Dichotic Word Test (DWT) in Indian English Speaking Children

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Abstract

The study was aimed in developing dichotic word test for children speaking English in India and also to investigate the effect of list, gender, age and ear. The developed test consists of two lists of monosyllables with each list having 25 word pairs. These word pairs have equal duration and aligned in such a way that both words were presented dichotically at the same time. The developed test material was administered on five groups of normal hearing children (20 in each group) with the age range of 7 to 12 years. The results revealed significant difference between age and ear. As the age increases, the performance of the children also increased showing greater right ear score followed by left ear score and double correct score which indicates the presence of right ear advantage. However, there was no significant difference between list and gender. Reliability measure showed good test retest reliability for both the list. Thus the present data findings can be used as reference for children with central deficits especially cortical lesions.

Key words: *Dichotic word test, Central auditory processing disorder*

Introduction

Auditory processing disorders (APDs) refer 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 (ASHA, 2005). Normal auditory processing involves a number of distinct processes or skills. A breakdown or deficit in any one of the skills leads to central auditory processing disorder (CAPD).

Numerous tests have been developed over the period of time to assess central auditory function as the CAPD represents a heterogeneous group of auditory deficits. One among the test is dichotic listening tests which is the most powerful 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 identification of lesions of the central auditory nervous system (Keith & Anderson, 2007). A number of studies have identified the presence of binaural integration deficits in children with learning and reading disorders (Moncrieff & Musiek, 2002).

Dichotic tasks utilizes syllables, digits, words, spondees and sentences to measure the dichotic listening. Of the variety of speech stimuli available to measure dichotic listening,

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digits are the most utilized due to limited contextual cues and quite easier. But digits are closed-set task that may tend to overestimate dichotic speech recognition ability and highly familiar that is relatively easy to recognize for both normal hearing and hearing-impaired listeners (Strouse & Wilson, 1999a, 1999b). As an alternative, monosyllabic words are meaningful components of speech that limit the use of syntactical cues; recorded monosyllabic word lists offer a standardized test of word recognition that are commercially available and in widespread use; presence of 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; and also words are an open set stimulus that may result in recognition performance in the middle of the difficulty continuum i.e. neither too easy nor too difficult, yet sensitive to performance differences between ears and groups (Roup, Wiley, & Wilson, 2006).

Damasio, Damasio, Castro-Caldus, and Ferro (1976) compared a digit test with multisyllabic word test and concluded that the "coding and decoding of words that stands for digits is, in many instances, not as lateralized a process as coding and decoding of words not representing digits". Developing Dichotic Word Test (DWT) is most 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 (Keith, 2000) and also to incorporate as part of the central auditory nervous system evaluation battery, since dichotic measures have demonstrated good sensitivity in identifying and differentiating cerebral level lesion (Roup, Wiley, & Wilson, 2006).

Normative data from a representative population is required to ensure if it is a valid and reliable measure of auditory processing ability (Musiek, Gollegly, & Ross, 1985) and also it is ideal to have speech tests in all languages as the individual perception of speech is influenced by their first language or mother tongue (Singh & Black, 1966). Currently, available data documenting dichotic monosyllabic-word recognition performance, other than dichotic digits, is limited for both young and older adults (Prior, Cumming, & Hendy, 1984) especially on Indian population for assessing the auditory processing. Hence the current study is aimed in developing and standardizing the dichotic word test on Indian English speaking children of Kannada origin and also to investigate the effects of different stimulus list, gender, age and ear difference.

Method

The current study was carried out in two phases that include the development of stimuli (Phase I) and to establishing the preliminary data for dichotic word test (Phase II).

