Dichotic Rhyme Test in Telugu: A Normative Data on Adults

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Abstract

Dichotic speech tests proved to have high sensitivity in assessing binaural integration tasks that often noticed in individuals having (Central) Auditory Processing Disorder [(C) APD]. Research focusing on one of the dichotic tests i.e. Dichotic Rhyme test has been relatively scanty. The present study aimed to develop one such test and collect normative data for Telugu speaking individuals. Stimulus was developed using 18 pairs of CVCV rhyming words that differ only in initial consonant. These stimuli were made similar in total duration and imposed on to stereo tracks and aligned such that these are played dichotically with no onset disparities. Normative data was collected from 60 young adult native speakers of Telugu, including equal number of male and female subjects. Analysis of the results revealed a significant right ear advantage in male subjects than in female subjects. Double correct scores were also to be greater in male subjects than in female subjects. The results correlated with gender differences that exist for language laterality.

Key words: *(C) APD, Dichotic Rhyme Test, Gender Differences, Right Ear Advantage.*

Introduction

Dichotic rhyme test (DRT) was introduced by Wexler and Halwes (1983) and modified by Frank E. Musiek (1989). This test uses well aligned and is composed of simple common words. The stimuli are aligned such that, although presented with two words, patients generally report only one, with slightly more than 50% of all words recognized being those presented to right ear (Wexler and Halwes., 1983; Musiek et al., 1989). This unique pattern of performance was presumed to be the result of some type of dichotic "fusion" of the signals, which occur low within the central auditory nervous system. The rationale behind this test has come from series of experiments carried by Repp (1976). Fusion in the dichotic listening condition takes place when words with similar spectral shape (waveform envelop) are presented to the listener (Repp, 1976). The waveform envelop for words is generally determined by the low frequency energy (Perrot and Berry, 1969), which is essentially its fundamental frequency (Repp, 1976, 1977a).

Therefore if two words presented dichotically, which have similar spectral envelopes and are temporally aligned, they will fuse and will be heard as one word (Repp, 1977a). The words in DRT for the most part, are words that are perfectly or partially fused. Due to the fusion this test also called as Fused Dichotic Words Test (FDWT). Musiek, Kurdzielschwan, Kibbe, Gollegly, Baran, and Rintelmann (1989) reported normative values of 30% - 73% for right ear and 27% - 60% for left ear in a group of 115 normal hearing subjects. Bellis (2003) normative data indicated no significant effect of age or ear on the Dichotic Rhyme test. Normative values (2 standard deviations above and below the mean) were 32% - 60% per ear.

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Bode, S.D. et al., (2007) examined DRT for measuring the degree of hemispheric specialization for language in individuals who had undergone cerebral hemispherectomy. Results revealed that most syllables or words are reported for the ear contralateral to the
remaining hemisphere, while few or none are reported for the ear ipsilateral to the remaining hemisphere. In the presence of competing inputs to the two ears, the stronger contralateral ear-hemisphere connection dominates/suppresses the weaker ipsilateral ear-hemisphere connection.

Musiek et al., (1989) studied the performance of normal hearing individuals and patient undergone commissurectomy on dichotically presented monosyllabic rhyme words. Data was collected from a group of 115 normal hearing individuals and 6 patients undergone commissurectomy for intractable seizures (2 weeks postoperatively). Results reveal that spilt-brain patients yielded marked left ear deficit, as seen on other dichotic speech tests and demonstrated a right-ear enhancement, producing a large inter-ear differences. This right-ear enhancement on the dichotic rhyme task (DRT) may suggest a release from central auditory competition in the left hemisphere. The dichotic rhyme task's normative data results and sensitivity to lack of callosal transmission make it worthy of further clinical and basic research.

