used oral form of communication performed better than with those using a total communication.

Eisenberg, Martinez, Holowecky and Pogorelsky in 2002, investigated the identification of easy and hard words in isolation and when embedded in a sentence. Two groups of participants were included in the study in the age range of 5 to 14 years. Twelve normal hearing children and 12 children using cochlear implant (nine high performing and three low performing) were included in the study. The sentences were constructed in such a way that they were syntactically correct and had three key words (either easy or hard words). The results revealed that the normal hearing

children and the nine children with cochlear implants performed better on the sentence task than on isolated words. However, the three low-performing children with cochlear implant had better scores on isolated words than sentences. In all the conditions, the lexically easy words were recognized better than the lexically hard words. The authors concluded that this indicated that the words were being organized with respect to the frequency and phonetic similarity of other words. The better word recognition in sentences was attributed to the syntactic cues. However, this was not true for the three low-performing children, reflecting that their linguistic and cognitive abilities were not appropriately developed.

In 2005, Yang and Wu evaluated 28 cochlear implanted Mandarin speaking children using the Mandarin Lexical Neighbourhood Test. They found that there was a significant difference between 'easy' and 'hard' words. They concluded that children with cochlear implants were sensitive to subtle acoustic-phonetic similarities and could organize the words that are phonetically similar in the same groups in the mental lexicon, as the children with normal hearing do.

Similarly, Yuen et al. (2008), Patro and Yathiraj (2010) and Apoorva and Yathiraj (2012) have found similar findings as Yang and Wu (2005) in the Cantonese language, Indian-English and Kannada version of the LNT respectively. Their findings were obtained either in hearing aid users or cochlear implant users.

Recently, Liu et al. (2013) studied the effect of lexical characteristics and demographic factors in Mandarian Chinese open-set word recognition in 230 children who were implanted between the age range of 0.9 to 16.0 years. They used the standardized version of Monosyllabic and Multisyllabic Lexical Neighbourhood test. They found that the children with the cochlear implants performed better on the multisyllabic LNT than the monosyllabic LNT. However, the performance of the

children was poorer than their age matched normal hearing children. Despite individual variations, there were improvements in performance seen with increasing age and those implanted earlier had greater benefits. They concluded that, the open-set word recognition was influenced by the lexical characteristics i.e. performance was better with easy words than hard words. Also, age of implantation and experience with the device also had an effect on spoken word recognition.

Thus, from the above studies it can be noted that hearing impairment influenced the performance on easy and hard words with easy words being recognised more easily and accurately than hard words. This implies that even children with hearing impairment are sensitive to the effects of lexical characteristics and thus recognise easy and hard words differently with easy words being recognised more easily than the hard words.

2.5 Procedural variables affecting the perception of lexically easy and hard words:

2.5.1 Type of stimulus used

Speech perception tests involve a variety of stimuli ranging from monosyllables, bisyllabic words to sentences. With respect to the Lexical Neighbourhood test, the stimuli used include bisyllabic words (Kirk et al., 1995; Yuen et al., 2008; Patro & Yathiraj, 2010; Singh, 2010; Apoorva & Yathiraj, 2012; Liu et al., 2011), monosyllabic (Yuen et al., 2008; Liu et al., 2011), multisyllabic words (Kirk et al., 1995; Yang & Wu, 2005), and sentences (Eisenberg, et al., 2002). Cluff and Luce (1990) have reported that length of the word in terms of the number of syllables it contains has an impact on the speech perception abilities.

A study conducted by Kirk et al. (1995) involved 19 cochlear implant users, who were tested using the LNT and MLNT wordlists. They reported that it was easier

to recognise multisyllabic words than monosyllabic words. They reasoned that multisyllabic words have fewer lexical neighbours and therefore lesser competition in the lexical selection. However, they found that the difference in scores for the MLNT and LNT with respect to phoneme scores of easy and hard words was less. From their findings, it was concluded that children with cochlear implant used length cues to recognise words.

In a later study, Kirk, Mc-Cutcheon, Sehgal and Miyomoto (2000) reasoned that the multisyllabic words have relatively fewer lexical neighbourhoods and are more redundant than monosyllabic or bisyllabic words.

Findings by Yuen et al. (2008) for LNT in Cantonese, and by Wang et al. (2010) for LNT in Mandarin which included monosyllabic and disyllabic wordlists, demonstrated no difference in recognition of easy and hard words in the monosyllabic lists. The authors concluded that the monosyllabic words in these languages had many homophones (similar sounding word with different orthography and meaning) which may had caused repetition responses without actually passing through the process of lexical selection and word recognition. In contrast, they reported that for the disyllabic word-lists, better performance was seen on the recognition of easy word compared to hard words.

Eisenberg, et al. (2002) investigated the identification of easy and hard words in isolation and when embedded in sentences. The results revealed that the normal hearing children and the nine children with cochlear implant performed better on the sentence task than on isolated words. However, the three low-performing children with cochlear implant had better scores on isolated words than sentences. In all the conditions, the lexically easy words were recognized better than the lexically hard words. The better word recognition in sentences was attributed to the syntactic cues.

However, this was not true for the three low-performing children reflecting that their linguistic and cognitive abilities were not appropriately developed.

From the literature, it can be seen that many authors using LNT in different languages (Kirk et al., 1995; Yuen et al., 2008; Wang, Wu, & Kirk, 2010; Liu et al., 2011) have found multisyllabic words to be better identified than monosyllabic words. The reason given for this finding was that multisyllabic words have sparse neighbours and hence more influenced by the word frequency. Whereas, monosyllabic words have dense neighbours and hence more influenced by lexical density. Therefore, it can be suggested that in children who have limited auditory perceptual abilities, multisyllabic words can be used for assessment.

2.5.2 Open vs closed-set presentation

In general it is reported in the literature that the LNT is administered using an open-set spoken word recognition task (Kirk et al., 1995; Yuen et al., 2008; Patro & Yathiraj, 2010; Wang et al., 2010; Liu et al., 2011 & Apoorva & Yathiraj, 2012). However, when administered as a closed-set task, it is reported that the performance of the individual varies. A few studies in literature (Sommers et al., 1996; Clopper, Pisoni, & Tierney, 2006) have quoted difference in the perceptual performance of children when the presentation was changed from open-set to closed-set.

The recognition of easy and hard words was studied by Clopper, et al., (2006), using a closed-set and open-set task. Sixty listeners in the age range of 18 to 25 years were considered for the study. A total of 132 words were selected from the Modified Rhyme Test (House et al., 1965) and Phonetically balanced wordlists (Egan, 1948). These words were classified into easy and hard words base on their characteristics. The words were presented in three blocks (44 words per block, 22 easy and 22 hard

words). The task for the first block was open-set identification and the other two were carried out as closed-set identification. The results revealed that there were no observable differences in the easy words and hard words when a closed-set task was used. However, the authors report that the easy words were efficiently recognized than the hard words for the open-set task. The participants tend to use a more generalized pattern of recognition for the different types of words.

Sommers, Kirk, and Pisoni (1997) carried out a study using 200 words of which 100 were lexically hard and the other 100 were lexically easy words. The test was carried out in both open-set and closed-set conditions on individuals with normal hearing and adults with cochlear implants having a mean age of 40 years. It was found that there was no difference in easy versus hard word recognition in a closet-set condition. However, significant differences between the words were observed in the open-set conditions. The findings were similar for both groups. They concluded that a closed-set task does not adequately evaluate the underlying complex perceptual and cognitive processes.

