DICHOTIC CV TEST - REVISED :

NORMATIVE DATA ON CHILDREN

(REGISTER NO. M2K06)

An Independent project submitted in part fulfillment of the first year
M.Sc (Speech and Hearing), University of Mysore, Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MANASAGANGOTHRI, MYSORE - 570 006

MAY 2001

Dedicated to
Appa, Amma, Ranjini
&
Ajji

Certificate

This is to certify that the Independent project entitled *"Dichotic CV Test - Revised : Normative Data On Children "* is the bonafide work done in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student (Register No. M2K06).

Mysore

May 2001

Director

All India Institute of
Speech and Hearing
Mysore - 570 006

Certificate

This is to certify that the Independent project entitled *"Dichotic CV Test - Revised : Normative Data On Children"* 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.

Guide

Mysore Dr. Asha Yathiraj
HOD and Reader
May 2001 Department of Audiology
All India Institute of
Speech and Hearing
Mysore - 570 006

Declaration

I hereby declare that this Independent project entitled *"Dichotic CV Test - Revised : Normative Data On Children"* is the result of my own study under the guidance of Dr. Asha Yathiraj, HOD and Reader, Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier in any other University for the award of any Diploma or Degree.

Mysore

May 2001 Register No. M2K06

ACKNOWLEDGEMENTS

First and foremost I would like to express my heartfelt gratitude to **Dr. ASHA YATHIRAJ,** HOD & Reader, Department of Audiology, All India Institute of Speech and Hearing, Mysore. Ma'am, thank you for all the guidance$_5$support and encouragement through out the study.

I would like to thank **Dr. M. J AYARAM,** Director, All India Institute of Speech and Hearing, Mysore, for permitting me to carry out the study.

I would also like to thank **Mr. ANIMESH, Mrs. MANJULA P.** and **Mrs. VANAJA,** for their guidance and help.

Appa and Amma, words can not express my feelings...., your love, encouragement, confidence, support and trust never ceases to amaze. Thanks for everything.

Ajji and Ammayya, I have always had a loving care under your shelter. Thank you so much for being there.

Ranjini, I feel so lucky to have a sister like you. You have shown me that there will fee never be a night or a problem that could defeat sunrise or hope. Thanks for all the encouragement and love.

Meera, Mava, Sowmya and **Gurudutt,** thanks for all the love and encouragement you have given me. My stay here would have been impossible without your support and encouragement.

Lakshmi, miles don't seem far when the bond is strong. U Will always remain close to the heart.

MAFIA: Thanks for being such a loving family. I am proud to say that I belong to this family.

Katz, a true friend is the greatest blessing of all. I really enjoy being in your company - all those long chats, perky notes and our KM (!!). You have always being there to cheer me up when I am having those bout of blues. Thanks for being my friend.

Vidya, we have shared some wonderful times together, thank you for being such nice friend.

Ctha, you have been a great roomie and friend. I will always cherish our friendship- and 'Crazy Times' we have had.

Sabi and **Neha,** A hundred and one pleasure which I would ever treasure, your timely help, fun, care have made my mood swing disappear !!

Mathew and **Prasanna,** encouragement and fun at all times have refreshed my mind, thank you guys.

I thank all my **classmates** for their loving company and wonderful time.

Prachi, KP and **Beula,** You have always been so caring and loving. Thank you so much for being funtabulous friends.

Boomsie, Anshula, Shereen, Anjana, Puru, Kundan, Kripal, Mili...., for all the fun times we have had. You guys make a sweet bunch of friends.

Joby, thanks for the timely help and support.

I thank the **librarians** for there help.

Last but not the least I thank the **Computer Professionals** for giving a nice expression for my study.

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INTRODUCTION

Dichotic listening is one of the behavioral central tests used to assess the central auditory nervous system (CANS) (Obrzut, Hynd , Obrzut, and Leitgeb 1980). Dichotic Listening (DL) is a noninvasive tool proven to be a reliable indicator of auditory and hence linguistic-laterality (Asbjornsen, 1994). The subject is given two different stimuli simultaneously (either single syllable words, numbers and short nonsense syllables starting with a stop consonant) through earphones, one in each ear. There are several tests that utilize dichotic tests. Dichotic CVs have long been used experimentally as well as clinically.

Kimura (1961) theorized that the contralateral pathways are stronger and more numerous than are the ipsilateral pathways. When monotic or noncompeting stimuli are introduced, either pathway is capable of transmitting the appropriate neural signals. However, when dichotic auditory stimuli are presented, the ipsilateral pathways are suppressed by the stronger contralateral pathways.

Primarily dichotic tests have been used to measure hemispheric asymmetry or to indicate brainstem dysfunction (Kimura, 1961). According to Musiek and Morgan, 1981, the application of dichotic speech tests is only to identify neuroauditory dysfunction but also to monitor changes in score. These stimuli are highly sensitive to CANS involvement (Speaks, Niccum and Tasell, 1985).

There are two main types of dichotic listening tasks : binaural summation or integration and binaural separation (Musiek and Pinherio, 1985). In the binaural summation task, the subject is asked to repeat what is presented to both ears. In a binaural separation task, the subject only repeats what is presented to the ear designated by the examiner.

Example for Binaural integration are :

- Dichotic digit test (Kimura ,1961)
- Dichotic consonant vowel test (Shankweiler and Studdert-Kennedy 1967)
- Staggered spondaic words test (Katz ,1962)
- Dichotic rhyme test (Wexler and Halwes, 1983)

Examples for Binaural separation are :

- Competing sentence test (Willeford ,1968)
- Synthetic sentence identification with ipsilateral competing message(Jerger 1970)

Central auditory processing function is an important consideration in the communication process. Efficient processing of auditory information is crucial for academic and work performance, social and emotional status and overall well being (Burleigh,1997).

A central auditory processing disorder is a condition in which one has difficulty processing auditory information when presented in a less than optimal listening environment. The vast majority of children and adults that have been evaluated, can hear even the faintest of sounds but are unable to process verbal stimuli in an effective manner in their effective listening situation (Burleigh, 1997). When dichotic speech is presented to individuals with temporal lobe lesions, reduced performance is expected on the ear contralateral to the lesion due to dominant crossed auditory fiber tracks(Berlin, Lowe-Bell, Cullen, Thompson and Stafford, 1972). Generally, in normal listeners, higher score are obtained from the material presented to the right ear than the left ear. This has been referred to as right ear advantage (REA) and is believed to reflect dominance of the left hemisphere for speech and language perception(Berlin, Lowe-Bell, Cullen and Thompson, 1973). Early lists for CANS function were primarily with adults for site of lesion testing. Such tests are now used with children and adults to assess the "functional proficiency" of their CANS. Thus the goal for testing is to administer a battery of tests which will uniquely stress the auditory mechanism at various levels of CANS function, to identify inefficient neural processing. It is essential that normative data be available for a particular test. This would be used to differentiate individual having normal or deviant auditory perceptual abilities.

Aim of the Study

- To establish normative data on children for the dichotic CV test revised developed by Yathiraj (1999) which was constructed using a computer which is having 16 bits sampling rate.
- To compare the data of the present study with that of Ganguly (1996) who had used the dichotic CV test developed by Yathiraj (1994). This was developed using a software having a 8 bit sampling rate.

- The present study also aimed at comparing the results with that of Puranik (2000) who has established normative data for dichotic CV test - revised on adults. This is to observe if there is any differences between the scores obtained by adults and children.

Need for the Study

- For clinical testing, normative data is very essential. It is required to interpret the results and to make accurate diagnosis. It is essential to demarcate the boundary between normals and children having CAPD, to provide them essential training to cope up with their problem.
- The need for early identification of CAPD has been stressed repeatedly in the literature (Cherry, 1992). Identification of CAPD can lead to a better performance which can help generate more positive attitudes towards the child.
- Dichotic speech tests, especially dichotic CV have long been used experimentally and clinically. These stimuli are highly sensitive to CANS involvement (Speaks et al., 1985).
- The rationale to evaluate for CAPD in school-aged children is based on the assumption that a deficit in auditory perception can be the underlying basis of many learning problems, including specific reading and learning disabilities (Bergman, 1971).

Thus the present study aims at establishing norms on children in the age range of 7-11 years, so as to identify CAPD early and implement an appropriate management program.

REVIEW OF LITERATURE

The central auditory test battery is very different from those used during traditional audiometric testing. Most tests of central auditory function involve speech stimuli that have been modified in some fashion to make their perception more challenging (Willeford, 1968).

A common technique for studying cerebral specialization and to understand central auditory function is dichotic listening. Broadbent (1954) introduced dichotic speech testing for detection of central auditory processing disorder. When two different stimuli are presented to the two ears simultaneously, in right handed individuals, there is a consistent ear difference in reposting them.

There are certain factors which influences dichotic listening. A few of them are:

(i) Ear Effects

(ii) Temporal Effects

(iii) Phonetic Effects

(vi) Stimulus Material

(v) Intensity Factors

(vi) Frequency Factors

(vii) Reliability

(viii) Age of the Subject

(ix) Report Strategies / Response Mode

(x) Attention

(xi) Deviant Population in Children

Ear Effects:

Generally, when speech is presented dichotically to normals listeners, higher scores are obtained from the material presented to the right ear than to the left ear. This has been referred to as right ear advantage (REA) and is believed to reflect dominance of the left hemisphere for speech and language perception (Studdert - Kennedy, Shankweiler and Schulman, 1970). Asbjornsen, (1994) reported that about 90% of the normal right handed population and 60% of the left handed population show a REA.

Cerebral dominance refers to the fact that the control of certain forms of learned behaviour in humans is exerted predominantly by one of the two hemispheres (Noback and Demarest, 1981). In the right handed population, the left hemisphere is dominance because the motor centres on this side control the right hand.

Evidence for hemispheric specialization was provided by Witelson (1977).

1) Left hemisphere processes stimuli in a linguistic, sequential, analytic manner to form the basis of receptive and expressive language.

2) Right hemisphere uses a synthetic and holistic approach for non language acoustic processing.

He summarizes the differences of the two sides of the brain with the conclusion that the left hemisphere serves, language, reading and mathematical skills, where as the right hemisphere serves visual spatial, musical and mathematical skills to a greater degree. The corpus collosum is a massive bundle of fibres that connects the two hemispheres, thus providing communication between the two functional processor of both.

Berlin *et al,* (1973) have given explanation for REA. They have noted that

1) The left posterior temporal lobe is most likely dominant for speech and language function.

2) Both the right and left temporal lobes participate and interact in some form of speech processing.

3) REA is seen in normals because the left anterior, temporal lobe is closer than the right anterior, temporal lobe to the primary speech area, therefore there would be less "transmission loss" to the left posterior parietal lobe on the basis of proximity.

