# DICHOTIC WORD (CVCV) TEST IN NATIVE KANNADA SPEAKING CHILDREN

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THIS DISSERTATION OF MINE IS DEDICATED TO

*DEAR,*
*DARJI*
*&*
*BIJI,*
*MUMMY,*
*PAPA*
*&*
*LILTLE SISTER!!*

# CERTIFICATE

This is to certify that this dissertation entitled “Dichotic word (CVCV) test in native Kannada speaking children” is a bonafide work in part of fulfillment for the degree of Master of Science (Audiology) of the student Registration number: 07AUD003.This has been carried under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any diploma or degree.

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May 2009 Manasagangothri, Mysore-570006

# CERTIFICATE

This is to certify that this dissertation entitled “Dichotic word (CVCV) test in native Kannada speaking children” has been prepared under my supervision & guidance. It is also certified that this dissertation has not been submitted earlier to any other university for the award of any diploma or degree.

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# DECLARATION

This is to certify that this master's dissertation entitled "Dichotic word (CVCV) test in Native Kannada speaking children" is the result of my own study and has not been submitted earlier to any other university for the award of any degree or diploma.

MYSORE Registration number: 07AUD003

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# Chapter.1

# INTRODUCTION

Central auditory processing is described as "what we do with what we hear" (Katz, Stecker & Henderson, 1992). Auditory processing disorders (APDs) refers to problems in the perceptual processing of auditory information by the central nervous system as demonstrated by difficulties in one or more of the following skills: sound localization and lateralization, auditory discrimination, auditory pattern recognition, temporal aspects of audition, auditory performance in competing acoustic signal, and auditory performance in degraded acoustic signals (American Speech–Language–Hearing Association, 2005).

Normal auditory processing involves a number of distinct processes or skills. A breakdown/ deficit in any one of the skills will lead to Central Auditory Processing Disorder (CAPD). Patients with APD often experience unusual difficulty in hearing or understanding speech in various adverse acoustic and listening situations, such as listening to distorted or rapid speech, or hearing in noisy or reverberant environments, despite normal-hearing thresholds. Approximately 3 - 5% of children are affected by APD and is more common than the incidence of hearing loss (Chermak & Musiek, 1998). In India, it has been found that percentage of children to have dyslexia ranges from 3 % (Ramaa, 1985) to 7.5 % (Nishi Mary, 1988; cited in Ramaa, 2000). Several studies have indicated that children with speech and/or language problems may experience (substantial) difficulties with respect to auditory processing (American Speech–Language–Hearing Association, 1996; Tallal, Miller, & Fitch, 1993), and that specific training of auditory processing abilities could be beneficial in many of these children (Tallal, Merzenich, Miller, & Jenkins, 1998).

There are numerous auditory tests used to assess central auditory function which reflect the variety of auditory processes and regions/levels within the Central Auditory Nervous System (CANS) (and in some cases also include measures involving more peripheral regions [e.g., OAEs]) that underlie auditory behaviour and listening, and which rely on neural processing of auditory stimuli. Among the test batteries, dichotic listening tests have been an essential part of the test battery for assessing individuals of all ages (Jerger & Musiek, 2000). Dichotic listening test are among the most powerful of the behavioral test battery for assessment of hemispheric function, inter-hemispheric transfer of information, and development and maturation of auditory nervous system in children and adolescents, as well as the identification of lesions of the central auditory nervous system (Keith & Anderson, 2007). Depending on the instructions given to the listener, dichotic tasks may assess the processes of binaural integration, binaural separation or a combination of both (Bellis, 1996).

Binaural integration performance has been the focus of a significant amount of attention over the past several decades. This is the ability of the listener to process different information being presented to each ear at the same time (Musiek, 2006). This task is assessed through a variety of dichotic listening tests with digits, words and consonant - vowels. Performance in each ear is measured as material is simultaneously presented in competition to the two ears (Moncrieff & Musiek, 2002). Many audiologists report that a majority of the individuals with Auditory processing deficit (APD) fit an Integration Deficit profile, characterized primarily by a large interaural asymmetry during dichotic speech tests. A number of studies have identified the presence of binaural integration deficits in children with learning and reading disorders (Hynd, Obrzut, & Weed, 1979; Obrzut & Boliek, 1988; Moncrieff & Musiek, 2002).

Of the variety of speech stimuli available to measure dichotic listening (e.g., digits, words, consonant-vowels and sentences), digits are the most utilized. An advantage of digit stimuli is that, unlike sentences, they limit contextual cues. Digits, however, are a closed-set task that may tend to overestimate dichotic speech recognition ability. Digits are highly familiar, are quite limited in the available number of possible responses, and have been shown to be relatively easy to recognize for both normal hearing and hearing-impaired listeners (Musiek, 1983; Speaks, Niccum, Van Tasell, 1985; Strouse and Wilson, 1999a, 1999b). A more difficult task than DDT (Dichotic Digit Test) is Dichotic Consonant-Vowel test (CV) developed by Berlin, Lowe-Bell, Jannetta, and Kline (1972). Although the test is lightly linguistically loaded, its difficulty lies in high similarity among the CV segments as well as the close acoustical alignment of the stimuli. (Niccum, Rubens, & Speaks, 1981). Dichotic CV stimuli consists of 6 CV segments (pa, ta, ka, ba, da, ga). The Dichotic CV test has been shown to be sensitive to cortical lesions; however, as in many central tests, laterality of dysfunction cannot be determined by the test results. (Berlin, 1972). But this test is been reported to be difficult in some population (Mueller & Bright, 1994). Bellis also states that “this test is often too difficult for young children, and variability is high in school-aged children”. As an alternative, monosyllabic words (other than digits) may offer several advantages as a dichotic stimulus including: (1) monosyllabic words are meaningful components of speech that limit the use of syntactical cues (Committee for Hearing, Bioacoustics and

Biomechanics [CHABA], Working Group on Speech Understanding and Aging, 1988); (2) recorded monosyllabic word lists offer a standardized test of word recognition that are commercially available and in widespread use; (3) there is a large normative database for these monaural word-recognition materials from listeners with normal hearing and listeners with hearing loss across age groups in both quiet and competing message listening environments (Dubno, Lee, Klein, Matthews , & Lam ,1995; Dubno, Mills, Matthews, & Lee, 1997; Sperry, Wiley, & Chial, 1997; Wiley et al, 1998; Stoppenbach, Wilson, Craig, & Wilson, 1999; Stockley & Green, 2000); and (4) unlike digits, words are an open stimulus set that may result in recognition performance in the middle of the difficulty continuum (e.g., neither too easy nor too difficult, yet sensitive to performance differences between ears and groups).

**Need for the study:**

- It is ideal to have speech tests in all languages as the individual perception of speech is influenced by their first language/mother tongue (Singh & Black, 1966). There is no specific data for dichotic word test in Kannada language, which is one of the Dravidian languages spoken in Southern India for assessing the auditory processing. Hence there is a need to develop a test and to detect their problems which is appropriate for Indian children.
- The need for developing Dichotic Word Test (DWT) is crucial because the auditory system is undergoing maturation, thus age-specific data are required to help in making decisions about whether a child’s auditory system is developing normally or otherwise. The availability of age-specific normative data also enables clinicians to monitor a child’s performance over time (Keith, 2000).

- To incorporate the Dichotic word test as part of the CANS evaluation battery, since dichotic measures have demonstrated good sensitivity in identifying and differentiating cerebral level lesion (Berlin, 1976; Noffsinger. 1979).
- According to Musiek, Gollegly, & Ross, (1985), normative data from a representative population is required to ensure if it is a valid and reliable measure of auditory processing ability would be a prerequisite.

**Aim of the study:**

The study was conducted with the following aims:

1. To develop dichotic word test in Kannada language.
2. To develop preliminary data for the Dichotic Word Test (In Kannada) for group of normal children in the age range of 7years to 12years.
3. Investigate the effect on different stimulus list.
4. Investigate if the scores are different across age and gender.
5. Investigate if there is any ear difference on the score of the dichotic word test.

# Chapter 2

# REVIEW OF LITERATURE

An auditory processing disorder (APD) may be broadly defined as a deficit in the processing of information that is specific to the auditory modality. The problem may be exacerbated in unfavorable acoustic environments. It may be associated with difficulties in listening, speech understanding, language development, and learning. In its pure form, however, it is conceptualized as a deficit in the processing of auditory input. (Jerger & Musiek, 2000).

The definition of a CAPD advanced by the Task Force is based on the principle that central auditory processes are the auditory system mechanisms and processes responsible for the following behavioral phenomena. These processes include: Sound localization and lateralization, Auditory discrimination, Auditory pattern recognition, Temporal aspects of audition, including: Temporal resolution, Temporal masking, Temporal integration, and Temporal ordering, Auditory performance decrements with competing acoustic signals; and Auditory performance decrements with degraded acoustic signals.

The definition of a CAPD proposed by the Task Force is “an observed deficiency in one or more of a group of mechanisms and processes related to a variety of auditory behaviors” (ASHA Task Force on Central Auditory Processing Consensus Development, 1996).

## Etiology

Historically, brain lesions were thought to be the underlying cause of APD. Persons with similar symptoms were thought to have some central auditory pathway lesion. Infact, sub-grouping of APDs was based upon theorized neuroanatomical and neurophysiological etiologies (Musiek & Gollegly, 1988). Causes of APD in children are not completely understood. Often, these children do not show any neurological disease or show any neurological abnormality (Schain, 1977).

Not all cases of APD have an underlying structural deficit, therefore, APD may be difficult to diagnose with computerized tomography or magnetic resonance imaging scans of the brain. Researchers have suggested that the problem underlying APD “may be invisible to many neurologic and radiolgic studies” (Musiek & Lamb, 1994). Other prenatal or perinatal factors that may be indicated in APD are: hyperbilirubinemia, ototoxic drugs, anoxia, low birth weight, RH incompatibility, prematurity, abnormal secretion that affects brain cell development prior to birth, and unspecified birth problems (Willeford & Burleigh, 1985). Maternal factors which may adversely affect the development of the central nervous system include diabetes, rubella, syphilis cytomegaloviruses, and toxemia (Willeford & Burleigh, 1985). Hereditary factors may also play an important role (Willeford & Burleigh, 1985; Bellis, 2003). Future brain imaging studies such as functional magnetic resonance imaging may prove of value in further understanding the mechanisms involved in brain function and auditory processing in normal children and children with APD.

