DICHOTIC RHYME TEST IN TELUGU: A NORMATIVE DATA ON ADULTS

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A Dissertation Submitted in Part Fulfillment of
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ALL INDIA INSTITUTE OF SPEECH AND HEARING
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This work of mine is dedicated to
My loving family members
Without whose support all these
Wouldn't be possible…

CERTIFICATE

This is to certify that this dissertation entitled ***"Dichotic Rhyme Test in Telugu:*** *A Normative* ***data*** *on Adults"* is the bonafide work submitted in part fulfillment for the degree of Master of Science (Audiology) of the student (Registration No.06AUD007). This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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<u>CERTIFICATE</u>

This is to certify that the dissertation entitled ***"Dichotic Rhyme Test in Telugu: A Normative data on Adults"*** has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in any other University for the award of any Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled ***"Dichotic Rhyme Test in Telugu: A Normative data on Adults"*** is the result of my own study under the guidance of Dr. K. Rajalakshmi, Reader in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted in any other university for the award of any diploma or degree.

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CHAPTER 1

INTRODUCTION

Spoken language is one of the most common forms of communication that enables humans to convey information with specificity and detail. For most of us perceiving speech is an effortless and overlooked task. When engaged in conversation one is primarily aware of tracking meaning; the sound pattern of what is heard is “linguistically transparent” (Polanyi., 1964), that is, it goes largely unnoticed. The nature of this perceiving meaning is crucial half of language’s dual structure, and hence speech perception is primary means of picking up linguistic information.

However, for some individuals communication breaks down because of hearing loss, (or) difficulties with articulation, voice, language (or) fluency. Perhaps, hearing loss is the most common disorder that affects communication. This is because hearing different kinds of environmental sounds is an important pre-requisite for normal cognitive-social development and acquisition and growth of aural-oral language.

But some individuals have serious difficulties understanding what other people say, even though they may demonstrate normal-hearing sensitivity on audiometric examination. This kind of disorder is considered as “Central Auditory Problem”. This is because the individual’s difficulty in processing and understanding auditory information is not caused by peripheral hearing loss.

(Central) Auditory Processing Disorder [(C)APD] refers to difficulties in the processing of auditory information in the central nervous system, as demonstrated by poor performance in one or more of the following 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, 2005b). This definition has been criticized for basing the diagnosis on test measurements rather than more general constructs (McFarland & Cacace., 2006). Moreover, there is no glossary of terms to define these skills, which could cause confusion. (As cited by Jutras, B. et al., 2007)

Comprehensive evaluation of persons with suspected (C)APDs is not a small task. Given the wealth of auditory functions ascribed to the brain, it should come as no surprise that a wealth of assessment is needed to assay those functions. As (C)APD represents a heterogeneous group of auditory deficits, it is important that a test battery approach be used so that different underlying processes, as well as different levels of functioning within the Central Auditory Nervous System (CANS) can be assessed. There are numerous tests of central auditory processing that have been developed over the past five decades (50 years). However, not all of these tests are equal in their ability to identify auditory processing disorders. The following table summarizes all the diagnostic tests including electrophysiological tests for diagnosing (C)APD and also provide information of probable test results expected in different pathological conditions.

Table 1: Patterns of Central Test Results that may be observed in Patients with Lesions at Various Sites along the CANS

Test category	Low Brainstem	High Brainstem	Auditory cortex	Interhemispheric Pathways
Binaural Interaction	Binaural deficit[a] (2)	Little or no deficit (3)	Little or no deficit (3)	Little or no deficit (3)
Phase Tests (e.g., MLD)	Binaural deficit[a] (2)	Little or no deficit (3)	Little or no deficit (3)	Little or no deficit (3)
Dichotic Speech	Ipsilateral ear deficit (2)	Contralateral ear deficit (2) Bilateral deficits (2) Ipsilateral ear deficit (2)	Contralateral ear deficit (3) Bilateral deficits (1)	Contralateral ear deficit (3)
Monaural Low-Redudancy Speech	Ipsilateral ear deficit (2)	Contralateral ear deficit (2) Bilateral deficits (2) Ipsilateral ear deficit (1)	Contralateral ear deficit (3)	No deficit (3)
Temporal Patterning	Ipsilateral ear deficit (1)	Contralateral ear deficit (1) Bilateral deficits (1) Ipsilateral ear deficit (1)	Bilateral deficits[b] (3)	Bilateral deficits[b] (3)
Auditory Brainstem Response[c]	Ipsilateral abnormality (3) Bilateral abnormalities (1) Contralateral abnormality (1)	Bilateral abnormalities (2) Ipsilateral abnormality (2) Contralateral abnormality (1)	No deficit (3)	No deficit (3)
Middle Latency Response[c]	Ipsilateral ear effect (1)	Contralateral ear effect (2) Bilateral ear effects (1) Ipsilateral ear effect (1)	Abnormality at electrode nearest pathology (2) Contralateral ear effect (2)	Little or no deficit (3)
Late response (N1 and P2)[c]	Ipsilateral ear effect (1)	Contralateral ear effect (1) Bilateral ear effects (1) Ipsilateral ear effect (1)	Abnormality at electrode nearest lesion (2) Contralateral ear effect (2)	Little or no deficit (3)
Auditory Cognitive (P3)[c]	Same as late response	Same as late response	Non localizing abnormality (2)	Little or no deficit (3)

Source: Central auditory processing disorders in children and adults (Baran & Musiek, 1995). Cited in Chermak & Musiek (2007): Handbook on (c)APD; vol 1.

