Dychotic Rhyme Test in Kannada: 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 CAPD. Research focusing on Dichotic Rhyme test has been relatively scanty. The present study aimed to develop one such test and to collect normative data on kannada speaking normal hearing individuals. Stimulus was developed using 18 pair of cvcv rhyming words that differ only in initial consonants. These stimuli were made similar in total duration and imposed on to stereo tracks and aligned in such a way that there was no onset delay between the two. Normative data was established on young normal hearing kannada speaking adults. Analysis of results revealed that there existed a significant right ear advantage for the dichotic stimuli. Females had greater mean ear correct scores as compared to males for both right and left ears. Females had greater men double correct scores as compared to males. The double correct scores were found to be lower when compared to the ear correct scores.

Introduction

The concept of dichotic listening was first introduced by Broadbent in 1954. Dichotic listening occurs when different auditory stimuli are presented to each ear simultaneously. It has been used historically to assess hemispheric dominance as well as hemispheric asymmetries (Kimura, 1961a, 1961b, 1967; Zattore 1989), with diminished scores on these types of listening tasks suggesting auditory and/or cognitive dysfunction or pathology (Kimura, 1961a, 1961b).

Dichotic listening tasks have been used in the evaluation of both normal and disordered auditory processes at the cortical level (Kimura, 1961; Berlin et al. 1972). The term 'dichotic' refers to the simultaneous competing presentation of two different speech signals to opposite ears. Subjects are asked to repeat back what is heard in one or both ears. Generally when speech is presented dichotically to normal listeners, higher scores are obtained from the material to the right ear, than the left. This has been referred to as right ear advantage and is believed to reflect the dominance of left hemisphere for speech and language perception (Studdert-Kennedy, Shankweiler, 1970).

The early work by Kimura has been the foundation for the widely accepted theory that in man, the contralateral (or crossed) auditory pathway has more neural connections than the ipsilateral pathway and is considered the dominant pathway. On dichotic listening task individuals will generally show an ear advantage in the ear contralateral to the hemisphere dominant for language. For most individuals this will result in an right ear advantage (REA), which is believed to be the result of left hemisphere dominance for language and the auditory perception of speech stimuli (Kimura, 1967). Objective evidence for this hypothesis has come from studies of dichotic listening in subjects with surgical sectioning of the corpus callosum. Milner et al. (1968) and Sparks and

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Geschwind (1968) demonstrated complete left-ear suppression of dichotically presented stimuli following surgical sectioning of the corpus callosum.

In a series of experiments, Musiek reveals that sectioning of the posterior portion of corpus callosum, but not the anterior portion results in a suppression of left-ear scores, where as right ear performance remains at preoperative levels (Musiek, Kibbe and Baran, 1984; Musiek, et al., 1985; Musiek and Reeves, 1990; Baran, Musiek and Reeves, 1990).

Dichotic speech tasks differ from each other in terms of the stimuli utilized as well as the task required for the listener. Stimuli used in dichotic tests range from digits and nonsense syllables to complete sentences. Depending on the test itself, listeners may require to repeat everything that is heard (binaural integration) or to direct their attention to one ear and repeat what is heard in that ear only (binaural separation). Dichotic stimuli may be viewed on a continuum from least to most difficult. In general most similar and closely aligned the stimuli presented to the ears are the more difficult dichotic task will be (Bellis, 2002).

One such test using most commonly spoken words is Dichotic Rhyme Task (DRT). The dichotic rhyme task (DRT) was first introduced by Wexler and Halwes (1983) and then later modified by Musiek, et al. (1989). The DRT uses temporally aligned consonant-vowel-consonant pairs that vary only in their initial consonants. Although subjects are presented two words (one word to each ear), the precise alignment of the words, as well as the fact that the final vowel-consonant elements in each pair of words are identical, result in the subjects perceiving only one word the vast majority of the time. As a result of these test features, normal right-handed subjects tend to demonstrate test scores that are slightly greater than 50% in the right ear and slightly less than 50% in the left ear (Musiek, et al., 1989). This unique pattern of performance is 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 DRT has come from series of experiments carried out 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 & Berry, 1969), which is essentially its fundamental frequency (Repp, 1976, 1977a). Therefore if two words are 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 this fusion this test is 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 (2006) 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.

