DICHOTIC CV TEST-REVISED

NORMATIVE DATA FOR ADULTS

Register No. M 9916

An Independent Project submitted as part fulfillment for the first year M.Sc. (Speech and Hearing), Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING, MYSORE - 570 006
MAY, 2000

Certificate

This is to certify that this Independent Project entitled DICHOTIC CV TEST-REVISED: NORMATIVE DATA FOR ADULTS is the bonafide work in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student with Register No.M 9916.

Mysore,
May, 2000

Director
All India Institute of
Speech & Hearing
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Certificate

This is to certify that this Independent Project entitled DICHOTIC CV TEST-REVISED: NORMATIVE DATA FOR ADULTS has been prepared under my supervision and guidance.

Mysore,
May, 2000

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Declaration

This Independent Project entitled DICHOTIC CV TEST-REVISED: NORMATIVE DATA FOR ADULTS is the result of my own study under the guidance of Dr. Asha Yathiraj, Reader, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier in any other University for any other Diploma or Degree.

Mysore, Register No. M 9916

May, 2000

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INTRODUCTION

"Communication is the basis of our social and cognitive being; without it, growth and development are stymied. This in turn, influences psychological, social and intellectual processes. The partial or complete absence of hearing interferes with the development of these processes, due to the absence of normal auditory development and the resultant effect on linguistic development" (De Conde , 1984 Pl9).

The act of hearing does not end with the detection of an acoustic stimulus. Rather, several neurophysiological and cognitive mechanisms and processes are involved in the accurate decoding of the auditory signal. The central auditory nervous system is responsible for this decoding.

Central Auditory Processing:

"Central auditory processes are the auditory system mechanisms and processes responsible for the following behavioural phenomena: sound localization, lateralization, auditory discrimination; auditory pattern recognition; temporal aspects of audition, including temporal resolution, temporal masking, temporal ordering; auditory performance with competing acoustic signals; and auditory performance with degraded acoustic signals" (American Speech-Language and Hearing Association 1996).

The central auditory nervous system (CANS) is a highly complex redundant system. Optimal functioning of the CANS is critical to the recognition and discrimination of even the most simple, nonverbal stimuli as well as of highly complex stimuli such as spoken language (Bocca & Calearo ,1963 ,Bellis 1996) Central auditory processing affects nonverbal signals and influences various higher functions including language and learning (ASHA, 1996; Philips, 1993, 1995).

A central auditory processing disorder (CAPD) refers to a disorder of the CANS from the cochlear nuclei to the auditory cortex in the temporal lobe including the interhemispheric pathways. Such lesions can be space occupying neoplasms, degenerative disorders, congenital neurologic deficits, or acquired neurologic deficits such as those resulting from head trauma, and also minimal dysfunction of the CANS which cannot be detected by sophisticated radiologic and neurologic techniques (Bocca & Calearo, 1963; Silman & Silverman, 1991).

The clinical features of CAPDs are subtle and may not be noticed when routine audiological evaluation is done. The routine pure-tone and speech identification scores do not rule out a CANS dysfunction (Goldstein, 1961; Hodgson, 1967).

The failure of pure-tone threshold tests to detect central auditory processing disorders is related to the decreasing importance of frequency analysis at increasingly rostral levels of the auditory pathway and the intrinsic redundancy of the CANS. The failure of conventional speech recognition tests and PB word tests to identify CAPDs is related to the concepts of intrinsic and extrinsic redundancy.

Intrinsic redundancy:

The concept of intrinsic redundancy is based on the multiplicity of neural pathways, centres and decussations; and bilateral representation of the auditory system. It is reduced by CANS lesions but it is not apparent on conventional speech recognition tests, unless the lesion affects a significant portion of the neurons and nuclei in the CANS.

Extrinsic redundancy:

Extrinsic redundancy comes from aspects of the signal, like frequency range, sound duration, context in which the message is given, rhythm, and the individual's familiarity with the semantic, syntactic and phonological rules of the language. It is inherent in the speech message and enables the message to be perceived even when parts of the message are degraded or absent. It can be reduced by various means of degradation such as presenting the signal dichotically, filtering, time alterations and noise (Bocca & Calearo, 1963 ; Silman & Silverman 199l).

The development of specialized tests for the assessment of CANS dysfunction was based on the concept that central auditory dysfunction is manifested by taxing the CANS through reduction in extrinsic redundancy [Bocca (1955); Calearo (1960; Silman & Silverman (1991)]. Several such tests have been developed, one category of them being dichotic speech tests.

Dichotic Listening:

The term "dichotic" refers to auditory stimuli that are presented to both ears simultaneously, with the stimulus presented to each ear being different (Katz, 1994) .

According to Kimura (1961 a,b), when the left hemisphere is dominant for language, the right hemisphere acts as a relay station for information from the left ear which is transferred across the corpus callosum to the left hemisphere.

When dichotic speech is presented to individuals with temporal lobe lesions, reduced performance is expected on the ear contralateral to the lesion due to the dominant crossed auditory fibre tracks.

Generally, when speech is presented dichotically to normal listeners, higher scores are obtained from the material presented to the right ear than to the left. This has been referred to as the right ear advantage (REA) and is believed to reflect dominance of the left hemisphere for speech and language perception.

Dichotic speech testing has been used primarily to measure hemispheric asymmetry (Kimura, 1961 a) or to indicate brainstem dysfunction.

Some of the dichotic tests used clinically are as follows:

- Dichotic Digits Test, Kimura (1961a)
- Dichotic Consonant-vowel Test, Shankweiler & Studdert-Kennedy (1967)
- Dichotic Rhyme Test, Wexler & Halwes (1983)
- Staggered Spondaic Words Test, Katz (1962)
- Competing Sentence Test, Willeford (1968)
- Synthetic Sentence Identification with contralateral competing message, Jerger (1970)

ATM OF THE STUDY:

- To establish normative data on adults for the dichotic CV test - revised, developed by Yathiraj (1999) at the All India Institute of Speech and Hearing, Mysore.

  Rajagopal (1996) had developed normative data on adults for the dichotic CV test, developed by Yathiraj (1994) at the CID, St. Louis. The material for the test was developed using a computer software with a sampling rate of 8 bits. The material for the dichotic CV test - revised was developed using a computer software with a sampling rate of 16 bits. The present study also aimed at evaluating the change in the scores on the test with increase in the sampling rate.

- It is reported in literature that scores on the dichotic CV test improve when there is a lag in the stimulus presented to one ear with reference to the other. This has been called as the "lag effect" (Berlin et al., 1972). The present study also verifies the lag effect in the adult Indian population.

NEED FOR THE STUDY:

- Normative data must be carefully established on any test before it is used clinically, to ensure accurate interpretation of results. Using normative data, we can determine whether a person is normal or has deviant perception, which aids us in diagnosis and line of management for the person.

- The dichotic CV test-revised uses nonsense syllables which are common across most Indian languages. Therefore, this test could be easily used with the multilinguistic Indian population, since language and dialect variations do not affect the test. Scoring sheets would, however, differ depending on the languages.

REVIEW OF LITERATURE

Dichotic speech testing was introduced by Broadbent (1954) for the detection of CAPD. It requires simultaneous presentation of different speech signals to each ear. Since their introduction in CAPD testing, dichotic speech tests have been found to have considerable clinical value. Primarily, dichotic tests have been used to measure hemispheric asymmetry or to indicate brainstem dysfunction (Kimura, 1961a, 1961b). According to Musiek and Morgan (1981), the application of dichotic speech tests is not only to identify neuroauditory dysfunction, but also to monitor changes in scores.

There are several commonly used dichotic speech which have tests clinical value in the detection of various central auditory processing disorders. These test include:

=> Dichotic Digits Test (Kimura, 1961a)

=> Dichotic Consonant-Vowel (CV) Test (Shankweiler and Studdert-Kennedy, 1967)

=> Staggered Spondaic Words (SSW) Test (Katz, 1962)

=> Dichotic Rhyme Test (Wexler & Halwes, 1983)

=> Competing Sentence Test (Willeford, 1968)

=> Synthetic Sentence Identification with Contralateral Competing Message (SSI-CCM) (Jerger, 1970)

DICHOTIC DIGITS TEST (DDT)

The technique of presenting competing sets of digits simultaneously to the two ears was introduced by Broadbent (1954). The technique was first used to test subjects with brain damage using triads of digits by Kimura (1961 a, b).

NORMATIVE STUDIES :

Dirks (1964) administered the DDT on normal adult subjects and found a right ear (left hemisphere) superiority of 2-6% for verbally reporting of the digits. Speaks (1975) has reported similar findings.

Musiek (1983 a) used pairs of digits presented dichotically and found that normals obtained 90% scores, or more on the DDT. He suggested a detailed central auditory nervous system (CANS) examination if the scores were less than 80%. He also reported that the test was relatively unaffected by peripheral hearing loss.

