EFFECT OF DICHOTIC OFFSET TRAINING (DOT) IN CHILDREN WITH AN AUDITORY PROCESSING DISORDER

Registration No. 05AUD013

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APRIL 2007

Dedicated to

my dearest
Amma, Appa,
Akka & Savi

Certificate

This is to certify that this dissertation entitled **"Effect of Dichotic Offset training in children with an auditory processing disorder"** is a bonafide work in part fulfillment for the degree of Master of Science (Audiology) of the student Registration No. 05AUD013. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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Declaration

This is to certify that the dissertation entitled **"Effect of Dichotic Offset training in children with an auditory processing disorder"** is the result of my own study and has not been submitted earlier to any other university for that award of any degree or diploma.

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INTRODUCTION

Auditory stimulation is so essential to development of humans that any interruption in this decoding process may have adverse effects on the overall maturation of an individual. The presence of an auditory processing problem is one condition that can disrupt the decoding of auditory signals (Hanson & Ulvestad, 1979). When a child develops well in all areas except the auditory, the specific nature of the problem should be investigated and appropriate remediation can be initiated.

A central auditory processing disorder (C)APD is a complex and heterogenous group of disorders usually associated with a range of listening and learning deficits despite normal hearing sensitivity (Chermak & Musiek, 1992).

The ASHA Task force on central auditory processing consensus development (1996) defined central auditory processes as the auditory system mechanism and functions responsible for the following behavioural phenomena: Sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal aspects of audition, including temporal resolution, temporal masking, temporal integration, temporal ordering; auditory performance decrements with competing acoustic signals; and auditory performance decrements with degraded acoustic signals.

The current definition of (C)APD explicitly recognizes both the auditory nature of the disorder and the inherent non-modularity of the CANS. ASHA (2005) defined central auditory processing as "the perceptual (i.e., neural) processing of auditory information in the central nervous system (CNS) and the neurobiologic activity that gives rise to the eletrophysiologic auditory potentials". It includes neural mechanisms that underlie a variety of auditory behaviours, including localization/lateralization, performance with degraded or competing acoustic signals, temporal aspects of audition, auditory discrimination and auditory pattern recognition.

A central auditory processing disorder (C)APD is an observed deficiency in one or more of the above listed behaviours. For some, (C)APD is presumed to result from the dysfunction of processes and mechanisms dedicated to audition; for others, (C)APD may stem from some more general dysfunction such as attention deficit or neural timing deficit, that affects performance across modalities. It is also possible for (C)APD to reflect coexisting dysfunctions of both sorts (ASHA Task force on central auditory processing consensus development, 1996).

Intervention for (C)APD should arise logically from the nature of an individual's auditory deficit and how that deficit relates to functional difficulties and sequelae. Although many management and remediation techniques have been proposed for treating (C)APD, the relative efficacy of any given approach will depend on its appropriateness to the specific (C)APD in question (Bellis, 2002).

Recent reports suggest that auditory training (AT) can serve as a valuable intervention tool, particularly for individuals with language impairment and central auditory processing disorder (C)APD (Chermak & Musiek, 2002). The use of AT for peripheral auditory problems is not a new concept, in that it has an extensive history (Musiek & Berge, 1998). Auditory training (AT) is designed to improve the function of the auditory system in resolving acoustic signals. Given the range of listening and learning deficits associated with APD, AT must be seen as only one component of a comprehensive management approach to improving auditory processing.

Musiek, Shinn and Hare, (2002) noted that the use of AT for treatment of APD is new and its application is different from the classic use of AT. Most important to this difference is that AT applied to APD is targeting the brain as the main site of mediation, and the brain, unlike the auditory periphery is plastic. Improvement in higher auditory function is related to the capacity of the central nervous system to change though peripheral sensorineural loss cannot be improved upon with AT, this may not be the case for deficits of the central auditory nervous system (CANS).

Appropriate auditory stimulation has been found to result in changes in the neural auditory system. Training for APD is not a short term achievement but a long term on going process which has to be carried out regularly and extensively. Diagnostic central test procedures can guide the clinician to the types of AT that are required by the patient (Musiek, Shinn & Hare, 2002). Some approaches to AT target a specific aspect of auditory ability (Alexander & Frost, 1982; Katz, Chertoff & Sawusch, 1984; Tallal et al., 1996), while other approaches are more eclectic (Chermak & Musiek, 1992; Sloan, 1986).

Chermak and Musiek (2002) categorize AT approaches as formal and informal. Formal AT is conducted by the professional in a controlled setting (i.e. a clinic or laboratory). Informal AT can be conducted at home or school. Formal AT have employed rigorous, acoustically controlled training paradigms using bottom-up (i.e. analytic) tasks with non-verbal signals (e.g. tones) and simple speech elements (e.g. discriminating paired consonant-vowel (CV) syllables) to target specific auditory processes. Several formal training programs have been suggested depending on the process that is being targeted (Katz, Chertoff & Sawusch 1984; Sloan, 1986; Tallal et al., 1996). Training for auditory integration is one such formal training program (Katz, Chertoff & Sawusch, 1984; English, Martonik & Moir, 2003). It has been shown that providing deficit specific therapy does result in improvement in auditory processing (Katz, Chertoff & Sawusch 1984; Putter-Katz et al., 2002; English, Martonik & Moir, 2003).

Need for the study:

According to Rupp and Stockdell (1978) between 15% to 20% of school age population has some type of language/learning disorder, 70 percent of these have some form of auditory impairment. Further, Chermak and Musiek (1997) estimated that as many as 2% to 5% of the school age population exhibit (C)APDs. In India it has been found that 3% of the children were found to have dyslexia (Ramaa, 1985). Since many of the school going children have this problem there is a need to find appropriate treatment procedures to help them develop their auditory skills and perform better academically.

Most of the children with central auditory processing problems find it very difficult to cope in school and they drop out. Appropriate treatment procedure will bring an effect in improving their defective auditory skill and it also brings about an overall development in other areas.

Many intervention procedures have been reported in literature but their efficacy have not been studied. Hence there is a need to study the effectiveness of an auditory training procedure which would enhance auditory perception.

Aim of the study:

The aim of the present study was to determine the effectiveness of Dichotic Offset Training in children with auditory processing disorder as evaluated using Dichotic CV and the Dichotic Digit Test.

REVIEW OF LITERATURE

The ultimate goal of screening and diagnostic assessment for (central) auditory processing disorders (C)APD is to determine an effective management strategy. Historically, confusion and vagueness in the definition and diagnosis of (C)APD was associated with scattered management approaches with unproven or at best questionable therapeutic value. Professionals, who approach (C)APD can be broadly divided into two groups: those who ascribe it to a language based origin, in which deficits are viewed in terms of their linguistic dependency (Mody & Studdert-Kennedy & Brady, 1994-1995) and those who maintain that disorders are auditory perceptual in nature, and occur due to a breakdown in the central auditory nervous system (Tallal, Miller & Fitch, 1993). Cognitive neuroscience correlates these two views as top-down processing or bottom-up processing. Intervention strategies have varied through the years depending on the processing model used (Wertz, Hall & Davis, 2002).

In a top down model, processing is concept driven with higher level constraints guiding the interpretation of input from lower levels (Chermak & Museik, 1997). Top-down forms of therapy focus on improving the use of metalinguistic and metacognitive strategies. According to Chermak and Musiek (1997) bottom-up processing refers to information processing that is data driven, in which the stimuli are the primary determinants of a higher level representation. Bottom-up theories are based upon the notion that listener's ability to encode incoming signals is deficient but can be improved through adaptive training.

