Computerized Therapy Modules in Kannada for Children with Auditory Processing Disorders

DOCTORAL THESIS

By

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Submitted for the degree of Doctor of Philosophy to the University of Mysore.

July 2005.

Dedicated to

My Wife Dr. S. Gowri

&

My Son Master R. Gokul Kannan

CERTIFICATE

This is to certify that the thesis entitled, Computerized Therapy Modules in Kannada for Children with Auditory Processing Disorders, submitted by M.P. Ravanan, for the degree of Doctor of Philosophy in Speech and Hearing to the University of Mysore, was carried out at All India Institute of Speech and Hearing, Mysore.

Place:
Date:

Prof. M. Jayaram
Director
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CERTIFICATE

I here by certify that the thesis entitled "Computerized Therapy Modules In Eannada For Children With Auditory Processing Disorders" submitted by M.P. Ravanan, for the degree of Doctor of Philosophy in Speech and Hearing to the University of Mysore, was carried out at All India Institute of Speech and Hearing, Mysore under my guidance.

Place: Mysore
Date: 11th July 2005

Dr. K. Rajalakshmi
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D E C L A R A T I O N

I declare that this thesis entitled, Computerized Therapy Modules In Kannada For Children With Auditory Processing Disorders, which is submitted here with for the award of the degree of Doctor of Philosophy in the field of Speech and Hearing to the University of Mysore, Mysore, is the result of work carried out by me at the All India Institute of Speech and Hearing, Mysore, under the guidance of Dr. K. Rajalakshmi, Lecturer, Department of Audiology, All India Institute of Speech and Hearing, Mysore. I further declare that the results of this work have not been previously submitted for any

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INTRODUCTION

INTRODUCTION

Hearing is a two-stage process; one stage is that of reception, the other is that of interpretation of the transmitted signal once it reaches the brain. Auditory processing is the name given to this second stage in the hearing process where the brain processes or interprets the auditory impulses it receives. Eisenson (1972) (Cited in Williford & Burleigh, 1985) defines it as "the process by which an individual oranizes and interprets sensory date he has received, on the basis of his past auditory experiences ". The process that take place beyond the level of the VIIIth cranial nerve, which are required for incoming sound to take on meaning, are commonly referred to as "Central Auditory Abilities" and the end product as "Auditory Perceptuion" (Williamson & Alexander, 1975) (Cited in Willifbrd & Burleigh, 1985).

The central auditory processing is the capacity to organize simultaneous or successive auditory elements into a definitive pattern. It refers to the process that occurs from the moment the sound enters the external ear canal till that particular event is experienced by the listener (Sloan, 1986). The result of processing is called perception, which has the quality of being organized or patterned event (Dember & Jenkins, 1970). Wood (1975) (Cited in Willifbrd & Burleigh, 1985) suggested that auditory processing requires a complex series of behaviors that include the ability to attend to the content source of a message, detect and identify the messages, transmit the message through the central nervous system, accurately sort the message on the appropriate perceptual and conceptual events in order to store and retain the message, retrieve and restore the message for response purpose.

Central auditory processing (CAP) has been defined in a number of ways. "Audiory processing involved attention to detection, and identification of the signal and decoding of the neural message" (Katz, Stecker & Henderson, 1992). "it is also the way our central mechanisms receive, perceive, decode and utilize speech/sound" (Lasky & Cox, 1983). Stark & Bernstein (1984) (Cited in Williford & Burleigh, 1985) define it as "the neural processes involved in obtaining infermation from signals presented in the auditory modality". Several primary researches have shown that central auditory processes involve the deployment of non-dedicated, global mechanisms of attention and memory in the service of acoustic signal processing (ASHA, 1996). The ASHA task force (1995) consolidates central auditory processing as "the auditory system mechanism and process responsible for sound localization, lateralization, auditory discrimination auditory pattern recorganization, temporal resolution, temporal masking temporal inyergertion, temporal ordering, and auditory performance decrement with degraded acoustic signals. Central auditory processing disorders are difined as deficiencies in any one or more of these behaviour". "CMPD or APD is a general breakdown in auditory abilities resulting in diminished learning (e.g comprehension) through hearing, even through peripheral audiory sensitivity is normal" (Whitelaw, 1997) (Cited in Chermack, & Museik, 1997). The theories of CAPD that have put forward the exclusionary criteria consider it as a deficit in the information processing of audible signals not attributable to impaired peripheral hearing sensitivity or intellectual impairment. "it specifically refers to limitation in the ongoing transmission, analysis, organization, transformation, elaboration, storage, retrieval and use of information contained in auditory signals" (Trace, 1993) (Cited in Chermak & Musiek, 1997). "CAPD is not a label for a unitary disease entity, but rather a description of a heterogeneous group of functional deficits which may reflect a loss of function, disordered function, or release of function" (ASHA, 1996, Chermak & Musiek, 1997). It may result from dysfunction of processes dedicated to audition; however, CAPD also may co-exist with a more global dysfunction that affects performance across modalities (e.g. attention deficit, neural timing deficit, language representation deficit) (ASHA, 1996; Chermak & Musiek, 1997).

Central auditory processing function is important for the communication process. Efficient processing of the auditory information is crucial for academic and work performance, social and emotional status and well being (Chermak & Museik, 1997). Break down in any part o the complex auditory and associated system might result in the auditory processing deficit (CAPD) which might differ in nature and severity. A central auditory processing disorder is a condition in which, one has difficulty processing auditory information when presented in a less than optimal listening environment. It has been shown that, the vast majority of children those have been evaluated, can hear even the faintest of sounds but are unable to process verbal stimuli in an effective manner in their effective training situation (Willeford & Burleigh, 1985). The term "Central" emerged years ago to differentiate the auditory processing disorders that occurred at the brainstem level and cortical levels from those originating in the cochlea or auditory nerve (Keith, 1999). The other terms used in the past to describe CAPD include central deafness, auditory agnosja, dysacusis, central auditory imperceptions, auditory processing disorders, central hearing loss, non-sensory hearing loss and obscure auditory dysfunction (Keith, 1999).

CAPD becomes more apparent in poorer listening environments such as open classrooms and background noise. Children may not show the problem until they begin school and have to actively listen in order to learn. Not all CAPD children present similar problems. Some experience problem in sequencing speech sounds while others have difficulty in understanding speech in the presence of background noise. CAPD affects how the brain processes spoken language. Children with CAPD have difficulty interpreting and storing information despite normal hearing. In addition to significantly restricting speech and language development, APD can affect other areas of learning, particularly reading and writing. These children have great difficulty processing the order of sounds and hence spelling and comprehension is compromised. Central auditory processing skills and speech perception are foundational skills for the emergence of phonological awareness. These skills are important building blocks to literacy. Many children with CAPD are slow and inaccurate at processing phonemic information which means that they are working harder to interpret what they hear.

In order for children to adequately decode speech they need to be able to process auditory information in less than 100 milliseconds. Many children with CAPD have processing speeds in excess of 400 -msec and sometimes as slow as 700- msec.

The cause for CAPD is not exactly known. Birth and developmental histories are often unremarkable and there is no evidence of brain damage. In some children, ear infections have been implicated as a factor. Neuro-maturation of the auditory system is often delayed in many children with CAPD. Some professionals consider that CAPD may be a form of learning disability. Children with CAPD have normal intelligence, but work far below their ability at school.

Children identified with CAPD behave as if peripheral hearing loss is present; even though hearing sensitivity is normal in such conditions. They may refuse to participate in classroom discussions or may respond inappropriately and remain withdrawn from classroom activities. Asking for frequent repetitions is generally noticed in such cases along with frequent episodes of auditory inattention. They may have trouble following complex auditory directions or commands and localizing sound. Often various kinds of behavioral measures show a deficit in their verbal IQ scores and significant scatter across subtests assessed by speech/language and/or psycho educational tests, with weaknesses in auditory dependent areas. Among other linguistic and cognitive deficits they show poor reading and/or spelling skills, fine and/or gross motor skill deficits, poor singing and music skills, and often a significant history of middle ear pathology. Clinically identified cases of CAPD have positive family history of ADHD and/or learning disabilities. Quite often children with CAPD are misdiagnosed as ADHD because of early and inappropriate measures.

Some of the auditory skills that may be affected in CAPD population:

- Phonologic awareness: Identifying sounds in words, the number of sounds in a word, and similarities among words; may show up in spelling, writing, and reading difficulties.

- Auditory discrimination: Recognizing differences when asked to say whether the sounds or words are the "same or different".

- Auditory memory: Storing, or retaining, pertinent auditory information may affect ability to follow oral directions, participate in discussions, and spell.

- Auditory figure-ground discrimination: Understanding spoken language in a noisy background may show up more in noisy environments or when expected to listen for information.

- Auditory sequencing: Remembering the order of spoken words or sounds in a series.

- Auditory blending: Combining isolated sounds together to form words.

Subtypes of CAPD:

There are many subtypes of CAPD. These include:

Auditory Decoding Deficit/Decoding:

This subtype is often considered as the "classic" manifestation of CAPD. The Auditory Decoding Deficit sub-profile may be the behavioral manifestation of poorly formed neural representation of acoustic features, particularly those important for phonemic discrimination and auditory closure. Children in this category are often described by their parents and teachers as having hearing difficulties even though peripheral hearing is-found to be normal. These children process information in a way that is slow and inaccurate. This inefficiency in processing means that they are working harder to interpret what they hear.

Output-organization deficit/organization:

Children with output-organization deficit have trouble organizing, sequencing, recalling, and/or expressing an answer. These children may have listened to, analyzed, correctly connected and pulled together the information but still have difficulty responding correctly. In general, children with output-organization difficulties often demonstrate difficulty on tasks where success is dependent on motor and/or planning skills.

Associative deficit/tolerance-fading memory:

Children with this sub-profile have difficulties applying the rules of language to sounds they hear. These children often have intolerance for background noise, and their understanding of speech/language declines markedly when noise is present. Often these children have early academic performance that is grade or age appropriate but as the language demands in the classroom increase these children have more and more difficulty. Children in this sub-profile often are undiagnosed until 3rd and 4th grade (Ferre, 1997).

Integration deficit:

Children with this sub-profile often demonstrate difficulty across modalities with any task that requires efficient inter-hemispheric communication. These children have problems tying together auditory and visual information. They frequently exhibit long delays in responding.

Prosodic deficit:

Children in this sub-profile often exhibit little or no expressive affect and may be described as "flat" or "monotonic" speakers and readers. They often have difficulty with pragmatic communication skills, sequencing, social judgment, gestalt patterning and spatial abilities. In other words these children may demonstrate a difficulty or inability to perceive the prosodic cues that underlie the communication of humor, sarcasm, and question forms etc., which rely heavily on intonational cues to gauge intent.

The problems of the children with auditory processing disabilities can also be broadly classified as those of integrating signals, separation of signals from the background noise, auditory memory/auditory sequencing etc.,. Several approaches have been proposed for each of these problems.

Auditory Integration/Interaction:

Binaural integration is the ability of a listener to process information being presented to each ear being different (Bellis, 1996). Integration deficits are characterized by the difficulty in tasks that require inter-hemispheric communication. This difficulty may be within or across modality. The child with integration deficits may have difficulty in integrating auditory and visual functions, or in integrating linguistic-based auditory information with non-linguistic auditory information such as rhythm and pattern perception (Bellis, 1996). On the tests of central auditory function, children with integration deficits typically will demonstrate abnormal left ear suppression on dichotic listening task, combined with bilateral deficits on tests of temporal patterning when verbal report is required.

At its more severe form, integration deficits may result in an ability to perceive prosody, with the result the spoken sentence will sound like strings or unrelated words with no relative stress to emphasize key words and other important cues. In this situation, comprehension of spoken message is severely affected. Behaviorally the child with integration deficit may also exhibit difficulty with multimodality task that requires inter-hemispheric co-operation, hence such skills like asking for dictation, which requires auditory and visual interaction, may be poor, as will the task that requires multi-sensory pattern perception.

The children with integration deficits may benefit from management approaches designed to improve inter-hemispheric transfer of information (Bellis, 1996).

Auditory Separation:

Auditory separation refers to a task where the individuals attend to one signal while ignoring another background signal. Such activities have been carried out as binaural as well as mono-aural. Binaural separation refers to the ability of a listener to process an auditory message coming into one ear while ignoring a desperate message being presented to the opposite ear at the same time (Bellis, 1996).

Binaural separation and integration are processes that are critical to everyday listening, particularly in school environment. Dysfunction in the process of binaural separation and integration may be expressed in the behavioral symptoms of difficulty in hearing in the presence of background noise or when more than one person is talking at the same time. The child with binaural separation/integration deficits will perform poorly in dichotic speech tests.

Auditory functions that rely upon binaural interaction include localization and lateralization of auditory stimuli, binaural release from masking, detection of signals in noise, and binaural fusion (Bellis, 1996).

Auditory training approaches for children with CAPD:

There are many different approaches to teaching auditory skills that presume to assist the child with a CAPD. Some of these techniques include, speech sound discrimination, Auditory discrimination by Sloan, 1986, Auditory closure by Bellis 1996, Auditory memory by Chermak & Musiek, 1997, Temporal processing strategies by Tallal et al. 1996.

Various studies have been conducted to study the effect of these perceptual training. Merzenich, Jenkins, Johnston, Schrenier, Miller, Tallal (1996) & Tallal et al,. (1996) have described the positive effects of computer based games that train to modify temporal processing deficits in these children. Merzenich et al. (1996) claimed that these studies strongly indicate that fundamental temporal processing deficits can be over come by training. The concept of auditory training to stimulate auditory related problems dates back to pre-medieval times (Musiek & Berge, 1998). Initially auditory training was used to enable hearing impaired individuals make maximum use of their residual hearing. However, since 1960 it has been used in the rehabilitation of individuals with CAPD.

The trend now in APD management is towards more individualized prescriptive and evidence based therapy (Wertz, Hall, & Davis, 2000). According to Bellis (2002) the utility of deficit specific intervention for APD is based on three primary assumptions. First assumption is that, certain basic auditory skills or processes underlie more complex listening, learning and communication utilities. The 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 processes will facilitate improvement in those higher orders, more complex functional ability areas with which a given individual is experiencing difficulties.

Auditory training programs must match the age of the child. Even though central tests results often cannot be obtained until the 6 or 7 years of age, auditory training can be initiated much earlier itself. Penfield (1959) (Cited in Willeford & Burleigh 1985), states that, the idea of learning a language was only possible up to the age of 10 -12 years. He also states that the nervous system has a finite period of development and that certain skills could not be learnt beyond a facilitating growth period.

According to Chermak & Musiek (1997) the assessment data should be used to guide intervention planning. Even information gathered from checklists and questionnaire used to identify children at risk for CAPD can provide insights regarding functional deficits and program planning (ASHA, 1996; Fisher, 1976 [Cited in Willeford & Burleigh, 1985]; Smoski, Brunt & Tannahill, 1992).

Although some drugs have been shown to improve memory losses associated with neurodegenerative diseases such as Alzheimer's disease, pharmacological therapies are not available for the treatment of CAPD.

Need for the study:

Need for Auditory training module for children:

Research in the recent past has indicated how auditory training improves auditory perceptual skills in children with auditory processing problems. One key factor related to improvement from auditory training is the nerve plasticity. When multiple experience occur over time, as it happens during direct auditory training new neural groups can form, grow and get strengthened (Merzenich,1999) (Cited in Keith, 1999).

Need for Computer based therapy program:

Tallal & Miller (1996) have described the positive effects of computer-based games that train or modify temporal processing deficits in children. They demonstrated that intensive computer training with temporally prolonged speech leads to improvement in temporal processing thresholds. Computer based procedures, is interactive in nature, and requires little assistance. Further computers are now-a-days widely available in schools. Hence there is a great need for such a computer based interactive program in India. Hence the present study was undertaken.

Need for training auditory integration and auditory Separation:

The review indicates that, of the many auditory processing disabilities, the child with auditory processing disorders faces, the predominant among them is auditory integration and auditory separation activities. So, these two activities have to be given more importance and more care in designing a training module. Hence the training module was developed including predominantly these two processes.

The objectives of the study:

1. To develop computerized training modules in Kannada language for Auditory integration and Auditory separation aspects of auditory processing disorder.

2. To check the efficacy of the developed therapy program.

Design of the study:

Three schools located in the city of Mysore were selected for the study. All the children in the age range of 8-12 years were initially screened for any speech, language, or hearing problems. Following this, the children were administered the auditory processing screening checklist. Those who failed the screening checklist were administered Raven's Progressive Matrix (Color) Raven, Court& Raven (1977) test to rule out mental retardation. Later those subjects who failed the APD check list and who were in the above average intelligence category were administered the APD tests (Dichotic digits, Pitch pattern tests, and CST). Those who failed in one or more of the test were taken as subjects for the study. The experimental subjects were given therapy for 30 sessions. All the subjects were assessed with these tests on day one, fifteenth day, thirtieth day, and after two months of therapy. Their response sheets were taken for analysis and the data's were tabulated and taken for analysis.

Analysis:

The response sheets of the different subject both experimental and control groups on different tests were scored. The data obtained was tabulated for each subgroup of the experimental and control group. Comparison between experimental and control group across the subgroups were made along with comparison between pre and post-therapy measures. Appropriate statistical analysis was applied to infer the obtained results.

Implications of the study:

This study will give an insight on developing more and more therapy material for children with APD. The results obtained will advise on whether therapy will improve the auditory processing abilities in children with training. The newly developed therapy material can be made available so that it can be used for children with APD. Apart from contributing towards the development of a training kit, the study will provide norms for further research.

Limitations:

As every other empirical research this particular study also has its own set of limitations. Only subjects from three schools were selected and taken for the study and hence making the range and diversity rather limited. Subjects in the age range of 8 to 12 years were taken for the study. Therapy with the newly developed module was given only for thirty sessions because of time constraints.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Central auditory processing disorders are deficits in the formation of processing of audible signals not attributed to impaired hearing, sensitivity or intellectual impairment. Specifically, CAPD refers to limitations in the ongoing transmission, analysis, organization, transformational, elaboration, storage, retrieval, and use of information contained in audible signals. This processing involves perceptual, cognitive, and linguistic functions which, with appropriate interaction, results in effective receptive communication of passive (e.g. conscious and unconscious, mediated and unmediated) ability to: attend, discriminate, and identify acoustic signals; transform and continuously transmit information through both the peripheral and central nervous systems; filter, sort and combine information at appropriate perceptual and conceptual levels; store and retrieve information efficiently; restore, using phonological, semantic, syntactic, and pragmatic knowledge and attach meaning to a stream of acoustic signals through utilization of linguistic and non-linguistic contexts (ASHA,1990).

Central Auditory Processes are the auditory system mechanisms and processes responsible for behavioral deficits observed in sound localization, lateralization, auditory discrimination, and auditory pattern recognition. Temporal aspects of audition, including temporal resolution, temporal masking, temporal integration, and temporal ordering may also be disturbed. Children with CAPD show auditory performance decrements with competing acoustic signals and with degraded acoustic signals.

These mechanisms and processes are presumed to apply to nonverbal as well as verbal signals and to affect many areas of intellectual functioning, including speech and language. They have Neuro-physiological as well as behavioral correlates. Many Neuro-cognitive mechanisms and processes are engaged in recognition and discrimination tasks. Some are specifically dedicated to acoustic signals, whereas others (e.g., attentional processes, long-term language representations) are not. With respect to these non-dedicated mechanisms and processes, the term central auditory process refers particularly to their deployment in the service of acoustic signal processing (ASHA, 1996).

The brain unlike the auditory periphery is plastic. Auditory plasticity according to Musiek & Burge (1998) is defined as "the alterations of nerve cells to better confirm to immediate environmental influences, which is often associated with behavioural change ". According to Scheich (1991) there are three general types of plasticity, developmental, compensatory and learning related. Recent studies by Hassamanova, Myslivecek & Novakova (1981) Knudsen (1988) (Cited in Chermak & Musiek, 1997), Recanzone (1991, cited in Chermak & Musiek, 1997), Edeline & Weinberger (1993) (Cited in Chermak & Musiek, 1997), Merzenich et al. (1996) have provided evidence to confirm that brain has the quality of plasticity and can be altered by constant and systematic acoustic stimulation. The brain plasticity is the foundation of modern auditory training. According to Musiek, Baran, & Schochat (1999), speech perception requires the involvement of the central mechanisms. These central mechanisms are plastic and can be improved with practice. The term "brain plasticity" refers to the phenomena in which experiences excite individual neurons and influence connections between networks of neurons. When multiple experiences occur over time, as it happens during direct training, new neural groups can form, grow and strengthen (Merzenich & Schreiner, 1999, cited in Veale, 1999). Plasticity effects have been documented in humans through Psychophysical studies by Ahissar & Hochstein (1993) (Cited in Gillam, 1999) and through electro physiological studies by Jirsa (1992). According to Merzenich et al. (1996) intensive training, that follows behavioral principles, will gradually increase the temporal processing requirement task and would result in maximum reorganization of the neural mechanism, which results in improved learning. "Brain plasticity seems to be greater when the animal or human being is young". Hence, young brain when provided with training shows rapid changes (Hassamannova, Myshveceko & Novakova, 1981). According to Chermak & Museik (1997) & Tallal et al., (1996) the auditory system needs to be challenged in an appropriate manner to trigger such changes in structure and function.

The purpose of remediation in CAPD is to attempt to alleviate the disorder through specific therapeutic activities either by training the recipient as to how to perform a specific auditory task, or by stimulating the auditory system in the hope of facilitating a structural and concomitant functional change (Bellis, 1996).

Prevalence of Central Auditory Processing Disorders:

Prevalence data for CAPD are sparse. Chermak (2001) has estimated that APD occurs in 2 to 3% of the children with a 2 : 1 ratio between boys and girls. Cooper & Gates (1991) estimated APD in 10% to 20 % of older adults. Stach et al. (1987), as cited in Chermak (2001) reported APD in 70% of clinical patients over the age of 60 years. Lewis (1986) [Cited in Chermak, 2001] estimated that 3% to 7% of all the school age children exhibit some forms of learning disability. Bellis (1996) estimated that about 3-7 % of all school aged children exhibit some amount of learning disability. According to Silverman & Metz (1973) (cited in Keith, 1977) at least 10 - 15 % of school population in the United States fit this criteria out of which only 1.4 % to 2.6 % are in special classes. In India, the percentage of children found to have dyslexia ranges from 3% (Ramaa, 1985) to 7.5 % Nishi Mary (1988) (Cited in Ramaa, 2000). Ravanan & Rajalakshmi (2005) estimated 7 to 8% prevalence of Auditory processing disorders in school going children in the age range of 8 to 12 years in India. Hurley & Singer (1989) (Cited in Bellis 2001) state that the number of children with APD within a population of learning disability cannot be stated with any certainty. It is likely to be very high. The difference in the findings is probably due to the method used to determine the presence of the problem. Most often these children go unidentified as they drop out of school because of poor academic performance.