There has been a report of decrease in performance with advancing age by Rodriguez et al. (1990). They administered the DDT on normal hearing, cognitively intact elderly adults. They scored less than 90% on the dichotic digits test. There was, however, a significant REA. The results indicated that central auditory processing disorders (CAPD) can occur without a concomitant decline in peripheral sensitivity, cognitive function or linguistic competence.

CORTICAL LESIONS.

Temporal lobe lesions:

Kimura (1961a, b) presented digit triads simultaneously to each ear of a group of patients with temporal lobe lesions. She found impaired digit recognition in the contralateral ear when the stimuli were presented in a dichotic paradigm, while no deficits were noted in either ear if the stimuli were presented in a non-competing condition. Similar findings were also reported by Shankweiler(1966).

Mazzuchi and Parma (1978) administered the test on normal and temporal lobe epileptic subjects. They found a right ear advantage in normal right-handed subjects. Temporal epileptics with macroscopic lesions in the right temporal lobe performed poorly on the left ear. This was explained as follows: "The lesion effect adds to the left hemisphere dominance for the stimuli so that right ear advantage is strengthened. In patients with left temporal lobe damage, on the other hand, overall scores are diminished because it interferes with the natural dominance effect for verbal stimuli."

In an attempt to explain the ipsilateral ear effect for left temporal lesions but not for right, Sparks et al. (1970) proposed a model for pathways of dichotic speech suggesting areas where lesions could cause a reduction in either right or left ear performance. According to the model, deep lesions affecting the callosal fibre tracts could be responsible for decreased scores for the left ear but not for the right (right temporal lobe lesion). The absence of an ipsilateral ear effect for the right hemisphere added to the notion that a dominant path exists to the left hemisphere for perception of dichotic speech.

Schulhoff and Goodglass (1969), reported that their left hemisphere damaged subjects presented a bilateral decrease in the perception of digits, while their right hemisphere damaged patients showed an analogous decrease for tones. In addition, left and right hemisphere damaged subjects showed significant increases in left ear preference for tones and right ear preference for digits respectively. This finding was attributed to a degrading of contralateral ear signal at the site of lesion resulting in a reduction in the competition between signals in the hemisphere responsible for decoding a particular type of signal.

Oxbury and Oxbury (1969) noted that hemispherectomy affected the order in which dichotic digits were reported, and they found that the digits presented to the contralateral ear were usually reported after those presented to the ipsilateral ear.

Musiek (1983 a) reported abnormal results on the DDT in at least one ear for patients with hemispheric lesions.

Temporal lobectomy cases were studied preoperatively and post-operatively by Collard et al. (1986), using the DDT . They found that the preoperative performance of these cases was poorer than the normal group. Postoperatively, ipsilateral scores improved. The reason speculated for this ipsilateral ear improvement was that the side of the lesion might have caused interference with the overall function of the contralateral, non-epileptogenic cortex pre-operatively. After surgery, this deleterious effect was reduced, resulting in improvement of scores.

A study by Niccum et al. (1981), revealed that aphasic patients scored 50% or less on the DDT for the contralateral ear and 85% or higher on the ipsilateral ear.

Musiek and Morgan (1981), found an intracranial right hemisphere involvement in a case of vasculitis. using the DDT, in which the left ear scores were poorer than right ear scores, indicating involvement of the right hemisphere. Post treatment scores indicated an obvious improvement in right hemisphere function on the DDT. They concluded that the DDT could be used to detect and monitor changes in neuro-audiological conditions.

Mueller et al. (1987) evaluated head injured patients using the DDT. They found that when the left temporal lobe was injured, both right and left ear scores were reduced, while right temporal lobe involvement affected only the scores of the left ear. Individuals with injury in other brain areas performed normally.

Thus, the review of the DDT on cortical lesions reveals that the test is quite sensitive in detecting cortical lesions and also in determining the side of the lesion.

INTERHEMISPHERIC LESIONS :

Abnormal DDT results have been reported in cases with corpus callosal lesions.

Sparks and Geschwind (1968) found poor performance on the digits presented to the left ear, while the right ear was normal, while Damasio et al. (1976) reported complete left ear extinction for dichotic digits on patients with interhemispheric lesions.

Dichotic digit test performance of patients who underwent anterior sectioning of the corpus callosum was studied by Baran et al. (1986). Their subjects showed better functioning on the right ear than the left ear pre-operatively. Postoperatively, little change was seen on either ear's performance. Right ear superiority was accounted for by the fact that the subjects had a neurologically and/or surgically confirmed right hemisphere damage, thus, reduced left ear performance could be expected.

As seen from the above studies, interhemispheric lesions lead to left ear extinction: which is evident from DDT scores.

BRAINSTEM PATHOLOGY :

Abnormal results on the DDT were reponed by Stephens and Thornton (1976) for thirteen patients with brainstem pathology.

Another study by Siegenthaller and Knellinger (1981) on a patient with a brainstem vascular disorder and three patients with brainstem neural degeneration showed abnormal results. The patient with a brainstem vascular disorder showed a severe right ear deficit and normal left ear performance. The remaining patients showed similar results for the left and right ear, the scores being slightly lower than normals.

Musiek and Guerkink (1982), and Mustek (1983a), have reported abnormal results on the DDT in patients with brainstem pathology also.

Thus, the DDT may be useful in diagnosing brainstem pathology also.

It can be concluded from the studies on the DDT, that the dichotic - digits test shows a contralateral deficit in cortical lesions, reduced scores in brainstem disorders and left ear extinction in corpus callosal lesions.

DICHOTIC CONSONANT-VOWEL (CV) TEST

The dichotic CV test consists of the syllables /pa/ /ta/, /ka/, /ba/, /da/, and /ga' presented in randomized pairs, one to each ear simultaneously. Shankweiler and Studert-Kennedy (1967) and Berlin (1968) composed some of the early paradigms of dichotic CV testing.

NORMATIVE STUDIES:

Berlin et al. (1973), presented CV syllables with onsets of syllables to the two ears separated by 0, 15, 30, 60 and 90 msec. They found a right ear advantage (REA) on simultaneous dichotic presentation of CV syllables. Between 15-3 0msec, the leading ear intelligibility dropped. Intelligibility of both lag and lead ears improved beyond 30msec time separation. At 15msec delay, the right ear superiority was still seen. However, if the CV to the left ear trailed that to the right ear, then no right ear advantage was seen.

Kimura (1961a); Shankweiler and Studdert-Kennedy (1970) believed that the REA was a reflection of the left hemisphere's dominance for speech perception and related functions. Since the auditory system has a strong contralateral path and since most people are left brained, more people showed a right ear advantage in a simultaneous listening task.

Berlin et al. (1973) assumed that:

a) The left posterior temporal lobe is most likely dominant for speech and language functions.

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

c) 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 temporal parietal lobe on the basis of proximity.

Studdert-Kennedy, Shankweiler and Schulman (1970) investigated the effects of delaying one channel during dichotic presentation of pairs of CV syllables differing in the initial consonant. The onset time asynchronies were 0, 5, 10, 20, 25, 50, 70 and 120msec. They found that the time advantage accrued to the lagging, not to the leading syllable. The right ear advantage, seen at simultaneity was more readily abolished by a left ear lag than a right ear lag. REA was present at all conditions except at 120msec lag. If the lag to the left ear was 20msec or more, the left ear outperformed the right ear. With increase in the lag time, the overall score improved. This, they termed as the lag effect.

Results consistent with the above studies have been reported by Gelfand et al. (1980), who administered the test on normal hearing young and elderly subjects. The older group demonstrated a mean REA not significantly different from the young adult group. Thus, they did not find any reduction in the REA with advancing age. There was, however, a significant reduction in the total dichotic scores of the elderly group compared to the young; suggesting an age-associated reduction in the channel capacity of the aging auditory system. They also found striking aberrations of the lag effect in the elderly group compared to the young subjects.

In agreement with other studies, Olsen (1983) also found a right ear advantage and a lag effect in adult normal hearing subjects. The scores (%) obtained by Olsen in his study are as follows:

	90 msec Left lag		0 msec		90 msec Right lag		Average	
	R	L	R	L	R	L	R	L
Mean	86.3	79.3	69.3	59.2	87.7	79.2	81.1	72.5
Range	63-100	56-100	47-93	43-77	69-100	50-100	66.95	60.89

Olsen (1983) noted that there was a high variability among subjects for the dichotic CV task. He attributed this to the task being difficult. This finding has also been reported by Berlin et al. (1973).

Keith et al. (1985), administered the dichotic CV task to normal adults aged 20-36 years with a simultaneous onset, using a directed listening task, i.e., for the first thirty pairs of syllables, subjects were asked to report the syllable heard in the right ear. For the next thirty pairs, they were asked to report what they heard in the left ear. Finally, a free recall instruction was given, in which the subjects had to repeat whatever CVs they heard, irrespective of the ear. They, too, found a wide variation among subjects indicating that dichotic CV materials present a difficult listening task. The adult subjects showed a 36% RE A on the directed right ear listening task and 21% LEA on the directed left ear listening task. In the free recall condition, the subjects got an average of 6.2% REA. They took these results to indicate that the dichotic CVs are recognized as 'nonsense' syllables with interpretation made by either hemisphere.

