EFFECT OF AUDITORY STIMULATION IN CENTRAL AUDITORY PROCESSING IN CHILDREN WITH CAPD

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INTRODUCTION

Auditory processing disorder (APD) is a complex and heterogeneous group of disorders usually associated with a range of listening and learning deficits despite normal hearing sensitivity (Chermak & Musiek, 1992; Chermak and Musiek, 1997; ASHA, 1996). Chermak and Musiek (1997) stated that APD "may be broadly defined as a deficit in the processing of information that is specific to the auditory modality". More specifically they described APD as a deficit observed in one or more of the central auditory processes responsible for generating the auditory evoked potentials and several auditory behaviours. These auditory behaviours include sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal aspects of audition including temporal resolution, temporal masking, temporal integration, and temporal ordering; auditory performance with competing acoustic signals and auditory performance with degraded auditory signals. Wood (1975 cited in Wertz Hall and Davis, 2002) and ASHA Task Force (1996) also gave similar definitions.

The ASHA Task force (1996) defined central auditory processing as the auditory system mechanism and process responsible for the following behavioural phenomena: sound localization and lateralizaton; auditory discrimination; auditory pattern recognition; temporal aspects of audition including temporal resolution temporal marking, temporal integration and temporal ordering; auditory performance decrement with completing acoustic signals; and auditory performance decrements with degraded acoustic signals.

Central auditory processing disorders (CAPD) are defined as deficiencies in any one or more of these behaviours.

The ultimate goal of screening and diagnostic assessment for APD is to determine effective management strategies (Wertz, Hall and Davis, 2002). Comprehensive intervention for APD should seek to remediate the underlying auditory deficit(s) as well as improve the individual's ability to function in real world communication and learning environments (Bellis, 2002). In 1997, Chermak and Musiek developed a comprehensive management approach to address the range of listening and learning deficits experienced by children with APD. The intervention was a combination of auditory training, metalinguistic and metacognitive strategies designed to increase the scope and use of auditory and central resources.

The trend now, in APD management is towards more individualized, prescriptive and evidence based therapy (Wertz, Hall and Davis, 2002). According to Bellis (2002) the utility of deficit specific intervention for APD is based on three primary assumptions. First is the assumption 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. According to Domitz and Schow

(2000), Schow, Seikel, Chermark and Berent (1996, cited in Bellis, 2002), no single test was sufficient to diagnose APD. Rather, the use of a combination of tests that assess multiple auditory processes was indicated.

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 order, more complex functional ability areas with which a given individual is experiencing difficulties.

According to Chermak and Musiek (1992) the assessment data should be used to guide intervention planning. Although remedial programs cannot be designed on the basis of test results alone, understanding the processes underlying successful task performance helps to bridge the gap between test findings and management strategies and techniques. Even information gathered from checklists and questionnaires used to identify children at risk for CAPD can provide insights regarding functional deficits and program planning (ASHA, 1996; Fisher, 1976 (cited in Willeford and Burleigh, 1985); Smoski, Brunt, and Tannahill, 1992).

The use of auditory training (AT) for APD is based on the belief that it would assist these individuals by maximizing the use of their 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 (e.g. frequency discrimination) and temporal processing (e.g. gap detection) which are essential for phonetic distinctions.

The more recent approaches to AT can be placed into several categories, namely analytic, synthetic, pragmatic and eclectic (Blarney and Alcantara, 1994). The analytic approach attempts to break speech into components (e.g. phonemes) that serve as a basis for AT. The synthetic approach is therapy that uses clues 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 AT procedures just mentioned.

The use of AT in treatment of APD is now targeting the brain, as the main site of mediation. The brain unlike the auditory periphery is plastic. Auditory plasticity according to (Musiek and Berge, 1998) is defined as the alterations of nerve cells to better conform to immediate environmental influences, with this alteration often associated with behavioural change. According to Scheich (1991, cited in Musiek and Berge, 1998) there are three general types of plasticity: developmental, compensatory (after lesions or damage), and learning related. Enhancement through AT for CAPD could involve all three types of plasticity. Appropriate auditory stimulation can result in changes in the neural auditory system. Recent studies by Hassamanova, Myslivecek and Novakova (1981, cited in Chermak and Musiek, 1997), Knudsen (1988, cited in Chermak and Musiek, 1997), Recanzone (1991, cited in Chermak and Musiek, 1997), Edeline and Weinberger (1993, cited in Chermak and Musiek, 1997), Merzenich et al. (1996, cited in Chermak and Musiek, 1997) and Tallal et al. (1996, cited in Chermak and Musiek, 1997) have provided evidence to confirm it. Thus, according to Musiek and Berge (1998) the first concept of AT is that the brain has the quality of plasticity and can be altered by acoustic stimulation or lack of it.