Strauss (1986) conducted a study in which normal men and women were given a dichotic listening test to determine the ear advantage. On the basis of a laterality preference questionnaire, subjects were classified and overall congruency across lateral preferences. The results revealed that hand preference was the most successful variable in predicting ear advantage on the dichotic listening test.

Right ear advantage was obtained in several studies done by researchers. Berlin *et al,* (1973) presented CV syllables with onset of syllables to the two ears separated by 0, 15, 30, 60 and 90 msec. They found right ear advantage on simultaneous dichotic presentation of CV syllables. Similar results was found by Bingea and Raffin (1986). They found REA at 0, 30, 60 and 90 msec, lag conditions. The double correct scores were found to increase with increase in the lag time.

Rajgopal (1996) obtained normative data on adults aged 18-30 years using dichotic CV material developed by Yatiraj (1994) using a 8 bit computer software. The results were consistent with the above studies, demonstrating the presence of REA and lag effect in the adult Indian population. Similar results were found by Puranik (2000) where in she had obtained normative data on adults aged 18-30 years using dichotic CV material developed by Yathiraj (1999) using 16 bit computer software. The magnitude of REA in the latter study was higher, which can be contributed to material differences.

Ear advantage also depends on the handedness of the subject. Identification performance by right and left handed subjects is different (Wilson and Leigh, 1996).

Normative data from 24 right handed and 24 left handed subjects were obtained using dichotic CV material with the right handed subjects, identification performances on the materials presented to the right ear were better than the left ear. In comparison to the right handed subjects, the left handed subjects exhibited a smaller REA and more inter subject variability. With the left handed subjects, identification performances on the material presented to the right ear also were better than performances on the materials presented to left ear. Studies have been done on children by several researchers and it has been found that even in children, significant REA can be seen. Harris, Keith and Novak (1983) administered dichotic CV on children aged 6-8 years. The children were grouped into two, based on normal or low token test scores. There was no significant difference between groups with respect to left ear scores, but there was a significant difference between right ear scores. Significant REA was however found in both the groups of children. On competing sentence test, subjects showed REA i.e., right ear showed a better performance than the left ear (Ivey, 1969).

REA is seen from very young age, even before 7 years. The scores of the left ear were found to improve with increasing age upto 8-10 years of age at which time, right and left ear performance is equal. This was investigated by Willeford (1978) using competing sentence test.

It was found that there was a significant REA even at the age of 2-3 years. (Gilbert and Climan, 1974). Thirty six children between the age range 2-3 years were administered single pares of words dichotically. A significant REA was seen indicating that at this age, left hemisphere would have achieved some degree of dominance for language.

Ganguly (1996) using the same material as Rajgopal (1996) obtained norms for children aged 8-17 years. She, too found a REA and a lag effect.

In children, by diverting the attention towards left ear. REA can not be abolished. A study by Hugdahl and Andersson (1986) revealed that the REA cannot be out performed in right handed children by explicit intervention to attend to the left ear.

A similar pattern of responding has been reported by 7 years olds by Geffen and Wale, (1979), Hiscock and Kinsbousne, (1980).

The studies reveal that subjects show a right ear advantage to dichotically presented stimuli. This advantage has been observed in adults and children in studies carried out in the west, as well as in India. It is evident that this right ear advantage can be reduced or over come by the instructions given to the subjects or depending on their handed ness.

Effect of temporal aspects of dichotic listening tasks:

When two different auditory signals are presented simultaneously one to each ear, one of them is usually perceived as having a greater perceptual salience than the other. This is called "ear advantage". Apart from this, when one signal lags another signal in a ear, then the lagging signal will be perceived better and this is called "lag effect". The amount of time separation between message onsets to overcome the right ear advantage was investigated by Berlin *et al,* (1972). It was found that when one of the CVs trailed the other by 30-60 msec, the trailing CV became more intelligible than when it was given simultaneously.

Studdert - Kennedy, Shankweiler and Schulman (1970) reported that the time advantage occurred not to the leading syllable but to the lagging syllable.

This study was supported by Berlin *et al,* (1973). They used CV nonsense syllable which were presented with onset of syllables separated by 0,15, 30, 60 and 90 msec. It was found that when it was given simultaneously the leading syllables intelligibility dropped from its simultaneous level when leading by 15 and 30 msec. Olsen (1983) has shown similar results.

Bingea and Raffin (1986) conducted a study to generate normative data involving the identification of dichotic CV at onset time asynchronies of 120, 90, 60, 30 and 0 msec, under right and left lag conditions. It was found that there was a significant right ear advantage at 0 msec and that there were significant variation of scores as a function of onset time asynchrony lengthened. This study did not support the presence of a lag effect in individual data but as a group, lag effect was seen. Although this study failed so demonstrate a significant lag effect, those who have identified such a phenomena found it was most obvious at 0 to 90 msec (Berlin and Lowe- Bell, 1973; Bellaire and Noffsinger, 1978). In a dichotic task, where signals were presented with onset asynchronies ranging from 0 to 150 msec. Subjects identified lagging signals more accurately and reported them as clearer than the leading signals asynchronies between 30 and 70 msec. Beyond 70 msec lag, much difference was not found (Porter, 1975).

Studies have shown that aging has an influence on the lag effect.

Herman, (1977) reported that lateralization as well as lag effect are affected by aging.

An aberration of the lag effect for CVs was observed in elderly subjects in a study done by Gelfand, Hoffman, Waltzman an Pipes (1980). In their study, young and elderly subjects participated in the dichotic speech perception task at various lag times. It was found that REA was maintained but there was an aberration of the lag effect in the older group.

There are several other studies which support the report on how time alteration degrades speech intelligibility in the elderly (Sticht and Gray, 1969, Koukle, 1977; Bergman, 1971).

Studies conducted in India, to obtain normative data on adults, significant lag effect was seen. The scores improved from 0 msec to 90 msec (Rajgopal, 1996 and Puranik, 2000). Lag effects were also seen in children between the age range of 8-17 years (Ganguly, 1996). The right ear advantage was maximum at 0 msec condition.

Berlin, Lowe-Bell, Cullen, Thompson and Loovis (1973) attributed the "lag effect" to a single left hemisphere speech processor being entered from two channels. This hypothetical processor require a finite time of 30-90 msec to handle a CV accurately provided it were not interrupted by different information arriving from another channel.

It was suggested by Hazemann, Oliver and Dupont (1969) and Happel (1972) that latency of less than 30 msec, the response recorded from the cortese ipsilateral to the side stimulation arrived by way of corpus -collosum in the somato - sensory system. In contract, long latency potentials were conveyed by the contralateral path. Thus a lag of 30 msec or more of the left . ear may take both ipsilateral and contralateral information out of competition with right ear information. The lag to the right ear can also be expected to improve its scores by virtue of freeing it from the suppression effects brought about by the left ear. The effect of "switching" intrusion, or interruption is at peak at 30 msec leading to a better perception of information of lag ears by suppressing performance to both ears.

Studies have demonstrated that REA and lag effect are independent of one another and there is evidence that lag effect might be a case of temporal masking not limited to speech stimuli (Darwin, 1971; Porter, 1975).

In summary, it can be said that the lagging signal is perceived better than the leading signal. This is usually seen for lags beyond 30 msec. The ear seems to perform better processing of signals when they are stimulated under a lag difference than at simultaneity.

Phonetic effects in dichotic listening:

Phonetic effect or stimulus dominance is a phenomenon where in higher scores are got for one of the two competing syllables - the dominant one - regardless of the ear to which it is presented. This effect is seen in natural CV syllables (Roeser Johns and Price, 1977). In some respects, stimulus dominance is a more interesting phenomenon in dichotic listening, than is the ear advantage. It occurs with greater frequency than does ear advantage and is of greater magnitude.

(a) Voice Vs Voiceless Consonants:

Berlin *et al.,* (1973) reported that scores were higher for voiceless stops /pa,ta,ka/ than for the voiced stops /ba,da,ga/ in pairs of natural syllables than contrasted in voicing. The voiceless stops are said to be "dominant" than the voiced stops Roeser, Johns and Price (1972 and Niccum, Rubens and Speaks, (1981) supported this finding.

In dichotic listening task, subjects taken by Lowe, Cullen, Berlin, Thompson (1970) reported voiceless consonants more frequently than the voiced. However in monotic tasks, perception of voiced consonants improved. Since both stimuli came to the same ear, the first transition from aperiodicity to periodicity occurs in the voiced CV. Thus, the potential for masking of the a periodic portion of the voiceless consonants by the initial segment of the voiced consonant is clearly established. Musiek, (1983) also reported similar finding. The performance was better for voiceless than voiced and had a higher accuracy for the immediate channel than delayed channel.

A few authors have studied different parameters which determines the voicing character of a sound. Repp (1976) conducted two studies to determine the effect of variations in voice onset time (VOT) on the perception of dichotic CV syllables contrasting in the voicing features. Variations in VOT had a systematic effect on the probability of hearing the fused stimuli as voiced or voiceless, sound. Changing the VOT of a voiceless stimuli had a larger effect than changing the VOT of a voiced stimulus.

Slightly different results were found by Hannah, (1971). In her study it was found that unvoiced consonants were more intelligible than the voiced, but it was not always true. She reported more intelligible identification of voiced items over unvoiced when either VOT or boundary alignment were simultaneous and onset trailed.

Porter, Troendle and Berlin (1976) reported that regardless of ear of presentation, the voiceless syllables are reported correctly when compared to the voiced syllables. Rajgopal, Ganguly and Yathiraj (1996) reported similar results. Thus, it has been established that the voiceless syllables are perceived better than the voiced syllable in a voiced - voiceless pair.

Hayes (1981) evaluated the role of distinctive features in 21 dichotically presented syllables.

Consistent with other studies, stops as a subgroup showed a larger REA and greater accuracy in identification, when the competing stimuli contrasted on one, rather than 2 or more distinctive features. The other consonants, on the other hand showed better identification with increase in feature contrasts. This divergence between stops and other consonant classes is probably related to the fact that the acoustic cues for stops are much briefer than the cues for other consonants.

(b) Place of Articulation Cues:

Another way to describe the pattern of stimulus is to focus on the place feature. Porter, Troendle and Berlin (1976) reported that velars were more often reported correctly than alveolars, which in turn are reported more correctly than labials. The above study is in agreement with the study by Berlin *et ah,* (1973) who found that velars were reported more correctly followed by the bilabials and the apicals with least correctness. Speaks *et ah,* (1985) used eight pairs in which velars competed with non velars (bilabials or alveolars). For six of these pairs velars dominated the non velars. This study is in consensus with earlier studies saying velars are more correctly identified than others. Rajgopal *et al.,(* 1996) found similar results in their study, where velars were best perceived, followed by labials and alveolars.