## Comorbidity of APD

There is an intimate relationship between language, attention, and auditory skills. Auditory processing disorders often coexist with learning disabilities, language disorders, attention deficit disorders, and dyslexia (Chermak & Musiek, 1997; Caccace & MacFarland, 1998). All of these groups are heterogeneous in nature. However, it is important to note that not all children with a language, learning or attention disorder will have an auditory processing disorder.

APDs have also been linked with children with chronic otitis media (Gravel & Wallace, 1992; Hall & Grose, 1993; Brown, 1994; Hall, Grose & Pillsbury, 1994) and with the elderly and aging population (Committee on Hearing, Bioacoustics and Biomechanics Working Group on Speech Understanding and Aging, 1988; Stach, Spretnjak, & Jerger, 1990). This has led some investigators to question if auditory processing deficits underlie language disorders, or if auditory processing disorders are but one type of language disorder (Rees, 1973, 1981; Keith 1981a, 1981b; ASHA 1996). Controversy exists about the label of APD in children with multi-sensory deficits. Some investigators argue that if multi-sensory deficits are present, then the diagnosis of APD is inappropriate and the diagnosis is only appropriate where there is a single auditory deficit (Cacace & Mc Farland, 1998). However, given the interconnections of the nervous system and the influence of higher-level functions such as language, cognition and attention, the single modality-specific definition for APD is not logical (Bellis, 2003).

Oral language acquisition depends upon the efficient processing of acoustic stimuli (ASHA, 1996). An auditory perception account of the etiology of children with specific language impairments has been proposed. This theory posits that some children with specific language impairments have difficulties in perceiving rapid acoustic events and have difficulty in processing auditory information of brief duration relative to surrounding segments (Tallal & Piercy, 1973; Tallal & Stark, 1981). This difficulty will not only affect phoneme recognition, but also affect the listener's ability to segment speech. Leonard (2001) reported that the primary flaw of the auditory perception account was that it does not account for the full range of linguistic problems of children with specific language impairments. A degraded acoustic environment may hinder speech processing. This degraded environment has also been theorized to be one of the etiologies of specific language impairments in that the amount and type of linguistic input necessary for optimal language acquisition is not present (Lasky & Klopp, 1982). However, it is important to note that not all children with specific temporal processing deficits show language or speech disorders.

There are two contrasting models regarding the influence of lower order perceptual processing and higher order cognitive processing on language and learning disabilities (Keith, 1981). Models describe how listeners "perceive the acoustic signal, conduct auditory analysis involving complex pattern recognition; match acoustic patterns to some internal representation(s); extract meaning from strings of lexical representations; and construct a message level interpretation.

Bottom-up processing is a term used in information processing which describes the cochlea and the brain's analysis of neural coding through the cortex (Chermak & Musiek, 1997). Top-Down Processing refers to the influence of higher level cognitive or language related knowledge on the interpretation of incoming sensory information.

## Sub-groups of APD

Investigators have attempted to document the heterogeneous nature of APDs by sub-grouping APD or describing the characteristics in terms of commonalities (Musiek & Gollegly, 1988; Katz, 1992; Bellis & Ferre, 1999). Although this may be beneficial in management, no sub-grouping system or model is universally accepted. The Buffalo Model (Katz, Smith, & Kurpita, 1992) focuses on the relationship between patterns of performance on one particular test of auditory processing, and learning difficulties in children. This model contains four subtypes: Decoding, Tolerance-Fading Memory, Integration, and Organization. Decoding describes individuals who "have difficulty keeping up with the flow of communication, have poor phonemic skills, are slow responders, often have articulation errors, have difficulty following directions, and have weak oral reading and spelling skills" (Steker, 1992).

Persons with tolerance-fading memory have difficulty understanding speech with competing background noise and have short-term memory problems. These individuals are often described as impatient and are easily over-stimulated. They tend to have poor reading comprehension and may have handwriting difficulty. Persons with integration problems have difficulty integrating the auditory modality with other nonverbal aspects of speech such as word finding, morphological and syntactical errors, or an expressive language disorder. Organization describes persons who have difficulty sequencing events and have sequencing errors. These individuals are often disorganized at home or school. Often a person will exhibit characteristics of more than one sub-type.

Musiek & Gollegly (1988) report three types of APD in children with learning disabilities. These three types are based upon an underlying neurophysiological deficit or neuromaturational delay, neuromorphological disorder, maturational delay of the CNS, and neurologic diseases and insults. These types are theoretical and have not been directly investigated due to the invasive nature of necessary research procedures.

The Bellis/Ferre model of APD (Bellis & Ferre, 1999) is based upon the underlying neurophysiology of the brain and the relationship among different types of APD and language, learning, and communication difficulties. This model proposes five subtypes of APD, which are: Auditory Decoding Deficit, Prosodic Deficit, Integration Deficit, Associative Deficit and Output Organization Deficit. Again, these theories and subtypes are conceptual descriptions of the academic problems of children. "Auditory decoding refers to persons with "poor auditory closure abilities, characterized by poor performance on tests of monaural low redundancy speech and speech-in-noise" (Bellis, 1996). Integration Deficit refers to difficulties in inter-hemispheric transfer. Associative Deficit refers to "an underlying inability to apply the rules of language to incoming acoustic information" (Bellis, 1996). Output-Organization Deficit is a deficit in organizing, planning, and sequencing responses. Again, it is possible that a person may have more than one sub-type.

## Integration Deficits in individuals with CAPD

The standard test of binaural integration is the dichotic listening test administered so that the listener is asked to repeat all information following presentation to both the right and left ears (Musiek & Pinheiro, 1985; Bellis, 2003). There are four patterns of responses that typically occur during the dichotic listening task. Normal listeners respond with strong performance from both ears with one ear performing slightly more poorly than the other ear, resulting in a small interaural asymmetry (Hugdahl, 1995).

Other listeners may respond with a small interaural asymmetry also, but demonstrate poor performance in both ears. This second pattern has been documented in patients with brainstem and cortical lesions (Musiek & Pinheiro, 1985). In children with no known lesions, similarl poor performance in both ears could be due to problems with binaural integration as well as to other factors, including language disorder, attention deficit disorder, short-term memory problems, poor motivation, fatigue, or limited cognitive abilities. In a third pattern, the listener's ear that is contralateral to the language-dominant hemisphere performs normally and the other ear performs poorly, resulting in a large interaural asymmetry. This pattern has suggested limited myelination of the corpus callosum leading to poor interhemispheric transfer of linguistic information in both children and adults (Jerger, & Musiek, 2000). Poor performance in one ear is sometimes referred to as a left-ear deficit and is also linked to an auditory processing disorder known as an integration deficit (Bellis & Ferre, 1999; Musiek, 1999; Moncrieff & Musiek, 2000).

## Different Test available For Binaural Integration Task

### Staggered Spondaic Words Test (SSW)

Katz (1962) first described the Staggered Spondaic Word (SSW) test. This test consists of spondaic words that are presented dichotically in a staggered manner so that the second syllable of the first spondee is overlapped with the first syllable of the second spondee. This test has been shown to be sensitive to brainstem and cortical lesions (Katz, 1962). It has also been widely used with children.

**Dichotic Digit Test**

According to Musiek, (1983) in dichotic digit test the digits are presented simultaneously to both ears. Results of investigations using the dichotic digits indicate contralateral deficits in subjects with right temporal lobe lesions and bilateral or contralateral deficits in subjects with left hemisphere lesions (Musiek, 1983; Baran & Musiek, 1991). Left ear deficits have been reported in subjects with interhemispheric compromise and are more frequently reported than right ear deficits (Musiek, & Lamb, 1994). This test is not highly linguistically loaded and is easy and quick to administer.

**Dichotic CV Test**

Berlin & Lowe (1972) introduced Dichotic Consonant Vowel Test for central auditory nervous system assessment. Although this test is lightly linguistically loaded, it’s difficult because of the similarity in the CVs (pa, ba, ta, da, ka, and ga). In addition, one version of the Dichotic CV test had a 15, 30, 60 or 90 msec delay in the presentation of the second stimulus. Investigators have reported either contralateral ear deficits or bilateral deficits with left hemisphere compromise (Berlin & Lowe, 1972; Mueller, Beck & Sedge, 1987).

**Dichotic Rhyme Test**

The Dichotic rhyme test was introduced by Wexler and Halwes (1983) and modified by Musiek et al. (1989). It is composed of rhyming pairs of consonant-vowels-consonants words that begin with one of the stop consonants. This test has become a valuable addition to the central auditory test battery for identification of inter-hemispheric or trans-callosal pathology (Muller and Bright, 1994). Bellis (2003) recommended that the DRT be administered at 50 dB SL (re: spondee threshold).

Because of close temporal alignment of the stimuli, listeners typically hear and report just one word for each stimulus presentation, resulting in an individual ear score near 50%.

## Factors Affecting dichotic Listening

### Stimulus Related Factors Affecting Dichotic Listening

Dichotic Speech Tests were first introduced in 1961 by Kimura. Different stimuli are presented simultaneously to the two ears.

i) **Effect of stimulus material on dichotic listening tasks**

Fusion in the dichotic listening condition takes place when words with similar spectral shape (waveform envelop) are presented to the listener. The waveform envelop for words is generally determined by the low frequency energy (Perrot & Barry, 1969), which is essentially its fundamental frequency (Repp, 1976, 1977a). Therefore, if two words presented dichotically, which have similar spectral envelopes and are temporally aligned, they will fuse and will be heard as one word (Repp, 1977a).

Repp, 1976 studied Seven synthetic syllables from a "place continuum" (/bae/–/dae/–gae/) presented in all dichotic combinations for identification. These syllables fused completely, so that dichotic pairs were perceived as single stimuli. Stimuli that were good instances of a category seemed to "dominate" stimuli that were closer to a category boundary. Average dichotic right-ear advantages of small magnitude were obtained for the dichotic fusions. They could not be reliably discriminated from binaural stimuli, and selective attention to one ear had little effect. With respect to the measurement of dichotic ear asymmetries, dichotic fusions offer certain methodological advantages over other dichotic stimuli.