A comprehensive approach to management of (C)APD, including auditory stimulation designed to bring about functional change within the central auditory nervous system, should be undertaken in all cases of (C)APD, according to Chermak and Musiek (1992). Katz (1994) summarized the foregoing generic management approach for children identified with (C)APD. Suggesting a shift on the traditional audiologic management approach, Katz noted that recommendations should be based on the individual's needs and the problem situations faced, rather than simply a generic approach. He has described individual and direct therapy techniques to improve phonemic concepts and skills, desensitization to background noise, and development of auditory memory and sequencing abilities.

Intervention for auditory processing disorders (APD) should arise logically from the nature of the individual's auditory deficit and how that deficit relates to functional difficulties and behavioural sequelae. Bellis (2002) noted that the utility of deficit specific intervention for auditory processing disorders (APD) is based on the following primary assumptions: First is the assumption that certain basic auditory skills or processes underlie more complex listening, learning, and communication abilities. A second assumption underlying the utility of deficit specific intervention for APD is that the capability exists for identifying those auditory processes that are dysfunctional in a given individual through the use of diagnostic tests of central auditory function. A final assumption, important to the utility of deficit specific intervention for APD is that, once identified, remediation of the underlying deficient auditory process or processes will facilitate improvement in those higher-orders, more complex functional ability areas with which a given individual is experiencing difficulties.

Recently, the trend in APD management has been focused towards more individualized, prescriptive and evidence-based therapy. Chermak and Musiek (1997) developed a comprehensive management approach to APD to address the range of listening and learning deficits experienced by children with APD. The intervention was a combination of auditory training and metalinguistic and metacognitive strategies. The auditory training portion focused on detection, discrimination, vigilance, binaural listening and inter hemispheric transfer.

Kelly (1995, cited Wertz, Hall & Davis, 2002) developed management strategies that blended both bottom-up and top-down processing, concentrating on auditory memory, auditory discrimination, auditory figure-ground, auditory cohesion, and auditory attention. The two most common management approaches, and the strategies that remain the most readily embraced by the audiologist, are modifications of the classroom and the recommendation for some type of assistive listening device.

Components of APD Intervention

Bellis (1996) opined that a comprehensive intervention for APD should seek to remediate the underlying auditory deficit(s) as well as improve the individual's ability to function in real world communication and learning environments. Any management plan for APD should include elements of each of the following three primary components:

> Environmental modifications to improve acoustic clarity and enhance learning/ listening: It is known that children with auditory processing deficits demonstrate difficulty hearing in noise. Therefore measures should be taken to improve their access to target information, while simultaneously decreasing background noise. Other environmental modifications may include teacher- or speaker-based interventions.

- > Compensatory strategies to strengthen higher-order top-down processing skills: Compensatory strategies training is not designed to remediate the underlying disorder, but rather to strengthen higher-order skills that can impact auditory functioning and to teach the individual to become an active participant in his or her own listening and comprehension success.
- > Direct remediation techniques: The purpose of remediation is to attempt to alleviate the disorder through specific therapeutic activities, either by training the recipient how to perform a specific auditory task, or by stimulating the auditory system in hopes of facilitating a structural, and concomitant functional change.

In other words, the management of (C)APD should focus on changing the environment, remediating the disorder, and improving the child's learning and listening skills.

Direct Remediation Techniques

According to Bellis (2002), the purpose of direct remediation activities is to maximize neuroplasticity and improve auditory performance by changing the way the brain processes auditory information. Depending on the specific deficit present, direct therapy may be targeted toward phoneme discrimination activities (and concomitant speech-to-print skills); dichotic listening training in which the intensity levels for each ear are gradually adjusted to improve the listener's performance in the weaker (usually left) ear; localization/lateralization training, enhancing perception of stress, rhythm and intonational aspects of speech; activities requiring temporal resolution or integration;

perception of acoustic patterns; or multimodality inter-hemispheric stimulation activities among others.

Deficit Specific Therapy

It has been recommended by Bellis (2002) that (C)APD intervention should be customized. When designing an individualized, deficit specific intervention for (C)APD, several steps are required according to her. These include the following:

> Identifying the auditory deficit(s): Programming deficit-specific intervention plans for (C)APD requires the identification of the specific auditory process(es) that is dysfunctional using diagnostic central auditory tests.

> Examining the individual's functional difficulties and sequelae: The second step in customizing (C)APD intervention is to determine how the underlying auditory deficit relates to (or coexists with) functional learning, language, and communication sequelae in the individual.

> Selecting the appropriate management strategies and remediation techniques: Once the underlying auditory deficit(s) and the secondary or associated functional difficulties are determined, appropriate environmental modifications, compensatory strategies, and direct treatment options should be selected that will address the individual's (C)APD in a deficit specific manner. Intervention for (C)APD should arise logically from the nature of the auditory deficit(s) and the behavioural sequelae the individual is experiencing.

> Monitoring intervention efficacy: All intervention techniques should be monitored on an ongoing basis and attractions to the individualized program made as needed.

For various (C)APDs, different broad forms of training have been recommended, tapping specific auditory deficits. These include phoneme synthesis training, auditory vigilance, auditory integration, auditory separation, auditory closure and auditory temporal processing. Different experts have suggested variations in activities to improve a specific process.

a) Phoneme Synthesis Training:

The purpose of phoneme training is to help the child learn to develop accurate phonemic representation and to improve speech-to-print skills. Several such programs have been developed over the years.

Auditory Discrimination in Depth (ADD) program /LiPS®: In 1971, Patricia and Phyllis Lindamood developed the multisensory Auditory Discrimination in Depth (ADD) program (now called The Lindamood Phonemic Sequencing® - LiPS®) which was described by Wertz et al. (2002). The program was based on research that stressed the importance of auditory perception and comparing phonemes in spoken syllables and its relationship to speech, reading and spelling. It was devised "for developing the function of the ear in monitoring the correspondence between the contrasts, sequences, and shifts of spoken language and the sets of graphic symbols which represent them." The program includes four levels of activities:

- > Gross level: which includes activities geared to problem solving techniques and the gross discrimination of sounds,
- > Oral-Aural level: pertaining to the teaching of auditory discrimination of sounds, consonant/vowel changes in syllable patterns, and changes in syllable combinations,
- > Sound Symbol level: teaching students to recognize graphic representations for different phonemes,
- > Coding level: coding of nonsense syllables into graphic and oral patterns and generalization into works.

A primary goal of this program was to help the child encode and decode multisyllable nonsense patterns until the student had achieved competency with real words (Lindamood & Lindamood, 1969, cited in Willeford & Burleigh, 1985). The Auditory Discrimination in Depth (ADD) program was recommended as a precursor for any speech, spelling or reading program for anyone from preschoolers to adults. The length of time that the individual was enrolled in this program varies according to the student's progress. However, the average amount of therapy consisted of 40-minute sessions daily for 2-3 months.

Sloan's program: Sloan (1986) developed an auditory perceptual approach to facilitate more accurate and efficient speech perception by training speech discrimination with the view that auditory perception was the outcome of auditory processing. She emphasizes that it is not only important to teach the child to discriminate speech sounds correctly, but also to help the child know when she or he has perceived a sound incorrectly or is unsure. In these situations, the child can put into use additional strategies he or she has learned in order to resolve the uncertainty, resulting in an improvement in confidence and self-esteem.

