Dichotic Word (CVC) Test for Native Hindi Speaking Children

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Abstract

The study was aimed in developing dichotic word test for native Hindi speaking children 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 23 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 (18 in each group) with the age range of 7 to 11.11 years. The results revealed significant influence of age and ear. As the age increased, the performance of the children also increased showing greater right ear score followed by left ear score and double correct score indicating the presence of right ear advantage. However, there was no significant influence of list and gender. This test can be administered on larger population for standardize and to be used as a clinical tool for assessment of central auditory processing disorder. This developed dichotic word test can be used in other clinical population such as learning disability, stutterer, ADHD.

Key Words: *Dichotic word test, right ear advantage, central auditory processing disorder*

Introduction

Central auditory processing disorder demonstrate difficulty in one or more of the following abilities or skills: sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal aspects of audition, including temporal integration, temporal discrimination (e.g., temporal gap detection), temporal ordering, and temporal masking; auditory performance in competing acoustic signals (including dichotic listening); and auditory performance with degraded acoustic signals (ASHA, 1996; Bellis, 2003; Chermak & Musiek, 1997). Central auditory system mechanism and processes affect non-verbal as well as verbal signals and influence various higher functions including language and learning (Phillips, 1995; ASHA, 1996).

Chermak and Musiek (1997) estimated that APD occurs in 2 to 3% of children, with a 2-to-1 ratio between boys and girls. While Cooper and Gates (1991) estimated the prevalence of adult APD to be 10 to 20%.

Numerous tests have been developed over a period of time to assess central auditory function, as the central auditory processing disorder 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).

Among the test battery, Dichotic listening tests have been an essential test and have been used across all age groups (Jerger & Musiek, 2000). It was originally introduced by Broadbent (1954) and is used to study the relationship between cerebral dominance and learning disabilities (Ayres, 1977), cognitive development (Obrzut & Hynd, 1981), auditory processing disorder (Tobey, Cullen, Rampp & Fleischer-Gallagher, 1979) and language disorder (Pettit & Helms, 1979). Depending upon the instruction given to the listener, dichotic task may assess the process of binaural integration, binaural separation or combination of both (Bellis, 2003). In dichotic listening skill the right ear advantage is observed through age 9 to 10 years, although performance varies based on the linguistic complexity of the signal, with development noted for specific type of dichotic skill through adolescence (Fischer & Hartnegg, 2004). The more difficult the task is the greater would be the right ear advantage (Moller, 2007).

Stimuli options available for dichotic listening tasks include consonant-vowel syllables, digits, words and sentences. In a study by Noffsinger, Martinez and Wilson (1994), digits were found to be the easiest stimulus in a dichotic listening task, followed closely by sentences. Nonsense consonant-vowel syllables proved to be significantly more difficult with accuracy levels of just over 70% in both ears.

Dichotic digit test unlike sentences limit contextual cues. However it is a close set task so it may tend to overestimate speech recognition ability. Dichotic word

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test limit the use of syntactical cues and is an open set stimulus that may result in recognition performance in the middle of the difficulty continuation (Roup, Wiley & Wilson, 2006). Furthermore, among other dichotic listening tests, the dichotic CV test does not show expected

neuromaturational effect in normally hearing children (Roeser, Millay & Morrow, 1983). However, words may have several advantages over digits because they are a much less restricted set than digits which allows for word sets of varying difficulties. There are also currently many standardized, recorded lists of words available which allows for performance comparisons across patients or subjects. The greatest benefit, however, may lie in using a combination of all stimulus options in dichotic listening tasks to obtain an even wider range of difficulties than just words alone allow for (Noffsinger, et al., 1994; Roup, et al., 2006).

Dichotic word test has a good sensitivity in identifying and differentiating the cerebral level lesion (Berlin, 1976). 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). 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). Hence the current study is aimed in developing the dichotic word test for native Hindi speaking children and also to investigate the effects of different stimulus list on gender, age and ear difference.

Method

This study was carried out in two phase that includes**;** Phase I- Development of test stimuli for Dichotic word test in Hindi language and Phase II- Establishing the preliminary data for Dichotic word test in Hindi language across different age groups.

I- Development of test stimuli

Selection of words: Around 800 monosyllabic words were collected from children's text book, magazine, day to day conversation and dictionary. The familiarity of these words were checked by administering it on 12 adult Hindi speaker and 6 children who were asked to rate these words on five point rating scale.