### ii) **Effect of frequency of stimulus on Dichotic listening task**

When two different auditory signals are presented simultaneously, one to each ear one of them is usually perceived as having a greater perceptual salience than the other. There are two main types of such perceptual asymmetry. The first asymmetry is because of a left hemispheric dominance for the processing of speech sounds and is called the right ear advantage (REA) for speech (Kimura, 1961). The second type of auditory perceptual asymmetry arises when two dichotic signals are two tones relative close in frequency (Efron & Yund, 1974, 1976). Ear dominance for pitch is independent of handedness as well as of the ear advantage observed with dichotic speech sounds (Yund & Efron, 1977). On the other hand, ear dominance is correlated with a difference in the frequency resolving power of the two ears (Divenyl, Efron & Yund, 1977). It thus seems reasonable to assume that ear dominance is a consequence of an asymmetry in the processing of spectral information and is produced by a mechanism different from that responsible for the REA observed with time varying auditory signals. However, since speech sounds carry spectral information, one might expect the REA for speech to be confounded with right ear dominance for tones. In subjects with left ear dominance for tones, any REA for speech must be a consequence of some other (time related) asymmetry that is unique to speech processing.

The dichotomy between the two ears in perception to verbal and non-verbal inputs is not unequivocal. It has been shown that subjects attending to non-verbal properties (pitch or loudness variation) of dichotic verbal input reported better from the left ear than from the right ear (Nachshon, 1970; Spellacy & Blumstein, 1970). Hence, the input is mediated by the right hemisphere when the non-verbal aspects of verbal input are attended to. It is assumed that non-verbal but sequentially patterned sounds will be mediated by the left hemisphere, since one of the important features of verbal materials is its sequential character (Lashley, 1951; Neff, 1964; Hirsh, 1967). Supporting this assumption is the evidence derived from studies showing that tasks involving sequential analysis if stimuli seem to be controlled by the left hemisphere.

Halperin, Nachshon and Carom (1973) tested this assumption by conducting a study on normal subjects. The subjects were presented with two dichotic listening task. They were instructed to identify sets of sounds with different sequential complexity of frequency or duration. The sequential complexity was defined by the number of frequency or of duration transitions in a set of 3 sounds. Results of the study reveal that the direction of ear superiority in report of dichotic set, varied as a function of the complexity of the temporal patterns. In case of zero transition (i.e. when no transition occurred within a set, left ear superiority was found) for between ears discrimination of pitch. Increase of complexity by increasing the number of transitions was accompanied by a gradual shift from the left ear to right ear superiority. This finding was in accordance with the finding showing a significantly greater right ear superiority in perception of dichotic consonants (which are more complexly encoded than vowels), than in perception of vowels (Studdert-Kennedy, Liberman, Harris & Cooper, 1970).

Thus, studies have reported perceptual asymmetries to occur when two different auditory signals are presented simultaneously. A right ear advantage for speech and a left ear advantage for processing of tones, and other non-verbal stimuli have been reported. It was seen that when non-verbal aspects of verbal material are attended to, the input was mediated in the right hemisphere, where as non-verbal but sequentially patterned sounds will be mediated by the left hemisphere. It thus seems reasonable to assume that ear dominance is a consequence of an asymmetry in the processing of spectral information.

### iii) **Effect of intensity of stimulus on dichotic listening tasks**

The effect of intensity on dichotic listening has not been very extensively studied. The few studies conducted have shown that the right ear laterality does not differ significantly as a function of sensation level.

Roeser, Johns and Price (1972) designed a study to investigate the right ear effects as the function of intensity and to determine, whether there was intensity or a general range of intensities at which the effect is most observable. Results indicated that at lower intensity levels there was a significant tendency for subjects to report fewer correct responses. Subjects however reported significantly more stimuli from the right ear across intensity that is the right ear scores were not found to vary as a function of intensity. Ryan (1974) showed that REA was held constant even when the left ear signal was 6 dB more intense than the right ear.

Hugdhal, (2008) examined the effect of differences in the right or left ear stimulus intensity on the ear advantage using dichotic CV test. For this purpose, interaural intensity difference were gradually varied in steps of 3 dB from -21 dB in favour of the left ear to +21 dB in favour of the right ear, also including a no difference baseline condition. The results showed that: (a) a significant right ear advantage for inter-aural intensity differences from 21 to -3 dB, (b) no ear advantage for the -6 dB difference, and

(c) a significant left ear advantage for differences form -9 to -21 dB. It was concluded that the right ear advantage in dichotic listening to CV syllables withstands an inter-aural intensity difference of -9 dB before yielding to a significant left ear advantage. The same can be applicable to DWT.

### iv) Effect of temporal aspects on dichotic listening tasks

When normal hearing listeners are stimulated dichotically with speech materials, there is a right ear advantage observed. However, when the stimuli are presented to the ears at onset time asynchronies of approximately 30 to 90msec, the lagging member of the pair is perceived more accurately than the stimuli presented first.

Gelfand, Hoffman, Waltzman, & Piper, (1980), studied the lag effect on dichotic listening task in 24 young adults (age range (17-28years) and in 24 elderly subjects (28-60years). Results for both the group were not similar. The left ear scores of the young group increased for the 30 ms left-lagging condition, and right ear performance improved for the 30 ms right-lagging condition. Beyond 30 ms, scores for both ears improved with offset in either direction. A different trend was noted in the elderly. Here, both right and left ear scores improved with lag in either direction; and left ear scores increased at a faster rate than right ear scores, regardless of the direction of lag.

Mirabile, Porter, Hughes, & Berlin, (1979) studied Children in age range of 7-15 yrs of age. Task was to identify simultaneous and time-staggered dichotic CV stimuli at 5 onset asynchronies: 0, 15, 30, 60, and 90 msec. For simultaneous presentation there was right-ear advantage and improvement in performance with age. For presentation with lag time, performance increase as asynchronies were increased and this was more for younger males than females. Suggesting that CV processing may take longer for younger children, especially males, than for adults.

### v) **Effect of stimulus dominance in dichotic listening**

Berlin, Hughes, and Berlin, (1973) reported that scores were higher for voiceless stops than for voiced stops in pairs of natural syllables that contrasted in voicing. The voiceless stops are said to be "dominate" over the voiced stops. This finding was replicated by Roser, Johns, and Prince, (1976) and by Niccum, Rubens, and Speaks, (1976).

Thus, for natural CV syllables, there appeared to be a "stimulus dominance effect", i.e., higher scores are got for one of the two competing syllables- the "dominant" one – regardless of the ear to which it is presented. Lowe, Cullen, Berlin, Thompson, and Willett, (1970) found that their subjects correctly reported voiceless consonants more frequently than the voiced, in the dichotic tasks. However, in monotonic tasks, perception of the voiced consonants improved. Since both stimuli came to the same ear, the first transition from aperiodicity to periodicity occurs in the voiced CV. Thus, the potential for masking of the aperiodic portion of the voiceless consonant by the initial segment of the voiced consonant is clearly established.

Ear advantage, in dichotic listening tasks, has been studied extensively with CV non-sense syllables. It was found that, at simultaneity, the voiceless consonant was more intelligible than the voiced. This finding was explained in terms of a so called 'lag-effect', where the lagging syllable was found to interrupt the processing of syllable presented first and since the voiceless CV's have a longer voice onset time (VOT) and longer burst duration, the later arriving syllable disrupts the processing of the earlier syllable and hence is perceived better. In terms of place and manner of articulation, the voiceless velars were the most intelligible during dichotic presentations followed by alveolars and labials. This was explained on the basis of variations in voice onset times and the burst intensities for the various CV's.

Di Stefano, Marano and Viti, (2004) evaluated stimulus-dominance and ear asymmetry in normal population (48 subjects of both gender and handedness) and in 2 patients with a single functional hemisphere. Results show that in normal's the number of stimulus-dominated responses is five times higher than in patients, and is negatively correlated to the index of laterality.

## Subject Related Factors Affecting Dichotic Listening

### i) Gender differences in Language Lateralization Using Dichotic Listening

Kahn, (2008) studied gender differences in handedness, asymmetry of the Planum Temporale and functional language lateralization. Their study was aimed to provide a complete overview of gender differences in several reflections of language lateralization: handedness, asymmetry of the Planum Temporale (PT) and functional lateralization of language, measured by asymmetric performance on dichotic listening tests (Right Ear Advantage) and asymmetry of language activation as measured with functional imaging techniques. Results of the meta-analysis on dichotic listening studies retrieved no gender difference in lateralization. When the studies were subdivided according to the paradigm they applied, studies that used the consonant-vowel task yielded a gender difference favoring males, while studies that applied other paradigms yielded no gender difference.

In conclusion, males are more frequently non-right handed than females, but there is no gender difference in asymmetries of the Planum Temporale, dichotic listening findings or functional imaging findings during language tasks.

Kalil, (1989) did an exhaustive survey of auditory laterality studies from six neuropsychology journals to see if there is a gender difference in human laterality. The entire contents of six neuropsychology journals (98 volumes, 368 issues) were screened to identify auditory laterality experiments. Of the 352 dichotic and monaural listening experiments identified, 40% provided information about gender differences. Among the 49 experiments that yielded at least one significant effect or interaction involving the gender factor, 11 outcomes met stringent criteria for gender differences in laterality. Of those 11 positive outcomes, 9 supported the hypothesis of greater hemispheric specialization in males than in females. The 9 confirmatory outcomes represent 6.4 % of the informative experiments. When less stringent criteria were invoked, 21 outcomes (14.9% of the informative experiments) were found to be consistent with the differential lateralization hypothesis. The overall pattern of results is compatible with a weak population-level gender difference in hemispheric specialization.

### ii) **Effect of Age On Dichotic Listening**

The effect of age on dichotic listening may be different depending on the type of stimuli used. Dichotic listening on children suggest that the more linguistically loaded stimuli presented, the more pronounced the maturational effects are likely to be (Bellis, 1996).

Berlin, Hughes and Lowe-Bell (1973) studied the performance of normal hearing children between ages 5 and 13 on a set of dichotic CV test. Their results showed a right-ear advantage (REA) that remained relatively constant throughout the age range. In contrast to these results in Indian context finding by Gowri Krishna (1996) reveals that even at the age of 12 the results were not matched with adult score on dichotic CV test.

Cross-sectional dichotic listening study by Pohl (1984) using thirty pairs of one-syllable words and thirty pairs of four-syllable numbers reveal the developmental course of ear asymmetry. Middle-class children with age range of 4 to 10 were taken as subjects. A significant decrease in REA for both word and number pairs was found. Although right-ear and left-ear performance both increased with age, the developmental gain in left-ear performance was greater than the gain in right-ear performance, thus resulting in a decrease in REA with age. But contrasting results were found using dichotic sentence identification by Jerger, Chmiel, Allen and Wilson (1994). They have analyzed the clinical records of 356 individuals, 203 males and 153 females, to whom the Dichotic Sentence Identification (DSI) test had been administered as part of routine audiometric assessment. The age range considered for study was 9 to 91 years. Results revealed that larger right-ear advantage, or left-ear deficit, was observed with increasing age. Comparison of male and female data suggested gender difference in the effect of age on the left-ear deficit. Males show a larger effect than females in both modes of test administration. Poor left-ear performance on dichotic sentence tasks in children may reflect a decreased ability of the corpus callosum to transfer complex stimuli from the right hemisphere to the left hemisphere. As the child becomes older and myelination of the corpus callosum is completed, inter-hemespheric transfer of information improves and left-ear scores approach those found in adults (Musiek, Gollegly & Baran, 1984).