Normative data obtained by Bingea and Raffin (1986) on the dichotic CV test at onset time asynchronies of 0, 30, 60, 90 and 120 msec, under right and left lag conditions, supported previous findings. They, too, revealed a REA at 0, 30, 60 and 90 msec lag conditions. They found that the mean score improved with increase in the lag, with the difference in score being significant between 0 & 120 msec lag, 30 and 120 msec lag, and 90 and 120 msec lag conditions. The right ear outperformed the left ear in both lag conditions. The double correct scores were found to increase with increase in the lag.

Rajgopal (1996) obtained normative data on adults aged 18-30 years using dichotic CV material developed by Yathiraj (1994) using an 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 too. In her study, she found that scores improved from 0 msec to 90 msec. lag. The mean single correct scores for lag 0 msec lag were 19.3 and 14.8 for right and left ears respectively. For 30 msec right lag and 30 msec left lag, right and left ear scores were 20.9, 15.8 & 18.3, 19.2 respectively. For 90 msec right and left lag, right and left ear scores were 22, 20.2 and 20.3 and 21. Double correct scores were 25.6%, 34%, 36.8%, 50.6% and 47% respectively for 0 msec, 30 msec, right lag, 30 msec left lag, 90 msec right lag and 90 msec left lag conditions.

Ganguly (1996), using the same material as Rajgopal (1996), obtained norms for children aged 8-17 years. She, too, found a right ear advantage and a lag effect. She found that children in the age group of 13-17 years performed better than those in the age range of 8-12 years. The difference, however, was not significant.

Thus, the dichotic CV in normals shows a right ear advantage with a lag effect.,)They also have higher single correct scores which are less variable compared to double correct scores. However, most of the studies have found a high intersubject variability, reflecting upon the difficulty of the dichotic CV task.

CORTICAL LESIONS :

The cortical lesions reviewed in this section include temporal lobe lesions, aphasia, corpus callosum lesions, stuttering and learning disability.

Temporal lobe lesions :

Berlin et al. (1972) measured central auditory dysfunction in patients after temporal lobectomy. They used dichotic simultaneous and time staggered nonsense syllables. They found that the syllable presented to the ipsilateral ear was reported accurately most of the time, while that presented to the contralateral ear was either not perceived at all or was distorted. Also, temporal lobectomy patients showed no lag effect. Comparing preoperative and postoperative scores, it was found that there was additional degradation of contralateral scores and enhanced ipsilateral function postoperatively. This was seen in both left and right temporal lobectomees. Thus, the advantage which normal listeners achieve when they hear a lagging message in a pair is lost to patients with temporal lobe lesions. Patients show a distinct failure to accurately perceive messages in the ear contralateral to the lesions, independent of the temporal sequence of the syllables.

Berlin et al. (1972), took these findings to indicate that both right and left temporal lobes must participate in some type of preliminary speech processing, otherwise there would be no postoperative laterally effects following temporal lobe lesions. Such patients generally show an almost complete suppression of dichotic speech perception sent to their contralateral ears. It was suggested that the temporal lobe plays a critical role in either preliminary speech analysis or in the relay of speech information to the posterior temporal cortex via association pathways.

It was hypothesized that information coming from the right anterior temporal lobe to the left posterior temporal areas need not pass through the left anterior temporal areas. If such a serial relationship existed, then a left anterior temporal lobectomy would have devastating effects on all speech and hearing function. On the contrary, only the left posterior temporal lobectomy has been found to have such deleterious effects.

The inference of the reduced scores on the contralateral ear in the temporal lobectomy patients was that the cortical processing areas for speech, presumably located in the left hemisphere, do not receive an effective dichotic input. Because of the temporal lobe lesion, the signal was degraded sufficiently so that correct processing of the weak ear signal was unlikely.

Berlin et al. (1975), also found reduced scores in the contralateral ear of temporal lobectomy patients, on the dichotic CV test. Speaks et al. (1975) found extremely depressed scores for the ear contralateral to the side of brain lesions in all patients with temporal lobe lesions using dichotic CVs. Scores in a monotic condition were also poorer in the ear contralateral to the lesion. Similar findings have been reported by Olsen and Kurdziel (1978) and Collard etal.(1982).

Research by Olsen (1983) revealed that over 40% of the temporal lobectomy patients fell within normal limits. Ipsilateral ear effects were also observed and he concluded that determination of the side of a cortical lesion can not be accomplished by using dichotic listening tests.

Collard et al. (1986) tested patients with temporal lobe epilepsy before and after temporal lobectomy. Ipsilateral ear scores improved post operatively, the difference being statistically significant. Preoperatively they performed poorer than the normal group. The reason speculated for the ipsilateral ear enhancement was that the side of the lesion might have caused interference with overall function of the contralateral, non-epileptogenic cortex preoperatively. After surgery, this deleterious effect was removed, resulting in improvement of scores.

Mueller et al. (1987) reported contralateral as well as ipsilateral ear effects for subjects with temporal lobe injury. Double correct scores were significantly lower than normal in these patients. They concluded that the double correct scores may be a useful indicator of posterior temporal lobe dysfunction, although hey are not likely to be useful in determining which hemisphere is involved.

It can thus be construed from the studies on temporal lobe lesions, that the dichotic CV test may be used to determine the side of the lesion (using single correct scores) and to indicate the lesion (using double correct scores).

Aphasia:

Johnson et al. (1977) found a significant left ear preference for verbal stimuli among their left hemisphere injured (posterior left hemisphere lesions i.e., temporal, parietal, temporal-parietal area) subjects with aphasia as opposed to the expected right ear preference in normal subjects. They also reported a factor of initial severity of aphasia to be a significant determinant of the extent of the left ear preference. They interpreted their results as reflecting the superiority of the right hemisphere over the left in auditory verbal recognition.

Similar to Johnson et al.'s findings, Niccum et al. (1981) administered the dichotic CV test to 14 aphasic patients with only left hemispheric involvement. They found a left ear advantage in these cases.

Niccum et al. (1981) postulated that dichotic tests are useful in determining whether language recovery is based on the transfer function to the right hemisphere. A left ear advantage can be interpreted as evidence that lateralization of language processing had shifted to the right hemisphere. The 'lesion effect" interpretation of ear advantages is based on the assumption that degradation due to the lesion might interact with and possibly override the pre-morbid ear asymmetry so that dominance can no longer be inferred.
Aphasics, thus, consistently show a LEA on the dichotic CV test.

Corpus Callosum Lesions :

Lortie et al. (1981) used the dichotic CV test in assessing subjects with callosal agenesis. Results demonstrated similar performance for both left and right ears on the test. They postulated that the agenesis of the corpus callosum perhaps allows the development in each hemisphere of functions that are usually dependent on interhemispheric interactions, such as speech and speech related functions.

High right ear scores were reported on dichotic CVs in split brain patients in a study by Springer et al. (1975). They believed that as the callosal pathway is severed, information from the left ear is not transmitted as the interconnection between the right and left hemispheres is not intact. Therefore the left hemisphere is required to process only the information coming from the right ear. This is called as 'left ear extinction" (Damasio et al. 1976).

Stutterers:

Rosenfield and Goodglass (1980) presented dichotic CVs and melodies to matched groups of right handed male stutterers and controls. They found a right ear advantage for dichotic CVs and a left ear advantage for melodies. Significantly greater number of stutterers failed to show the expected ear laterality for either type of material.

Blood (1985), found that severe stutterers show more left ear advantage than mild and moderate stutterers, Moore and Haynes (1980) reported that it might be predicated that the greater the severity of stuttering, more the stutterers depend upon right hemisphere processing.

Bhat (1999) found non-significant right ear preference for stutterers at 0 msec and 30 msec lag. But a significant left ear advantage was found at 90 msec lag. Double correct scores decreased as severity of stuttering increased and stutterers show lower scores than normals. This latter finding is in concurrence with that of Blood (1985).

Studies on dichotic CV on stuttering, thus, showed that stutterers also show central auditory deficits.

Learning Disability (LD) :

Obzrut et al. (1980) administered the dichotic CV test to twentyfive normal and twentyfive LD children. Both normal and LD children showed a REA but the amount of REA shown by normals was more than that of LD children. The LD children scored less than normal children, though the difference was not significant.

Similarly, no significant group difference was found by Roeser et al. (1983), in the ear asymmetry, auditory capacity, or lag effect, for both normal and LD children. Based on this, they construed that the test has limited value in identifying auditory processing disorders in LD children. However, findings reported by Hynd et al. (1983), showed a significant difference in the scores of normal and LD children, the LD children scoring poorer than normals. The authors attributed this difference to the attention deficit in LD children and not to the auditory dysfunction.

Dermody et al. (1983) found that poor readers got better single correct and poorer double correct scores than good readers on the dichotic CV. Also, a greater REA was reported in poor readers than good readers. They indicated that there might be specific processing limitations in low verbal children, on tasks where there is auditory information overload, e.g., the dichotic CV'task.