Techniques available for the Management of Auditory processing Deficits:

1. Barry's Program: (Barry (1961) [Cited in Barr, (1976)] :

Barry (1961) (Cited in Barr, 1976) describes awareness training as a three-phase process.

The three phases are:

a) Awareness of gross sounds where a motor response in solicited to frequency differences in the sound of a bell, drum, whistle and horn.

b) Awareness of finer sounds where beads are dropped into a tin, pebbles are rattled in a box, coins are jangled and a spoon is stirred in a cup.

c) Awareness of voice and speech, where the child gives a motor response to digit, word, phrases and nonsense syllables.

2. Auditory Discrimination In-Depth Program (ADD): Lindamood & Lindamood (1969) (Cited in Willeford & Burleigh 1985)

This program was developed by Lindamood & Lindamood (1969) (Cited in Willeford & Burleigh 1985). This program aims in developing the function of the ear in monitoring the correspondence between the contrasts, sequences and shifts of our spoken language and the sets of graphic symbols which represents them. The program includes four levels of activities.

i) Gross levels: This includes activities geared to problem solving techniques and the gross discrimination of sounds.

ii) Oral-Aural level: Pertaining to the teaching of auditory discrimination of sounds, consonants or vowel changes in syllable patterns and changes in syllable combinations.

iii) Sound symbol level: Here the child is taught to recognize the phonemes.

iv) Coding level: Coding of nonsense syllables into graphic and oral patterns and generalization into words are done here.

The primary goal of this program is to help the child encode and decode multi-syllabic nonsense patterns until the student has achieved competency with real words (Lindamood & Lindamood, 1969) (Cited in Willeford & Burleigh 1985). This program is appropriate for anyone from preschoolers to adults. The length of the time the individual is enrolled in this program varies according to the student's progress. The average amount of therapy consists of 40-minutes sessions daily for 2-3 months.

Willeford & Burleigh, (1985) state that there is no mention about whether there is any improvement in the auditory discrimination ability or auditory processing ability with auditory discrimination in-depth program.

3.. Auditory perception Training (APT): Willette, Jackson & Perkins (1970) (Cited in Willeford & Burleigh 1985)

Willette, Jackson & Perkins (1970) (Cited in Willeford & Burleigh 1985) designed this remediation program. It trains essential processing skills based on progressive levels of attainment. There are five basic units at three levels of difficulty. This program is designed for children in primary and intermediate grade levels.

4. Slingerlands's Method: Slingerland (1971) (Cited in Chermak & Musiek 1997).

This is a more traditional method given by Slingerland in 1971 (Cited in Chermak & Musiek 1997). In this method the child is not asked to blend the phonemes to words, but the teacher first says the word, slowly emphasizing on the medial vowel. The child repeats the word, listens for the vowel sound, selects its letter card (Color coded if necessary to differentiate vowels from consonants) from a wall-pocket chart and places it in a lower tier of the pocket chart. The teacher then repeats the whole word and asks the child for the initial sound in the word. The child is then directed to pick out the appropriate letter card and place it in front of the vowel. The teacher then draws the finger along the two letters that the child has placed on the lower tier and makes the child listen to the sound again and encourages the child to find the letter that makes the last sound. The lesson continues with the child reading aloud the whole word that has just been constructed and ends with the child writing the word either on the blackboard or at the desk and reading it back after it is written.

5. Phonemic Synthesis Training (PS training):

In this therapy, the children are taught to blend individual phoneme in correct sequence to form a word. This therapy program uses prerecorded tapes form which the child is requested to blend two and three phoneme words.

Katz & Burge (1971) studied phonemic synthesis, which is an ability to blend individual phonemes in correct sequence to form a word. Katz & Harmon (1981) (cited in Willeford & Burleigh, 1985) state that phonemic synthesis training might be effective because the child learns that the words are made up of discernable units, which can be manipulated and the child uses his own ability to decode new words.

6. Speech-in-Noise training: (Katz & Burge, 1971)

This program has been developed to improve the auditory discrimination abilities of an individual under different noise conditions. Katz & Burge (1971) analyzed the improvement of speech-in-white noise performance after eight 30 minutes therapy sessions with a group of children from 5 to 14 years of age. They noted post therapy improvement in selecting pictorial representation of monosyllabic words presented in the presence of noise.

Rees (1973) hypothesized that if the ability to discriminate speech is innate, it cannot be improved with therapy. If it is true it would be applicable to speech discrimination in the presence of noise too.

7. Sensory Integration Therapy: Ayres(1972)

The concept of sensory integration (SI) was developed based on studies done by Ayres (1972). The Sensory Integration therapy is useful for children with auditory processing deficit with sensory integrative dysfunction. The original definition of sensory integration was the ability to organize sensory information and use it (Ayers, 1972). Later the definition was elaborated as "Sensory Integration is the neurological process that organizes sensation from one's own body and from the environment and makes it possible to use the body effectively with the environment." The spatial and temporal aspects of inputs from different sensory modalities are interpreted, associated and unified. Sensory Information is the information processing which the brain must select, enhance, inhibit, compare and associate in a flexible constantly changing pattern, in other words the brain must integrate it (Ayres, 1979).

According to Ayres (1979) "Sensory Integration intervention are based on the premise that plasticity exists within the Central Nervous System (CNS)". Usually Sensory Integration develops in course of ordinary childhood activities without effort. Visual and auditory processes are considered to be the end products of many more fundamental aspects of the brain. For some children these processes are inefficient demanding effort and attention. The goal of sensory integration therapy was to improve the way the brain processes and organizes sensations. Based on the principle that the brain functions as an integrated whole, but it is made of systems that are hierarchically organized, the primary goal of sensory integration therapy is to provide the child with sensory information that will assist in organizing the vestibular, tactile and proprio-receptive systems so that he or she can develop higher functioning abilities such as attention, language interaction and motor abilities.

Traditional Sensory Integration therapy is narrowly defined as more than a collection of sensory stimulation activities (Ayresl979). It involves the use of enhanced, controlled, sensory stimulation in the context of a meaningful, self-directed activity in order to elicit an adaptive behavior. (Koomar & Bundy, 1991) (Cited in Mauer, 1999). The important characteristics of Sensory integration therapy includes the client's self selection of activities, individualized treatment based on the client's characteristics of sensory integrative dysfunction and appropriately graded levels of challenge. A child who exhibits difficulties in sensory modulation is helped to respond in a more adaptive way to sights, sounds, touch, and movement experiences (Parham & Mailloux, 1996) (cited in Mauer, 1999). Clinical studies in Sensory integration therapy have shown significant changes in behavior during and after therapy, including improved ability to organize responses to the physical environment (Humphries, Wright, Snider & Mc Dougall, 1992) (Cited in Mauer, 1999).

8. Kottler'sprogram: (Kottler, 1972) (Cited in Barr, 1976)

In this program Kottler (1972) (Cited in Barr, 1976) presents activities for rehabilitating children with auditory localization, sound discrimination and sound sequencing deficits. Class activities and games are designed to train students in each auditory skill. Activities for sound localization progress in difficulty from child to sound, to stationary child to moving sound, to moving child to stationary sound.

9. Auditory perceptual training program: (Butter, Hedrick & Manning, 1973) (Cited in Willeford. J. A. & Burleigh J. M. 1985)

Butter, Hedrick, & Manning developed the auditory perceptual training sprogram (APT) in the year 1973. This remediation program consists of 39 tape recorded lessons that are divided into four basic units which include exercises such as:

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

Listen for words and speakers- intonation patterns, voice identification, temporal sequencing, auditory closure and auditory synthesis.

Listen to remember- recognition of the number of sounds and syllables in words and phrases and figure ground discrimination through competing messages.

Listen to learn more difficult competing messages and recognition of subject verb agreement, active and passive voice and complex syntactical structures.

This remediation plan is intended for children who have learning or reading problems related to inadequate or faulty processing of auditory information. If the child fails Composite Auditory Perceptual Test, the authors recommend this program twice a week. The authors of auditory perceptual training program have expressed that the program was extensively researched and field tested on over 1500 children. But no documentation is provided to support the contention that improvement is the result of the program rather than of maturation or of other factors (Willeford & Burleigh, 1985).

10. Elkonin procedure: (Elkonin, 1973) (Cited in Chermak & Musiek, 1997)

This procedure was given by the Soviet Psychologist, Elkonin in 1973 (Cited in Chermack & Musiek, 1997). In this procedure, the child is presented with a line drawing of an object, which will reliably elicit a word in the child's active vocabulary. Below the picture is a rectangle divided into sections equivalent to the number of phonemes in the pictured word. The child is taught to say the word slowly putting a counter into the appropriate section of the diagram for each phoneme as a word is pronounced. After this game is played with many different picturized words, and when the child can do the task successfully without the diagram, the concept of vowel and consonant is introduced. The color of the counter is different for vowels and consonants (e.g. pink for vowels and white for consonants). When only vowel is present the child is asked to put it in the pink color counter.

The Elkonin procedure has many advantages. The line drawing enables the child to perceive the whole word which is placed in front of the child, throughout the process of analysis. This eliminates the need to relay on auditory memory to retain the word being studied. The sections of the diagram calls attention to the actual number of segments in the word, thus the child does not need to resort to guessing.

The actual content of the Elkonin procedure can be varied to fit the needs of a particular child or group of children.

11. Semel Auditory Processing Program (SAPP): (Semel, 1976) (Cited in Willeford & Burleigh, 1985).

This program was developed by Semel in 1976 to help teachers to remediate children with auditory processing disorders who had problems related to skills involved in reading cognition and communication. (Semel, 1976) (Cited in Willeford & Burleigh, 1985). Semel (1976) stated that "Auditory training to awaken the child's potential is directed towards releasing the accumulated stored auditory information that was never properly developed". This type of training was ordinarily accomplished through "feeding sequential ordered micro-units of auditory configuration patterns to the brain" (Semel 1976) (Cited in Willeford & Burleigh, 1985).

Semel (1976) also advocates teaching the child to listen to what he /she hears. The child is shown how to recognize, focus, discriminate, memorize, categorize, integrate and synthesis the various pattern of all parts that are essential to the total auditory process. The primary emphasis of SAPP involves the identification of target sounds in various words. Semel (1976) states that central auditory processing problem can be treated by working primarily on speech sound identification. A study done by Semel & Wiig (1981) shows that there are significant gains in auditory attention span for unrelated words and related syllables using this program.

12. Mnemonic techniques: (Loftus & Loftus, 1976; Harris, 1992) (Cited in Chermak & Musiek, 1997).

Mnemonics refer to artificial or contrived memory aids for organizing information (e.g. Acronyms, rhymes, Verbal mediators, visual imagery, drawing) that operate through the application of basic learning principles (Examples of basic learning skills are association, organization, meaningfulness, attention) (Harris, 1992; Loftus & Loftus, 1976, cited in Chermak & Musiek, 1997).

In contrast to naturally learned strategies, mnemonics are consciously learned and used. Mnemonic techniques and systems have shown to improve memory in subjects of different ages, including preschool age children and older adults (Lenin, 1976) (Cited in Chermak & Musiek, 1997).

According to Musiek & Chermak (1995) (Cited in Bellis 1996) elaboration, transformation, chunking and coding are the four mnemonic techniques encompassing the majority of frequently used internal memory devices.

(i) Elaboration: This involves assigning meaning to items to be remembered by recasting them in meaningful sentences, analogies or acronyms.

(ii) Transformation: This involves recasting complicated material into a more basic form that can be remembered more easily. This gives the individual a concise means for storing complicated material.

(iii) Chunking: This involves organizing items into categories.

(iv) Coding: Creating mental images or drawing pictures to capture information presented auditorily.

(v) Practice: practice or rehearsal is a necessary and common method employed to improve memory, however the quantity of practice is secondary to the quality of practice (Wong 1982; Swanson, 1983; Bauer & Emhert, 1984) (Cited in Chermak & Musiek, 1997).

13. Visco Developmental Training Program (VDTP): (Etten & Watson 1977) (Cited in Chermak, 1997)

Etten & Watson (1977) (Cited in Chermak 1997) have described a four-year program developed by Visco (1977) (Cited in Chermak, 1997). This focuses on the development of auditory perception using nonverbal auditory stimuli. The program is divided into two units and is designed for students in kindergarten through third grade. Unit I has 64 lessons and Unit II has 70 lessons. Each unit has seven levels of nonverbal auditory perception. The seven levels represent a hierarchy of development. They are, attention to auditory stimuli, sound verses no sound, sound localization, discriminating between sounds, discriminating sound sequences, auditory figure ground, associating sound sources. This hierarchy assumes that each task leads to the next and that the mastery of each step of the developmental sequence is necessary to accurate processing of the auditory stimuli.

The above levels are elicited by three types of responses, listening telling and sensori-motor. In unit I listening activity, the child has to listen and respond by telling, singing or saying. In Unit I I , the child is provided with worksheets with visual representations. The Auditory stimuli are provided, the child has to listen and match the auditory stimulus with the correct visual representations.

According to Etten & Watson (1977) (Cited in Chermak, 1997) the positive feature of this program is the worksheets. They contain large clear illustrations in unclustered format. There are often three or four lines per page with no more than five stimulus item per line. This helps to assure that the primary efforts can be directed towards solving the auditory problems, rather than making the child shift through a complicated visual display.

14. The fourth 'R' remembering: (Hays & Pereira, 1977) (Cited in Katz., Stecker, N.A., & Henderson, 1992)

This is a program by Hays & Pereira for parents and teachers. This program is in a book form. The activities are in the form of games. They are designed to develop memory and attention ability of young children. The book is divided into eight chapters. The first lesson includes memory techniques. The lessons are organized according to the Guilford's structure of the intellect. The sequence of the lessons are (i) Teacher and children discuss and handle lesson materials, (ii) Memory technique for a particular game is discussed and practiced, (iii) the game is demonstrated, (iv) the game is played, (v) the game is repeated. A work book of exercises and supplementary aids accompany the text. According to the authors, it is a well organized program, which is informative without being technical. However, the efficacy of this program has not been mentioned by the authors.

15. Heasley's Method: (Heasley, 1980)

Accordingly to Heasley (1980) the development of auditory attention and attention span will help the listener to attend to the desired message while ignoring the other sounds.

In this method initially a child has to listen to repeat words and sentences that are presented in the presence of soft background sound from a record player or a radio. The questions will be asked in the presence of gradually louder extraneous sound. The next step is to tell a story against background sound that can be controlled for loudness and questions should be asked about the story. Appropriate reinforcement should be given for the correct responses.

16. Auditory continuous performance tasks: (Lindgren & Lyons, 1984; Keith, 1994) (Cited in Chermak & Musiek, 1997)

Auditory vigilance is trained using this procedure (Keith 1994; Lindgren., Lyons, 1984; Sergeant & Vander Mere, 1990) (Cited in Chermak & Musiek, 1997). In this technique, the client is required to sustain attention to a continuous stream of auditory stimulus, such as environmental sounds, syllables, or words and to respond by raising a hand or tapping the table whenever a particular stimulus is heard. Failure to detect the target stimulus reflects inattention. False positive errors i.e. responding to a stimulus other than the target stimulus may reflect impulsivity. Auditory continuous performance task along with appropriate reinforcement strategies will help in improving attention span.

17. Auditory Integration training (AIT): (Berard, 1993)

Berard (1993) reported that distortions in the auditory system (Peaks & Valleys in the audiogram) could produce problems in behavior and cognition. Threshold differences between adjacent frequencies of 5 dB were considered to be significant. He reported that AIT strengthened the middle ear muscles, which in turn improved the person's ability to respond to loud sound. Another theory is that the stimulus used in AIT (Music modulated in a random, unpredictable way) stimulates an area of the reticular activating system (Locus coeruleus and lateral tegmental area). The reticular activating system receives input from vestibular and auditory pathways. It contains neurotransmitters, which have a role in arousal, alerting, motivation, emotion, memory and reorganization (Cool & Farber, 1990; Frick & Lawton-Shirley, 1994). AIT involves listening to music with frequencies that result in hyperacquity filtered out. The auditory system reacts to this therapy by adjusting the totality of the frequencies heard. Thus the audiometric curve tends to flatten and hearing is normalized maintaining the frequency differences but eliminating the hyper acute areas. The out come of AIT leads to reduction in sound sensitivities (Rimland & Edelson, 1994), reduction in behaviour problems (Cortex-Mcker & Pankseep, 1993; Creedon, Edelson, & Scharee, 1994, cited in Madell, 1999), improved auditory attention, less difficulty understanding speech in the presence of noise and an increased rate of language learning (Keith, 1999). However, Yencer (1998) studied the effectiveness of AIT on children diagnosed with CAPD and he concluded that there was no effect on auditory measures or behaviours after attending AIT.

18. Bellis Method: (Bellis, 1996)

Bellis (1996) suggested approaches for the management of binaural separation dysfunction. It includes environmental adaptations that improve the listener's access to target auditory information while decreasing competing signals and also teaching of compensatory strategies to assist the listener in directing attention.

19. Earobics: (Cognitive Concepts Inc., 1997-2000)

This program has been developed by Cognitive Concepts Incorporation. Earobics includes program for providing explicit comprehensive phonological awareness and auditory processing training for the prevention and remediation of reading and other language based disabilities in children aged between 4-7 years (Cognitive Concepts Inc., 1997-2000). There are six games and they are directed to tap different auditory perceptual sub skills. The games Karloon's Balloon, C.C.Coal Car, Rap-A-Tap-Tap, Rhyme Time, Caterpillar connection, and Basket full of eggs work on auditory attention.

20. Prosody Training: (Musiek & Chermak, 1997)

According to Musiek & Chermak (1997), the prosodic training should begin with words in which a change in syllabic stress pattern changes the meaning of the word. Once the child is trained with words, the focus should then be on sentences in which subtle differences in stress, temporal cueing or other prosodic features alter the meaning of the entire sentence. The child should also be trained to detect the key words. The child is taught to listen specifically for subject, verb and object while placing less emphasis on article, conjunctions and other less important words.

Reading aloud daily with special emphasis on animation is a good exercise for these children. It not only increases the reading aptitude but also reinforces the use of rhythm, stress and intonation in expressive language (Bellis, 1996). According to the authors the children will be able to process auditory information more efficiently after training with this program.

21. Fast Forward: (Scientific learning Corporation, 1998)

Fast forward is a computer software program that has been designed to build skills that child with language learning impairment need for listening, speaking and reading. It incorporates acoustically modified speech in exercises to improve language decoding skills of children with language learning impairments by helping them to discriminate subtle differences in sounds. The games are designed to train children with language impairment to process sounds and words at increasing rate of presentations until they are able to discriminate and follow directions that are presented at the typical rate of conversational speaking. There are also games to build phonological awareness, a skill which scientific learning corporation suggests is necessary for children to read.

This program consists of seven games. Clients play five games each day as automatically determined by the software. A total of 100 minutes of playing the game per day is necessary. When the child demonstrates mastery of skills necessary for the first level of the game for several successive times, the software automatically advances to the next level. The child's performance is continuously monitored and saved by the program so that the level of the game the child is playing is both challenging and rewarding. The suggested criterion for finishing the fast forward program is completing at least 80% (or reaching level 5 game play) on five of the seven games. Time for achieving this criterion differs from child to child, but it is usually achieved within 4 to 8 weeks range.

Fast forward is one of the learning intervention options that are designed to improve language skills by targeting specific auditory abilities such as temporal processing or the ability to process sound segments as they occur sequentially in time (Scientific learning Corporation, 1998). According to Veale (1999), Speech-Language pathologists, teachers, and parents report increase in overall language abilities including auditory processing speed, working memory, phonological awareness, listening and comprehension skills and syntactic abilities using this program. Children who have completed the protocol are described as being more focused and attentive, and more involved in class activities. They appear to have increased self confidence and fewer behaviour problems (Scientific Learning corporation, 1999). However, Gillam (1999) suggests that extensive scientific studies are needed to substantiate the claim that improvements in language measures can be validated several months after the intervention.

22. Simon: (Musiek, Baran & Schochat, 1999)

This is a commercially available program in the form of game, described by Musiek, Baran & Schochat, (1999). This game taps the temporal abilities. It requires the sequencing of the tones that generate patterns of sounds and associated with flashing colored lights. A tone is added to the sequence every time the previous sequence is recognized correctly. This game is useful for frequency discrimination training.

Computer Based Therapy/ Computer Program Materials:

Here is a list of computer based therapy programs that are in practice to remediate auditory problems in children with CAPD.

- Captain's Log Personal Trainer
- Diphonics
- Earobics
- Fast Forward
- Laureate Special Needs Software
- Lindamood Bell

Captain's Log Personal Trainer

Captain's Log Personal Trainer trains auditory discrimination, auditory attention and memory. The program is designed for individuals from age 4 through adult who have difficulty processing information due to brain injuries, ADHD, auditory processing disorders, learning disabilities or cognitive deficits.

Diphonics:

It is a computer-driven self paced dichotic phonic tutorial for CAPD and dyslexia which is published by Sonido, Inc. The program is available as a school based version and a version for parents. The program was developed by Leslie W.D.

Earobics:

Earobics' Auditory Development & Phonics CD-ROM Programs teach the listening skills. Children need to be better readers, listeners and learners.

- Earobics Step 1; teaches phonemic awareness and auditory processing skills. Recommended for developmental ages four to seven.
- Earobics Step 2; teaches listening, phonological awareness, phonics, and language comprehension skills. Used for children in the developmental age of seven to ten.
- Earobics 1 for Adolescents & Adults develops auditory processing, phonological awareness and spoken language processing skills. Recommended for ages ten through adult.

Fast Forward:

Fast forward is computer software that has been designed to build skills that child with language learning impairment need for listening, speaking, and reading. This language intervention option is designed to improve language skills by targeting specific auditory abilities such as temporal processing or the ability to process sound segments as they occur sequentially in time (Scientific learning Corporation, 1998). The fast-for-word has the following five games to be played. The game play is both challenging and reinforcing.

- Away We Go: Develops skills including phonological awareness, rhyming, letter - name association, relational differences, following directions, working memory, and mouse-motor skills. The program is intended for children between the developmental ages of four through seven. Parents may buy the program directly from the Scientific Learning Company.

- Fast Forward: Is a set of CD-ROM exercises for language-learning impaired children ages four through twelve. The program works on auditory processing speed, working memory, serial order processing, phonological awareness, listening comprehension, syntax and morphology.

- Step Forward (formerly known as Fast Forward 2) is available to children who have completed the first Fast Forward program.

- 4 WD: Is a training program for adolescents and adults. The program works on phonological awareness, language and listening comprehension, working memory, syntax, grammar and sequencing skills, sustained and focused attention.