It is confirmed from the studies mentioned above that word difficulty cannot be determined through closed-set tasks. The studies recommend that if difference in performance between 'easy' and 'hard' words is to be seen, the LNT test should be carried out as an open set task.

2.5.3 Scoring procedure (phoneme vs. word score)

According to Kirk et al. (1995), word recognition was significantly poorer than phoneme recognition on both the LNT and MLNT. They reported of a significant difference between easy and hard words when only word scores [$F(1, 391) = 20.03$, $p < 0.0001$] were considered, with the easy words being recognised

accurately. Such a difference between easy and hard words was not observed when the phoneme scores were considered. The reason that they provided was that the phoneme recognition is the first process that occurs followed by the lexical selection. Therefore, the individual may recognize more number of phonemes correctly than the number of words.

Kirk et al. (1995) also administered LNT and MLNT on 28 and 19 children. They found poor mean scores when compared to children with normal hearing. Within the hearing impaired the authors reported significant difference in recognition of easy and hard words. The authors quoted that the phoneme scores were better than word scores for easy and hard words. But the phoneme scores did not differ significantly between easy and hard words. They opined that children using cochlear implants used length cues and spectral information in recognizing words.

A recent study conducted by Apoorva and Yathiraj (2012), word and phoneme scores of their LNT in Kannada was studied. The results revealed that the phoneme scores were better than the word scores in both lexically easy and hard words. Thus, as per the reports of the above study, there is no consensus regarding the lexical effects when word and phoneme scores are considered. While Kirk et al. (1995) observed a lexical effect for word recognition but not for phoneme recognition, Aproorva and Yathiraj (2012) observed it for both word and phoneme scores. Not many studies have compared word scores and phoneme scores on the perception of easy and hard words. Thus, more research is required in this area to confirm the findings of earlier done studies.

2.6 The Lexical Neighbourhood Test developed in different languages

The NAM, based on which LNT based tests are developed, depends on the long-term memory and the mental lexicon for word recognition. Hence, it is essential that LNT tests should be administered in the individual's native language, making it necessary to develop the test in several languages. Over the years, several versions of the LNT have been developed in different languages. The original test was developed in English by Kirk et al. (1995). Since then, the test has been adapted in Mandarin by Yang and Wu, 2005, Cantonese by Yuen et al., 2008, and Standard-Chinese by Liu et al., 2011. In India, the test is available in Indian-English by Patro and Yathiraj, 2010; Hindi by Singh, 2010 and Kannada by Apoorva and Yathiraj, 2012.

The original test developed in English by Kirk et al. (1995) used the CHILDES database for the selection of words which provided the lexical difficulty of the words as given by Logan (1992). The 'hard words' containing dense neighbourhoods and low frequency of occurrence, as well as 'easy words' having sparse neighbourhoods and high frequency of occurrence. Kirk et al. (1995) developed two 50-item word-lists, with each list having equal number of easy words and hard words.

Yang and Wu in 2005 developed the Monosyllabic Lexical Neighbourhood Test (M-LNT) in Mandarin language. This test was developed for children in the age range of 2 to 6 years. The developed test was evaluated on 80 children, 20 each in the age ranges of 2 to 3, 3 to 4, 4 to 5 and 5 to 6 years. Age appropriate material was used for the development of word-lists. The developed material consisted of eight lists (four with lexically easy and four with lexically hard words). After the test was developed it was validated by administering it on 28 cochlear implantees. The results of the study indicated that the children with cochlear implants also organised their

words according to the acoustic-phonetic similarity between them, just like the normal hearing children.

Using the Mandarin M-LNT developed by Yang and Wu (2005), the hypothesis of the NAM was disputed by Wang et al. (2010). Wang et al., studied the effects of lexically hard and easy words in 30 normal hearing children and 36 children using cochlear implants. The material that was used in the study was Mandarin monosyllabic words and Mandarin disyllabic words. The results of the study revealed no significant difference between the recognition of easy and hard words in either group of children on the Mandarin Monosyllabic test. However, better scores were obtained on the easy words when compared to hard words when the Mandarin disyllabic wordlists were used. The authors concluded that the Mandarin language had high occurrence of homophones (words that sound alike, but differ in their meaning and orthography) in the monosyllabic words. Therefore, these lexical effects were not observed in the spoken word recognition. The authors concluded that, the frequency of the words was a more noteworthy factor than the neighbourhood density of the words.

LNT in Cantonese language was developed by Yuen in 2008. Cantonese CHILDES language database was used for the construction of the material. This material was developed for children in the age range of 2.5 to 5.5 years. Twelve lists were developed, of which six lists consisted of monosyllabic words and six lists consisted of disyllabic words. Both the monosyllabic words and the disyllabic words had three lists having ‘easy words’ and three lists having ‘hard words’ with 25 items in each list. Children with hearing impairment below ten years of age participated in the study. Four of them used a cochlear implant and 10 children used hearing aids in both ears. The results revealed better performance on easy words than hard words in

the disyllabic word-lists. No such differences between the recognition of easy and hard words was found in the monosyllabic word-lists. This lack of difference was attributed to the fact that there was high occurrence of homophones in the Cantonese language for the monosyllabic words.

Liu et al. (2011) developed a Standard-Chinese version of the LNT and tested 96 children in the age range of 3 to 5 years who had normal hearing. Twelve lists were developed having six lists of disyllabic words and six lists of monosyllabic words. In the disyllabic word lists three sub-lists were for easy and three sub-lists were for the hard words, each sub-list consisting of 20 words. The division of word-lists was similar for the monosyllabic words. The results of the study revealed that in both the monosyllabic and disyllabic word lists, the performance on easy words was better than the hard words. However, the performance on the disyllabic word-lists was better when compared to the monosyllabic word-lists. The reason for this finding, given by the authors, was that the disyllabic words had lesser neighbourhoods in comparison to the monosyllabic words. The results also revealed equivalency between the word lists and a high inter-rater reliability for the monosyllabic wordlists and disyllabic wordlists separately.

In India, LNT has been developed in Indian-English by Patro and Yathiraj (2010) for children aged 6 to 8 years. The test was administered on 30 typically developing children and five children using hearing aids. The test consisted of two lists, consisting of 40 words each. Each list had 20 lexically easy words and 20 lexically hard words. The study revealed that there was a significant effect of lexical properties on spoken word recognition scores in both children with normal hearing as well as those with hearing impairment. The lexical easy words had better scores than

the lexically hard words. Age and hearing impairment also had an effect on the performance.

The Hindi version of the LNT was developed by Singh (2010). The test consisted of consisted of two word lists with 40 words each. One list consisted of lexically easy words and the other list had hard words. Both the lists were administered on 30 children with normal hearing and seven children with mild-moderate hearing loss who wore hearing aids. The results of this study were similar to the previous studies quoted.

LNT was also developed in Kannada by Apoorva and Yathiraj (2012). The consisted of two word lists each having 40 words. Each list consisted of 20 easy and 20 hard words. The words within a list were randomised to avoid bias while testing. The lists were administered on 30 typically developing children and five children using cochlear implants. It was found that in both the groups, perception of lexically easy words was better than the hard words.

Thus, LNT developed in different languages across the globe concur with the assumptions made in the NAM. These studies provide information regarding the reliability of the tool in assessing the recognition ability of spoken words in children using cochlear implants and hearing aids.