I. I do not know the word
II. I know the word but not the meaning of the word
III. I know both word and meaning, but do not use the word
IV. I know both word and meaning and use the word occasionally
V. I know both word and meaning and use the word frequently

The words which were rated as 'V' were selected for the recording. Words were recorded on data acquisition system with a 16 bit analogue to digital convertor at a sampling frequency of 44.1 kHz by 5 native Hindi female speakers in an acoustically treated room. All five recordings were given to five experienced audiologists (native Hindi speakers) to choose the best recoding in terms of intelligibility, rate of speech and clear articulation. The elicitation and scaling of selected recording test material was done using Adobe audition (Version 3.0) software to ensure that the intensity for all the words was same.

Preparation of dichotic word pairs: Two lists of twenty three 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 10 ms as per the guidelines given by Lamm, Share, Shatil, and Epstein (1999). Two different lists of dichotic word-pairs consisted of 3 practice word pairs followed by 20 test word-pairs. In 20 test word-pairs, 20 words would go to the right ear and 20 words goes to the left ear but in each pairs the two words which goes to the right and left ear were not the same. The word pairs with same phoneme in the same word positions were avoided as per the guidelines of Roup, et al., (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 three practice word pairs followed by twenty test word pairs were formed. A 60-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.

II- Establishing the preliminary data for Dichotic word test in Hindi language

Subjects

Data were collected from 90 native Hindi speaking children between 7 to 11.11 years. These subjects 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=18). Subjects included for the collection of data had bilateral normal-hearing thresholds at frequencies, 250 Hz to 8000 Hz for air conduction thresholds and 250 Hz to 4000 Hz for bone conduction thresholds. They had bilateral type-A tympanogram with presence of acoustic reflexes (ipsi & contra) in both ears. Subjects also had Speech recognition threshold of ±12 dB (re: PTA of 0.5, 1 & 2 kHz), Speech identification score greater than 90% at 40 dBSL (re: SRT) in both ears. All subjects passed the Screening Checklist for Auditory Processing (SCAP) developed by Yathiraj & Mascarenhas (2003), ruling out any auditory processing deficits. All subjects were right handed and it was confirmed on laterality preference schedule which is a part of *Functional Neuropsychological Assessment Battery* (Venkatesan, 2011). Subjects included for the dichotic word test did not have otologic and/or neurologic problems and illness on the day of testing.

Instrumentation

All the evaluations were carried out in an acoustically treated two-room situation as per ANSI S 3.1 (1991). A Calibrated two channel diagnostic audiometer MA-53 audiometer coupled with acoustically matched MAICO headphone and radio ear B-71 bone vibrator was used to estimate pure tone thresholds, speech recognition threshold and speech identification scores. A calibrated Intra acoustic AT-235 immittance meter coupled with Telephonic TDH-39P was used for obtaining tympanogram and acoustic reflex thresholds. A laptop with adobe audition (Version 3.0) software was used to record and present the test material.

Administration of developed Dichotic word test

The dichotic word test material was presented through laptop connected to the calibrated MA-53 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 (40 dBSL ref. 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 hear two words simultaneously in both ears. You should repeat both the words that you hear. You may repeat word from any ear first’. Task understanding was ensured using three practice items in each list before proceeding to the real test. Verbal responses were taken from all children and tester marked “√” for the correct response on the dichotic word test data sheet.

Score calculation of dichotic word test: 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. Three practice item word pairs were not considered in the testing score. The possible total correct response for each test paradigm was 20 for each ear.

Analysis

Mean and standard deviation for Right ear score (RES), Left ear score (LES), and Ear advantage (EA) for each test condition was calculated by using Statistical Package for the Social Science (SPSS) Version 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), Paired t-test (ear effect & list effect within subjects) and whenever necessary, Duncan’s post-Hoc analysis was used to find out significant differences in scores across the age groups.