Phase I: Development of the English Dichotic Word Stimuli

The test stimulus was prepared using monosyllable words developed by Sivaprasad and Yathiraj (2006) as a reference. These words were phonetically balanced using frequencies of occurrences of English speech sounds in India by Ramakrishna et al. (1962) and were familiarized for the children within the range of 7 years to 7 years 11 months. These familiarized words were spoken by a female speaker who had a clear articulation using standard spoken Indian English of the Mysore region in an accent widely used in formal speech and were recorded using the Praat version 5.0.32 software with a sampling rate of 24,000 Hz. The digitized word signals were then edited and equalized for overall intensity to achieve equal average levels using Adobe Audition version 2.0 software. A goodness test of recorded material was done to ensure the good quality of the stimuli by presenting the recorded material to ten Indian-English speaking normal hearing adults of the Mysore region. The word pairs with more than 90% acceptance by these individuals were selected as stimuli.

Using these familiar words, two lists of twenty-five pairs of words were constructed in such a way that the onset and offset of the stimulus coincides with a deviation in duration not exceeding 0.2 ms as per the guidelines given by Lamm, Share, Shatil, and Epstein (1999) and the paired words were of either voiced or voiceless at the initial position. The word pairs with same phoneme in the same word positions were avoided as per the guidelines of Roup, Wiley, and Wilson (2006). Inter-stimulus interval of about ten seconds was added between word pairs to function as the response time. Two different sets of single word pairs consisting of five practice word pairs followed by twenty test word pairs were formed. 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.

Phase II – Establishing preliminary data for dichotic word test

Participants

Data were collected from 100 English speaking children of the Mysore region between 7 to 12 years whose mother tongue was Kannada and their of instruction was English for at-least two year. These participants were divided into five age groups (7-7.11; 8-8.11; 9-9.11; 10-10.11; 11-11.11 years) with equal males and females in each group (N=20).

Participants included for the collection of preliminary data had bilateral normal-hearing thresholds (0-15 dB HL) at frequencies 250 Hz to 8000 Hz for air conduction thresholds and 250 Hz to 4000 Hz for bone conduction thresholds; Bilateral type-A tympanogram with presence of acoustic reflexes (ipsi & contra) in both ears; Speech recognition threshold of ±12 dB (re: PTA of 0.5, 1 & 2 kHz); Speech identification score of > 90% at 40 dBSL (re: SRT) in both ears; Passed the Screening Checklist for Auditory Processing (SCAP) developed by Yathiraj & Mascarenhas (2003), ruling out any auditory processing deficit; no otologic and/or neurologic problems; no illness on the day of testing; no behavioral problems and; good academic performance. Parental consent was obtained before the children participated in the study.

Testing environment

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 Grasen-Standler Model GSI 61 coupled with acoustically matched TDH 39 headphones housed in MX - 41/AR and Radio ear B-71 bone vibrator used to estimate the Pure tone threshold, Speech Recognition Thresholds (SRT), Speech Identification Scores (SIS), and Uncomfortable level for speech (UCL), Calibrated middle ear analyzer GSI- Tympstar version 2 for Tympanometry and reflexometry and Pentium IV computer with Adobe Audition 2.0 version software for presenting the developed test material.

Procedure: The test was carried out in two stages.

Stage I – Procedure for participants selection

Screening checklist for Auditory Processing (SCAP) developed by Yathiraj and Mascarenhas (2003) was given to the class teacher and were asked to score on a two point rating scale (Yes/No). 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 & Jerger, 1959). Speech recognition threshold was obtained using the spondee word list for children in English developed by Swarnalatha and Rathna (1972) which were presented at 20 dBSL (re: PTA). Speech identification score was carried out at 40dBSL (re: SRT) using the monosyllabic words in English developed by Rout and Yathiraj (1996). Tympanometry (226 Hz) and Reflexometry (500, 1000, 2000, & 4000 Hz both ipsi and contra) were carried out to rule out any middle ear pathology.

Stage II – Administration of Dichotic Word Test

The dichotic word test material was played through Pentium IV computer connected to the calibrated GSI 61 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 subject was asked to listen to the instructions for dichotic tasks that were recorded before each set of dichotic words on the compact disc. The children were instructed as '*You will be hearing two words, one to each ear at the same time. You should repeat both the words that you heard*'. Task understanding was ensured using five practice items in each list before proceeding to the real test.