Ganguly, Rajgopal and Yathiraj (1996) found lower scores on the dichotic CV in LD children when compared to normals though a right ear advantage was seen in both groups.

Thus, research on dichotic CV in LD shows controversial results, with some studies reporting abnormalities, and others showing results similar to normals.

BRAINSTEM LESIONS :

Jacobson et al. (1983) administered dichotic tests on a group of multiple sclerosis cases (high brainstem lesion). They found 76.5% mean correct scores for the right ear, and 45.8% mean correct scores for the left ear on the dichotic CV test. The right ear scores were not significantly lower than normal but left ear scores significantly differed from norms. There was a significant REA in the lesion group too. Berlin et al. (1975) found partially complete suppression of the CVs presented to the left ear while right ear scores were grossly normal in patients with lesions in the right medial geniculate. These findings suggest that brainstem lesions may influence higher order auditory processing as measured by the dichotic CV test.

Research regarding dichotic CV on brainstem lesions, though limited, does show abnormalities and therefore, may aid in their diagnosis.

PERIPHERAL HEARING LOSS :

Absence of REA was found in subjects with bilateral moderately severe SN hearing loss, as reported by Roeser et al. (1976) who carried out dichotic CV testing at 30dBSL. In contrast, Cattey (1981) who also administered dichotic CV test to moderate SN hearing loss cases at 75dB SPL found a right ear advantage even when the lagging syllable was presented to the left ear, and it was not enhanced when the lagging syllable was presented to the right ear.

Speaks, Bauer and Carlstrom (1983) assessed the extent to which a peripheral loss may confound the interpretation of dichotic listening tests in the assessment of central auditory dysfunction. They tested normal hearing subjects with CVs monotically and dichotically in two conditions. :

(i) Conductive hearing loss simulated with ear plugs: This testing was carried out at 78dB SPL.

(ii) Without ear plugs: This testing was carried out at 40-110 dB SPL.

With the plug, the magnitude and direction of the RE A varied with the test intensity even when the monotic speech recognition in both ears was greater than 95%. Thus, when dichotic tests are used to assess central auditory dysfunction in patients with peripheral hearing loss, the authors recommended that the intensity be at least 10 dB from both the upper and lower knees of the monotic performance intensity function. Niccum et al. (1987) reported similar findings.

The effects of use of amplification on patients with high frequency hearing loss were studied by Surr, Allen and Miller (1986) using the dichotic CV test. They administered the test at 55 dBHL, once before hearing aid fitting and again after 1 month and 6 moths following the use of amplification. They found no consistent changes in scores after use of amplification.

Thus, research on the dichotic CV in peripheral hearing loss, reveal changes in the ear advantage.

It is evident from the review of literature on the dichotic CV test, that it would be useful in detecting cortical level lesions, like learning disability aphasia, temporal lobe lesions, etc. Studies on brainstem lesions, though limited, also show deviant results.

STAGGERED SPONDAIC WORDS (SSW) TEST

The SSW test was given by Katz (1962). It is composed of two spondees with a staggered onset. The latter half of the first spondee and the first half of the second spondee are presented dichotically, while the remaining spondee segments are presented in isolation to opposite ears. Katz developed extensive scoring and interpretation for the test.

NORMATIVE STUDIES:

Amerman and Parnell (1980) administered the SSW test on normal hearing adults aged 60-79 years. They found a reduced response accuracy and increased variability in comparison to younger subjects. There was a non-significant correlation between age and SSW scores which suggests minimal change in those central auditory functions tested by the SSW for these subjects.

Young adults with no history of central auditory dysfunction showed that response bias results used to locate the area of dysfunction were not prevalent in the normal population. Katz (1968), Katz (1977), and Arnst (1981). Arnst (1982) found that corrected SSW scores increased as a function of age, consistent with the central aging effect reported in literature for older populations.

Harris, Keith and Novak (1983) administered the SSW and dichotic CV test on children aged 6-8 years. The children were divided into 2 groups based on their performance on the token test, as those having normal scores and those having below normal scores. They found a significant difference between the 2 groups on the right competing and left competing conditions of the SSW. They implied that below average SSW performance indicated delayed maturation of the auditory system in these children

CORTICAL LESIONS:

Abnormal SSW results were reported in brain damaged subjects by Katz (1962,1970). Lowest scores were obtained for the contralateral ear.

Lynn and Gilroy (1972) reported SSW results on 5 patients with anterior and 10 patients with posterior temporal lobe tumors. All the patients had abnormal SSW scores, and those with posterior lesions showed poorer results than those with anterior lesions.

Patients with left hemisphere as well as right hemisphere lesions demonstrated significantly poorer results on the SSW than normals. (Me Clellen et al. 1973). Ears contralateral to the brain lesions yielded mean lower scores, but this was not as evident for left hemisphere lesions as for right. Katz and Pack (1975) clearly showed greater contralateral deficits for patients with lesions in the auditory reception area, while SSW scores for patients with CNS lesions in other areas of the brain were normal. Jerger and Jerger (1975), found the SSW test to be the most sensitive among SSI-CCM, SSI-CCM and SSW to temporal lobe lesions. On the contrary, Olsen and Kurdziel (1978) found an excess member of errors on the SSW in only four out of twentyrwo patients with cortical lesions. Collard et al. (1982) reported similar performance of temporal lobectomy patients on the SSW, dichotic CV and dichotic digits test. Musiek (1983b) reported more abnormal scores on the dichotic digits test than the SSW in patients with brainstem and hemispheric lesions.

Collard et al. (1986) tested patients with SSW and some other dichotic speech tests before and after temporal lobectomy. They found that ipsilateral scores improved on all tests postoperatively; and statistical significance was reached for SSW and dichotic CV tests.

Katz (1977) reported that the SSW is most useful in the diagnosis of lesions associated with areas of auditory reception. Damage to the Heschl's gyrus, for example, led to moderate-severe SSW scores. Lesions involving non-auditory area may exhibit normal or near normal test scores.

As seen from the above studies, the SSW does show deviant performance consistently on cortical lesions.

Interhemispheric Lesions:

The SSW showed left ear deficits for left parietal lobe lesions in several patients as reported by Lynn and Gilroy (1977) and Rintelmann and Lynn (1983). This finding could indicate that the corpus callosum had been compromised.

Baran et al. (1986) found slightly better function on the right ear than on the left ear, preoperatively in cases with anterior sectioning of the corpus callosum. Postoperatively there was little change seen on either ear's performance. The right ear superiority was accounted for by the fact that subjects had neurologically and/or surgically confirmed right hemisphere damage, therefore, reduced left ear performance could be expected.

The left ear extinction, seen in persons with interhemispheric lesions on the other dichotic tests is consistent on the SSW also, as construed from the above studies.

Learning Disability :

Johnson et. al. (1981) evaluated normal and learning disabled children aged 6-12 years with pure tone hearing within normal range using the SSW . They found that children with learning disability performed poorly than their normal peers, suggesting that learning disabled children may be identified by auditory performance on the SSW test.

BRAINSTEM LESIONS :

Katz (1970) reported SSW results on a case of left sided low brainstem tumor. The SSW showed normal performance for the right ear and a severe deficit for the left competing and noncompeting conditions. Also, a left sided high brainstem lesion showed a left ear deficit in the competing condition.

Jerger and Jerger (1975), compared SSW results in ten patients with intra axial brainstem lesions to lOn normal subjects. The pathological group showed 44% poorer scores for the ear contralateral and 16% poorer scores for the ear ipsilateral to the side of the lesions. Stephens and Thornton (1976) found abnormal SSW results in 6 out of 14 patients with brainstem disorders. Four of them demonstrated unilateral and two of them demonstrated bilateral deficits.

In a study on a patient with a gunshot wound on the right side of pons, Pinheiro et. al. (1982) reported a mild to moderate left ear deficit and a significant order effect on the SSW. Rintelmann and Lynn (1983) reported two brainstem lesion cases with SSW results. A post-mesencephalic lesion yielded a slight left ear competing condition deficit. A left sided pontanedullary lesion showed a severe left ear deficit.

Musiek and Guerkink (1982) and Musiek (1983b) reported abnormal SSW results on 60% of their subjects with brainstem disorders. Majority of those who demonstrated only unilateral brainstem lesions showed ipsilateral and bilateral ear abnormalities.

The research thus shows that the SSW is a sensitive test for detecting brainstem lesions, as well as cortical lesions.

PERIPHERAL HEARING LOSS:

Flynn et al. (1984) investigated effects of intensity on mild to moderate cochlear hearing impaired adults' performance on the SSW test. The SSW test was presented at 20, 30, 40, and 50 dB SL reference PTA. The responses were used to generate performance intensity functions. No significant differences were found for these hearing impaired listeners' performance for items presented at the standard 50 dB SL and those at the low sensation levels.

Thus, the authors concluded that the SSW may be administered on cochlear HL patients at SLs as low as 20 dB SL.