From the review of literature it can be discerned that the LNT is a reliable tool to assess spoken word recognition in children using cochlear implants or hearing aids. The literature indicates that LNT is a useful measure to assess speech identification abilities of children who find it difficult to carry out standard phonemically balanced, open-set tests like the PB-K. The literature also indicates that unless the LNT is

carried out as an open-set task, the effect of the lexical word-types cannot be evaluated.

CHAPTER III

METHOD

The study was carried out in two phases. In the first phase, the test material was developed and in the second phase, the developed material was administered on a group of typically developing children.

3.1 Participants

For the development of the material in the Phase I, thirty adults who spoke fluent Telugu were involved. Of these thirty individuals, seven adults helped in the selection of words for children in the age range of 6 to 8 years, thirteen helped in the construction of the of the tests and ten individuals were used to test the goodness of the recorded material test. Additionally, ten typically developing children who were exposed to Telugu from early childhood were enrolled to test the familiarity of the selected words. The participants that were used for the construction of the material were not involved in second phase of the study. None of these participants had any history of speech and hearing problems.

For Phase II of the study, data were collected from 30 typically developing children in the age range of 6 to 8 years. The children selected for the study were exposed to Telugu from early childhood; Had no history of speech and hearing, otologic or neurologic problems; Had pure-tone hearing sensitivity was within 15 dB HL for octave frequencies between 250 Hz and 8000 Hz for AC and between 250 Hz to 4000 Hz for BC; Obtained speech identification scores of 90% or higher for bisyllabic word test (Mayadevi & Vyasamurthy, 1974) presented at 40 dB SL (ref: PTA); Had 'A' type of tympanogram with acoustic reflexes present in both ears; and no illness on the day of testing.

3.2 Instrumentation

A calibrated two channel diagnostic audiometer (ORBITER-922) with headphones (TDH-39), a bone vibrator (B-71) was used to obtain pure-tone thresholds and speech identification scores (ref PTA). The same audiometer with calibrated sound-field speakers was utilised for the presentation of the developed recorded material. A computer loaded with Adobe Audition (version-2) was used for the recording and presentation of the developed speech material. A calibrated middle ear analyzer, GSI Tympstar version-2 was used to rule out middle ear pathology.

3.3 Test Environment

The testing was carried out a sound treated suite. A test facility that meets the specifications of ANSI S3.1 (1991) was chosen.

3.4 Procedure

3.4.1 Phase I: Procedure for developing the test material

The material was developed in three steps. The first step was to determine the familiarity of the words that were considered to be in the vocabulary of the children in the age range of 6-8 years. The second step was to check for the lexical density of these words. The third step was to determine the frequency of occurrence of these words in the language.

Initially, bisyllabic words were selected from age appropriate printed material and from seven adults who were exposed to Telugu from childhood. This initial list consisted of 306 words. The familiarity of the 306 words was determined on 10 children in the age range of 6 to 8 years by asking them to describe the meaning of the words. 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 the next stage for the construction of the test. Of the 306 words, 264 words were found to be highly familiar.

To establish the lexical neighbours, the 264 words that were familiar were given to ten adults who spoke fluent Telugu from early childhood. They were instructed to construct as many lexical neighbours as possible for each of the words. 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. The information from the ten adults was pooled to form a single list by eliminating the neighbourhoods that were repeated. Depending upon the number of neighbourhoods formed, the lexical density was calculated. The lexical neighbourhood density was found to range from 0 to 21. Those words that had seven and less than seven neighbours were categorized to have a 'sparse neighbourhood', while those words that had more than seven neighbours were considered to have a 'dense neighbourhood'. This cut-off criterion was done by calculating the median for word density which was found to be seven.

Next, the frequency of occurrence of each of the words in the text material was calculated manually. This was done by calculating the number of times each of the words occurred in text books / story books used by age appropriate children. The text material had 447 pages with 49,170 words. Independently, the word count was done manually by two adults who read Telugu fluently. The frequency of occurrence was noted to range from 1 to 310. These words were then classified as 'frequently occurring words' if they occurred 6 or more than six times in the material and as 'infrequently occurring words' if their frequency of occurrence was less than six. The cut-off criterion was set by calculating the median for word frequency that was found to be six.

After determining the word frequency and word density for each word, the words for the material for the final test were selected. The words that had high frequency of occurrence and dense neighbourhoods as well as the words that had low frequency of occurrence and sparse neighbourhoods were eliminated from the test material. Two sets of words were selected, one having a high frequency of occurrence and low density and another set having low frequency of occurrence and high density. Thus, a total of 130 words were short-listed. Of these 130 words 59 were 'easy' words i.e. words having high frequency of occurrence and sparse neighbourhoods and 71 were 'hard' words i.e. having low frequency of occurrence and dense neighbourhoods. Randomly, 40 easy and 40 hard words were selected and were distributed equally such that two word lists were formed. Each word list had 20 easy and 20 hard words. The order of 'easy' and 'hard' words in the list was randomized to exclude homogeneity and maintain equivalency among the two lists (Appendix).

3.4.1.a Recording of developed word-lists

These word-lists were recorded by a female speaker who spoke Telugu fluently. It was ensured that the fundamental frequency of the speaker was within normal limits as measured on the diagnostic module of Vaghmi software. The recording was done on a computer loaded with Adobe Audition software version 2. A 44.1 kHz sampling rate with 16-bit quantization was used for the recordings. A directional boom microphone, placed 6 cm from the mouth of the speaker and connected to a computer was used for the recording. All the words were normalized using the Adobe Audition Software. A calibration tone of 1 kHz was presented prior to the commencement of each word-list. An inter-word interval of 5 second was maintained. A goodness test was run by administering the recorded lists on 10 adult

native speakers. Words that were not intelligible to 90% of these adults were recorded again.

3.4.2 Phase II: Administration of the developed test

The recorded word-lists were played using a computer loaded with and Adobe audition software. The output from the computer was routed to the auxiliary input of the two channel diagnostic audiometer. The 1 kHz calibration tone was utilised to adjust the VU-meter deflection to '0'. The testing was done in a sound-field condition at 40 dB SL (ref: PTA). The participants were seated comfortably on a chair at a distance of 1 meter. The word lists were presented through the speaker placed at 0 degree azimuth. The participants were instructed to listen to the words and repeat them. Before the commencement of the test, practice items were played to ensure that each child understood the instruction. The order of presentation of the lists was alternated to eliminate any list order effect. The verbal responses were noted on a response sheet by the tester and scoring was done.

3.5 Scoring

Both words and phonemes were scored. For every correctly identified word a score of one was given. Similarly for every correctly identified phoneme a score of one was given. Any word or phoneme that was not correctly identified was scored 'zero'. The maximum score for the easy words and hard words in list 1 and 2 was 20 for each word type per list. The maximum phoneme scores for easy and hard words in list 1 were 82 and 75 respectively. Similarly, for list 2 the maximum phoneme scores were 81 and 80 respectively. Therefore, for list 1 the maximum phoneme scores 157 and lists 2 it was 161. Thus, separate scores were obtained for words and phonemes. These scores were converted into percent score for further comparison.

3.6 Analyses

The data obtained from the 30 typically developing were analysed using Statistical Package for Social Sciences (SPSS) software version 17. Initially, a three way repeated ANOVA was carried out to study the within subject factors and within subject interaction. Further analysis using t-test was done to study the effect of lexical difficulty (easy words vs. hard words and easy phonemes vs. hard phonemes) and effect of word lists (inter-list equivalency). A two-tailed Pearsons paired correlation was done to determine the relation between words and phonemes.