Key: (3) high probability of occurrence, (2) moderate probability of occurrence, (1) low probability of occurrence.

[a] Binaural is used in this context as both ears are receiving segments of the stimulus and only one score is derived.
[b] Specified deficits would be predicted if the patient was asked to verbally describe the patterns perceived.
[c] Abnormal results may be noted for one or more of the indices derived during the electrophysiological procedure.

*The use of the singular form in this context indicates that any abnormalities that exit are limited to one ear.

Dichotic listening tasks utilizing sentences, words, digits and syllables have been useful in predicting cerebral dominance for speech. These tests have also been used to study the relationship between cerebral dominance and learning disabilities (Ayers., 1980; Obrzut., 1980), cognitive development (Obrzut & Hynd., 1981), auditory linguistic deficits (Wiltelson & Rabinovitch., 1972), auditory processing disorders (Tobey & Rampp., 1976) and language disorders (Springer & Eisenson., 1977; Pettit and Helms., 1979).

Dichotic speech tests involve those tests in which different speech materials are presented to the two ears in a simultaneous or overlapping manner. Dichotic speech tests are particularly sensitive to lesions of the auditory cortex and the interhemispheric fibers and to a lesser degree to auditory brainstem lesions (Baran & Musiek., 1999).

Most typically contralateral ear effects are noted with lesions of the auditory cortex, although binaural deficits can be noted if there is significant compromise of the left side of brain. With lesions involving corpus callosum and/or the interhemispheric pathways, left ear deficits are commonly noted. In cases of brainstem pathology, ipsilateral deficits are commonly observed in patients with extra-axial lesions (i.e., lesions originating from the periphery of the brainstem), where as bilateral, contralateral, or ipsilateral ear deficits may be observed with intra-axial lesions (i.e., lesions originating from within the brainstem) (Baran & Musiek., 1999).

Some of the most commonly used dichotic test and their sensitivity towards a particular auditory process are depicted in table 2.

Table 2: Summary of Dichotic Speech tests

Test	**Process assessed**	**Sensitive to**
Dichotic Digits	Binaural Integration	Brainstem, cortical and corpus callosal lesions
Dichotic consonant vowels	Binaural Integration	Cortical lesions
Staggered spondaic word test	Binaural Integration	Brainstem and cortical lesions
Competing sentence test	Binaural separation	Neuromaturation and language processing
Synthetic Sentence Identification test with Contralateral Competing Message	Binaural separation	Cortical versus brainstem lesions
Dichotic sentence identification test	Binaural Integration	Brainstem and cortical lesions
Dichotic rhyme test	Binaural Integration	Interhemispheric transfer

Source: James Bellis (2003): Assessment and Management of Central Auditory Processing Disorders in the Educational settings: 2nd Edn.

To get further details on dichotic rhyme test (DRT), it was introduced by Wexler and Halwes (1983) and modified by Frank E. Musiek (1989). This test is well aligned and composed of simple common words. The patient, although presented with two words, generally reports only one, with slightly more than 50% of all words recognized being those presented to right ear (Wexler & Halwes., 1983; 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.

Zattore (1989) investigated speech lateralization using the carotid sodium amytal test supports the validity claims of DRT made by Wexler and Halwes (1983, 1985). The DRT was also used in studying dichotic listening performance in split-brain patients (Musiek et al., 1989). The results of these studies demonstrated that, in addition to clinically feasible for use with patients with compromise of the central auditory nervous system, this test was highly sensitive in assessing the integrity of inter-hemispheric transfer of auditory information.

Need for the study:

It is ideal to have speech tests in all languages as the individual perception of speech is influenced by his/her first language or mother tongue (Singh 1966, Singh and Black., 1966). As DRT is not been developed in any of the Indian languages, there is a need to develop DRT in regional languages, and the developed DRT could be used to assess the binaural integration phenomenon and could be used as an assessment tool for Central Auditory Processing Disorder (CAPD).

Aim of the study:

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.

CHAPTER 2

REVIEW OF LITERATURE

The term dichotic refers to auditory stimuli that are presented to both ears simultaneously, with the stimulus presented to each ear being different. Broadbent (1954) was the first to utilize a technique of presenting competing sets of digits to both ears simultaneously. Kimura (1961a, b) is generally credited with the introduction of dichotic speech tests into the field of central auditory assessment by adapting Broadbent's technique for assessing hemispheric asymmetry and unilateral lesions.