On dichotic tasks, speech signals are preferred to non-speech signals as they can be manipulated in more complex ways than tones or other non-speech stimuli (Berlin 1973). Speech signals that are linguistically similar and spectrally time aligned short and of similar duration are preferred to other types of speech stimuli in CANS evaluation due to their greater lesion detection capacity (Speaks, 1974).

The present study was taken to generate normative data regarding the performance of young Indian adults on a dichotic rhyme test in Kannada.

Method

The present study was carried out with an aim of developing the dichotic rhyme test and also to generate the normative data. The test was developed in Kannada language.

The study was carried out in two phases.

Phase I - Development of test material

Phase II - Establishing the normative data for the developed test material.

Phase I: Procedure for developing test material

Construction of test material

18 pairs (36 members) of Kannada rhyming words consisting of /p,th,k,b,dh,g/ in the initial position and which has a syllable structure of CVCV was taken from a standard Kannada dictionary. Members of each pair differed from each other only in the initial consonant and the members of the pair differed only on one phonetic feature (either voicing or place of articulation).

Familiarity test

These 36 words were given to 10 adult native speakers of Kannada (5 males and 5 females) to rate on a 5 point scale, with following rates:

0 – Very unfamiliar (Not heard)
1- Unfamiliar (Heard but not commonly used)
2- Quite familiar (Less commonly used)
3- Familiar (Commonly used)
4- Very familiar (Most commonly used)

The rating score of two or more was set as the criteria for inclusion in the test material. All of the words had a rating of greater than or equal to 2. So, all the 36 words were considered as familiar and were taken for the construction of test material.

Recording of test stimulus

An adult native speaker of the language was asked to produce each of these 36 words 3 times in a continuous manner and the words were recorded using "PRAAT" software with a sampling frequency of 22050 Hz and digitization of 16 bits. For the test material, the middle word of the 3 continuous words was considered to get a flat frequency spectrum. These words were analyzed using Adobe Audition 1.0 computer software.

Construction of Stimulus

The final portions of the members of each pair were made identical using cross-splicing. (i.e, the initial, distinctive portion of the one member of each pair was cross spliced onto the final, non-distinctive portion of the other member, making the final portion of the members of each pair identical).

E.g., in /pennu/ - /bennu/, the portion of /ennu/ in either /pennu/ or /bennu/ was selected and positioned in both the words, thus the portion /ennu/ was same in both the words.

After cross splicing, the total duration of rhyming words were made equal by reducing the voicing bars or by reducing the steady state portion of the vowel, of the initial CV portion of the word. Cross splicing was done to reduce the intrinsic variability among the final syllables in a rhyming pair.

Using Adobe Audition 1.0 Software, the two members of each Rhyming pair were recorded on stereo tracks with 0 millisecond delay between each member of the pair. The word pairs were 10 seconds apart on stereo tracks.

Stimuli were placed on a stereo track such that one member of the pair was routed to one ear and the other member of the pair was routed to the other ear. These 18 rhyming pairs (randomly) along with initial calibration tones were recorded onto the Compact Disk. These 18 rhyming pairs were randomly chosen again and words in each pair were counterbalanced (i.e, in the first 18 pairs if "Pennu" was presented to the right ear and "bennu" was presented to the left ear, then in the second 18 pairs the channel designations were reversed).

Thus, the list consisted of a total of 36 pairs of rhyming words.

Phase II: Establishing Normative data

Subjects:

- 50 young normal hearing adults (25 males and 25 females) with Kannada as mother tongue were taken as subjects.
- The age ranges of the subjects were 18 to 30 years.