Due to the complexity of the test material, researchers do not use this test as much as the dichotic CV, but it does have application in detecting brainstem and cortical lesions.

DICHOTIC RHYME TEST

The dichotic rhyme task was introduced by Wexler and Halwes (1983) and modified by Musiek et al. (1989). It is composed of rhyming pairs of consonant-vowel-consonant (CVC) words that begin with one of the stop consonants. The stimuli are perfectly aligned so that fusion takes place and the listener most often hears just one of the two words presented.

NORMATIVE STUDIES :

Musiek et al. (1989) administered the DRT on 115 normal subjects and obtained a mean of 30-73% for the right ear and 27-60% for the left ear. Bellis (1996) reported normative values of 32-60% per ear scores below or above these values should considered abnormal according to him.

Research on the dichotic rhyme test has been very limited which may be because the performance of normals is also around 50% on this task..

Musiek et al. (1989) evaluated the performance of split-brain patients on the dichotic rhyme test. They found a marked left ear deficit and right ear enhancement, postoperatively. The depressed left ear scores were accounted for as follows.

In dichotic listening, the left hemisphere receives direct contralateral input from the right ear and input via the corpus callosum from the left ear. Therefore, there is competition for a limited amount of neural substrate activated by the stimuli presented to both ears. The more complex and aligned the dichotic stimuli, the greater the demand on the left hemisphere, and performance is compromised. If the competition via the corpus callosum is removed by sectioning or a lesion in this area, the left hemisphere is released from processing these stimuli, and it has to process only right ear input, which it can to efficiently. Therefore, the left ear scores get depressed and right ear scores get enhanced in cases like split-brain patients.

Similar to the DDT, the DRT also reveals suppression of left ear scores.

COMPETING SENTENCE TEST (CST)

The competing sentence test was developed by Willeford (1968). The test comprises of 25 pairs of simple sentences that are 6 & 7 words in length. The sentences are presented dichotically one at 35 dB SL and the other at 50 dB SL, reference SRT. The lower intensity sentence is the target and the higher intensity sentence serves as the competition. The subject has to repeat only the target sentence and ignore the competing sentence.

NORMATIVE STUDIES:

Ivey (1969) obtained norms on the CST. He found that the CST was a very easy task for the subjects and that the right ear showed a slightly better performance than the left ear. All the subjects got a 100% score on the CST.

Lynn & Gilroy (1972) found 100% scores on the CST with a sentence to competition ratio (SCR) of 0 dB in normal young adults.

Willeford (1978) found that subjects 5-10 years of age generally score 100% on the right ear. The other ear scores may lie anywhere between 0 and 100%. The scores in the weak ear were found to improve with increasing age up to 8-10 years of age at which time right and left ear performance is equal. Thus, adult performance is achieved by age 10.

BRAINSTEM LESIONS:

Musiek and Guerkink (1982) and Musiek (1983b) reported abnormal CST results in half of their subjects with brainstem lesions. Majority of the subjects showed unilateral deficits in the ears ipsilateral to the lesion. Rintelmann & Lynn (1983) reported normal CST results in a patient with a high, bilateral brainstem lesion. However, a patient with a low left sided brainstem tumor yielded a 0% score on that side and a 100% score contralaterally. Pinheiro et al. (1982), in their patient with a right pontine lesion reported a marked left ear deficit on competing sentences.

The CST, as construed from the above studies, is a good tool to diagnose brainstem lesions.

CORTICAL LESIONS:

Lynn and Gilroy (1972) reported a 0% score for the ear contralateral to a posterior temporal lobe tumor and 100% score for the ipsilateral ear. Patients with anterior temporal lobe lesions revealed normal findings on the CST.

When parietal lobe tumors were deeply situated (affecting the corpus callosum), no difference between ears was noted on monotic distorted speech tests. However, CST revealed poorer performance in the left ear regardless of which hemsphere was damaged. Lynn & Gilroy (1975, 1976) attributed this to the poor access that the left ear has to the dominant left hemisphere. In the same study five out of eleven patients with frontal lobe tumors had normal results on CST. Four of them had abnormal results for the ipsilateral ear. Lynn & Gilroy (1975, 1976) also reported significantly poor scores on the CST in vascular and degenerative type intracranial lesions.

Collard et al. (1982) reported abnormal results on the CST for 72% of their temporal lobectomy candidates. They found that CST yielded a greater percentage of abnormalities than the SSW, dichotic CVs and dichotic digits.

Bergman et al. (1987) used the GST technique to test two groups of brain damaged subjects. One group had suffered diffuse cerebrocranial injuries (CCI) and the other cerebrovascular accidents (CVA) that did not involve the temporal lobe. High incidence of central auditory dysfunction was found in both groups. Among the patients with CCI who showed abnormal results, 79% had abnormal left ear scores while 15% had abnormal right ear scores and 4 of the subjects had bilateral deficits. The patients had no difficulty with the sentences when it was presented without competition. The CVA group showed markedly poorer scores on the left ear in case of right hemisphere damage, while those with left hemisphere lesions showed equally poor performance on both ears, a poorer performance in the left (ipsilateral) ear.

Thus, the CST is useful in the diagnosis of cortical lesions also.

SYNTHETIC SENTENCE IDENTIFICATION WITH CONTRALATERAL COMPETING MESSAGE (SSI-CCM)

The SSI-CCM was developed by Jerger (1970). It consists of third order approximations of English sentences which are presented to one ear, and meaningful connected discourse to the other ear. The primary message is introduced at 40 dB SL, and the competing message is varied to produce message to competition ratios (MCRs) from 0 to 40 dB.

NORMATIVE STUDIES:

Jerger and Jerger (1974, 1975) administered the SSI-CCM on normal subjects. They found that all subjects obtained 100% scores in all MCRs from 0 to 40 dB, varied in 20 dB steps.

The SSI-CCM, thus is an easy task for normal subjects.

CORTICAL LESIONS:

Jerger and Jerger (1975) revealed poor scores for the ear contralateral to the lesioned hemisphere on the SSI-CCM. They concluded from their study that SSI-CCM was valuable in differentially diagnosing brainstem and cortical lesions. Keith (1977) and Jerger and Jerger (1981) reported similar findings on patients with temporal lobe disorders.

BRAINSTEM LESIONS:

Jerger and Jerger (1975) found normal SSI-CCM results in patients with intra axial and extra axial brainstem lesions. They concluded that SSI-CCM is not a very sensitive test for brainstem lesions.

Jacobson et al. (1983) found 100% scores in twenty patients with brainstem lesions for every MCR. Jerger and Jerger (1974) also reported normal (90-100%) SSI-CCM performance in intra axial brainstem disorders.

Since the SSI-CCM shows normal results in brainstem lesions, and abnormal results in cortical lesions, it can be used for differential diagnosis between the two.

COMPARISON BETWEEN DICHOTIC SPEECH TESTS

NORMATIVE STUDIES:

Harris, Keith and Novak (1983) administered the SSW and dichotic CV on children aged 6-8 years. The children were grouped into two based on normal or low Token Test scores. On the dichotic CV, there was no significant difference between groups with respect to left ear scores, but there was a significant difference between right ear scores. They also found a greater REA in the normal receptive language group, indicating that the CV syllables are signals with low linguistic load, and interpreted by the left hemisphere. The children with below average receptive level scores interpret CV signals equally well in both hemispheres. They appear to lack normally strong asymmetry of hemispheric function.

The SSW showed a significant difference between the two groups on the right competing and left competing conditions. They interpreted below average SSW performance as indicative of delayed maturation of the auditory system.

Thus, the combination of SSW and dichotic CV results imply a relation between neuromaturational development, hemispheric dominance and receptive language skills.

CORTICAL LESIONS:

Collard, et al. (1986) administered four dichotic tests to thirty patients before and after temporal lobectomy. The tests administered were - dichotic CV, SSW, CST and DDT. Preoperatively, scores on all those tests were found to be close to normal. Postoperatively, ipsilateral scores showed improvement, which was significant for SSW and dichotic CV. Contralaterally, there was a small deficit for the DDT, CST and the CV, but no statistical significance was found. Marginal significance was reached, however, for right ear lesion.

Relative ear difference increased postoperatively which could be due to ipsilateral ear improvement, rather than contralateral ear decline.

Musiek & Morgan (1981) reported results of the DDT, CST and SSW on a case of vasculitis. The lesion in such cases may extend from the auditory nerve, cochlea, brainstem to the middle cerebral artery which supplies to the superior temporal gyrus. The CT scan, and neurological examination etc., showed normal results. Pure tone and speech discrimination scores were normal.

On the DDT, SSW & CST, the right ear showed normal scores while left ear showed abnormal scores, before the treatment. The post treatment scores improved for the left ear. The DDT scores improved from 20% to

90%, CST scores from 65% to 100% while SSW from 82% to 95%. Thus, dichotic speech tests indicated right hemisphere involvement consistent with the symptomatology of the case while neurological examination did not. This adds to the validity of the dichotic speech tests.