There have been several factors that affect the performance of DRT that include both subjective and stimuli parameters. One such major subjective factor for the performance on DRT was gender differences. As right-ear advantage in dichotic listening is a reflection of the left hemisphere's dominance for speech perception and related functions (Studdert-Kennedy and Shankweiler, 1970; Kimura, 1961a, 1967). A much debated question is whether sex differences exist in the functional organization of the brain for language. A long-held hypothesis posits that language functions are more likely to be highly lateralized in males and to be represented in both cerebral hemispheres in females, but attempts to demonstrate this have been inconclusive.

From these findings one can understand that DRT is highly sensitive to the lesions that involve corpus callosam. The primary lesion for the patients with (C) APD facing auditory integration deficits was thought to be involving posterior commissural fibers (Baran et al., 1986). Thus having DRT to assist clinically in the assessment of the patients facing such difficulties. As DRT involves rhyming meaningful words, and the rhyming words across languages differ, developing DRT in different languages will help audiologists to assess patients having different languages spoken and facing problem with auditory integration deficits. Thus the aim of the present study was

A. To develop the Dichotic Rhyme test using commonly spoken words in Telugu and establishing the normative data on newly developed DRT.

B. To evaluate the gender differences on dichotic performance using dichotic rhyme test.

Method

The present study was carried out in two phases. Phase I involved construction of test material for "Dichotic Rhyme test in Telugu". Phase II involved obtaining normative data for the newly constructed "Dichotic Rhyme test in Telugu".

Phase I: Construction of the test material

Forty pairs of bi-syllabic words, in which each word had syllable structure as CVCV, were selected from "Brown's Telugu- English Dictionary" as well as from text books (below V Grade). Each word of a rhyming pair had started with one of the six consonants (/p/, /ṭ/, /k/, /b/, /ḍ/ and /g/). In a pair of rhyming words, the two words (here onwards referred as members of a pair) differ only in the initial consonant. Furthermore, the difference in the initial consonant was either in terms of place of articulation or in terms of voicing. Thus, it leads to have nine possible combinations with the six consonants. Of these 40 rhyming words, 25 were selected based on subjective ranking given by the native speakers of Telugu. From these 25 rhyming words, 18 were selected to include two rhyming pairs for each consonantal difference.

These thirty six words (i.e.,), eighteen rhyming pairs were given to an adult female (native speaker of Telugu), and was asked to say out these words. This voice sample was picked up with an electret condenser type Omni-directional microphone. These speech samples were recorded as mono sound using "PRAAT" software with a sampling rate of 22050Hz and 16-bit amplitude rate. Using the same software, the final CV portion of one member of each pair was then replaced with final non-distinctive portion of the other member, making the final portions of the members of each pair identical. This was a preliminary step to reduce the variation in the final portion of members in a rhyming pair.

E.g., the final CV portion in /ṭala/ (/la/) was replaced with final CV portion in /kala/ (la), to reduce the perceptual difference in the final portion of both words.

After cross-splicing process, the two members in a pair were made identical in stimulus duration by reducing the glottal pulses and/or by reducing the steady state portion in the initial CV portion of longer durational member. By doing so, the duration of members within a pair has been kept the same. But the duration of different rhyming pairs was not maintained, as the duration of different consonants in different words varies.

The selected stimuli were then normalized to 6dB and imposed onto stereo tracks. These were aligned such that when one member of the pair was presented to one ear and at the same time other member played in the other ear. This was achieved by using the software "ADOBE AUDITION 3.0". In addition a counter balanced design was used to decrease the ear effects, by aligning the stimuli which was reversed between ears. This leads to a total number of 36 stimuli for total 18 pairs of words. 10 seconds silence was

inserted between each stimulus, during which subject wrote their responses. All the stimuli were constructed into 4 tracks. Content of these tracks are shown in Appendix A. These were recorded on to a compact disk with initial calibration tone of 1 KHz of equal intensity in both ears as stereo tracks.

The recorded material was presented to the native speakers of Telugu, for noticing any distortion embedded in the altered signal and to observe stimulus dominance effects. Stimulus dominance is the tendency for one member of a pair to be consistently reported regardless of ear of presentation. It was made sure that all the stimuli selected for the final testing to have acceptance (without any distortion) by 80% of total 20 native speakers. Rhyming pairs with more than 60% of stimulus dominance were identified and modified by altering amplitude of some important acoustic cue (mainly the burst amplitude and voicing amplitude) in the dominant member of the pair, to reduce the effects of stimulus dominance.