Table 1: Descriptive statistics for single and double correct scores for both lists

Age group (Years)		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	10.44	10.78	6.55	6.50	2.28	2.39
	SD	1.82	1.93	1.46	2.09	1.71	1.38
8-8.11	Mean	11.44	11.33	8.39	8.28	3.83	3.50
	SD	1.24	1.85	1.29	2.70	2.25	1.95
9-9.11	Mean	12.94	13.11	9.33	9.28	6.00	6.06
	SD	1.55	1.53	1.71	1.99	1.19	1.00
10-10.11	Mean	15.44	15.67	12.44	12.39	9.50	9.50
	SD	1.38	1.24	1.92	1.29	1.62	1.15
11-11.11	Mean	17.05	16.94	15.06	15.28	13.33	13.61
	SD	1.26	1.10	1.11	1.81	1.18	1.79

List effect

The mean and standard deviation (SD) for single correct scores (right and left) and double correct scores were obtained for the two lists across five age groups as represented in Table 1.

From Table 1, it can be seen that there is minimal difference in the mean values for the right ear correct scores, left ear correct scores and double correct scores for the two lists. Mixed ANOVA was carried out to see the overall list effect. Mixed ANOVA results showed no significant effect on lists for single correct scores [F(1, 80)=0.05, p>0.05] and double correct scores [F(1, 80)=0.01, p>0.05]. Paired 't' test was done to evaluate the difference in scores between two lists across five age groups. Results of the paired 't' test did not show significant difference between two lists for right, left and double correct scores in all five age groups. It indicates that when the two words are presented in two different channels at 0 ms lag time it does not alter the performance of the subjects between the lists. Hence, it can be concluded that both lists are equal in difficulty level and so either of the lists can be used for clinical purpose.

Gender effect

Mean and standard deviation for males and females across the two lists for all the five age groups were calculated and are tabulated in Table 2.

From Table 2, it can be seen that mean scores for males and females are almost similar for right, left and double correct scores across all the five age groups for both the lists. The mixed ANOVA was done to find out the overall effect of gender. Results revealed no significant differences between the two genders for single correct scores [F(1, 80)=0.68, p>0.05] as well as double correct scores [F(1, 80)=0.18, p>0.05].

Present study reveals that there is no significant difference between the performance of male and female across age groups and for each list of the dichotic word test. This 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. Bellis and Wilber (2001) administered dichotic listening test of consonant-vowel in adult and reported that no gender effect was seen.

Table 2: Mean and standard deviation for males and female across list 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	10.33	1.66	6.33	1.58	2.44	1.33	10.67	1.41	6.11	2.84	2.56	1.74
	F	10.55	2.07	6.78	1.39	2.11	2.09	10.89	2.42	6.89	0.93	2.22	0.97
8-8.11	M	11.78	1.30	8.33	1.58	3.78	2.33	11.11	2.08	8.44	3.09	3.56	2.60
	F	11.11	1.17	8.44	1.01	3.89	2.31	11.56	1.67	8.11	2.42	3.44	1.13
9-9.11	M	13.00	1.41	9.22	2.11	5.89	1.16	13.11	1.27	9.22	2.11	6.11	1.05
	F	12.89	1.76	9.44	1.33	6.11	1.27	13.11	1.83	9.33	2.00	6.00	1.00
10-10.11	M	15.55	1.67	12.33	2.34	9.44	2.13	15.66	1.22	12.11	1.54	9.33	1.32
	F	15.33	1.12	12.56	1.51	9.56	1.01	15.67	1.32	12.67	1.00	9.67	1.00
11-11.11	M	17.00	1.00	15.00	0.71	13.22	0.83	16.67	1.00	15.00	1.22	13.44	1.13
	F	17.11	1.54	15.11	1.45	13.44	1.51	17.22	1.20	15.56	2.29	13.78	2.33

Note- RCS- Right correct score; LCS- Left correct score; DCS- Double correct score, M- Male; F- Female.

Table 3: Mean and standard deviation (SD across the age groups for both lists

Age group (Years)		List I			List II		
		RCS	LCS	DCS	RCS	LCS	DCS
7-7.11	Mean	10.44	6.55	2.28	10.78	6.50	2.39
	SD	1.82	1.46	1.71	1.93	2.09	1.38
8-8.11	Mean	11.44	8.39	3.83	11.33	8.28	3.50
	SD	1.24	1.29	2.25	1.85	2.70	1.95
9-9.11	Mean	12.94	9.33	6.00	13.11	9.28	6.06
	SD	1.55	1.71	1.19	1.53	1.99	1.00
10-10.11	Mean	15.44	12.44	9.50	15.67	12.39	9.50
	SD	1.38	1.92	1.62	1.24	1.29	1.15
11-11.11	Mean	17.05	15.06	13.33	16.94	15.28	13.61
	SD	1.26	1.11	1.18	1.10	1.81	1.79