Sloan's program focuses primarily on consonant discrimination skill which involves the presentation of minimal contrast phoneme pairs, or phoneme pairs that are very similar (e.g., /t/ versus /d/). Phonemes are presented to the child in isolation, and the child must demonstrate mastery of minimal contrast pair discrimination, in terms of both accuracy and promptness of response, before adding new pairs. Following discrimination of phonemes presented in isolation, activities move to discrimination of minimal contrast pairs of phonemes in consonant-vowel and vowel-consonant syllables, and then to words of increasing complexity. The final portion of Sloan's program focuses on speech-to-print skills, and involves demonstrating the connection between the phoneme segments previously trained auditorily with their corresponding printed letter symbols. In her program a child learns to discriminate speech sound contrasts in increasingly more difficult phonetic sequences. It has been noted by Willeford and Burleigh, (1985) that, although her program deals primarily with consonant discrimination, the need for vowel training should not be overlooked. They suggested additional therapy to develop better use of contextual cues in auditory perception and comprehension since her program was not intended to address all aspects of auditory processing difficulties.

Katz and Burge (1971, cited in Willeford & Burleigh, 1985) also studied phonemic synthesis (PS), which is the ability to blend individual phonemes in correct sequence to form a word. Forty-three children from 5-15 years of age were enrolled in 8 training sessions of 30 minutes duration. Twenty-nine of these children were used for the final analysis of the success of the program. The phonetic synthesis program used prerecorded tapes from which the child was requested to blend two and three phoneme words. Out of 29 children seven of them (in the age range of five to seven years) improved with mean sores of 10.9 correct pre therapy to 25.8 correct post therapy. The other 22 children (in the age range of 11 to 12 years) also demonstrated improvement but not as significant, increasing from a mean score of 10.8 correct to 18.1 correct, post therapy. The authors felt that the lack of improvement in this group may be due to several reasons such as lack of motivation, feelings of inadequacy and the children were beyond the optimum age for developing increased ability in these two skills.

Earobics: This program was developed by Cognitive Concepts Incorporation. It is a software program for teaching auditory and phonological awareness skills for the prevention and remediation of reading and other language based disabilities in children between the age range of 4-7 years (Cognitive Concepts Inc., 1997-2000). There are 6 games with over 300 levels of play which includes Karloon's Balloon, C.C.Coal Car Trains, Rap-A-Tap-Tap, Rhyme time, Caterpillar connection, Basket full of eggs. It systematically teaches critical phonological awareness, auditory processing and introductory phonics skills required for learning to read and spell. These games also help develop general cognitive skill that support learning such as memory and attention.

b) Auditory Vigilance

Auditory vigilance refers to sustained attention. Individuals with auditory vigilance deficit will fail to detect the target stimulus in a continuous stream of auditory stimuli. The individuals also show false positive errors by responding to a stimulus other than the target stimulus (Bellis, 1996). The following programs have been used to improve auditory vigilance:

Auditory Perception Training (APT). Willete, Jackson and Peckins (1970, cited in Willeford & Burleigh, 1985) developed this program which is a remediation plan used to train "essential" auditory skills based on the progressive levels of attainment. In this program five basic units of study are presented at three levels of difficulty. The units are: 1) auditory memory 2) auditory motor 3) auditory figure-ground 4) auditory discrimination and 5) auditory imagery. This program was designed for children in primary and intermediate grade levels.

The APT II therapy plan is an extension of the APT program which was developed to help young adolescent students to improve their ability to listen and follow directions. The units of the program were similar to those in APT except for the exclusion of auditory discrimination.

Auditory perceptual training program: Butler, Hedrick and Manning (1973, cited in Willeford and Burleigh, 1985) developed this program (APT) primarily for children in grades one to three, or LD students through grade six. The program includes 39 tape recorded lessons that were divided into four basic units that include the following exercises:

> Listen for sounds: This involves selective listening, vigilance, temporal sequencing, speech-sound discrimination, and analysis.

> Listen for Words and Speakers: Training is provided for intonation patterns, voice identification, temporal sequencing, auditory closure, and auditory synthesis.

> Listen to remember: Here recognition of number of sounds and syllables in words or phrases and figure-ground discrimination through competing messages, is carried out.

> Listen to Learn: Training using more difficult competing messages and recognition of subject-verb agreement, active and passive voice, and complex syntactical structures is done.

They reported that after training, children will be able to process auditory information more efficiently. Though this program was extensively researched and field tested over 1500 children, no documentation was provided to support that there was improvement rather than of maturation or of other factors.

c) Therapy for Binaural Integration:

Binaural integration (BI) is the ability of a listener to process information presented to both ears at the same time. This process also involves working memory and divided attention. Poor performance in binaural integration may be expressed in the behavioural symptoms of difficulty in hearing background noises or difficulty listening to two conversations at the same time (Bellis, 1996). An individual with deficit in binaural integration will not be able to integrate or process information from more than one source at a time.

Binaural integration and binaural separation tasks are considered warranted when deficits are identified during dichotic evaluations. A common finding in children with APD is a left ear deficit on dichotic speech tasks (Musiek, Shannon & Hare, 2002). Musiek and Schochat (1998) used auditory training which involved directing the stimuli to the stronger ear at a reduced level. While maintaining the higher intensity level to the weaker ear this sound field condition provided more cross-over between signals and greater demands on the patient than if the task was conducted under earphones. The stimuli used were words, sentences and consonant vowel consonant (CVC) words. It was suggested by Musiek et al. (2002) that this procedure can also be modified using temporal offsets that lag in the poorer ear, which improves the poorer ear performance. By using adaptive techniques, the offset differentials are reduced over multiple practice sessions. This allows the improved performance of the good ear to stabilize back to normal and maintain the improvement of the weak ear at a higher level of performance.

One form of remediation for individuals with binaural integration problems is dichotic offset training, originally proposed by Rudmin and Katz (1982, cited in Katz, Chertoff & Sawusch, 1984). The main objective of Dichotic Offset Training (DOT) was to train the child to differentially integrate the two different stimuli which were separately given to both ears. Katz, Chertoff and Sawusch (1984) studied 10 children aged 7-10 years who demonstrated difficulty on a dichotic test (SSW). They were given Dichotic Offset training for 15 one-hour sessions. The training was given using different offset conditions (500, 100, 300, 200, 100 and 0 msec). A consistent pattern of improvement was documented for Staggered Dichotic Digit Test (SDD). However, they found a lack of statistically significant improvement on the SSW and Speech-in-Noise tests. Generalization of learning was not clearly substantiated and they suggested that a battery of auditory training tasks is likely to be more beneficial than training any single skill.

A case study by Musiek and Schochat (1998) profiled a 15 year old patient who demonstrated bilateral mild deficits on dichotic digits test and moderate bilateral deficits on the frequency pattern test and the compressed speech with reverberation test. A 6-week auditory training program was given that included three 1-hour sessions per week. The training tasks included intensity training, frequency training, temporal training, dichotic speech perception training and speech perception in competition training. In addition, home training was given 2 to 3 times per week for 15-30 minutes per session. Post auditory training performance showed higher scores on all central auditory tests. The greatest improvement was noted on the compressed speech with reverberation test.

A study by English, Martonik and Moir (2003) described another treatment for children with deficit in dichotic learning skill. Ten children with reduced left ear Dichotic Digit Test (DDT) scores (with the age range of 5 years 10 months to 10 years 9 months) were taken as subjects. In addition to dichotic listening deficits, subjects had problems in auditory discrimination, auditory sequential memory, and temporal resolution. The children were in the age range of 5 years 10 months to 10 year 9 months. They received additional auditory training in conjunction with the left-ear-only stimulation. A book on tape (Arthur's Chapter Books, Volume I) was used as a stimulus for auditory training. The training was given for 1 hour a week for 10 to 13 weeks. One of the subjects received the same left ear stimulation twice a week for 1 month, for a total of eight 20 minute sessions with no other auditory training. Dichotic Digits Test-Double Pairs was administered after treatment and again 4 to 6 weeks later. It was found that for most subjects, providing auditory stimulation to the left ear only improved left ear dichotic deficits as measured by the dichotic digit test.