Phase II: Obtaining normative data

Subjects:

The subjects for the study were 50 normal young adults (25 males and 25 females) in the age range of 17 to 25 years. All the subjects had normal hearing sensitivity in both ears with no previous otological problem and having greater than 80% of SIS scores in each ear. All subjects were right hand users (Established through verbal report and tested by comparing the writing ability of the two hands). Some of the subjects taken for normative data also participated in the stimulus dominance experiment. For these individuals, to avoid practice effect minimum of 15 days time period was given between two experimental phases.

Instrumentation:

A two channel diagnostic audiometer (Madsen OB 922), which was calibrated in accordance with ISO 389 (As mentioned in Madsen electronics Instrumental Manuel), was used for preliminary testing (Air conduction, Bone conduction and Speech audiometric measures) and also to present the test material. Stimuli were played from a computer that constituted the sound drives namely, “legacy audio devices”. All stimuli were presented through TDH-39 earphones mounted in MX-41/AR cushions.

Test environment:

The testing was carried out in a well lit air-conditioned sound treated double room and ambient noise levels within permissible limits according to ANSI S3.1 -1999 (As cited by Tom Frank, 2000).

Procedure:

The test stimuli were presented at a level of 60dB HL, through audiometer routed to head phones. The subjects initially had to match the loudness of the calibration tone between ears. Then the test stimuli were presented dichotically, with no lag between ears. The subjects were instructed to write down the words they heard, and also not to guess any word of the pair (if only one word was heard). Subjects were encouraged to write down both words in a pair.

Scoring:

Responses were scored in terms of single correct and double correct scores. A single correct score was given when the subject writes only one word presented to any one ear correctly. A double correct score was given when the subject reported the words presented to both ears correctly. From these scores, the total number of stimuli repeated from one ear (right or left) was calculated and named as ear correct score. These include the total number of responses that were correct from one ear (right or left) out of 36 (total number of stimuli) and were used for further analysis.

Reliability measure:

Intra subject reliability of the test results was verified, by testing 10 individuals (Constitute 20% of total population) including 5 males and 5 females, repeatedly. Further results of the reliability test measure are discussed under results and discussion chapter.

Analysis:

The raw data was subjected to statistical analysis from which descriptive statistics such as mean, standard deviation and range were calculated. Ear correct scores were examined for gender differences. A 2 X 2 repeated measure analysis of variance was performed with gender (2 levels: Male, Female) as between-group factor and ear (2 levels: Right and Left) correct scores as the within-group factors. As significant Ear X Gender interactions were revealed in the analysis of variance, indicating differential effects of gender on the magnitude of ear correct scores, separate planned t-tests (Paired and Independent samples) were carried out for right- and left-ear correct scores on within and between genders to explore these interactions.

Results

To have normative values, data collected on 25 male and 25 female subjects in the age of 17 to 25 years was subjected to statistical analysis using the software program SPSS version 10.0. Analysis was carried out to reveal information on,

I. Comparison of ear correct scores within gender
II. Comparison of ear correct score across genders
III. Double correct scores across gender
IV. Reliability measures

I. Comparison of ear correct scores within gender:

Ear correct scores were used for statistical analysis. Left ear and right ear correct scores were analyzed for differences in both males and females. The average values of raw data (ear correct score) for both males and females are depicted in the following graph:

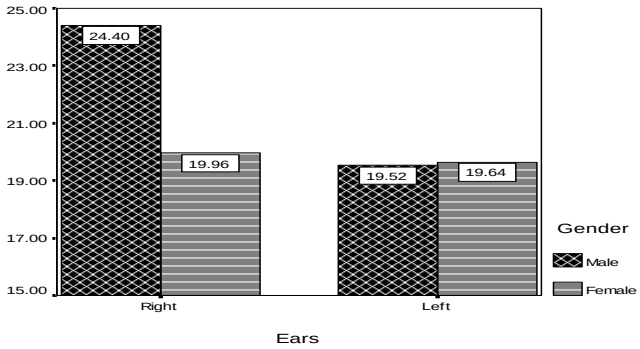

Figure 1: Comparison of ear correct scores across gender.