CHAPTER IV

RESULTS

The raw data obtained from the 30 normal hearing children were analysed using the Statistical Package for Social Sciences (SPSS) software version 17. The data obtained were analysed using the three way repeated measure ANOVA and paired-t test.

The following comparisons were made:

1. The word scores obtained by the children on the 'easy' words were compared with that obtained in the 'hard' words within each list.
2. The phoneme scores obtained by the children for the 'easy' words were compared with that got on the 'hard' words within each list.
3. The word scores and phoneme scores of the easy words, as well as the word and phoneme scores of hard words, obtained by the children was compared within each list.
4. The word scores and the phoneme scores of the children across the two developed lists was compared in order to check for the equivalency of the two lists.

Prior to the above comparisons being done, in order to check age effects on the children aged 6 to 7 years and 7 to 8 years, Mauschly's test of sphericity was carried out. This was done to check for homogeneity among the age groups. It was found that the age groups were not homogeneous. Hence, the age effect was not studied and the participants were studied as one group to determine the effect of lexical word-type, list equivalence, and scoring procedure.

4.1 Easy words versus hard words

The performance of the normal hearing children, between the easy and hard words within each list was compared. This was done by analysing the mean and standard deviation (SD) for both groups of words. Table 4.1 shows the mean and SD for both groups of words in list 1 and 2.

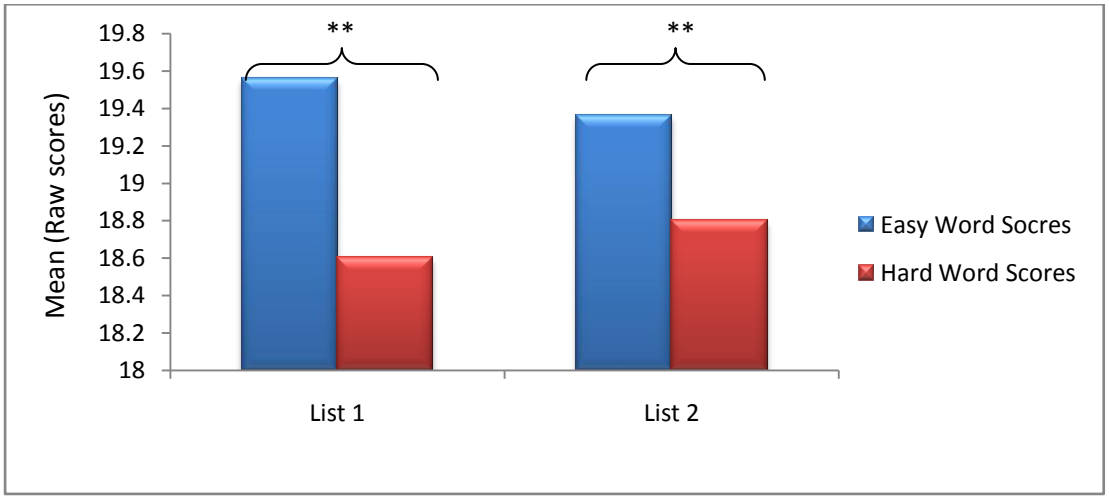
Table 4.1: *Mean and SD of word scores for easy, hard and total scores*

List	Word type	Mean raw (%) word score	SD	Range of word score	
				Minimum	Maximum
List 1	*Easy	19.56 (97.83%)	0.77	17	20
	*Hard	18.60 (92.66%)	0.93	17	20
	#Total	38.16 (95.41%)	1.34	36	40
List 2	*Easy	19.36 (96.83%)	0.71	17	20
	*Hard	18.80 (94.00%)	1.06	16	20
	#Total	38.16 (95.45%)	1.36	35	40

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

In both list 1 and list 2, the mean word scores were found to be similar for the lexically easy words [19.56 (97.83%) & 19.36 (96.83%) respectively], the lexically hard words [18.60 (92.66%) & 18.80 (94.00%) respectively] and the total scores [38.16 (95.41%) & 38.16 (95.45%) respectively]. From a two-way repeated measure ANOVA (2 lists x 2 lexical types of words) that was carried out, a significant difference was observed between the two types of words with the two lists combined [$F(1, 29) = 32.36$, $p < 0.05$]. Further, to check if this significant difference between

the lexically easy and difficult words was present within each of the lists, paired t-tests were carried out. The results showed that there was a significant difference between easy and hard words in list 1 ($t = 5.01$; $p < 0.001$) and list 2 ($t = 4.90$; $p < 0.001$). Thus, a significant difference between the lexically easy and lexically hard word was established (Figure 4.1).



Note. ** = *p < 0.001*

Figure 4.1: Mean and significance of difference between word scores for easy and hard words.

Additionally, a two-tailed Pearsons paired correlation was administered to check the relation between the word scores for the easy and hard words. No correlation was found when comparisons were made between the word scores for the easy versus hard words in list 1 ($r = 0.254$; $p > 0.001$) and list 2 ($r = 0.144$; $p > 0.001$).

4.2 Phoneme score of easy and hard words:

The performance of the normal hearing children on the phoneme scores for easy and hard words within the lists was compared. This was done by analysing the mean and standard deviation (SD) for both groups of words. Table 4.2 shows the mean and SD for both groups of words in list 1 and 2.

Table 4.2*: Mean and SD of raw and percentage phoneme scores for easy, hard and total word scores*

List	Word type	Mean raw (%) phoneme score	SD	Range of phoneme scores	
				Minimum	Maximum
#List 1	Easy	81.5 (99.39%)	0.93	79	82
	Hard	73.5 (97.99 %)	1.19	70	75
	Total	155 (98.72%)	1.66	152	157
^List 2	Easy	80.20 (99.01%)	0.99	77	81
	Hard	78.53 (98.16%)	1.43	74	80
	Total	158.7 (98.56%)	1.84	155	161

Note. # *Maximum possible phoneme score =157(82 phonemes for easy words & 75 for hard words)*

^ *Maximum possible phoneme score =161(81 phonemes for easy words & 80 for hard words)*

The mean for the phoneme scores for the easy words and hard words in list 1 [81.5 (99.39%) & 73.5 (97.99%) respectively] and list 2 [80.2 (99.01%) & 78.53 (98.16%) respectively] are shown in the Table 4.2. A two-way repeated measure ANOVA (2 lists x 2 lexical types of words) was carried out, to check if there was a significant difference between the phoneme scores of the two lexical categories of words. A significant difference was got between the two when the two lists were combined [$F(1, 29) = 29.37$, $p < 0.05$]. Paired t-tests done for each list confirmed that there was a significant difference between phoneme scores of easy and hard words within list 1 ($t = 4.32$; $p < 0.001$) and within list 2 ($t = 3.19$; $p < 0.001$).

Therefore, a significant difference between the phoneme scores of lexically easy and lexically hard word was established as can be seen in Figure 4.2.