(c) Vowels Vs Consonants:

Most of the studies have shown little or no REA for vowels (Shankweiler and Studdert,-Kennedy, 1967; Darwin, 1969; Studdert - Kennedy and

Shankweiler, 1970). Weiss and House (1973) revealed REA for vowels in a consonantal context which was interpreted to mean that vowels surrounded by transitions or acoustic correlates of vocal tract adjustment towards a given target will have a REA.

Berlin *et al.,* (1973) have suggested that REA in speech like tasks may be related to the use of any acoustic event which is perceptually linkable to a rapid gliding motion of the vocal tract, as in a transition.

Even in vowels, some are better perceived than the other. Weiss and House (1973) reported that /a, *x/* were better perceived than /e, o/, which were better than /i, u/. Among short vowels /E, a/ were better perceived than /i, u/

They also studied the ear preference for compeleting vowels. The results show that regardless of utterance format, materials presented at a S/N ratio that reduced the overall intelligibility, were more often heard correctly in the right ear. When the listening was difficult, the listeners tended to hear and report the presence of only one stimulus or if two, one was incorrect. On the other hand, in the more favourable noise condition, both compelling stimuli were typically identified correctly. These findings suggest that dichotic stimulation as such does not tax the perceptual system sufficiently to allow vocal ear preferences to manifest themselves.

Studies have been done on difference positions of the consonants. Trost, Shewan, Nathanson and Samt (1968) reported equal REAs for initial and final consonants in natural CVC syllables. In contrast to this study, Darwin (1969) reported stronger REA for final consonants in dichotically presented synthetic VC syllables Studdert -Kennedy and Shankweiler (1970) also reported REA for final consonants in natural speech stops.

In an experiment conducted by Repp (1976). Seven different CV syllables were presented for identification in all possible dichotic parings. The stimuli were distinguished only by the initial transitions of the second and third formants (F_2, F_3) whose onset frequencies were varied to form a continuum from /*bx/* to /dx/ to /gx/. The results showed a clear effect of variations in F_2 and F_3 transitions on stimulus dominance, even when these variations occurred within a phonetic category.

There are at least three different levels at which dichotic competition between speech sounds may be conceived to occur one is the phonetic level (Studdert - Kennedy, Shankweiler and Pisoni, 1972). If dichotic competition occurred solely between categorical phonetic representation (syllables, phonemes or features), acoustic stimulus variations within a phonetic category should have no influence on the degree of dominance that a stimulus from that category exerts over stimuli from other categories. However, there is now ample evidence that this is not true : within - category changes in the VOT or the formant transitions of competing syllable - initial stop consonants do significantly change stimulus dominance relationships (Miller, 1977). Thus, dichotic competition is certainly not exclusively phonetic in nature, although there may conceivably be a phonetic component to the process.

Explanations for this phenomenon have been given as

(i) Inherent Intelligibility:

One possibility could be the inherent intelligibility of the syllables. It might be assumed that certain syllables are more intelligible than others and that the differential intelligibility would be evident regardless of whether the syllables are presented dichotically or in same other mode. Speaks *et al,* (1985) tested this notion. They presented 6 CV syllables, binaurally in noise to 4 listeners. They found that the two most intelligible syllables diotically /ba/ and /ka/ were the least dominant dichotically. Thus, binaural intelligibility scores in noise, did not explain dichotic stimulus dominance.

(ii) Lag Effect:

Another possibility is the lag effect which has been explained by Berlin *et al,* (1973). They studied the dominance of voiceless over voiced stops in voicing contrasted pairs of natural syllables. Voiceless stops were found to have longer VOT than voiced stops. Therefore, when competing stops are aligned by reference to the onset of noise burst, the larger amplitude vocalic position of the voiceless stops is delayed relative to the vocalic position of the voiced stops. Hence it was reasoned that the later arriving voiceless stop might interrupt processing of the earlier arriving voiced stops.

Speaks *et al,* (1985) however had reported finding contrary to the above study. They reported that using 9 voicing contrasted pairs, out of which 7 had voiceless dominant over voiced stops. Also lag effect could not account for the dominance of /ga/ a voiced velar over /pa/ a voiceless labial. Also, the pattern of stimulus dominance reversed for synthetic syllables, where voiced stops dominate voiceless stops in a dichotic presentation, even though the VOTs were same.

(iii) Prototype Matching Hypothesis:

Repp (1976) proposed a "Prototype matching hypothesis" and "Category goodness hypothesis" to explain stimulus dominance.

According to the first hypothesis, the perceptual system is assumed to determine how well a stimulus matches any of the several category prototypes. When two competing dichotic stimuli enter the system, the stimulus that is close to the prototype will tend to dominate over a stimulus that is far from the prototype.

Category goodness model says that stimuli that are distant from the category boundary are likely to dominate than those lying close to the boundary. This distance from a prototype or a boundary is assumed to be a function of acoustic characteristics of the stimulus.

Repp (1976) claimed support from his experiment by systematically manipulating the F_2 and VOT of the stimulus. He reported that stimulus dominance can be changed systematically with variations in the VOT of the competing stimuli.

Lisker and Abramson (1970) and found category boundaries for VOT, labials + 20 ms, alveolars + 35 ms and velars + 40 ms. The model could predict that the syllable most distant (in VOT) from its category boundary would be the dominant member eq. /pa-ba/ pair, /pa/ has VOT of + 50 ms and /ba/ has + 20 ms, which is 30 ms and 10 ms away the boundary of + 20 ms, respectively. Hence /pa/ should be the dominant member.

However, analysis of results of Speaks *et ah,* Study (1985) showed only 5 of the 15 syllable pairs, showing agreement between prediction and observation. Murphy (1970) had also obtained almost identical results as Speaks *et al.,* (1985).

Thus Repp's model was not a very satisfactory in explaining the phenomenon of stimulus dominance.

(iv) Burst Amplitude:

Another explanation given was concerned with the relative amplitude of the brief moment of articulatory release. Since burst of friction constitute a cue for perception of different classes of stops (Halle, Hughes and Radley, 1957) burst may also be partly responsible for producing stimulus dominance.

The peak intensity of burst as well as its duration is generally greater in voiceless stops than for voiced (Klatt, 1975) because of greater drop in pressure across the oral occlusion at the moment of release for a voiceless stop.

Speaks *et ah,* (1985) measured the voltage of initial burst frication of 6 steps /p, t, k, b, d, g/ and converted it to decibels relative to the peak intensity. It was seen that the velars /k, g/ had greatest peak intensity followed by alveolars and labials. Although difference in burst intensity accounted for the presence or absence of significant stimulus dominance fairly well, magnitude of stimulus dominance could not be predicted well. This could explain the reverse pattern observed in one of the pairs where voiced stop was dominant over voiceless. Those syllables were synthesized without burst cues.

In any case, stimulus dominance does seem to exert a strong influence on the direction of ear advantage for a given pair of syllables.

Rajgopal, Ganguly and Yathiraj (1996) also yielded similar results. They found that voiceless syllables were better perceived followed by labials and alveolars.

It is evident from the review on phonetic effects of dichotic stimuli that at simulatanuity, the voiceless consonants were more intelligible than the voiced. In terms of place and manner of articulation, the voiceless velars were the most intelligible during dichotic presentation followed by alveolars and labials.

Effect of stimulus material in dichotic listening:

Several test procedures have been developed to measure dichotic listening. All the dichotic speech tests are aimed at reduce both external and internal redundancies so that it becomes difficult for the subject to respond. The test materials commonly used are:

(a) Dichotic Digits (Kimura, 1961)

(b) Dichotic CV Test (Berlin, 1972)

(c) Staggered Spondaic Word Test (Katz, 1962)

(d) Synthetic Sentence Identification (Speaks and Jerger, 1965)

(e) "Dichotic Rhyme Test (Wexler and Halwes, 1983)

These tests are commonly used to assess the auditory processing in normals and disordered population.

A study conducted by Koomar and Cermak (1981) using dichotic CV and dichotic digit formats on normal and learning disabled children between the age group of 7 and 10 years revealed that there was no significant difference in ear advantage between the two material. In the same study, the learning disabled group performed significantly lower than the normal group on dichotic digit format.

Noffsinger, Martinez and Wilson (1994) used three tests of dichotic Listening utilizing speech signals as stimuli. They include a dichotic monosyllabic digit tasks, a dichotic synthetic sentences task and a dichotic nonsense syllable (CV) task. Data revealed that listeners had little difficulty in identifying digits or synthetic sentences but correct responsiveness was less frequent when the stimuli were dichotic CVs.

Normal right handed adults engaged in dichotic listening with free report instruction showed that the usual REA for dichotic digit was altered according to the attention to any particular ear. Most notably, the REA was absent among subjects who had monitored the left ear (Hiscock and Stewart, 1984). Additional experiments showed that the "priming bias" is material specific and fit did not occur if consonant vowel nonsense syllables (CVs) were substituted for digits in either the selective attention or the subsequent free -report task.

Obrzut, Bolick and Obrzut (1986) supported the hypothesis that perceptual asymmetries can be strongly influenced by the type of stimulus material used and the effect of attentrocial strategy. In this study, 12 (mean age of 10.5 years) high academically performing children were administered four types of dichotic stimuli (words, digits, CV syllables and melodies) in three conditions of free recall, directed right and directed left. While expected REA for words and CV syllables and the expected LEA for melodies were found under free recall, the directed conditions produced varied results depending on the nature of the stimuli. Directed condition had no effect on recall of CV syllables but had a dramatic effect on recall of digits. Word stimuli and directed condition interacted to produce inconsistent perceptual asymmetry. While directed condition reduced overall recall for melodies.

It has been stated by Niccum, Rubens and Speaks (1981) that the dichotic CV test is a more difficult task when compared to dichotic digit test.

This was confirmed by a study done by Rajgopal, Ganguly and Yathiraj (1996) on Indian population. The performance of subjects was poor on dichotic CV because in dichotic CVs, the presentation of stimulus is more simultaneous and also CVs are less meaningful than digits and rarely occur in isolation.

Dichotically presented CVs have an apparent advantage over digits in that alignment of acoustic energy is relatively simple because of the high degree of similarity among the syllables. This allows for a more simultaneous presentation than is possible for digits, which reduces the linguistic value of the CV task and maximizes the acoustic and phonetic competition (Berlin and McNeil, 1976).

The dichotic CV task also relies less hearing on short term memory than the digit test in which as many as to digits must be remembered.

From the above studies it can be noted the responses obtained from subjects varied depending on the material used. Dichotic CVs were found to be more difficult when compared to dichotic digits or synthetic sentences.