The Fast Forward programs are available only through professionals who have been trained and certified to use the program.

Laureate Special Needs Software

Laureate Special Needs Software program consists of the following activities:

- Nouns and Sounds
- The Following Directions Series includes:
    - o Following Directions: One and Two-Level Commands
    - o Following Directions: Left and Right

Linda mood Bell

Lindamood-Bell Learning Processes contains programs like:

- Visualizing/Verbalizing for Language Comprehension and Thinking
- Lindamood Phoneme Sequencing (LiPS)
- Formerly called Auditory Discrimination in Depth ("ADD").

Dichonics CAPD Software Package: Auditory Processing Therapy & Diagnostics

It is a rigid instrumental (operant) baseline-controlled drill and assessment program. It meticulously documents central auditory processing abilities, and step-by-step tutorial progress. Progress is measured on a minute-to-minute basis and data is immediately available for review. Assessment for many common entities is built into the ongoing behavioral analysis.

Dichonics is an integrated multi-tasked program constructed to measure and modify the operant behavior of persons who display depressed language and learning acquisition skills centered on auditory processing activities. More succinctly, Dichonics is a rigid operant (instrumental) program. Operant "conditioning" depends on growth and character of baseline as a measure of quantity and quality of a stimulus-based response paradigm. However, while the forgoing is a very important segment of Dichonics, the component that is the main focus is the temporal asymmetry test called Virtual Image Analysis (VIA).

Dichonics Probes:

Dichonics disk 1 is built on nine phonemic lessons which are threaded into each drill, probe, and game. During the lesson drills, games and probes will arise that must be completed. These tasks are comprised of phonemes in the current lesson or from any lesson that the student has completed. Phonemes are taught using visual, auditory, and kinesthetic modes of learning.

Listed below is a brief description on the probes and games that the student will encounter.

Phoneme Memory - Auditory memory span and retention are critical factors in CAPD and ADHD type disorders. Auditory memory seems to fluctuate almost from moment to moment. A lesson learned today is a lesson forgotten tomorrow. This portion of the Dichonics program aims to provide basic diagnostic information indicating and qualifying the presence of an auditory memory problem. To a lesser degree, the activity quantifies memory problems.

Phoneme Inventory - The ability to decipher phonemic content is diminished in students with CAPD. The Phoneme Inventory activity is both an assessment tool for defining any weakness and drill for improvement.

Word Discrimination with Noise - The student will hear two words that he/she must decide are the same or different. This test is performed in several types of noise. The Word Discrimination test is performed and tracked in three different positions, left only, right only, and diotic.

Virtual Image Analysis - The Virtual Image Analysis (VIA) is a patented dichotic listening test included with the Dichonics software. The VIA data tracked in Dichonics shows central auditory processing routing of a stimulus that has been systematically altered in the time domain. Helps to determine which side of the brain is dominant or if there is a dominant side.

Tic-Tac-Toe - One of the first tasks the student completes is tic-tac-toe. This game is used along with the therapist to verify that the student is able to use the mouse properly. Requires the student to click on game pieces and drag them into the empty board, thus performing the two main tasks of using the mouse.

Word Search - Word Search allows students to build three sound words out of a bank of phonemes. These words can then be checked to see if they are correct words or just random letters.

Egg Hunt - The Egg Hunt game helps students learn discrimination of phonemic sounds. This game has three levels of increasing complexity.

Phonemic Farm - This board style game requires students to spin a phoneme and then move the game piece (chicken) to the next occurrence of this phoneme. It is usually the favorite of all the games.

Catalogs Offering CAPD Remediation Materials

Apart from the computer based approaches, materials in the form of catalogs and manuals are also available for treatment of auditory processing disorders.

Lists of Materials/Catalogs:

- Academic Communication Associates
- Academic Therapy Publications
- Linguisystems
- Communication Skill Builders
- Imaginart Communication Products
- Pro-Ed
- The Speech Bin
- Super Duper Publications
- Thinking Publications

Academic Communication Associates

Listen, Think, and Remember: Activities for Attention, Memory and Comprehension Skills, A collection of games, activities and reproducible worksheets for ages 4 through 12. Available April 1998.

- Language Exercises for Auditory Processing (LEAP): For ages 4 through 9.

- Language Exercises for Auditory Processing - Preschool (LEAP-P): For ages 3 through 5 (preschool and kindergarten).

- LEAP Auditory Processing Games: For ages 5 through 10. Available April 1998.

- Pragmatic Adventures in Listening: Language Activities for Improving Attention, Memory and Comprehension. For ages 5 through 9.

- Story Sequencing Activity Resource: Worksheets activities to strengthen storytelling and sequencing skills. For ages 7 through 14.

- Language Adventure Games: Kit includes four full-color game boards for auditory processing, vocabulary, and verbal reasoning skills. For ages 4 through 8.

- Perceive and Respond Auditory Programs: Three-volume audiotapes program designed to help students with auditory attention, discrimination and / or memory problems. For ages 5 through Adult.

- Listening Lesson for the Early Elementary Classroom Curriculum: For ages 5 through 8.

- Listening Lessons for the Classroom Curriculum: For ages 9 through 16.

- Auditory Processing Enhancement Programs: Four-volume set of audiotapes and worksheets. Volume I -- Auditory Memory/Chunking Techniques; Volume II-Phonological Awareness and Discrimination; Volume III—Following Auditory Directions; Volume IV--Critical Listening and Speed Listening. For ages 5 through Adult.

Academic Therapy Publications

- Auditory Processes, by Pamela G. This is a book about auditory processing disorders. The author provides many suggested remedial exercises grouped according to specific auditory difficulties. Also included is a chapter on commercially available auditory processing programs.

- The Listen and Learn Connection by Grace W. F, Ed. D. Intended for classroom use, the program has 67 lessons presenting facts about biology, geology, language arts, history and functional facts of everyday living. Students listen to short paragraphs read aloud and mark answers on worksheets.

- Fine Tuning: An Auditory Visual Training Program.

Communication Skill Builders- the Psychological Corporation:

- Listening with Kids: Parents as Partners: Carryover assignments intended to be sent home to reinforce skills worked on in therapy. Targets four areas: tuning in, listening for details, listening to remember, and listening to understand. For ages 4 to 10.
- Listen and Draw, an integrated skills activity program: While listening to audiotape directions, children draw pictures which include dinosaurs and butterflies. Skills emphasized are semantic aspects of language, listening/auditory perception, comprehension and memory. For ages 6 to 12. Manual plus two audiotapes.

Imaginart Communication Products

- Memory Stretch Following Direction Tapes. There are two sets of tapes: Primary Memory Stretch, for K through grade 2 and Memory Stretch II, for grade 2 through special grade junior high.

- Following Directions with R-S-L-CH-TH Sounds.
  - Auditory Processing Activities for ages 6 through 11.
  - Listening Skills Indoor Sounds and Outdoor Sounds.
  - Listening Games and Activities: Separate workbooks for Pre-Readers, Beginning Readers, Grades 3-4 and Grades 5-8.

LinguiSystems

- No-Glamour Auditory Processing: For ages 5 to 11.
- SPARC for Phonological Awareness and Listening Comprehension: For ages 4 to 10.
  - HELP for Auditory Processing: For ages 6 to Adult.
  - HELP Handbook of Exercises for Language Processing: For ages 6 to Adult.

Pro-Ed Speech Language and Hearing Catalog

- Auditory Perception Training (APT) for kindergarten through grade 6.
  - Auditory Discrimination Game
  - Auditory Memory for Language for nonreaders and preschoolers.

The Speech Bin: 1-800-4-SPEECH

- What Is Auditory Processing? Suggestions for Parents and Teachers: Package of ten 16-page booklets.
  - Boredom Rx: A collection of activities emphasizing listening carefully, pragmatics, remembering and following directions
- Processing Power: A Guide to CAPD Assessment and Treatment by Jeananne, M. Ferre, Ph.D.
- Auditory Processing Activities
  - Listening With Kids: Parents as Partners

- Memory Stretch
- Auditory Perceptual Development Remedial Activities
- Auditory Reasoning and Processing Remedial Activities
- The Listen and Learn Connection
- Lindamood Phoneme Sequencing Program (LiPS) for Reading, Spelling and Speech: This is a revision of Lindamood Bell's Auditory Discrimination in Depth. (ADD)

- Central Auditory Processing Disorders: Strategies for Use with Children and Adults by Dorothy Kelly.
- Fine Tuning: Kids listen to spoken directions to draw pictures on a grid.
- Listening Skills: Indoor and Outdoor Sounds
  - Listen to This! Auditory Processing

Super Duper Publications

- Auditory Processing Super Pak: 114 pages of activities, for grades K-4.
- Following Auditory Directions: Reproducible workbook for grades K-3.
- Coordinating Auditory Information: Designed to improve students' ability to listen and categorize. For Grades K-6.

- Processing Auditory Messages Exactly & Totally: Reproducible workbook for grades K-6.

- Listening & Remembering Specific Details: Workbook for grades PreK-2.

- Auditory Discrimination Game: Game has three parts: Part I has rhyming words; Part II has words with same initial and final consonants sound, with changes in vowel sounds; Part III has words with changes in final consonant sound only.

- Auditory Memory for Language: Multisensory program for teaching young children oral syntax and grammar. Grades K-2.

- Auditory Processing Activities: For ages 6-11.

- Auditory Processing of " WH" Words: For grades K-3.

- Building Auditory Direction Skills: For grades PreK-2.

- Listening and Following Directions 8 Pack: Set of 8 workbooks and audio cassettes. Four of the audio cassettes have background noise added to simulate a classroom environment.

- Listening Lotto-ry: Lotto games emphasizing auditory discrimination and listening skills. For grades K-3.

- Listen to This: An Auditory Processing Program Auditory processing exercises using picture symbols. No reading skills required. For any age.

Thinking Publications

- Listen and Recall: Memory Strategies for Adolescents and Adults
- Attention and Memory Volume I: CD ROM package. The Language Attention Module may be purchased separately. Designed to improve vocabulary development, sound segmentation and word blending, auditory processing of single and multi-syllabic words.

Chermak (1981) studied and classified the available therapy techniques into the following four basic approaches:

1. Traditional direct approach: (Lesener, 1976) (Cited in Chermak 1981):

This approach emphasizes on the assessment and remediation of an individual's auditory processing skills such as memory, attention, discrimination etc. Although this approach appears logical, its validity is questionable. The client may manifest progress in the specific skill areas being remediated and tested, however the carryover to border kinds of learning is uncertain (Lesener, 1976, cited in Chermak, 1981).

2. Supportive services and counseling: (Willeford & Bilger, 1978):

Willeford & Bilger (1978) suggested a remediation program that involves counseling the child, family and educational personnel concerning the nature of auditory processing problems and controls for coping with the auditory world. According to the authors, carryover in the form of improved communication skills, better grades and heightened self-esteem may result from this approach.

3. Experimental-Linguistic approaches: (Ling 1978)

This approach was advocated by Ling (1978) it emphasizes on active communication within realistic and meaningful contexts. Even though some time is spent in developing the individuals' auditory processing skills as in the "Traditional direct approach", most of the time is aimed at developing a mobilization toward auditory stimuli and the successful incorporation of these stimuli into communicative and academic endeavors. It is believed that through proper counseling and the provision of realistic and meaningful experiences that demand good listening skills, the child presenting deficient auditory skills will benefit in terms of better communication skills, improved academic function and enhanced self image.

4. Psychoacoustic or molecular approach: (Mazeas, 1972)

Auditory processing remediation conducted within the frame work of psychoacoustic (molecular) approach focuses on the skills delineated by Mazeas (1972). Remediation activities resolve around attempts to improve the client's detection of frequency, intensity, and time differences.

The more recent approaches to auditory training can be placed into several categories, namely analytic, synthetic, pragmatic and eclectic (Blarney & Alcantara, 1994). The analytic approach attempts to break speech into smaller components that serves as the basis for auditory training. The synthetic approach is therapy that uses cues from context and syntax to help derive meaning. The pragmatic approach has the listener control communication factors such as intensity, signal-to-noise ratios and so on. The eclectic approach is defined by combining several of the auditory training procedures mentioned above.

The use of auditory training for auditory processing disorders is not new. The concept of auditory training to stimulate auditory related problems dates back to pre-medieval times (Musiek & Berge, 1988). Initially auditory training was used to enable hearing impaired individuals make maximum use of their residual hearing. However, since 1960 it has been used in the rehabilitation of individuals with CAPD (Musiek & Berge 1998) (Cited in Veale, 1999). The use of auditory training for APD is based on the belief that it would assist these individuals by maximizing the use of hearing abilities. Auditory Training is directed towards improving basic auditory skills such as auditory vigilance, temporal and spectral detection and discrimination, and inter-hemispheric transfer. These skills encompass both spectral processing and temporal processing which are essential for phonetic distinctions. Contemporary training or auditory skills development training is used to strengthen perceptual process and teach specific academic skills.

The use of auditory training in treatment of APD is now targeting the brain as the main site of mediation. The brain unlike the auditory periphery is plastic. According to Scheich (1991) (Cited in Musiek & Berge, 1998) there are three general types of plasticity, developmental, compensatory (After lesion or damage) and learning related. Enhancement through auditory training for CAPD could involve all the three types of plasticity. Musiek & Berge, (1998) states that auditory plasticity can be defined as the alteration of nerve cells to better confirm to immediate environmental influences, with this alteration often associated with behavioral change. Appropriate auditory stimulation can result in changes in the auditory system. One of the earliest studies showed that white rats reared in the environment that provided a varied and systematic sound stimulation have auditory cortices that were different from those of control animals that were reared in normal sound environment (Hassmannaova, Myslivecek & Novakova, 1981). Logan (1982) (Cited in Jirsa, 1992) reported that auditory stimulation of the fetus strengthen nerve connections and provides the neurons the "information nourishment" that exercises them the most. This increases the synaptic connections between neurons, which helps in saving a percentage of neurons from dying before birth. Thus, appropriate stimulation can result in changes in the neural auditory system.

The trend now in APD management is towards more individualized prescriptive and evidence based therapy (Wertz, Hall, & Davis, 2002). According to Bellis (2002) the utility of deficit specific intervention for APD is based on three primary assumptions. First assumption is that, certain basic auditory skills or processes underlie more complex listening, learning and communication utilities. The 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 processes will facilitate improvement in those higher orders, more complex functional ability areas with which a given individual is experiencing difficulties.

The use of direct therapeutic techniques has gained considerable importance in the recent past. These techniques aim at alleviating specific auditory processing problems that an individual might have. The purpose of direct remediation activities is to maximize neuro-plasticity and to improve auditory performance by changing the way the brain process auditory information (Bellis, 1996; Chermak & Musiek, 1997; Musiek & Jerger, 2000, cited in Bellis, 2002).

Katz & Burge (1971) (Cited in Katz & Wilde, 1994) have discussed the use of speech in noise desensitization therapy tapes. They found that children who were exposed to speech under controlled noise conditions were able to develop a greater tolerance for background noise and showed a greater ability to respond correctly to speech under noise conditions. Minetti & Mc Cartney (1979) (Cited in Katz, Chertoff & Sawusch, 1984) studied the effect of practice on the staggered spondaic word test. They compared the performance on the first 20 SSW items with the remaining 20 items and found that after counter balancing the half of the test given first, there was a significant improvement on the second half. The results indicate that the subjects benefited in dichotic listening performance after practice.

Katz, Chertoff, & Sawusch (1984) provided dichotic offset training for children presenting auditory processing problems. Children who demonstrated difficulty on staggered spondaic word test (Katz, 1962) were given a systematic series of programmed dichotic listening sessions. Ten subjects in the age range of 7-10 years were taken for the study. The experimental group consisted of 4 male and 1 female subjects while the control group consisted of 5 male subjects. The children were given a systematic series of programmed dichotic listening sessions everyday for one hour, twice a week, for fifteen sessions. The dichotic offset training material were an expanded version of the staggered dichotic digit test, developed as part of the study. They further compared the pre and post therapy scores. The results revealed a consistent pattern of improvement after the initial therapy sessions. Improved performance was noted on the test-retest results for the staggered dichotic digit test. However, they found a lack of statistically significant improvement on the staggered spondaic word test and in speech in noise test. However, observation of the individual subject's performance revealed a trend towards improvement.

Hayes & Jerger (1979) evaluated aided performance in a sound field by a group of patients with a speech audiometric pattern consistent with peripheral sensitivity deficit and a group with a pattern consistent with auditory processing disorder. They found that those with auditory processing disorder did not perform well with hearing aid as those with no auditory processing disorders. They also found that, performance declined with increasing degree of auditory processing component.

Hasbrouck. (1980) (Cited in Keith 1999) studied the performance of students with auditory figure-ground disorders under conditions of unilateral and bilateral ear occlusion. The subjects comprised of 21 learning disabled students in the age range of 4 years 7 months to 17 years and 2 months. All the subjects had hearing within normal acuity within the speech frequency and scored below the 25th percentile on the noise subtest of the Goldman-Fristoe &

Woodcock Test of Auditory discrimination. Stimuli were presented in sound field by means of an audio tape-recorder under the following conditions of ear occlusion, (a) Occlusion of the right ear only (b) Occlusion of the left ear only and (c) occlusion of both the ears simultaneously. Each subject was randomly assigned to one of the six different orders of occlusion. Ear occlusion was accomplished using one or both muffs of Clark model 117 ear protectors. The results showed that occlusion of the ear served by the defective neurological system reduces or eliminates its figure-ground malfunction, eliminates the binaural interference, and allows the unaffected ear to filter background noise, all of which resulted in improved figure-ground performance.

Kahler (1983) (Cited in Katz & Wilde, 1994) selected a set of children from the first grade who performed poorly on a phoneme synthesis test and provided programmed phoneme synthesis therapy for half of the children for one year. At the end of the first grade the children in the therapy group scored significantly better on phoneme synthesis test as well as on test of reading ability than the children who did not receive therapy. Thus the results suggest that programmed phoneme synthesis therapy will bring about a significant improvement in children with APD. The results of a sound by sound therapy approach have also been found to show beneficial effects on post-phoneme synthesis, auditory processing tests and articulation performance tasks (Katz & Harmon, 1981, Katz. 1983).

Mullin & Lange (1984) (Cited in Katz, Chertoff & Sawusch, 1984) studied the efficacy of auditory, visual, and memory training lessons in 42 kindergarten children. The lessons consisted of variety of listening tasks lasting for 15 minutes each. The pre and post test consisted of identifying the correct pictures which were given in a multiple choice format. The post training performance was shown to be significantly higher at the 0.01 level of confidence.

Shapiro & Mistal (1985) studied whether ITE hearing aids aided auditory training for reading and spelling disabled children. Two boys and two girls in the age range of 7.5 years to 11.0 years with essentially normal hearing but associated with reading and spelling problems were fitted high frequency enhanced ITE hearing aids. The preliminary result showed definite improvement in speech and auditory memory performance in the children fitted with high frequency enhancing aids. They also stated that unlike FM auditory trainer this trainers has unlimited mobility, is tiny and is commercially available.

Musiek & Shochat (1990) (Cited in Musiek & Chermak, 1997) showed that there was a significant improvement in binaural listening when dichotic training was incorporated in the auditory training. Prior to the auditory training, the listener demonstrated a unilateral deficit on dichotic digit test and moderate bilateral deficits on compressed speech. Training involved directing the stimulus to the better ear at a reduced level, while maintaining the higher intensity to the ear with poor scores. This paradigm maintains a good performance level in the weaker ear as the intensity level of the good ear is gradually raised over a period of time. This allowed improved performance of the good ear to stabilize back to normal and to maintain the improvement of the weaker ear at a higher lever of performance.

Jirsa (1992) investigated whether P300 could be used to reflect behavioral changes resulting from therapeutic intervention in a group of children with CAPD. Results showed a significant decrease in P300 latency, along with a significant increase in its amplitude following a structured treatment program.

Various studies have been conducted to study the effect of perceptual training. Merzenich, Johnston, Schrenier, Miller & Tallal (1996) (Cited in Veale, 1999) & Tallal et al. (1996) (Cited in Veale, 1999) have described the positive effects of computer based games that train to modify temporal processing deficits in these children. Merzenich et al (1996) (Cited in Gillam, 1999) claimed that these studies strongly indicate that the fundamental temporal processing deficits can be over come by training.

Studies by Merzenich, Jenkins, Johnston, Schreiner, Miller & Tallal (1996) reported improvement in children with language learning problems with auditory perceptual training and training on time extended and amplified transition of speech. These well controlled studies show the importance of auditory training and demonstrate how auditory training can improve performance. Auditory discrimination and phoneme analysis are so important to spoken language comprehension, that treatment programs for auditory processing disorders have been constructed (Sloan, 1986). Chermack & Museik (1997) developed a comprehensive management approach, to tackle the range of listening and learning deficits experienced by children with auditory processing disorders. The intervention was a combination of auditory training, meta-linguistic and meta-cognitive strategies designed to increase the scope and use of auditory and central mechanism.

Yencer (1998) studied the effects of Auditory Integration Training on thirty six children who were diagnosed as CAPD. He used three conditions, an experimental condition (who listened to AIT music), a placebo condition (who listened to modulated music), and control condition (who did not listen to music at all). Children with autism, pervasive developmental disorder and multiple handicaps were excluded from the study. A battery of tests was administered to the subjects prior and one month following the listening sessions. The test battery included, standard audiometric testing, the SSW test, the phonemic synthesizer, ABR, P300, and speech in noise test. Significant improvements were found for the first two conditions on all measures except for the speech in noise test. Electro physiological changes have been found in ABR results pre and post auditory integration therapy (Edelson, et al. 1999). In the study by Highfill and Cimoulli (1995) (Chermack & Museik, 1997) changes in brain stem functioning using positron emissions tomography (PET) was measured before treatment, one day and six months post AIT. The results indicated normalized brain activity in the occipital lobe. Electro physiological changes have been found in auditory brain stem evoked response results pre and post AIT (Edelson, et al. 1999).

Kraus, McGee, Carrel, King, Tremblay, Nicol (1999) tried to determine whether training in speech contrast discrimination would result in changes in the neurophysiology of the central auditory system. MMN which reflects the central processing by five stimulus difference and shows promise as a tool for studying the neurophysiology underlying the perception of subtle speech contrast were used. In the behavioral discrimination task the results indicated a significant improvement in pre vs. post training discrimination of the two stimuli dal and da2. The mean scores increased from56% to 67% before and after training. This improvement in scores was noticed after a course of six one hour discrimination sessions. The training paradigm consisted of a same-different two alternative forced choice discrimination task. A visual feedback was presented after each trial to indicate whether the response was correct. The training was given for 13 healthy normal hearing adults. To assess the stability of behavioral performance over time, 11 of the subjects were retested one month following the last training sessions. The behavioral performance was remarkably stable after a month of the last training session. MMN was recorded immediately before the first training session and immediately after the sixth session. MMN was elicited by the same synthetic speech stimulus pair used for behavioral training. Speech stimuli were presented through insert phones to the right ear at 75 dB SPL and the subjects were instructed to watch videotaped movies. The stimulus was presented using an oddball paradigm in which the deviant stimuli (5%) was presented in a series of standard stimuli (85%). The results showed that there was a significant change in the duration and area of the MMN latency and magnitude after training.