From the studies carried out to improve auditory integration, it is evident that different forms of training can be provided which would result in an enhancement in dichotic performance. Both dichotic offset training as well as stimulation of the deviant ear, have shown to bring about improvement in auditory integration.

d) Therapy for Binaural Separation

Binaural separation is the ability of a listener to process an auditory message coming into one ear while ignoring a disparate message presented to the other ear at the same time. It is critical in everyday listening, particularly in a school environment. The behavioural symptom of binaural separation deficit can be difficulty hearing in background noise when more than one person is talking at the same time (Bellis, 1996).

Figure-ground or competing sound stimuli often represent serious learning blocks to the auditorially disabled individual. The listener's attention is easily distracted from the signal in the presence of extraneous, irrelevant sounds. According to Heasley (1980) the development of auditory attention and attention span will help the listener to attend to the desired message while ignoring other sounds. Initially the child was asked to listen and repeat two or three words in the presence of soft background noise heard from a record player or radio. Then the task was made difficult by asking them to repeat short sentences and asking questions in the presence of gradually louder extraneous sound. The next step was to tell a story against background sound that could be controlled for loudness or softness and asking questions related to the story. A system of timed reinforcements was used.

Putter-Katz et al. (2002) studied 20 children who had auditory processing problems. Their common complaint was difficulty in understanding verbal stimuli in the presence of noise or competing speech. They were scheduled for 45 minute treatment session per week for over a 4 month period (i.e. 13 -15 sessions). The management program focused on environmental modification techniques, remediation techniques and compensatory strategies. The children, who had deficit only in the speech-in-noise test, showed an improvement of approximately 10% following therapy. However, the improvement was seen only in the right ear and not in the left ear. In contrast, children who showed poor performance in both the speech-in-noise test and dichotic listening tasks showed 15% of improvement on almost all measures.

e) Auditory Closure

It is defined as the ability of the listener to utilize extrinsic and intrinsic redundancy to fill in missing or distorted portions of auditory signal and recognize the whole message. Deficit in auditory closure have been found to lead to difficulty in understanding speech in background noise or with unfamiliar speakers (Bellis, 1996).

According to Bellis (1996), the purpose of auditory closure activities is to assist the child in learning to fill in the missing parts in order to perceive a meaningful whole. Context plays an important role in auditory closure, since prediction of the complete word or message often depends on the surrounding context. The following exercises were designed to treat the children with deficit in auditory closure: missing word exercises, missing syllable exercises, missing phoneme exercises and vocabulary building. Several activities have been suggested for each of the above exercises. For the missing word exercises the activities suggested were familiar songs or rhymes, prediction of rhyming words, unfamiliar messages in which context is used to fill in the missing word; for missing syllable exercises the activities suggested were sentences in which the target word is embedded and single words; for missing phoneme exercises the activities suggested were sentences in which the target word is embedded, single words; repeating the above activities in noisy or distracting situations; for vocabulary building the activities suggested were reauditorization, contextual derivation of word meaning, immediate provision of definition, and reinforcement of definition. Virtually any method whereby the external redundancy of the acoustic signal is reduced was suggested to be utilized to train auditory closure skills.

f) Training for Temporal processing

Deccelerated speech training: Alexander and Frost (1982) reported about an auditory training program using decelerated speech that was time expanded 60-80 ms for transitions. This technique documented improvement in auditory discrimination in children with language disabilities. Tallal et al. (1996) used a similar auditory training paradigm as that of Alexander and Frost, but used a 50% time expansion and enhanced the intensity of fast transitional elements by 20 dB. This approach was also reported to show an improvement in the auditory discrimination of children with language learning disabilities.

Fast ForWord: This is a commercially available program with temporally altered speech. Fast ForWord is a computer software program that has been designed to build skills those children with language-learning impairment need for listening, speaking, and reading (Scientific Learning Corporation, 1999). The Fast ForWord consists of seven computer games incorporate acoustically modified speech in exercises to improve language decoding skills of children with language-learning impairments through helping them to discriminate subtle sound differences. The signals are digitally manipulated to increase the duration and intensity of certain phonemic or transition elements that have been previously identified to cause processing problems for children with specific language impairment. Each successive level of the game reduces the parameters by which the signals are modified until the fifth level of each game where the signal reflects the dynamics of normal adult conversational speech patterns.

Tallal and associates conducted large scale investigations to study the effectiveness of Fast ForWord. Merzenich, Tallal, and their colleagues have published two studies concerning changes in temporal processing and language comprehension in children with language-learning impairment (LL1). Merzenich et al. (1996) studied temporal processing in language learning impaired children. For training, two audio visual (AV) games were designed. The first AV game was a perceptual identification task and the second game was phonetic element recognition exercise. The first trial of these games was conducted with seven 5.9 to 9.1 year old children with LLI. Training was given for 19 to 28 training sessions of 20 minutes each conducted over a 4 week training period. Tallal Repetition test was conducted before and after training and it revealed a statistically significant improvement in the temporal event recognition and sequencing abilities. A second study was conducted on a larger sample of children with LLI. The pre and post training group differences were again significant. This study strongly indicated that the fundamental temporal processing deficits of LLI children can be overcome by training.

Tallal et al., (1996) studied language comprehension in seven children with language learning impairment by giving them training with temporally modified speech.

The children received the training in the form of games. In the first stage, the duration of the speech signal was prolonged by 50% while preserving its spectral content and natural quality. In the second processing stage, fast (3 to 30 Hz) transitional elements of speech were differentially enhanced by as much as 20 dB. Training exercises were conducted for 3 hours a day, 5 days a week, at the laboratory. In addition they did homework 1 to 2 hours a day, 7 days a week, over a 4 week period. The children with LLI were between 1 and 3 years behind their chronological age in speech and language development, based on their pre-training scores. After training, the scores significantly improved by 2 years with the children approaching or exceeding normal limits for their age in speech discrimination and language comprehension. A similar study was done on a larger group of subjects with LLI and the results were found to be similar as the first study. They demonstrated that training children with speech stimuli in which the brief, rapidly changing components have been temporally prolonged and emphasized, coupled with adaptive training exercises designed to sharpen temporal processing abilities, resulted in a dramatic improvement in receptive speech and language in children with LLI.

From the above studies it is evident that training using temporally altered speech does bring about an overall improvement in language development. Thus, it can be construed that direct remediation techniques bring about an improvement not only in the process being targeted, but brings about a global improvement in the language development of children having LLI.

Turner and Pearson (1999) reported four case studies of children diagnosed with a language-learning impairment in one of the following: receptive phonology, listening comprehension, or general language abilities. They used Fast ForWord Language for one hour and forty minutes, 5 days a week for about a 6 to 8 week period. The training program consisted of seven individual training exercises - three sound and four word exercises. The sound exercises present auditory information in a pre-word format using different frequencies, times, deviations and phonemes. As a child's performance improved, the degree of speech processing changed from Level 1 to Level 5, which was natural, unmodified speech. Once a child reached the criteria for dismissal from training, post-evaluation was done. These results demonstrated that Fast ForWord Language did not aid each child in the same area or in the same degree. Some children exhibit great improvement after completing Fast ForWord Language, but other children show only minimal improvement. It was noted that the success of a child's participation was based on many factors and the selection criteria were extremely important.