### iii) Effect of Practise on Dichotic Listening

Porter, Troendle and Berlin (1976) studied practice effects on dichotic listening task using dichotic CV material. They investigated long-term effects of practice on performance by testing once a week over a period of 8 weeks. Results revealed that a slight increase in double correct responses (28% - 38%), a slight drop in both single correct responses (65% - 58%) and decreased either correct responses (7% - 4%). However, overall dichotic performance does not become a stable measure (i.e., does not reach an asymptote) until subjects have experienced at least 300 dichotic trials. Similar results were also reported earlier by Ryan and Mc Neil (1974); Johnson and Ryan (1975).

### iv) **Effect of Response Mode on Dichotic Listening**

The response of the listener can be of number of ways on dichotic listening task. These include written down response, or orally repeating the heard stimuli and also visual recognition. As the process involved in these activities varies, there could be some differences exists on responses. Jäncke (1993) evaluated the difference in results with respect to the three response conditions using dichotic CV test. Testing was administered three times to 56 male right handers and 50 male left handers. During each experimental session the subjects had to perform this dichotic test using a different response condition. On one occasion they were required to verbally report the perceived syllables (*speak* condition), on another occasion they were asked to write down the syllables they had heard (*write* condition), and lastly, they were asked to visually recognize the stimuli (*visual* condition) which were presented onto a monitor screen. Results revealed that there is no significance influence of response mode on right ear advantage.

### v) Performance on Dichotic Listening Using Different Report Strategies

The studies on dichotic listening have evaluated the performance of normal subjects using two response modes or report strategies. The response modes are free-recall and directed recall. Free –recall is one in which the subject reports the stimuli in any order, and directed recall is one in where in the subject is instructed to report the stimuli heard in one of the ears (either right or left). Bryden (1962) found that right ear superiority consistently occurred when a free-recall procedure was used, as well as when the order of report was controlled. Similar findings were reported by Satz, Bakker, Goebel, and Glut, (1975). Gerber and Goldman (1970) conducted a study, where subjects were tested in different reporting conditions (free-recall and directed response). It was found that a significant right ear preference for dichotically presented stimuli existed regardless of the report strategy employed.

In contrast Keith, Tawfik, and Katbamma, (1985) examined the response of adult subjects to directed listening tasks using the dichotic consonant-vowel (CV) test. Results indicated that subjects showed right ear advantage in directed right listening condition and a left ear advantage in directed left listening condition. Free-recall listening conditions showed a right ear advantage.

Baran and Musiek (1987) studied the performance of adult subjects on a dichotic speech test under both directed and free recall listening conditions. Twenty-five young adult subjects with negative otologic histories were administered a dichotic rhyme test under three different listening conditions: (1) free recall, (2) directed listening to the right ear, and (3) directed listening to the left ear. The nature of the test was such that under normal conditions (i.e., free recall), listeners tend to repeat either the word presented to the left ear or to the right ear. Normal performance was approximately 50% correct identification in each ear, with a slight right ear advantage evident. In an earlier investigation using a dichotic CV test, Keith *et al.* (1985)] demonstrated a clear left ear advantage on a directed left ear task and an obvious right ear advantage on a directed right ear task. This investigation showed no significant differences in the test scores observed when the right and left ear scores were compared with the same ear scores across the three test conditions. In all three test conditions, a slight right ear advantage was noted.

Musiek, (2006) studied the Differential attention effects on dichotic listening. The purpose of this study was to assess the performance of normal listeners on a dichotic consonant-vowel and a dichotic rhyme (fusion) test. Both test procedures were administered to 20 young adults in three different listening conditions (free recall, attention directed to the left ear, and attention directed to the right ear). Results from this study supported the hypothesis that dichotic rhyme tests are resistant to alterations in the laterality of attention and have implications for the development of test paradigms that can be used to segregate attention from pure auditory deficits in the clinical domain.

Asbjornsen and Bryden (1996) studied the effect of biased attention on the fused dichotic words test (FDWT) and the CV syllables dichotic listening test (CVT). Eight males and eight females were given both tests with two different instructions: to direct attention to the left ear (DL), or to the right ear (DR). These instructions led to highly significant differences in response on the CVT, but only a marginal shift in performance on the FDWT. While the FDWT is not completely unaffected by attentional manipulations, it is far less influenced by such effects than the CVT. This indicates that subject-initiated shifts of attention are much less likely to affect performance on the FDWT than on other dichotic tests and makes it a more valuable task to assess cerebral speech lateralization.

Hiscock, Kinsbourne, and Inch, (1999) studied allocation of attention in dichotic listening and differential effects on the detection and localization of signals. 96 normal right-handed adults attended selectively to the left and right ear and divided their attention equally between both ears. Participants listened for specified targets and reported the ear of entry. The material consisted of pairs of consonant-vowel syllables in Experiment 1 and pairs of rhyming consonant-vowel-consonant words in Experiment 2. Both experiments yielded a right-ear advantage for detection and for localization. Attention instructions had no effect on detection. However, focusing attention on 1 ear increased the number of targets attributed to that ear while decreasing the number of targets attributed to the opposite ear. The dissociation between detection and localization indicates that volitional shifts of attention influence late (response selection) processes rather than early (stimulus identification) processes. Selective-listening effects can be accounted for by a 2-stage model in which a fixed input asymmetry is modulated by a biased selection of responses.

## Dichotic Test and Clinical population

### 1. Peripheral hearing loss

### 1a. **Conductive hearing loss**

Niccum et al (1987) reported that conductive hearing loss does not affect performance of listeners on dichotic listening tasks as long as the stimuli are presented at an intensity at least 12dB above the monotic "knee" for the affected ear(s). The monotic knee represents that point in the performance-intensity functions at which listener reaches a 95% accuracy level for monotic presentation of stimuli.

### 1b. **Sensori Neural hearing loss**

Roeser, johns, and Price (1976) investigated the effect of bilaterally symmetrical hearing loss on dichotic listening using digits and CV non-sense syllables. They reported larger ear advantage (right or left). This suggests that sensorineural hearing loss can significantly affect the size and direction of ear advantage.

### 2. Temporal Lobe Lesion

Berlin et al. (1972) measured central auditory deficits in patients after temporal lobectomy. They used dichotic simultaneously and time staggered speech material on four patients with temporal lobectomies and compared the results with that of normals. In their test, competing non-sense syllables were used in following manner: /ba/ was presented to the right ear /ta/ was presented to the left ear, both at the same time. The patient was asked to repeat what he heard. The message to the ear ipsilateral to the lesion was usually reported accurately, the one to the contralateral ear was either not perceived at all or was distorted. Thus, if /ba/ was given in the right ear of patient with right temporal lobectomy, he would report /ba/ and miss the /ta/. The syllables, in Berlin et al.

(1972) study were presented simultaneously, then with the separations ranging from 15 to 500 msec. it was seen that with simultaneous onset normals showed right ear superiority, and with time separation of 30 msec to 90 msec, normals showed a lag-effect, i.e., better scores for the trailing stimulus. In sharp contrast, temporal lobectomy patients showed poorer contralateral ear function than ipsilateral ear function, and no lag-effect. Comparing preoperative and postoperative scores, it was seen that postoperatively there was additional degradation of contralateral ear scores and enhanced ipsilateral ear function in dichotic listening. Patients with both left and right temporal lobectomies behave similar in this respect. It is clear from this data that the advantage which normal listeners achieve when they hear a lagging message in a pair is lost to patients with temporal lobe lesions. Patients show a distinct failure to accurately perceive messages in the ear contralateral to the lesion, independent of the temporal sequence of the syllables. Berlin et al. (1972) believed that both right and left anterior temporal lobes must participate in some type of preliminary speech information processing, otherwise there would be no prospective laterality effects following temporal lobe lesions. Such patients generally show an almost complete separation of dichotic speech information sent to their contralateral ears. It was suggested that the anterior temporal lobe play a critical role in either preliminary speech analysis or in the relay of speech information to the posterior temporal cortex via association pathways. It was hypothesized that the information coming right anterior temporal lobe to the left posterior temporal areas need not pass through the left anterior areas. If such a serial relationship existed, than a left anterior temporal lobectomy would have devastating results on all speech and hearing functions. On the contrary, it is only the left ‘posterior’ temporal parietal removals that have such serious effects (Berlin et al. 1972). Sparks, Goodglass, and Nickel, (1970) have suggested that if deep left hemisphere lesions interfere with connection from the right to the left temporal lobe, one might also see ipsilateral “extinction” in the left ear with a left hemisphere lesion.

When two competing stop consonant-vowel (CV) syllables were presented dichotically to a listener with a temporal lobe lesion, the scores for syllables in the ear contralateral to the lesion usually was much lower than scores for syllables in the ipsilateral ear. Ample documentation exists to show that the weak ear score for temporal lobe patients was suppressed markedly in dichotic tasks. The existence of separation has been documented with CV syllables (Berlin et al. 1972, 1973), digits or words (Kimura, 1961; Speaks, Goodglass, 1970), sentences (Jerger, Sharbrough, & Jerger, 1969, Speaks, Podraza, & Kuhl, 1973). The inference seems to be that the cortical processing areas for speech presumably located in the left hemisphere; do not receive an effective dichotic input. Because of the temporal lobe lesion the signal was degraded sufficiently such that correct processing of the weak ear signal was unlikely.

### 3. Split-Brain patients

The DRT was also used in studying dichotic listening performance in split-brain patients (Musiek et al, 1989). In this study, two significant observations were made for the population of patients. The first of these was that the subjects in this investigation consistently demonstrated the “expected” left ear deficit due to the compromise of the normal inter-hemispheric pathways, and the second was that the subjects not only showed the expected REA but that the size of this advantage was noticeably greater than that noted for normal subjects. The results of this study demonstrated that in addition to being clinically feasible for use with patients with compromise of the central auditory nervous system, this test was highly sensitive in assessing the integrity of inter-hemispheric transfer of auditory information.