Tremblay et al. (2001) noticed dramatic changes in FMRI study after fast-for-word therapy. They have shown that dyslexic subjects who listen to synthetic speech utterances with slow versus fast consonant like onsets differ markedly from normals. The normal brain responds more vigorously to the fast onset stimuli that emulate speech in the left frontal areas and cerebellar areas.

Kujala, Kamura, Lepoeine, Belitz, Turkkila, Ter Vainemi, Naatanem (2001) conducted a study to determine whether audiovisual training without linguistic material has a remediation effect on reading skills and central auditory processing in dyslexic children. Forty eight reading disabled children were selected. They were divided equally into experimental and control group. A computer game consisting of abstract nonverbal task that require audiovisual non-linguistic matching was used for training. There were 14 training sessions for a period of seven weeks each lasting for 10 minutes each twice a week. Both electrophysiological and behavioral recordings in terms of reaction time were carried out for tones. Pre and post test group difference were found in them following the audiovisual training. The results suggest that perceptual training with nonlinguistic audiovisual stimuli causes changes in the neural substrate of sound discrimination and an improvement in reading skills.

Bischof, Gratzka, Strchlow, Haffner, Parzer, & Resch (2002) studied the effect of auditory discrimination training on reading and orthographic performance in children with dyslexia. The training was given for discrimination of tonal and speech stimuli. The results showed a significant difference between the pre and post training auditory discrimination performance. They also observed a significant correlation between auditory discrimination, reading and orthography performance. Kujala & Naatanam (2001) reported that in dyslexic children the change in the reading skills measures with training correlated with change in MMN amplitude.

Putter-Katz et al, (2002) compared the listening skills of a group of children with APD, before and after a structured intervention program. A group of 20 children in the age range of 7 years and 11 months to 14 years and 4 months of age participated in the study. These children were divided into two groups. Group-I consisted of 11 children who had poor scores on the speech-in-noise test but normal scores on the dichotic test, while the Group-II children consisted of 9 children who had reduced scores on both the tests. Both the group children were given treatment. The treatment program extended for one 45 minute session per week for a period of 4 months. The treatment program focused on environmental modifications, remediation techniques and compensatory strategies. The environmental modification in the program included teaching suggestions, counseling about the nature of APD and importance of keeping the learning environment highly redundant, recommendations to decrease background noise, use preferential seating and use of tape-recorders in lecturers. The compensatory strategies included auditory closure, speech reading, assistive listening devices and meta-cognitive awareness enhancement. Parental involvement was also instrumental towards success. Remediation techniques aimed at improving overall auditory processing abilities, especially in a noisy environment. Training tasks included listening and comprehension activities in the presence of noise or competing verbal stimuli and selective, divided attention tasks. The treatment tasks were built hierarchically as a function of language complexity and at different levels of background noise and competing speech. The results revealed a significant improvement in the right ear scores for the speech in noise test in the group I subjects following treatment. No difference was found in the performance scores of the left ear before and after treatment. No difference was found in the pre and post treatment performance scores of the group I subjects in the dichotic listening tasks. However, the pre and post treatment scores for the group-II subjects was significantly different for each test in the battery following intervention, except for the short competing sentence test for the right ear. The results revealed a significant improvement in children who underwent training in the listening skills. The study revealed that the auditory function of the children participating in the study demonstrated some improvement following intervention as indicated by the improved performance on speech-in-noise and competing sentence tasks. In addition, the authors report that these improvements were approved by parents and teachers who reported improvement in overall listening behaviours at home and in the classroom.

Hayes et al. (2003) examined the plasticity of the central auditory pathway and accompanying cognitive changes in children with learning problems. Twenty seven learning disabled children were enrolled in Earobics (1997) training program and the control group was normals and learning disabled children who did not undergo remediation program. ABR was evaluated in response to clicks and speech stimuli in quite and cortical responses to speech stimuli were obtained in quite and noise. Results revealed that in quiet condition, the cortical responses reflected an accelerated maturational pattern and in noise, cortical responses became more resistant to degradation. They concluded that, ABR didn't change with training.

Yathiraj & Mascarenhas (2003) studied five fluent English speaking children diagnosed as APD by a battery of tests including speech-in-noise test, dichotic C-V test, and duration pattern test, auditory sequencing test. The control group consisted of 5 age and gender matched children. The experimental group children were given therapy in English. Deficit specific therapy was given for thirty sessions of forty five minutes duration each, for the deficits they demonstrated. The material included activities for phoneme synthesis, auditory integration, auditory separation and recognition of low redundancy speech, auditory memory (recall and sequencing) and duration pattern recognition. The performance of the experimental group children pre and post therapy was compared with the scores of the control group children. There was a significant improvement in the children for all the tests that were administered, suggesting that deficit specific therapy does bring about an improvement in their auditory performance. The feedback from parents and teachers also revealed that there was a generalization of the newly learned skills both at the home and in the classroom. They concluded that children with APD can be helped if they are given rigorous training to improve their perception.

An auditory training technique to improve dichotic listening skills was attempted by English, Martonik, & Moir (2003). They hypothesized that providing left ear auditory stimulation improves dichotic listening skills in typically developing children. Ten children with reduced left ear dichotic digit test scores were taken as subjects for the treatment. In addition to dichotic listening deficits, subjects presented with problems in auditory discrimination, auditory sequential memory and temporal resolution. Eight out of the ten subjects had right ear scores within normal limits but left ear scores were reduced. All subjects were given training in auditory training program for 10 to 13 weeks and received two hours of individualized auditory training per week. Each subject was instructed to listen carefully to the tape recorded material for two minutes with headphones placed on the ears and the story delivered to the left ear only. Following this treatment it was found that all the ten subjects had improved left ear scores following treatment. Thus the result shows that, providing auditory stimulation to the left ear improves left ear scores.

Phonemic synthesis has been another technique used in children with auditory processing problems (Katz & Wilde, 1994). Bellis (1996) states that the purpose of phoneme training is to help the child to learn to develop accurate phonemic representation and to improve speech-to-print skills. Phonemic synthesis skills involve the blending of discrete phonemes into the correctly sequenced and co-articulated sound patterns.

Tremblay et al. (2001) studied two groups of children with specific language impairment and normals. Both groups went through Fast Forward program and the clinical evaluations of the language fundamentals-3 were administered on both the groups before and after training. Preliminary results show that there was an improvement of language skills in concomitant with an increase of Medial Olivary Cochlear Functions. When MLR's were run on the children before and after training, it was found that majority of the children showed no Pb and after successful treatment with fast forward, their MLR's normalized. Tremblay et al (2001) showed dramatic changes in FMRI after fast-for-word.

Deppeler, Taranto & Bench (2004) examined changes in performance of eight Australian children with language impairment of varying severity and with auditory processing difficulties. The subjects were trained with fast-for-word program for one hour and forty minutes each week for six weeks. The results showed increase in receptive and expressive language scores.

Although some drugs have been shown to improve memory losses associated with neurodegenerative diseases such as Alzheimer's disease, Pharmacological therapies are not available for the treatment of CAPD.

External compensatory aids e.g. prosthetic devices and cognitive orthotic devices may be preferred over internal strategies by children younger than 11 years, because they offer a relatively powerful and immediate means to augment memory. However, external devices should not be used to the exclusion of internal aids and repetitive practice are preferable because they require an individuals active role and self regulation and therefore more likely to be applied across settings and maintained over time. Prosthetic devise are non-electronic or non-computerized electronic devices or systems which are usually inexpensive and relatively simple to learn to use. E.g. alarm clocks, watches, signs, icons, checklists etc. Cognitive orthotic devices employ computers and software to perform memory functions for the subject. E.g. telephone answering machine, spelling and grammar checkers, etc.

Binaural separation and integration are processes that are critical to everyday listening, particularly in school environment. Dysfunction in the process of binaural separation and integration may be expressed in the behavioural symptoms of difficulty in hearing in the presence of background noise or when more than one person is talking at the same time. Auditory function that rely upon binaural interaction include localization and lateralization of auditory stimuli, binaural release from masking, detection of signal in noise, and binaural fusion (Bellis 1996).

Binaural integration is the ability of a listener to process information being presented to both ears simultaneously, with the information presented to each ear being different (Bellis, 1996). Integration deficits are characterized by the difficulty in tasks that require inter-hemispheric communication. This difficulty may be within and or across modality. The child with integration deficit will have difficulty in integrating auditory and visual functions, or in integrating linguistic-based auditory information with nonlinguistic auditory information such as rhythm and pattern perception (Bellis, 1996). Children with integration deficits typically demonstrate abnormal left ear suppression on dichotic listening tasks combined with bilateral deficit on tests of temporal patterning when verbal report is required. At the most severe form, integration deficit will result in an inability to perceive prosody, with the result, the spoken sentences sounds like strings of unrelated words with no relative stress to emphasize key words and other important cues. In this situation, comprehension of spoken message is severely affected. Behaviorally the child with integration deficit will exhibit difficulty with multimodality task that requires inter-hemispheric co-operation. Hence, such skills like asking for dictation, which requires auditory visual interaction, may be poor, as well as the task that require multi-sensory pattern perception.

Binaural separation refers to the ability of a listener to processes an auditory message coming into one ear while ignoring a disparate message being presented to the opposite ear at the same time (Bellis, 1996). Auditory separation refers to a task where the individual attends to one signal while ignoring another background signal. Such activities have been carried out in binaural as well as mono-aural situations. It is directed towards improving the basic auditory skills which include vigilance, temporal gap detection, and intensity or frequency discrimination, tone glide discrimination, temporal order discrimination, flutter fusion, lateralization and inter-hemispheric transfer. Katz & Burge (1971) analyzed the improvement in speech-in-noise in a group of children and noted post therapy improvement of monosyllabic words presented in the presence of noise. Thus such activity would help in better auditory perception in the presence of noise in children with auditory processing disorders. Studies by Olsen, Noffsinger & Kurdziel (1975), Sinha (1959) (Cited in Willeford & Burleigh, 1985 & Bellis, 2001), Noffsinger, Olsen, Carhart, Hart & Sahgal (1972) & Morales-Gracia & Poole (1972) have suggested that speech discrimination in the presence of monotically presented noise, decreases with both brainstem and temporal lobe involvement.

Research in the recent past has indicated how auditory training improves auditory perceptual skills in children with auditory processing problems. Appropriate auditory stimulation can result in changes in the auditory system. From the review it can be noted that, of the many auditory processing disabilities the child with auditory processing disorder faces, the predominant among them is auditory integration and auditory separation activities. So, these two activities have to be given more importance and more care in designing a training module. Hence, it would be ideal to develop training module to tackle these processes in order to improve the overall auditory perceptual skills.

Hence in the present study an attempt has been made to develop a computer based therapy module in Kannada for children with auditory processing disorders and to evaluate the efficacy of computer based therapy program in improving auditory perceptual skills in children with auditory perceptual problems. It also aims in evaluating the usefulness of the therapy program immediately after termination of the therapy and also after a gap of two months to see how the children are able to maintain the newly acquired skills. Development of auditory training material in Kannada, for children who have auditory processing problems, would be highly beneficial for a large number of children who suffer from this problem. Further, personal computers are now-a-days widely available in schools. Hence a large population would have easy access to computer based training.

METHOD

METHOD

Objectives of the study

The objectives of the present study were:

1) To develop a computer based therapy module in Kannada for children with auditory processing disorders in the processes of auditory separation and auditory integration.
2) To examine the efficacy of the newly developed therapy module in treating children with auditory processing disorders.

Subjects

A total of 34 subjects with auditory processing disorder participated in the study. The diagnosis was based on the results of series of tests to identify central auditory processing disorder (CAPD). Based on the type of auditory process impaired, the subjects were classified into three groups: Group 1 consisted of 9 Subjects with difficulty in auditory separation task: Group 2 comprised of 11 subjects with difficulty in auditory integration task and the remaining 14 subjects who exhibited difficulty in both auditory separation and auditory integration tasks formed the third group. The subjects from these three groups were randomly selected and subclassifed into experimental and control group. The experimental subjects from the respective groups received therapy using the newly developed computerized training module in the specified tasks, whereas the control group subjects were not given any therapy.

Table M 1: Shows the distribution of subjects among the Experimental and Control group.

Auditory Processing tasks	Experimental group	Control Group	Total number of subjects
Auditory separation	5	4	9
Auditory integration	6	5	11
Auditory separation and auditory integration	7.	7	14

Test Material Used for Identification of Children with Central Auditory Processing Disorder:

- The Auditory Processing Screening Checklist- Teachers/Parents (Rajalakshmi & Gopi Sankar, 2003).
- The CD version of Dichotic Digit Test (DDT) developed in Audio lab version - I I (Regishia, 2003).
- The CD version of Pitch Pattern Test (PPT) developed in Audio lab version - I I (Shivani, 2003).
- The CD version of Competing Sentence Test (CST) developed in Audio lab version - I I (Ravanan & Rajalakshmi, 2004).

Therapy Materials Used for Facilitating Auditory Integration and Auditory Separation Tasks:

Materials for Auditory Integration:

Auditory integration module included two different activities- auditory closure and Dichotic offset training activities. The activities for auditory closure were: missing word exercises at the sentence and phrase level, missing syllable and missing phoneme exercises at the word level. The materials were organized at varying levels of difficulty.

For Dichotic Offset training activities, dichotic material with words, phrases and sentences were developed. The lag was varied starting with gross offset lags, where the stimuli were presented one after the other with a sufficient time gap in between two stimulus presentations. The hierarchy of items was prepared ranging from easy to the more difficult activities.

Material for Auditory Separation:

This involved preparing speech material in the presence of different types of noise at different levels. Material such as words, phrases, sentences were used. The material was presented at different signal-to-noise ratios with the different types of noise including white noise, speech noise, narrow band noise, traffic noise, cafeteria noise, classroom noise, kitchen noise, market place noise and noise from the chirping of birds. The S/N ratio varied from +20 dB to -10 dB. The material was prepared in increasing level of difficulty, such that the children were trained first with the easier task and then moved to the more difficult task. Initially phrases and sentences were presented at a +20 dB S/N ratio. As the child became proficient at performing a task, the S/N ratio was decreased. A similar procedure was followed for words as well.

The therapy modules for auditory integration and auditory separation were initially recorded in the form of wave files into a computer and then using the Audio lab version - II they were converted to dichotic files and saved into separate wave files. The subjects receiving therapy were played the files through auditory mode using head phones for the first 25 sessions. Later it was presented through speakers. The subjects were given training for 45 minutes daily. Initial 20 minutes of therapy was utilized to train the child in the specific task while during the remaining time, the child played interactive games. This was done to make the child more attentive and it also acted as reinforcement for the child.

Environment

All the tests for the diagnosis of auditory processing disorders were carried out in a sound treated room of the Department of Audiology, AIISH, Mysore. The training was carried out in a distraction free environment.

Instrumentation:

- A calibrated two-channel audiometer with facility for CD/Tape input.
- A calibrated Immittance instrument.
- An audio CD player to present the various tests' stimuli for identifying auditory processing disorder.

- Audio lab version-II for developing the Competing Sentence Test and for preparing the training modules.
- A personal computer to impart training.

Procedure

The procedure involved the following stages.

Stage one: Competing Sentence Test-revised in Kannada for children (Ravanan & Rajalakshmi, 2004) was developed and standardized.

Stage two: Screening was carried out to identify children at risk for auditory processing disorders. Three schools located in the city of Mysore were selected. A total of 440 children in the age range of 8 to 12 years were screened for any speech, language, hearing or ENT problems. 21 children were found to present speech, language or hearing problem. These children were not included in the study. Following this, the children were administered Auditory Processing Screening Checklist- parents/teachers (Rajalakshmi & Gopi Sankar, 2003). 98 children failed the screening checklist. These 98 children were later administered Ravines Colored Progressive Matrices (RCPM) Raven., Court, & Raven.,(1977). Of which, eight children were found to posses below average intelligence and thus were not part of the present study. The remaining 90 subjects were carried to next stage of the study.

Stage three: A battery of diagnostic tests was administered on the 90 children who failed in the auditory processing checklist. The tests administered were

Dichotic Digit Test (DDT), Pitch Pattern Test (PPT), and Competing Sentence Test (CST).

A) Dichotic Digit test (DDT) in Kannada: The CD version of Dichotic Digit Test (Kannada) developed in Audio lab version-II (Regishia, 2003) was used. Two pairs of digits in Kannada were presented dichotically, while the children repeated orally what they heard. A total of 30 presentations were given for each child. Initially, the children were given practice trails followed by the test material. The time interval between two stimulus presentations was varied from 4 to 8 seconds. Both single and double correct scores were obtained.

B) Pitch Pattern Test (PPT): The CD version of the Pitch Pattern Test developed in Audio lab- version-II (Shivani, 2003) was used. It consists of thirty items per ear. There were three presentations per item. The subjects were instructed to report the tonal pattern heard in each ear. The responses were scored as each item correct.

C) Competing Sentence Test (CST) in Kannada: Based on the available Competing Sentence Tests (Jerger & Jerger, 1975), a Kannada version of CST for Children was developed and standardized for the purpose of this study. It consists of 30 target and 30 competing sentences. The sentences were presented binaurally such that the target sentence was routed to the test ear while the competing sentence fed to the non-test ear. The child should hear both the sentences and respond to the target sentence. Scores were obtained for the correct responses.

Following the tests administration, 34 children failed in either or all of the tests. These children were selected as subjects for the study. The scores obtained for the various tests were tabulated and formed the baseline assessment score of each child. The 34 subjects were grouped into three categories as children who had problem in auditory integration task, auditory separation task, and those who had difficulty in both the tasks. The subjects were then classified into experimental group and control group within these three categories.

Stage four involved development of master CD. The CD contained therapy material for the processes of auditory separation and auditory integration. The material consists of extensive range of vocabulary with pictures in the form of audio files. The vocabulary was selected from the school text books appropriate to the age level of children.

Stage five: A pilot study was carried out on two learning disabled children aged 10 and 12 years respectively, to check the feasibility of newly developed computerized therapy material. The children performed below par on the Auditory Processing Screening Checklist (Rajalakshmi & Gopi Sankar, 2003) and the diagnostic tests of DDT, PPT, and CST. Computer based training was imparted to these children with the newly developed therapy modules in auditory separation and auditory integration tasks for thirty sessions, with each session lasting 45 minutes. Following therapy, for the children with APD, the scores of the experimental group (Learning Disability Children) were compared with the age and gender matched normal control group children who did not receive any training. The results showed a steady improvement in the test scores of experimental group children at pre and post therapy. The normal controls, however, did not show any change in scores after the same period. The pilot study was also helpful in making certain alterations that led to improvement of the training modules. An abstract of the article based on the pilot study has been accepted for presentation at the World Congress of Applied Linguistics to be held in Madison, USA from 25th to 27th July 2005 (Ravanan & Rajalakshmi 2005).

Stage six: Children diagnosed as APD were divided into experimental group and control group based on random sampling. The experimental group children were given therapy with either or both of the newly developed material for thirty sessions of approximately 45 minutes duration each. The type of training module to be used depended on the auditory process that was found to be deficient in the baseline assessment. The therapy included interactive games as well. The items were prepared in a hierarchical order such that the tasks were easier initially and gradually progressing to the more difficult items.

Stage Seven: Re-evaluation with the same test materials was done for all the subjects at the end of fifteen sessions, thirty sessions, and after two months of therapy to check any improvement in the test scores compared to the baseline measures. The re-evaluation was also needed to examine the consistency of performance or if any degradation in scores is present over a period of time during therapy. In addition, feedback was obtained from the school teachers, care takers and family members regarding progress of the child, any behavioral changes, or any other relevant changes. After the completion of therapy for thirty sessions, all the subjects were given a break of two months and re-evaluated again on the same tests to determine if there was any variation in scores. This provided information whether the subjects who attended therapy were able to sustain improvement or if any deterioration is noticed after the termination of therapy.

The results have been presented and discussed in detail in the next chapter.

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Thirty-four children with various auditory processing difficulties were selected as subjects by assessing using checklist and a battery of three tests. The data obtained were tabulated and statistical evaluations were carried out using SPSS Version 10.0 for windows. Mean and standard deviation of the results of DDT, PPT, and CST tests for three different activities: auditory separation, auditory integration, and both auditory integration & auditory separation were obtained, to assess if there was any improvement in children who underwent therapy with the newly developed training module and to check if there was any change in the scores of subjects after the therapy was terminated. Comparisons were made for each activity, between the test results of DDT, PPT, and CST at four different intervals of therapy (pre-therapy, at the end of fifteenth session, at the end of thirtieth session, and after a gap of two months following cessation of therapy) and between experimental and control groups. The significance of differences between the means was tested.

Multivariate analysis of variance (MANOVA) was employed to see the main effect and interaction effects of conditions (four different intervals of therapy), and groups (Experimental vs. Control group) in all the three tests. For better understanding, this was followed by one-way ANOVA with repeated factors for four conditions (separately for experimental and control groups). In instances where significant results were observed with ANOVA, Duncan's Post Hoc test was administered to see the pair-wise differences. The similar statistical procedure was used for auditory separation activity, auditory integration activity, and for both auditory integration & auditory separation activities.

Two-way ANOVA, followed by one-way ANOVA for repeated factors was used to observe the main and interaction effects of conditions and groups for double correct scores. The significant results were followed by Duncan's Post Hoc test.

Repeated measure ANOVA was performed for each activity (combining DDT, PPT and CST scores) to see the difference in test scores at different intervals of therapy using the newly developed computerized training module in experimental group.