Calculation of Scores for Dichotic Word Tests

The subject's responses were recorded in-terms of correct responses for each ear. The right-ear score (RES), left-ear score (LES) and double correct score (DCS) were calculated for both the lists. A score of one was given to each correct pair and each correct word. The possible total correct response for each test paradigm was 20 for each ear.

Test Retest Reliability

The test retest reliability of dichotic word test was examined by repeating the tests on two randomly selected subjects from each age group, two to four weeks after the administration of the first test.

Analysis

The data for the dichotic word test was calculated by computing the means and standard deviations for right ear score, left ear score, and double correct score using SPSS 17.0 software.

Results and Discussion

The statistical analyses were carried out to investigate the effect of list, gender, age and ear and also to obtain the preliminary data. Along with descriptive statistics, Mixed analysis of variance (overall list, gender, & age effects), Multivariate analysis of variance (age effect within each list), Paired t test (ear effect & list effect within subjects) and Cronbach's Alpha test (test reliability) were carried out. Whenever necessary, Duncan's post Hoc analysis was used.

List Effect

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

Table 1. Descriptive statistics for single and double correct scores for two lists.

Age Group		Right Correct Score		Left Correct Score		Double Correct Score	
		List I	List II	List I	List II	List I	List II
7 – 7.11 years	Mean	5.85	6.00	4.25	4.45	2.30	2.25
	SD	1.59	1.29	1.25	1.66	1.52	1.86
	Range	2 - 8	4 - 8	2 - 6	1 - 8	0-5	0 - 6

8 – 8.11 years	Mean	8.15	8.80	6.55	6.50	4.45	4.95
	SD	1.42	1.64	1.14	1.31	0.68	1.57
	Range	6 - 12	6 - 12	4 - 8	4 - 8	3 - 6	2 -7
9 – 9.11 years	Mean	10.45	10.70	8.80	8.55	7.20	7.10
	SD	2.39	2.10	2.33	1.50	1.79	1.55
	Range	6 - 16	6 - 14	6 - 15	6 - 12	5 - 12	4 - 10
10 – 10.11 years	Mean	12.85	12.70	11.05	10.85	9.05	8.95
	SD	2.08	1.68	1.79	1.63	1.82	1.46
	Range	10 - 16	10 - 15	8 - 15	8 - 13	6 - 12	6 - 11
11 – 11.11 years	Mean	14.60	14.20	12.45	12.35	9.65	9.30
	SD	3.84	1.73	3.25	3.01	3.11	2.17
	Range	8 - 20	11 - 17	6 - 17	8 - 19	5 - 14	7 - 14

From the Table 1, it can be seen that the mean values between the two lists for the single correct scores and double correct scores are almost similar. Mixed ANOVA was carried out to examine the overall list effect. Mixed ANOVA results showed no significant difference on lists for single correct scores [F (1, 90) = 0.002, $p > 0.05$] and double correct score [F (1, 90) = 0.01, $p > 0.05$] but there was an interaction seen in single correct score for the list, ear, and gender [F (1, 90) = 4.24, $p < 0.05$] and list, ear, gender, and group [F (4, 90) = 3.83, $p < 0.05$]. Hence, 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 shown in Table 2.

Table 2. 't' value, Degrees of freedom and its significance between the two lists across age groups.