Zaehle, Jäncke, and Meyer, (2007) studied two commonly used dichotic listening tests for measuring the degree of hemispheric specialization for language in individuals who had undergone cerebral hemispherectomy: the Consonant-Vowel (CV) nonsense syllables and the Fused Words (FW) tests, using the common laterality indices $f$ and $\lambda$. Hemispherectomy on either side resulted in a massive contralateral ear advantage, demonstrating nearly complete ipsilateral suppression of the left ear in the right hemispherectomy group but slightly less complete suppression of the right ear in the left hemispherectomy group. The results are consistent with the anatomical model of the ear advantage (Kimura, 1961). Most syllables or words are reported for the ear contralateral to the remaining hemisphere, while few or none are reported for the ear ipsilateral to the remaining hemisphere. In the presence of competing inputs to the two ears, the stronger contralateral ear-hemisphere connection dominates/suppresses the weaker ipsilateral ear-hemisphere connection. The $\lambda$ index was similar in the two tests but the index $f$ was higher in the CV than the FW test. Both indices of the CV test were sensitive to side of resection, higher in the right hemispherectomy than in the left hemispherectomy groups.

Bamiou, et al., (2005) studied auditory Interhemispheric Transfer in Patients with Congenital Abnormalities of the Commissural Pathways due to a PAX6 Mutation. Patients with a heterozygous PAX6 mutation have absent or hypoplastic anterior commissure and may have a reduced size corpus callosum. Both these formations contain auditory interhemispheric fibers. They assessed central auditory function in 8 patients with a PAX6 mutation and 8 age- and sex-matched controls. Brain MRI results were available for all PAX6 subjects. Subjects and controls had baseline audiometric tests, and central auditory tests, which included the dichotic digits, rhyme and CVs, frequency and duration pattern, and a Gap in Noise tests. The anterior commisure was absent in 5 and hypoplastic in 1 subject. The callosal area was reduced in 3 subjects. All subjects and controls had normal peripheral hearing. The PAX6 group had a greater left ear deficit in the dichotic digit and the dichotic CVs tests and a greater right ear advantage in the dichotic rhyme test than controls ($p<0.05$). The PAX6 group gave worse scores than the control group in the frequency and duration pattern tests ($p<0.05$). The Gap in Noise test result was similar in patients and controls. The PAX6 group had significantly worse results in tests that require interhemispheric transfer (dichotic speech and pattern tests) than the control group, but similar results in the Gap in Noise test, which does not require such transfer. The results may reflect deficient auditory interhemispheric transfer in the PAX6 group. The profile in the PAX6 group was very similar, albeit less severe, than the profile of patients who have undergone surgical section of the corpus callosum. This profile could be attributed to the absence/aplasia of the anterior commisure and/or deficiency of the corpus callosum, although other subtler abnormalities of the central auditory pathway, undetected by MRI may also have contributed to their findings.

## 4. Screzophenic

Friedman, et al., (2001) used Dichotic listening techniques to compare subjects with paranoid and undifferentiated subtypes of schizophrenia. The Fused Rhymed Words Test was used to compare perceptual asymmetries in 16 patients with paranoid schizophrenia, 28 patients with undifferentiated schizophrenia, and 29 healthy comparison subjects. Results indicated that Patients with paranoid schizophrenia had the largest left hemisphere advantage and patients with undifferentiated schizophrenia had the smallest. The asymmetry of healthy subjects was intermediate. Hemisphere advantage varied as a function of gender only in the patients with undifferentiated schizophrenia. The findings support the hypotheses that undifferentiated schizophrenia is associated with under-activation of left hemisphere resources for verbal processing and that paranoid schizophrenia is characterized by preserved left hemisphere processing.

From the above literature it is evident that application of Dichotic listening task is widespread. Also, there are many factors influencing the dichotic listening paradigm so care has to be taken of each of these factors when developing a dichotic test. Since, there are numerous factors affecting dichotic listening tests, and also, owing to the widespread applicability there is a need to develop normative data

# Chapter 3

## Method

The present study was conducted with below two aims:

- To develop the dichotic word test on native Kannada speaking children
- Establishing the preliminary data for Dichotic Word Test.

The study was conducted in two phases.

Phase I: Construction of test material for dichotic word test.

Phase II: Obtaining the data for the newly constructed word material across different age groups.

### Phase – I:

### Development of test material:

The Dichotic Word test was constructed using the bi-syllabic word list developed by Yathiraj & Vijayalakshmi (2005) for Indian children. This word list contains four different word lists of equal difficulty, each containing 25 bi-syllabic words, which are phonemically balanced. The words spoken in a conversational style by a female native speaker of Kannada were digitally recorded in an acoustically treated environment on a data acquisition system with a 16 bit analogue to digital convertor at a sampling frequency of 44.1 kHz. Using this recorded words two lists of twenty five pairs of bi-syllabic words were prepared. The material was edited and scaling was done using Adobe Audition (version 2) software to ensure that the intensity of all sounds were at the same level.

## Dichotic Word List

Duration of each of the 100words was calculated and words with equal duration were paired together such that the onset and the offset of the words overlapped. The maximum difference in the duration of each word in a pair was not greater than 0.2ms. This duration was taken on basis of study by Lamm, Share, Shatil and Epstein, (1999) in which they used maximum difference in onset for two channels of 1msec. Two word lists of 25 bi-syllabic words paired in the above manner was obtained. It was ensured that each word occurred only once in the presentation of 100 words. As per the guidelines given by Roup, Wiley, & Wilson (2006) care was taken that two words in a pair never had a same starting phoneme. Two different sets of single word pairs consisting of five practice word pairs followed by twenty test word pairs were formed. Inter-stimulus interval of 10 seconds is added between word pairs to function as the response time. A specific instruction was recorded in both channels three seconds before the beginning of each word set/list. A 30-second, 1000 Hz calibration tone was recorded at the beginning of the compact disc at a level equal to the average intensity of the words.

## Preparation of the Dichotic Tests on a Compact Disc (CD)

Each word of a word pair was recorded in two different channels on a CD. This was done such that, one word got presented to the right ear and the other to the left ear simultaneously. The compact disc consists of two lists of 25 word pairs. The subjects were instructed to repeat both words, in a free recall manner.

### Phase - II

### Administration of developed test material:

Data was collected from native Kannada speaking children in age range of 7 to 12 years old. Subjects were assigned to one of the five groups.

- 7 years to 7 years 11 months (10 Males & 10 Females)
- 8 years to 8 years 11 months (10 Males & 10 Females)
- 9 years to 9 years 11 months (10 Males & 10 Females)
- 10 years to 10 years 11 months (10 Males & 10 Females) and
- 11 years to 11 years 11 months (10 Males & 10 Females).

A total of 120 children (20 in each age group) were tested with equal males and females in each age group. Class teachers assisted in identifying children with any language, behavioural problems and children with below average academic performance. These children were excluded from the study. Parental consent was obtained before the children participated in the study. A rapport was build with the child to avoid any apprehensions.

## Subject Selection Criteria:

Subjects were selected based on the following criteria:

- Bilateral normal-hearing thresholds (0-15 dB HL) at frequencies from 250 Hz to 8000 Hz for air conduction thresholds and 250Hz to 4000 Hz for bone conduction thresholds.
- Speech recognition threshold should be ±12 dB (re: PTA of 0.5,1 and 2 kHz)
- Speech identification score of > 90% at 40 dBSL (re: SRT) in both ears.

- Bilateral type-A tympanograms and normal acoustic reflexes (ipsi and contra) in both ears
- A report from teachers indicating no language or behavioural difficulties or poor academic achievement.
- Passed the Screening Checklist for Auditory Processing (SCAP) developed by Yathiraj & Mascasenhas (2003) to rule out any auditory processing deficit.
- No history of hearing loss and no otologic /neurologic problems.
- No illness on the day of testing.

## Testing environment

All the testing were carried in a sound treated double room situation and noise levels maintained within permissible limits as per ANSI S 3.1- 1991.

## Instrumentation

1. A Calibrated two channel diagnostic audiometer ORBITER 922 version 2 (OB-922) coupled with acoustically matched TDH 39 headphones housed in MX-41/AR and Radio ear B-71 bone vibrator were used to estimate the pure tone threshold, Speech recognition thresholds, Speech identification scores and Uncomfortable level for speech. Audiometer was calibrated according to ANSI 1996 standards.
2. Calibrated middle ear analyzer GSI- Tympstar version 2 was used for Tympanometry and reflexometry.

3. Pentium IV computer with Adobe Audition (version 2.0) software for presenting the developed test material.

**Test Administration Procedure:**

1. SCAP was administered in the classroom. This checklist has 12 questions concerning the symptoms of deficits in auditory processing (Auditory perceptual processing, Auditory Memory and other miscellaneous symptoms). The class teacher was asked to score on a two point rating scale (Yes/No). Each answer marked ‘Yes’ carried one point and ‘No’ carried zero point. Children who scored less than 50% (<6/12) were considered for the study (passed SCAP).
2. Pure tone thresholds were obtained at octave intervals between 250 Hz to 8000 Hz for air conduction and between 250 Hz to 4000 Hz for bone conduction (Mastoid placement) using modified version of Hughson and Westlake procedure (Carhart and Jerger, 1959). The minimum intensity at which the child was able to respond was calculated and the average was taken for 500, 1000 and 2000 Hz.
3. Speech recognition threshold was obtained using the spondee word list in Kannada developed by Rajshekhar (1978). The intensity at which spondees presented was 20 dB SL (re: PTA) and the children were asked to repeat the spondees. The minimum intensity at which the children were able to repeat two out of three spondees correctly was considered as speech recognition threshold of children.
4. Speech identification score was carried out at 40dBSL (re: SRT) using the monosyllabic words in Kannada developed by Mayadevi (1978). The children

tasks were to correctly repeat the words presented lively. Each correct response was given a score of 4%. The total correct response was calculated and termed as speech identification score.

5. Tympanometry and reflexometry were carried out to rule out the middle ear pathology. Children were made to sit comfortably and were asked not to swallow during the testing period. Initially tympanometry was carried out at 226 Hz and then acoustic reflex was done at 500, 1000, 2000 and 4000 Hz ipsilaterally and contralaterally.