The results of the statistical analysis are as follows:

Auditory Separation activity

Table R 1 shows the mean and standard deviation of Dichotic Digits Test, Pitch Pattern Test and Competing Sentence Test at pre-therapy, fifteen days post-therapy, thirty days post-therapy, and at two months after the completion of therapy, of all the subjects who underwent therapy for auditory separation task (See Graph 1, 2, 3). As can be observed from the table, all the subjects performed well in Dichotic Digits Test (DDT) and Pitch Pattern Test (PPT) with their pre-therapy scores above 27. The subjects had a passing score for DDT and PPT at pre-therapy stage and maintained similar performance all through the training period and even after two months after the break of therapy. However, the subjects demonstrated poor performance prior to the therapy on the Competing Sentence Test (CST). The score was within 12 for both experimental and control group subjects in either ears. Since the scores were below par compared to the existing norms, the subjects were diagnosed as children with APD, who had specific problem in auditory separation task. The training was initiated for this group of experimental subjects in auditory separation activity. It can be noted from the table that the CST score of the experimental group children improved steadily from Rt-9.80, Lt-10.80 at the pre-therapy stage to Rt-12.20, Lt-12.00 on the fifteenth day, to Rt-16.80, Lt-16.20 on the thirtieth day. The score continued to improve slightly even after the cessation of therapy. At two months following the cessation of therapy, the CST score stood at Rt-18.20, Lt-17.60. It reveals that the improvement was maintained even after the training stopped. At the same time, it can be noted from the table that the CST score of the control group subjects did not vary similar to the experimental group. The CST scores of the control group subjects were Rt-10.75, Lt-9.75 at pre-therapy stage and remained at Rt-10.50, Lt-10.50; Rt-11, Lt-11 on fifteenth day and thirtieth day respectively. It can also be noted that upon re-evaluation after two months gap, the scores obtained were Rt-11.25, Lt-10.50. The CST results of the control group thus remained almost similar through out the training period and did not show any obvious variability. The improvement in CST scores of the experimental group subjects in both left and right ear suggests that the subjects benefited by therapy using auditory separation activity. The experimental group subjects infact demonstrated consistent improvement even at two months following therapy. It can thus be inferred that the newly developed computerized training module is useful for alleviating problems in auditory separation in children with Central Auditory Processing Disorders.

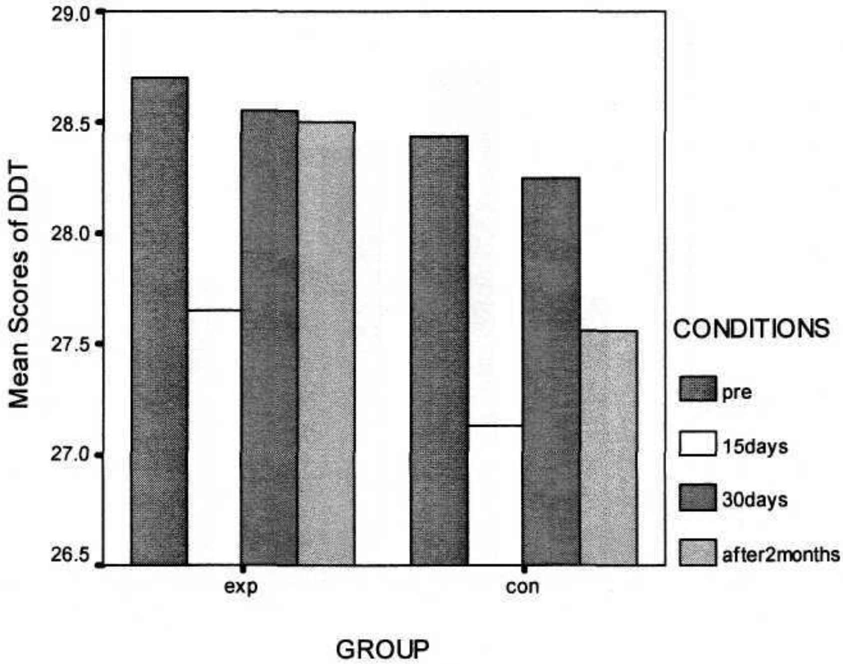
Table R 1: Auditory Separation activity [Mean, Standard Deviation of Dichotic Digit Test (DDT), Pitch Pattern Test (PPT), and Competing Sentence Test CST)].

Ear	Group	Condition	N	DDT		PPT		CST	
				Mean	S.D	Mean	S.D	Mean	S.D
Rt	Exp	pre	5	28.80	1.09	28.60	1.67	9.80	1.48
		15 days		27.90	.96	27.00	.70	12.20	1.92
		30 days		28.60	.54	28.80	.83	16.80	2.28
		After 2 m		28.60	1.08	29.40	.54	18.20	2.28
	Con	pre	4	29.00	1.08	29.50	1.00	10.75	.95
		15 days		26.75	1.84	28.00	1.15	10.50	.57
		30 days		27.75	1.50	28.50	.57	11.00	.81
		After 2 m		27.75	1.19	27.75	.95	11.25	1.25
Lt	Exp	pre	5	28.60	1.24	29.00	1.73	10.80	.44
		15 days		27.40	1.34	28.80	.44	12.00	2.23
		30 days		28.50	1.00	29.00	1.00	16.20	1.92
		After 2 m		28.40	1.08	29.40	.54	17.60	2.07
	Con	pre	4	27.87	1.65	30.00	.00	9.75	.95
		15 days		27.50	1.47	28.50	1.29	10.50	.57
		30 days		28.75	.86	29.00	.81	11.00	.81
		After 2 m		27.37	1.54	28.00	.81	10.50	1.29

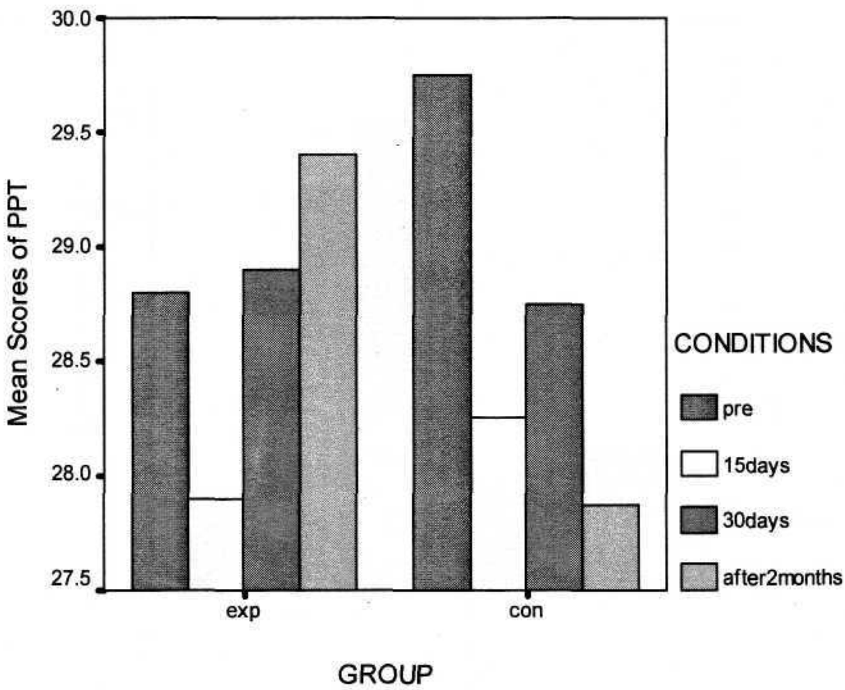
Table R 2 shows the mean and standard deviation of the double correct scores of the Dichotic Digit Test of the subjects who underwent therapy for auditory separation activity at pre-therapy, fifteen days after therapy, thirty days after therapy and after two months of therapy (see Graph 4). It can be seen that all the subjects had a passing score for double correct scores of DDT at the pre-therapy stage and they maintained similar scores all through the period and after two months following therapy. The double correct score for the experimental group subjects was 25.00 at the pre-therapy condition, 25.80 at the end of thirty days, and 26.00 at two months of therapy. It can be noted that there was no change in the double correct scores of the DDT in experimental group subjects, who underwent therapy for auditory separation activity. The scores of the control group were 25.50 on the pre therapy assessment, 24.75 on the fifteenth day, 25.50 on the thirtieth day and 24.50 on the assessment after two months. Thus, it can be observed that in the control group subjects the scores did not change and remained similar throughout the study period.

Table R 2: Auditory separation activity (Mean and Standard Deviation of Dichotic digit test- Double correct score).

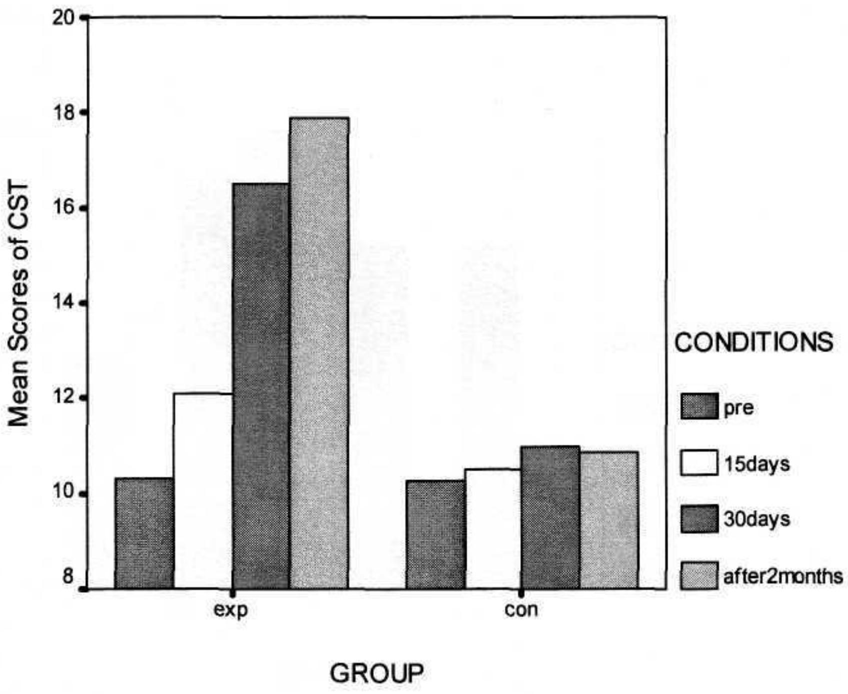
Group	Condition	N	DDT- Double correct scores	
			Mean	S.D
Experimental	Pre-Therapy	5	25.00	4.30
	15 days		25.20	4.14
	30 days		25.80	3.27
	After 2 m		26.00	3.16
Control	Pre-therapy	4	25.50	4.20
	15 days		24.75	2.50
	30 days		25.50	2.88
	After 2 m		24.50	3.69



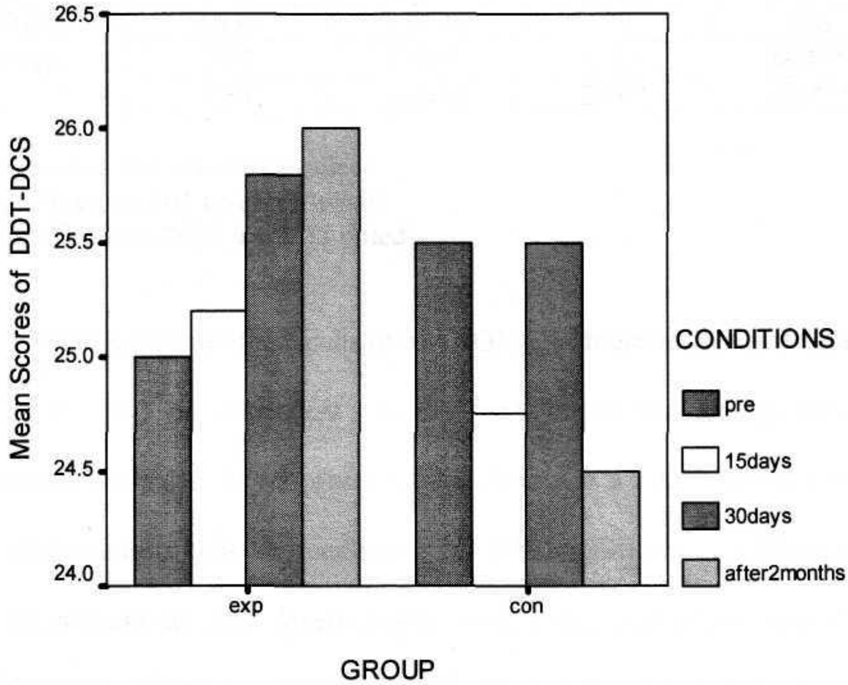
Graph 1: Showing the DDT scores of auditory separation activity.



Graph 2: Showing the PPT scores of auditory separation activity.



Graph 3: Showing the CST scores of auditory separation activity



Graph 4: Showing the DDT-Double correct scores of auditory separation activity

Table R3: Results of MANOVA Showing the F-value and significance values of auditory separation activity.

Source	Dependent Variable	df	F	Sig.
Conditions	DDT	(3,64)	3.38	.023*
	PPT	(3,64)	4.31	.008**
	CST	(3,64)	29.70	.000***
Groups	DDT	(1,64)	3.16	.080
	PPT	(1,64)	.153	.697
	CST	(1,64)	97.34	.000***
Conditions Vs Groups	DDT	(3,64)	.29	.828
	PPT	(3,64)	4.85	.004**
	CST	(3,64)	20.62	.000***

* Significant at 0.05 levels (2-tailed)
** Significant at 0.01 levels (2 tailed)
*** Significant at 0.001 levels (2 tailed)

Table R 3 shows the results of MANOVA with the various tests (DDT, PPT, and CST) as dependent variable and conditions and groups as independent variables. It was observed that there was a significant difference in all the three tests between conditions. The PPT (significant at .01 level) and CST (significant at .001 level) scores were more significant than DDT (significant at .05 level). Since the CST was highly significant it gives an opinion that the subjects showed improvement in the scores in auditory separation activity (from table Rl). Also, in CST, we can see significant difference between the groups (significant at .001 level). It is evident from Table R 3 that, there is significant effect of the interaction of conditions and groups. Hence, One-way ANOVA was carried out for conditions (separately for experimental and control groups) and the result is as follows.

Table R 4: Results of one-way ANOVA of the experimental group subjects auditory separation activity.

Tests	df	F	Sig.
DDT	(3,36)	2.169	.109
PPT	(3,36)	3.205	.035*
CST	(3,36)	37.843	.000***

* Significant at 0.05 levels (2-tailed)
*** Significant at 0.001 levels (2 tailed)

Table R 4 shows the results of one-way ANOVA of the experimental group subjects with the various tests (DDT, PPT, and CST). It is observed that there was a significant difference in PPT (significant at .05 level) and CST (significant at .001 level), but not in DDT. Duncan's post Hoc Test was administered to see the pair-wise differences. It is evident from Table R5 that in PPT, there is significant difference between fifteen days and after two months. Table R 6 shows the Post Hoc test result of CST. It is evident from the table that there is significant difference between pre-therapy, fifteen days and thirty days (or after 2 months). There is no significant difference between thirty days and two months after therapy in the experimental group subjects. In both PPT and CST, we can observe an increasing trend in the scores.

Table R 5: Results of the Post Hoc Tests-Condition- homogeneous Subtests PPT of the Experimental group subjects - auditory separation activity.

Conditions	N	Subset for alpha = .05	
		1	2
15 days	10	27.90	
Pre-therapy	10	28.80	28.80
30 days	10	28.90	28.90
After 2 months	10		29.40
significance		.062	.259

Table R 6: Results of the Post Hoc Tests-Condition- homogeneous Subtests CST-in the Experimental group subjects - auditory separation activity.

Conditions	N	Subset for alpha = .05		
		1	2	3
Pre-therapy	10	10.30		
15 days	10		12.10	
30 days	10			16.50
After 2 months	10			17.90
Significance		1.00	1.00	.098

Table R 7: Results of one-way ANOVA of the control group subjects - auditory separation activity.

Test	df	F	Significance
DDT	(3,28)	1.51	.232
PPT	(3,28)	6.91	.000***
CST	(3,28)	1.08	.370

*** Significant at 0.001 levels (2 tailed)

Table R 7 shows the results of one-way ANOVA for the control group subjects with the various tests (DDT, PPT, and CST). It is evident from the table R 7 that there is significant difference between conditions in the PPT in the control group subjects. Duncan's post hoc test was administered, and results are given in Table R 8. It shows that there is no significant difference between 15 days, 30 days and after 2 months, but they have significant difference with pre-therapy. We can observe a decreasing trend.

Table R 8: Results of the Post Hoc Tests-Condition- homogeneous Subtests PPT- of the Control group subjects - auditory separation activity.

Conditions	N	Subset for alpha = .05	
		1	2
After 2 months	8	27.87	
15 days	8	28.25	
30 days	8	28.75	
Pre-therapy	8		29.75
Significance		.067	1.000

Table R 9: Results of Two-way ANOVA Showing the F-value and significance values of Double correct scores of DDT- Auditory separation activity.

Source	df	F-Value	Significance
Condition	(3,28)	.053	.984
Groups	(1,28)	.131	.720
Condi* Groups	(3,28)	.116	.950

The two-way ANOVA reveals no significant difference in double correct scores of DDT (Table R9). It can be inferred that the scores remained similar in both experimental and control group subjects during the course of study.

Auditory Integration activity

The mean and standard deviations of the scores of DDT, PPT, and CST at pre therapy, fifteen days after therapy, thirty days after therapy and after two months of therapy of the subjects who underwent therapy for auditory Integration activity are shown in Table R 10 (See Graph 5, 6, 7). It can be seen that all the subjects performed below par prior to the therapy in Dichotic Digits Test. The subjects who demonstrated poor performance for DDT were diagnosed as APD. The scores of the experimental group subjects were Rt- 19.50, Lt -18.50, while the control group subjects scored 17.70 in right ear, 20.00 in left ear at the pre-therapy condition. The scores were far below than the norms at that age. The subjects were found to have difficulty in auditory integration activity. It can also be seen from the Table R10 that all the subjects put in relatively better performance on the Pitch Pattern Test. The subjects had a passing score for PPT at the pre-therapy stage. The experimental group subjects had pre-therapy PPT scores of Rt- 28.16, Lt- 28.33, where as the control group subjects presented scores of Rt-27.60, Lt- 28.80. The scores remained similar all through the therapy period. The score of the PPT test on the thirtieth day for the experimental group subjects was Rt 28.33, Lt-29.16, and for the control group subjects it was Rt-25.8, Lt-27.20. At two months after therapy, the scores were Rt-28.50, Lt-28.83 for the experimental subjects and Rt-27, Lt-28.40 for the control group subjects. It can thus be seen that the subjects maintained similar PPT measures all through the study period. Similar to the performance on PPT, all the subjects exhibited favourable performance on Competing Sentence Test. The scores of the experimental group subjects in the pre-therapy condition were Rt- 22.16, Lt- 23.16 and for the control group subjects the results were Rt- 21.20, Lt- 22.60. The variation in scores of CST was less in both experimental group subjects and control group subjects. But an increasing trend can be seen in experimental group and decreasing trend in control group. The result on thirtieth day of therapy for the experimental group subjects was Rt- 24.00, Lt- 23.50, and Rt- 20.20, Lt- 20.40 for the control group subjects. When the assessment was done after two months, the score of experimental group was Rt-24.50, Lt-24, and for the control group it was Rt-19.60, Lt 20.60. Since the subjects presented difficulty in auditory integration activity, the computerized therapy was given for this specific activity. It can be noticed in table 10 that the DDT scores of experimental group improved steadily from the pre-therapy stage to the thirtieth day of therapy. The scores remained high when re-evaluation was carried out after two months of therapy. The results reveal the utility of the computerized training module in alleviating problems related to auditory integration process.

Table R 10: Auditory integration activity (Mean, Standard Deviation of the Raw Scores of Dichotic Digit Test, Pitch Pattern Test, and Competing Sentence Test).

Ear	Group	Condition	N	DDT		PPT		CST	
				Mean	S.D	Mean	S.D	Mean	S.D
Rt	Exp	pre	6	19.50	4.43	28.16	2.04	22.16	.75
		15 days		19.91	4.65	27.50	1.37	22.33	1.03
		30 days		22.91	3.41	28.33	1.21	24.00	.89
		After 2 m		24.41	2.28	28.50	1.04	24.50	.54
	Con	pre	5	17.70	3.11	27.60	3.57	21.20	.44
		15 days		18.20	3.32	26.40	2.60	21.60	1.14
		30 days		17.50	3.58	25.80	3.03	20.20	2.38
		After 2 m		17.70	3.34	27.00	2.82	19.60	.54
Lt	Exp	pre	6	18.50	2.34	28.33	2.33	23.16	1.72
		15 days		18.58	2.47	28.16	1.83	22.16	1.72
		30 days		22.50	1.51	29.16	.75	23.50	1.51
		After 2 m		23.08	1.02	28.83	.75	24.00	.63
	Con	pre	5	20.00	5.72	28.80	1.78	22.60	1.51
		15 days		19.00	3.51	26.00	3.00	22.20	1.30
		30 days		20.20	5.32	27.20	3.03	20.40	1.14
		After 2 m		20.40	4.80	28.40	1.34	20.60	.89

Table R1 1 shows the mean and standard deviation of the results of the double correct scores of DDT at pre-therapy, fifteen days after therapy, thirty days after therapy and two months after therapy of the subjects who underwent therapy for auditory integration activity. Prior to the start of therapy, all the subjects performed poorly on the double correct scores of DDT. There was a gradual and consistent improvement in performance of subjects who had undergone training in auditory integration activity, as can be seen in the results demonstrated at the termination of therapy relative to the pre-therapy stage (Table RIO) (see Graph 8).

Table R 11: Auditory Integration activity (Mean Standard Deviation of the raw scores of Dichotic digit test- Double correct score).

Group	Condition	N	DDT-Double correct scores	
			Mean	S.D
Exp	Pre-therapy	6	7.83	8.20
	15 days		8.33	6.59
	30 days		13.66	5.35
	After 2 m		14.50	5.24
Con	Pre-therapy	5	6.80	4.81
	15 days		7.40	2.30
	30 days		8.20	3.70
	After 2 m		8.00	3.60

Table R 12: Results of MANOVA Showing the F-value and significance values -Auditory Integration activity.