Subject selection criteria

The subjects selected for the study had

- No history of Hearing loss
- No Chronic otological problems
- No neurological problems or Trauma to the brain
- No previous experience with dichotic listening tasks
- Right-handedness
- Pure-tone thresholds less than 15dB in both ears for both air conduction and bone conduction measurements
- Speech identification scores of 80% or greater

Instrumentation

- A calibrated two channel (ANSI S3.6-1996) diagnostic audiometer Madsen Orbiter 922 with TDH-39 headphones housed in MX-41 AR ear cushions and B71 bone vibrator was used to check the hearing threshold in all the participants.
- GSI Tympstar tympanometer was used to evaluate the status of the middle ear in all the participants.
- A CD player was used to play the compact disc. The signal from the CD player was fed to the tape input of the audiometer.

Test Environment

The testing was carried out in a well lit air conditioned sound treated double room and ambient noise levels were within 35 dB SPL (ANSI 1999).

Test procedure

1. Puretone 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.
2. Immittance audiometry was carried out with a probe tone frequency of 226 Hz. Ipsilateral and contralateral acoustic reflexes thresholds were measured for 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz.
3. Subjects who passed the subject selection criteria were administered the dichotic rhyme test. The VU meter was adjusted to the 1 kHz calibration tone. The 36 pairs of dichotic stimuli were presented at an intensity level of 60 dB HL. Subjects were instructed to respond on an open set answer sheet (APPENDIX-B). The task involved writing down the rhyming words heard after each presentation. All subjects were encouraged to guess when unsure of the word or words.

Scoring

The subject responses were scored in terms of

Single correct scores: Total number of correct responses for the right ear or the total number of correct responses for the left ear.

Double correct scores: Scores obtained when subject correctly responded both the stimuli presented to the two ears.

Ear correct scores: To get total ear correct scores, the double correct score was added to single correct score of respective ear and were used for analysis.

Statistical analysis

The raw data was subjected to statistical analysis where the mean, the range and standard deviation were calculated. 'Repeated measure of ANOVA for ears with independent factor as gender' was used to evaluate the main effect and the interaction between gender and ear. Independent and paired t-test was also used to reveal the significant difference between genders on ear correct scores and between ear correct scores with-in gender. Further details on results are discussed under results and discussion chapter.

Results and Discussion

The aim of present study was to develop Dichotic Rhyme Task in Kannada and to have normative data for the developed test. To have normative values, data collected on 25 male subjects and 25 female subjects in the age of 18 to 30 years was used. The data was subjected to statistical analysis using the software program SPSS version 10.0.

The following statistical analyses were done:

- Repeated measures of ANOVA to see the main effect and the interaction between gender and ear
- Paired sample 't' test was done to see the significant difference between right and left ears. And also to see the significant difference between single correct and double correct scores.
- Independent 't" test was done to see the significant difference between genders on ear correct scores and double correct scores.

The results were analyzed by calculating the mean, standard deviation and the range. Analysis was done to obtain information on:

(i) Ear correct scores: Total number of correct responses for the right ear or the left ear plus the double correct scores.

(ii) Double correct scores: Scores obtained when subject correctly responded both the stimuli presented to the two ears.

I. Comparison of ear correct scores with-in gender

The mean and the standard deviations for male and females were calculated separately. As it can be seen form the table, the mean scores for the right ear were better than the left ear scores for both males and females. Repeated measures of ANOVA revealed a significant main effect for the ears [F (1, 48) =34.560 (p<0.001)] but it did not show the interaction effect for the ear and gender [F (1, 48) = 1.840 (p>0.05)].