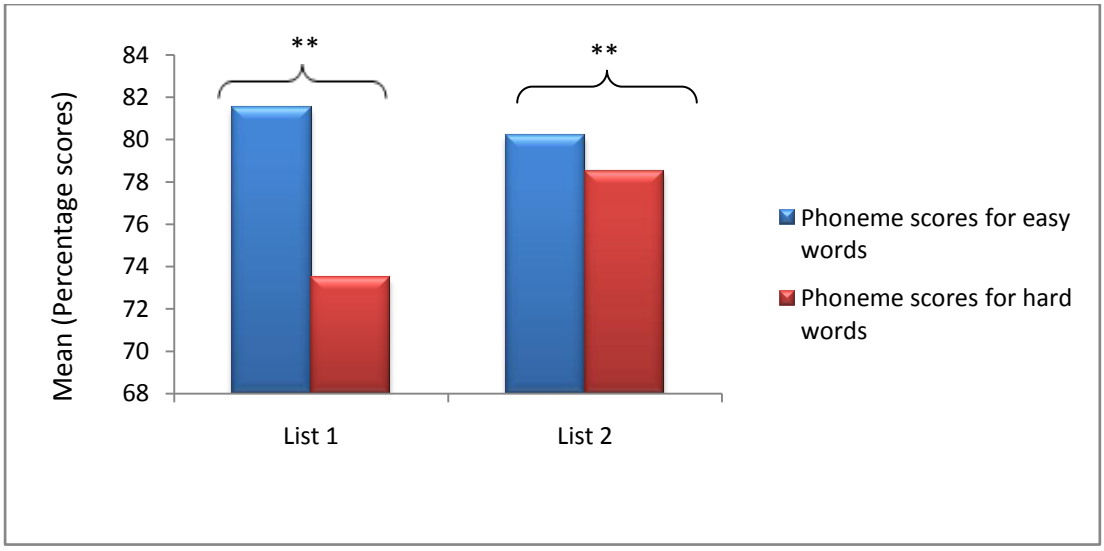


Figure 4.2: Mean & significance of phoneme scores of easy & hard words in lists 1 & 2

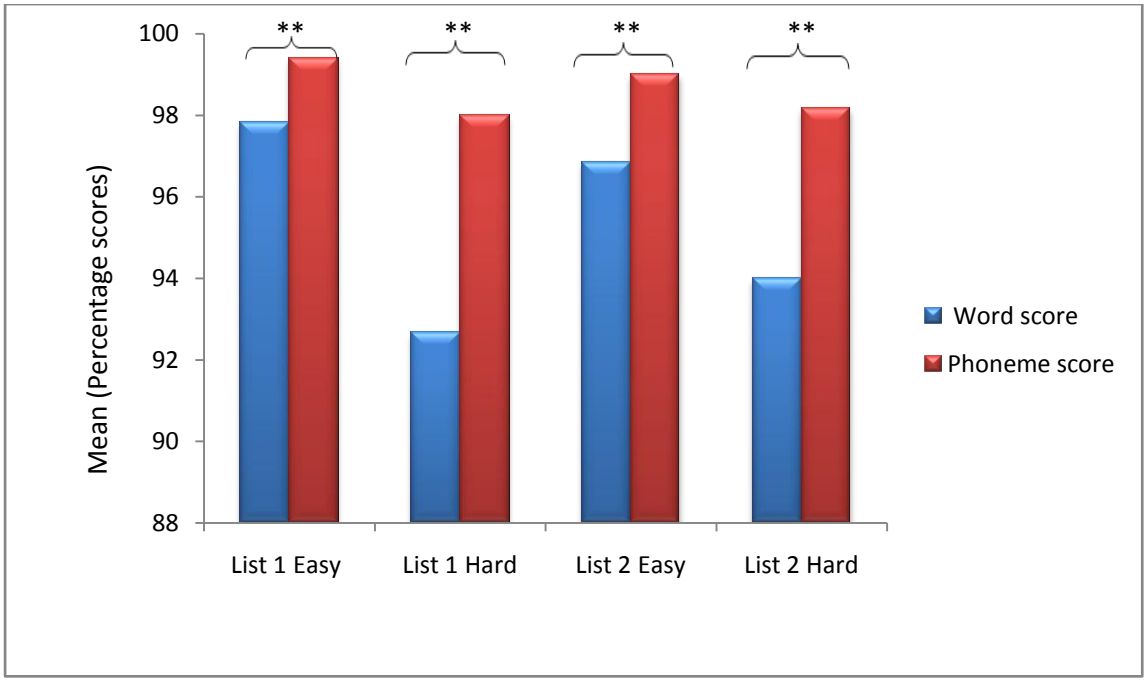
Further, to study the correlation between phoneme scores obtained for easy words and hard words, a two-tailed Pearsons paired correlation was done. The analysis indicated that there was no correlation when the comparisons were made between the phoneme scores for the easy versus hard words in list 1 ($r = 0.201$; $p > 0.001$) and list 2 ($r = 0.068$; $p > 0.001$). This was similar to that obtained for the word scores.

4.3 Comparison of word and phoneme scores of easy and hard words:

The comparison of the two procedures used to scores the responses of the children (word scores & phoneme scores) to the easy and hard words was done after converting the raw scores to percentage scores. The scores were converted to percentage scores since the total number of test words / phonemes varied. Additionally, the number of phonemes varied across the two lists. While list 1 had 157 phonemes (82 phonemes for easy words & 75 for hard words), list 2 had 161 phonemes (81 phonemes for easy words & 80 for hard words).

The mean and SD for the word scores (Table 4.1) and phoneme scores (Table 4.2) are provided for the raw as well as percentage scores for the easy, hard and the total set of words. This information is provided for both lists 1 and list 2. From Figure 4.3 it can be seen that for the easy words the difference between the percentage phoneme score and percentage word score was 1.56% for list 1 and 2.18% for list 2. On the other hand, for the hard words, the difference was 5.33% for list 1 and 4.16% for list 2. Thus, the difference was much more for the hard words compared to the easy words.

Three way repeated measure ANOVA (2 lists x 2 lexical types x 2 scoring procedures) revealed that there was significant difference between the word and phoneme scores with word type and lists combined [$F(1, 29) = 65.44$, $p < 0.05$]. Further to confirm the significant difference between the word and phoneme scores for easy words and hard words in list 1 and 2, paired sample t-tests were carried out. A significant difference was found between word and phoneme scores for the easy words in list 1 ($t = 3.081$, $p < 0.001$) and list 2 ($t = 4.711$, $p < 0.001$). A significant difference was also noted between the word and phoneme scores for the hard words in list 1 ($t = 7.327$, $p < 0.001$) and list 2 ($t = 6.066$, $p < 0.001$). This difference can be noted in the Figure 4.3.



**p < 0.001

Figure 4.3: Mean and significance of word and phoneme scores between easy and hard words within lists.

A two-tailed Pearsons paired correlation was done to determine the relation between word and the phoneme scores. The Pearson correlation for the easy word scores and the easy phoneme in list 1 and list 2 was found to be very high and significant ($r = 0.974$, $p < 0.001$ & $r = 0.906$, $p < 0.001$, respectively). Similarly, the Pearson correlation for hard word scores and phoneme was significantly high for list 1 and list 2 ($r = 0.830$, $p < 0.001$ & $r = 0.910$, $p < 0.001$, respectively). Also, the correlation between the total word and phoneme scores for the lists 1 and 2 was found to be high and significant ($r = 0.914$, $p < 0.001$ & $r = 0.906$, $p < 0.001$, respectively).