Another study comparing dichotic speech tests was carried out by Musiek (1983b) who adminstered DDT, CST and SSW on subjects with surgically, radiologically and/or neurologjcally diagnosed intracranial lesions. Of these, eighteen had hemispheric lesions. DDT detected thirteen out of eighteen patients with the lesions, while SSW detected twelve out of eighteen subjects. The CST could identify nine out of eighteen subjects with hemispheric lesions. All the 3 tests, thus, were found to be sensitive for detecting hemispheric lesions than brainstem lesions.

Olsen (1983) administered the dichotic CV and SSW on thirtythree subjects with temporal lobectomy. Preoperatively, mostly normal scores were obtained for both ears. Postoperatively, ten of them showed abnormal results on the dichotic CV. On the SSW, scores reduced slightly postoperatively in case of temporal lobectomy. They concluded that dichotic CV was more sensitive than SSW for temporal lobe lesions.

Jerger and Jerger (1975) compared the SSW and SSI-CCM. Patients with nonauditory CNS lesions get 100% scores at all MCRs on the SSI-CCM, while 10% showed deficits on SSW. Patients with eighth nerve disorder showed normal SSI-CCM results while slight deficit on SSW. Subjects with brainstem disorders also showed normal scores on the SSI-CCM while deficit in performance for leading, competing and lagging condition of the contralateral ear. Ipsilateral ear showed reduced performance for competing conditions. The group with right temporal lobe disorder showed normal SSI-CCM results on the right ear and reduced performance on the left ear. SSW also revealed similar findings. Aphasics showed normal left ear performance, and impaired right ear performance on the SSI-CCM. SSW results showed reduced scores in the competing condition.

BRAINSTEM LESIONS:

Jacobson et al. (1983) evaluated twenty patients with brainstem lesions with the SSW, dichotic CV, and SSI-CCM. Two out of twenty patients showed abnormal scores on the SSW. All twenty showed 100% performance for SSI-CCM. Dichotic CV showed no statistically significant abnormality in the right ear, but left ear scores were reduced. Thus, the use of some dichotic speech tests may contribute to the diagnosis of brainstem lesions.

The clinical applicability of the dichotic tests reviewed above can be summarised in the following table given by Bellis (1996):

Table comparing dichotic speech tests in terms of processfes) assessed and sensitivity:

TEST	PROCESSES) ASSESSED	SENSITIVE TO
Dichotic Digits	Binaural integration	Brainstem, cortical and Corpus callosal lesions
Dichotic CV	Binaural integration	Cortical lesions
Staggered Spondaic Word Test	Binaural integration	Brainstem and cortical lesions.
Competing Sentences Test	Binaural integration	Neuromaturation & language processing.
Synthetic Sentence Identification with contralateral competing message	Binaural separation	Cortical Vs brainstem Lesions •
Dichotic Rhyme	Binaural integration	Interhemispheric transfer.

The dichotic CV test assesses the central auditory process of binaural integration. The review of literature on the dichotic C V test reveals that it is an especially sensitive test for detecting cortical lesions. The aim of the present study is to obtain norms on the test, so that the test can be used on the disordered population, and aid in diagnosis.

METHODOLOGY

The present study aimed at obtaining normative data on the "dichotic CV test-revised" developed by Yathiraj (1999) on a 16 bit computer. Another purpose of the study was to compare the normative data with that obtained by Rajagopal (1996) on the dichotic CV test developed by Yathiraj (1994) on a 8 bit computer.

Subjects:

The subjects for the study were 50 normal young adults, in the age range of 18 to 30 years, 25 of whom were males and 25 females.

Subject Selection Criteria:

The subjects selected for the study had:

(i) no known history of hearing loss,

(ii) no chronic otologic problems

(iii) no neurologic problems or trauma to the brain

(iv) no previous experience with dichotic listening tasks

(v) right-handedness

(vi) pure-tone thresholds less than 15 dB in both ears, in the frequency range of 250 Hz-8000 Hz for air conduction and 250 Hz - 4000 Hz for bone conduction.

(vii) 90% or higher scores on monotic presentation of the consonant-vowel (CV syllables)

Instrumentation:

Preliminary testing was done using the clinical audiometer Madsen OB 822 coupled to TDH-39 earphones housed in MX-41/AR ear cushions and the bone vibrator Radio Ear B-71.

For the dichotic CV test, the audio cassette consisting of the dichotic lists were played on the tape recorder, Philips AW 606. The signal from the tape recorder was fed to the tape input of the audiometer Madsen OB822. The output of the audiometer was given to TDH-39 earphones housed in MX-41/AR ear cushions.

The audiometer was calibrated for AC, BC and tape input to conform to ANSI standards (ANSI, 1989).

Material:

The material used were dichotic consonant-vowels, each list consisting of 30 standardized pairs of syllables /pa/, /ta/, /ka/, /ba/, /da/ & /ga/. The test material was developed by Yathiraj (1999) at the All India Institute of Speech and Hearing, Mysore. This was done using a computer software developed at the Voice & Speech Systems, Bangalore, with a sampling rate of 16 bits. The CVs were

- recorded such that the onset of syllables was simultaneous (0 msec) or delayed at asynchronics of 30 msec or 90 msec. The lag was either in the right or the left track.

Thus, the following five subtests 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 left 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 channel 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 downloaded onto a magnetic tape using the tape deck SONY FH-411R.

I. Procedure for subject selection:

(1) Pure-tone audiometry was done for all subjects prior to the dichotic CV test. Only those who got thresholds less than 15 dB in air conduction and bone conduction were administered the dichotic CV test.

(2) The C Vs were presented monotically using the single track of the dichotic CV to each ear separately. Those who obtained more than 90% scores were selected.

II. 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 'O' The dichotic stimuli were presented at 80 dB HL through TDH-39 earphones housed in MX-41/AR ear cushions.

The subjects were asked to respond on a multiple choice scoring sheet by marking off the two CVs heard among six alternatives [Appendix A]. Subjects were asked to guess if they were unsure of the responses.

Scoring:

Responses were scored in terms of single correct and double 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 subject reported the syllables presented to both ears correctly. The scores were recorded on a scoring sheet [Appendix B].

Analysis:

The raw data was subjected to statistical analysis where the mean, range and standard deviation was calculated. The t-test was used to find out significance of difference between the two means. The Number Crunching Statistical Software (Hintze, 1982) was used for the statistical analysis.

RESULTS AND DISCUSSION

The raw data was statistically analysed using the software program Number Crunching Statistical Software (Hintze, 1982). The mean, standard deviation, and range were calculated. The paired t-test was used to determine the significance between different parameters. Analysis was done to reveal information on:

(I) Single correct scores:

A single correct score was awarded when the subject identified the syllable presented to any one ear [right ear or left ear] correctly.

(A) Single correct scores at simultaneity.

(B) Single correct scores across onset time asynchronies.

(a) Comparison between right and left ear scores.

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

(I) Double correct scores:

A double correct score was awarded when the subject could correctly identify the syllables presented to both the ears.

I. SINGLE CORRECT SCORES:

(A) Single correct scores at simultaneity:

Table 1 : Mean, standard deviation, range, t-scores and level of significance for single correct scores (raw scores) at simultaneity.

EAR	MEAN	S.D.	RANGE	t-SCORE	LEVEL OF SIGNIFICANCE
RIGHT	27.46 (91.35%)	1.76	23-30	3.90	0.01
LEFT	25.82 (85.5%)	2.98	19-30		

Max. Score = 30.
Note: The values in the bracket are the single correct scores averaged in percentage.

Table 1 gives the mean, standard deviation, and t-scores with the level of significance for single correct scores at simultaneity. As seen from table 1, right ear scores were significantly higher than left ear scores (0.01 level) at simultaneity. Thus, the table 1 reveals that there was a significant right ear advantage (REA) in the subjects tested.

REA in normal subjects has also been reported by Studdert-Kennedy et al. (1970), Berlin et al. (1973), Orsen (1983), Bingea and Raffin (1986) on the western population and by Rajgopal (1996) and Ganguly (1996) on Indian population.

According to Berlin et al. (1973), this RE A is seen in normals because the left anterior temporal lobe is closer to the left primary speech area than the right anterior temporal lobe. Due to this, there would be lesser "transmission loss" to the left posterior temporal lobe, on the basis of proximity within the areas of the braia Owing to this proximity, there is more efficient interaction between the shorter pathways, giving rise to a REA.

Kimura (1967) on the other hand, attributed the REA to bilateral asymmetry in brain function. This hypothesis holds that-

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

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

This implies that the left hemisphere is dominant in the perception of sounds conveying language information (Kimura, 1967). REA is, therefore, a reflection of the hemispheric dominance.

(B) Single correct scores across onset-time-asynchronies

(a) Comparison between right and left ear scores:

Table 2 : Mean, standard deviation, range, t-sores, and level of significance for single correct scores (raw scores) at different onset-time-asynchronies.