Effect of Intensity on dichotic listening task:

Effect of intensity on dichotic listening has not been studies as extensively as other factors. It was found in a study done by Roeser, Johns and Price (1972) that right ear scores do not vary as a function of intensity. These investigators had designed a study to investigate the intensity function of the right ear effect and to determine, whether there was an intensity or a general range of intensities at which the effect is most observable. They considered a range of intensity levels 10, 30, 50, 70 dBSL (ref, SRT). The results indicated that there was a significant tendency for subjects to report fewer correct responses at lower intensity levels i.e., at 10 dBSL (ref. SRT).

Interaural intensity differences were introduced in a dichotic listening experiment with CV syllables in a study by Speaks and Bissonette (1975). They used four intensity levels 80, 70, 60 and 50 dBSPL. In the first condition speech level in the right ear was attenuated in 8 dB steps from each of four reference intensities for the left ear. In the second condition, speech level in the left ear was amplified in 8dB steps. The REA was cancelled by attenuation of signal level in the right ear, but the amount of attenuation required to cancel the REA varied with reference intensity.

In contrast, to the above studies, Royan (1969) has shown that REA was held constant even when the left ear signal was 6 dB more intense than the right ear.

Some investigators report that the intensity of the signal does influence the responses received. Dobie and Simmons (1971) found that when two speech sounds are presented simultaneously to the two ears, normal subjects were able to report accurately the input to either ear until the signal amplitude to the unattended ear exceeded that of the attended ear by 15 dB.

An experiment conducted by Bloch and Hellige (1989) investigated the effects of relative difference in intensity levels of the stimuli presented to the two ears. The results indicated that identification of stimuli presented to one ear improved when those stimuli were relatively higher in intensity than the stimuli presented to the other ear.

Studies on the effect of intensity has not been carried but extensively, the few studies which have been conducted indicate that the right ear advantage was not overcome by increasing the intensity in the left ear by 6 to 10 dB.

Effect of frequency on dichotic listening tasks:

Siditis (1980, 1981) presented dichotically two pure tones of low frequency and required his right handed subjects to report whether a subsequent test tone was or was not one of the tones. Under these conditions he found no ear advantage. When he added higher harmonics of the fundamental frequency to each of the dichotic tones, a left ear advantage was observed. Sidtis concluded that the right hemisphere was specialized for the analysis of steady state harmonic information.

In right handed subjects Divenyi, Efron and Yund (1977) also studied the ear advantage for two pure tones of different frequencies using a variety of center frequencies. Although about 75% of "normal hearing" subjects exhibited a left hemisphere dominance at a centre frequency of 1700 Hz. Divenyi *et al,* (1977) observed that a subject might be left ear dominant at one centre frequency but right ear dominant at another, or the reverse.

Employing dichotically presented pure tones, around a centre frequency of 1700 Hz. Efron, Koss and Yund (1983) found 71.4% of 63 right handed subjects exhibited a left ear dominance when the frequency difference (AF) was 100 Hz. However, increasing the Af to 400 caused a statistically significant right ward shift of ear dominance.

In another study, using the paradigm, described above and employing only subjects who were strongly left ear dominant for pure tones. Divenyi and Efron (1979) showed that the progressive addition of temporal and spatial information (ultimately using speech tokens) caused a right ward shift of ear dominance.

Auditory perceptual asymmetry arises when two dichotic signals are two tones relatives close in frequency (Efron and Yund, 1974, 1976). Ear dominance for pitch is independent of handedness as well as of the ear advantage observed with dichotic speech sounds (Yund and Efron, 1976). It is reasonable to assume that ear dominance is related to asymmetry in processing spectral information. Since, speech sounds carry spectral information, one might expect the REA for speech to be confounded with right ear dominance for tones. In subjects who have left ear dominance for tones, any REA for speech must be a consequence of some other asymmetry that is unique to speech processing.

It has been reported in several studies that subjects attending to non verbal properties of dichotic verbal input reported better from the left ear than from the right ear (Nachson, 1970; Spellacy and Blumstein, 1970).

Kimura (1967) reported a significantly greater number of accurate identifications from the left ear than right in an identification task of dichotically presented melodies in 20 normal subjects.

This finding is supported by Ei. senson (1969) who reported that right hemisphere activity is responsible for processing nonverbal auditory stimuli such as musical tones and tonal patterns.

Cook (1973) studied the left and right hemisphere differences by presenting dichotic stimuli, in the form of music. He concluded that the number of musical phrases correctly recognized when presented to the left ear them those correctly recognised when presented to the right.

Thus, studies have reported perceptual asymmetries to occur when two different auditory stimuli are presented simultaneously. A right ear advantage is seen for speech stimuli whereas left ear advantage is seen for nonspeech stimuli. It is thus reasonable to assume that the ear dominance is a result of the material being used.

Reliability of dichotic listening task:

Dichotic testing has been used as a behavioural indicator of the hemispheric dominance for verbal and non verbal material in normal children and adults, as well as to different groups of pathological subjects such as dyslexics, stutterers etc. The interpretation of the result from studies on dichotic listening must take into account such design factors such as practice, response mode, and the type of analysis used to score the response.

Porter, Troendle and Berlin (1976) studied the changes in subjects performance on dichotic pairs of CVs over an eight week period. The results indicated that certain performance characteristics remained invariant with practice whereas some underwent change. A significant improvement was seen over the first 3 sessions, while the performance remained stable for the last five sessions. The magnitude of REA, however was not significantly different across the eight sessions.

Koomer and Cermak, (1981) in their study on children between the ages of 7 and 10 years reported that the children obtained higher reliability on the CV format than on the digit format. Wide variability in reliability was found when using different laterally formulas to determine ear advantage.

In contrast to the study done on children, adults did not have a very high test retest reliability as reported by Flight (2000). Twenty four right handed adults completed a dichotic CV pairs task twice in a test retest approach. Results showed the expected REA in dichotic listening but the reliability was not high.

Practice effects and list effects should be accounted for when using the dichotic tests. A study by Janke (1994) suggests that verbal tasks performed prior to the dichotic listening experiment primes the hemisphere for verbal stimuli, resulting in superior dichotic listening performances.

This indicates that the recall accuracy from the right ear was significantly used when subjects performed verbal tasks prior to the experiment as compared to those experiment conditions subjects did not receive any prior tasks.

The practice effect has also been reported by Feeney and Hallo well (2000) using synthetic sentence identification on young and elderly listeners. They found that there was significant practice effects. They suggested that minimum of one practice for young listeners and three practice task for elderly should be given to reduce practice effects. From the above studies, it is seen that with practice, the dichotic scores improve. To nullify this effect it has been suggested to use practice trials prior to the testing.

Effects of age on dichotic listening:

The variations of age in dichotic listening can be referred to as "developmental dichotic listening". The area indicates the age at which the dichotic listening tasks show a hemispheric dominance for speech and language and how the changes occur in dichotic listening with the developmental changes with age and difference between the age groups.

Ingram (1975) reported that a right ear superiority was indicated on dichotic listening tasks at the age as early as three years, suggestive of the left hemisphere dominance to certain extent for speech functions by that age. This study supports the findings of Kimura (1961 1967), where she found that the REA appeared no later than the age of 6, for speech and language hemispheric dominance.

Horning (1972) reported that the REAs for both elderly and young subjects were virtually identical. The children acquired functional differences by the age of 5 and behave in the same manner as the elders behave for dichotic listening.

Some researchers have shown that the magnitude of REA increases with age, becoming more lateralized (Satz, Bakker and Goebel, 1975), while others have shown it to be constant throughout development (Berlin, Hughes and Berlin 1973, Kinsbourne, 1975, Kinsbourne and Hiscock, 1977). Further there are other studies on perceptual asymmetries have suggested that normal children show a development similar to that of an adult where in a REA is clearly seen by puberty (Bryden and Allard, 1978; Krashan, 1973).

In agreement to the study by Berlin, *et al*., (1973) Berlin and McNeil (1976) reported that the language skills develop throughout the developmental period. They observed a significant difference in the behaviour of 6 and 7 years olds with 9, 11 and 13 years olds in the perception of voiced and unvoiced consonants in a dichotic task. They concluded that the language skills as the children develop from the age of 5 to 13 years can be reflected in the presence of REA suggesting the left hemisphere dominance.

Several studies suggest that selective listening ability begins to develop in early childhood and that children reliably can overcome the REA by the age of 8 or 9 years. In a study by Hiscock and Beckie (1993), they found that children of 7 and 10 years were able to overcome the REA for dichotic CV stimuli when instructed to focus attention on the left ear.

The magnitude of REA was studied using different stimuli. Bellis,(l996) reported a greater REA in children when complex, linguistically loaded dichotic stimuli were used than with the use of less complex stimuli. As the child matures, the REA will decrease, reaching adult values by approximately 11 to 12 years.

Studies on normal children using dichotic listening paradigm have shown that most right handed children show a REA suggesting adult like asymmetry. This asymmetry may be seen as early as three years.

Effect of the response mode on dichotic listening:

There are evidence which suggest that, in humans, the two cerebral hemispheres differ in the degree to which they are involved in processing different kinds of information. Auditory, symbolic, sequential material is best recalled or identified when presented in the right ear and processed in the left cerebral hemisphere (Lackner and Teuber, 1973).

The mode of response is an important factor in establishing preferential processes by one hemisphere over the other. Subjects can indicate the perception of the test items either by pointing, selecting, repeating or by writing. There are two types of response mode. One is an open set response and the other is a closed set response.

Open set response:

In this response mode, an individual can either repeat the test stimuli verbally or can write down the test word.

Studies done by Mereill and Atkinson (1965) and Nelson and Chaiklin (1970) showed that the oral discrimination scores were always higher than write down discrimination scores.

Closed set response:

Here the subject has to select this response from a given set of choices. This can be either written, oral or pointing.

Llyod, Reid and Mc Manis (1967) tested normal hearing retarded children and found that both written and oral responses were reasonably reliable though there was a small but statistically significant difference between the responses obtained between the two response modes. There are studies which compares the two modes of responses (i.e., open set and closed set responses).

Olsen and Matkin (1979), reported that the closed set response could be used with disordered population. He also found that closed set responses provided good estimates of word recognition performance. The review, suggests that the closed set response provide higher scores than the open set response.

Ear advantage was studied using different modes of response. Janke (1993) administered a dichotic test of monosyllabic CV syllables three times to 36 male right handers and 50 male left handers. Different response modes (Reposting verbally the perceived syllables, writing down the syllabus heard and to visually recognize the stimuli) were utilized in the study. The results suggested that ear advantage scores are not influenced by the response condition.

Similar results were obtained by Krishna and Yathiraj (2001) where written and oral responses were obtained by children of 10-11 years old using dichotic CV. Results showed no significant difference between the two modes of response and the REA was not influenced by the response moiiality. In summary, it can be said that response mode has a minor role to play in the dichotic listening task.

Attentional Factors:

Perceptual advantages in dichotic listening can be biased by attentional factors. Most dichotic listening experiments permits the subject to deploy attention in anyway they choose, but this adds to the uncontrolled variance to the observed REA.