**Stage II – Administration of dichotic word test:**

The dichotic word test material was played through Pentium IV computer connected to the calibrated OB 922 audiometer. Equipment testing was done at the beginning of each test session to ensure appropriate routing of signals, and channel balancing. Intensity setting was set to a most comfortable level (40dB SL re SRT). Each child was asked to listen to the instructions for dichotic tasks that were recorded before each set of dichotic words on the compact disc. Instruction given to the chid was 'you will be hearing two words, one to both ears at the same time. You should repeat both the words that you hear. You may repeat words from any ear first. Pay attention, this wont take long'. Task understanding was ensured using the practice items before proceeding to the real test. Verbal responses were taken from all the children that participated in the study. They were instructed to repeat the two words that they hear in both the ears, irrespective of which ear they hear first. Tester noted down the response on the data sheet.

### Calculation of scores for dichotic word tests:

The subject's responses were recorded on the scoring form. A correct response was allocated to each word that was repeated correctly, irrespective of the order required. The right-ear score (RES), left-ear score (LES) and double correct score (DCS) were calculated for both the list. A score of one was given to each correct pair and also each correct word. The possible total correct response for each test paradigm was 20 for each ear, since out of 25 word pairs, 20 were the test items and 5 were the practise items. Practise items were not scored for the testing. The right-ear score was defined as the total number of correctly repeated words in the right ear. The left-ear score was calculated in a similar manner. The double correct score was calculated as total number of correctly repeated words in both ears in any order.

### Test retest Reliability

The test retest reliability of dichotic word tests was examined by repeating the tests on 20 randomly selected subjects 4 from each age group (2 males and 2 females), two to four weeks after the administration of the first test.

### Analysis

Mean and Standard Deviation for RES (Right Ear Scores), LES (Left Ear Scores), and EA (Ear advantage) for each test condition was calculated. Retest analysis was done for the data. All the statistical analysis was performed using SPSS 17.0 software.

# Chapter 4

# RESULTS AND DISCUSSION

The current study was carried out to develop Dichotic word test in Kannada and also to have a preliminary data for the developed test. In the present study dichotic word test has two different lists of twenty five word pairs which were administered on five groups of children from 7 years to 12 years. Each group had twenty participants with equal number of males and females. The data collected were subjected to statistical analysis using Statistical Package for Social Science (SPSS) version 17 software. The following statistical analyses were carried out to analyze the data.

1) Descriptive statistics for gender, two lists and ear across all the age groups.
2) Mixed Analysis of Variance was done to investigate overall main effect of age, gender, list for single correct scores and for double correct scores and ear effect. For the detailed description of results the Mixed ANOVA for each of these variables have been discussed separately.
3) Multivariate Analysis of Variance was done to evaluate the age effect within each of the list.
4) Paired t test was done to investigate the ear effect and the list effect within the subjects.
5) Reliability measure was done using Cronbach's Alpha test.

**List effects**

The mean and standard deviation for single correct scores and double correct scores were obtained for the two lists across five age groups and are tabulated in Table 1.

Table 1.

*Descriptive Statistics for Single and Double Correct Scores for Two Lists*

| Age Group(Yrs) | | Right Correct Score | | Left Correct Score | | Double Correct Score | |
|---|---|---|---|---|---|---|---|
| | | List I | List II | List I | List II | List I | List II |
| 7 – 7.11 | Mean | 11.85 | 12.10 | 7.85 | 7.80 | 4.35 | 4.50 |
| | SD | 2.25 | 2.14 | 2.20 | 2.23 | 2.18 | 2.25 |
| 8 – 8.11 | Mean | 11.55 | 12.05 | 8.00 | 7.90 | 4.95 | 4.90 |
| | SD | 2.08 | 2.43 | 1.80 | 2.10 | 1.66 | 1.86 |
| 9 – 9.11 | Mean | 13.85 | 14.25 | 9.95 | 10.25 | 7.4 | 7.8 |
| | SD | 2.05 | 1.72 | 2.58 | 2.32 | 2.39 | 2.26 |
| 10 – 10.11 | Mean | 16.70 | 16.90 | 14.70 | 15.10 | 12.85 | 13 |
| | SD | 1.89 | 1.97 | 3.18 | 2.30 | 2.87 | 2.88 |
| 11 – 11.11 | Mean | 18.10 | 18.40 | 17.20 | 17.35 | 16.75 | 17 |
| | SD | 1.25 | 1.45 | 1.88 | 1.66 | 2.04 | 2.10 |

From Table 1, it can be seen that there is slight difference in the mean values for the right ear correct scores, left ear correct scores and double scores for the two lists. Mixed ANOVA was done to see the overall list effect. Mixed ANOVA results showed no significant effect on lists for single correct scores [F (1, 90) = 1.47 p>0.05] and double correct score [F (1, 90) = 0.01 $p > 0.05$] but there was an interaction seen for single correct score between list, ear and gender [F (1, 90) = 4.24 $p < 0.05$] and also list, ear, gender and group [F (4, 90) = 3.83 $p < 0.05$]. So to explore these interactions, paired t test was done to evaluate the difference in scores between two lists across age groups. Results for the paired t test are tabulated in Table 2.

Table 2.

*t value, degrees of freedom and its significance between the two lists across the all age groups*

| Age (Years) | Pairs | Dependent variable | t – value | df | Sig.(2 tailed) |
|---|---|---|---|---|---|
| 7 – 7.11 | 1 | RCSI – RCSII | 0.52 | 19 | $p > 0.05$ |
| | 2 | LCSI – LCSII | 0.12 | 19 | $p > 0.05$ |
| | 3 | DCSI – DCSII | 0.54 | 19 | $p > 0.05$ |
| 8 -8.11 | 1 | RCSI – RCSII | 1.05 | 19 | $p > 0.05$ |
| | 2 | LCSI – LCSII | 0.38 | 19 | $p > 0.05$ |
| | 3 | DCSI – DCSII | 0.17 | 19 | $p > 0.05$ |
| 9 – 9.11 | 1 | RCSI – RCSII | 1.69 | 19 | $p > 0.05$ |
| | 2 | LCSI – LCSII | 1.32 | 19 | $p > 0.05$ |
| | 3 | DCSI – DCSII | 2.02 | 19 | $p > 0.05$ |
| 10-10.11 | 1 | RCSI - RCSII | 1.28 | 19 | $p > 0.05$ |
| | 2 | LCSI - LCSII | 1.14 | 19 | $p > 0.05$ |
| | 3 | DCSI - DCSII | 1.83 | 19 | $p > 0.05$ |
| 11 – 12 | 1 | RCSI - RCSII | 1.24 | 19 | $p > 0.05$ |
| | 2 | LCSI - LCSII | 0.59 | 19 | $p > 0.05$ |
| | 3 | DCSI - DCSII | 0.49 | 19 | $p > 0.05$ |

*Note.* RCSI – Right Correct Score for List I; RCSII - Right Correct Score for List II,LCSI – Left Correct Score for List I; LCSII - Left Correct Score for List II, DCSI – Double Correct Score for List I; DCSII - Double Correct Score for List II

It can be seen from table 2 that paired t test revealed no significant difference between two lists for both single correct scores and double correct scores. This trend is seen in all the age groups which indicates that aligning the two words in two different channels at 0 ms lag time does not alter the performance of the subjects between the lists. Both the lists have equal difficulty and hence any of the two lists can be used in clinical practice.

### Gender effect

Mean and standard deviation (SD) for males and females across the two lists for all the five age groups were calculated and are tabulated in Table 3.

Table 3.

*Mean and Standard Deviation (SD) for Males and Females across Lists and Age group*

| Age(Years) | Gender | List I | | | | | | List II | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RCS | | LCS | | DCS | | RCS | | LCS | | DCS | |
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| 7.11 – | M | 12.00 | 2.44 | 8.10 | 1.44 | 4.50 | 0.97 | 12.30 | 2.11 | 7.30 | 1.70 | 4.50 | 1.58 |
| | F | 11.70 | 2.16 | 7.60 | 2.83 | 4.20 | 3.01 | 11.90 | 2.28 | 8.30 | 2.66 | 4.50 | 2.87 |
| 8.11 – | M | 10.90 | 2.13 | 7.00 | 1.33 | 4.30 | 1.15 | 11.30 | 2.31 | 7.00 | 1.76 | 4.20 | 1.47 |
| | F | 12.20 | 1.93 | 9.00 | 1.69 | 5.60 | 1.89 | 12.80 | 2.44 | 8.80 | 2.09 | 5.60 | 2.01 |
| 9.11- | M | 14.20 | 2.20 | 9.6 | 2.71 | 7.40 | 2.59 | 14.40 | 1.34 | 10.10 | 2.55 | 7.70 | 2.21 |
| | F | 13.50 | 1.95 | 10.30 | 2.54 | 7.40 | 2.31 | 14.30 | 2.21 | 10.6 | 2.17 | 7.90 | 2.42 |
| 10.11 - | M | 17.00 | 1.76 | 15.10 | 2.68 | 13.30 | 2.09 | 17.30 | 1.82 | 15.30 | 2.56 | 13.50 | 2.06 |
| | F | 16.40 | 2.06 | 14.30 | 3.71 | 12.50 | 3.56 | 16.50 | 2.12 | 15.10 | 2.13 | 12.50 | 3.56 |
| 11.11 - | F | 18.20 | 1.47 | 17.10 | 2.37 | 16.50 | 2.59 | 18.30 | 1.05 | 17.00 | 1.69 | 16.60 | 2.22 |
| | M | 18.00 | 1.05 | 17.30 | 1.33 | 17.00 | 1.41 | 18.50 | 1.43 | 17.70 | 1.63 | 17.40 | 2.01 |

*Note.* RCS – Right Correct Score; LCS - Left Correct Score; DCS – Double Correct Score

From the above Table 3, it can be seen that mean scores for males and females are almost similar for single and double correct scores. This similarity is seen in almost all the age groups for both the lists. The mixed ANOVA was done to find out the overall effect on gender. Results of mixed ANOVA revealed no significant difference in gender for single correct scores [F (1, 90) = 1.47, p>0.05] as well as for the double correct scores [F (1, 90) = 0.01 p > 0.05].

Reports in the literature in the area of gender and language proficiency are not equivocal. Mccoby, & Jacklin, (1974) reported that girls have more verbal ability than boys though it is not obvious until about the age of 11 years. On the other hand, Dionne, Dale, Boivin, & Plomin, (1998) reported that language performance is generally better among females than among males, even in children as young as 2-3 years. Lynn, (1992) further stated that females have advantages for both verbal and as well as written persisting through the school years. Hyde, (1994) concluded that although there appears to be a gender difference favoring a better language proficiency in females, this difference is relatively small and thus has little significance (Hyde, 1994).