Age Group	Dependent variable	t - value	df	Sig. (2 tailed)
7 – 7.11 years	RCSI - RCSII	0.39	19	$p > 0.05$
	LCSI - LCSII	0.59	19	$p > 0.05$
	DCSI - DCSII	0.20	19	$p > 0.05$
8 – 8.11 years	RCSI - RCSII	1.94	19	$p > 0.05$
	LCSI - LCSII	0.19	19	$p > 0.05$
	DCSI - DCSII	1.39	19	$p > 0.05$
9 – 9.11 years	RCSI - RCSII	0.36	19	$p > 0.05$
	LCSI - LCSII	0.40	19	$p > 0.05$
	DCSI - DCSII	0.25	19	$p > 0.05$
10 – 10.11 years	RCSI - RCSII	0.28	19	$p > 0.05$
	LCSI - LCSII	0.49	19	$p > 0.05$
	DCSI - DCSII	0.21	19	$p > 0.05$
	RCSI - RCSII	0.58	19	$p > 0.05$

11 – 11.11 years	LCSI - LCSII	0.14	19	$p > 0.05$
	DCSI - DCSII	0.29	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 the Table 2, that the paired 't' test did not reveal significant difference between two lists for both single and double correct scores. 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 either of the lists can be used in clinical practice.

Gender Effect

The mean and standard deviation for males and females across the two lists for all the five age groups are calculated and are listed in Table 3.

Table 3. Mean and Standard Deviation (SD) for males and females across lists and age group

Age Group	Gender	List I						List II					
		RCS		LCS		DCS		RCS		LCS		DCS	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
7-7.11	M	6.50	1.35	4.80	1.03	2.70	1.49	5.80	1.47	5.10	1.79	2.50	2.17
	F	5.20	1.61	3.70	1.25	1.90	1.52	6.20	1.13	3.80	1.31	2.00	1.56
8-8.11	M	8.30	1.56	6.90	1.10	4.50	0.84	8.60	1.77	6.60	1.34	5.20	1.22
	F	8.00	1.33	6.20	1.13	4.40	0.51	9.00	1.56	6.40	1.34	4.70	1.88
9-9.11	M	10.30	1.70	8.50	1.95	6.90	1.28	10.70	2.00	8.10	1.59	6.60	1.34
	F	10.60	3.02	9.10	2.72	7.50	2.22	10.70	2.31	9.00	1.33	7.60	1.64
10-0.11	M	12.90	2.28	11.50	2.12	9.60	1.64	12.50	1.17	10.70	1.70	8.10	1.44
	F	12.80	1.98	10.60	1.34	8.50	1.90	12.90	2.13	11.00	1.63	8.80	1.47
11-11.11	F	15.20	4.13	10.90	3.17	8.60	2.75	13.60	1.50	11.20	3.48	9.10	1.52
	M	14.00	3.65	14.00	2.62	10.70	3.23	14.80	1.81	13.50	2.01	10.50	2.17

Note. RCS - Right Correct Score; LCS - Left Correct Score; DCS - Double Correct Score; M - Male; F – Female.

From Table 3, it can be seen that mean scores for males and females are almost similar for single and double correct scores for both the lists. 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) = 0.243, *p* > 0.01] as well as for the double correct scores [F (1, 90) = 1.04, *p* > 0.05].

Existing literature has also shown that girls have more verbal ability than boys though it is not obvious until about the age of 11 years (Maccoby, & Jacklin, 1974). Young girls, aged 1 to 5 years are more proficient in language skills, talk at an earlier age, produce longer utterances, and have larger vocabularies than boys (Ruble, & Martin, 1998; cited in Plotnik, 1999) and these advantages for verbal and written language persist even through the school years (Lynn, 1992). Although there appear to be a gender difference favoring for females, this difference is relatively small and thus has little practical significance (Hyde, 1994; cited in Plotnik, 1999). Bellis and Wilber (2001) also advocated that the gender effects on the auditory evaluation of inter-hemispheric transfer are small and clinically insignificant.

The present study is in congruence with the previous studies done by Roberts et al. (1994) and Meyers, Roberts, Bayless, Volkert, and Evitts (2002) on dichotic word test indicating that, there exist no significant difference between the performance of the males and females across age and lists. Hence it can be concluded that boys and girls in the age range of 7 to 12 years develop in a similar manner in the way they develop binaural integration.