Bryden, Munhall and Allard (1983) found robust laterality effects in an identification task with focused than with divided attention.

An experiment conducted by Bloch and Hellige (1989) investigated the effects of the instructions to attend to both ears or to focus attention on one ear. For verbal task, more CVs were identified from the right ear than from the left ear. When subjects were instructed to focus attention on only one ear rather than distribute attention across both ears, identification of stimuli presented in that ear improved. Similar results were found by Keith, Tawfik and Katabamma (1985) in their experiment with adult subjects.

Hiscock and Stewart (1984) conducted a series of four experiments on normal right handed adults. They were given dichotic listening task with free report instructions after having completed a selective listening task. The usual REA for dichotic digit names was altered according to the ear previously monitored. Most notably, the REA was absent among subjects who had monitored the left ear. Additional experiments showed that the "Priming bias" is material specific, it did not occur if CV syllables were substituted for digit names in either the selective listening task or the subsequent free-report task.

Twelve high, academically performing subjects (mean age of 10.5 yrs) participated in a study conducted by Obrzut, Bolick and Obrzut, (1986). They were administered four types of dichotic stimuli (words, digits, CV & melodies) in three experimental conditions (free recall, directed left and directed right) to examine perceptual a symmetry as reflected by the RE A. REA for words & CV and left ear advantage (LEA) for melodies were found as expected in free recall. The directed conditions produced varied results depending on the nature of the stimuli. Directed condition had no effect on recall of CV syllables but had a dramatic effect on recall of digits. Word Stimuli and directed condition interacted to produce inconsistent perceptual . asymmetry while directed condition reduced overall recall for melodies. The findings lend support to the hypothesis that perceptual asymmetries can be strongly influenced by the type of stimulus material used and the effect of attentional strategy employed.

Dobie and Simmons (1971) conducted a study in which 17 normal right handed subjects obtained a mean dichotic threshold of 4.8 dB higher when the right ear was attended compared to left ear. In a group of 16 left handed subjects, there was a slight left ear superiority. These results suggest a role for the non dominant hemisphere in processing and or storage of competing speech stimuli.

Dichotic listening was evaluated in pre & post cued response condition using hierarchial set of 1, 2 & 3 pair dichotic digit materials. Strause, Wilson and Brush (2000) administered this on 30 young adults and 30 older adults with sensorineural hearing loss. Results of the study were.

- Recognition performance of pressed (Eg: Say only right ear stimuli) were better than postured.

- REA in pre and post cued response condition for both age groups.
- As complexity of the listening task increased from easy to difficult, there was a corresponding decrease in recognition performance in both age groups.

Even in children, by diverting the attention to left ear, it is possible to overcome REA. Hiscock and Beckie (1993) in their experiment with 58 children in the age range of 7 to 10 yrs were instructed to focus attention to the left ear. The children were able to overcome the REA for dichotic CV stimuli.

In contrast with above studies, several studies on children indicate that normal right handed children of various ages show a right ear advantage for dichotic verbal stimuli even when instructed to attend to the left ear.

Study done by Bryden (1962) indicated that there was a REA consistently when a free recall procedure was used, as well as when the order of report was controlled.

Most of the studies on directed attention indicate that perceptual asymmetries can be influenced by the effect of attentional strategy employed.

Performance of stutterers on dichotic listening tasks:

One of the earliest investigations done on stutterers using dichotic listening was by Curry and Gregory (1969). Twenty adult stutterers and twenty control subjects, all right handed participated in the study. Dichotic word test was administered and it was found that 75% of normals had right ear scores which were higher than their left ear scores. This was true for only 45% of the stutterers. This study was supported by Blood & Blood (1989). Where they found significant difference between stuttering and controls in the magnitude of ear performance.

Dietrich (1997) measured ear advantage on 11 stutterers on dichotic sentence identification. The stutterers were found to have significant difference between the two ears.

Ninety young boys of age group 5 yrs, 7 yrs and 9 yrs were administered dichotic CV listening task. In each group, half of the subjects were stutterers and half non-stutterers. It was found that the stutterers, most of the time displayed either left ear advantage or no ear advantage (Strong, Frick, and Gilbert 1983).

Brady and Benson (1975), Quinn (1972) observed that a few of the stutterers had higher scores in the left ear while none of the normal controls had a left ear advantage.

Slorach and Noehr (1973) examined 15 stutterers aged 6-19 years. They presented dichotic digit pairs. Free recall of digits as well as performance on instructed order of report from particular ear were also tested. The stutterers scores were similar to those of controls in their study. This study was supported by Gruber and Powell (1974), Sussman and McNeilage (1975), Blood (1985).

Tsunda and Moriyama (1972) performed the Tsonda's cerebral dominance test on 57 adult Japanese stutterers. 79.3% of normal controls showed a preference for vowels in the right ear and a preferance for non-verbal sounds in the left ear but this pattern existed only for 39.6% of stutterers. Among 29.6%, some showed dominance of vowels sounds in left ear and of non-verbal sounds in right ear. This finding suggests that among stutterers, there is a subgroup in whom stuttering may be due to abnormal cortical function resulting from minimal brain damage.

Blood (1985) investigated 76 stutterers and 76 control subjects of age range 7-15 years using dichotically presented synthetic syllables. Results revealed that although the direction of ear preferences was the same for stutterers and non stutterers, the magnitude of ear preferences scores for the two groups were significantly different.

It is suggested by Koroleva and Shrugaja (1997) that in dichotic listening of speech stimuli, noise reduced the correct response in stuttering and normal individuals. The influence of noise was more considerate in stutterers, half of them lost the right ear superiority in noise.

Dichotic CVs and melodies were presented to matched groups of right handed male stutterers and controls in a study done by Rosenfield and

Goodglass (1980). Expected REA for CVs and LEA for melodies were obtained. Without significant ear differences between groups. More number of stutterers than controls failed to show the expected ear laterality for either type of material.

In a recent study done by Bhat (1999), significant difference between the right and the left ear scores were obtained. The studied 20 young adult male stutterers. She found right ear preferance though not significant at Omsce, 30 msu right lag & 30msu left lag but there was a significant left ear advantage at 90 msec right lag & 90 msec left lag.

In her study, she found that as the lag time increased, the scores improved significantly. However the mean scores were significantly reduced when compared to normals. When the severity was considered, it was found that when severity increased, scores decreased significantly.

Thus there are contradictory, studies about the ear advantage in stutterers. Some authors have reported left ear advantage seen in stutterers, however this is not well established. This indicates that the severity of stuttering may alter the dichotic listening response in stuttering.

Dichotic Listening In Learning Disabled:

Most of the studies done on learning disabled (LD) population reports that these children do not show a typical REA. The scores obtained by these children are poorer a compared to normal children (Bryden, 1970).

Dermody (1976) studied LD children on the dichotic CV test. He concluded that the LD Children perform less efficiently on the dichotic task than do normals.

Bryden (1970) and Thompson (1977) suggested that children with LD have diminished or nonexistent REA. This study is consistent with the study by Tobey, Cullen, Rampp and Fleischer - Gallagher (1979) who found significant REA in a group of LD Children compared to control group. Likewise, an auditory capacity studied by Dermody (1976) and Tobey *et al.* (1979) has shown that this measure is significantly reduced in LD children.

Dermody, Mackie and Katsch (1983) studied the dichotic listening performance using CV pairs in a group of 30 children, 15 of whom were good readers and 15 were poor readers. The results indicate similar laterality and phonetic processing effects in both good and poor readers. There was however a significant difference in their ability to identify both items on a dichotic trial correctly.

The effect of hemispatial and found attention were examined with 50 normal and learning disabled children to determine the extent of the attentional strategies influenced perceptual laterality as reflected by the dichotic listening right-ear advantage (Bolick, Obrzut & Shaw, 1988) reported a significant REA for normal children across all attentional conditions whereas learning disabled did not produce a consistent REA across all attentional conditions, and in several instances, produced equivalent left and right hemisphere processing. Right hemisphere orientation increased the magnitude of the REA for both groups, whereas left hemispatial orientation increased the magnitude of the left ear report, only in learning disabled subjects.

Obrzut, Conrad and Bolick (1989) Studied cerebral lateralization of 60 left and right handed good readers and reading disabled who ranged in age from 7-13 years. Results indicated that left handed good readers and reading disabled children were left ear dominant in free recall and in the direct right left condition, but were right ear dominant in the directed right condition. Right-handed reading -disabled children produced a REA during free recall and directed right conditions, but were left ear dominant in the directed left condition.

Kershner and Micallef (1989) showed that dyslexics were more weakly lateralized. Correlations suggest cautiously that CV lateralization may be associated inversely with reading comprehension and word decoding in the dyslexics and normal readers.

This study provides mild support for the hypothesis that weak attentional lateralisation for CVs in dyslexia may result from the precocious development for posterior right hemisphere attentional systems in compensation for presumed left hemisphere lesions

Higher left ear advantage was seen in learning disabled group in a study done by Morton and Siegel (1981). Children with learning disability showed an attentional bias. The right ear report was lower when subjects were asked to report what was heard in the left ear first. This was probably due to the difficulty in shifting attention to right ear in those who were directed to report the left ear stimulus first.

Ganguly, Rajgopal and Yathiraj (1996) found that the performance of learning disabled children were poorer compared to that of normal children on a dichotic CV test. However a REA was exhibited by both normal and LD Children.

In majority of the studies done on LD population, show that the typical REA is not seen. A few studies report a left ear advantage seen in these children. Further the magnitude of scores obtained by learning disabled children may be lesser compared to normals.

As seen in the review, there are variety of factors which affect the dichotic listening. A few factors have been studied extensively than others. There isn't a total consensus on the effect of these variables on dichotic listening. These factors should be considered while interpreting the dichotic scores.

METHODOLOGY

The present study aimed at obtaining normative data on the "Dichotic CV test-Revised" developed by Yathiraj (1999) on a computer with 16 bit recording facility and to compare the results obtained with the normative data obtained by Ganguly (1996) on the dichotic CV developed by Yathiraj (1994) on a computer with 8 bit recording facility. The present study also aimed at comparing the results with the results obtained by Puranik (2000) on adult subjects utilizing "Dichotic CV test-Revised" developed by Yathiraj (1999) on a computer with 16 bit recording facility.

Subjects

The subjects for the study were 50 normal children, 25 of whom were males and 25 females. Age range of children was 7-11 years. They were divided into 5 groups according to their age (7-7.11, 8-8.11, 9-9.11, 10-10.11, 11-11.11 years). There were ten subjects in each group.