Note- RCS- Right correct score; LCS- Left correct score; DCS- Double correct score

However there are studies in literature showing that language performance is better in females than males, even in children as young as 2 to 3 years (Dionne, Dale, Boivin & Plomin, 2003). Girl aged 1 to 5 years are more proficient in language skills, produce larger utterences, and have more vocabularies than boys (Ruble & Martin, 1998) and these advantage persist even through the school years for verbal and written language (Lynn, 1992). Here, gender differences favoring for females, but the difference is relatively small so it has little practical significance. Hence, it can be concluded that boys and girls in the range of 7 to 12 years develop in similar manner for binaural integration task.

Age effect

There was no difference in the mean scores of males and females so the data of both the gender were combined to see the overall age effect for both the lists. The mean and standard deviation across the age groups for both the list is tabulated in Table 3.

From Table 3, it can be seen that mean scores for right correct score, left correct scores and double correct scores increased as the age increases. The right ear scores are greater compared to left ear scores and double correct scores indicating right ear advantage in both the list. It can also be seen that mean double correct scores are lesser for all the age groups compared to single correct scores.

Mixed ANOVA was done to evaluate overall significant difference between the groups. Mixed ANOVA results revealed significant effect of age group [F(4, 80)=185.27, p<0.01] for single correct scores. There was also significant interaction between ear and age groups [F(4, 80)=5.63, p>0.05]. However, there was no statistically significant interaction seen between age group and gender [F(4, 80)=0.22, p>0.05], age group and list [F(4, 80)=0.04, p>0.05], age group, list and gender [F(4, 80)=0.03, p>0.05], ear, age group and gender [F(4, 80)=0.10, p>0.05], list, ear and age group [F(4, 80)=0.21, p>0.05] and list, ear, gender and age group [F(4, 80)=0.36, p>0.05]. Similarly for double correct scores, there was a significant difference seen for the age group [F(4, 80)=251.39, p<0.01]. However, there was no statistically significant interaction seen between age group and gender [F(4, 80)=0.18, p>0.05], age group and list [F(4, 80)=0.20, p>0.05] and age group, list and gender [F(4, 80)=0.05, p>0.05] for the double correct score.

Further investigation was done though MANOVA to see the significant difference in the different age groups within these two lists. Results revealed significant difference across the age groups for right ear correct scores [F(4, 85)=63.23, p<0.01], left ear correct scores [F(4, 85)=88.44, p<0.01] and double correct score [F(4, 85)=133.32, p<0.01] for list I and right correct scores [F(4, 85)=52.99, p<0.01], left correct score [F(4, 85)=53.29, p<0.01] and double correct scores [F(4, 85)=169.39, p<0.01] for list II. Duncan's Post-hoc analysis was done within the age groups, to find out which of the groups are significantly different. Except for the left ear scores of second (8–8.11 year) and third (9–9.11 year) groups it showed significant differences across all the age groups at 95% of the confidence level for right correct scores, left correct scores and double correct scores for list I. Duncan's post hoc analysis of list II showed significant differences across all the age groups at 95% of the confidence level for right correct scores, left correct scores and double correct scores except right correct scores of first (7–7.11 year) and second (8–8.11 year) group and left correct score of second (8–8.11 year) and third (9–9.11 year) group.

Yakovelev and Lecousis (1967) reported that dichotic listening performances do not reach adult values till around 10 to 11 years of age. The functional development time is consistent with the myelination time course. However, corpus callosum and certain auditory association areas may not have completed myelinogenesis until 10 to 12 years or older (Salamy, Mendelson, Tooley & Chapline, 1980). Hayakawa et al., (1989) reported that corpus callosum becomes adult like by the age of 11-12 year, whereas Johnson, Farnsworth, Pinkston, Bigler and Blatter (1994) reported that growth and efficiency of corpus callosum increases till early adult years. Pujal, Vendrell, Junque, Marti-Vilalta and Capdevila (1993) reported that corpus callosum is the last structure to be fully developed and to show the age related changes. Due to incomplete maturation of corpus callosum and delay in myelination of higher cortical structure, there is not much information passed to the higher level and hence score may be reduced in the lower age group for dichotic listening task. As age increases, the myelination of the cortical structure especially corpus callosum gets completed and the scores of the dichotic listening increases.