In addition to the above mentioned remedial procedures, training has also been offered for problems such as auditory memory and sequencing problems (Chermak & Musiek, 1997), metalinguistic and metacognitive strategies (Chermak, 1998) and inter-hemispheric transfer (Bellis, 1996). Depending on the problem faced by a particular child, the choice of therapy activities would have to be selected.

From the review of literature, it is evident that training for children with (C)APD has gained momentum since the last two decades. While several therapy strategies have been suggested for various processing problems, not all of them have been used to confirm their utility. Further, the number of studies substantiating improvement with specific training programs are relatively few. Hence, there is a need to carry out further studies in this area.

METHOD

The main objective of the present study was to study the effectiveness of Dichotic Offset Training (DOT) in children with an Auditory Processing Disorder. This was tried on children with low scores on dichotic tests.

Participants

Experimental Group

Two groups of participants were included in the present study, an experimental group and a control group. While the experimental group received Dichotic Offset therapy, the control group did not. The inclusion criteria of the participants into each of the groups are given below.

- Should have studied in an English medium school for at least 3 years,
- Should be in the age range of 7 - 12 years,
- Have normal pure tone air conduction thresholds (from 250 Hz to 8 kHz) and bone conduction thresholds (from 250 Hz to 4 kHz),
- Have normal immittance results at the time of testing,
- Have normal speech identification scores,
- Have no speech problems,
- Have normal IQ,
- Failed the "Screening Checklist for Auditory Processing" (SCAP) developed by Yathiraj and Mascarenhas (2002),
- Fail the Dichotic CV test Yathiraj (1999) and/or the Dichotic Digit test.

developed by Yathiraj (1999) using the norms of Krishna (2001) and the "Dichotic Digit test" developed at AIISH, with the norms obtained by Regishia (2003).

The material developed by Yathiraj (2006) was used for the training (Appendix A). It consisted of 12 dichotic word lists with six lists having monosyllables without blends and six lists having monosyllables with blends. Each list had 10 word pairs. The material had 6 offset lags (500 msec, 300 msec, 200 msec, 100 msec, 50 msec and 0 msec). Each offset lag consisted of 4 word lists, two having a right ear lag and two with a left ear lag. Prior to administering the dichotic material, the familiarity of the words was checked on ten children in the age range of 7 to 7; 11 years. In addition, the intelligibility of the recorded material, which had been done on a computer by a female speaker with a sampling rate of 16 kHz, was checked on ten adults. The material was found to be familiar to children as well as intelligible to adults.

Procedure

Participant Selection Procedure

The initial inclusion of the participants was done by screening for children using the "Screening Checklist for Auditory Processing" (SCAP), developed by Yathiraj and Mascarenhas (2002). The checklist was administered by teachers who had a good knowledge about the abilities of the children. Twelve of those children who had scored less than 50% were taken for further evaluation. They were evaluated using two dichotic tests. This included the dichotic CV test developed by Yathiraj (1999) and the dichotic digit test developed at AIISH.

Administration of Dichotic Tests

Baseline Evaluation (Evaluation I)

Dichotic CV test:

The test consisted of 30 pairs of CV segments. The 0 msec lag test was administered at 50 dBHL. The children were asked to repeat the phonemes and the responses were written down by the clinician. The scores obtained were compared with the norms developed by Krishna (2001). Of the twelve children who were administered the test ten failed the Dichotic CV test.

Dichotic Digit Test:

The 0 msec lag test stimuli were presented at 40 dBSL. The children were instructed to repeat all the numbers heard regardless of the order and the responses were written down. The test was scored and obtained scores were compared with the age matched norms developed by Regishia (2003). Eleven out of the twelve children failed the test. Half of the subjects were administered the Dichotic CV first, while the other half the Dichotic Digit test.

Table 1: Number of children who passed and failed the dichotic tests

Test	**Passed**		**Failed**	
	Experimental	Control	Experimental	Control
Dichotic CV	1	1	5	5
Dichotic Digit test	0	1	6	5
Dichotic CV and Dichotic digit test	0	0	5	5

Dichotic Offset Training:

Six of the children who failed either of the above tests were included for next stage of the study. The training was carried out using the Dichotic Offset Training (DOT) material developed by Yathiraj (2006), using an audio CD player with headphones. The training was started with the easier offset lag (500 msec) and once a child obtained approximately 70% double correct scores, the next lower lag material was used. If the double correct scores obtained did not reach the 65% criteria, the lists were presented again in a randomized order. Gradually the offset lag was reduced and the task was made more difficult. Each child went through all the lag times for both monosyllables without and with blends. Throughout the training the children were provided feedback regarding their performance (a head nod for every correct response). On completion of the 0 msec lag lists, therapy was stopped. The number of sessions required by the children varied between 10 sessions to 15 sessions, depending on the abilities of the child.

Post therapy evaluation (Evaluation II)

After completion of the 0 msec lag therapy, post therapy evaluation/II evaluation was done after 15 days. The dichotic CV and dichotic digit test were administered and the single correct and double correct scores were obtained. The children who did not receive training were also evaluated using the same two tests. The I and II evaluation scores were tabulated and scored using appropriate statistical procedures.

Scoring

Both single correct (right ear score and left ear score) and double correct scores were computed. A single correct score referred to the score when the subject reported the syllable or numbers presented to anyone ear correctly. A double correct score referred to the score when the subject reported the syllables or numbers presented to both the ears correctly.

RESULTS AND DISCUSSION

The study was done to find the effectiveness of Dichotic Offset Training in children with central auditory processing problems. The data of twelve children who failed in the SCAP and Dichotic Digit Test and/or Dichotic CV test were analyzed. While six of these children received dichotic offset training, six did not. The following statistical evaluations were done to analyze the data collected:

I) Comparison of the I and II evaluations done for the

a) Experimental group

b) Control group

II) Comparison of evaluation I and II across groups.

III) Comparison of dichotic offset scores in the experimental group

I a) Comparison of evaluations I and II in the experimental group.

The scores obtained by the experimental group during evaluation I (pre training evaluation) and evaluation II (post training evaluation) on the Dichotic tests were compared (Table 2). The comparison was done using the Wilcoxon Signed ranks test for the Dichotic CV test as well as Dichotic Digit test. For each of the dichotic tests, the single correct and double correct scores were compared.

The results revealed a statistically significant difference between the evaluation I and II scores following the dichotic offset training in the experimental group. The test scores were statistically significant at 0.05 levels for both single correct and double correct scores in the dichotic CV test. For the dichotic digit test, the scores were statistically significant only for the right ear single correct scores at a 0.05 level of significance. The left single correct scores and double correct scores did not show any statistically significant improvement (Table 3 & Figure 1).

Table 2: Evaluation I (pre training) and evaluation II (post training) dichotic scores for the experimental group.