Subjects selection criteria

The subjects selected for the study had

- No known history of hearing loss
- No chronic otologic problem
- No neurologic problems or trauma to the brain
- No previous experience with dichotic listening task
- Right handedness
- Pure tone thresholds less than 15 dB in both ears in the frequency between 250 Hz to 8 kHz for AC and 250-4000 Hz for BC

- Scores on a speech identification test (Mayadevi, 1974) should be between 90 % - 100 % in both ears.
- Ability to read Kannada or English letters of the alphabet.

Instrumentation

Preliminary testing of the subjects was done using the clinical audiometer Madsen OB-822 coupled to TDH-39 ear phones housed in MX - 41/AR ear cushions and the bone vibrator Radio ear B-71. For the dichotic CV test, the Sony HF audio cassette consisting of the dichotic lists were played on the tape recorder Philips AW606. The signal from the tape was fed to the tape input of Madsen OB822. The output of the audiometer was given to TDH-39 earphones housed in MX-41/AR ear cushions. The audiometer used was calibrated for AC, BC, and tape input to confirm to ANSI (1989) standards (Appendix 1). •

Material

The material used was the "Dichotic CV test - Revised" which has total of five lists. Each list consisted of thirty pairs of syllables /pa/, /ta/, /ka/, /ba/, /da/, /ga/. Test material was developed by Yathiraj in 1999 at the All India Institute of Speech and Hearing, Mysore. This was done using computer software 'AudioLab'.

The sampling rate of the computer was 16 bits. The CVs were recorded such that the onset of syllables was simultaneous (0 msec) or delayed at asynchronous of 30 msec or 90 msec. The lag was either in the right or the left track.

Thus the following five sub tests were constructed with each list consisting of thirty pairs of test items.

1. 0 msec onset, where both syllables were given simultaneously to both ears
2. 30 msec left channel lag, where the stimulus to the left ear was given with a lag of 30 msec with reference to the right ear.
3. 30 msec right channel lag, where the stimulus to the right ear was given with a lag of 30 msec with reference to the left ear.
4. 90 msec left channel lag, where the stimulus to the right ear was given with a lag of 90 msec, with reference to the right ear.
5. 90 msec right channel lag, where the stimulus to the right ear was given with a lag of 90 msec, with reference to the left ear.

A calibration tone of 1 kHz was recorded prior to each list. The computer generated list was recorded onto a magnetic tape using the tape deck SonyFH-411R.

Procedure for obtaining normative data

Subjects who passed the selection criteria mentioned above were administered the dichotic CV test. The 1 kHz calibration tone was used to adjust the VU meter to zero in both channels. The dichotic stimuli were presented at 70 dBHL through TDH - 39 earphone housed in MX-41/AR ear cushions.

The subjects were asked to respond on a multiple choice scoring sheet (Appendix 2) by making the 2 CVs heard among six alternatives. Subjects were asked to guess if they were unsure of the responses. All subjects listened to all the five lists, which were presented randomly to them.

Scoring

Responses were scored in terms of single correct and double correct scores. A single correct score was given when the subject reported the syllable presented to any one ear correctly. A double correct score was given when the subjects reported the syllables presented to both ears correctly. The scores were recorded on a scoring sheet (Appendix 3). The raw data was subjected to statistical analysis.

RESULTS AND DISCUSSION

The data obtained was analyzed using different statistical procedures. These included the mean, standard deviation (SD) and range. The t-test was also used to check the significance of difference between the various parameters analyzed.

Analysis was done to compare

(i) The single correct scores between the right and the left ear scores at:

(a) Simultaneity

(b) Across onset time asynchronies.

(ii) The single correet scores for each ear across lag conditions

(iii) The double correct scores at'.

(a) Simultaneity

(b) Across onset time asynchronies.

(iv) The scores across five different age groups [7 to 7.1 lyears, 8 to 8.11 years, 9 to 9.1 lyears, 10 to 10.1 lyears, 11 to 11.1 lyears]

(v) The scores of children with that of adults as obtained by Puranik (2000) using similar material.

(vi) The scores obtained on a 16 bit computer software (present study) with that of an 8 bit computer software (Ganguly, 1996) using similar material.

I. Single correct scores at simultaneity and across lag times

Table 1: Mean, Standard deviation (SD), Range, t-scores and levels of significance for single correct scores at simultaneity anducross lag times

Lag time	Ear	Mean	S.D	Range	t-Scores	Significance
0 msec	R	21.68	3.41	13-28	3.23	0.01*
	L	20.44	3.52	10-28		
30 msec Right lag	R	21.86	3.01	10-29	3.44	0.01*
	L	20.58	3.98	07-30		
30 msec Left lag	R	22.36	2.35	14-29	3.6	0.01*
	L	20.22	3.91	14-29		
90 msec Right lag	R	22.28	3.87	05-28	2.94	0.01*
	L	20.86	2.43	10-29		
90 msec left lag	R	22.52	2.81	14-30	2.73	0.01*
	L	21.48	3.22	11-30		

*Significant at 0.01 level,

(a) At Simultaneity

As seen from the Table I, right ear scores were significantly better than the left ear scores at simultaneity as well as across onset asynchronies. The results of the single correct responses at simultaneity, reveals that there was a significant right ear advantage (REA). The REA was found to be statistically significant on the t-test at the 0.01 level. The percentage correct score at simultaneity of right ear was 72.26% and left ear was 68.13%.

The right ear advantage observed at simultaneity correlates with studies quoted in literature (Studdert-Kennedy, and Shankweiler, 1970) , Asbjornsen,1994 and Olsen,1983).The REA at simultaneity reflects the prepotency of the crossed neural pathways from the right ear to language dominant left hemisphere (Kimura,1961). In right handed population, the left hemisphere is dominant because the motor centres on this side controls the right hand (Asbjorsen, 1994). Thus, it can be expected that most people would show right ear dominance in simultaneous listening tasks.

Studies on children using dichotic listening paradigm have shown that most right-handed children show right ear advantage, suggesting adult like asymmetry (Bellis, 1996 ; Satz et al, 1975). Horning (1972) reported that the REA's for both elderly & young subjects were virtually identical.

(b) Average scores of the right & left ear scores at simultaneity

Average scores of the right and left ear scores at simultaneity was 70.19%. Bryden and Allard (1973) found the average correct for kindergarten and second grade children to be 50%, while Berlin et al., (1973) found the average percent scores for children between 5-13 years to be between 55-60 %.

The higher scores obtained in the present study, may be attributed to the age difference of the subjects in the studies by Bryden & Allard (1973) and Berlin et al, (1973). The youngest children evaluated in the present study was seven years, while that in the above studies it was five years. This could have contributed to a lower score obtained in their studies.

(b) At different lag times

As seen in table I, at both (30 msec and 90 msec) lag times for both right and left lag conditions, right ear scores were significantly higher than the left ear scores. In this case, we find the right ear advantage irrespective of the ear to which lag is given. This REA seen in normals on the dichotic listening task is a reflection of the left hemisphere's dominance for speech perception and related functions (Studdert-Kennedy, and Shankweiler, 1970, Kimura, 1961).

Even when lag was given to the left ear, there was no reduction in the right ear scores. This was seen in both 30 msec and 90 msec lag conditions. The result of the present study regarding the lag effect contradictory to the study by Berlin et al. (1973) who reported that higher left ear scores were obtained if the lag was given to the left ear. Studdert-Kennedy and shankweiler(1970) also reported that right ear superiorly was abolished by a left ear lag greater than 20 msec, which contradicts the present study.

But the present study in consensus with the studies by Bingea and Raffin (1986). They found REA at all lag times (0,30, 60,90,120 msec) in both right & left ear lag conditions.

The findings of the study indicate that the REA is so robust that a lag of 90 msec to the left ear is not adequate to overcome this effect It is possible that the REA may be overcome if the lag time to the left ear is further increased.

(i) Comparison of single correct scores across lag conditions.

Table II: Comparison of single correct scores at simultanesly. and across onset time asynchronies in right and left lag conditions.

Lag condition	Ear	Comparison between lag times	Mean scores	t- scores	Levels of significance
Right Lag	RE	0 msec	21.68	0.83	NS
		30 msec	21.86		
		0 msec	21.68	2.46	0.05*
		90 msec	^22.28		
		30 msec	21.86	0.97	NS
		90 msec	' 22.28		
	LE	0 msec	20.44	0.79	NS
		30 msec	20.58		
		0 msec	20.44	1.64	NS
		90 msec	20.86		
		30 msec	20.58	0.94	NS
		90 msec	20.86		
Left Lag	RE	0 msec	21.68	1.84	NS
		30 msec	22.36		
		0 msec	21.68	2.02	0.05*
		90 msec	22.52		
		30 msec	22.36	1.04	NS
		90 msec	22.52		
	LE	0 msec	20.44	0.52	NS
		30 msec	20.22		
		0 msec	20.44	1.85	NS
		90 msec	21.48		
		30 msec	L20.22	L68	NS
		90 msec	21.48		

* Significant at 0.05 level

Right ear lag conditions:

(i) Right ear scores: It is clearly seen from the Table II that the right ear scores at 30 msec right lag were marginally greater than those at 0 msec lag and those at 90 msec right lag were marginally greater than those at 0 msec as well as 30 msec right lag. However a statistically significant improvement in the scores at the 0.05 level, was obtained only when the right ear was increased from 0 msec to 90 msec.

(ii) Left ear scores: There was no statistically significant increase in the left ear scores across the lag times when the lag was given to the left ear.

Left ear lag conditions:

(i) Right ear scores: It can be seen that there is a significant difference at the 0.05 level in the performance of the right ear when the lag was increased from 0 msec to 90 msec. No significant difference was found between 0 msec to 30 msec and between 30 msec to 90 msec lag conditions.

(ii) Left ear scores: No significant difference was found between the left ear scores at 0 msec & 30 msec, 30 msec & 90 msec between 0 msec & 90 msec left lag conditions.

Thus, in both right and left lag conditions, significant improvement was seen when the lag increased from 0 to 90 msec in right ear. No significant improvement was seen in left ear scores across different lag times in both right & left lag conditions.

The result can be discussed on the basis of left hemisphere's dominance for speech perception (Kimura, 1961). As the lag to the right ear was increased the left hemisphere gets more time to process the syllable going to the right ear & hence we can se improvement in the right ear scores. The information transmitted along the auditory pathway from left ear is not sufficient to cause disruption of processing of the right ear signal.

II Double Correct Scores at simultaneity and across lag times:

Table III: Mean, SD, range of double correct scores at simultaneity and across lag times

Lag Time	Mean	SD	Range
0msec	14.24	5.35	4-25
30 msec right lag	15.28	5.44	5-26
30 msec left lag	15.66	4.26	5-28
90 msec right lag	16.98	3.8	4-29
90 msec left lag	16.67	3.35	4-24

As with the single correct scores, the double correct scores also varied across the different lag times in both ears. However, the double correct scored were lower than the single correct scores. It is evident from the table that double correct scores has a lot more variability when compared to single correct scores. The variability decreased as the lag time increased. Also, it was less when the lag was given to the left ear rather than the right ear. The double correct scores steadily increased with increasing lag time, as seen in the table, with the maximum at 90 msec right lag.

