EFFECT OF MATURATION ON DICHOTIC TESTS: A COMPARISON OF DICHOTIC DIGIT AND DICHOTIC CONSONANT VOWEL TEST

Reg.No.02SH0012

Independent Project as a part of fulfillment of
First year M.Sc, (Speech and Hearing),
Submitted to the University of Mysore,
Mysore.

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE - 570006
May, 2003

CERTIFICATE

This is to certify that this Independent project entitled

"EFFECT OF MATURATION ON DICHOTIC TESTS: A COMPARISON OF DICHOTIC DIGIT AND DICHOTIC CONSONANT VOWEL TEST:

is a bonafide work in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student with **Register No.02SH0012.**

Mysore
May,2003

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CERTIFICATE

This is to certify that this Independent project entitled

"EFFECT OF MATURATION ON DICHOTIC TESTS: A COMPARISON OF DICHOTIC DIGIT AND DICHOTIC CONSONANT VOWEL TEST:

has been prepared under my supervision and guidance.

Mysore
May,2003

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DECLARATION

I hereby declare that this Independent project titled **"EFFECT OF DICHOTIC TESTS: A COMPARISON OF DICHOTIC DIGIT AND DICHOTIC CONSONANT VOWEL TEST"** is the result of my own study under the guidance of **Dr.C.S. Vanaja,** Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted in any other diploma or degree.

Mysore
May, 2003

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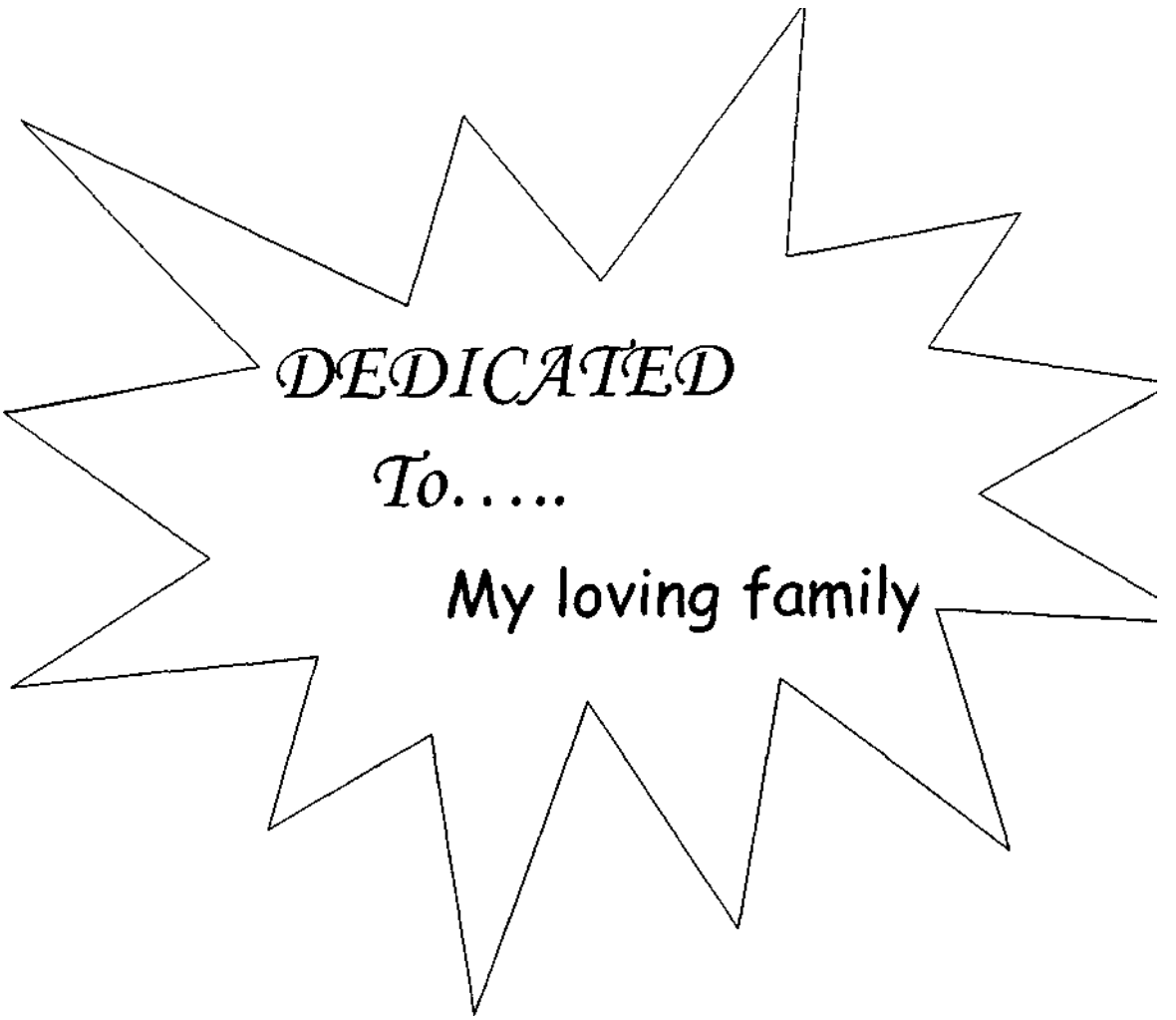
DEDICATED
To.....
My loving family

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INTRODUCTION

Auditory processing 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. Some individuals may have Central Auditory Processing Disorder or Auditory Processing Disorder in which one has difficulty processing auditory information when presented in a less than optimal listening environment. A majority of these individuals hear even the faintest of sounds, but are unable to process verbal stimuli in an effective manner.

For the successive treatment of this condition proper assessment is necessary. The test battery used in the evaluation should assess all the phenomena responsible for auditory processing. An individual's auditory performance with competing signals can be assessed through tasks which require dichotic listening. Dichotic listening refers to auditory stimuli that are presented to both ears simultaneously, with the stimulus presented to each ear being different. There are several tests that utilize dichotic listening. The dichotic listening tasks used in these tests can be divided into two main types. They are binaural summation task in which the subject is asked to repeat what is presented to both ears and binaural separation task in which subject is asked to repeat only what is presented to the ear designated by the examiner (Katz, cited in Katz & Ivey, 1994).