The results of present study are also indicating that there exist no significant difference between the performance of the males and females across age and lists for the Dichotic listening task and is well supported by the literature on various dichotic listening tests. Geffen, (1987) studied dichotic listening tests using 1, 2, 3, or 4 pairs of digits and reported no gender difference in terms of right ear advantage. Hertrich, Mathiak, Lutzenberger, and Ackermann, (2002) noted gender-related differences for the consonant-vowel dichotic test with artificial stimuli, but not with natural speech. Bellis, & Wilber (2001) in their study using dichotic listening tests in adults using the consonant-vowel, also reported of no gender effect on the dichotic listening task. Dichotic Studies done with words by Robets et al (1994) and Meyers, Roberts, Bayless, Volkert, and Evitts (2002) also report of the similar findings. Hence, it can be concluded that boys and girls in the age range of 7 to 12 years develop in similar manner, in the way they develop the binaural integration task.

## Age effect

Since there was no difference in the scores of males and females, the data of both the gender were combined to see the overall age effect for both the lists. The means standard deviation (SD) and range across the age groups for both the list were obtained and are tabulated in Table. 4.

Table 4.

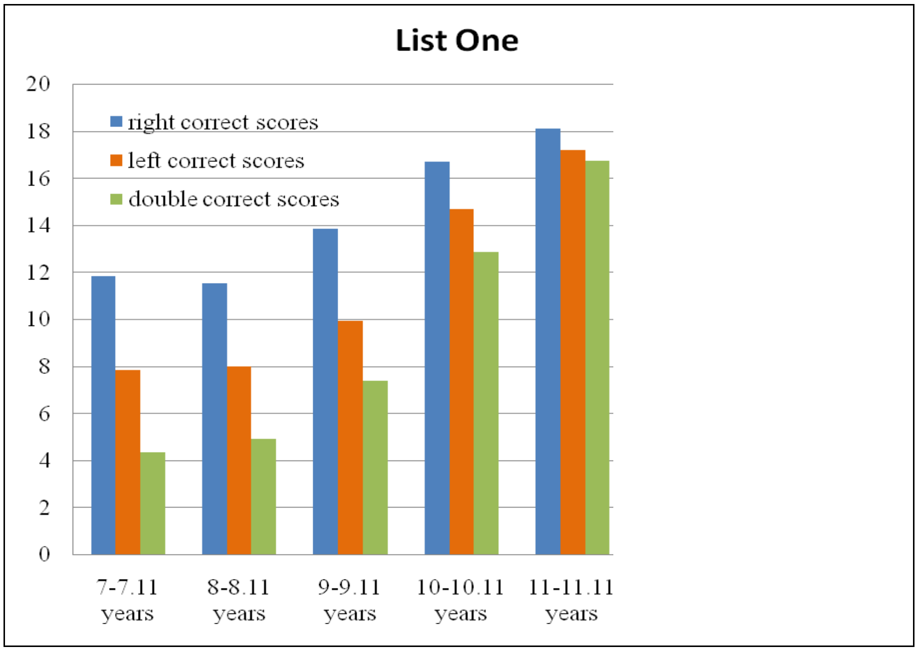
*Mean, standard deviation and range across age groups for both lists*

| Age Group | | List I | | | List II | | |
|---|---|---|---|---|---|---|---|
| | | RCS | LCS | DCS | RCS | LCS | DCS |
| 7-7.11 years | Mean | 11.85 | 7.85 | 4.35 | 12.10 | 7.80 | 4.50 |
| | SD | 2.25 | 2.20 | 2.18 | 2.14 | 2.23 | 2.25 |
| | Range | 8-16 | 4-14 | 1-12 | 8-15 | 5-14 | 2-12 |
| 8 – 9 years | Mean | 11.55 | 8.00 | 4.95 | 12.05 | 7.90 | 4.90 |
| | SD | 2.08 | 1.80 | 1.66 | 2.43 | 2.10 | 1.86 |
| | Range | 8-16 | 5-12 | 2-9 | 8-16 | 5-12 | 2-9 |
| 9 - 10 years | Mean | 13.85 | 9.95 | 7.4 | 14.35 | 10.35 | 7.80 |
| | SD | 2.05 | 2.58 | 2.39 | 1.72 | 2.32 | 2.26 |
| | Range | 10-18 | 7-16 | 4-13 | 11-18 | 7-15 | 5-12 |
| 10 - 11 years | Mean | 16.70 | 14.70 | 12.85 | 16.90 | 15.20 | 13.00 |
| | SD | 1.89 | 3.18 | 2.87 | 1.97 | 2.30 | 2.88 |
| | Range | 14-20 | 8-19 | 8-17 | 14-20 | 11-18 | 8-17 |
| 11 - 12 years | Mean | 18.10 | 17.20 | 16.75 | 18.40 | 17.35 | 17 |
| | SD | 1.25 | 1.88 | 2.04 | 1.23 | 1.66 | 2.10 |
| | Range | 16-20 | 12-19 | 11-19 | 16-20 | 14-20 | 12-20 |

*Note.* RCS – Right Correct Score; LCS – Left Correct Score; DCS – Double Correct Score

From Table 4, it can be seen that the mean scores for right correct scores, left correct scores and double correct scores increased as the age increased. On comparison between ears, right ear scores have greater scores compared to left ear scores and double correct scores indicating right ear advantage for both the list. Also we can find that the mean double correct scores are lesser for all the age groups compare to single correct scores.

Figure 1 also indicates that the mean right ear correct score increased as the age increases from 7 to 12 years for list I. Similar trend is also seen for the mean left ear correct score and mean double correct score across the age groups. But the mean value is much lesser for double correct score compare to left ear correct score and right ear correct score.



*Graph 1:* Mean right correct scores, left correct scores and double correct scores across the five age groups for list one.

Similar trend was found for the in list II as shown in Figure 2. The mean scores for single correct score and the double correct scores increases as age increases.

*Graph 2*: Mean right correct scores, left correct scores and double correct scores across the five age groups for list two.

Mixed ANOVA was done to evaluate overall significant difference between the groups. Mixed ANOVA results revealed significant main effect on age [F (4, 90) = 70.00 $p < 0.01$] for single correct scores. There was also significant interaction between ear and group [F (4, 90) = 21.92 $p < 0.01$]. However, there were no statistically significant interactions between group and gender [F (4, 90) = 0.88 $p > 0.05$], group and list [F (4, 90) = 0.49 $p < 0.05$], group, list and gender [F (4, 90) = 0.25 $p > 0.05$], ear, group and gender [F (4, 90) = 0.96 $p > 0.05$], list ear and group [F (4, 90) = 0.20 $p > 0.05$], list, ear, gender and group [F (4, 90) = 1.29 $p > 0.05$]. Similarly for double correct scores, there was a significant difference seen for the group [F (4, 90) = 115.11 $p < 0.001$]. However, there was no significant interaction seen for group and gender [F (4, 90) = 0.68 p >

0.005], group and list [F (4, 90) = 0.48 $p > 0.005$] and group, list and gender [F (4, 90) = 0.15 $p > 0.005$] for the double correct score.

MANOVA was done to further investigate the significant difference in the different age groups within each list. Results of MANOVA revealed significant difference across the age groups for Right ear correct scores [F(4,98)=44.98,$p<0.01$], Left ear correct scores[F(4,95)= 62.08,$p<0.01$] and Double correct scores [F(4,95)= 111.20, $p<0.01$] for list one and Right ear correct scores [F(4,98)=42.78,$p<0.01$], Left ear correct scores[F(4,95)= 82.54, $p<0.01$] and Double correct scores [F(4,95)= 111.21, $p<0.01$] for list two. To further explore within the age groups, to see which of the groups are significantly different, Duncan Post-Hoc analysis was done. Means of the groups were presented in homogeneous subsets depending on the result of Post-Hoc analysis. Except for the first two groups Duncan’s post Hoc analysis showed significant difference across all the age groups at 95% of the confidence level for right correct scores, left correct scores and double correct scores. The mean scores for all age groups fall into different subsets indicating a significant difference between all the age groups except the first two groups which were in the same subset.

There was improvement seen in the dichotic word scores as the age increased and this could be due to the differential myelination of the sub-cortical from the cortical structures. Dichotic listening performances do not reach adult values approximately 10 to 11 years of age. This functional development time is consistent with the myelination time course (Yakovlev & Lecousis, 1967). Myelinogenisis of Corpus callosum and some other auditory association areas may not have completed until 10 to 12 years or older.

Similarly, Hayakawa et al, (1991) reported that corpus callosum becomes adult like by the age of 11years-12years, whereas Johnson, Farnsworth, Pinkston, Bigler, and Blatter (1994) reported that growth and efficiency of corpus callosum increases till early adult years. There is also evidence from somatosensory evoked potentials, which are used to measure inter-hemispheric transfer time by comparing ipsilateral to contralateral stimulation latencies indicating that, corpus callosum maturity ranges from 10 to 20 years (Salamy, Mendelson, Tooley, & Chapline, 1980). Pujol (1993) also reported corpus callosum as the last structure to be fully developed and also one among to show the age related changes.

The effect of age on dichotic listening of higher cortical structures is that, there is not much information passed on to the higher levels at an younger age due to incomplete maturation of corpus callosum and thus scores may be reduced in the lower age group. As age increases, the myelination of the cortical structures especially corpus callosum might get completed and thereby resulting in increase in the scores on the dichotic tests.

The mean scores for left ear are less compared to right ear scores. This poor left ear performance on dichotic listening in children may reflect a decreased ability of the corpus callosum to transfer complex stimuli from the right hemisphere to the left hemisphere. As the child becomes older and myelination of the corpus callosum is completed, the inter-hemispheric transfer of information improves and left ear scores approach to those found in adults (Musiek, Gollegly, & Baran, 1984).

The double correct scores are less compared to single correct scores in all the age groups. It is suggested that the single correct scores should be used to calculate the norms rather than double correct scores. Dermody, Mackie, and Katach, (1983) also found that the double correct scores do not provide information about the differential ear effects compared to ear correct scores.

Along with the maturation of the sub-cortical and cortical structures, the effect of age on dichotic listening may be different depending on the type of stimuli used. Dichotic listening requires communication between the cerebral hemispheres and functional integrity of both temporal lobes (Kimura, 1963, 1967). Bellis, (1996) stated that, more the linguistically loaded stimuli presented, more pronounced the maturational effects.

The present study is in good agreement with the study done by Berlin et al (1973) where the number of CV stimuli presented to both the right and the left ear increased significantly with age which is suggests that with increase in age there is corresponding increase in the brain's ability to process two channel stimuli. Similar findings were seen by Willeford and Burleigh, (1994) using sentences dichotically. However, ear advantage reported in the above two studies varied for the type of the stimuli used. The dichotic CV had higher right ear advantage (Berlin et al., 1973) where as dichotic sentences had right ear advantage which reduced with age (Willeford and Burleigh, 1994).