Age Effect

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

Table 4. Mean and Standard Deviation (SD) across age groups for both the lists

Age Group		List I			List II		
		RCS	LCS	DCS	RCS	LCS	DCS
7 – 7.11 years	Mean	5.85	4.25	2.30	6.00	4.45	2.25
	SD	1.59	1.25	1.52	1.29	1.66	1.86
8 – 8.11 years	Mean	8.15	6.55	4.45	8.80	6.50	4.95
	SD	1.42	1.14	0.68	1.64	1.31	1.57
9 – 9.11 years	Mean	10.45	8.80	7.20	10.70	8.55	7.10
	SD	2.39	2.33	1.79	2.10	1.50	1.55
10 – 10.11 years	Mean	12.85	11.05	9.05	12.70	10.85	8.95
	SD	2.08	1.79	1.82	1.68	1.63	1.46
11 – 11.11 years	Mean	14.60	12.45	9.65	14.20	12.35	9.30
	SD	3.84	3.25	3.11	1.73	3.01	2.17

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

It can be seen from the Table 4, that the mean scores for right correct scores, left correct scores and double correct scores increased as the age increased. On comparison between the ears, the right ear scores have higher scores compared to left ear 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 as compared to single correct scores.

It can also be inferred from Figure 1 and 2 that, the mean right correct score increased as the age increases from 7 to 12 years for both the lists. Similar trend is also seen for the mean left correct score and mean double correct score across the age groups. But the mean value is much lesser for double correct score compared to right ear correct score and left ear correct score.

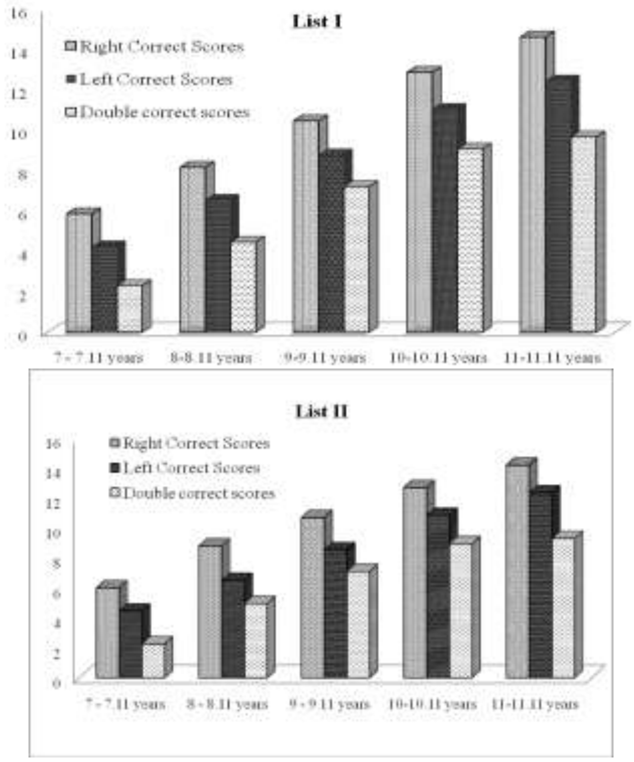

Figure 1 & 2. Mean Right Correct Scores, Left Correct Scores and Double Correct Scores across age groups for list I and II.

Mixed ANOVA was done to investigate overall significant difference between the groups. Results of Mixed ANOVA revealed significant effect on age [F (4, 90) = 108.48, $p < 0.001$] for the single correct scores. There was also a significant interaction for ear, gender, and group [F (4, 90) = 3.376, $p < 0.05$], and for the list, ear, gender, and group [F (4, 90) = 3.83, $p < 0.05$]. But there was no interaction seen for the list, and group [F (4, 90) = 0.24, $p > 0.05$], list, gender, and group [F (4, 90) = 0.13, $p > 0.05$], ear, and group [F (4, 90) = 0.18, $p > 0.05$], and list, ear, and group [F (4, 90) = 0.89, $p > 0.05$]. Similarly for double correct scores, there was a significant difference seen for the group [F (4, 90) = 87.83, $p > 0.01$]. However, there was no significant interaction seen for list, and group [F (4, 90) = 0.45, $p > 0.05$], gender, and group [F (4, 90) = 1.98, $p > 0.05$], and list, gender, and group [F (4, 90) = 1.36, $p > 0.05$] for the double correct score.