Some of the tests that check binaural integration are Dichotic Digit test (Kimura, cited in Pinherio & Musiek, 1985); Dichotic Consonant Vowel test (Berlin, cited in Bingea & Raffin,1986); Staggered Spondaic Words test (Katz, cited in Katz & Ivey,

1994) and Dichotic Rhyme test (Wexler & Halwes 1983). Tests such as Competing Sentence test (Willeford, cited in Willeford,1977) and Synthetic Sentence Identification with Contralateral Competing Message (Jerger, citrd in Pinherio & Musiek,1985) test binaural separation.

Dichotic test is a non-invasive tool which is a reliable indicator of auditory capacity and also linguistic laterality (Asbjornsen, cited in Helland, 1995). Of all these tests Dichotic Digit test (DDT) and Dichotic Consonant Vowel test (DCVT) have long been used experimentally as well as clinically (Bellis 1996).

In DCVT different pairs of numbers are presented simultaneously to the two ears and the subject is asked to repeat all the four digits heard (Musiek 1983a). In DCVT, stimuli consist of six CV segments (|pa|, |ta|, |ka|, |ba|, |da|, |ga|). Single CV segments are presented to each ear using a dichotic paradigm and the listener is asked to repeat both segments heard (Berlin, Lowe-Bell, Jannetta & Kline, cited in Shivashanker &Herlekar, 1991).

Both DDT and DCVT have been shown to be sensitive to brainstem and cortical lesion (Musiek 1983 a; Musiek 1983b) as well as lesions of corpus callosum (Musiek, Kibbe & Baran, cited in Shivashankar & Herlekar, 1991).These tests can also be used to check cerebral dominance. Generally in normal listeners higher scores are obtained for the material presented in right ear than 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 & Thompson, 1973).The REA is more pronounced in linguistically loaded dichotic listening tasks (Keith, cited in Bellis, 1996).

Both these tests can be administered to individuals of all age groups and have advantages as well as limitations. DDT is quick and easy to administer and score. DCVT is more difficult than DDT. So this test precludes its use to some population (Muller & Bright, cited in Bellis,1996). The advantage of this test is that it is not language specific. It only has to be ensured that these syllables are present in the language known to the subject whereas DDT is language specific. Maturational effects observed in dichotic tests are more pronounced for linguistically loaded stimuli (Bellis, 1996).

Aims of the Study

The aims of the study were as follows:

1. To establish normative data for DDT for age group from 7 years to 11.11 years and adults.
2. To compare the scores of children and adults for DDT.
3. To compare the developmental trend in DDT and DCVT i.e., to compare the maturational effect on single correct scores and double correct scores.

Need for the study

The need for the study is justified as follows.

- Normative data is very essential in a clinical setting to separate the normals and persons with Auditory Processing Disorder to work for their betterment. The performance of dichotic tasks increases as a function of age (Bellis, 1996). Effect of age on DCVT has already been studied and norms have been established on

Indian population. Shivashankar (cited in Shivashankar & Herlekar, 1991) has developed DDT in Kannada. Shivashankar and Herlekar (1991) consider a 90% score as low cutoff point for both adults and children. Since a review of literature says that age has an effect on dichotic tests it is essential to establish age specific norms for DDT in Kannada before using it in clinical population. So the present study investigates the maturational effect of DDT as a function of age and tries to establish normative data for DDT for children of age ranging from 7 to 11.11 years and adults.

- It has been reported that the maturational effect observed for dichotic tests are more pronounced for linguistically loaded stimuli (Bellis 1996). Also studies have shown that DCVT is a more difficult task when compared to DDT (Niccum, Rubens & Speaks, 1981). From this one can infer that there will be a difference in the maturational effect observed for right ear scores, left ear scores and double correct scores in the two tests. So the present study compares the developmental trend seen in the performance of DDT and DCVT since there is dearth of studies comparing DDT and DCVT.

REVIEW OF LITERATURE

The dichotic tests are highly sensitive in assessing Auditory Processing Disorders (APD). Both Dichotic Digit test (DDT) (Kimura, cited in Pinherio & Musiek, 1985) and Dichotic Consonant Vowel test (DCVT) (Berlin, cited in Bingea & Raffin, 1986) are binaural integration tests. These tests are used to assess the auditory capacity i.e., the maximum amount of information that can be handled by the auditory system which is measured by the accuracy of recall by computing the double correct scores (Bellis, 1996).

A number of factors affect the results of dichotic tests. A few of them are:

1. Age of the client.
2. Stimulus material.
3. Stimulus dominance.
4. Intensity of the signal.
5. Temporal aspect.
6. Attention of the client (focused or diffused)
7. Response mode.
8. Reliability of the test (test - retest reliability)
9. Deviant population.

The effect of these factors on the performance of dichotic listening tasks is discussed briefly.

Age of the client

The central auditory processing has maturational effect as the age increases (Katz, cited in Katz & Ivey, 1994). The number of incidences in which stimuli presented to both left and right ear was reported correctly, increased significantly as a function of age. The improvement in performance reflects an increase in the brain's ability to process two-channel stimuli as a function of age (Bellis, 1996). A study done by Krishna (2001) reports that the double correct score i.e., the correct score obtained from right ear and left ear increases from 7 to 11 years of age. Similar results were reported by Rajgopal (1996) and Puranik (2000). The more linguistically loaded the stimuli presented are, the more pronounced the maturational effects are likely to be (Bellis, 1996).

In normal individuals, when speech stimulus is presented dichotically higher scores are obtained from the material presented to the right ear than to the left ear. This is referred to as Right Ear Advantage (REA) (Bingea & Raffin, 1986).The standard explanation for the REA is that the contralateral pathways suppress the unilateral pathways at the level of the brainstem thus favouring the right ear input to the language dominated left hemisphere in right handed population (Springer & Deutsch, cited in Willeford & Burleigh, 1986).