Kimura (1961) theorized that the contralateral pathways are stronger and more numerous than are in ipsilateral pathways. When monotic or non-competing stimuli are introduced, either pathway is capable of transmitting the appropriate neural signal. However, when dichotic (competing) auditory stimuli are presented, the ipsilateral pathways are suppressed by the stronger contralateral pathways. Objective evidence for this hypothesis has come from studies of dichotic listening in subjects with surgical sectioning of the corpus callosam. Milner et al., 1968 and Sparks and 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 callosam, but not the anterior portion results in a suppression of left-ear scores, whereas right ear performance remains at preoperative levels (Musiek, Kibbe & Baran, 1984; Musiek et al., 1985; Musiek & Reeves., 1990; Baran, Musiek & Reeves., 1986).

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 syllable 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, 2003).

One such test using most commonly spoken words is Dichotic Rhyme Task (DRT). DRT introduced by Wexler and Halwes (1983) and modified by Musiek (1989) is well aligned and composed of simple common words. 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 & 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. As research on DRT has been very limited, some inferences in stimulus alignment can be taken from Dichotic Consonant-Vowel tests (CV). This is due to some similarity in the stimulus alignment involved in both these tests.

There are certain factors that can influence the performance on DRT. These factors can be majorly divided into two.

1. Stimulus related factors
2. Subject related factors

There are several different parameters of stimulus that would affect the performance of the subject. The major factors related to stimulus are

a. Stimulus dominance/ Phonetic effect
b. Intensity
c. Temporal aspect

Some of the subject related factors that have influence on DRT are,

i. Attention

ii. Gender

iii. Age

iv. Practice effect

v. Response mode

1. ***<u>Stimulus related factors:</u>***

a. Stimulus dominance/ Phonetic effect

Stimulus dominance is the phenomenon where in higher scores are got for one of the two competing syllables – the dominant one – regardless of the ear which it is presented. In DRT the initial syllabic portion (CV portion) of the two competing words are presented dichotically along with non-distinctive portion in both words. Thus there are chances of having stimulus dominance/ phonetic effect. This can be viewed in two ways.

I. Voiced Vs Voiceless syllable

II. Place of articulation

I. Voiced Vs Voiceless syllable

Speaks et al., 1981 reported that voicing feature was contrasted for 9 of the 15 pairs of natural stop – vowel syllables. Seven of those pairs resulted in significantly higher scores (dominance) for the voiceless stop than for the voiced, one resulted in a higher score for the voiced member of the pair, and for one pair the scores for the two members were essentially the same.

Berlin et al., 1973 also reported that scores were higher for voiceless stop /pa, ta, ka/ than for the voiced stops /ba, da, ga/ in pairs of natural syllable. The voiceless stops are said to be "dominant" than voiced stops. Roser, Jhons & Price (1976), Niccum, Speaks & Carney (1976) support this finding.

II. Place of articulation

Porter, Troendle and Berlin (1976) reported that velar sounds were reported correctly than alveolar sounds, which in turn more correctly identified than labial sounds. Similar findings were observed by Berlin et al (1973), who reported that velars are more correctly followed by the bilabials and the apicals (alveolar sounds) with least correctness. Speaks et al., 1985 used eight pairs in which velars competed with non-velar sounds (bilabials or alveolars). For six of these pairs velars dominated non-velar sounds.

In Indian context Rajagopal (1996) found similar results in their study, where velar sounds were best perceived followed by labial sounds and alveolar sounds.

Studies on stimulus dominance using DRT:

Di Stefano, Marano & Viti (2004) evaluated stimulus-dominance and ear asymmetry in normal population (48 subjects of both sex and handedness) and in 2 patients with a single functional hemisphere. Results show that in normals the number of stimulus-dominated responses is five times higher than in patients, and is negatively correlated to the index of laterality. It is suggested that dichotic stimuli may interfere one with another during the subcortical acoustic processing and at cortical level, when competing for verbal output. Subcortical interference accounts for stimulus-dominance in the single-hemisphere patients.

Thus the presence of high stimulus dominance in the stimuli in dichotic listening task masks the right ear advantage. Hence eliminating stimulus dominance factor is preliminary step one has to follow to construct useful dichotic listening test.

b. Intensity

Hugdhal et al., (2008) examined the effect of differences in the right or left ear stimulus intensity on the ear advantage using dichotic CV test. For this purpose, interaural intensity difference were gradually varied in steps of 3 dB from -21 dB in favour of the left ear to +21 dB in favour of the right ear, also including a no difference baseline condition. The results showed that: (a) a significant right ear advantage for interaural intensity differences from 21 to -3 dB, (b) no ear advantage for the -6 dB difference, and (c) a significant left ear advantage for differences form -9 to -21 dB.