Source	Dependent Variable	df	F	significance
Conditions	DDT	(3,80)	2.847	.043*
	PPT	(3,80)	1.603	.195
	CST	(3,80)	.184	.907
Groups	DDT	(1,80)	9.584	.003**
	PPT	(1,80)	7.470	.008**
	CST	(1,80)	66.728	.000***
Condition Vs Groups	DDT	(3,80)	2,266	.087
	PPT	(3,80)	1.105	.352
	CST	(3,80)	12.694	.000***

* Significant at 0.05 levels (2-tailed)
** Significant at 0.01 levels (2 tailed)
*** Significant at 0.001 levels (2 tailed)

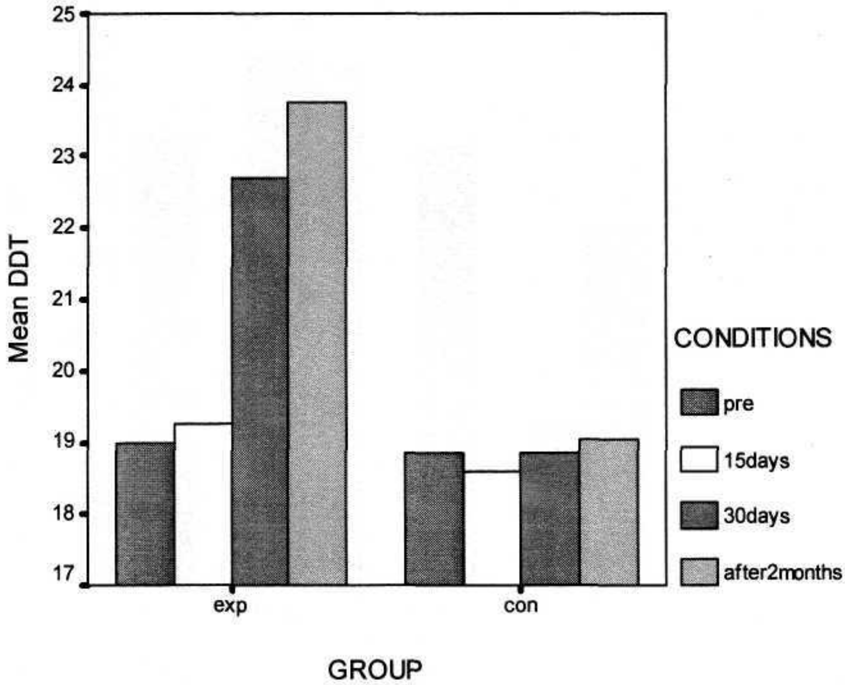
Table R 12 shows the results of the MANOVA with the various tests as dependent variable and conditions and groups as independent variables. It was observed that there is a significant difference in DDT between conditions (Significant at .05 levels) and between groups, all the three tests showed significant results (DDT significant at .01 levels, PPT significant at .01 levels and CST highly significant at .001 levels). In interaction of conditions and groups, there was significance for CST (Significant at .001 levels). This gives the opinion that if one auditory process is worked on, the other two auditory processes also show improvement. This was followed by one-way ANOVA.

Table R 13: Results of one-way ANOVA of the experimental group subjects auditory integration activity.

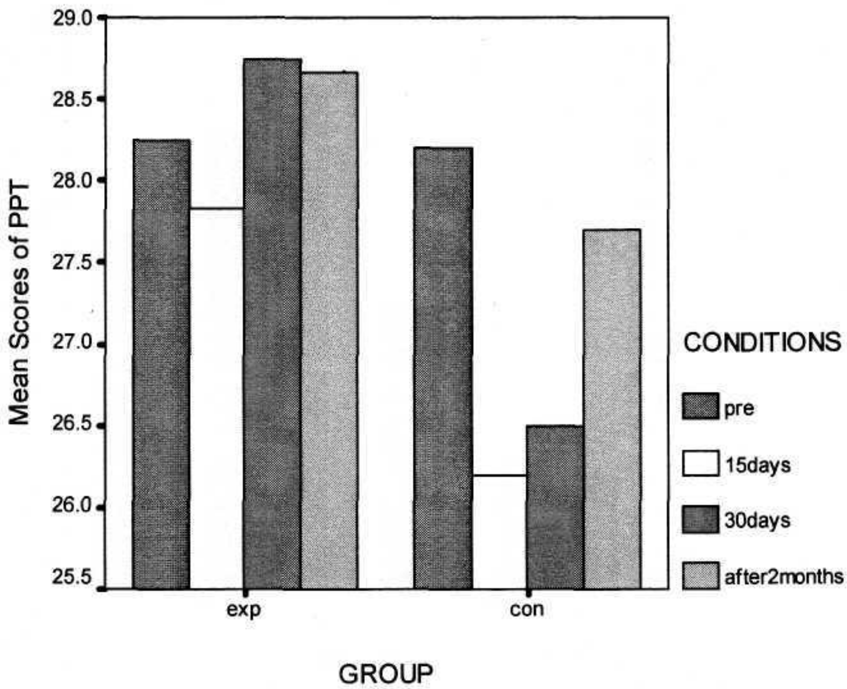
Tests	df	F	Sig.
DDT	(3,44)	8.062	.000***
PPT	(3,44)	.972	.415
CST	(3,44)	7.418	.000***

*** Significant at 0.001 levels (2 tailed)

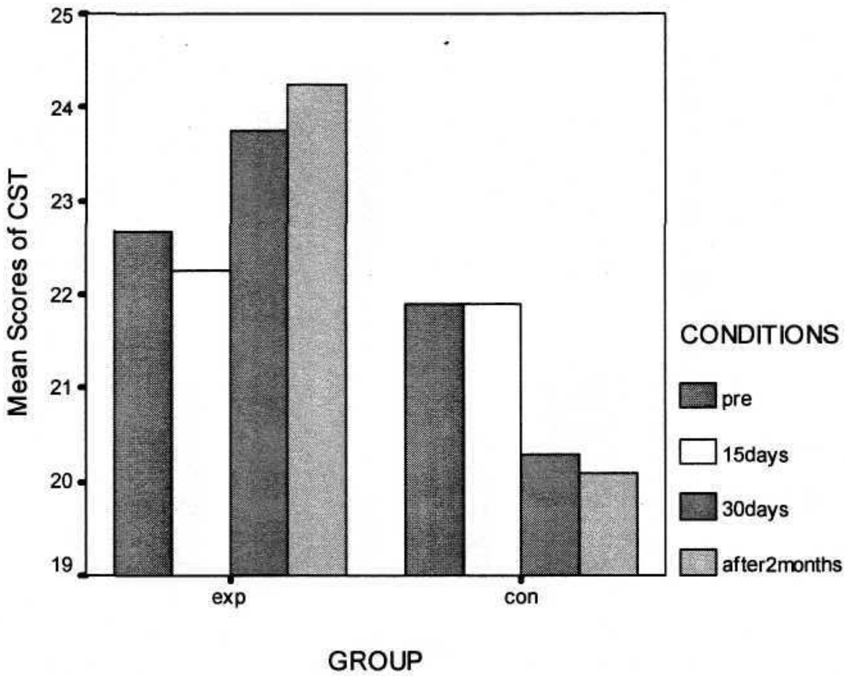
Table R13 shows the results of one-way ANOVA of the experimental group subjects with the various tests (DDT, PPT, and CST) in auditory integration activity. It was observed that there was a significant difference in DDT (significant at .001 levels) and CST (significant at .001 levels), but not in PPT. Duncan's post Hoc Test was administered to see the difference. It is evident from Table R14 that in DDT there is no significant difference between Pre- therapy and fifteen days and also, thirty days and after two months. There is significant difference between fifteen days and thirty days (or after 2 months). Table R15 shows the Post Hoc test result of CST. Almost the same trend as DDT can be observed. However, the important thing is, an increasing trend can be observed through pre-therapy to after 2 months in both DDT and CST.



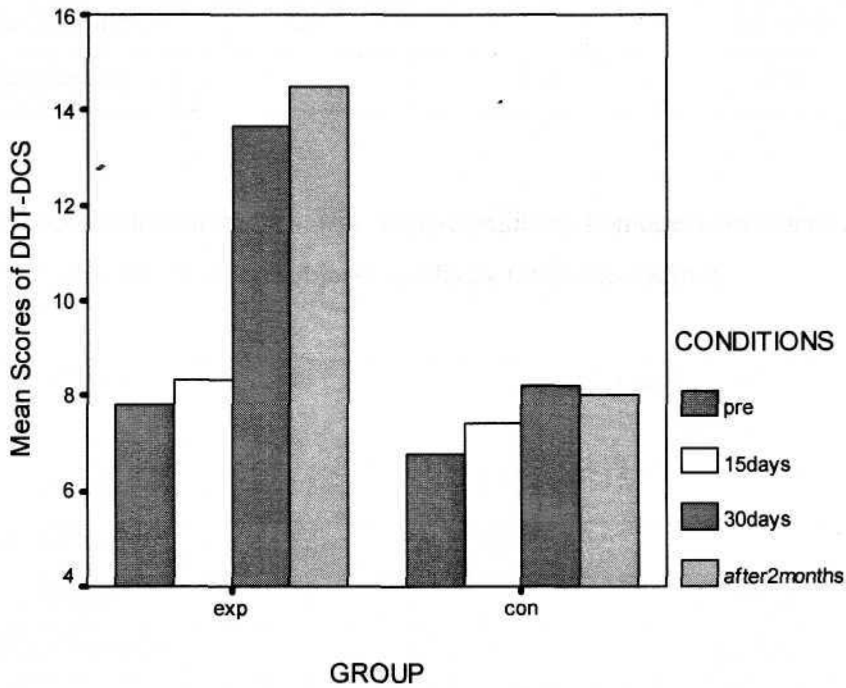
Graph 5: Showing the DDT scores of auditory integration activity



Graph 6: Showing the PPT scores of auditory integration activity



Graph 7: Showing the CST scores of Auditory Integration activity



Graph 8: Showing the DDT-Double correct scores for auditory Integration activity

Table R14. Results of the Post Hoc Tests-Condition- homogeneous Subtests DDT of Experimental group subjects -auditory Integration activity.

Conditions	N	Subset for alpha = .05	
		1	2
Pre-therapy	12	19.0000	
15 days	12	19.25	
30 days	12		22.7083
After 2 months	12		23.7500
significance		.836	.390

Table R 15: Results of the Post Hoc Tests-Condition- homogeneous Subtests CST of Experimental group subjects - auditory Integration activity.

Conditions	N	Subset for alpha = .05	
		1	2
15 days	12	22.2500	
Pre-therapy	12	22.6667	
30 days	12		23.75000
After 2 months	12		24.25000
Significance		.392	.306

Table R 16: Results of one-way ANOVA of the control group subjects - auditory Integration activity.

Test	df	F	Significance
DDT	(3,36)	.020	.996
PPT	(3,36)	1.291	.292
CST	(3,36)	5.561	.003*

Significant at 0.01 levels (2 tailed)

Table R16 shows the results of one-way ANOVA for the control group subjects with the various tests (DDT, PPT, and CST) in auditory integration activity. There is significant difference in the CST alone (Significant at .01 levels). Duncan's post hoc test was performed for the CST in the control group subjects to see pair-wise differences.

Table R 17 Shows the Duncan's post hoc test result of the CST in control group subjects of auditory integration activity. It can be seen that there is no significant difference between pre-therapy and fifteen days and also, thirty days and after two months and the scores are reduced from pre-therapy to after 2 months.

Table R 17: Results of the Post Hoc Tests-Condition- homogeneous Subtests CST-Control group subjects - auditory Integration activity.

Conditions	N	Subset for alpha = .05	
		1	2
After 2 months	10	20.1000	
30 days	10	20.3000	
Pre-therapy	10		21.9000
15 days	10		21.9000
Significance		.737	1.000

Table R18: Results of Two-way ANOVA showing F-value and significance of DDT-Double correct scores - auditory Integration activity.

Source	df	F-Value	Significance
Condition	3	1.544	.220
Groups	1	4.513	.041*
Condi* Groups	3	.792	.507
Error	36		
Total	44		

* Significant at 0.05 levels (2-tailed)

From the Table R18 (see Graph8) it can be observed that in double correct score there is significant difference between the control group and experimental group.

Auditory Integration & Separation activity

The results of evaluation on DDT, PPT, and CST at pre-therapy, fifteenth day, thirtieth day, and after two months following therapy of the subjects who underwent therapy for both auditory integration & auditory separation activity are given in Table R19 (see Graph 9, 10, 11). All the subjects demonstrated reduced performance compared to the norms at that age on the tests of DDT and CST before the therapy began. The subjects thus were found to present deficits in both auditory integration and auditory separation processes. Subsequently, the therapy program focused on remedial activities for both these processes. It can be observed that there was a steady improvement in the experimental subjects performance beginning right from the pre-therapy stage to the termination of therapy. Moreover, the scores remained consistent even after two months of therapy. The DDT scores at pre-therapy of the experimental and control group was Rt- 17.00, Lt- 19.42; Rt- 15.28, Lt- 16.71 respectively. The subjects undergoing training for both the auditory processing aspects registered scores of Rt- 18.28, Lt- 19.28 on the fifteenth day, Rt- 20.71, Lt- 22.64 on the thirtieth day of therapy. The scores remained high even after two months of therapy (Rt-21.21, Lt-22.78). Thus, suggesting that the subjects were able to sustain better performance even when the therapy was stopped. Similar results were observed for repeated evaluations on CST test at different intervals of therapy (table R20). The scores on CST varied from Rt- 14.57, Lt- 17.00 to Rt- 16.57, Lt- 16.14 on the fifteenth day, to Rt- 21.14, Lt-21.28 on the thirtieth day and remaining steady at Rt- 21.28, Lt- 20.71 after two months of therapy. The experimental and control group subjects performed well on the PPT test. The scores of the experimental group subjects on PPT at the pre-therapy stage was Rt- 24.42, Lt- 24.00; Rt- 24.57, Lt- 25.28 at fifteen days of therapy; Rt- 26.42, Lt- 25.85 at thirty days of therapy; Rt-26.71, Lt-26.28 after two months of therapy. Similarly, the performance of the control group subjects on PPT was equally good as the experimental group. A score of Rt-24.42, Lt- 25.71 was obtained at pre-therapy, Rt-23.85, Lt-24.57 at fifteenth day, Rt-23.42, Lt-24.85 at thirtieth day, and Rt-24.00, Lt-24.71 at two months after the therapy was terminated. Thus, all the subjects had a passing score for Pitch Pattern Test at the pre therapy stage and they maintained the similar high score all through the training period. The results of DDT and CST tests suggest that the deficits in auditory integration & auditory separation processes can be overcome with the newly developed training modules.

Table R 19: Auditory Integration and Separation activity (Mean Std. Deviation of the Raw Scores of Dichotic Digit Test, Pitch Pattern Test, and Competing Sentence Test).

Ear	Group	Condition	N	DDT		PPT		CST	
				Mean	S.D	Mean	S.D	Mean	S.D
Rt	Exp	pre	7	17.00	2.78	24.42	4.31	14.57	3.55
		15 days		18.28	2.64	24.57	3.40	16.57	2.93
		30 days		20.71	2.21	26.42	2.82	21.14	3.33
		After 2 m		21.21	2.44	26.71	3.03	21.28	2.92
	Con	pre	7	15.28	6.22	24.42	5.59	11.71	2.28
		15 days		15.78	6.01	23.85	4.01	12.42	2.14
		30 days		15.71	5.18	23.42	4.57	12.71	2.69
		After 2 m		15.57	5.79	24.00	4.58	11.85	2.73
Lt	Exp	pre	7	19.42	4.65	24.00	2.38	17.00	6.08
		15 days		19.28	3.19	25.28	3.77	16.14	2.03
		30 days		22.64	3.23	25.85	2.11	21.28	3.68
		After 2 m		22.78	2.67	26.28	2.28	20.71	3.54
	Con	pre	7	16.71	4.09	25.71	4.23	13.28	2.49
		15 days		15.92	3.33	24.57	3.15	13.85	1.21
		30 days		16.85	3.82	24.85	3.48	13.42	2.14
		After 2 m		16.21	4.14	24.71	3.86	13.85	1.86

Table R20: Auditory Integration and Separation activity (Mean, Std. Deviation of the Raw Scores of Dichotic Digit Test- Double correct score).

Group	Condition	N	DDT-Double correct scores	
			Mean	S.D
Exp	Pre-Therapy	7	6.71	3.19
	15 days		8.42	2.99
	30 days		11.71	2.05
	After 2 m		13.14	1.77
Con	Pre-therapy	7	3.00	3.41
	15 days		4.57	2.99
	30 days		5.14	2.47
	After 2 m		6.28	2.36

The Table R 20 shows the mean and standard deviation of the results of the double correct scores of DDT at pre-therapy, fifteen days after therapy, thirty days after therapy and two months after therapy of the subjects who underwent therapy for auditory integration & auditory separation activity.

Prior to the start of therapy, all the subjects performed poorly on the double correct scores of DDT. There was a gradual and consistent improvement in performance of subjects who had undergone training in auditory integration and auditory separation activity as can be seen in the results demonstrated at the termination of therapy relative to the pre-therapy stage (Table R 20) (see Graph-12). From Table R 20 it can be noted that at the beginning of therapy, the performance of all the subjects was not upto the mark in the double correct scores of the DDT. As the training was initiated in these activities, performance steadily started to improve from the pre-therapy stage to the end of therapy. Further, the high performance was maintained even after two months of cessation of therapy. It can be seen from the table R20 that the double correct scores of the dichotic digits test for the experimental group improved from 6.71 on the pre-therapy condition to 8.42 on the fifteenth day, to 11.71 on the thirtieth day. It can also be seen that, on the re-assessment done two months after the cessation of therapy the score was 13.14, suggesting that there was no deterioration in the results long after the therapy was discontinued. On the contrary, for the subjects who did not receive any training with newly developed treatment module, the scores did not vary much during the course of the study. The double correct scores of the control group were 3.00 at pre-therapy condition, 4.57 on the fifteenth day, 5.14 on the thirtieth day and 6.28 on the assessment after two months. It can be seen that the scores were less variable compared to the group, which got training. This suggests that training had a significant effect in bringing about an improvement in the double correct scores of the dichotic digit test in the experimental group subjects. This was followed by MANOVA and One-way

ANOVA. Wherever there was a significant difference, Duncan's post hoc test was performed.

Table R 21: Results of MANOVA Showing the F-value and significance values - Auditory Separation and Integration activity.

Source	Dependent Variable	df	F	Significance
Conditions	DDT	(3,104)	1.782	.155
	PPT	(3,104)	.363	.780
	CST	(3,104)	7.093	.000***
Group	DDT	(1,104)	29.995	.000***
	PPT	(1,104)	2.159	.145
	CST	(1,104)	99.909	.000***
Condition Vs Group	DDT	(3,104)	1.532	.211
	PPT	(3,104)	1.050	.374
	CST	(3,104)	6.143	.001***

*** Significant at 0.001 levels (2 tailed)

Table R 21 shows the results of MANOVA with the various tests (DDT, PPT, and CST) as dependent variables and conditions and groups as independent variables. Between conditions, the CST showed highly significant difference (significant difference at .001 levels). Between groups both DDT and CST showed highly significant results (significant at .001 levels). In interaction effect, CST showed a high significance (significant at .001 levels). In the PPT scores, there was no significant difference between the conditions, groups and interactions. This gives an opinion that the subjects showed improvement in the scores in auditory separation activity and Integration activity. This result was followed by one-way ANOVA.

Table R 22: Showing the results of one-way ANOVA of the experimental group subjects - auditory Integration & Separation activity.

Tests	df	F	Sig.
DDT	(3,52)	5.549	.002**
PPT	(3,52)	1.759	.166
CST	(3,52)	9.225	.000***

** Significant at 0.01 levels (2 tailed)
*** Significant at 0.001 levels (2 tailed)

Table R 22 shows the results of one-way ANOVA of the experimental group subjects with the various tests (DDT, PPT, and CST) in auditory integration and auditory separation activity. It was observed that there was a significant difference in DDT (significant at .01 levels) and CST (significant at .001 levels). Duncan's post Hoc Test was administered to see the difference. It is evident from Table R 23 that in DDT there is no significant difference between Pre- therapy and fifteen days and also, thirty days and after two months. There is significant difference between fifteen days and thirty days (or after 2 months). Table R 24 shows the Post Hoc test result of CST. It is evident from the table that the results are almost same as DDT. An increasing trend can be observed from pre-therapy to 30 days and the results were almost same even after 2 months of therapy. This shows that the experimental group subjects benefited from the therapy with the newly developed training modules.

Table R 23: Results of the Post Hoc Tests-Condition- homogeneous Subtests DDT-Experimental group subjects-Auditory Integration and Separation activity.

Conditions	N	Subset for alpha = .05	
		1	2
Pre-therapy	14	18.2143	
15 days	14	18.7857	
30 days	14		21.6786
After 2 months	14		22.0000
significance		.627	.784

Table R 24: Results of the Post Hoc Tests-Condition- homogeneous Subtests CST-Experimental group subjects-Auditory Integration and Separation activity.

Conditions	N	Subset for alpha = .05	
		1	2
Pre-therapy	14	15.7857	
15 days	14	16.3571	
After 2 months	14		21.0000
30 days	14		21.2143
Significance		.676	.875

Table R 25: Results of one-way ANOVA of the control group subjects auditory Integration and separation activity.

Test	df	F	Significance
DDT	(3,52)	.023	.995
PPT	(3,52)	.150	.929
CST	(3,52)	.222	.881

Table R 25 shows the results of one-way ANOVA of the control group subjects with the various tests (DDT, PPT, and CST) in auditory integration & auditory separation activity. There is no significant difference among condition in all the three tests, so Duncan's post hoc test was not performed for the control group subjects.

Table R26: Results of Two-way ANOVA showing the F-value and significance of- DDT-Double correct scores- Auditory Integration & auditory separation activity.