With the introduction of a lag, the separation of two signals is more, leading to them being perceived better. This can account for the scores improving with increase in lag time. Earlier studies by Bingea and Raffin (1986), Berlin et al., (1973), support the finding of present study.

Table IV: Comparison of double correct scores across different onset time asynchronies and lag conditions.

EAR	Comparison between lag times	Mean scores	t- scores	Levels of significance
RIGHT	0 msec	14.24	1.2	NS*
	30 msec	15.28		
	0 msec	14.24	3.52	0.01
	90 msec	16.98		
	30 msec	15.28	2.92	0.01
	90 msec	16.98		
LEFT	0 msec	14.24	1.02	NS*
	30msec	15.66-		
	0 msec	14.24	2.28	0.05
	90 msec	16.67		
	30 msec	15.66	1.34	NS*
	90 msec	16.67		

* NS : Not significant

Table IV compares the double correct scores obtained at different onset time asynchronies in the right left lag conditions.

Right ear lag

Double correct (DC) scores improved as the lag to the right ear increased from 0 to 30 msec, and 30 to 90 msec. Significant improvement was seen from the lag to the right ear was increased from 30 msec to 90 msec or from 0 msec to 90 msec.

Left ear lag

Double correct (DC) scores improved as the lag time to the left ear improved. Significant improvement in the performance was seen when the lag time was increased from 0 to 90 msec.

Table V : t-scores & significance of difference across the five age groups.

Age groups	t-score	0 msec	30 msec Rt. lag	30 msec Lt.lag	90 msec Rt. lag	90 msec Lt. lag
7-7.11with 8-8.11	t-score	1.20	0.79	0.33	0.30	0.64
8-8.11 with 9-9.11	t-score	0.55	0.42	1.62	0.85	0.96
9-9.11with 10-KUL	t-score	0.22	1.21	1.86	0.41	0.53
10-10.11 with 11-11.11	t-score	6.00*	6.19*	3.83*	4.22*	3.76*

* Significance at the 0.01 level.

As seen in the table V, there was a significant improvement in the scores from 10-10.11 to 11 toll.11 years.

Table VI : t- scores & significance of difference of DC scores at simultaneity across age groups.

Age groups	t-scores	Significance of difference
7-7.11 to 9-9.11	2.48	0.05
7-7.11 to 10-10.11	3.25	0.01
8-8.11 to 10-10.11	2.14	NS*
8-8.11 to 11-11.11	3.84	0.01
9-9.11 to 11-11.11	2.99	0.05
7-7.11 to 11-11.11	4.01	0.01

*NS : not significant

From Table VI it can be seen that there is a developmental trend. From table V & VI, it is seen that there is no significant difference between the scores obtained by subjects when the age difference is just one year. However, when the age difference is two years or more a significant improvement at either the 0.05 or 0.01 level was seen in double correct scores. Willeford (1978) suggested that the CANS matures with age. The system typically functions at its adult level by 10-11 years of age.

In the present study, it can be seen that at the age of 11 years, the scores approximates the adult standards . This is in agreement with the study by Willeford(1978) who has said that majority of the children achieve adult scores by 10-11 years.

Ill Comparison between dichotic CV test and dichotic CV test-revised :

Ganguly (1996) used dichotic CV material developed by Yathiraj(1994) using 8bit computer software. Subjects in her study were children of age range 8-17 years while in present study; material used was developed by Yathiraj (1999) using a 16-bit computer software & the subjects were children of age range 7-11 years.

Table VII: Comparison between mean, standard deviation and range of single correct scores obtained in the present study and those obtained by Ganguly (1996).

Lag time	Ear	Mean		SD		Range		t-score	Significance
		I	II	I	II	I	II		
0 msec	R	17.56	21.68	3.72	3.41	9-27	13-28	5.80	0.01
	L	14.50	20.44	3.77	3.52	8-21	10-28	7.92	0.01
30 msec right lag	R	20.04	21.86	3.98	3.01	19-27	10-29	2.63	0.05
	L	19.14	20.58	3.54	3.98	5-20	7-30	1.97	0.05
30 msec left lag	R	16.60	22.36	3.85	2.35	10-26	14-29	9.39	0.01
	L	18.54	20.22	4.07	3.91	11-25	12-29	2.12	0.05
90 msec right lag	R	21.88	22.28	3.81	3.87	13-29	5-28	1.3	NS*
	L .	17.84	20.86	4.93	2.43	9-29	10-29	5.69	0.01
90 msec left lag	R	18.28	22.52	4.64	2.81	7-27	14-30	5.36	0.01
	L	20.14	21.48	3.78	3.22	13-29	11-30	1.91	NS*

*NS: not significant
Maximum score: 30

I: Ganguly (1996)

II: Present study

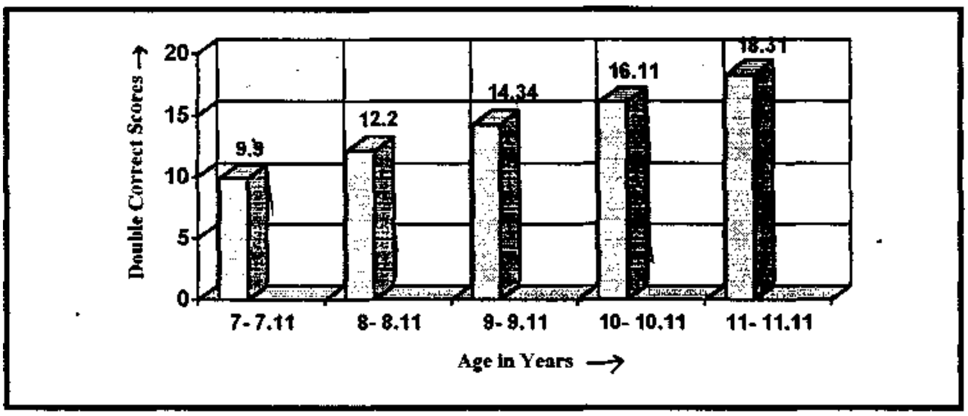
Comparison was done for both single correct (SC) and double correct (DC) scores between the present study and the study by Ganguly (1996). In the comparison of the SC scores table VII it can be noticed that the mean values obtained in the present study are higher than that obtained by Ganguly (1996). The scores of the present study are significantly higher than obtained by Ganguly (1996) except in two conditions. The scores were significantly higher for almost all the lag conditions in both the left & right ears. This could be due to the poor quality of the signal used in the study by Ganguly (1996) material developed using 8 bit computer software. The two conditions where there was no significant difference were 90 msec right ear, right lag condition & 90 msec left ear, left lag condition. This could be attributed to the "lag effect". As 90 msec lag condition, subjects obtained higher scores in the ear where the lag was present done by Ganguly (1996). The scores obtained by Ganguly (1996) were almost equal to that obtained in the present study, in this condition. The lag effect at 90 msec could help overcome the perception difficulty due to the poor quality of the signal. In the present study at 90 msec lag condition, the scores obtained are similar to that of Ganguly (1996). This probably indicates that at 90 msec lag condition, the score, which has been got, is the maximum score that can be expected. Hence there is no statistically significant difference between the present study & study by Ganguly (1996) at 90 msec lag condition.

These results can be attributed to the speech & language function dominance of the left hemisphere, left ear required 90 msec lag to show a significant improvement but in right ear, when the lag was increased from 30 to 90 msec, there was improvement in performance. Berlin and McNeil (1976) noted that the number of double correct responses on a dichotic task increased with age from 5 to 13 yrs. And thus may be correlated with improved language skills throughout that age range.

Ill Effect of age on dichotic ear advantage

Variation of dichotic scores with age was analyzed to check for any developmental trend in dichotic Listening. This reflects the age at which the hemispheric dominance is achieved for speech and also the developmental changes. The double correct scores were analyzed to study this developmental change. Bellis (1996) has suggested that to study the developmental changes, double correct scores should be considered.

Graph I: Mean scores at simultaneity for double correct scores.



As seen in graph I, the scores improve from 7 to 11 years. This improvement is gradual and steady.

Table VIII: Mean, standard deviation, t-scores of the present study as compared to Ganguly (1996) study.

Lag time	Mean		SD		Range		t-score	Significance
	I	II	I	II	I	II		
Omsec	6.9	14.24	2.00	5.35	1-17	4-25	9.17	0.01*
30 msec right lag	7.66	14.28	3.97	5.44	2-17	5-26	6.96	0.01*
30 msec left lag	8.17	15.66	3.07	4.26	0-21	5-28	10.12	0.01*
90 msec right lag	12.34	15.98	5.50	3.8	3-25	4-29	3..87	0.01*
90 msec left lag	11.17	16.67	4.74	3,35	4-27	4-24	6.7	0.01*

* Significant at 0.01 level

I: Ganguly (1996)

II: Present study

Table VIII Comparison of double correct scores between the present study as compared to Ganguly (1996). This demonstrates a comparison between the double correct scores as obtained by Ganguly (1996) & the present study. It can be noticed that in all conditions, there was a significant difference in the scores between the present study & Ganguly's study (1996). It can also be observed that the upper limit of the range is higher in the present study, implying better performance in test. As mentioned earlier, this difference can be attributed to the quality of the material used in the two studies.

IV Comparison between scores obtained by children and adults :

Puranik (2000) in her study on adults between the age range of 18-25 years has used "Dichotic CV-Revised" developed by Yathiraj(1999). She has found a significant REA and lag effect

Both the single correct scores & the double correct scores of the present study were compared with that obtained by Puranik (2000).

Table IX : Comparison between mean, standard deviation and range of single correct scores at simultaneity and across lag times.

Lag time	Ear	Mean		SD		Range		t-score	Significance
		I	II	I	II	I	II		
Omsec	R	27.46	21.68	1.76	3.41	23-30.	13-28	4.83	0.01*
	L	25.82	20.44	2.98	3.52	19-30	10-28	3.78	0.01*
30 msec right lag	R	28.06	21.86	1.71	3.61	23-30	10-29	6.29	0.01*
	L	26.16	20.58	2.66	3.98	19-30	7-30	3.77	0.01*
30 msec left lag	R	27.82	22.52	2.24	2.35	17-30	14-29	5.25	0.01*
	L	25.78	20.22	2.87	3.91	17-30	12-29	3.70	0.01*
90 msec right lag	R	28.22	20.86	1.59	3.87	23-30	5-28	5.70	0.01*
	L	26.88	22.28	2.36	2.43	21-30	10-29	4.30	0.01*
90 msec left lag	R	28.36	22.36	1.63	2.81	22-30	14-30	5.98	0.01*
	L	26.02	21.48	2.71	3.22	20-30	11-30	3.49	0.01*

* Significant at 0.01 level

Table X : Comparison between mean, standard deviation and range of double correct scores at simultaneity and across lag times.