It was concluded that the right ear advantage in dichotic listening to CV syllables withstands an interaural intensity difference of -9 dB before yielding to a significant left ear advantage. The same can be applicable to DRT.

c. *Temporal aspect*

Berlin et al., (1973) showed greater right ear advantage as the onset time discrepancy increases. It was found that intelligibility for leading ear increases as time separation increases, which is called as "lag effect". Between 15 and 30msec of onset time separation the leading ear intelligibility was dropped. But intelligibility in both lag and lead ears improved beyond 30msec of time separation.

In dichotic rhyme task there is no onset time variations, as both the competing words are aligned temporally to fuse. Thus lag effects may not significantly influence the performance of DRT.

2. *Subject related factors*

i. *Attention*

Shinn, Baran, Moncrieff and Musiek (2005) studied the performance of 20 normal hearing listeners on a dichotic consonant-vowel and a dichotic rhyme (fusion) test in three different listening conditions (free recall, attention directed to the left ear, and attention directed to the right ear). Results from this study supported that dichotic rhyme tests are resistant to alterations in the laterality of attention and have implications for the development of test paradigms that can be used to segregate attention from pure auditory deficits in the clinical domain.

Similar results were obtained by Asbjornsen and Bryden (1996). Their study examined the effect of biased attention on the fused dichotic words test (FDWT) and the CV syllables dichotic listening test (CVT) with two different instructions: to direct attention to the left ear or to the right ear. Results revealed that highly significant differences in response on the CVT, but only a marginal shift in performance on the FDWT. While the FDWT is not completely unaffected by attention manipulations, it is far less influenced by such effects than the CVT.

ii. Gender

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.

The first report on gender difference using fused dichotic word test was been reported by Wexler and Lipman (1988). They have used fused dichotic word test of 120 trials. Results reveal 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.

The electrophysiological supports for these findings have come from experiment by Shaywitz et al (1995). They have used echo-planar functional magnetic resonance imaging (fMRI) using blood oxygen level- dependent (BOLD) method, during orthographic (letter recognition), phonological (rhyme) and semantic (semantic category) tasks. The results reveal the 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. Similar results were obtained by Ikezawa et al., (2008) using dichotic consonant- vowel test and also by Clements et al., (2006) during phonological and visuospatial tasks.

But meta-analysis of functional imaging studies by Sommer et al., (2004) reveals that there is no significant difference in language lateralization between men and women. In Indian context, experiments using dichotic CV test reveals that there was no gender difference on right ear advantage (Moumitha, 2003).

iii. Age

The effect of age on dichotic listening may be different depending on the type of stimuli used. Dichotic listening on children suggest that the more linguistically loaded stimuli presented, the more pronounced the maturational effects are likely to be.

Berlin, Hughes and Lowe-Bell (1973) studied the performance of normal hearing children between ages 5 and 13 on a set of dichotic CV test. Their results showed a right-ear advantage (REA) that remained relatively constant throughout the age range. In contrast to these results in Indian context finding by Krishna (1996) reveals that even at the age of 12 the results were not matched with adult score on dichotic CV test.

Cross-sectional dichotic listening study by Pohl (1984) using thirty pairs of one-syllable words and thirty pairs of four-syllable numbers reveal the developmental course of ear asymmetry. Middle-class children with age range of 4 to 10 were taken as subjects. A significant decrease in REA for both word and number pairs was found. Although right-ear and left-ear performance both increased with age, the developmental gain in left-ear performance was greater than the gain in right-ear performance, thus resulting in a decrease in REA with age.

But contrasting results were found using dichotic sentence identification by Jerger, Chmiel, Allen and Wilson (1994). They have analyzed the clinical records of 356 individuals, 203 males and 153 females, to whom the Dichotic Sentence Identification

(DSI) test had been administered as part of routine audiometric assessment. The age range considered for study was 9 to 91 years. Results revealed that larger right-ear advantage, or left-ear deficit, was observed with increasing age. Comparison of male and female data suggested gender difference in the effect of age on the left-ear deficit. Males show a larger effect than females in both modes of test administration.

Poor left-ear performance on dichotic sentence tasks in children may reflect a decreased ability of the corpus callosum to transfer complex stimuli from the right hemisphere to the left hemisphere. As the child becomes older and myelination of the corpus callosum is completed, inter-hemespheric transfer of information improves and left-ear scores approach those found in adults (Musiek, Gollegly & Baran., 1984).

iv. Practice effect

Porter, Troendle and Berlin (1976) studied practice effects on dichotic listening task using dichotic CV material. They investigated long-term effects of practice on performance by testing once a week over a period of 8 weeks. Results revealed that a slight increase in double correct responses (28% - 38%), a slight drop in both single correct responses (65% - 58%) and decreased either correct responses (7% - 4%). However, overall dichotic performance does not become a stable measure (i.e., does not reach an asymptote) until subjects have experienced at least 300 dichotic trials. Similar results were also reported earlier by Ryan and Mc Neil (1974); Johnson and Ryan (1975).

v. Response mode

The response of the listener can be of number of ways on dichotic listening task. These include written down response, or orally repeating the heard stimuli and also visual recognition. As the process involved in these activities varies, there could be some differences exists on responses.