Ear advantage depends on the handedness of the subject. Identification performance by right and left handed subjects is different (Wilson & Leigh, 1996). In a study conducted by Strauss (1986) normal men and women taken as subjects were classified on overall congruency across lateral performance and the subject were presented dichotic listening test to determine the ear advantage. The results revealed

that hand preference was the most successful variable in predicting ear advantage on the dichotic listening test.

It was observed by Gilbert and Climan (1974) that there was a significant REA even at the age of 2-3 years. In this study thirty six children between the age range 2-3 years were administered single pairs of words dichotically. The result shows that a significant REA was seen at this age, indicating that left hemisphere would have achieved some degree of dominance for language. Ingram (cited in Jerger & Jerger, 1975) also reported that right ear superiority is indicated on dichotic listening tasks at the age as early as 3 years, suggestive of the left hemisphere dominance to certain extent for speech functions by that age. Although the above studies say that REA is seen at around 2 to 3 years of age, individual variations are noticed. But Kimura (cited in Pinherio & Musiek, 1985) reported that REA appeared no later than the age of 6 years for speech and language.

Many studies have been done to investigate the maturation of REA. The results of the studies vary in three dimensions. Some report that REA increases as a function of age, some report that it decreases with age and some others say it remains constant throughout.

Several studies have shown that the REA matures with age and becomes more lateralized, Satz, Bakker and Goebel (1975) reported in their study that a significant difference was noticed in the behaviour of 6 and 7 year old children in comparison to 9, 11 and 13 year old children in the perception of voiced and un-voiced consonants in the dichotic task. They concluded that the language skills can be reflected in the presence of REA suggesting the left hemisphere dominance as the children develop

from the age of 5 to 13 years. Similar results have been reported by other investigators (Berlin, Lowe -Bell, Cullen, Thompson & Stafford, 1973; Gilbert & Climann, 1974; Strauss, 1986; Rajgopal, 1996; Puranik, 2000; Krishna, 2001).

On the other hand study by Willeford (cited in Katz &Ivey, 1994) using Competing Sentence test revealed that the scores of the left ear improved with increasing age up to 8-10 years of age at which time, right and left ear performance is equal. This study is supported by another study done by Willeford & Burleigh (cited in Bellis, 1996) which showed that left ear score increases and REA decreases as a function of age. Musiek,Gollegy & Baran (cited in Bellis, 1996) hypothesis that as the child becomes older and myelination of the corpus callosum is completed, inter hemispheric transfer of information is improved and left ear scores approach those found in adults. They reported that as the child matures, the REA would decrease, reaching adult values by approximately 11 to 12 years.

Contrary to these studies some studies suggest that REA is constant throughout development (Kinsbourne, cited in Morris, Bakker, Satz, Van der vlugt, 1984). The REAs of both elderly and young subjects were virtually identical. The children acquired functional differences by the age of 5 years and behave in the same manner as the elders behave for dichotic listening (Bellis, 1996).

From the above studies it is evident that performance of dichotic tests improve with age. REA is observed for dichotic tests in children as well as in adults. There is controversy regarding the maturational effect on REA.

Stimulus Material

Several stimulus materials are used in dichotic tests. The test materials commonly used are digits (Kimura, cited in Pinherio & Musiek, 1985), CV (Berlin, cited in Bingea & Raffm, 1985), sentences (Speaks & Jerger, cited in Pinherio & Musiek, 1985; Willeford, cited in Willeford, 1997) and rhyme (Wexler & Halwes, 1983).

The performance for dichotic listening tasks vary depending on the stimulus material used for testing. A study done by Noffsinger, Martinez and Wilson (1994) included three tests of dichotic listening via., dichotic monosyllabic digit task, dichotic synthetic sentence task and dichotic nonsense syllable (CV) task. The result revealed that the listeners had little difficulty in identifying digits or synthetic sentences but correct responsiveness was less frequent when the stimuli were dichotic CVs. Similar results were obtained by Niccum, Rubens & Speaks (1981) who reported in their study that the DCVT is a more difficult task when compared to dichotic digit test.

These studies evidence that DDT is easier than DCVT. This may be because the stimuli are more similar and closely aligned in DCVT whereas in DDT linguistic cues are relatively more though the stimuli are closely aligned (Miller et al., cited in Strouse, Wilson & Brush, 2000).

A Study done by Koomar and Chermak (1981) contradicts the above findings. They conducted a study using dichotic CV and dichotic digit formats on normal aswellas learning disabled children between the age group of 7 and 10 years. The results

revealed that there was no significant difference in ear advantage between the two materials.

From the above studies it can be understood that response obtained from subjects varied depending on the linguistic content of the material used. The dichotic CV test is difficult when compared to dichotic digit test. The REA also varied depending on the stimulus material.

Stimulus dominance

The phonemic content of the stimulus material also has an effect on dichotic listening. DCVT is affected more by this factor when compared to DDT since linguistic loading is more in DDT.

In the perception of the dichotically presented syllables (DCVT) a phenomenon called phonetic effect or stimulus dominance is seen in which higher scores are got for one of the two competing syllables - the dominant one, regardless of the ear to which it is presented (Roeser , Johns & Price, 1972). It has certain cues that are responsible for the phenomenon, and several studies have been done to study this phenomenon.

Berlin et al., (1973) found that velars were reported more correctly followed by the bilabials and the apicals had least correctness. A study done by Porter, Trondle and Berlin (1976) also reported that velars were more often reported correctly than alveolars, which in turn are reported more correctly than labials. These studies are supported by the studies done by other investigaters (Speaks, Niccum & Tasell, 1985; Rajgopal, 1996).

A study done by Hayes (cited in Pinherio & Musiek, 1985) evaluated the role of distinctive features in twenty one dichotically presented syllables. The results showed that plosive syllables showed a larger REA and greater accuracy when the competing stimuli contrasted on one, rather than two or more distinctive features. The other consonants, on the other hand showed better identification with increase in feature contrasts. This divergence between stops and the consonant classes is probably related to the fact that the acoustic cues for stops are much briefer than the cues for other consonants.