Poor left ear performance in dichotic listening task in children may reflect a decrease ability of the corpus callosum to transfer complex stimuli from the right hemisphere to the left hemisphere. As age increases 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).

Berlin, Hughes, Lowe-Bell and Berlin (1973) reported that when CV stimuli presented to both the right and left ear the single and double correct scores increased significantly with age, which suggests an increase in the brain's ability to process two channel stimuli as function of age. Similar finding were seen by Willeford and Burleigh (1994) who used sentence material which were presented dichotically. However, ear advantage varies with the type of stimuli used in the above two studies. Possible explanation for these findings is that CV nonsense syllable are less linguistically loaded than sentences. So, processing demand on two hemispheric and inter-hemispheric connections would be less complex. In contrast dichotic sentences are more linguistic loaded so require more inter-hemispheric communication via corpus callosum as well as integrity of both temporal lobes (Bellis, 1996). But dichotic words 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) nor too difficult (like sentences), yet sensitive to performance difference between ear and groups (Roup, et al., 2006).

Ear effect

The mean and standard deviation (SD) for right and left ear scores across the five age groups for both the list are tabulated in Table 1. From the Table 1 it can be inferred that mean scores of right ear was greater than that of left ear in both the list across all five age groups. Mixed ANOVA was done to find out the difference in score across two ears in both of the lists. Results showed significant difference in scores between right and left ears [$F(1, 80)=383.93$, $p<0.01$] for both the list. Paired t test was done to find out difference in the scores between the two ears across five age groups for both the lists. Paired t test results revealed a significant difference between the right ear scores and left ear scores for all the five age group in both list as evident in Table 4.

Berlin, Lowe-bell, Cullen, Thompson and Loovis (1973) reported that dichotic CV had higher right ear

Table 4: Paired t test showing 't' value, and its significant differences across two ears

Age (years)	Dependent variables	Mean differences	t- value '17'	Sig.(2 tailed)
7 – 7.11	RCS I – LCS I	3.89	7.34	P<0.01
	RCS II – LCS II	4.28	7.50	P<0.01
8 – 8.11	RCS I – LCS I	3.05	7.08	P<0.01
	RCS II– LCS II	3.06	4.98	P<0.01
9 – 9.11	RCS I – LCS I	3.61	8.42	P<0.01
	RCS II – LCS II	3.83	8.35	P<0.01
10 – 10.11	RCS I – LCS I	3.00	4.64	P<0.01
	RCS II – LCS II	3.28	11.33	P<0.01
11 – 11.11	RCS I – LCS I	1.99	9.35	P<0.01
	RCS II – LCS II	1.66	6.52	P<0.01

Note- RCS I- Right correct score for list I; RCS II- Right correct score for list II LCS I- Left correct score for list I; LCS II- Left correct score for list II advantage where as Willeford and Burleigh (1994) reported that dichotic sentence gave right ear advantage which reduces as the age increases. Right ear advantage in dichotic listening task was postulated by Kimura's structural model (Kimura, 1967). This model postulated that, it is the bilaterally asymmetry in brain function as a stimulus type whichgive rise to the right ear advantage. Hugdhal (2005) said that the contralateral ascending auditory system consist more fibers and is consequently stronger leading to more cortical activity than the ipsilateral projection. Also, left hemisphere is dominant for speech in most cases which explains the right ear advantage (Rasmussen & Milner, 1977). Right ear advantage occurs in dichotic listening task because of stronger activity in the contralateral system which inhibits the ipsilateral side processing (Yasin, 2007).

Conclusions

The collected data was subjected to appropriate statistical analysis and 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 and double correct scores) increased as the age increased for all the age groups irrespective of gender and list.

Future Research

In future this test can be administered on larger population for standardizing the developed test and to be used as a clinical tool for assessment of auditory processing disorder. This developed dichotic word test can be used in other clinical population such as learning disability, stutterer, ADHD. Preliminary data for this dichotic word test in adult population can also help in understanding the age of maturation for dichotic words.

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