4.4 Inter-list equivalency

The performance of the typically developing children was compared 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 easy words

[19.56 (99.39%) & 19.36 (99.01%) respectively], hard words [18.60 (97.99%) & 18.80 (98.16%), respectively] and total scores [38.16 (98.72%) & 38.16 (98.56%), respectively] as can be seen in Table 4.1.

Similarly, the mean phoneme scores in list 1 and list 2 were similar for the easy words [81.50 (99.39%) & 80.20 (99.01%), respectively], the hard words [73.50 (97.99%) & 78.53(98.16%) respectively] and the total scores [155.00(98.72%) & 158.70 (98.56 %) respectively] as seen in Table 4.2.

Three way repeated measure ANOVA (2 lists x 2 lexical types of words x 2 scoring procedures) revealed that there was no significant main effect for list [F (1, 29) = 2.567, p > 0.05]. Further, to confirm if the two lists were equivalent for the easy words, hard words and for total word scores, separate paired-t tests were carried out for each lexical word type and the total score got from combining the two word types. This revealed that there was no significant difference between the two lists for easy words (t = 1.235, p > 0.05), hard words (t = 1.137, p > 0.05) and also for the total scores (t = 2.004, p > 0.05). Similarly, to confirm list equivalency for the phoneme scores, paired t-tests were carried out for easy words (t = 1.341, p > 0.05) and hard words (t = 0.426, p > 0.05). The absence of a difference between the two lists is apparent from Figure 4.4.

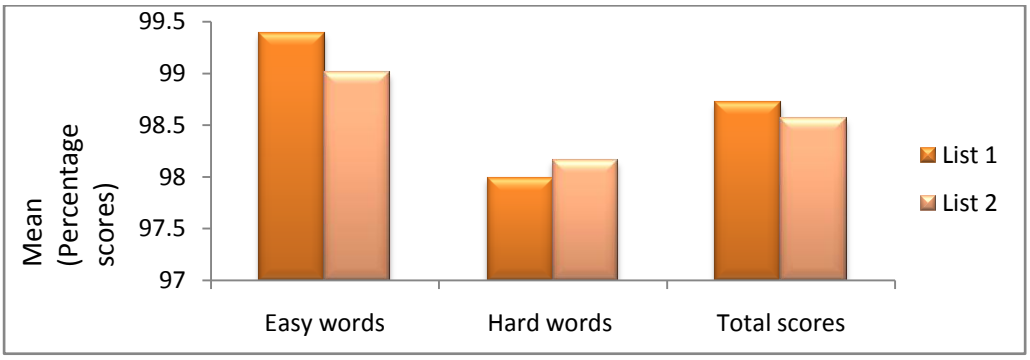


Figure 4.4: Comparison of word scores for easy, hard words and total scores between list 1 and list 2.

From the results of the study, it can be observed that:

- There was a significant difference between the scores obtained by the typically developing children on the easy and hard words in both the lists.
- There was a significant difference between the phoneme scores obtained by the typically developing children on both easy and hard words.
- There was a significant difference between the easy word and easy phoneme scores in both list 1 as well as list 2. Also, there was a significant difference noted between the hard word and phoneme score in each of the lists.
- There was a significant and high positive correlation between the words and phoneme scores, which was seen for the ease as well as hard words.
- There was no significant difference between the word lists.

CHAPTER V

DISCUSSION

The results of the data obtained using the newly developed LNT test in Telugu are discussed in this section. The outcome of the lexical word type (easy & hard words), the scoring procedure (word & phoneme score) and inter-list equivalency obtained from the 30 typically developing children are discussed.

In the present study, depending on the *lexical word type (easy & hard words),* the scores of the participants varied. It was observed that the children obtained significantly higher scores on the lexically easy words when compared to the lexically hard words. These results are in accordance with earlier reported studies using LNT developed incorporating monosyllabic words in languages like English (Kirk et al., 1995), Mandarin (Yang & Wu, 2005), Cantonese (Yuen et al., 2008) and Indian-English (Patro, & Yathiraj, 2010), as well as LNT developed using disyllabic words in languages like Cantonese (Yuen et al., 2008), Standard-Chinese (Liu et al, 2011), and Kannada (Apoorva, & Yathiraj, 2012). Pisoni and Luce (1986) attributed the better performance for the 'easy words' in contrast to the 'hard words' to the organisation of words in the mental lexicon based on their phonetic similarity and word frequency. Words having sparse neighbourhoods and high frequency of occurrence were considered easy to identify as they have less competition from the phonetically similar words and as they occur frequently. This was unlike words having dense neighbourhoods and low frequency of occurrence. These 'hard words' resulted in them having more competition with the words that are phonetically similar. Additionally, the low frequency of occurrence resulted in them being more confusing.

However, unlike the findings of the current study and that of earlier reported literature (Kirk et al., 1995; Patro, & Yathiraj, 2010; Liu et al., 2011; Apoorva, & Yathiraj, 2012) a few studies reported no significant lexical effects (Sommers et al., 1997; Clopper et al., 2006; Yuen et al., 2008 & Wang et al., 2010). The studies by Sommers et al. (1996) and Clopper et al. (2006) used a closed-set response mode as opposed to the open-set mode used in the earlier set of studies. This could have accounted for Sommers et al. (1996) and Clopper et al. (2006) not obtaining a difference between lexically easy and hard words. Further, the studies by Yuen et al. (2008) and Wang et al. (2010) had used monosyllabic LNT in Cantonese and Mandarin languages respectively. They reported that the monosyllables in these languages contained homophones (phonemes that had are identical tones, but had different meaning and orthography), due to which there were no lexical differences between easy and hard words. From the findings of Sommers et al. (1996), Clopper et al. (2006), Yuen et al. (2008), & Wang et al. (2010), it can be construed that the lexical effects can only be observed when the test is administered as an open-set word recognition task without homophones. The LNT in Telugu, developed in the present study, does not contain homophones and was carried out as an open-set task; hence the impact of the lexical word was observed.

Further, in the present study, a strong and positive correlation between the hard and easy words was found. This was found for the word scores as well as the phoneme scores. Thus, it can be inferred that the scores of the hard words can be predicted from the scores of the easy words or vice versa.

On comparison of the two *scoring procedures (word & phoneme scores)*, it was found that the overall word recognition scores were poorer than the phoneme recognition scores. The reason for the poorer word scores compared to the phoneme

score was that even a single phoneme error in a particular word resulted in the whole word being scored wrong. On the other hand, a single phoneme error in a particular word resulted in only $1/4^{th}$ or $1/3^{rd}$ of the word being scored wrong, as the words consisted of three to four phonemes. This led to the word scores being poorer than the phoneme scores. These results were consistent with different studies that compared the word scores (Kirk et al., 1995, Yuen et al., 2008; Patro & Yathiraj, 2010; Wang et al., 2010; Liu et al., 2011) and phoneme scores of tests that considered the lexical neighbourhood (Apoorva, & Yathiraj, 2012).

The present study also revealed that the phoneme recognition scores of hard words were poorer than easy word lists and the difference in scores was statistically significant. Similar results were also noted by Apoorva and Yathiraj (2012) on their disyllabic LNT. Unlike the findings of the current study and that of Apoorva and Yathiraj (2012), Kirk et al. (1995) reported that that there were no significant differences easy and hard words when phoneme scores were used but the difference existed only when word scores were utilised. They reasoned that phoneme recognition was the first process that occurred after which lexical selection took place. Thus, they opined that children may recognize more number of phonemes correctly than the number of words leading to a difference in between the hard and easy words only when word scores are used and not when phoneme scores are used. The present study and that of Apoorva and Yathiraj (2012) indicated that there is not such sequencing in the processing of phonemes and words.