Lutz Jäncke (1993) evaluated the difference in results with respect to the three response conditions using dichotic CV test. Testing was administered three times to 56 male right handers and 50 male left handers. During each experimental session the subjects had to perform this dichotic test using a different response condition. On one occasion they were required to verbally report the perceived syllables (*speak* condition), on another occasion they were asked to write down the syllables they had heard (*write* condition), and lastly, they were asked to visually recognize the stimuli (*visual* condition) which were presented onto a monitor screen. Results revealed that there is no significance influence of response mode on right ear advantage.

Studies in clinical population using DRT:

Research using dichotic rhyme task in clinical population has been restricted, as large variation observed in normal hearing subjects. But using dichotic rhyme task along with electrophysiological measures, there have been several studies on language lateralization in normal hearing individuals (Shaywitz et al 1995; Clements et al., 2006; Sommer et al., 2004).

Patients with Cerebral Hemispherectomy:

Bode, S.D. et al., (2007) examined two commonly used dichotic listening tests for measuring the degree of hemispheric specialization for language in individuals who had undergone cerebral hemispherectomy: the consonant–vowel (CV) nonsense syllables and the fused words (FW) tests, using the common laterality indices f and λ. Results reveal 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.

The λ index was similar in the two tests but the index f was higher in the CV than the FW test. Both indices of the CV test were sensitive to side of resection, higher in the right hemispherectomy than in the left hemispherectomy groups.

Patients with Spilt-brain:

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.

Patients with Panocular Developmental Aniridia:

Bamiou, D-E. et al., (2007) evaluated 11 subjects with Panocular Developmental Aniridia (due to PAX6 mutations) to assess auditory processing using central auditory test and brain Magnetic Response Imaging (MRI). Central auditory testing involved 3 tests: (1) Dichotic speech tests, including digits, CV and fused rhyme words, (2) Pattern test (frequency and duration), and (3) Temporal resolution (gaps in noise).

Results revealed that on dichotic digit test all of the cases had normal results in the right ear, and 7 cases had abnormal results in the left ear. On dichotic CV test; there was no significant difference in right and left scores between the cases and the controls. On the dichotic rhyme test; there was no significant difference in the right ear scores between the cases and controls, but the left ear scores were lower among the cases. These results explain the functional role of the corpus callosum and anterior commissure in audition, as these pathways were sectioned in the patients.

From these studies one can conclude that the sensitivity of dichotic rhyme test is high in finding out lesions involving corpus callosum. Due to lack of availability in clinics, further research using dichotic rhyme test has been limited.

CHAPTER 3

METHOD

The present study was aimed for development of Dichotic Rhyme Task in Telugu and also establishing normative data for the newly developed test. This procedure 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 the rhyming pair had started with one of the six consonants (/p/, /t̪/, /k/, /b/, /d̪/ 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 nine possible combinations using the above mentioned six consonants. These combinations could be depicted pictorially as,

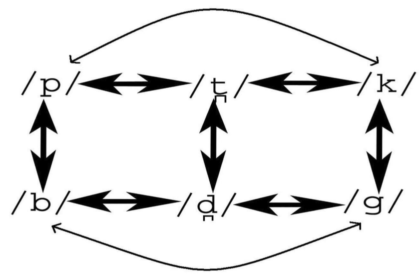

Figure 1: *Depiction of 9 possible combinations for initial consonantal differences.*

Familiarity test:

All the 40 pairs of words were given to 10 normal young adults (5 males and 5 females), whose native language is Telugu. These individuals were asked to judge the familiarity of these bi-syllabic words using 5 point rating scale.

The rating scale used was as follows;

0 – Very unfamiliar (Not heard this word)

1 – Unfamiliar (Heard this word, but not commonly used)

2 – Quite familiar (Less commonly used word)

3 – Familiar (Commonly used word)

4 – Very familiar (Most commonly used word)

Of all 40 rhyming pairs 25 pairs have got an average rating of more than two on 5 point rating scale and were considered for test material. Rest fifteen pairs were discarded as the familiarity was too low. From the twenty five pairs, eighteen pairs were selected to have at least two rhyming pairs for each possible consonantal difference.

Recording of test stimulus:

The thirty six words (i.e.,) eighteen rhyming pairs selected on familiarity test were given to an adult female (native speaker of Telugu), and was asked to say out each word three times. 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. As the fluctuations in the speech were more in the initial and final portions to get plateau, the middle sample of three times spoken was extracted using “PRAAT” and used for construction of test material. This was to avoid the raising or falling patterns that occur in initial and final positions of speech, which might change the spectral envelop of the rhyming words in a pair leading to reduced fusion of these words.