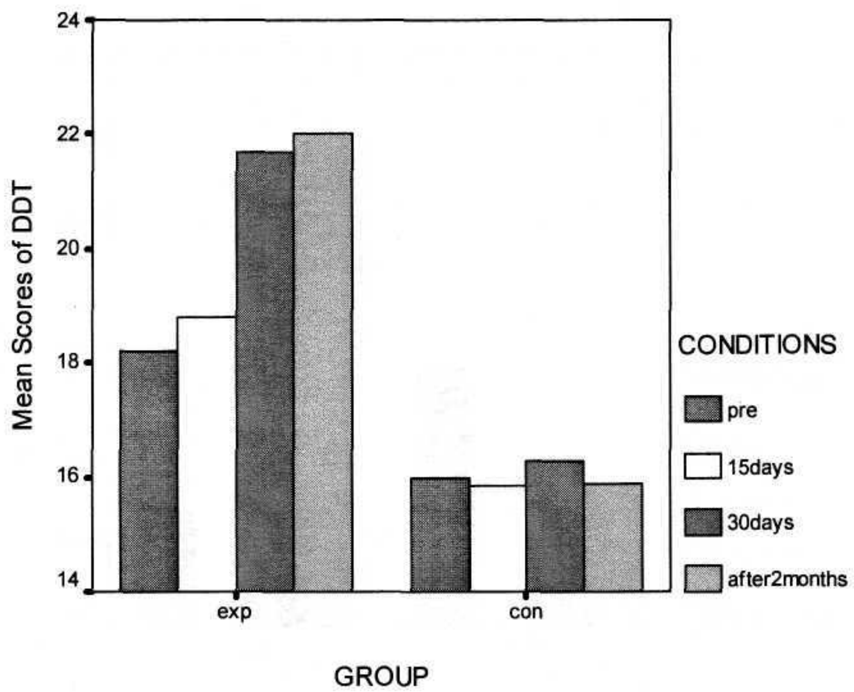
Source	df	F-Value	Significance
Condition	3	8.675	.000***
Groups	1	52.407	.000***
Condi* Groups	3	1.367	.264
Error	48		
Total	56		

*** Significant at 0.001 levels (2 tailed)

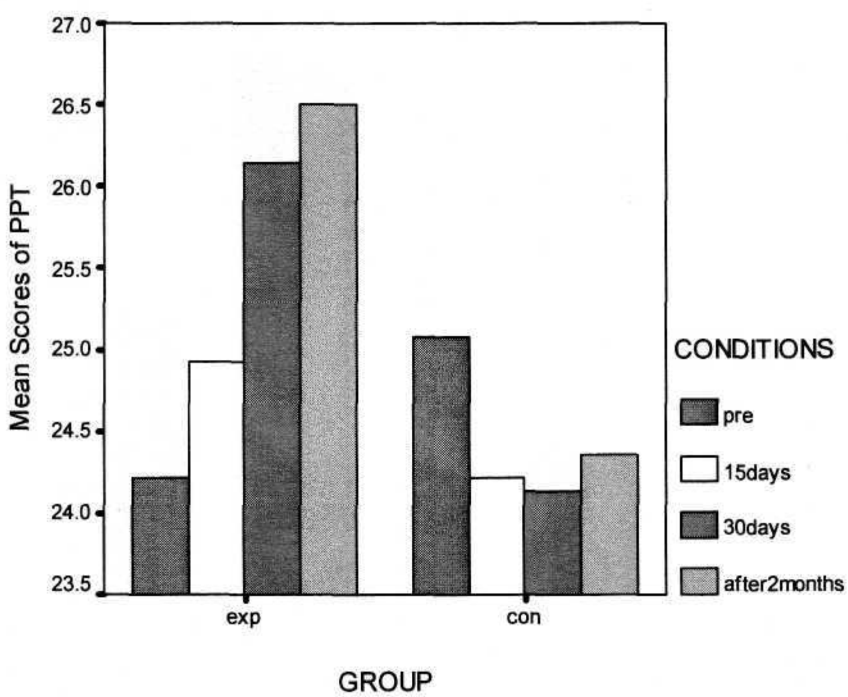
The results of between subjects effects- Dependent variable DDT-Double correct scores- Auditory Integration & auditory separation activity (Table R 26)

It can be noted that there was significant difference in the condition (Significant at .001 level) and groups (Significant at .001 level) in the DDT double correct scores of the subjects. This is an evident to show that there was improvement in subjects who underwent therapy for both auditory separation activity and auditory integration activity, this was followed by one-way ANOVA (Table R 27), separately for both the groups.

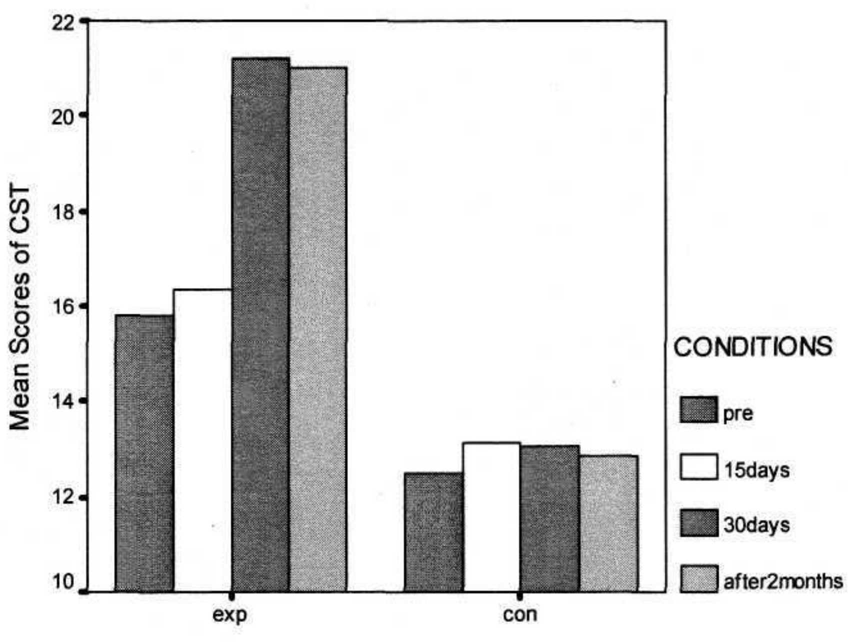
There are significant differences among different conditions in experimental group. Since there are significant differences (significant at .001 levels), Duncan's Post Hoc Test was performed for DDT- Double correct score of Experimental group subjects in auditory integration and separation activity



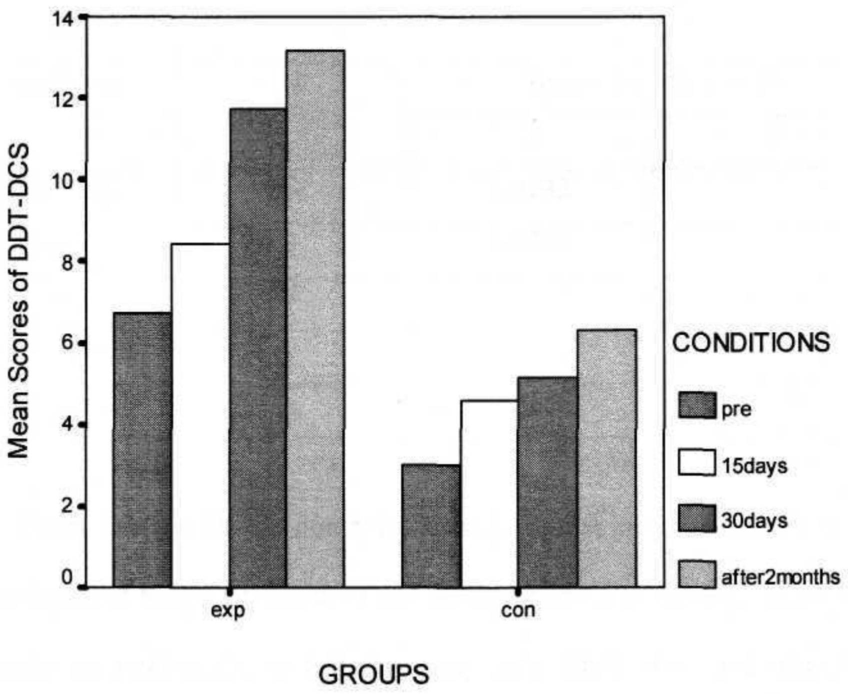
Graph 9: Showing the DDT scores of subjects who underwent training for both activities



Graph 10: Showing the PPT scores of subjects who underwent training for both activities.



Graph 11: Showing the CST scores of subjects who underwent training for both activities.



Graph 12: Showing the DDT-Double correct scores of subjects who underwent training for both auditory separation and auditory integration activities.

Table R 27: Results of one-way ANOVA of the experimental group subjects of auditory Integration & Separation activity. DDT Double correct scores.

Test	df	F	Significance
DDT-Double correct scores	(3,24)	9.161	.000***

*** Significant at .001 level.

Table R 28: Results of the Post Hoc Tests-Condition- homogeneous Subtests DDT- Double correct score Experimental group subjects- Auditory integration and separation activity.

Conditions	N	Subset for alpha = .05	
		1	2
Pre-therapy	7	6.7143	
15 days	7	8.4286	
30 days	7		11.7143
After 2 months	7		13.1429
significance		.225	.310

From Table R 28 it is noted that there is significant difference between fifteen days and thirty days in the DDT double correct scores and there is no difference in pre-therapy, fifteen days and also, thirty days and after two months condition. We can observe an increasing trend through pre-therapy to 30 days and even for after 2 months.

Table R 29: Results of one-way ANOVA of the control group subjects of auditory Integration & Separation activity- DDT- Double correct scores.

Test	df	F	Significance
DDT-double correct score	(3,24)	1.619	.211

Table R 29 Shows the results of one-way ANOVA of the control group subjects of auditory Integration & Separation activity of the DDT- Double correct scores. It can be noted that there was no significant difference in the scores in the control group subjects.

Comparison of performance at different intervals of training in all the three activities within the experimental group subjects.

Table R 30 (See Graph 13) shows the total mean and standard deviation of the test results of DDT, PPT, and CST at pre-therapy, fifteen days after therapy, thirty days after therapy and after two months of therapy, for subjects who underwent therapy for auditory separation, auditory integration, and both activities. It is seen from the Table R30 in the auditory separation activity the mean of the total scores at the pre-therapy stage was 22.60. It reduced to 22.55. There is a slight difference in the mean, which can be considered as negligible as the difference is only .05. On the thirtieth day it increased to 24.65. On the re-evaluation done after two months of therapy, the mean score improved to 25.26. The difference of 0.61 is very less but the significant observation is that there is no deterioration in the mean score. The results suggest that the subjects were able to maintain the scores even after the therapy was discontinued.

On seeing the mean scores of auditory Integration activity, the total mean of the pre-therapy stage was 23.30, it decreased to 23.11 on the fifteenth day. The difference between the pre- therapy condition and fifteen days after therapy was 0.19. It can be seen that the scores reduced slightly and the difference can be considered as negligible. The scores increased to 25.06 on the thirtieth day. On the assessment done after two months after therapy the scores increased slightly to 25.55. The difference was 0.49 which is again very less but there is no deterioration in the mean score which suggests that the subjects were able to maintain the scores even after cessation of therapy.

On seeing the mean scores of the next activity that is therapy on both auditory integration & auditory separation activity, it can be seen that the pre therapy scores was 19.40. The scores increased on the fifteenth day to 20.02, on the thirtieth day it increased to 23.01. On the assessment done after two months after cessation of therapy the scores increased to 23.16. The difference was very less. There was no deterioration in the scores even after cessation of therapy, which suggests that the subjects were able to maintain the scores even after therapy was stopped.

Table R 30: Results (Mean and Standard Deviation) of all the three Types of therapy activity in different conditions within the experimental group subjects alone.

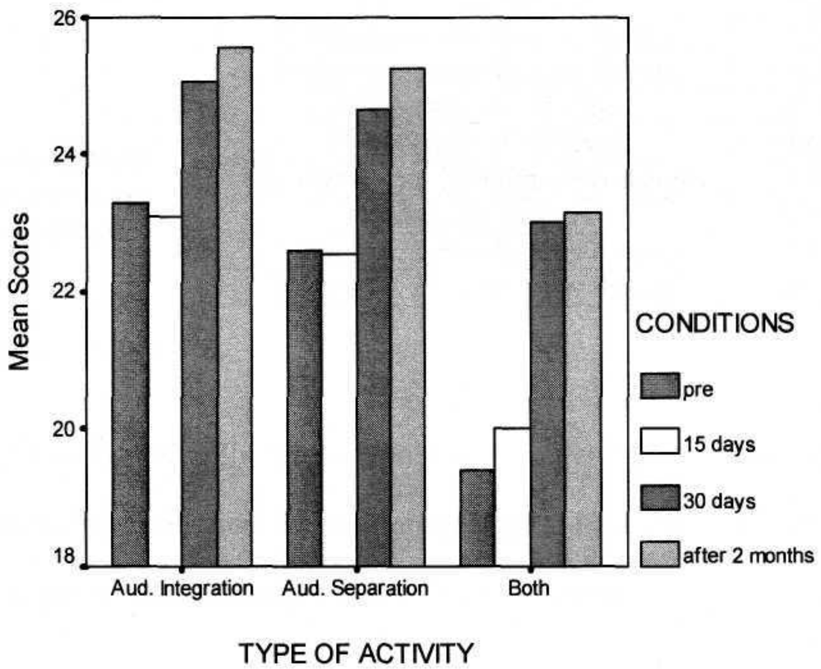
Type of activity	Condition	Mean	S.D
Auditory Separation	Pre- therapy	22.60	8.93
	15 Days	22.55	7.64
	30 Days	24.65	6.00
	After 2 Months	25.26	5.47
Auditory Integration	Pre- therapy	23.30	4.53
	15 Days	23.11	4.30
	30 Days	25.06	3.15
	After 2 Months	25.55	2.53
Both auditory integration and auditory separation	Pre- therapy	19.40	5.38
	15 Days	20.02	4.65
	30 Days	23.01	3.61
	After 2 Months	23.16	3.64

Table R 31: shows the results of Repeated measure ANOVA between conditions in all the three activities.

Activity	df	F	significance
Auditory Separation	(3,87)	15.683	.000*
Auditory Integration	(3,105)	30.055	.000*
Both Auditory Integration and Separation	(3,123)	51.476	.000*

*** Significant at .001 level

Repeated measure ANOVA between conditions was performed in all the three activities separately. Results are given in Table R 31. There is significant difference (significant at .001 level) between conditions in all the three activities.



Graph 13: showing the combined scores of all the tests of the experimental group subjects.

Table R 32: Shows the Mean difference of pairwise comparison of the conditions in different therapy activity.

Type	Comparison of conditions	Mean Difference
Auditory Separation	Pre- therapy vs. 15 Days	-0.05
	Pre- therapy vs. 30 days	-2.05*
	Pre- therapy vs. 2 months after therapy	-2.66*
	15 days vs. 30 days	-2.10*
	15 days vs. 2 months after therapy	-2.71*
	30 days vs. 2 months after therapy	-0.61*
Auditory Integration	Pre- therapy vs. 15 Days	+0.19
	Pre- therapy vs. 30 days	-1.76*
	Pre- therapy vs. 2 months after therapy	-2.25*
	15 days vs. 30 days	-1.95*
	15 days vs. 2 months after therapy	-2.44*
	30 days vs. 2 months after therapy	-0.49
Both Auditory Integration and Separation	Pre- therapy vs. 15 Days	-0.62
	Pre- therapy vs. 30 days	-3.61*
	Pre- therapy vs. 2 months after therapy	-3.76*
	15 days vs. 30 days	-2.99*
	15 days vs. 2 months after therapy	-3.14*
	30 days vs. 2 months after therapy	-0.15

Significant at .05 level

From Table R 32 it can be seen that the difference in all the activity increased satisfactorily from the pre therapy stage to the thirtieth day, and the improvement was maintained after the cessation of therapy.

Table R 33: Shows the Mean, Standard deviation, upper and lower bound of the scores of different types of activity on different conditions.

Conditions	Type of activity Therapy given	Mean	95%Confidence Interval		Standard Deviation
			Lower bound	Upper bound	
Pre-therapy	Auditory Separation	22.60	19.26	25.93	8.93
	Auditory Integration	23.30	21.77	24.83	4.53
	Both auditory Integration and Auditory separation	19.40	17.72	21.08	5.38
15 Days	Auditory Separation	22.55	19.69	25.40	7.64
	Auditory Integration	23.11	21.65	24.56	4.30
	Both auditory Integration and Auditory separation	20.02	18.57	21.47	4.65
30 Days	Auditory Separation	24.65	22.40	26.89	6.00
	Auditory Integration	25.06	24.00	26.13	3.15
	Both auditory Integration and Auditory separation	23.01	21.88	24.13	3.61
After 2 Months	Auditory Separation	25.26	23.22	27.31	5.47
	Auditory Integration	25.55	24.69	26.41	2.53
	Both auditory Integration and Auditory separation	23.16	22.03	24.30	3.64

From the Table R 33, it can be noted that in the both activity training, there was very good improvement. There was improvement in the mean scores from 19.40 to 23.16 (a difference of 3.76), followed by auditory separation activity in which the mean scores improved from 22.60 to 25.26 (a difference of 2.66), followed by auditory integration activity in which the mean scores improved from 23.30 to 25.55 (a difference of 2.25). This suggests that those children who underwent training for both activities, acquired the skills faster than children who received training either for auditory separation or auditory integration. Further, the subjects who were trained in auditory separation process demonstrated quick improvement in scores relative to those who were trained in auditory integration process.

Thirty four subjects participated in the study. The subjects were all diagnosed to have APD and had difficulty in auditory separation activity or auditory integration activity or both. Based on the processes they had problem they were grouped as subjects with auditory separation problems, subjects with auditory integration problems and subjects having both auditory separation and integration problems. All the subjects who were willing to attend therapy were taken as experimental group subjects and the others were considered as control group subjects. The experimental group subjects were given deficit specific therapy based on the deficit seen with the newly developed therapy modules. Therapy was given on the listening skills. The activities for auditory integration included auditory closure activities and dichotic offset training. The hierarchy of items was prepared ranging from easy items to that were more difficult. The auditory separation included activity like, speech in the presence of different types of noise at different levels. The present study is in accordance with the earlier study of Bellis (2002). According to Bellis (2002) the utility of deficit specific intervention for APD is based on three primary assumptions. First assumption is that, certain basic auditory skills or processes underlie more complex listening, learning and communication utilities. The 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 processes will facilitate improvement in those higher orders, more complex functional ability areas with which a given individual is experiencing difficulties. The present study also included all the three assumptions of Bellis (2002) namely basic auditory skills, use of diagnostic tests & deficit specific training.

The use of direct therapeutic techniques has gained considerable importance in the recent past. These techniques aim at alleviating specific auditory processing problems that an individual might have. The purpose of direct remediation activities is to maximize neuro-plasticity and to improve auditory performance by changing the way the brain process auditory information (Bellis, 1996; Chermak & Musiek, 1997; Musiek & Jerger, 2000, cited in Bellis, 2002). In the present study the auditory training was directed for problems related to auditory seperation , auditory integration and problems with both the processes. The therapy was direct and aimed at improving the deficit specific problems of children with APD. Hence the results of the present study support the previous studies.

Katz & Burge (1971) (Cited in Katz & Wilde, 1994) have discussed the use of speech in noise desensitization therapy tapes. They found that children who were exposed to speech under controlled noise conditions were able to develop a greater tolerance for background noise and showed a greater ability to respond correctly to speech under noise conditions. The results indicate that the subjects benefited in dichotic listening performance after practice. The present study included various noise conditions for the activities of auditory seperation. The results of the study showed good improvement in the performance of tasks in the presence different levels of various background noises.

Katz, Chertoff, & Sawusch (1984) provided dichotic offset training for children presenting auditory processing problems. Children who demonstrated difficulty on staggered spondaic word test (Katz, 1962) were given a systematic series of programmed dichotic listening sessions. Ten subjects in the age range of 7-10 years were taken for the study. The experimental group consisted of 4 male and 1 female subjects while the control group consisted of 5 male subjects. The children were given a systematic series of programmed dichotic listening sessions everyday for one hour, twice a week, for fifteen sessions. The dichotic offset training material were an expanded version of the staggered dichotic digit test, developed as part of the study. They further compared the pre and post therapy scores. The results revealed a consistent pattern of improvement after the initial therapy sessions. Improved performance was noted on the test-retest results for the staggered dichotic digit test. However, they found a lack of statistically significant improvement on the staggered spondaic word test and in speech in noise test. However, observation of the individual subject's performance revealed a trend towards improvement. The results of the present study confirm that dichotic offset training is useful as a tool for the children with auditory processing problems.

Various studies have been conducted to study the effect of perceptual training. Merzenich, Johnston, Schrenier, Miller & Tallal (1996) (Cited in Veale, 1999) & Tallal et al. (1996) (Cited in Veale, 1999) have described the positive effects of computer based games that train to modify temporal processing deficits in these children. Merzenich et al (1996) (Cited in Gillam, 1999) claimed that these studies strongly indicate that the fundamental temporal processing deficits can be over come by training. The results of the present study ascertain the above fact.

Yencer (1998) studied the effects of Auditory Integration Training on thirty six children who were diagnosed as CAPD. He used three conditions, an experimental condition (who listened to AIT music), a placebo condition (who listened to modulated music), and control condition (who did not listen to music at all). Children with autism, pervasive developmental disorder and multiple handicaps were excluded from the study. A battery of tests was administered to the subjects prior and one month following the listening sessions. The test battery included, standard audiometric testing, the SSW test, the phonemic synthesizer, ABR, P300, and speech in noise test. Significant improvements were found for the first two conditions on all measures except for the speech in noise test. Electro physiological changes have been found in ABR results pre and post auditory integration therapy (Edelson, et al. 1999). In the study by Highfill and Cimoulli (1995) (Chermack & Museik, 1997) changes in brain stem functioning using positron emissions tomography (PET) was measured before treatment, one day and six months post AIT. The results indicated normalized brain activity in the occipital lobe. Electro physiological changes have been found in auditory brain stem evoked response results pre and post AIT (Edelson, et al. 1999). In the present study the children with APD were grouped as experimental and control group. The children who belonged to the experimental group received therapy whereas the control group children did not receive any therapy. It was found that the performance of the children who received therapy improved and no improvement was found in the control group children. The results of the present study suggest that the improvement could be due to the nerve plasticity.

It can be seen from the results of this study that there was noticeable improvement in auditory processing abilities when computer based auditory training was given. The improvement is seen in all the processes in all the subjects of the experimental group. So, this result can be attributed to the phenomena of auditory plasticity and brain plasticity, which increases, by training. So, the results of the present study are in accordance with Musiek & Burge (1998), Scheich (1991), Knadsen (1988) (Cited in Chermack & Musiek 1997), Musiek, Baran, Schochat (1999), Merzenich et al. (1996) Asshsir & Hochstein (1993) (Cited in Gillam 1999), Jirsa (1992), Merzenich, Jinkins, Johnston, Schreiner, Miller & Tallal (1995). They say that brain in plastic and training brings an improvement and the quality of functioning of the brain improves by constant and systematic acoustic stimulation. The improvement found in the experimental group subjects in this study when training was given on the listening skills correlates with the findings by Tallal & Miller (1996) & Tallal et al, (1996) who say that if the auditory system is challenged in an appropriate manner it will trigger the changes in the structure and functioning of the brain.

The therapy material used in this study was computer based training modules. There was very good improvement seen in the experimental group children after training with the newly developed training module. This also shows us the effects of computer interactive programs with auditory training. The results of the present study is in accordance with the results of Tallal & Miller (1996) Merzenich, Johnston, Schreiner, Miller, Tallal (1996), & Tallal et al, (1996) who say that computer based training with interactive games helps in modifying the temporal processing deficits. Here it can be noticed that there is very good improvement in the auditory separation and auditory integration deficits also if training is given with computer based training materials as far as it is deficit specific and appropriate to the age.

The results of the present study are encouraging from the viewpoint of deficit specific therapy. The experimental group subjects in this study were given only deficit specific training. Therapy was given for either auditory separation activity or auditory integration activity or both. The activities included for alleviating auditory integration deficits were auditory closure and dichotic offset training. For children exhibiting problems in auditory separation, speech-in-noise training and dichotic training were used. It can be noted from the results that if deficit specific training is given there is very good improvement in that specific deficit area alone. The results are in accordance with Wertz, Hall & Davis (2002), Bellis (2002), Bellis (1996), Chermak & Musiek (1997), Jerger & Musiek (2000) Yathiraj & Mascarenhas

(2003). The improvement in deficit specific training was also noticed by the researcher himself when the pilot study was carried out (Ravanan & Rajalakshmi 2005).