The high, positive and highly significant correlation between the word and phoneme scores indicates that it is possible to predict one score from the other. This would be possible for the easy words and the hard words. The finding of the present

study was in supported with Kirk et al. (1995), who reported a strong and positive correlation between phoneme recognition and word recognition.

The results of *the inter-list equivalency* indicated that the two lists were equal when the data of all the participants were pooled together. This equivalency was observed for the easy as well as the hard words, immaterial whether word scores or phoneme scores were calculated. However, it was observed that a few hard words in list I resulted in greater errors in children aged 6 to 7 years of age compared to list II in the same age group. The words in which more than 20% of the children had errors included /anna/, /kəlU/ and /atʃU/. The difficulty in perceiving these words by the younger children (6 to 7 years) can be attributed to the higher density of these words. These three words, /anna/, /kəlU/ & /atʃU/, had a large number of neighbourhoods, with it being 21, 17, and 20, respectively. In contrast, the other hard words had neighbourhoods ranging from just 8 to 15. It has been reported in previous studies (Pisoni & Luce, 1986 & Kirk et al., 1995) that target words that have very dense neighbourhoods caused more confusion in deciding which words to choose from the mental lexicon. From the findings of the present study, it can be seen that such confusion occurred more with some of the children aged 6 to 7 years and not with those who were older. Thus, the two lists of the LNT in Telugu can be used interchangeable provided children are familiar with the above three words.

The results of the current study support the assumptions of the Neighbourhood Activation Model proposed by Luce and Pisoni (1998). Thus, the LNT in Telugu, words with dense neighbourhoods were difficult to recognize as more confusion occurred during the lexical selection and decision-making process. On the other hand, words with sparse neighbourhoods were easy to recognise and resulted in less confusions.

Additionally, it is known that repeated exposure to a particular word has a strengthening effect and is better represented in memory (Dahan, Magnuson, & Tanenhaus, 2001). This has been substantiated in the present study where it was found that words that had a high frequency of occurrence were identified better than those which had a low frequency of occurrence. However, from the findings of the present study it cannot be said that better perception was solely on account of the frequency of occurrence of words since this aspect was combined along with the word neighbourhood density.

The findings of the current study indicate that the LNT in Telugu represents different lexical difficulties. Hence, be used as an effective assessment tool for children who find it difficult to perform on standard open-set phonemically balanced word lists for children. It can be used to quantize the perceptual differences in children and can be used as a valid clinical tool in examining perceptual processes underlying spoken word recognition in Telugu.

CHAPTER VI

SUMMARY & CONCLUSION

It is essential that the perceptual problems in individuals with hearing impairment be detected using appropriate tests. This included tests to determine the problems individuals have in the perception of speech. Several speech perception tests are available and they range from very simple closed-set tests to complex open-set tests. In order to detect the perceptual problems of children who have a fair amount of speech, the use of open-set speech identification tests are advocated. Researchers (Osberger et al. 1991; Staller, et al., 1991; Fryauf-Bertschy, et al., 1992; Miyamoto, et al., 1993) claim that open-set tests that are phonemically balanced are difficult for children using cochlear implants and such tests do not reflect their true perceptual abilities in a real-life situation.

Therefore, considering this fact and abiding by the rules of NAM, Kirk et al. (1995) developed the Lexical Neighbourhood Test in English and validated it on 28 cochlear implant users. Similarly, LNT was developed in Mandarin (Yang & Wu, 2005), Cantonese (Yuen et al., 2008) and Standard-Chinese (Liu et al., 2011). In the Indian languages, it was developed in Indian-English (Patro & Yathiraj, 2010), Hindi (Singh, 2010) and Kannada (Apoorva & Yathiraj, 2012). There was no such test developed in Telugu. Therefore, this study aimed at developing the lexical neighbourhood test in Telugu.

The development of the test involved two phases. In the first phase, the test material was developed taking into consideration the ‘word frequency’ and the ‘neighbourhood density’. Using these two aspects, the words were categorised as ‘lexically easy’ and ‘lexically hard’. Lexically easy were those words that had a high

frequency of occurrence and low density of neighbours, whereas, lexically hard words were those that had a low frequency of occurrence and high density of neighbours. Two lists were formed consisting of 40 words each (20 easy & 20 hard words). These words were recorded by a native female speaker.

In the second phase, the developed material was administered on 30 normal hearing listeners. All children heard both lists, the order of which was altered. The responses obtained from the children were then scored. Both word scores and phoneme scores were calculated for each child. The data was analyzed using the SPSS version 17.

Repeated measure ANOVA, paired t-test were carried out to check the significance of difference of the scores obtained by the children on the easy and hard words for each of the lists. This was done for the word scores and the phoneme scores. The correlation between the above was also checked using the Pearsons correlation test. Additionally, the inter-list equivalency was also checked. The results of the study indicated the following:

- There was a significant difference between the scores obtained by the typically developing children on the easy and hard words in both the lists. This occurred for the word as well as the phoneme scores.
- There was a significant difference between the easy word and easy phoneme scores in both list 1 and list 2. Also, there was a significant difference noted between the hard word and phoneme score in each of the lists.
- There was a significant and high positive correlation between the words and phoneme scores, which was seen for the ease as well as hard words.
- There was no significant difference between the word-lists.

The findings of the study are in consonance with that of Kirk et al. (1995); Yuen et al. (2008), (when disyllabic words were used); Patro and Yathiraj (2010); Liu et al. (2011); and Apoorva and Yathiraj (2012). The impact of the low density of neighbourhood and the high frequency of occurrence of the easy word was reflected by the children performing better on them compared to the hard words. The low density is reported to make it easy for the children to select words from fewer acoustic-phonetically similar words. In addition, their high frequency of occurrence is reported to aid in the better perception, as repeated exposure leads to better learning and memory storage. This is in contrast to what occurs with hard words that have dense neighbourhoods, leading to confusion in selecting a test item from the mental lexicon. In addition, the low frequency of occurrence of these words, would have led to the children having less experience with them, making them difficult for them to be identified.

Implications of the study

The developed lexical neighbourhood test in Telugu will be useful to:

- Assess the perceptual abilities of the children using cochlear implants, or hearing aids who find it difficult to respond to open-set phonemically balanced speech identification tests,
- Make adjustments in the maps / programmes of cochlear implants / hearing aids, and
- Planning therapy activities for children with hearing impairment.