Roeser et al., (1972) reported that voiceless consonants scored better when compared to voiced consonants in a dichotic listening task. Berlin et al., (1973) also reported that scores were higher for voiceless stops |pa|, |ta|, |ka| than for the voiced stops |ba|, |da], |ga|. Porter et al., (1976) reported that regardless of ear of presentation, the voiceless syllables are reported correctly when compared to the voiced syllables. Similar results were reported by other investigators (Niccum et al., 1981; Rajagopal, Ganguly & Yathiraj, 1996).

Hannah (cited in Kumar, 1971) 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 items. Repp (1976) conducted two studies to determine the effects of variation in VOT on the perception of dichotic CV syllables contrasting in 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 voiceless stimuli had a larger effect than changing the VOT of voiced stimuli.

Lisker and Abramson (cited in Klatt, 1975) found category boundaries for VOT labial +20 msec, alveolar + 35 msec and velars + 40 msec and proposed a model. The model could predict that the syllable most distant in (VOT) from its category boundary would be the dominant member e.g., in |pa-ba| pair |pa| has VOT of+40 msec and |ba| has +20 msec which are 30 msec and 10 msec away respectively from the boundary of + 10 msec. Hence it was concluded that |pa| should be the dominant member. This supports the hypothesis proposed by Repp (1976) which says that stimuli that are distant from the category boundary are likely to dominate than those lying close to the boundary.

It is evident from the above studies that in dichotic presentation of CV stimulus voiceless consonants are more intelligible than voiced and also velars are more intelligible when compared to alveolars and labials when place and manner are considered.

Intensity of the signal

It is a known fact that the speech identification scores vary depending on the intensity of the signal. So even for dichotic tests presentation level of the signal is expected to influence the response received. Another factor, which influence dichotic test is the relative difference in the intensity levels of the signals presented to the two ears.

Roeser et al., (1972) designed a study to investigate the intensity function on right ear effect. They considered a range of intensity levels 10,30,50,70 dBSL. 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. Results did not show REA to differ significantly as a function of SL.

Dobie and Simmons (1971) conducted a study in which speech sounds were presented dichotically to normal subjects. They found that the 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 dBSPL.

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

Thus very few studies have investigated the effect of intensity on dichotic listening. These studies show that the responses were poor at low intensity levels and REA does not differ as a function of SL. Though relative difference in intensity affects the results, it is not of concern for DDT and DCVT as the signals are generally presented at equal intensity.

Temporal aspects

The performance for dichotic listening varies when both the stimuli are presented simultaneously to stimuli presented with a gap between the two. 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 resulting in 'ear advantage'.

There are many studies done on DCVT varying the temporal alignment and it was found that temporal alignment has a strong effect on the performance. Berlin and Lowe-Bell (cited in Katz & Ivey, 1994) conducted a study using CV nonsense syllables which were presented with syllables separated by 0, 15, 30, 60 and 90 msec. It was found that intelligibility was poor for simultaneous presentation when compared to the 15, 30, 60 and 90msec separation of the stimuli. Olsen (1983) also has shown similar results.

Bingea and Raffin (1986) conducted a study in which they used 30, 60, 90 and 120msec as onset time asynchrony for dichotic CV. They found that there was a significant REA at 0msec and significant variation of scores as 0msec time asynchrony lengthened. Studies done by other invesatigators (Rajgopal, 1996; Puranik, 2000; Krishna, 2001) also show that the overall scores improved from 0msec to 90msec. The right ear advantage was maximum at 0msec condition. Generally lagging signal is perceived better than leading signal in DCVT.

It can be noticed from the above studies that there is an improvement in the performance when there is a lag in the stimulus presented to the two ears than when presented simultaneously. From this we can infer that in DDT also lagging signal will be perceived better than the leading signal.

Attention of the client (focused / distributed)

The difference in perception of speech signal presented dichotically can be biased based on whether the person is asked to pay attention to one ear (directed recall)

or distribute attention to both ears (free recall). There are many studies done to study the effect of attention on different stimulus materials.

In a study conducted by Hiscock and Stewart (1984) on normal right handed adults, using dichotic listening task with free report instructions after having completed a selective listening task. 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 tools or the subsequent free report task.

Bloch and Hellige (1989) investigated the effect of attention to both ears or focused attention on one ear is dichotic listening tasks. 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 Katbamma (1985).

Obrzut, Bolick and Obrzut (1986) conducted a study on twelve subjects of mean age of 10.5 years and whose academic performance is high. They were administered four types of dichotic stimuli (words, digits, CV and melodies) in three experimental conditions (free recall, directed left and directed right) to examine perceptual asymmetry as reflected by the REA. REA for words and CV aswellas 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. Hiscock and Beckie (1993) studied fifty eight children in the age range of 7 to 10 years. The subjects were asked to focus attention to the left ear. The children were able to overcome the RE A for dichotic CV stimuli.

In contrast to the above study, a study done by Hugdahl and Anderson (1986) suggested that by diverting the attention towards left ear, REA couldnot be abolished. Similarly Brydan, Munhall and Allard (1983) found in his study that REA is present in free recall condition and also when the order of report was controlled.

From the above studies it can be summarized that REA is sometimes absent when a direct recall procedure is followed and the result varies depending on the linguistic content of the material.

Response mode

For the dichotic listening test subjects can be asked to respond in many different ways like pointing, selecting, repeating orally or by writing. There are many studies done to investigate the effect of response mode on dichotic listening tasks. It has been reported that oral identification scores were always higher than write down identification scores (Merill & Atkinson, 1965; Nelson & Chaiklin, 1970).

Investigations were conducted to study if REA changes in different response modes. In a study done by Janke (1993) thirty six male right handers and fifty male left handers were asked to respond in three modes (verbal repetition, written , visual recognition) for monosyllabic CV syllables which were dichotically presented. The results suggested that ear advantage scores are not influenced by the response condition.