Regarding training for children with APD using dichotic stimulation for both the right and the left ear simultaneously, it can be seen from the present study that there is improvement in the scores of both the ears on dichotic stimulation. (There is no significant difference between the ears - Independent T test - P > 0.05). It is in accordance with Putter-Katz et al. (2002), Yathiraj & Mascarenhas (2003). It also suggests that training for children with APD should be dichotic rather than ear specific. The results of the present study are not in support of the earlier studies by English, Mortonik & Moir (2003), Katz, Cherhff & Sawusch (1984) who have quoted that providing left ear auditory stimulation with speech or speech in the presence of noise showed improvement in the dichotic listening skills of children with poor left ear score.

In reference to the age of onset of training for children with APD, it should be started early in life. But identifying a child with APD is difficult even till the age of 13 to 14 years. This delay could be due to maturation of few auditory processes, which is taking place till the age of 13 to 14 years. Training can be started as early as the subject is identified with some kind of auditory processing deficit. But identifying a subject with APD is difficult even till the age of 12 years or 13 years as the processes development is even till the age of 13 to 14 years. In the present study thirty-four children ranging in age from 8 to 12 years were subjected to different tests for identifying auditory processing disorders. The higher age of 12 years has facilitated for checking the maturation of some of the auditory processes. Hence, accurate diagnosis of various problems related to auditory processing difficulties was achieved. Immediately after the identification, training was given through computerized modules for the children on the deficit processes. This has provided an improvement in the deficit specific problems even after the training was stopped. Hence, it can be concluded that identification of APD should include varieties of tests to assess various processes in auditory processing and training can be geared to overcome various problems as early as possible.

The present study used various activities such as auditory closure, dichotic offset training, speech in noise training to improve the performance in auditory separation and auditory integration processes or both. It is very clearly evident from the improvement of scores in the experimental group subjects that if auditory separation and auditory integration are worked together, the performance improves significantly rather than when training is given for auditory integration or auditory separation alone.

The results of the present study also indicate the need for developing more such computer based training modules focusing on variety of auditory processing difficulties. As it was found out during the course of the present study that there is 7 to 8 % prevalence of auditory processing disorders in school going children in the age range of 8 to 12 years (Ravanan & Rajalakshmi, 2005), there is a great demand for developing various therapy tools to train these children. If such computer based therapy modules are widely available it would ameliorate the problems of larger number of children suffering with auditory processing disorders. There is a greater need to develop the therapy modules in various Indian Languages also.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

The ASHA task force (1985) defines central auditory processing as the auditory system mechanism and process responsible for sound localization, lateralization, auditory discrimination, auditory pattern reorganization, temporal resolution, temporal masking, temporal integration, temporal ordering, and auditory performance decrement with degraded acoustic signals. Central auditory processing disorders are defined as deficiencies in any one or more of these behaviors.

Various studies have been conducted to study the effect of these perceptual training. Merzenich, Johnston, Schrenier, Miller & Tallal (1996) (Cited in Veale, 1999) & Tallal et al. (Cited in Veale, 1999) have described the positive effects of computer based games that train to modify temporal processing deficits in these children. Merzenich et al (1996) (Cited in Gillam, 1999) claimed that these studied strongly indicate that the fundamental temporal processing deficits can be over come by training. The concept of auditory training to stimulate auditory related problems dates back to pre-medieval times (Musiek & Berge, 1988). Initially auditory training was used to enable hearing impaired individuals make maximum use of their residual hearing. However since 1960 it has been used in the rehabilitation of individuals with CAPD.

There are number of computer based training material like Captain's Log Personal Trainer, Earobics, Fast-forward, Laureate Special needs software, and Lindamood Bell. Only Earobics (Cognitive Concepts Inc., 1997-2000) and Fast Forward: (Scientific learning Corporation, 1998) are widely used. There are reports widely available only about the Earobics and Fast-forward program. And all the programs are in English and can be used with western population only. So this successful attempt has been made to develop a computer based training material in one of the Indian Language (Kannada).

Looking into the prevalence data for APD even though it is sparse it is high. In India, the percentage of children found to have dyslexia ranges from 3% (Ramaa, 1985) to 7.5 % (Nishi Mary 1988) (Cited in Ramaa, 2000). Ravanan & Rajalakshmi (2004) estimated 7 to 8% prevalence of Auditory processing disorders in school going children in the age range of 8 to 12 years in India. Hurley & Singer (1989) states that, the number of children with APD within the population of learning disability cannot be stated with any certainty or accuracy. It is likely to be very high. The difference in the findings is probably due to the method used to determine the presence of the problem. Most often these children go unidentified as they drop out of school because of poor academic performance. It can be noted it is quite high in India. It is estimated to be nearly 7 to 8% in the school going children in the age range of 8 to 12 years (Ravanan & Rajalakshmi 2005). Thus, the newly developed tool will be very helpful to manage children with APD as soon as they are identified.

The objectives of the present study were to develop computerized training modules in Kannada language for Auditory integration and Auditory separation aspects of auditory processing disorder and to check the efficacy of the developed therapy program. A total of 34 subjects with auditory processing disorder participated in the study. The diagnosis was based on the results of series of tests to identify central auditory processing disorder (CAPD). Based on the type of auditory process impaired, the subjects were classified into three groups. Group 1 consisted of 9 Subjects with difficulty in auditory separation task, Group 2 comprised of 11 subjects with difficulty in auditory integration task and the remaining 14 subjects who exhibited difficulty in both auditory separation and auditory integration tasks formed the third group. The subjects from these three groups were randomly selected and sub-classified into experimental and control group. The experimental subjects from the respective groups received therapy using the newly developed computerized training modules in the specified tasks, whereas the control group subjects were not given any therapy. All the subjects knew to read and write Kannada and they were attending school. All the subjects who attended the therapy program were aware about their problem and they were highly motivated to undergo treatment.

Every subject was evaluated initially with The Auditory Processing Screening Checklist - Teachers/Parents (Rajalakshmi & Gopi Sankar, 2003). Those subjects who failed the checklist were administered the CD version of Dichotic Digit Test (DDT) developed in Audio lab version - II (Regishia, 2003). The CD version of Pitch Pattern Test (PPT) developed in Audio lab version - II (Shivani, 2003). The CD version of Competing Sentence Test (CST) developed in Audio lab version - II (Ravanan & Rajalakshmi, 2004). Based on the test scores the children were diagnosed as children with Auditory processing Disorders (APD). Based on the test score they were classified as children with auditory separation deficit or auditory integration deficit or both. Volunteers from the subjects who failed the test were taken as experimental group children and given deficit specific therapy.

Here in this study the target set forth was improvement of auditory processing skills and maintaining it. Results were represented in the tabular form and standard graphical representation for each process worked, separately and discussed.

In the present study two processes were focussed and worked on. These were auditory separation or auditory integration or both combined. These two processes are considered to be the most important activities a child faces to in his/her daily life, so these two activities were concentrated on and worked on. Five subjects underwent therapy for auditory separation activity, six subjects underwent therapy for auditory integration and seven subjects underwent therapy for both the activity. All the subjects who attended therapy were highly motivated and they were regular in their therapy. The subjects underwent therapy for thirty sessions. Assessment was done on the first day which formed the baseline score for the subjects. Assessment was done for all the subjects with the same tests on fifteenth day, thirtieth day, and after two months after cessation of therapy.

From the scores it is evident that, the subjects who underwent therapy for auditory separation activity improved by therapy and they were also able to maintain the scores even after cessation of therapy.

From the scores of the subjects who underwent therapy for auditory integration it is evident that there is good improvement in the subjects, who underwent training for auditory integration task and they were also able to maintain the scores even after cessation of therapy.

From the scores of the subjects who underwent therapy for both auditory integration and auditory separation task, it is evident that subjects who underwent training with the newly developed training modules for both auditory integration & auditory separation deficits, showed good improvement and they were also able to maintain it even after the cessation of therapy.

Conclusions

1. Present study indicated that there is very good improvement in the subjects who underwent therapy with the newly developed computerized training modules in Kannada language for auditory integration and auditory separation aspects of auditory processing disorder. This also shows us that if deficit specific therapy is given, based on the processes affected there will be very good improvement.

2. The present study also indicates that if systematic and a well planned therapy is given with computer based material and with interactive games the child is able to maintain the improvement over a period of time without any deterioration in the newly improved skills even after the cessation of therapy.

Suggestions for future research

1. More studies on similar lines if carried out will confirm the results.
2. This is an experimental design if carried out with larger population for a longer period emphatic results may be obtained.
3. The use of many more test in the test battery are likely to be useful in the choice of the treatment.
4. Since electrophysiological measures are also proved to be of importance in the study of children with learning disability and in children with auditory processing disorders it can also be used for evaluation and for monitoring the progress in any given subject.
5. Studies can be undertaken with subjects having APD and treatment given for more longer duration, till the child is able to overcome the problem fully and the scores improves to the normal level. It can also be studied if the child is able to maintain the improvement over time.
6. Computerized training modules can be developed to tackle other auditory processing aspects as memory, sequencing etc.
7. Since India is a multilingual country computerized training modules can be developed in other languages.
8. Further, personal computers are now-a-days widely available in schools in India, hence if such computer interactive programs are developed in other languages it would be very helpful for the children to overcome their problem.

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APPENDIX

APPENDIX-A

Auditory Processing Screening Checklist-Parents (APSC-P)

(K.Rajalakshmi &R. Gopi Sankar, 2003)

ALL INDIA INSTITUTE OF SPEECH AND HEARING

Manasagangothri, MYSORE-570006.

DEPARTMENT OF AUDIOLOGY

Checklist to be filled out by parents/ Guardians.

Name of the child...

Name of the person filling out the form..

Relationship to the child: Mother/Father/Grandmother/Grandfather/Brother/Sister or Friend or others (Specify).......................................

Read the following questions and circle 'YES' or 'NO'

1. Does the child give slow response to name call at home? YES NO

2 a) Does the child have gross motor skills deficits? YES NO

b) Does the child have fine motor skills deficits? YES NO

3. a) Does the child have history of ear pain? YES NO

b) Does the child have history of ear discharge? YES NO

4. Does child's family history show any hearing problems? YES NO

5. Does the child show behavioral problems? (e.g. Temper tantrums, stealing) YES NO

6. Does the child get easily distracted by background noise/ sound? YES NO

7. Does the child show poor attention and concentration span? YES NO

8. a) Does the child have problem in paying attention to the information presented orally? YES NO

b) Does the child have problem in remembering information presented orally? YES NO

9. Does the child have difficulty following direction and instructions? YES NO

10. Does the child have problems carrying out complex instruction? YES NO

11. a) Does the child have problem in developing vocabulary? YES NO

b) Does the child have difficulty in understanding language? YES NO

c) Does the child get confused with syllable sequence? YES NO

12. Does the child have difficulty in reading &spelling? YES NO

13. Does the child request that information be repeated? YES NO

14. Does the child say "huh" or " what" frequently? YES NO

15. Does the child have difficulty following long conversations? YES NO

16. Does child have difficulty in telephone conversation? YES NO

17. Does the child have difficulty in understanding non-speech information (lack of music appreciation.)? YES NO

18. Does he learn poorly through hearing? YES NO

19. Does the child have difficulty relating what he heard with what is seen? YES NO

20. Does the child have poor auditory memory and sequencing skills? YES NO

21. Does the child have low academic performance despite normal intelligence (I.Q) ? YES NO

22. Does the child have history of neurological problems? YES NO

23. Is the child sensitive to loud sounds? YES NO

24. Does the child get very fatigued after school hours? YES NO

Auditory Processing Screening Checklist-Teachers (APSC-T)

(K.Rajalakshmi &R.Gopi Sankar, 2003)

ALL INDIA INSTITUTE OF SPEECH AND HEARING

Manasagangothri, MYSORE-570006.

DEPARTMENT OF AUDIOLOGY

Checklist to be filled out by Teachers.

Name of the child...

Name of the person filling out the form..

Read the following questions and circle 'YES' or 'NO'

1 Does the child not participate in classroom discussion? YES NO

2 Does the child work best in a highly organized classroom? YES NO

3 Does the child have difficulty in taking down dictated notes? YES NO

4 Does the child misunderstand instructions in the class? YES NO

5 Does the child respond inappropriately in the classroom? YES NO

6 Does the child have difficulty participating in groups? YES NO

7 Does the child appear to daydream in the classroom? YES NO

8 Does the child need more time to process information? YES NO

(Understand what is said)

9 Is the child's performance not up to potentials? YES NO

11 Does the child have poor performance in academics (particularly with reading spelling, writing, and mathematics) despite of normal I.Q? YES NO

12 Does the child have difficulty remembering information? YES NO

13 Does the child forget what is said in a few minutes? YES NO

14 Is the child be easily distracted? YES NO

15 Does the child be easily distracted in classroom? YES NO

16 Does the child have behavior problems? (e.g. Temper tantrums, stealing) YES NO

17 Does the child appear withdrawn or sullen? YES NO

18 Does the child have problem paying attention to the information presented orally in the classroom? YES NO

19 a) Does the child have trouble following complex instruction? YES NO

b) Does the child have problem in identifying from where the sound is presented? YES NO

20 Does the child exhibit difficulty in directing, sustaining or dividing attention? YES NO

21 a) Does the child have difficulty in understanding language? YES NO

b) Does the child have poor expressive skills? YES NO

22 Does the child exhibit echolalia (repeating back words & phrase without understanding)? YES NO

23 a) Does the child have gross motor skills deficits? YES NO

b) Does the child have fine motor skills deficits? YES NO

24 Does the child have poor sequencing skills? YES NO

Does the child have difficulty to repeat what has been heard in the correct order? YES NO

26 Does the child have difficulty repeating words or numbers in sequence? YES NO

27 Does the child show slow or delayed response to verbal requests and instructions presented in the class room ? YES NO

28 Does the child have difficulty following oral-instruction? YES NO

29 Does the child have unintelligible speech, but with adequate vocal YES NO

Inflection & gestures?

30 Does the child have difficulty in speech sound discrimination? YES NO

31 Does the child get confused with similar sounds and words? YES NO

(e.g. s/z Bat/Pad)

32 Does the child have difficulty following complex instruction? YES NO

33 Does the child have difficulty with organizational skills? YES NO

34 Does the child appear not to hear (Although hearing is normal)? YES NO

35 Does the child have difficulty relating what is heard with what is seen? YES NO

36 Does the child have difficulty listening in the presence of background sound? YES NO

37 Does the child have difficulty in reading and spelling? YES NO

38 Does the child have difficulty in understanding non-speech information YES NO

(e.g. lack of music appreciation)?

39 Does the child exhibit poor singing and music skills? YES NO

APPENDIX-B

Dichotic digit Test (Regishia, 2003)

SI. No.	Right Ear		Left Ear	
1	7	10	6	8
2	5	7	8	10
3	1	8	3	5
4	3	8	10	6
5	6	1	7	10
6	5	7	6	3
7	6	3	10	5
8	8	3	1	6
9	5	6	10	5
10	8	1	3	5
11	7	10	1	3
12	1	8	6	10
13	6	1	3	8
14	6	10	1	3
15	10	6	5	8
16	1	5	7	3
17	10	5	6	3
18	3	10	8	7
19	5	8	3	1
20	3	10	1	6
21	8	3	7	1
22	8	5 .	6	7
23	3	6	7	10
24	8	3	10	6
25	1	5	8	7
26	5	7	1	6
27	6	10	5	3
28	6	7	8	10
29	7	5	1	10
30	7	10	3	1

APPENDIX -C

Pitch Pattern Test (Shivani, 2003)

S.No	Presentation
1	HHL
2	HLL
3	LLH
4	LLH
5	LHH
6	HHL
7	HLH
8	LHH
9	LHH
10	HLH
11	LHL
12	LLH
13	LLH
14	HHL
15	HLL
16	LLH
17	LHH
18	LHH
19	HLL
20	HLH
21	HLH
22	HHL
23	HLH
24	LHL
25	LHL
26	HLL
27	HLL
28	LHL
29	HHL
30	LHL

APPENDIX –D

Kannada Sentences Used As Stimuli In The Competing Sentence Test (Ravanan & Rajalakshmi, 2004)

	COMPETING SENTENCES		TARGET SENTENCES
೧.	ನಮ್ಮ ತಾಯಿ ಮನೆಗೆ ಬಂದಿದ್ದಾರೆ.	:	ಅಣ್ಣ ಈಗ ಊಟ ಮಾಡ್ತಾರೆ.
೨.	ರಾಮು ಈಗ ತಿಂಡಿಗೆ ಬರ್ತಾನೆ.	:	ರಾಜು ಮನೆಗೆ ಊಟಕ್ಕೆ ಹೋಗ್ತಾನೆ.
೩.	ಹುಡುಗರು ಈಗ ಆಡ್ತಿದಾರೆ	:	ಹುಡುಗಿಯರು ಈಜ್ತಾ ಇದಾರೆ.
೪.	ಮೇಷ್ಟ್ರು ದಿನಾಸ ಸ್ಕೂಲ್‌ಗೆ ಹೋಗ್ತಾರೆ.	:	ವಿದ್ಯಾರ್ಥಿಗಳು ಬೋರ್ಡ್ ಮೇಲೆ ಬರೀತಾರೆ.
೫.	ನಮ್ಮ ಅಮ್ಮ ಅಂಗಡಿಗೆ ಹೋಗ್ತಾರೆ.	:	ನಿಮ್ಮ ಅಪ್ಪ ಮನೆಗೆ ಬರ್ತಾರೆ.
೬.	ಬೆಂಕಿಯ ಹತ್ತಿರ ಹೋದರೆ ಸುಡುತ್ತದೆ.	:	ಕಾಡಿಗೆ ಒಬ್ಬರೇ ಹೋಗಬಾರದು.
೭.	ಅವಳು ಚೆನ್ನಾಗಿ ಹಾಡು ಹೇಳ್ತಾಳೆ.	:	ನನಗೆ ರಮ ಸಂಗೀತ ಕಲಿಸ್ತಾಳೆ.
೮.	ರೈತರು ಕಷ್ಟಪಟ್ಟು ಕೆಲಸ ಮಾಡ್ತಾರೆ.	:	ಕೂಲಿಗಳು ತುಂಬಾ ಬಡವರು.
೯.	ಹಸು ಹಸಿ ಹುಲ್ಲು ತಿನ್ನುತ್ತೆ.	:	ಎಮ್ಮೆ ಕೊಚ್ಚೇಲಿ ಮಲಗುತ್ತೆ.
೧೦.	ರವಿ ಪುಸ್ತಕ ಒದ್ತಾನೆ.	:	ಸುರೇಶ ಚಿತ್ರ ನೋಡ್ತಾನೆ.
೧೧.	ನಮ್ಮ ತಾಯಿ ಕೆಲಸ ಮಾಡ್ತಾರೆ.	:	ನಿಮ್ಮ ಅಣ್ಣ ಅಲ್ಲಿ ಹೋಗ್ತಿದ್ದಾರೆ.
೧೨.	ಗೋಪಿ ಹತ್ತಿರ ದುಡ್ಡು ಇಲ್ಲ.	:	ರಾಮು ನನಗೆ ಹಣ ಕೊಡಬೇಕು.
೧೩.	ನಮ್ಮ ನಾಯಿ ತುಂಬಾ ಚೆನ್ನಾಗಿದೆ.	:	ಬೆಕ್ಕು ಮನೆ ಮೇಲೆ ಓಡುತ್ತಾ ಇದೆ.
೧೪.	ನಮ್ಮ ಮನೆ ಹತ್ತಿರ ಮಾರ್ಕೆಟ್ ಇದೆ.	:	ಬೆಕ್ಕು ಮನೆ ಮೇಲೆ ಓಡುತ್ತಾ ಇದೆ.
೧೫.	ಇವತ್ತು ಅವನ ಮನೇಲಿ ಹಬ್ಬ.	:	ನಾಳೆ ಇವನ ಹಳ್ಳಿಯಲ್ಲಿ ಜಾತ್ರೆ.
೧೬.	ಸೀತೆ ಮನೇಲಿ ಗುಲಾಬಿ ಗಿಡ ಇದೆ.	:	ಕಮಲನ ತೋಟದಲ್ಲಿ ಮಲ್ಲಿಗೆ ಗಿಡ ಇದೆ.
೧೭.	ಅಲ್ಲಿ ಮರದ ಕುರ್ಚಿ ಇದೆ.	:	ಇಲ್ಲಿ ಸ್ಟೀಟ್ ಟೇಬಲ್ ಇದೆ.
೧೮.	ದಿನಾ ಬೆಳಿಗ್ಗೆ ಕೋಳಿ ಕೂಗುತ್ತೆ.	:	ಸಂಜೆ ಆರು ಘಂಟೆಗೆ ಕತ್ತಲಾಗುತ್ತೆ.
೧೯.	ಈ ರಸ್ತೇಲಿ ವಾಹನಗಳ ಓಡಾಟ ಜಾಸ್ತಿ.	:	ಆ ದಿನ ಒಂದು ಆಕ್ಸಿಡೆಂಟ್ ಆಯ್ತು.
೨೦.	ಶೋಭ ಕೆಂಪು ಲಂಗ ಹಾಕ್ಕೊಂಡಿದಾಳೆ.	:	ಲೀಲ ಹಸಿರು ಸೀರೆ ಉಟ್ಕೊಂಡಿದ್ದಾಳೆ.
೨೧.	ಆ ಪಕ್ಷಿ ಆಕಾಶದಲ್ಲಿ ಹಾರ್ತಾ ಇದೆ.	:	ಎಲ್ಲಾ ಕಾಗೆಗಳ ಬಣ್ಣ ಕಪ್ಪು.
೨೨.	ದೋಣೀಯಲ್ಲಿ ನೀರಿನ ಮೇಲೆ ಹೋಗಬಹುದು	:	ಹಡಗಿನಲ್ಲಿ ಊರಿಂದ ಊರಿಗೆ ಹೋಗ್ತೀವಿ.

೨೩.	ನಮ್ಮ ಮನೆ ಹತ್ತಿರ ಅಂಗಡಿ ಇದೆ.	:	ನಿಮ್ಮ ಬಟ್ಟೆ ವ್ಯಾಪಾರ ಜೋರಾಗಿದೆ.
೨೪.	ನಾನು ಶನಿವಾರ ದೇವಸ್ಥಾನಕ್ಕೆ ಹೋಗಿದ್ದೆ.	:	ನೀನು ಇವತ್ತು ಪೂಜೆ ಮಾಡಬೇಕು.
೨೫.	ನನ್ನ ತಂಗಿ ಹತ್ತಿರ ಬಳೆ ಇದೆ.	:	ನಿನ್ನ ಅಕ್ಕನ ಸರ ಚೆನ್ನಾಗಿದೆ.

APPENDIX -E

Master CD- Used for the preparation of therapy modules for auditory integeration activity and auditory separation activity.

The CD has to be downloaded in the system before use

Instructions are given in the CD

User name: admin

Password: vignl421979