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Appendix

LNT - List 1

Sl no	Words		Easy/ Hard	Sl no	Words		Easy/ Hard
1	అన్న	/anna/	Hard	21	చూడు	/ʧu:du/	Hard
2	ఉండు	/vunḍu/	Easy	22	డబ్బు	/ḍabbu/	Easy
3	ఎండ	/ændɳa/	Easy	23	తండ్రి	/t̪andri/	Easy
4	అద్దం	/ad̪d̪am/	Hard	24	నేను	/næ:nu/	Easy
5	ఎంత	/æna/	Easy	25	దున్న	/d̪unna/	Hard
6	అచ్చు	/atʃ u/	Hard	26	నిద్ర	/nid̪ra/	Easy
7	ఐదు	/æid̪u/	Easy	27	నాది	/na:d̪i/	Hard
8	ఎక్కు	/ækku/	Hard	28	పాప	/pa:pa/	Easy
9	కాకి	/ka:ki/	Easy	29	నేల	/næ:la/	Hard
10	ఓడ	/o: ɖa/	Hard	30	బస్సు	/bassu/	Easy
11	కళ్ళు	/kaɭɭu/	Hard	31	నూరు	/nu:ru/	Hard
12	గుర్రం	/gurram/	Easy	32	భాష	/bʰaʃa/	Easy
13	కట్టు	/kaṭṭu/	Hard	33	నల్ల	/nalla/	Hard
14	గడ్డి	/gaɖɖi/	Easy	34	పెట్టు	/pæṭṭu/	Hard
15	గుర్తు	/gur̪tu/	Easy	35	ప్రక్క	/prakka/	Hard
16	గొప్ప	/goppa/	Easy	36	రోజు	/ro:ʤu/	Easy
17	కల	/kala/	Hard	37	రైతు	/ræ:t̪u/	Easy
18	చెవి	/ʧævi/	Easy	38	మొన్న	/mo:nna/	Hard
19	కూలి	/ku:li/	Hard	39	సన్న	/sanna/	Hard
20	చీమ	/ʧi:ma/	Easy	40	నీతి	/ni:t̪i/	Hard

LNT - List 2

Sl no	Words		Easy/ Hard	Sl no	Words		Easy/ Hard
1	ఎలా	/æ:la:/	Easy	21	తెల్ల	/t̪alli/	Hard
2	అవ్వ	/avva/	Hard	22	దొంగ	/d̪onga/	Easy
3	ఏమి	/æ:mi/	Easy	23	పైన	/pæna/	Easy
4	ఆమె	/a:maæ/	Hard	24	పాము	/pa:mu/	Easy
5	ఒక	/o:ka/	Easy	25	పిండి	/pin̪di/	Easy
6	కోతి	/ko:t̪i/	Easy	26	నీరు	/ni:ru/	Hard
7	కప్ప	/kappa/	Hard	27	నగ	/naga/	Hard
8	కొంగ	/ko:nga/	Easy	28	బుద్ది	/bud̪d̪i/	Easy
9	క్రింద	/krin̪da/	Easy	29	నిప్పు	/nippu/	Hard
10	కాయ	/ka:ja/	Hard	30	మామ	/ma:ma/	Easy
11	కారు	/ka:ru/	Hard	31	పన్ను	/pannu/	Hard
12	కారం	/ka:ram/	Hard	32	రాత్రి	/ra:t̪ri/	Easy
13	చేప	/ʧæ:pa/	Easy	33	రవి	/ravi/	Easy
14	గుద్దు	/gud̪d̪u/	Hard	34	పొట్ట	/poṭṭa/	Hard
15	చెక్క	/ʧækka/	Hard	35	రెండు	/rændu/	Easy
16	చెప్పు	/ʧæppu/	Hard	36	లేదు	/læ:d̪u/	Easy
17	తల్లి	/t̪alli/	Easy	37	బర్రె	/baræ:/	Hard
18	తోలు	/t̪o:lu/	Hard	38	రాదు	/ra:d̪u/	Hard
19	తాత	/t̪a:t̪a/	Easy	39	లారి	/la:ri/	Hard
20	దాని	/d̪a:ni/	Easy	40	వేడి	/væ:di/	Hard

Appendix

LNT - List 1

Sl no	Words		Easy/ Hard	Sl no	Words		Easy/ Hard
1	అన్న	/anna/	Hard	21	చూడు	/ʧu:du/	Hard
2	ఉండు	/vunḍu/	Easy	22	డబ్బు	/ḍabbu/	Easy
3	ఎండ	/ændɳa/	Easy	23	తండ్రి	/t̪andri/	Easy
4	అద్దం	/ad̪d̪am/	Hard	24	నేను	/næ:nu/	Easy
5	ఎంత	/æna/	Easy	25	దున్న	/d̪unna/	Hard
6	అచ్చు	/atʃ u/	Hard	26	నిద్ర	/nid̪ra/	Easy
7	ఐదు	/æid̪u/	Easy	27	నాది	/na:d̪i/	Hard
8	ఎక్కు	/ækku/	Hard	28	పాప	/pa:pa/	Easy
9	కాకి	/ka:ki/	Easy	29	నేల	/næ:la/	Hard
10	ఓడ	/o: ɖa/	Hard	30	బస్సు	/bassu/	Easy
11	కళ్ళు	/kaɭɭu/	Hard	31	నూరు	/nu:ru/	Hard
12	గుర్రం	/gurram/	Easy	32	భాష	/bʰaʃa/	Easy
13	కట్టు	/kaṭṭu/	Hard	33	నల్ల	/nalla/	Hard
14	గడ్డి	/gaɖɖi/	Easy	34	పెట్టు	/pæṭṭu/	Hard
15	గుర్తు	/gur̪tu/	Easy	35	ప్రక్క	/prakka/	Hard
16	గొప్ప	/goppa/	Easy	36	రోజు	/ro:ʤu/	Easy
17	కల	/kala/	Hard	37	రైతు	/ræ:t̪u/	Easy
18	చెవి	/ʧævi/	Easy	38	మొన్న	/mo:nna/	Hard
19	కూలి	/ku:li/	Hard	39	సన్న	/sanna/	Hard
20	చీమ	/ʧi:ma/	Easy	40	నీతి	/ni:t̪i/	Hard

LNT - List 2

Sl no	Words		Easy/ Hard	Sl no	Words		Easy/ Hard
1	ఎలా	/æ:la:/	Easy	21	తెల్ల	/t̪alli/	Hard
2	అవ్వ	/avva/	Hard	22	దొంగ	/d̪onga/	Easy
3	ఏమి	/æ:mi/	Easy	23	పైన	/pæna/	Easy
4	ఆమె	/a:maæ/	Hard	24	పాము	/pa:mu/	Easy
5	ఒక	/o:ka/	Easy	25	పిండి	/pin̪di/	Easy
6	కోతి	/ko:t̪i/	Easy	26	నీరు	/ni:ru/	Hard
7	కప్ప	/kappa/	Hard	27	నగ	/naga/	Hard
8	కొంగ	/ko:nga/	Easy	28	బుద్ది	/bud̪d̪i/	Easy
9	క్రింద	/krin̪da/	Easy	29	నిప్పు	/nippu/	Hard
10	కాయ	/ka:ja/	Hard	30	మామ	/ma:ma/	Easy
11	కారు	/ka:ru/	Hard	31	పన్ను	/pannu/	Hard
12	కారం	/ka:ram/	Hard	32	రాత్రి	/ra:t̪ri/	Easy
13	చేప	/ʧæ:pa/	Easy	33	రవి	/ravi/	Easy
14	గుద్దు	/gud̪d̪u/	Hard	34	పొట్ట	/poṭṭa/	Hard
15	చెక్క	/ʧækka/	Hard	35	రెండు	/rændu/	Easy
16	చెప్పు	/ʧæppu/	Hard	36	లేదు	/læ:d̪u/	Easy
17	తల్లి	/t̪alli/	Easy	37	బర్రె	/baræ:/	Hard
18	తోలు	/t̪o:lu/	Hard	38	రాదు	/ra:d̪u/	Hard
19	తాత	/t̪a:t̪a/	Easy	39	లారి	/la:ri/	Hard
20	దాని	/d̪a:ni/	Easy	40	వేడి	/væ:di/	Hard