Age in years	Gender	Evaluation I scores (pre training)						Evaluation II scores (post training)					
		Dichotic CV (Max. score = 30)			Dichotic digit test (Max. score = 30)			Dichotic CV			Dichotic digit test		
		RE	LE	DC	RE	LE	DC	RE	LE	DC	RE	LE	DC
10	F	4	2	0	21	24.5	6	20	23	16	24.5	25	12
8	F	9	7	2	18	8	0	13	20	5	22	17	0
10	F	8	12	0	13.5	29	1	18	27	16	25.5	29.5	22
7	M	11	18	0	6.5	4.5	0	13	21	6	20.5	25	7
7	F	4	22	0	12	16.5	0	12	23	8	16.5	27	0
8	M	16	19	9	15.5	26.5	3	17	25	14	23	22	4

Note: RE = Right ear single correct score
LE = Left ear single correct score
DC = Double correct score

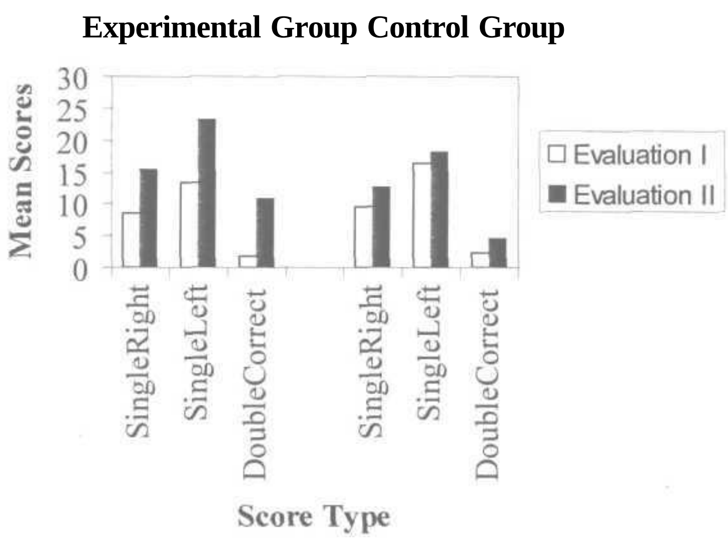
The results revealed that the dichotic offset training given for children who had deficit in binaural integration was found to be effective in acquiring that particular auditory skill. The improvement was found to be lesser in Dichotic Digit test when compared to the Dichotic CV test. This difference may be because the Dichotic Digit test requires auditory memory skills also along with binaural integration.

Table 3: Comparison of pre and post test scores in the experimental group

Test	Score type	Mean pre therapy score	Mean post therapy score	z value
Dichotic CV	Right single correct	8.7	15.5	-2.201*
	Left single correct	13.3	23.2	-2.01*
	Double correct	1.8	10.8	-2.207*
Dichotic digit	Right single correct	14.4	22.0	-2.201*
	Left single correct	18.2	24.3	-1.577
	Double correct	1.7	7.5	-1.826

Significant at 0.05 level

Figure 1: Evaluation I and II for the Dichotic CV test for the experimental and control group



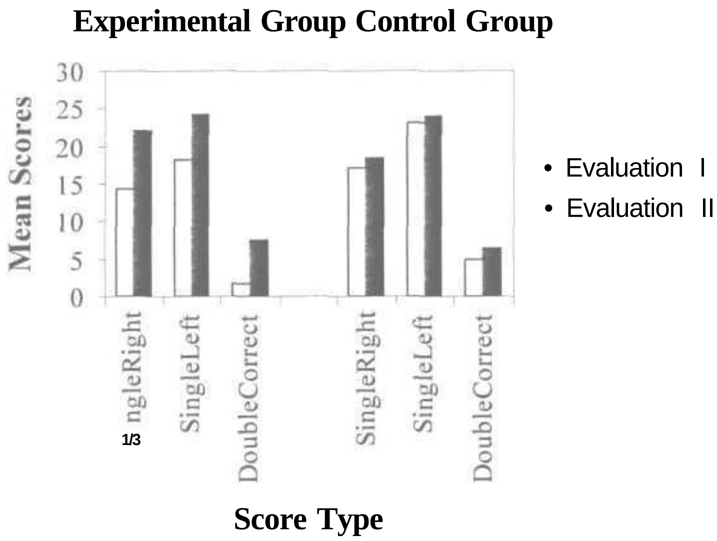
I b) Comparison of evaluations I and II done in the control group

The scores obtained by the control group during evaluations I and II are shown in the Table 4. These scores were compared using the Wilcoxon Signed rank test for both Dichotic CV and Dichotic Digit test. For each of the dichotic tests, the single and double correct scores were compared. The results revealed that there was not much improvement seen in scores of Dichotic CV and Dichotic Digit test for the control group who did not receive any training. The Z scores obtained shows that the difference in the scores was not statistically significant (Figure 2).

Table 4: Dichotic test scores on evaluations I and II for the control group.

Age in years	Gender	Evaluation I scores						Evaluation II scores					
		Dichotic CV (Max. score = 30)			Dichotic digit test (Max. score = 30)			Dichotic CV (Max. score = 30)			Dichotic digit test (Max. score = 30)		
		RE	LE	DC	RE	LE	DC	RE	LE	DC	RE	LE	DC
9	M	16	24	12	19.5	26	6	13	25	10	19	28.5	7
9	F	8	7	0	17	22.5	1	12	17	6	17.5	28	5
9	M	8.5	15	0	11.5	26	0	10	18	0	19	27	7
8	M	8	19	0	18.5	19	0	15	18	3	15	18	0
8	M	5	22	2	24	29.5	22	15	20	9	26.5	28	20
7	M	12	11	0	12	16.5	0	10	11	0	13.5	15	0

Figure 2: Evaluation I and II for the Dichotic Digit Test for the experimental and control group



Thus, it can be construed that without Dichotic Offset Training the subjects do not show any marked variation in their performance. The finding of the present study is similar to Katz, Chertoff and Sawusch (1984) who also reported that children, who did not receive Dichotic Offset Training, did not show an improvement in performance. Besides the improvement seen using Dichotic Offset Training, a study by English, Martonik and Moir (2003) showed that even training those with poor dichotic scores in the one ear, resulted in improvement in dichotic scores. In their study the poorer ear was stimulated and improvement was seen in left ear alone.

II) Comparison of evaluation I and II across groups

The scores obtained were compared between the experimental and control groups, separately for evaluations I and II (Table 5). For evaluation I, the mean scores for both the groups did not vary much for the Dichotic CV and the Dichotic Digit Test. However, for evaluation II, there were variations in the mean scores for the Dichotic CV test, but not much for the Dichotic Digit Test.

Table 5: Mean and standard deviation scores for both the groups on I and II evaluations.

Evaluation	Test	Score Type	Experimental group		Control group	
			Mean	SD	Mean	SD
Evaluation I	Dichotic CV	RE	8.7	4.5	9.6	3.9
		LE	13.3	7.7	16.3	6.6
		DC	1.9	3.6	2.3	4.8
	Dichotic digit test	RE	14.4	5.0	17.1	4.7
		LE	18.2	10.2	23.3	4.9
		DC	1.7	2.4	4.8	8.7
Evaluation II	Dichotic CV	RE	15.5	3.3	12.5	2.3
		LE	23.2	2.7	18.2	4.5
		DC	10.8	5.0	4.7	4.4
	Dichotic digit test	RE	22.0	3.2	18.4	4.5
		LE	24.3	4.3	24.1	5.9
		DC	7.5	8.4	6.5	7.3

To compare the mean scores between the experimental and control groups for evaluations I and II, non-parametric Mann-Whitney test was carried out. From Table 6 it is evident that there was no significant difference between the experimental and control group for evaluation I in the Dichotic CV and the Dichotic Digit Test. However, in evaluation II there was a statistically significant difference across the groups in the Dichotic CV test. The left single correct score showed a significant difference at the 0.05

level whereas the right single correct score and double correct score showed a significant difference at 0.1 level. The Dichotic Digit test did not show any significant difference when compared across the group. Thus, it can be concluded that following training, the experimental group showed a significant difference when compared to the control group, on a test that purely tapped auditory integration (dichotic CV). In contrast, the test that tapped both auditory integration and auditory memory (dichotic digit test), did not show such an improvement.