Similar results were obtained by Krishna and Yathiraj (2001) where children between 10 to 11 years of age were asked to respond by oral repetition and also written for dichotic CV test. Results showed no significant difference between the two modes of response and the REA was not influenced by the response mode.

From the above studies in can be noticed that response mode does not have notable effect on the dichotic tests. Though these studies have used only DCVT, similar results can be expected for DDT also.

Reliability of test (test-retest reliability)

Being behavioural tests dichotic tests may show a tendency for variation of scores from time to time. The reliability of the test also depends on the design factors such as practice, response mode, and type of analysis used to score the response.

Millay, Roeser and Godfrey (1977) studied the reliability of scores for eight normal hearing adult females, for eight weekly sessions, for dichotically presented CV syllables. They found that the responses did not vary across the sessions, the ear laterality also remained constant across the sessions. Similar findings were obtained by Gadea, Gomer and Espert (2000) who studied sixteen subjects on dichotic listening of CV syllables. The subjects were tested twice, two weeks apart. The results showed that there is a high stability of scores obtained between the two testings.

A study done by Porter et al., (1976) also supports the above findings. In this study performance of subjects on dichotic CV test was observed over an eight week period. A significant improvement was seen over the first three sessions, while the

performance remained stable for the last five sessions. The magnitude of REA however was not significantly different across the eight sessions.

Attempts have also been made to compare the reliability of different tests. Koomer and Chermak (1981) conducted a study on children between the age of 7 and 10 years reported that the children obtained higher reliability on the CV format than on the digit format.

It can be evidenced from the above studies that the reliability of scores is good for both DDT and DCVT.

Deviant population

Dichotic tests are developed to assess Auditory Processing Disorders (APD). It has been reported in literature that peripheral hearing loss also has an effect on the tests for APD (Katz, Burkard & Medwetsky, 2002). An investigation was conducted by Speaks et al., (1985) to study the effect of sensory neural hearing loss in four dichotic speech tests via., Dichotic digits, Vowel words, Consonant words and CV nonsense syllables. Tests were administered at an intensity that produced asymptotic monotic performance for both ears with CV syllable. The results show that DDT appeared to be the most promising test for assessing Central Auditory function when the patient had sensory neural hearing loss because performance for the digits was only slightly afflicted by peripheral loss.

Deviant populations in whom Auditory Processing may be affected include subjects with temporal lobe lesion and learning disability. Broadbent (cited in Pinherio & Musiek, 1985) studied subjects with unilateral temporal lobe ablation. The results

showed a reduced score in the ear contralateral to the side of ablation in DDT. Musiek (1983a) also studied twenty subjects with intra cranial lesion and found that there was a markedly reduced performance for the ear contralateral to the hemispheric lesion in DDT.

Similar findings were found for Competing Sentence tests, Staggered Spondaic Words test and DDT on thirty subjects with intra cranial lesion Musiek (1983b). In a study done by Shivashankar and Herlekar (1991) using DDT he found significantly poorer performance in the ear contralateral to the lesioned hemisphere. In subjects with sub-cortical lesion and bilateral cortical lesion he found bilaterally depressed score.

Bryden (cited in Morris et al., 1984) found that the scores obtained by the learning disabled (LD) children are poorer when compared to normal children. A study done by Dermody (1976) also concluded that LD children perform less efficiently on DCVT. Dermody, Mackie and Katsch (1983) studied the dichotic listening performance using CV pairs in a group of thirty children, fifteen of whom were good readers and fifteen were poor readers. The results show that identification of good readers was significantly better than poor readers. Similar results were found by Ganguly et al., (1996) who reported that the performance of LD children were poorer compared to that of normal children on a dichotic CV test.

Bryden (cited in Morris et al., 1984) suggested that children with LD have diminished or nonexistent REA. A similar result was found by Kershuer and Micallef (1989). Bolick, Obrzut and Shaw (1988) reported a significant REA for normal children across all attentional conditions whereas LD did not produce a consistent REA

across all attentional conditions and several instances produced equivalent left and right hemisphere processing.

Dichotic tests are also used in people with stuttering to study the cerebral dominance. Results of dichotic tests on people with stuttering is equivocal. Curry and Gregory (1969) studied the performance of twenty right handed adult stutterers and twenty right handed control subjects in dichotic word test. It was found that 75% of normals had right ear scores, which were higher than their left ear scores. This was seen only in 45% of the people with stuttering. Quinn (cited in Blood, 1985) observed that a few of the people with stuttering had higher scores in the left ear while none of the normals had a left ear advantage. Blood (1985) investigated seventy six people with stuttering and seventy six control subjects of age range 7-15 years using dichotically presented synthetic syllables. Results revealed that the direction of ear preference was the same for people with stuttering and control subjects, the magnitude of ear preference scores for the two groups were significantly different.

Bhat (1999) studied performance of twenty young adult males who have stuttering using dichotic CV test. In this study significant difference between the right and the left ear scores were obtained. She found right ear preference was not significant at 0msec right lag, 30msec right lag and 30msec left lag. But there was a significant left ear advantage at 90msec right lag and 90msec left lag. As the lag time increased the scores improved significantly. However, the mean scores were significantly reduced when compared to normals.

Contrary to these results, a study done by Slorach and Noehr (1973) revealed that scores of people with stuttering were similar to that of controls in DDT. This was supported by results of other investigations (Sussman & Mc Neilage, 1975).

It is evidenced from the studies that in patients with temporal lobe lesion, the ear contralateral to the site of lesion gets poorer score. LD children get poorer score compared to normals. REA is not seen in LD. People with stuttering most of the time do not get REA as seen in normals for dichotic tests. But some studies say they exhibit ear advantage.

In. summary, we can say that there are many factors that affect the performance of dichotic tests. These factors affect each test in a different degree and in a different way. There are many studies done to investigate the effect of these factors on dichotic test. These factors should be taken into the account during interpretation of the scores of the present study.