Construction of test stimulus:

Using “PRAAT” 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 /t̪ala/ (/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 with in 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.

Goodness test:

As the stimuli were manipulated using analysis by synthesis method, there is a chance of reducing the natural quality of the test stimuli. This was checked, by presenting all the 18 pairs (after both the members in a pair temporally equated), to 10 young normal adults having Telugu as their native language. The words with more than 80% acceptance by these individuals were selected as stimulus. When the acceptance level was below 80% for a member, these were not considered for test material. Instead along with distorted members, the other member in the same rhyming pair were also reconstructed from the original voice sample and given for goodness test again.

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.

Stimulus dominance:

Stimulus dominance is the tendency for one member of a pair to be consistently reported regardless of ear of presentation. Initial version of the test was evaluated for the stimulus dominance by presenting to 20 normal young adults having Telugu as their native language. Such 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

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 met the following criteria.

1. No history of hearing loss
2. No chronic otological problems
3. No neurological problems or trauma to the brain

4. No previous experience with dichotic listening tasks
5. Right-handedness (Established through verbal report and tested by comparing the writing ability of the two hands)
6. Pure-tone thresholds less than 15dB in both ears for both AC and BC measurements
7. SIS scores of 80% or greater in each ear

Some of the subjects taken for normative data were 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) 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.
b) Stimuli were played from a computer that constituted the sound drives namely, “legacy audio devices”
c) 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 rage were calculated. Ear correct scores were examined for gender differences. A 2 X 2 repeated measures 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.

*The CD containing the developed and utilized as dichotic rhyme stimuli in this study has been enclosed with this dissertation.

CHAPTER 4

RESULTS AND DISCUSSION

The aim of present study was to develop Dichotic Rhyme Test in Telugu and also to have normative data for the newly developed test. To have normative values, data collected on 25 male subjects and 25 female subjects in the age of 17 to 25 years was used. The data 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 with-in gender

II. Comparison of ear correct score across genders

III. Double correct scores across gender

IV. Reliability measures

Ear correct scores were examined for gender differences. A 2 X 2 repeated measures 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. Results indicate a significant right ear advantage $\{F (1, 48) = 7.792, (P^* < 0.01)\}$. It was also revealed that no significant effect of gender on overall dichotic rhyme test performance $\{F (1, 48) = 3.988, (P > 0.05)\}$.

Ear X Gender interactions $\{F (1, 48) = 5.992, (P^* < 0.05)\}$ were also revealed in the analysis of variance, indicating differential effects of gender on the magnitude of ear correct scores. To explore these interactions, separate planned t-tests were carried out for right- and left-ear correct scores on within and between genders.

I. Comparison of ear correct scores with-in 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:

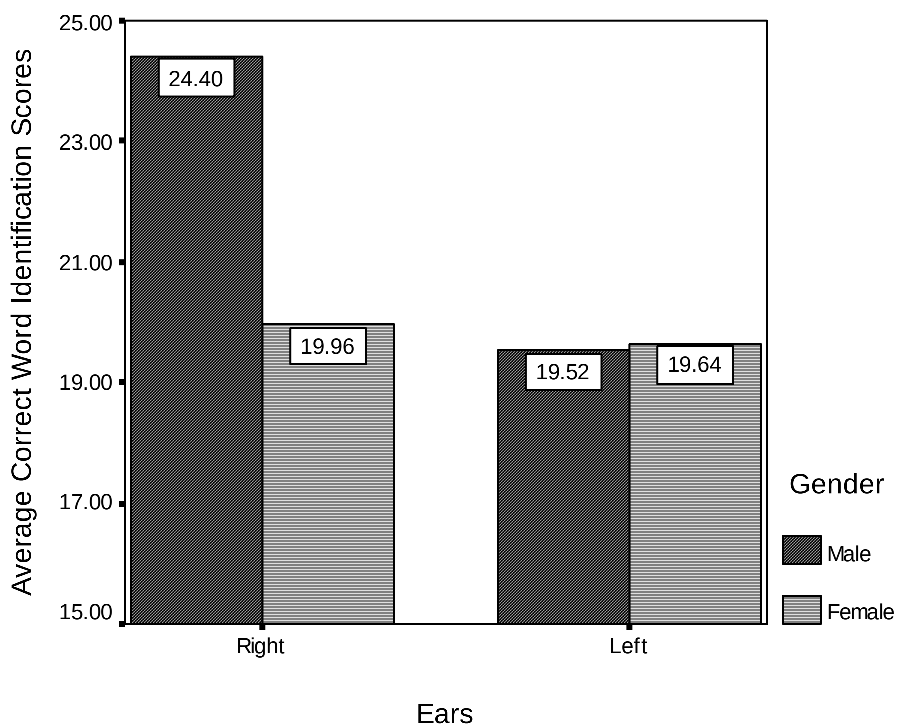

Figure 2: *Comparison of ear correct scores across gender.*

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 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 with-in a gender, paired samples t-test was performed. Results of paired t-test are shown in the table 3.