Table 6: Comparison of mean scores across the groups.

Test	Group	Score Type	Evaluation I Mean scores	Significance	Evaluation II Mean scores	Significance
Dichotic CV	Experimental	RE	8.666	NS	15.500	0.124**
	Control	RE	9.583		12.500	
	Experimental	LE	13.333	NS	23.166	0.036*
	Control	LE	16.333		18.166	
	Experimental	DC	1.833	NS	10.833	0.091**
	Control	DC	2.333		4.666	
Dichotic Digit Test	Experimental	RE	14.416	NS	22.000	NS
	Control	RE	17.083		18.416	
	Experimental	LE	18.166	NS	24.250	NS
	Control	LE	23.250		24.083	
	Experimental	DC	1.666	NS	7.500	NS
	Control	DC	4.833		6.500	

* Significant at 0.05 level
** Significant at 0.1 level

Ill) Comparison of dichotic offset scores in the experimental group.

The scores obtained by the experimental group during the dichotic offset training were also analyzed. The scores obtained at each of the lag times for the monosyllables without blends (Figure 3) and with blends (Figure 4) were analyzed. The double correct scores obtained during the therapy sessions were compared across various offset lags. This was done separately for the training material having a right lag and that having a left lag. For each the conditions, the baseline scores obtained at the start of the training were compared with the scores obtained at the end of the training, for a particular lag.

Figure 3: Double correct scores for monosyllables-without-blends, for varying lag times

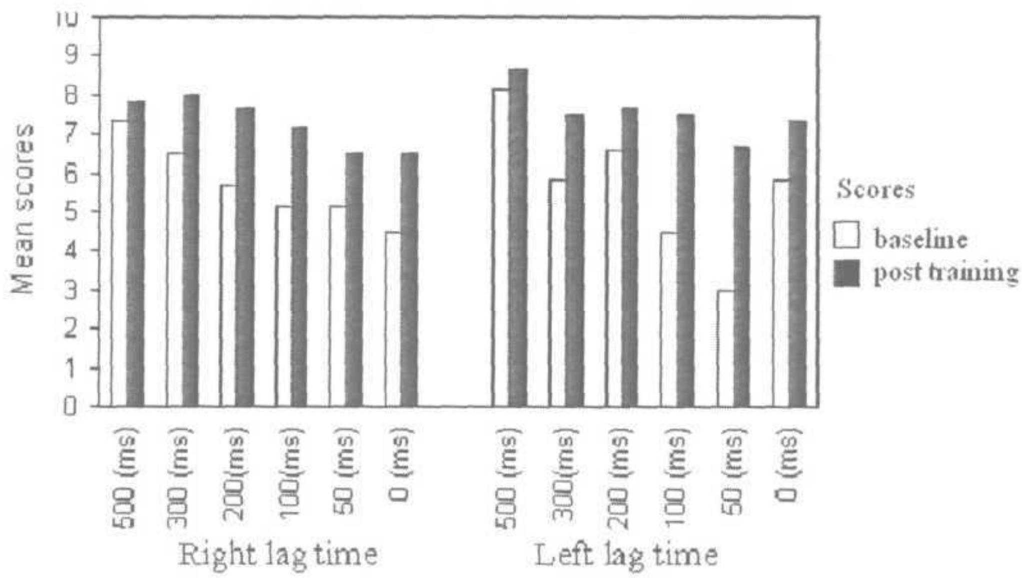
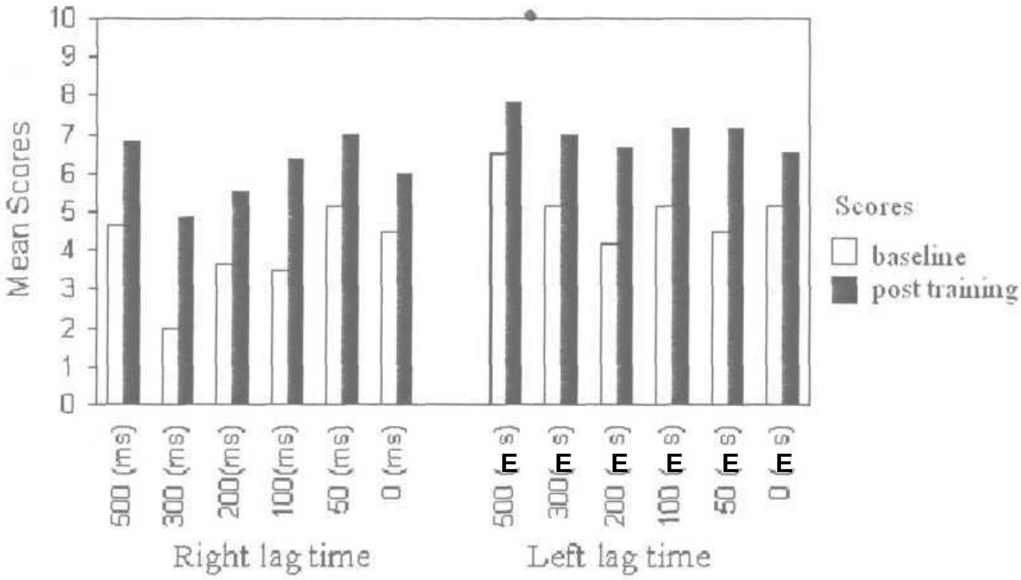


Figure 4: Double correct scores for monosyllables-with-blends, for varying lag times



From Figures 3 and 4, it can be observed that for all the lag conditions, material type (non blends and blends) and ear of lag, there was an improvement in performance with training. The improvement seen during therapy was greater for the monosyllables without blends, than for the monosyllables with blends. The Mann-Whitney test was carried out to check for overall changes between the baseline performance and the post therapy scores for each lag time. A statistically significant response was observed only for the 100 msec lag time. For other lag times, though there was an improvement, it was not statistically significant.

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

1. The Dichotic Offset training (DOT) is found to be effective in treating the children with deficits in binaural integration.
    a. Only those who underwent dichotic offset training showed an improvement in dichotic CV scores.

b. Those who did not undergo dichotic offset training did not show an improvement over time.

2. The experimental group showed a significant improvement ($p < 0.05$) in both the single and double correct scores in Dichotic CV test followed by the training.
3. In Dichotic Digit test the significant improvement was found only for the right ear single correct score ($p < 0.05$) and not for the left ear single correct and double correct scores.
4. It was concluded that the improvement is more for a dichotic test that taps only binaural integration (Dichotic CV) and not a test that taps both binaural integration and auditory memory (Dichotic Digit test).

SUMMARY AND CONCLUSION

Management of children with auditory processing disorders had gained wide importance in recent years. Various studies in the literature have shown that training children with central auditory processing problems using deficit specific intervention, results in the improvement of the auditory skills. Katz, Chertoff and Sawusch (1984) reported that the children with binaural integration deficit showed marked improvement in their dichotic scores following Dichotic Offset Training. However, there is limited literature in this area and there is a need to conduct further studies in order to know the efficacy of training children on a specific auditory deficit.