Table 1: The mean values, standard deviation, the range and the t-scores along with the level of significance for the ear correct scores

	Gender	**Mean**	**SD**	**t**	**Sig. (2-tailed)**
Females	Right	24.24	4.75	3.76	.001
	Left	21.64	3.45		
Male	Right	22.32	4.16	4.52	.001
	Left	18.16	4.35		

Maximum score = 36

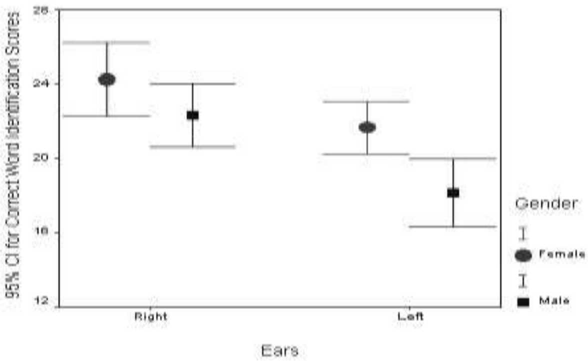

Figure 2: Error bars showing the mean values and the standard deviation for the ear correct scores for the right and left ears.

As it can be seen from figure 1, the scores for right ear were better than the left ear for both males and females, which was statistically significant. As depicted in table 1, the mean scores for the right ear was 23.28 and the mean scores for the left ear was 19.90. Paired sample ‘t’ test results revealed a significant difference (p<0.01) between the left and the right ear scores for both males and females.

The results obtained from the present study are consistent with results from studies conducted on the western population by Musiek et al. (1989), Wexler and Halwes (1983) and Berlin et al. (1973). Musiek, et al. (1989) reported normative values of 30% - 73% for right ear and 27% - 60% for left ear in a group of 115 normal hearing subjects.

Berlin et al. (1973) reported a right ear advantage (REA) for dichotic speech stimuli. This REA is seen in normals because the left anterior temporal lobe is closer to the left primary speech areas than the right anterior temporal lobe. Therefore, it is postulated that there is less ‘transmission loss’ to the left posterior- temporal- parietal lobe on the basis of proximities within areas of the brain. Due to this proximity there is more efficient interaction between the shorter pathways (Berlin et al. (1973). Similar findings have been reported in studies conducted by Studdert-Kennedy and Shankweiler (1967). They reported of right ear superiority in the perception of speech stimuli when normal hearing listeners are stimulated dichotically with speech stimuli.

Kimura (1967) attributed this difference in ear accuracy as a function of stimulus type to bilateral asymmetry in brain function (BAF).

The BAF hypothesis suggest that

(i) The contralateral auditory neural pathways are dominant over the ipsilateral pathways during the dichotic stimulation.

(ii) Performance superiority of a particular ear is a result of that ear being contralateral to the hemisphere involved in the perception of a given type of sound.

In particular, the hypothesis implies that the left cerebral hemisphere is dominant in perception of sounds conveying language information while the right hemisphere is dominant for perception of non-speech sounds such as melodies (Kimura, 1967).

Thus, the results of the present study indicated that there existed a significant REA for the dichotic rhyme stimuli.

II. Comparison of ear correct scores and double correct scores across gender

II. A) Comparison of ear correct scores across gender

As it can be seen from table 2, the mean ear correct scores for females were better than males for both left and right ears. For the right ear, the mean score for females were 24.24 and the mean score of males were 22.32. For the left ear, the mean score for females were 21.64 and the mean scores for the males were 18.16.

Independent t-test was carried out for comparison of gender within each ear. Table-II highlights the difference in ear correct scores between males and females for both right and left ears. Independent sample 't' test revealed a significant difference for the left ear ($p < 0.05$) whereas, difference in mean scores for the right ear was not statistically significant ($p > 0.05$).