LAG TIME	EAR	MEAN	S.D.	RANGE	t- SCORE	LEVEL OF SIGNIFICANCE
30 msec. Right lag	R	28.06 (93.52%)	1/71	23-30	4.344	0.01
	L	26.16 (86.76%)	2.66	19-30		
30 msec. Left lag	R	27.82 (93.84%)	2.24	17-30	5.352	0.01
	L	25.78 (85.97%)	2.87	17- 30		
90 msec. Right lag	R	28.22 (94.04)	1.59	23-30	3.644	0.01
	L	26.88 (89.57%)	2.36	21-30		
90 msec. Left lag	R	28.36 (94.42%)	1.63	22-30	5.603	0.01
	L	26.02 (86.96%)	2.71	20-30		

Max. score = 30

Note: The values in the bracket are the single correct scores averaged in percentage.

Table 2 depicts the mean, standard deviation and range of right & left correct scores at different lag times, along with the t-scores and level of significance. The values in the brackets are the averaged percent correct scores.

As seen from table 2, 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. That is, a right ear advantage was seen, irrespective of the ear to which the lag was presented. This persistence of higher right ear scores in spite of lag to left ear may be interpreted as reflecting the potential of the right ear advantage to overcome lag effects. This would again, indicate the superiority/ dominance of the left hemisphere in processing speech information.

Comparing the right ear scores in the 30 msec right and 30 msec left ear lag conditions, it can be seen that the right ear scores in the latter condition was slightly lower than that in the former, though the difference was not statistically significant.

From these latter findings, it can be inferred that though there was a slight reduction in the right ear scores when a lag of 30 msec is given to the left ear, as opposed to the right, no such reduction of right ear scores was observed when a 90 msec lag was given to the left ear, as opposed to the right.

The results of the present study regarding the lag effect are contradictory with those obtained by Berlin et al. (1973) who reported that right ear scores were higher than the left ear scores, only if the lag was to the right ear, and higher left ear scores were obtained if the lag was given to the left ear. Studdert-Kennedy et al. (1970) also reported that right ear superiority was abolished by a left ear lag greater than 20 msec, contradictory to the findings of the present study.

However, the present study is in agreement with Bingea and Raffin (1986) who also found a RE A at all lag times in both right and left ear lag conditions. The overall scores obtained in the present study were, however higher than those obtained by Bingea and Raffin (1986) which could be due to the differences in the procedure used to develop the dichotic CV material.

Individual data analysis was carried out for the present study at the 30 msec & 90 msec right and left lag conditions to check whether the absence of a lag effect was because some subjects showed lag effects while some did not, leading to a cancelling effect when the data are averaged across the whole group. It revealed that:

(i) When a 30 msec lag was given to the left ear, 12% of the subjects showed higher left ear scores, whereas, when the same lag was given to the right ear, only 4% subjects showed higher left ear scores. Higher scores for the right ear were found for 70% and 76% subjects for left ear and right ear lag conditions respectively.

(ii) When a 90 msec lag was given to the left ear, 18% of the subjects showed higher left ear scores. While in the 90 msec right lag condition, only 14% of the subjects showed higher left ear scores. In the left lag condition, 72% of the subjects showed higher right ear scores, while

74% of the subjects showed higher right ear scores in the right lag condition.

Bingen and Raffin (1986) had also done individual data analysis to explain the absence of a lag effect. They found that most of their subjects did not demonstrate a lag effect.

(b) Comparison of single correct scores across lag conditions:

1 .Right ear lag:

Table 3 : Comparison of single correct scores (raw scores) at simultaneity and across onset-time asynchronies in the right lag condition.

EAR	COMPARISON BETWEEN LAG TIMES	MEAN SCORES	t-SCORES	LEVEL OF SIGNIFICANCE
RIGHT EAR SCORES	0 msec	27.46	1.870	Not significant
	30 msec	28.06		
	0 msec	27.46	2.319	0.05
	90 msec	28.22		
	30 msec	28.06	0.548	Not significant
	90 msec	28.22		
LEFT EAR SCORES	0 msec	25.82	0.699	Not significant
	30 msec	26.16		
	0 msec	25.82	2.335	0.05
	90 msec	26.88		
	30 msec	26.16	1.527	Not significant
	90 msec	26.88		

Max. score = 30

Table 3 compares single correct scores at simultaneity and across onset time asynchronies when the lag was given to the right ear. This analysis was done to find out whether there was any significant improvement in the single correct scores in the right lag condition as the lag time increased.

(i) Right ear scores:

It is clear from table 3 that right ear scores at 30 msec right lag were greater than those at 0 msec lag, and those at 90 msec right lag were greater than those at 0 msec as well as 30 msec right lag. But statistically significant improvement (at the 0.05 level) in the scores could be obtained only when the lag to the right ear was increased from 0 msec to 90 msec.

(ii) Left ear scores:

The results obtained for the left ear scores were similar to those obtained for the right ear scores, with significant difference (at the 0.05 level) obtained only between the 0 msec and 90 msec right lag conditions.

2. Left ear lag:

Table 4 : Comparison of single correct scores (raw scores) at simultaneity and across onset-time asynchronies in the left lag condition.

EAR	COMPARISON BETWEEN LAG TIMES	MEAN SCORES	t-SCORES	LEVEL OF SIGNIFICANCE
RIGHT EAR SCORES	0 msec	27.46	0.929	Not significant
	30 msec	27.82		
	0 msec	27.46	3.53	0.01
	90 msec	28.36		
	30 msec	27.82	1.70	Not significant
	90 msec	28.36		
LEFT EAR SCORES	0 msec	25.82	0.507	Not significant
	30 msec	27.78		
	0 msec	25.82	0.527	Not significant
	90 msec	26.02		
	30 msec	25.78	0.795	Not significant
	90 msec	26.02		

Max. score = 30

Table 4 shows the comparison of single correct scores at 0 msec, 30 msec left lag and 90 msec left lag conditions.

(i) Right ear scores:

Right ear scores for 90 msec left lag were found to be significantly higher than those at 0 msec lag (0.05 level). No significant difference was found between the right ear scores at 0 msec and 30 msec left lag or between 30 msec and 90 msec left lag conditions.

(ii) Left ear scores:

No significant difference was found between the left ear scores at 0 msec and 30 msec, 30 msec and 90 msec, or between 0 msec and 90 msec left lag conditions.

Thus, in the right lag condition significant improvement in right and left ear scores was seen when the lag is increased from 0 to 90 msec. However, in the left lag condition, significant improvement in scores was seen only for right ear scores when the lag time was increased from 0 msec to 90 msec, while no significant improvement was seen in left ear scores across different lag times.

The above results can again be explained on the basis of left hemisphere dominance leading to right ear superiority. As the lag to the right ear is increased, the left hemisphere gets more time to process the syllable going to the right ear, and hence the right ear scores improve in the right lag condition. In the left ear lag condition, however, the right hemisphere gets more time to process the syllable going to the left ear, but since it is not specialized to process speech signals, significant improvement may not be seen in the left ear scores in spite of increase in lag time. Right ear scores show an improvement in spite of increasing lag to the left ear due to the inherent superiority of the left hemisphere to process speech signals.

Improvement in scores with increase in lag time has also been reported by Berlin et al. (1973) and Studdert-Kennedy et al. (1970).

II. DOUBLE CORRECT SCORES:

Table 5 : Mean, standard deviation and range for double correct scores (raw scores) at simultaneity and across lag times.

LAG TIME	MEAN	S.D.	RANGE
0 msec	23.46(78.37°/)	3.69	15-30
30 msec Right Lag	23.98 (79.9%)	3.73	15-20
30 msec Left lag	24.36 (80.37%)	3.66	15-30
90 msec Right lag	25.08(83.17%)	3.06	18-30
90 msec Left lag	24.56 (81.97%)	3.29	16-30

Max. score = 30.

Note: The values in the brackets are percentage scores of the mean.

Table 5 depicts the mean, SD, and range for double correct scores at simultaneity and across onset time asynchronies, along with scores in percent.

It is evident from the table that double correct scores improved with increase in lag time, for both right and left lag conditions. Single correct scores were found to be higher than double correct scores, and less variable than double correct scores. Thus, it is more difficult to correctly identify both syllables presented dichotically, than to identify any one of the two, which is why the variability in scores was found to be more in double correct scores.

Table 6 : Comparison of double correct scores across different onset time asynchronies and lag conditions.

EAR	COMPARISON BETWEEN LAG TIMES	MEAN SCORES	t-SCORES	LEVEL OF SIGNIFICANCE
RIGHT	0 msec 30 msec	23.46 23.98	1.12	Not significant
	0 msec 90 msec	23.46 25.08	3.63	0.01
	30 msec 90 msec	23.98 25.08	2.5	0.01
LEFT	0 msec 30 msec	23.46 24.36	1.84	Not significant
	0 msec 90 msec	23.46 24.56	2.13	0.05
	30 msec 90 msec	24.36 24.56	1.38	Not significant

Max. score = 30.

Table 6 compares the double correct scores obtained at different onset time asynchronies in the right and left lag conditions.