A possible explanation for these findings lie in degree of complexity of stimuli utilized. CV nonsense syllable are less linguistically loaded than sentences. Thereby, processing demands on two hemispheric and inter-hemispheric connections would be much less complex. In contrast dichotic sentences are more linguistically loaded so require more inter-hemispheric communication via corpus callosum as well as integrity of both temporal lobes. But dichotic word are an open stimulus set that may result in recognition performance in the middle of the difficulty continuum that is neither too easy (like the CV's) nor too difficult (like sentences), yet sensitive to performance difference between ears and groups (Roup, Wiley & Wilson, 2006).

***Ear Effect:***

The means and standard deviation (SD) for right and left ear across the age groups for both the list are tabulated in Table 1. From the Table 1, it can be inferred that mean score of right ear was greater than that of left ear in both the lists irrespective of the age groups. Mixed ANOVA was done to investigate the difference in scores across two ears in both the lists. Results of mixed ANOVA revealed significant difference in scores between right and left ear [F (1, 90) = 113.37, $p < 0.001$] for both the lists. There is also interaction seen for the ear, gender, and group [F (4, 90) = 3.37, $p < 0.05$], list, ear, and gender [F (1, 90) = 4.24, $p < 0.05$] and also list, ear, gender, and group [F (4, 90) = 3.83, $p < 0.05$]. Hence, Paired t test was done to further evaluate difference in the scores between the two ears across age groups for both the lists. Results of paired T test revealed a significant difference between the right ear scores and the left ear scores for all the age groups except for the list I in 11 to 12 year group, where it reached to a significance level but did not show a significant difference.

Table 5.

*Paired t Test showing t value and its Significant Difference across Two Ears*

| Age group | Pairs | T | Df | Sig. (2 tailed) |
|---|---|---|---|---|
| 7 – 7.11 years | RCSI – LCSI | 8.71 | 19 | p < 0.01 |
| | RCSII - LCSII | 11.18 | 19 | p < 0.01 |
| 8 -8.11 years | RCSI – LCSI | 8.21 | 19 | p < 0.01 |
| | RCSII - LCSII | 11.37 | 19 | p < 0.01 |
| 9 – 9.11 years | RCSI – LCSI | 8.85 | 19 | p < 0.01 |
| | RCSII - LCSII | 11.75 | 19 | p < 0.01 |
| 10 – 10.11 years | RCSI – LCSI | 5.62 | 19 | p < 0.01 |
| | RCSII - LCSII | 5.84 | 19 | p < 0.01 |
| 11 – 12 years | RCSI – LCSI | 4.15 | 19 | p < 0.01 |
| | RCSII - LCSII | 4.47 | 19 | p < 0.01 |

Results of present study of having right ear advantage are in consonance with earlier literature on dichotic listening (Musiek et al., 1989; Wexler and Halwes, 1983 & Berlin et al., 1973). Converging evidence in the field of dichotic listening strongly suggests that the right ear advantage arises through mechanisms postulated by Kimura's structural model (Kimura, 1967). According to this model it is postulated that, it is the bilateral asymmetry in brain function as a function of stimulus type that gives rise to the right ear advantage. This Right ear advantage has been interpreted as resulting from rigid bottom up neural connections (Hugdahl, 2005), that is the contralateral projections of the ascending auditory system consists of more fibers and consequently are more stronger leading to more cortical activity than the ipsilateral projections. Also, the fact that the left hemisphere is dominant foe speech in most cases (Kandel, Schwartz, & Jessell, 1991; Rasmussen & Milner, 1977) explains the right ear advantage. In addition, stronger activity in the contralateral system inhibits the processing on the ipsilateral side (Yasin, 2007) and thus resulting in a better performance for the right ear than the left ear.

Right ear advantage in dichotic listening has also been attributed to proximity of the left temporal lobe which is closer to the left primary than the right anterior temporal lobe (Berlin et al., 1973). It is postulated that owing to the proximity, there is less transmission loss to the left posterior temporal parietal lobe on the basis of proximities within the areas of the brain. Due to this proximity there is efficient interaction between shorter pathways. Similar findings have been reported by Studdert-Kennedy and Shankweiler (1967).

## Reliability Measure

The reliability measure for 10% of the total subjects participated were analyzed using SPSS 17.0 using Cronbach's Alpha test. The results of the reliability measure are shown in Table 6.

Table 6.

*Reliability Measures for Single Correct Scores (right & left) and Double Correct Scores for Both the Lists*

| Dependent variable | Alpha values |
|---|---|
| RCSI | 0.89 |
| LCSI | O.85 |
| DCSI | 0.79 |
| RCSII | 0.87 |
| LCSII | 0.80 |
| DCSII | 0.77 |

*Note.* RCSI – Right Correct Score for List I; RCSII - Right Correct Score for List II

LCSI – Left Correct Score for List I; LCSII - Left Correct Score for List II

DCSI – Double Correct Score for List I; DCSII - Double Correct Score for List II

The above Table reveals that all the scores obtained on dichotic word test at two different times are having an alpha value of greater than 0.7 which indicates good reliability of the test.

## Chapter 5

## SUMMARY AND CONCLUSIONS

Dichotic listening test are among the most powerful of the behavioral test battery for assessment of hemispheric function, inter-hemispheric transfer of information, and development and maturation of auditory nervous system in children and adolescents, as well as the identification of lesions of the central auditory nervous system (Keith and Anderson, 2007). Dichotic listening tests have long been used in the evaluation of cerebral dominance in both children and adults (Hugdahl, 1988) and also in assessment of cortical lesions (Musiek & Pinherio, 1985). In dichotic tests the two ears are stimulated simultaneously with different speech sounds (Hugdahl, 1995). The task of the subject is to report what is being heard, either in both ears (free recall) or in one of the ears, either left or right (directed attention) (Bellis, 1996). Dichotic listening task has been carried out using various stimuli like digits, non-sense CV syllables, words and sentences. (Bellis, 1996). Although dichotic sentence test have more linguistic load than the dichotic CV's, dichotic CV's are considered to be more difficult than sentences (Niccum, Rubens, & Speaks, 1981). Hence, the present study was carried out using words which are an open stimulus set that may result in recognition performance in the middle of the difficulty continuum (Roup, Wiley, & Wilson, 2006).

The present study was taken up with aim of developing preliminary data for dichotic word test in Kannada language. The test was developed using the word list developed by Yathiraj and Vijayalakshmi (2005). These words were paired in such a way that they differed in initial syllable and were either voiced or voiceless and total duration of each word in a pair was similar. Test consists of two lists of 25 word pairs each. Five word pairs were used as practice items. These paired words were aligned and imposed on a stereo track in such a way that word pairs were played simultaneously in both ears.

A total of 100 children with 20 in five age groups with equal number of males and females in each age group (7years-12years) were evaluated on the dichotic word list developed. All the children evaluated had native language as Kannada. Prior to administration of dichotic word test these children were tested with routine audiometric testing (PTA, SRT, SIS & Immittance) and Screening Checklist for Auditory Processing Disorder (SCAP) to ensure normal auditory functioning.

Responses were scored in terms of single correct scores (right & left ear) and double correct scores. The raw data was subjected to statistical analysis. The mean and the standard deviation were also calculated for both the list across the age groups. Results of the present study are summarized below.

**Age effect:**

For the Kannada word list used in the present study there was significant difference found for both single correct scores and double correct scores between the age groups from 9years to 12 years however there was no statistically significant difference in scores for 7years-8years and 8years-9years.

**List effect:**

There was no statistically significant difference between the two lists for right correct scores, left correct scores and double correct scores. This finding is suggestive that any of the two lists can be used with equal efficiency for clinical use.

**Ear effect:**

The single correct scores were much higher than the double correct scores for all the age groups considered in this study. Within the single correct scores right ear scores were greater than the left ear scores with statistical significance. Also it was observed that with increase in age there was more increase in left ear scores and double correct scores than right ear scores. However, even with the eldest age group (11years-12years) the right ear scores were significantly greater than the left ear scores suggesting presence of right ear advantage even with eldest age group.

The results of the present study are very much in consonance with the available literature on dichotic listening task and so it can be used clinically along with the other battery of tests for evaluation of children in the age range evaluated for central auditory processing disorder. The present study also provides with preliminary data for the age group evaluated which again is of clinical importance.

## Future research:

- The sensitivity of the dichotic word test using the developed test stimuli in assessing the children with auditory processing disorder should be evaluated before using or incorporating in to clinical tool.
- Research carried out with dichotic word test is very limited in clinical population such as reading disability, where it can be used as a tool to find the poor readers. Hence further research should be done in this area to probe the difficulties faced by the children with auditory processing disorder.
- Preliminary data for dichotic word test in adult population would help understanding the age of maturation for dichotic words.

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# APPENDIX

## List I

| LEFT | RIGHT |
|---|---|
| Practise items | |
| Akka | Sushma |
| Chandra | Lota |
| Deepa | Meeke |
| Dimbu | Varsha |
| Illi | Nadi |
| Test items | |
| Jana | Nalli |
| Mandi | Rani |
| Mole | Amma |
| Nona | Tuti |
| Puri | Tale |
| Railu | Krishna |
| Rakta | Muuru |
| Ravi | Tande |
| Shale | Ballu |
| Shalu | Yake |
| Sooji | Gombe |
| Taayi | Raita |
| Tande | Keelu |
| Tv | Vaani |
| Uppu | Sara |
| Vade | Mara |
| Vajra | Shampoo |
| Veene | Pinnu |
| Yava | Kaage |
| Rave | Idli |

# List 2

| LEFT | RIGHT |
|---|---|
| Practise items | |
| Anna | Baala |
| Batta | Guube |
| Bekku | Hotte |
| Chukki | Neeli |
| Danna | Bale |
| Test items | |
| Daana | Baggu |
| Daara | Jebu |
| Divya | Goli |
| Drakshi | Chaku |
| Hallu | Doni |
| Haddu | Kashta |
| Hagga | Brashu |
| Havu | Dappa |
| Huuvu | Katte |
| Idu | Suttu |
| Yaru | Hasu |
| Karu | Adu |
| Kattu | Jade |
| Male | Elu |
| Mancha | Rotti |
| Meju | Vachu |
| Mola | Kivi |
| Nayi | Kashta |
| Odu | Beega |
| Pada | Paisa |