Table 2**:** The Mean values, standard deviation and 't' test results for the comparison across genders for the ear correct scores

	Gender	**Mean**	**SD**	**t**	**Sig.(2-tailed)**
Right	Female	24.24	4.75	1.519	.135
	Male	22.32	4.16		
Left	Female	21.64	3.45	3.13	.003
	Male	18.16	4.35		

Maximum score = 36

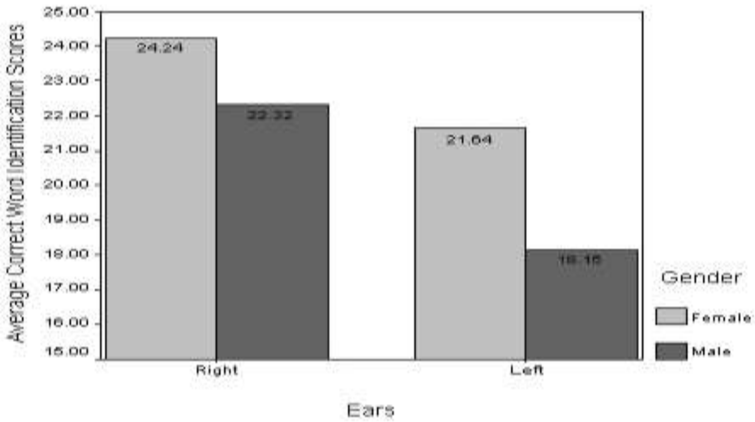

Figure 2: The mean values of ear correct scores for males and females.

As it can be seen from figure 2, females had higher scores compared to males for both right and left ears.

II. B) Comparison of double correct scores across gender

As it can be seen form table 3, the mean double correct scores were better for females as compared to males. The mean double correct scores were, 11.52 for females and 7.16 for males, respectively. This difference in double correct scores across gender was statistically significant ($p < 0.05$).

Table 3: The mean values, standard deviation, the range and results of independent 't' scores for the double correct scores

Gender	Mean	95% Confidence Interval for Mean		SD	t	Sig. (2-tailed)
		Lower Bound	Upper Bound			
Females	11.52	5.87	16.16	9.41	2.54	.014
Males	7.16	4.80	12.51	7.70		

Maximum score = 36

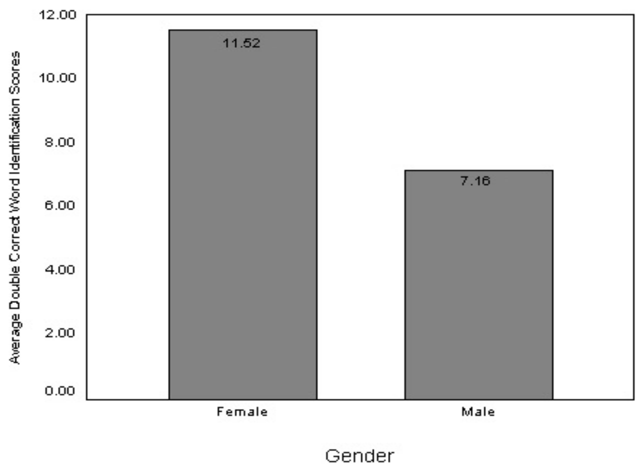

Figure 3: The mean values of double correct scores for both males and females.

Elliot and Welsh (2001) concluded that gender differences found utilizing dichotic procedure may be due to differences in strategic approach to the task rather than to differences in cerebral laterality. Although the dichotic listening procedure has been used as a non-invasive neuropsychological technique for assessing laterality of speech perception, it has tended to underestimate the proportion of the right-handed population that is left-hemisphere lateralized for speech perception (Segalowitz & Bryden, 1983) and individual differences in hemispheric representation of language. These underestimations may be due to dichotic procedures being susceptible to attentional biases, order of report effects, and/or memory effects that obscure functional differences between the cerebral hemispheres.

Kalil, et al. (1994) did an exhaustive survey of auditory laterality studies from six neuropsychology journals to see if there is a sex difference in human laterality. The entire contents of six neuropsychology journals (98 volumes, 368 issues) were screened to identify auditory laterality experiments. The overall patterns of results were compatible with a weak population-level sex difference in hemispheric specialization.