From the graph it can be observed that, there is large difference between right and left ear correct score for males, but a less difference for the same in female subjects. It can also be observed that on right ear scores there is greater difference obtained for males and females, but for the left ear scores were similar. To explore the statistical difference on right and left ear correct scores within gender, paired samples t-test was performed. Results of paired t-test are shown in the table 3.

Table 1: Descriptive statistics for each ear correct scores & Right ear advantage

Gender	**Ear**	**Mean**	**SD**	**t-value**	**Significance level (2-tailed)**
Male	Right	24.4	6.18	3.07	0.005 (P* < 0.01)
	Left	19.52	5.61		
Female	Right	19.96	3.66	0.33	0.745 (P > 0.05)
	Left	19.64	4.34		

The maximum correct score that could be obtained for each ear is 36.

The above table indicates there exists a significant difference (P* < 0.01) between ears for males and no significance difference (P > 0.05) between ears for females. From these results, one can understand that the right ear advantage is more in male subjects than female subjects. Overall scores from right ear are higher than from left ear. This indicates that the stimulus processed through right ear has been superior to left ear. This is called as Right Ear Advantage (REA).

II. Comparison of ear correct score across genders:

Using independent samples t-test, each ear correct scores were analyzed for differences among gender. Results from independent samples t-test is shown in the following table 2.

Table 2: Comparison of ear correct score across genders.

Ear	Gender	Mean	SD	t-value	Significance level (2-tailed)
Right	Male	24.4	6.18	3.09	0.003 (P* < 0.01)
	Female	19.96	3.66		
Left	Male	19.52	5.61	0.85	0.933 (P > 0.05)
	Female	19.64	4.34		

The maximum correct score that could be obtained for each ear is 36.

From the table, it can be understood that, right ear scores are significantly different (P* < 0.01) among males and females(higher scores for males). There is no significant difference (P > 0.05) on left ear correct scores among males and females. This reveals that the stimulus processed through left ear is same in both male and females subjects, but the stimulus processed through right ear is superior in male subjects than in female subjects.

III. Double correct scores across gender:

When the subject repeats both stimuli presented to both ears, one double correct score was given. These double correct scores obtained in both males and females are depicted graphically as given in the figure below:

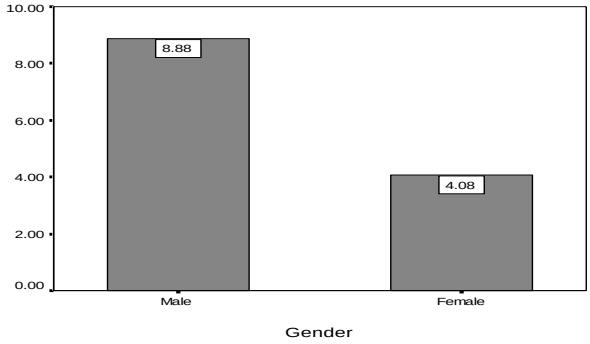

Figure 2: Gender differences on double correct scores.

From the graph, one can notice a difference in double correct scores obtained from males and females. But the amount of double correct scores is always less than either ear (Right or Left) correct score, and also constitutes a very less portion to identification score. This reflects the difficulty involved in processing two temporally equated rhyming words simultaneously.

This difficulty could be due to the precise alignment of the two members of a pair. Subjects generally report only one, although presented with two words, with slightly more than 50% of all words recognized being those presented to right ear (Wexler & Halwes, 1983; Musiek et al, 1989). The difference between males and females evaluated using independent samples t-test. The results are displayed in the following table:

Table 3: Comparison of double correct scores across genders.