MANOVA was done to further investigate for the significant differences in different age groups within each list. Results of MANOVA revealed significant difference across the age groups for right correct scores [F(4,95) = 41.95, $p < 0.01$], left correct scores [F(4,95) = 47.77, $p < 0.01$] and double correct scores [F(4,95) = 61.89, $p < 0.01$] for the list I, and right correct scores [F(4,95) = 71.05, $p < 0.01$], left correct scores [F(4,95) = 54.97, $p < 0.01$] and double correct scores [F(4,95) = 62.31, $p < 0.01$] for list II. To understand which group is specifically different, Duncan Post-Hoc analysis was carried out. Means of the groups were presented in homogeneous subsets depending on the results of Post-Hoc analysis. Duncan's post Hoc analysis also shows significant difference across all the age groups at 95% of the confidence level for right ear correct scores, left ear correct scores and double correct scores. Mean scores for different age groups fall into different subsets indicating a significant difference between all the age groups.

The improvement in the dichotic word scores with the advancement of age could be due to the differential myelination of the sub-cortical and the cortical structures. The corpus callosum and certain auditory association areas may not have completed myelinogenisis until 10 to 12 years or older (Salamy, Mendelson, Tooley, & Chapline, 1980; Hayakawa et al., 1989) and hence the dichotic listening performances (Yakovlev, & Lecouis, 1967; cited in Chermak & Musiek, 1997). Somatosensory evoked potentials used to measure inter-hemispheric transfer time also indicates that the maturity of the corpus callosum ranges from 10 to 20 years of age (Salamy et al., 1980) and are one among to show significant age related changes (Pujal, Vendrell, Junque, Marti-Vilalta, & Capdevila, 1993). Due to the delay in myelination of higher cortical structures, there is not much information transmitted to the higher level and hence scores may be reduced in the lower age group. As age increases, the myelination of the cortical structures especially the corpus callosum might get completed and the scores of the dichotic listening increases.

The present study is in consonance with that of Berlin, Hughes, Lowe-Bell, and Berlin (1973) as well as Willeford and Burleigh (1994), where the right and left ear score increased significantly with age, which suggests an increase in the brain's ability to process two channel stimuli as function of age. However, ear advantage varies with the type of the stimuli used. More the linguistically load on the stimuli presented, more pronounced are the maturational effects (Bellis, 1996). The dichotic CV had higher right ear advantage (Berlin et al., 1973) where as dichotic sentences had right ear advantage which reduces as the age increases (Willeford & Burleigh, 1994). Since the dichotic word are an open stimulus set, it results in recognition performance in the middle of the difficulty continuum i.e., neither too easy nor too difficult, yet sensitive to performance differences between ears and groups (Roup, Wiley, & Wilson, 2006).

The mean scores for left ear are reduced as compared to right ear scores due to the inability 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 obtained in adults (Musiek, Gollegly, & Baran, 1984).

The double correct scores are less compared to single correct scores in all the age groups may be due to the inability to process both channel at the same time at the younger age and also 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.

Ear Effect

The means and standard deviation (SD) for right and left ear across the age groups for both the lists are tabulated in Table 1. From 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. This indicates the presence of right ear advantage for all 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, $p < 0.01$] for both the lists. There is an 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 list, ear, gender, and group [F (4, 90) = 3.83, $p < 0.05$]. Hence, paired 't' test was administered to further evaluate difference in the scores between the two ears across age groups for both the lists. Results of the paired 't' test across the age groups are shown in Table 5. 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 11.11 year group, where it reached a significance level and yet, 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 - value	df	Sig. (2 tailed)
7 – 7.11 years	RCSI – LCSI	6.02	19	$p < 0.01$
	RCSII – LCSII	4.72	19	$p < 0.01$
8 - 8.11 years	RCSI – LCSI	5.44	19	$p < 0.01$
	RCSII – LCSII	8.15	19	$p < 0.01$
9 – 9.11 years	RCSI – LCSI	5.47	19	$p < 0.01$
	RCSII – LCSII	6.27	19	$p < 0.01$
10 – 10.11 years	RCSI – LCSI	6.28	19	$p < 0.01$
	RCSII – LCSII	7.95	19	$p < 0.01$
11 – 11.11 years	RCSI – LCSI	2.04	19	$p = 0.05$
	RCSII – LCSII	2.90	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