METHOD

Subjects

The subjects taken for the present study were seventy four normal individuals of whom thirty seven were males and thirty seven were females. These subjects were divided into two groups, children and adults. The age of the children ranged from 7 to 11.11 years and they were further divided into five sub groups in the age interval of 1 year (7-7.11, 8-8.11, 9-9.11, 10-10.11, 11-11.11). Each subgroup had ten children, five males and five females. Adult group included twenty four subjects in the age range of 18 to 25 years (twelve males and twelve females).

Subject selection criteria

Only those subjects who met the following criteria were selected for the study.

> Native speaker of Kannada

> Normal IQ

> No Known history of hearing loss

> No history of chronic otological problems

> No history of neurological problems or trauma to the brain

> No previous experience with dichotic listening task

> Right handedness

> Pure tone thresholds 15 dBHL in both ears in the frequency range of 250 Hz to 8 kHz

> Scores on speech identification task (Mayadevi, 1974) should be 90%

> On monaural presentation, of CV syllable or digit, scores should be >80%

Material

The test materials used were (a) Dichotic Digit test (DDT) and (b) Dichotic CV test (DCVT).

(a) The Dichotic Digit test in Kannada was developed at AIISH using a computer software 'AudioLab version 2'. The digits included were bisyllabic digits (|ontu|, |mu:ru|, |aidu|, |a:ru|, |e:lu|, |entu|, |hattu|) as suggested by Shivashankar (cited in shivashankar & Herlekar, 1991). The digits spoken by an adult female in Kannada were recorded using a 16 bits computer with a sampling rate of 22050 Hz. The noise in the signal was cut down using a software 'Cool Edit Pro version 2'. The digits were then normalized so that they are of equal intensity and aligned so that two digits of one channel are in alignment with two digits of the other channel. The inter stimulus interval between the first and the second pair of digits was around 500msec and it varied depending on the length of the first digits in the pair. The material consists of a total of 30 presentations each consisting of two pairs of digits in Kannada. It was ensured that all possible digit pairs were included in the test material. A calibration tone of 1kHz was recorded prior to the test material.

(b) Dichotic CV test revised, was developed by Yathiraj (1999) and recorded on CD 'in 2003. It has a total of five lists. Each list consisted of thirty pairs of syllables (|pa|, |ta|, |ka|, jba|, |da|, |ga|) recommended by (Berlin 1972). The list consists of

syllables presented dichotically with 0msec lag and also 30msec and 90msec lag either in right and left ear track. For the present study only the 0msec lag is used.

Instrumentation

Preliminary testing of the subjects was done using the clinical audiometer 'OB 922' coupled to 'TDH- 39' earphones housed in 'mx-41/AR' ear cushions and the bone vibrator 'Radio ear B-71'.

For the tests two CDs 'Premium CD-R80' consisting of Dichotic digit test and dichotic CV test respectively were used and they were played in 'Philips AZ2160V CD player. The signal from the CD was fed to the tape input of 'Madsen OB922'. 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 ISO-389 (1991) standards.

Procedure

Subjects who passed the selection criteria mentioned earlier were administered the DDT and DCVT. For some subjects DDT was administered first and for some subjects DCVT was administered first to eliminate the practice effect. The 1kHz calibration tone was used to adjust the VU meter to zero in both channels. The dichotic stimuli were presented at 40 dBSL.

The subjects were initially given practice trials for both the tests (five for children and three for adults). Then the test materials were presented and the subjects were asked to repeat whatever they heard and the tester recorded the responses. The interval between the two presentations was varied from 4 to 8 sec.

Scoring

Responses were scored in terms of single correct score (right ear score and left ear score) and double correct score. 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 tester recorded the scores on a scoring sheet and the raw data was then subjected to statistical analysis.

RESULTS AND DISCUSSION

The data obtained was analyzed using computer software "SPSS 7,5 for windows". The mean, standard duration (SD) and range of the scores obtained across the age groups for both the tests was calculated.

Table 1: ***Mean, SD and Range of scores for DDT.***

Age **group(years)**	**Scores**	**Mean**	**SD**	**Range**
7-7.11	RES	25.35	1.84	23-28
	LES	25.00	3.76	19-30
	DCS	13.4	6.94	1-22
8-8.11	RES	27.20	1.76	23-29.5
	LES	26.45	1.89	24-29
	DCS	18.80	5.37	13-28
9-9.11	RES	26.95	1.60	23-28.5
	LES	26.35	2.04	21.5-28.5
	DCS	18.10	3.92	12-23
10-10.11	RES	27.60	2.14	22.5-29.5
	LES	25.50	2.99	20-28.5
	DCS	17.70	7.74	1-25
11-11.11	RES	27.34	1.78	24.5-29.5
	LES	26.35	1.39	24-28.5
	DCS	18.60	4.71	11.24
18-25	RES	28.70	0.67	27.5-30.
	LES	26.30	2.11	27.5-30
	DCS	25.1	1.72	22-29

RES : Right Ear scores ; **LES** : Left Ear Scores ; **DCS:** Double Correct Scores.

Table 2: *Mean, SD and Range of scores for DCVT*

Age group(years)	Scores	Mean	SD	Range
7-7.11	RES	19.60	4.85	11-27
	LES	15.1	3.60	9-19
	DCS	8.70	4.73	1-16
8-8.11	RES	22.6	3.83	17-29
	LES	20.7	4.00	13-26
	DCS	15.40	3.92	10-25
9-9.11	RES	24.8	3.04	20-29
	LES	19.9	4.28	14-26
	DCS	16.00	4.85	13-25
10-10.11	RES	20.6	6.27	11-28
	LES	18.30	5.51	11-26
	DCS	12.00	6.68	3-19
11-11.11	RES	24.80	4.66	15-29
	LES	20.60	2.27	17-24
	DCS	16.90	4.67	9-23
18-25	RES	28.75	0.79	23-30
	LES	23.30	3.88	21-29
	DCS	20.50	4.74	13-27

RES : Right Ear scores ; **LES** : Left Ear Scores ; **DCS:** Double Correct Scores.