(i) Right ear lag:

Double correct scores improved as the lag to the right ear increased from 0 to 30 msec, 30 to 90 msec and 0 to 90 msec. There was a significant improvement, however, only when the lag to the right ear was increased from 30 msec to 90 msec or from 0 msec to 90 msec. No significant improvement was seen when the lag was increased from 0 to 30 msec.

(ii) Left ear lag:

Double correct scores showed an improvement as the lag to the left ear increased from 0 to 30 msec, 30 to 90 msec and from 0 to 90 msec, but significant difference (at the 0.05 level) was obtained only when the lag was increased from 0 to 90 msec.

These results can again be attributed to the left hemisphere dominance, due to which a lag to the right ear aids in improving double correct scores, while a lag to the left ear fails to do so due to the non-specialization of the right hemisphere for processing speech stimuli. Therefore, significant improvement was seen in double correct scores even when the lag to the right ear was increased from 30 to 90 msec, while the left ear lag had to be increased from 0 to 90 msec to show a significant improvement in scores.

Berlin et al, (1973), Studdert-Kennedy et al. (1970) and Bingea and Raffin (1986) have also reported an increase in overall double correct scores with increase in lag time. Bingea and Raffin (1986) found the improvement in scores to be significant between 0 and 120 msec, 30 and 120 msec, and 90 and 120 msec lag conditions, which is in agreement with the present study.

The overall double correct scores obtained in the present study were higher than those obtained by Bingea and Raffin (1986), which could be due to the difference in the procedure used to develop the dichotic CV material.

III. COMPARISON BETWEEN PRESENT STUDY AND STUDY BY RAJGOPAL (1996):

Table 7 : Comparison between mean, standard deviation, and range of single correct scores (raw scores) obtained in the present study and those obtained by Rajgopal (1996).

LAG TIME	EAR	MEAN •		S.D.		RANGE		t-SCORE	LEVEL OF SIGNIFI-CANCE
		I	II	I	II	I	II		
0 msec	R	19.3	27.46	4.38	1.76	12-29	23-30	12.22	0.01
	L	14.8	25.82	5.21	2.98	8-27	19-30	12.98	0.01
30 msec Rlag	R	20.9	28.06	4.27	1.71	11-28	23-30	11.838	0.01
	L	15.8	26.16	2.26	2.66	5-28	19-30	21.68	0.01
30 msec Llag	R	18.3	27.82	4.37	2.24	9-28	17-30	13.70%	0.01
	L	19.2	25.78	4.56	2.87	13-30	17-30	8.636	0.01
90 msec Rlag	R	22	28.22	4.47	1.59	19-29	23-30	9.2711	0.01
	L	20.2	26.88	5.72	2.36	10-29	21-30	7.634	0.01
90 msec Llag	R	20.3	28.36	5.09	1.63	9-30	2230	10.66	0.01
	L	21	26.02	10.42	2.71	15-28	20-30	3.2969	0.01

Max score = 30

I : Rajgopal (1996) II: Present study

Table 8 : Comparison between mean, standard deviation and range of double correct scores (raw scores) obtained in the present study and those obtained by Rajgopal (1996).

LAG TIME	MEAN		S.D.		RANGE		t-SCORE	LEVEL OF SIGNIFI-CANCE
	I	II	I	II	I	II		
Omsec	7.68	23.46	3.1	3.69	0-22	15-30	23.154	0.01
30 msec Rlag	10.24	23.98	3.4	3.73	0-22	15-30	19.237	0.01
30 msec Llag	11.6	24.36	4.27	3.66	4-29	15-30	14.537	0.01
90 msec Rlag	15.2	25.08	5.4	3.06	1-27	18-30	12.422	0.01
90 msec Llag	14.2	24.56	6.4	3.29	1-28	16-30	10.226	0.01

Max. score: 30
I : Rajgopal (1996) II: Present study

Table 7 and 8 demonstrate a comparison between the single correct (right and left) and double correct scores respectively, as obtained by Rajgopal (1996) and in the present study. From the tables, it is clear that both double and single correct (mean) scores obtained from the present study were significantly higher than those obtained by Rajgopal (1996). Also, the ranges of scores were lesser than that obtained by Rajgopal (1996), implying lesser intersubject variability in the present study.

The material used by Rajgopal (1996) was developed by Yathiraj (1994) with a computer software with 8 bit sampling rate, while the present study used material also developed by Yathiraj (1999) on a 16 bit computer. The only difference between the two materials was the sampling rates of the computer used to develop them. Therefore, the difference in scores of the two studies can be attributed to the increased sampling rate of the computer used to develop the material by Yathiraj (1999).

Thus, the findings of the present study confirmed the presence of RE A on the Indian population similar to the western population. Also single and double correct scores were found to improve the increase in lag time. Double correct scores were lower and more variable than the single correct scores. The scores of the present study were significantly higher than those obtained by Rajgopal (1996) obtained on material developed using a 8 bit computer, indicating that resolution and clarity of the signal improves with increased sampling rate.

SUMMARY AND CONCLUSIONS

The present study was carried out with the aim of developing normative data on adults 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 for the study were fifty normal hearing, right-handed adults, ranging in age from 18-30 years. None of them had a history of any otologic or neurologic problems. All of them were tested to ensure normal hearing prior to the administration of the test. The task involved identification of dichotic nonsense CV syllables presented at simultaneity and across onset-time asynchronies. The various onset time asynchronies used were 0 msec, 30 msec and 90 msec, with the lag given either to the right or the left ear.

Scoring was done in terms of single correct and double correct scores. A single correct response refers to correct identification of the syllable presented to the right ear or the left ear. A double correct response refers to correct identification of the syllables presented to both the ears. The raw data was statistically analysed, where the mean, standard deviation and range was calculated. The t-test was used to check the significance of the difference between means of different parameters.

The results of the study can be summarised as follows:

(I) Single correct scores:

(i) The analysis of single correct scores at simultaneity revealed a significant right ear advantage. Right ear advantage was also found across the different onset-time asynchronies. These findings are consistent with those of Berlin et al. (1973), Bingea & Raffin (1986), Olsen (1983), Studdert-Kennedy et al. (1970) and Rajgopal (1996)^ Ganguly (1996) who also reported a right ear advantage for dichotic presentation of CV syllables.

(ii) Comparing the single correct responses across the onset-time synchronies, it was found that the scores improved with increase in the 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.

(II) Double correct scores:

Double correct scores were also found to improve with increase in lag time. The improvement was found to be statistically significant only when the lag time was increased from 30 msec to 90 msec and from 0 msec to 90 msec in the right lag condition. In the left lag condition, a statistically significant improvement was found only when the lag time was increased from 0 msec to 90 msec.

In general, the double correct scores were lower than single correct scores at simultaneity as well as across lag time. The variability in terms of the standard deviation and range was found to be higher in case of double correct scores when compared to the single correct scores.

The above findings were discussed with respect to left hemiphere dominance, and were in agreement with Bingea and Raffin (1986), Olsen (1983), Berlin et al. (1973), Studdert-Kennedy et al. (1970), and Rajgopal (1996) and Ganguly (1996).

(ID) Comparison with findings of Rajgopal (1996):

The scores of the present study were compared with those of Rajgopal (1996), who developed normative data on adults 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 Rajgopal (1996). Also, the scores in the present study were found to be less variable compared to those reported by Rajgopal (1996), both, in terms of standard deviation and range. This difference in scores could be attributed to the use of a computer with a higher sampling rate (16 bits) for developing the material for the present study, which lead to a better clarity and resolution of the speech signal.

To conclude, the findings of the present study are fairly consistent with those previously reported in literature done both on the western population (Berlin et al. 1973; Studdert-Kennedy et al. 1970; Olsen, 1983, Bingea and Raffin, 1986) as well as on the Indian population (Rajgopal, 1996, Ganguly, 1996). This shows that the dichotic CV test is resistant to linguistic and dialectal variations, unlike other dichotic speech tests like the SSW, CST, SSI-CCM, DRT, etc., which are very language specific. It can be inferred, therefore, that the dichotic CV test is best suited for administration on the multilinguistic Indian population.

Clinical Implications:

As seen from the review on the dichotic CV tests, it is especially sensitive for cortical lesions. The norms obtained from the present study can be used to detect CAPD in cortical lesions.

Implications for future research:

- The variation of scores with a directed listening instruction could be investigated.
- Effects of aging on the scores of the test could also be determined.
- Normative data could be obtained on children and compared with that of adults to obtain information about the developmental trend in scores.
- The test could be administered on individuals having various disorders such as stuttering and learning disability.

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APPENDIX A

SCORING SHEET

Date:

Name: Mother Tongue:

Age / Sex: Other Language(s):

Education: Socio-economic Status:

AUDIOLOGICAL INVESTIGATION:

EAR	FREQUENCY IN Hz							
	250	500	1000	2000	4000 8000	PTA	SRT	PBMax
Rt.								
Lt.								
BC								

Monotic Scores (%):

Riaht ear: Left ear:

Dichotic Scores (%):

R L	R L	R L	!R L	R L

APPENDIX It

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	BAJ	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