Dichotic Word (CVCV) Test in Native Kannada Speaking Children

Gurdeep Singh & N. Devi*

Abstract

The present study was taken up with the 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, with five word pairs as practice items. 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 (7 years - 12 years) were evaluated on the dichotic word list developed. All the children evaluated had native language as Kannada. Normal auditory functioning was ensured. Responses were scored in terms of single correct scores {right (RCS) & left ear (LCS)} and double correct scores (DCS). 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. There was significant difference found for both single correct scores and DCS between the age groups from 9yrs to 12 yrs. No statistically significant difference between the two lists for RCS, LCS and DCS. The single correct scores were much higher than the DCS for all the age groups considered in this study. Within the single correct scores RCS were greater than the LCS with statistical significance. With increase in age there was more increase in LCS and DCS than RCS. Even with the eldest age group (11yrs-12yrs) the RCS were significantly greater than the LCS suggesting presence of right ear advantage even with eldest age group.

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).

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). 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). Binaural integration is the

* Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore.
email: deviaiish@gmail.com

ability of the listener to process different information being presented to each ear at the same time (Musiek, 2006).

Of the variety of speech stimuli available to measure dichotic listening (e.g., digits, words, consonant-vowels and sentences), digits are the most utilized. However, they are a closed-set task that may tend to overestimate dichotic speech recognition ability. A more difficult task is Dichotic Consonant-Vowel test (CV) developed by Berlin, Lowe-Bell, Jannetta, and Kline (1972). Monosyllabic words (other than digits) may offer several advantages as a dichotic stimulus (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 (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.

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 7 years to 12 years.
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.

Method

The study was conducted in two phases.

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

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, such that, one word got presented to the right ear and the other to the left ear simultaneously. The CD consists of two lists of 25 word pairs. The subjects were instructed to repeat both words, in a free recall manner.

Administration of developed test material

Data was collected from native Kannada speaking children in age range of 7 to 12 years old. 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:

1. 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.
2. Speech recognition threshold should be ±12 dB (re: PTA of 0.5,1 and 2 kHz).
3. Speech identification score of > 90% at 40 dB SL (re: SRT) in both ears.
4. Bilateral type-A tympanograms and normal acoustic reflexes (ipsi and contra) in both ears.
5. A report from teachers indicating no language or behavioural difficulties or poor academic achievement.
6. Passed the Screening Checklist for Auditory Processing (SCAP) developed by Yathiraj & Mascarenhas (2003) to rule out any auditory processing deficit.
7. No history of hearing loss and no otologic /neurologic problems.
8. 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

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. Calibrated middle ear analyzer GSI- Tympstar version 2 was used for Tympanometry and reflexometry. Pentium IV computer with Adobe Audition (version 2.0) software for presenting the developed test material.

Test administration procedure

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). 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. 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. 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. 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.

Phase 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 child 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 won't 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

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 practice items. Practice items were not scored for the testing. The RES was defined as the total number of correctly repeated words in the right ear. The LES was calculated in a similar manner. The DCS was calculated as total number of correctly repeated words in both ears in any order.

Test retest Reliability & Analysis

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. Mean and Standard Deviation (SD) for RES, LES, 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.

Results and Discussion

List effects: The mean and SD for single correct scores and DCS 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 results showed no significant effect on lists for single correct scores [$F (1, 90) = 1.47$ $p>0.05$] and DCS [$F (1, 90) = 0.01$ $p > 0.05$] 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 DCS. This trend is seen in all the age groups which indicate 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 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 – 8.11	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 – 9.11	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 .11-10.11	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 - 11.11	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 - 12.11	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 DCS [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 Roberts 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, 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 RCS, LCS and DCS increased as the age increased. RCS is greater than compared to LCS and DCS indicating right ear advantage for both the list. Also we can find that the mean DCS are lesser for all the age groups compare to single correct scores.

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 was 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.

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 (RCS) & left ear (LCS)} and double correct scores (DCS). 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. There was significant difference found for both single correct scores and DCS between the age groups from 9yrs to 12 yrs. No statistically significant difference between the two lists for RCS, LCS and DCS. The single correct scores were much higher than the DCS for all the age groups considered in this study. Within the single correct scores RCS were greater than the LCS with statistical significance. With increase in age there was more increase in LCS and DCS than RCS. Even with the eldest age group (11yrs-12yrs) the RCS were significantly greater than the LCS 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.

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