Score	**Gender**	**Mean**	**SD**	**t-value**	**Significance level (2-tailed)**
Double correct score	Male	8.88	7.92	2.38	0.021 (P < 0.05)
	Female	4.08	6.25		

Maximum double correct that could be obtained is 36

From the table, one can understand that, there is significant difference (P < 0.05) between males and females on double correct scores. But the variability in double correct score was high in both genders.

IV. Reliability measures:

The reliability measures for 20% of the total subjects participated, were analyzed using SPSS 10.0. Mainly alpha value between two measurements (done at different times) was considered for reliability index. The results of reliability measure are shown in the following table 4.

Table 4: Reliability measure results

	Alpha values		
Gender	**Right ear correct**	**Left ear correct**	**Both ear correct**
Males	0.75	0.7087	-11.68
Females	0.9636	0.9681	0.99824

The above table reveals that all the scores obtained on dichotic rhyme task at two different times, are having alpha value more than 0.7, which indicates a good reliability of the test. But for the double correct scores in male subjects' revealed poor reliability. This can be due to large variability observed on double correct scores. Thus, it is wise to advice measuring ear correct scores rather than double correct scores in a clinical practice.

Discussion

These normative results obtained from the present study are consistent with the results of studies conducted on western population using dichotic rhyme test by Musiek et al., (1989). Musiek, Kurdzielschwan, Kibbe et al., (1989) reported slightly better (more than 50% correct) scores in right ear using dichotic rhyme test. Results reveal normative values of 30% - 73% for right ear and 27% - 60% for left ear in a group of 115 normal

hearing subjects. In Indian population the similar results on REA, were reported by Rajagopal (1996), Ganguly (1996), Puranik. P. (2000), Krishna (2001) and Moumitha (2003), using dichotic Consonant-Vowel test. From the current study, it can be concluded that significant right ear advantage (REA) was present in male subjects, but not so in female subjects. These gender differences can be attributed to functional lateralization of auditory stimuli processing during dichotic rhyme test.

The gender differences observed in the present study are in correlation with the findings of Wexler and Lipman (1988). They reported that the gender differences of right ear advantage using fused dichotic word test of 120 trials. Results revealed that males showed higher right ear advantage on the first 60 trials, relative to female subjects. These results suggest that males respond to the novelty of a new task with relative left hemisphere activation while females respond with relative right hemisphere activation. These results are in correlation with the findings of present study as the number of stimuli used in the present study was 36 and thus leading to better right ear advantage in males.

The similar results were also obtained by Shaywitz et al (1995), on functional magnetic resonance imaging (fMRI) using blood oxygen level- dependent (BOLD) method. The results revealed that, for phonological task (rhyme) men showed lateralized left inferior frontal gyrus, where as women showed more diffuse neural systems that involve both right and left inferior frontal gyrus regions. The similar results on gender difference was also noticed by Ikezawa et al., (2008), using other type of dichotic stimuli. Ikezawa et al (2008), reveal that gender differences were observed on dichotic CV tasks using Mismatch Negativity(MMN). MMNs generated by pure-tone and phonetic stimuli were compared, using EEG amplitude and scalp current density (SCD) measures. The results revealed that, males exhibited left-lateralized activation with phonetic MMNs, whereas females exhibited more bilateral activity.

As right-ear advantage in dichotic listening is a reflection of the left hemisphere's dominance for speech perception and related functions (Studdert-Kennedy and Shankweiler, (1970); Kimura, 1961a, 1967), it could be concluded that males have more lateralized dominance ability for speech perception. These results are in support of findings by Clements et al (2006), where functional magnetic resonance imaging (fMRI) was used to study gender differences during phonological and visuospatial tasks. Results indicate that lateralization differences exist, with males more left lateralized during the phonological task, whereas females showed greater bilateral activity.