The presence of a right ear advantage as obtained in the present study is in accordance with the literature reported earlier (Kimura, 1961a, 1961b; Katz, 1962; Berlin et al., 1973; Wexler & Halwes 1983; Musiek et al., 1989). 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, the ear difference is attributed to the bilateral asymmetry in brain function as a function of stimulus type and the 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 consist of more fibers and consequently produce more cortical activity than the ipsilateral projections and the fact that the left hemisphere is dominant for speech in most cases (Rasmussen, & Milner, 1977; Kandel, Schwartz, & Jessell, 1991). In addition, stronger activity in the contralateral system inhibits the processing on the ipsilateral side (Yasin, 2007) 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 the close proximity of the left temporal lobe which is closer to the left primary speech areas than the right anterior temporal lobe (Berlin et al., 1973). Hence, it is postulated that 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 more efficient interaction between shorter pathways (Berlin et al., 1973). Similar findings have been reported by Studdert-Kennedy and Shankweiler (1970).

In the present study, 11 to 11.11 year age group did not show significant difference between right ear and left ear scores in list I but the mean scores of right ear scores are higher compared to left ear scores and the significance level for this group was p = 0.05. Thus we expect that the right ear advantage was present for this age group also.

Reliability Measure

The reliability measure for 10% of the total subjects participated were analyzed using Cronbach's Alpha test in SPSS 17.0 software. The subjects were retested after a gap of two to four weeks. The results of the reliability measure are shown in Table 6.

Table 6. Reliability measures for single correct scores and double correct scores for both the lists.

Lists	Dependent variable	Alpha values
List I	Right Correct Score	0.84
	Left Correct Score	0.86
	Double Correct Score	0.81
List II	Right Correct Score	0.78
	Left Correct Score	0.76
	Double Correct Score	0.78

Table 6 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.

In conclusion, analysis of the results obtained from the present study revealed significant difference in Ear and Age but did not show significance for list and Gender. Also good reliability of the test was seen across the lists and ears.

Summary and Conclusions

The purpose of the present study was to develop a dichotic word test in English for Indian children and to establish the preliminary data. The test consist of two lists of 25 monosyllables each, with five being the practice words and were familiar for seven years old children. The duration of the monosyllabic pairs was equal and they were either voiced or voiceless. These paired words were aligned and imposed on a stereo track in such a way that monosyllable pairs were played simultaneously in both ears.

To establish the preliminary data for developed dichotic word test, five groups of children with the age range from 7 to 12 years were taken and each group consisted of twenty children with equal number of males and females. All the children had English as the medium of instruction for at least one year, belonged to the region of Mysore, were right handed and none of them had a history of any otological or neurological disturbances. These children were initially tested with routine audiometric testing (PTA, SRT, SIS & Immittance) and Screening Checklist for Auditory Processing Disorder (SCAP) to ensure normal auditory functioning prior to the administration of the dichotic test stimuli.

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 revealed no significant difference in list and gender for all the age groups whereas ear and age showed significant difference. Right ear scores were greater compared to left ear scores whereas mean double correct score values were less compared to single correct scores (Right & Left correct scores). All the correct scores (single & double correct scores) increased as the age increased for all the age groups irrespective of gender and list. Test retest reliability measures showed good reliability indicating the usefulness of the developed test in clinical population.

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