It can be clearly seen from Table 1 and Table 2 that there is a developmental trend seen in Right Ear Scores (RES), Left Ear Scores (LES) and the Double Correct Scores (DCS) as the age increases. This is true for both DDT and DCVT. This developmental trend is noticed more for DCVT. For DDT the scores are relatively higher even in the younger age groups.

The data was further analyzed using a 'Paired-Samples T Test' to check the aims of the study.

The results are tabulated in Tables 3 to 7 for different set of comparisons.

Effect of age on single correct scores of DDT and DCVT

Table 3: ***Results oft - test for single correct score of both DDT and DCVT between different age groups.***

Age group(years)	DDT		DCVT	
	RES	**LES**	**RES**	**LES**
7-7.11 with 8-8.11	1.87	1.02	1.78	3.15**
8-8.11 with 9-9.11	0.30	0.12	1.37	0.35
9-9.11 with 10-10.11	1.41	0.73	2.36*	0.60
10-10 with 11.11.11	0.39	1.06	2.49*	1.17
11.11.11 with 18-25	2.41*	0.05	2.59*	1.72

•Significant at 0.05 level; **Significant at 0.01 level

It is evident from Table-1 and Table-2 that as the age increases, there is an improvement in the RES and LES in both DDT and DCVT. From Table-3 it can be observed that for RES a significant difference is observed only when scores of 11 year old children are compared with that of adult scores. No significant difference is noticed in LES.

In DCVT, no significant difference is noticed for RES at younger age groups. But significant difference at 0.05 level is observed when comparison is made for 9-9.11 Vs 10-10.11, 10-10.11 Vs 11-11.11 and 11-11.11 Vs 18-25. For LES of DCVT significant difference is noticed only between the scores obtained by 7-7.11 and 8-8.11 year old children at 0.01 level. These results indicate that for both DDT and DCVT, RES mature even after 11 years.

Thus the results show that there is an increase in the right ear scores as well as left ear scores for both the tests, though it is not significant between some age groups.

The increase in right ear score as a function of age supports the results of earlier investigations (Satz et al., 1975; Rajagopal, 1996; Puranik, 2000; Krishna 2001).

Though there is no significant difference in the LES across age groups, LES of adults is more than children. This correlates with the study by Willeford (cited in Katz 1994);Willeford and Burleigh (cited in Bellis, 1996); Rajgopal (1996); Krishna (2000).

The results of the present study indicates that RES matures even after 11 years. So further studies need to be taken up for age levels above 11 years to find the age at which the maturation of RES is complete.

Only the RES shows significant difference between age groups. But it is supposed to be seen in LES also (Musiek et al., cited in Bellis, 1996). In this study may be because of the small sample size it is not seen.

Effect of age on double correct scores obtained for DDT and DCVT

Table 4: ***Results oft - tests for double correct scores of DDT and DCVT between consecutive age groups.***

Age group(years)	DDT	DCVT
7-7.11 with 8-8.11	1.78	3.38**
8-8.11 with 9-9.11	0.33	0.28
9-9.11 with 10-10.11	0.20	1.50
10-10 with 11.11.11	0.51	2.33*
11.11.11 with 18-25	4.09**	1.33

•Significant at 0.05 level; **Significant at 0.01 level

It can be evidenced from Table-4 that there is a significant difference noticed at the 0.01 level for the DCS of DDT when 1 lyear old children's scores are compared with adults. This shows that maturation of DCS takes place after 11 years also. For DCVT there is 0.01 level significance noticed when scores obtained by 7 years are compared with 8 years and 0.05 level significance noticed when the scores often year old children are compared with 11 year old children. There is no significant difference

noticed between the performance of 11 year old children and adults. From this it can be inferred that probably the DCS for DCVT matures at 10 years to 11.11 years of age.

Table 5 -*Results oft-testsfor double correct scores of DDT and DCVT between alternate age groups*

Age group (years)	DDT	DCVT
7-7.11 with 9-9.11	1.65	3.25**
7-7.11 with 10-10.11	1.91	1.38
7-7.11 with 11-11.11	1.71	3.72**
7-7.11 with 18-25.11	5.75**	6.71**
8-8.11 with 10-10.11	0.36	1.26
8-8.11 with 11-11.11	0.08	0.663
8-8.11 with 18-25.11	3.76**	3.22**
9-9.11 with 11-11.11	0.40	0.44
9-9.11 with 18-25.11	4.71**	2.00
10-10.11 8.11 with 18.25	3.13**	3.01**

**significant at 0.01 level

From Table 5 it can be understood that for DDT there is a significant improvement in the scores at 0.01 level from 7 years to adults, 8 years to adults, 9 years to adults and also 10 years to adults. There is maturation taking place even after 11

years. So further studies need to be done to find at what age the scores reach the adult value. In DCVT, there is significant improvement in the scores at 0.01 level from 7 years to 9 years, 7 years to 11 years, 7 years to adults, 8 years to adults and also 10 years to adults. From this it can be understood that DCS for DCVT increases as the age increases and reaches the adult score at 11 years of age.

The increase in double correct scores as a function of age correlates with studies quoted in literature (Bellis, 1996; Rajgopal, 1996 ; Puranik, 2000; Krishna, 2001). This improved performance reflects an increase in the brain's ability to process two-channel stimuli as a function of age.

REA in DDT and DCVT.

Table 6 : ***Results oft - test of RES and LESfor DDT and DCVT***

Age group(years)	DDT	DCVT
7-711	.30	2.60*
8-8.11	1.16	1.11
9-9.11	.71	3.15**
10-10.11	2.61*	1.36
11-11.11	2.44*	3.42**
18-25	4.76**	8.75**

•Significant at 0.05 level ; **Significant at 0.01 level

It is evident from the Table-6 that for DDT significant difference is noticed between the scores of right ear and left ear, in the age group of 10 and 11 years. The difference between RES and LES is significant at 0.01 level in adults and 0.05 level in 10 year old and 11 year old children. This shows that REA is seen from the age of 10 years.