The present study aimed at studying the efficacy of Dichotic Offset Training (DOT) in children with auditory processing disorders. Twelve children who failed the "Screening Checklist for Auditory Processing" (SCAP), developed by Yathiraj and Mascarenhas (2002) and the Dichotic CV and/or the Dichotic Digit test were included in the study. The initial dichotic test results served as the baseline evaluation (Evaluation I). Six of these children were given training using dichotic material developed by Yathiraj (2006). The training material consisted of lists of monosyllabic words with and without blends with various offset lags. The training was given under headphones for around 10-15 sessions, based on the ability of the child. Initially the children were trained with the easiest lag time (500 msec) and gradually they were trained with the more difficult lag times. Once the children performed well with the 0 msec lag word lists, the training was terminated. After the training, post therapy evaluation (Evaluation II) was done using the dichotic tests for the experimental group to check the effectiveness of the treatment technique used. The control group who did not receive any training was also evaluated.

The data obtained were statistically analyzed using non-parametric Wilcoxon signed rank test. The control group did not show any statistically significant improvement in evaluation II. In contrast, the experimental group showed a statistically significant improvement following the dichotic offset training. This improvement was found to be significant in the Dichotic CV test for the single correct scores and the double correct scores. In contrast, for the Dichotic Digit Test, it was significant only for the right single correct scores. Based on the results of the present study it can be concluded that:

1. The Dichotic Offset training (DOT) is found to be effective in treating the children with deficits in binaural integration.
2. No significant improvement was found in pre and post training scores for control group in both Dichotic CV and Dichotic Digit test.
3. The experimental group showed significant improvement ($p < 0.05$) in both the single and double correct scores in the Dichotic CV test following training.
4. In Dichotic Digit test the significant improvement was found only for right ear single correct score ($p < 0.05$) and not for left ear single correct and double correct score.

Implications of the study:

Treating children with an auditory processing disorder using deficit specific intervention will helps in improving their auditory skills. Specifically, Dichotic Offset Training can be used in treating children with binaural integration problem.

The study adds to the scanty literature which has shown that dichotic offset training is a useful technique in improving auditory integration.

Similar studies can be carried out in order to check the effectiveness of various other intervention procedures which are deficit specific. Studies can also be done in order to find whether treating children with deficit specific method brings about an improvement in other areas also.

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APPENDIX A

Dichotic Offset Training Material developed by Yathiraj (2006)

Monosyllable word lists without blends	
500 msec lag in right ear - List 1	**500 msec lag in left ear - List 2**
1. tie- pen	1. eat- fan
2. hat- ball	2. rat- use
3. bed -hop	3. hair-pull
4. boat -see	4. far- ripe
5. rope-tap	5. see- beet
6. mouse-bone	6. fall- leaf
7. take -fish	7. box- our
8. map- line	8. hut-bike
9. pit- gun	9. fox- late
10 pot-shed	10. bell-ran
300 msec lag in right ear - List 3	**300 msec lag in left ear - List 4**
1. can- four	1. nut- book
2. pit- rat	2. cake- foot
3. fair- soap	3. man- back
4. red-tea	4. ship- bit
5. bean- lime	5. fun- sat
6. hit- saw	6. bag- tall
7. knee- bin	7. oil -sad
8. key- pan	8. jam- get
9. chair- bun	9. lid-hot
10 put- ate	10. seed-pup

200 msec lag in right ear - List 5	200 msec lag in left ear - List 6
1. dog-one	1. pat- mad
2. zip- men	2. less- goat
3. shop-top	3. zoo- six
4. mug- sit	4. coat- bad
5. pet-light	5. sheep- mat
6. cap- wet	6. bull- ear
7. fat-big	7. wall- cow
8. dig- shine	8. toy- lid
9. hide- net	9. hill-neck
10.bat- two	10. pig- head
100 msec lag in right ear - List 7	**100 msec lag in left ear - List 8**
1. men- full	1. eat- back
2. nose- duck	2. rat- car
3. eye-roof	3. hair- moon
4. red- nine	4. far-bull
5. four- run	5. see- feel
6. ten- cut	6. fall- door
7. pit- rain	7. box- egg
8. dot-leaf	8. hut-kite
9. gum- mouse	9. fox- hole
10. boy- shut	10. bell-tap

50 msec lag in right ear - List 9	50 msec lag in left ear - List 10
1. boot- fan	1. pat- mad
2. leg- use	2. less- bus
3. god-pull	3. zoo- five
4. lick- ripe	4. coat- hut
5. wheel- beet	5. sheep- leaf
6. bite-lit	6. bull- man
7. lip- our	7. wall- feet
8. us- bike	8. toy- fun
9. bill-late	9. hill-kite
10. tin- ran	10. pig-lock
0 msec lag in right ear - List 11	**0 msec lag in left ear - List 12**
1. nut- pen	1. dog- book
2. cake- ball	2. zip- foot
3. man-hop	3. shop-back
4. ship- see	4. mug- bit
5. fun- tap	5. pet- sat
6. bag- bone	6. cap- tall
7. oil-fish	7. fat- sad
8. jam- line	8. dig-get
9. lid- gun	9. hide-hot
10. seed- shed	10. bat- pup

Monosyllable word lists with blends	
500 msec lag in right ear - List 1 1. bring-clap 2. cloud-trap 3. train-blue 4. crowd-clean 5. black-try 6. block-free 7. blind-from 8. floor-spin 9. steel-please 10. blow-sleep	**500 msec lag in left ear - List 2** 1. tree-cross 2. prize-dried 3. grind-press 4. grass-print 5. fried-grapes 6. bridge-grand 7. frame-club 8. strong-sky 9. slap-gray 10. skirt-ground
300 msec lag in right ear - List 3 1. stop-cream 2. spoke-flag 3. stamp-crack 4. steam-blade 5. flow-drown 6. slide-twist 7. slip-trick 8. spot-fright 9. slam-plane 10. snore-flat	**300 msec lag in left ear - List 4** 1. free-plum 2. steam-three 3. drop-clip 4. crash-play 5. small-place 6. store-stick 7. frog-step 8. shirt-crow 9. flag-slow 10. stool-fresh

200 msec lag in right ear - List 5

1. tree- plan
2. prize- clap
3. grind-true
4. grass- crab
5. fried- gray
6. bridge- drive
7. frame- dress
8. strong- cross
9. slap- trip
10. skirt-break

200 msec **lag in left ear - List 6**

1. bring- twist
2. cloud- trick
3. train- fright
4. crowd- plane
5. black-flat
6. block- cream
7. blind-flag
8. floor- crack
9. steel- blade
10. blow-drown

100 msec lag in right ear - List 7

1. slide- clap
2. slip-trap
3. spot- blue
4. spoon- clean
5. snore-try
6. stop- free
7. spoke- from
8. stamp- spin
9. steam- please
10. flow- sleep

100 msec lag in left ear - List 8

1. step-fly
2. school-throw
3. slide-cry
4. star-bright
5. slim-brown
6. crawl-twin
7. bleed-swim
8. stand-class
9. spend-clip
10. branch-clock

50 msec lag in right ear - List 9	50 msec lag in left ear - List 10
1. store- twin	1. smoke-drive
2. frog- swim	2. smell-dress
3. shirt- class	3. skip-cross
4. flag- clip	4. strong-trip
5. stool- clock	5. spring-break
6. free- throw	6. skin-plan
7. steam- fly	7. sweet-clap
8. drop- cry	8. sneeze-gray
9. crash- bright	9. spell-crab
10. small- brown	10. state-true
0 msec lag in right ear - List 11	**0 msec lag in left ear - List 12**
1. skin- cross	1. step- plum
2. sweet- dried	2. school- three
3. sneeze- press	3. slide- clip
4. spell- print	4. star- play
5. state- grapes	5. slim- place
6. smoke- grand	6. crawl- stick
7. smell- club	7. bleed- step
8. skip- ground	8. stand- crow
9. strong- gray	9. spend- fresh
10. spring- sky	10. branch- slow