Table 3: *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. Over all scores from right ear are been higher than from left ear. This indicates the stimulus processed through right ear has been superior to left ear. This is called as Right Ear Advantage (REA). These 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 slight 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. Similar results of REA being present were also obtained by Studdert-Kennady et al., (1970), Berlin et al., (1973), Olsen (1983) and Bingea & Raffin (1986) in normal hearing subjects using various dichotic speech testing.

In Indian population the similar results on REA, were reported by Rajagopal (1996), Ganguly (1996), Prachi (2000), Krishna (2001) and Moumitha (2003), using dichotic Consonant-Vowel test.

The 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). According to Berlin et al., (1973), since the auditory system has a strong contralateral path (Rosenzweig and Rosenblith, 1953), and since most people are left-brained for language, independent of their handedness (Penfield and Roberts, 1959), one would expect that most people would show right-ear dominance in simultaneous listening tasks.

From the present study, it could 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. To evaluate further on gender differences, specific ear correct scores are evaluated for differences among genders.

II. Comparison of ear correct score across genders:

Using independent samples t-test, each ear correct scores were analyzed for differences among gender. Results form independent samples t-test is shown in the following table 4.

Table 4: *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 one can understand that, right ear scores are significantly different (P* < 0.01) among males and females, being 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 been same in both male subjects and females, but the stimulus processed through right ear is superior in male subjects than female subjects.

The gender differences observed in the present study are in correlation with the findings of Wexler and Lipman (1988). They reported the gender differences on 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 suggested 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 findings of present study as the number of stimuli used in 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), reveals that gender differences were observed on dichotic CV tasks using 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, where as 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 were 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.

Though there was a good correlation among results of these studies on gender differences, there are contradictory results obtained by different authors. In Indian contest, one good example could be experiments using dichotic CV material reveals that there is no gender difference on right ear advantage (Moumitha, 2003).

In conclusion results of the present study 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).

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,

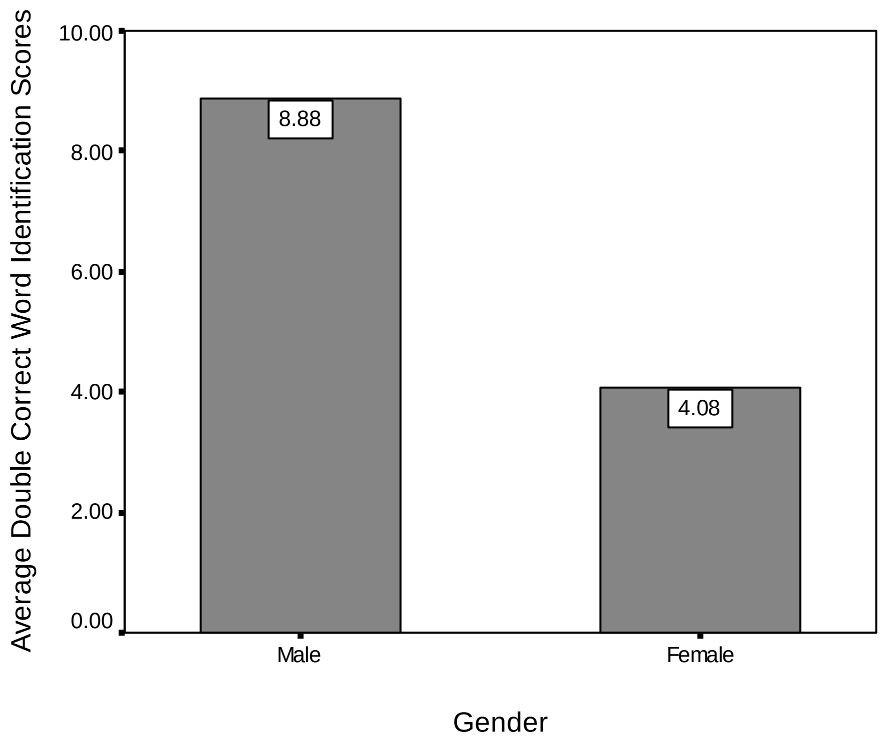

Figure 3: *Gender differences on double correct scores.*

From the graph, one can notice a difference on double correct score 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 reports 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 5: *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 score. But the variability in double correct score was high in both genders.

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 does not exhibited significant right ear advantage, the present test may have limited useful in testing this group.

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 on reliability measure are shown in the following table 6.

Table 6: *Reliability measure results*

Gender	Alpha values		
	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.