Kahn, et al. (2008) studied sex differences in handedness, asymmetry of the Planum Temporale and functional language lateralization. This study was aimed to provide a complete overview of sex differences in several reflections of language lateralization: handedness, asymmetry of the Planum Temporale (PT) and functional lateralization of language, measured by asymmetric performance on dichotic listening tests (Right Ear Advantage) and asymmetry of language activation as measured with functional imaging techniques. Based on the results they concluded that there is no sex difference in asymmetries of the Planum Temporale, dichotic listening or functional imaging findings during language tasks. The observed sex effect may therefore be caused by publication bias.

Thus, gender difference seen for the left ear in the present study, can be the result of procedural variability or underestimation of this dichotic test to individual differences in hemispheric representation of language. It is difficult to attribute this difference in scores on dichotic task between males and females to sex difference in hemispheric lateralization.

III. Comparison of ear correct scores with double correct scores

As it can be seen from Table 4, the double correct scores were lower when compared to the ear correct scores. The mean values were, 21.59 for the ear correct scores and 9.34 for the double correct scores, respectively. Standard deviation and ranges were higher for the double correct scores as compared to single correct scores.

Table 4: The Mean values, standard deviation and the ranges for the comparison between ear correct scores and double correct scores

			95% Confidence Interval for Mean			
	Mean	**SD**	**Lower Bound**	**Upper Bound**	**t**	**Sig. (2 tailed)**
Ear correct scores	21.59	4.39	19.85	23.3	3.37	.003
Double correct scores	9.34	8.55	5.33	14.33		

The double correct scores were found to be lower when compared to the ear correct scores. Paired sample ‘t’ test was done to see the difference between single correct scores and double correct scores. The difference in scores between ear correct scores and double correct scores were statistically significant ($p< 0.05$). This is in agreement with the previous reports by Wexler and Halwes (1983) and Musiek et al. (1989) that on a dichotic rhyme task although subjects are presented two words (one word to each ear), the precise alignment of the words, as well as the fact that the final vowel-consonant elements in each pair of words are identical, result in the subjects perceiving only one word the vast majority of the time.

The range was also calculated which showed the double correct scores to be highly variable across subjects. It is suggested that the ear correct scores be used to calculate the norms than the double correct scores because of its larger variability among subjects. This finding is in accordance with the finding by Dermody, et al. (1983) where they found that the double correct scores do not provide information about differential ear effects, when compared to the ear correct scores.

Summary and Conclusions

The purpose of the present study was to generate normative data for the dichotic rhyme test on adults with Kannada as their mother tongue. The 36 pairs of dichotic stimuli were presented at an intensity level of 60 dB HL. Subjects were instructed to respond on an open set answer sheet (APPENDIX-B). The task involved writing down the rhyming words heard after each presentation.

The subjects taken for the study were fifty young normal hearing adults with Kannada as their mother tongue in the age range of 18 to 30 years. None of the subjects had any history of neurological involvement and were initially tested to ensure normal auditory functioning prior to administering the dichotic rhyme test. The responses were scored in terms of ear correct and double correct responses. The raw data was subjected to statistical analysis. The mean, standard deviation and range were also calculated. The results obtained from the present study were consistent with results from studies conducted on the western population by Musiek et al. (1989), Wexler and Halwes (1983) and Berlin et al. (1973).

The results from the present study are as follows:

1) There existed a significant right ear advantage for the dichotic stimuli.
2) Females had greater mean ear correct scores as compared to males for both right and left ears.
3) Females had greater men double correct scores as compared to males.
4) The double correct scores were found to be lower when compared to the ear correct scores.
5) Since the variability is lesser for the ear correct scores as compared to double correct scores, it is recommended that ear correct scores be utilized while scoring the responses on the dichotic rhyme test.

In conclusion, the findings of the present study in Indian language context are consistent with the findings obtained on the western population.

Future Implications

Dichotic listening tasks can be used in the identification of cortical lesions. Hence, the dichotic rhyme test developed can be incorporated as part of the CANS evaluation battery, to evaluate central auditory processing in adults with Kannada as their mother tongue.

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