Results of DCVT show that there is significant difference at 0.05 level in the age group of7 years while it is significant at 0.01 level in 9 years, 11 years and adults. From this it is understood that REA for DCVT is seen from the age of 7 years but it is not clear, why it is statistically not significant in 8 year and 10 year old children.

It is reported that left hemisphere is dominant for language (Gilbert & Climan, 1974 ; Ingram, cited in Jerger & Jerger, 1975). REA seen in both DDT and DCVT can be attributed to this fact.

Kimura (1961) reported that REA appears no later than the age of 6 years. Similar findings have been reported by other investigators (Gilbert & Climan, 1974; Ingram, cited in Jerger &Jerger, 1975). In the present study REA is seen in children as young as 7 years for DCVT , however it is not seen in DDT. This is seen probably because DDT is easier than DCVT (Miller et al.,cited in Strouse,Wilson & Brush 2000). A significant REA was seen for DDT only after 10 years of age. This can be attributed to the fact that left hemisphere becomes more lateralized for speech as the age increases.

Some studies say that REA is more pronounced in DDT when compared to DCVT (Keith, cited in Bellis, 1996; Hiscock & Stewart, 1984). In contradiction to the above studies, the present study shows more REA in DCVT when compared to DDT.

REA in both DDT and DCVT is increasing as a function of age. This is in consensus with several investigations (Satz et al., 1975;; Strauss, 1986; Rajgopal, 1996; Puranik, 2000; Krishna, 2001). There are some studies, which contradict the above findings by saying REA decreases with age. Willeford and Burleigh (cited in Bellis, 1996) found in their study that LES increases and so REA decreases as the age increases. However this study was done on competing sentence, which is more linguistically loaded than DDT or DCVT.

Comparison of results of DDT and DCVT.

Table 7: ***Results oft - test for scores of DDT and DCVT***

Age group(years)	**RES**	**LES**	**DCS**
7-7.11	4.09**	8.70**	2.02
8-8.11	3.50**	4.55**	2.53*
9-9.11	2.33*	5.23**	1.19
10-10.11	3.07**	4.88**	1.97
11-11.11	2.02	6.46**	.99
18-25	.42	4.63**	5.44**

•Significant at 0.05 level ; **Significant at 0.01 level

From Table 1 & 2 it is understood that the RES ,LES and DCS are better for DDT when compared to DCVT. Results of t test (Table 7) reveal that this difference was significant at 0.01 level for LES in all age groups. For the RES the difference is significant at 0.1 level for the age group of 9 years while at 0.5 level for 7 years, 8 years and 10 years. But it is not statistically significant in 11 years and adults. When the DCS of DDT and DCVT were compared subjects of 8 years and adults have done better at 0.01 and 0.05 levels of significance respectively.

All the scores (RES, LES and DCS) are better in DDT when compared to DCVT. This correlates with the result of some investigations (Niccum etal., 1981; Koomar & Chermak, 1981; Noffsinger et al., 1994). This can be discussed on the fact that DCVT is more difficult than DDT since it is lightly linguistically loaded and closely aligned (Berlin 1996).

In RES when the age level increased the difference between DDT and DCVT became less. This can be discussed based on the maturational effects of left hemisphere for speech perception (Kimura,cited in Pinherio & Musiek, 1985).

However, the difference between LES and RES was seen even in adults for both DDT and DCVT. This may be due to the degradation of stimuli when it passes through the corpus callosum. Since DDT is more linguistically loaded when compared to DCVT it becomes easier to perceive even if there is degradation and hence score for DDT are found better than DCVT.

SUMMARY AND CONCLUSIONS

Efficient auditory processing is crucial for a successive communication and overall well being of an individual. Difficulty in processing auditory information may create problem in academic, work performance, social and emotional status. So it is important to assess and intervene the Auditory Processing disorder (APD) at an early stage possible.

Dichotic listening is one of the phenomena responsible for auditory processing. There are many tests which assess (APD) using dichotic listening task. Among them Dichotic Digit test (DDT) and Dichotic Consonant Vowel test (DCVT) are the most commonly used tests (Bellis 1996). The present study is aimed at obtaining normative data for children (7 to 11 years) and adults on DDT and to compare the maturational effect seen in both DDT and DCVT as a function of age.

The subjects taken for the study were fifty right handed Kannada speaking children (7 years to 11 years) with normal hearing and twenty four right handed Kannada speaking adults (18 to 25 years) with normal hearing. The children were divided into five groups having ten children in each age level.

The DDT was developed in AIISH using the bisyllabic digits in Kannada as suggested by Shivashankar (cited in Shivashankar & Herlekar, 1991). The DCVT was developed by Yathiraj (1999) and recorded on CD in 2003. The two tests recorded in CDs were played in CD player connected to an audiometer. The stimulus was presented through headphone at 40 dBSL.

The subjects were asked to repeat the syllables and digits heard in DCVT and DDT respectively and the tester recorded the responses. Both single correct scores and the double correct scores were calculated and then statistically analyzed. Mean, standard deviation and range were calculated. The 'Paired samples T- test' was used to check the significance of the difference between the means of different parameters.

Following conclusions are drawn from the present study

- In both DDT and DCVT increase in Right Ear Scores (RES), Left Ear Scores(LES) and Double Correct Scores(DCS) are noticed as a function of age.
- Performance is better in DDT when compared to DCVT in all the age groups.
- REA is seen in both the tests for all the age groups. Magnitude of REA is more in DCVT than DDT.

Implication of the Study

- The present study has established normative data for DDT. So children from the age of 7 years can be tested for Auditory processing disorder having these norms.
- The present study has concluded that DDT is easier when compared to DCVT. So preference can be given for DDT when testing children.

Suggestions for future research

- Normative can be developed for both DDT and DCVT for the age groups ranging from 12 years to 18 years.

- DDT can be developed in other languages also and normative can be developed for those languages.
- Studies can be taken up to compare DDT and DCVT with other more linguistically loaded tests.
- Studies can be done by taking larger samples to confirm the results of the present study.

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