Conclusions

In conclusion, the findings of the present study on Indian population are consistent with the findings obtained on western population. The present study also revealed the gender differences on dichotic rhyme test, which is consistent and also proved using electrophysiological measures. The results of this study also provide normative data for adults, that is for men right ear scores ranges 60% to 74% and left ear 47% to 60% and for females right ear scores ranges 51% to 59% and left ear scores 49% to 59% (values

given were 95% confidence interval for mean). Before using for clinical assessment, the test material developed as a part of present study has to be further studied. This is due to the large variation noticed in results between genders. As females did not exhibit significant right ear advantage, the present test may have limited usefulness in testing this group.

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References

Baran, J.A., Musiek, F.E. & Reeves, A.G. (1986). Central auditory function following anterior sectioning of the corpus callosum. *Ear and Hearing,* 7, 359-362.

Bellis, T.J. (2003). *Assessment and Management of central Auditory Processing Disorders in the Educational setting From science to practice. 2nd Edn,* Cliftonpark, NY, Thompsonrights, Inc.

Bode, S.D., Sininger, Y., Healy, E.W., Mathern, G.W. & Zaidel, E. (2007). Dichotic listening after cerebral hemispherectomy: Methodological and theoretical observations. *Neurophysiologica,* 45(11*),* 2461-66.

Ganguly, L. (1996). Dichoti CV test: Normative data on Chidren. *Unpublished Master's Dissertation.* University of Mysore, India.

Ikezawa, S., Nakagome, K., Mimura, M., Shinoda, J., Itoh, K., Homma, I. & Kamijima, K. (2008): Gender differences in lateralization of mismatch negativity in dichotic listening tasks. *International journal of psychophysiology,* 68 (1), 41-50.

Kimura, D. (1961a). Some effects of temporal-lobe damage on auditory perception. *Canadian Journal of Psychology,* 15, 156-165.

Kimura, D. (1967). Functional asymmetry of the brain in dichotic listening. *Cortex,* 22, 163-178.

Krishna, G. (2001). Dichotic CV test- revised: Normative data on Chidren. *Unpublished Master's Independent Project.* University of Mysore, India.

Moumitha, C. (2003). Normative data for adults on dichotic CV test- revised: CD version. *Unpublished Master's Independent Project.* University of Mysore, India.

Musiek, F.E., Kurdziel-Schwan, S., Kibbe, K.S, Gollegly, K.M., Baran, J.A. & Rintelmann, W.F. (1989): The dichotic rhyme task: Results in spilt brain patients. *Ear and Hearing,* 10, 33-39.

Perrott, D. & Barry, S. (1969). Binaural fusion. *Journal of Auditory Research,* 3, 263-69.

Puranik, P.P. (2000). Dichotic CV test- revised: Normative data on Adults. *Unpublished Master's Independent Project.* University of Mysore, India.

Rajagopal, L. (1996). A dichotic CV test: Normative data on Adults. *Unpublished Master's Dissertation.* University of Mysore, India.

Repp, B. (1976). Identification of dichotic fusions. *Journal of Acoustical Society of America,* 60, 456-469.

Repp, B. (1977a). Measuring laterality in dichotic listening. *Journal of Acoustical Society of America, 62,* 720-37.

Shankweiler, D.P. & Studdert- Kennady, M. (1970). Hemispheric specialization for speech perception. *Journal of Acoustical Society of America,* 48, 579-94.

Shaywitz, B. A., Shaywitz, S.E., Pugh, K.R., Constable, R.T., Skudlarski, P., Fulbright, R.E., Bronen, R.A., Flectcher, J.M., Shanweiler, D.P. & Katz, L. (1995). Sex differences in functional organization of the brain for language. *Nature,* 373 (6515), 607-609.

Wexler, B. & Halwes, T. (1983). Increasing the power of dichotic methods: The fused rhyme word test. *Neurophysiologica,* 21, 59-66.

Wexler, B.E. & Lipman, A.T. (1988). Sex differences in change over time in perceptual asymmetry. *Neurophysiologica,* 26 (6), 943-946.