CHAPTER 5

SUMMARY AND CONCLUSION

The purpose of the present study was to develop dichotic rhyme test in Telugu and also to establish normative data for newly developed test on Telugu speaking individuals. The test involved identification of bi-syllabic words that are dichotically presented. These bi-syllabic words are commonly spoken ones, and started with six plosive consonants (/p/, /t̪/, /k/, /b/, /d̪/ and /g/). These rhyming pairs were selected such that the two words in a pair were differed only in initial consonant. The last portion (CV portion) of both the words in a pair were made identical using cross-splicing, to reduce the variation in the signal. These pairs were then well aligned and imposed onto stereo tracks, such that the two words of a rhyming pair are played dichotically. There are total of 36 stimuli, including counterbalance design for ear effects.

The subjects taken for developing normative values were fifty (25 males and 25 females), right handed normal young adults in the age range of 17 to 25 years and having mother tongue as Telugu. None of the subjects had history of any neurological problems and were initially tested to ensure normal auditory functioning prior to administration of dichotic rhyme test.

Responses were scored in terms of single correct, double correct and ear correct responses. The raw data was subjected to statistical analysis using repeated measures

ANOVA and also t-tests (independent and paired) to explore Ear X Gender interaction effects. Results of this study reveal that,

1. Right ear advantage observed was greater in male subjects than female subjects, suggesting the laterality for processing auditory stimulus is more focused for male subjects than female subjects.
2. The correct scores obtained from left ear were same across genders, revealing the processing of stimulus through left ear is equivalent for both males and females. But for stimulus presented through right ear males performed better than females, leading to a significant difference. This provides probable reason for increased right ear advantage among male subjects.
3. On comparing the ear correct and double correct scores, it was found that the variability was greater for the later. Since the variability for the ear correct score was much lesser, it is recommended that ear correct scores be utilized while scoring the responses on Dichotic Rhyme Test.

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 does not exhibited significant right ear advantage, the present test may have limited useful in testing this group.

Future implications:

1. Sensitivity measures of dichotic rhyme test in Central Auditory Processing Disorders could be evaluated before incorporating this test in to routine clinical tool.
2. As the research using Dichotic Rhyme test has been limited in different clinical population such as Learning disability, Patients having pure word deafness etc. this gives a broader opportunity for further research.

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APPENDEX A

When commercial available audio connector is used with red terminal connected to CD/Tape 1 and white terminal to CD/Tape 2, and if the stimuli was routed to right ear through CD/Tape 2 and to left ear through CD/Tape 1, the key for the presentation of the stimuli will be;

Track 1: Calibration tone of 1 KHz.

Stimulus No.	Right Ear	Left Ear	No.	Right Ear	Left Ear
Track 2			**Track 4**		
01	గుడి /guḍi/	కుడి /kuḍi/	19	పాట /pa:ṭa/	బాట /ba:ṭa/
02	దండ /d̪anḍa/	బండ /banḍa/	20	కుడి /kuḍi/	గుడి /guḍi/
03	దాత /d̪a:t̪a/	తాత /t̪a:t̪a/	21	తాత /t̪a:t̪a/	దాత /d̪a:t̪a/
04	కాలు /ka:lu/	పాలు /pa:lu/	22	బడి /baḍi/	గడి /gaḍi/
05	గడి /gaḍi/	బడి /baḍi/	23	బండ /banḍa/	దండ /d̪anḍa/
06	బాట /ba:ṭa/	పాట /pa:ṭa/	24	తల /t̪ala/	కల /kala/
07	తడి /t̪aḍi/	పడి /paḍi/	25	దాటు /d̪a:ṭu/	గాటు /ga:ṭu/
08	గాటు /ga:ṭu/	దాటు /d̪a:ṭu/	26	పాలు /pa:lu/	కాలు /ka:lu/
09	కల /kala/	తల /t̪ala/	27	పడి /paḍi/	తడి /t̪aḍi/
Track 3			**Track 5**		
10	కోట /ko:ṭa/	తోట /t̪o:ṭa/	28	బంటు /banṭu/	దంటు /d̪anṭu/
11	తాడు /t̪a:ḍu/	పాడు /pa:ḍu/	29	బుడ్డి /buḍḍi/	గుడ్డి /guḍḍi/
12	గుడ్డి /guḍḍi/	బుడ్డి /buḍḍi/	30	తోట /t̪o:ṭa/	కోట /ko:ṭa/
13	గాలం /ga:lam/	కాలం /ka:lam/	31	తుమ్ము/t̪ummu/	దుమ్ము /d̪ummu/
14	బుట్ట /buṭṭa/	పుట్ట /puṭṭa/	32	దానం /d̪a:nam/	గానం/ga:nam/
15	దంటు /d̪anṭu/	బంటు /banṭu/	33	పుట్ట /puṭṭa/	బుట్ట /buṭṭa/
16	కన్ను /kannu/	పన్ను /pannu/	34	పన్ను /pannu/	కన్ను /kannu/
17	దుమ్ము /d̪ummu/	తుమ్ము/t̪ummu/	35	కాలం /ka:lam/	గాలం /ga:lam/
18	గానం/ga:nam/	దానం /d̪a:nam/	36	పాడు /pa:ḍu/	తాడు /t̪a:ḍu/