Lag time	Mean		SD		Range		t-score	Significance
	I	II	I	II	I	II		
0 msec	23.46	14.24	3.69	5.35	15-30	4-25	4.56	0.01*
30msec right lag	23.98	14.28	3.73	5.44	15-30	5-26	4.73	0.01*
30 msec left lag	24.36	15.66	3.66	4.26	15-30	5-28	5.01	0.01*
90 msec right lag	25.08	15.98	3.66	3.8	18-30	4-29	6..02	0.01*
90 msec left lag	24.56	16.67	3.29	3.35	16-30	4-24	5.44	0.01*

* Significant at 0.01 level

The results show that the scores of the present study are significantly different from that of Puranik (2000). This indicates that the children between the age range of 7-11 years have not yet reached the adult standards. When the overall scores are considered, it gives an impression that the children between 7-11 year olds do not obtain adult scores. However when only the scores obtained by 11 year olds are considered, it approximates the scores obtained by adults. So, we can infer that the children at around 11 years achieve the adult scores. Thus the finding of the present study confirms the presence of REA on the Indian population. The performance improved as the lag time was increased. This was seen for both single and double correct responses. Further, it was seen that even at the age of 11 years the scores approximate that of the adult scores. This is in accordance with the earlier studies by Willford, (19735) and Berlin and McNeil, (1976) that the adults like scores are achieved by 10-1 lyears of age.

SUMMARY AND CONCLUSIONS

Dichotic speech testing requires the simultaneous presentation of a different speech signal to each of the ears. Dichotic CV is one such test. It is used as a tool in the deletion of lesions of the central nervous system (Willeford & Burleigh, 1986). It is necessary to run such tests in children so that it is possible to detect central auditory processing problems early and to implement appropriate management program.

The study aimed at obtaining normative data on children for the dichotic CV test-revised, developed by Yathiraj (1999). The material for the test was developed using a 16 bit computer software, at the All India Institute of Speech and Hearing, Mysore.

The subjects in the study were 50 normal right handed children between the age group 7-11 years. They were divided in to 5 groups according to then-age and there were 10 children in each group. The task for the subjects was to identify the nonsense CVs presented dichotically at simultaneity and across onset time asynchronous (0 msec, 30 msec, 90 msec). The lag was given either to the right or the left ear scoring was done in terms of single correct and double correct responses. The raw data was then statistically analyzed, mean, standard deviation and range was calculated. The t-test was used to check the significance of the difference between the means of different parameters.

The results of the present study can be summarized as follows:

1. The analysis of the single correct scores at simultaneity revealed a significant right ear advantage. Right ear advantage was also seen across the different onset time asynchronies

2. Single correct scores as well as the double correct scores improved with increasing lag time. This improvement in scores was significant only when the lag was increased from 0 msec to 90 msec, in both right and left lag conditions.

In general, the double correct scores were lower than single correct scores at simultaneity as well as across lag times.

These findings are consistent with those of Berlin et al.,(1973), Bingea and Raffin(1986), Olsen(1983), Studdert-Kennedy et al.,(1970) , Rajgopal (1996) and Ganguly (1996).

Comparison between dichotic CV test and dichotic CV test- revised

The scores of the present study were compared with those of Ganguly (1996), who developed normative data on children for dichotic CV material developed by Yathiraj (1994) using 8 bit computer software.

It was found that the scores obtained in the present study were significantly higher than those obtained by Ganguly (1996). Though the lag effect and REA was seen in both the studies. This difference can be attributed to the material used in the study. The material used in the present study had a better clarity and resolution of the speech signal.

Comparison of children Vs adult scores

Scores of the present study was compared with the data obtained by Puranik (2000) on adults using dichotic CV test revised developed by Yathiraj (1999) using 16 bit computer software. The overall scores of the present study were significantly lower than that of adults. But when the scores of the 11-11.11 year olds were considered , it was seen that the scores approximated the adult scores, as obtained by Puranik (2000)

For dichotic test, monosyllables are frequently chosen because of the relative ease of obtaining precise temporal alignment of the stimuli presented to each ear. Also dichotic CVs are resistant to linguistic and dialect variations. In a country like India, dichotic CV test is best suited for the above reasons.

It is also more difficult task than bisyllables or sentences, employed for dichotic testing.

The normative data obtained in the study can be used to demarcate the normal and the abnormal population. As seen in the review several factors should be considered while testing a client.

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APPENDIX - 1

Calibration of Audiometer

Both intensity and frequency calibration was done for puretone generated by the clinical audiometer (Madsen OB 822).

Intensity calibration for air conducted tones were carried out with the output of the audiometer set at 70 dB HL (ANSI, 1989). Through the earphones (TDH 39 with MX-41/AR ear cushions). The acoustic output of the audiometer was given to a condenser microphone (B&K 4144) which was fitted into an artificial ear (B&K 4152). The signal from the artificial ear was then fed in to a calibrated sound level meter (B&K 2209) with an octave filter set (B&K 1613) Through a preamplifier (B&K 2616) using a half inch to one inch adapter (B&K DB 0962). The output SPL value were noted for frequencies 250 Hz through 8000 Hz and compared with the expected values according to ANSI standards, 1992. If there was a discrepancy of more than 2.5 dB, it was corrected by means of internal calibration.

Bone Vibrator Calibration

Radio ear B-71 (bone conduction vibrator) was calibrated for frequencies 250 Hz through 4000 Hz. The output of the audiometer was set at 40 dB HL. The output of the audiometer was set at 40 dB HI. From the bone conduction vibrator, the acoustic signal was fed to the artificial mastoid (B&K 4980). This output was then fed via a preamplifier to the SLM (B&K 2209). A difference of more than 2.5 dB between the observed SPL value and the expected value (ANSI Standards, 1989) was internally calibrated.

Frequency Calibration

The electrical output of the audiometer was fed into the time / frequency counter (Radart 230) which gave a digital display of the generated frequency. If the difference between the dial reading on the audiometer and the digital display of a given frequency, exceeded + or - 3 % (ANSI standards, 1989) of the characteristic frequency tested, then an internal calibration was done.

Linearity check

The linearity attenuator was checked. The intensity dial of the audiometer was set at the maximum level and the frequency dial was set to 1000 Hz. The attenuator on the SLM was set at a level corresponding to the maximum level on the audiometer. The attenuator setting on the audiometer was decreased in 5 dB steps till 30 dB and the corresponding reading on the SLM was noted. For every decrease in the attenuator setting the SLM indicated a corresponding reduction.

Tape Calibration

A 1000 Hz tone at 70 dBHL was presented for tape calibration. The VU meter gain was set so that the needle peaked at 0. This was carried out prior to the presentation of each list.

Frequency response characteristics of earphones

The frequency response characteristics of the TDH 39 earphone was obtained using signal generator (B&K 1023), pressure microphone (B&K 4145), frequency analyzer (B&K 2107) and graphic level recorder (B&K 2616). The electrical output of the signal generator (B&K 1023) was fed to the headphone. The output picked up by microphone (B&K 4145) was fed to the frequency analyzer (B&K 2107). The output was recorded on graphic level recorder (B&K 2616).

APPENDIX 2.

RESPONSE SHEET

1	PA	TA	KA	BA	DA	GA
2	PA	TA	KA	BA	DA	GA
3	PA	TA	KA	BA	DA	GA
4	PA	TA	KA	BA	DA	GA
5	PA	TA	KA	BA	DA	GA
6	PA	TA	KA	BA	DA	GA
7	PA	TA	KA	BA	DA	GA
8	PA	TA	KA	BA	DA	GA
9	PA	TA	KA	BA	DA	GA
10	PA	TA	KA	BA	DA	GA
11	PA	TA	KA	BA	DA	GA
12	PA	TA	KA	BA	DA	GA
13	PA	TA	KA	BA	DA	GA
14	PA	TA	KA	BA	DA	GA
15	PA	TA	KA	BA	DA	GA
16	PA	TA	KA	BA	DA	GA
17	PA	TA	KA	BA	DA	GA
18	PA	TA	KA	BA	DA	GA
19	PA	TA	KA	BA	DA	GA
20	PA	TA	KA	BA	DA	GA
21	PA	TA	KA	BA	DA	GA
22	PA	TA	KA	BA	DA	GA
23	PA	TA	KA	BA	DA	GA
24	PA	TA	KA	BA	DA	GA
25	PA	TA	KA	BA	DA	GA
26	PA	TA	KA	BA	DA	GA
27	PA	TA	KA	BA	DA	GA
28	PA	TA	KA	BA	DA	GA
29	PA	TA	KA	BA	DA	GA
30	PA	TA	KA	BA	DA	GA

1	PA	TA	KA	BA	DA	GA
2	PA	TA	KA	BA	DA	GA
3	PA	TA	KA	BA	DA	GA
4	PA	TA	KA	BA	DA	GA
5	PA	TA	KA	BA	DA	GA
6	PA	TA	KA	BA	DA	GA
7	PA	TA	KA	BA	DA	GA
8	PA	TA	KA	BA	DA	GA
9	PA	TA	KA	BA	DA	GA
10	PA	TA	KA	BA	DA	GA
11	PA	TA	KA	BA	DA	GA
12	PA	TA	KA	BA	DA	GA
13	PA	TA	KA	BA	DA	GA
14	PA	TA	KA	BA	DA	GA
15	PA	TA	KA	BA	DA	GA
16	PA	TA	KA	BA	DA	GA
17	PA	TA	KA	BA	DA	GA
18	PA	TA	KA	BA	DA	GA
19	PA	TA	KA	BA	DA	GA
20	PA	TA	KA	BA	DA	GA
21	PA	TA	KA	BA	DA	GA
22	PA	TA	KA	BA	DA	GA
23	PA	TA	KA	BA	DA	GA
24	PA	TA	KA	BA	DA	GA
25	PA	TA	KA	BA	DA	GA
26	PA	TA	KA	BA	DA	GA
27	PA	TA	KA	BA	DA	GA
28	PA	TA	KA	BA	DA	GA
29	PA	TA	KA	BA	DA	GA
30	PA	TA	KA	BA	DA	GA

APPENDIX 3

SCORING SHEET

Date:

Name: Mother tongue:

Age/Sex: Other languages:

Education Socio-economic status:

AUDIOLOGICAL INVESTIGATION:

EAR	Frequency in Hz								
	250	500	1000	2000	4000	8000	PTA	SRT	PBMax
Right									
Left									
BC									

Monotic Scores (%):

Right ear: **Left ear:**

Dichotic scores(%):

R L	**R L**	**R L**	**R L**	**R L**