Management of CAPD requires a comprehensive approach, given the range of listening and learning deficits associated with this complex and heterogeneous group of disorders. (Chermak and Musiek, 1992). According to Ferre (1998) effective management for CAPD must include

1. Modification of the client's environment to minimize auditory overload and maximize coping.
2. Teaching and usage of compensatory and coping strategies by the client.
3. Direct therapeutic techniques designed to improve the deficient auditory (and / or other related) skills.

v/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 may have. The purpose of direct remediation activities is to maximize neuroplasticity and improve auditory performance by changing the way the brain processes auditory information (Bellis, 1996; Chermak and Musiek, 1997; Musiek and Jerger 2000 cited in Bellis, 2002). Depending an the specific deficit present, direct therapy may be targeted towards dichotic listening training, phoneme-discrimination activities, localization / lateralization training, enhancing perception of stress, rhythm and international aspects of speech, activities requiring temporal resolution or integration, perception of acoustic patterns, or multi-modality inter-hemispheric stimulation activities (Bellis, 2002).)

Dichotic training:

An auditory training technique to improve dichotic listening skills was attempted by English, Martonik and 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 recruited 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 that were depressed. All subjects were enrolled in an AT program for 10-13 weeks and received two hours of individualized AT training per week. To improve dichotic listening skills, each subject was instructed to listen carefully to tape recorded material for two minutes. Headphones were placed on the subject and the subject listened to the taped story delivered to the left ear only. Following this treatment it was found that all 10 subjects had improved left ear scores. Thus, it appears that for most subjects, providing auditory stimulation to the left ear only improved left ear scores.

Katz, Chertoff and Sawusch (1984) conducted a study in which they provided dichotic offset training for children shown to have auditory processing problems. In this study, children who demonstrated difficulty on a 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. The children were administered dichotic offset training (DOT) twice a week for one hour per session. The training began within a week after the pre-test baseline. The DOT materials were an expanded version of the Staggered Dichotic Digit test, developed as part of their study. 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 the Speech-in-Noise tests. Inspection of individual subjects' performance did reveal a trend towards improvement despite the lack of statistical significance.

Similarly Minetti and McCartney (1979, cited in Katz, Chertoff and Sawusch, 1984) studied the effect of practice on the staggered spondaic word (SSW) test, a dichotic procedure. They compared the performance on the first 20 SSW items with the remaining 20 items and found that even after counter balancing the half of the test given first, there was a significant improvement on the second half. The results indicated that the subjects benefited in dichotic listening performance after practice.

Phoneme training:

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

The results of a sound-by-sound therapy approach have been found to show beneficial effects on post-tests of phoneme synthesis, other auditory processing tests and articulation performance (Katz and Harmon, 1981, cited in Katz and Wilde, 1994; Katz, 1983, cited in Katz and Wilde, 1994). Kahler (1983, cited in Katz and Wilde, 1994) provided programmed phoneme synthesis therapy for half of the children who performed poorly on a phoneme synthesis test on entering first grade. At the end of the first grade the children in the therapy group scored significantly better on the post-phoneme synthesis test as well as on a test of reading ability than the children who had scored poorly at the beginning of the school year but did not receive therapy.

Sloan (1998) details a comprehensive program for consonant discrimination training. According to her, the most important feature of this type of therapy is not only to teach the child to discriminate speech sounds correctly, but, even more crucial, to help the child know when he/ she has perceived a sound incorrectly or is unsure. The primary goal of phonemic analysis is to develop phonemic encoding and decoding skills using either multi-syllabic nonsense sequences (Lindamood and Lindamood, 1975 cited in Ferre, 2002). A four-part program develops skills in auditory discrimination, sound analysis and sound-symbol (phoneme-grapheme) association and applies these skills to reading and spelling words. Similar to Sloan's program was the Auditory Discrimination-in-Depth (ADD) training program (Lindanood and Lindamood, 1975, cited in Ferre, 2002).

Another approach to AT introduced by Katz and Harmon (1982, cited in Katz and Wilde, 1994) centered on blending sounds into words. This method improved phonemic synthesis ability and increased decoding skills on the Lindamood auditory conceptualization (LAC) test (Katz, 1983, cited in Katz and Wilde, 1994). Similarly many studies have been done, in various aspects of auditory processing, which have been implemented in a variety of AT approaches to use with children with APD (Sloan 1986; Chermak and Musiek, 1992; Tallal et al., 1996, cited in Chermak and Musiek, 1997; Merzenich et al., 1996, cited in Chermak and Musiek, 1997; and Chermak and Musiek, 1997).

The drawback of the phonemic analysis and phonemic synthesis program is that they treat the spoken word as a concatenated string of consecutive sounds rather than a system of co-articulated and acoustically and phonetically overlapping and merged sounds (Liberman, Shankwielen, Blachman, Camp and Werfelman, 1980, cited in Chermak and Musiek, 1997).

Elkanin, (1973, cited in Chermak and Musiek, 1997) suggests it may be more appropriate to work at the level of syllable segmentation and syllabic blending, rather than create artificial sound categories, which create problems in fusing phonemes.

Speech-in-noise desensitization:

Katz and Burge (1971, cited in Katz and 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.

Mullin and Lange (1984, cited in Katz, Chertoff and Sawusch, 1984) demonstrated in 42 kindergarten children the effectiveness of 25 auditory, visual and memory training lessons, lasting 15 minutes each, on the ability to follow directions. Lessons consisted of a variety of listening tasks. The pre- and post-tests consisted of identifying the correct pictures which were given in a multiple-choice format. The post-test performance was shown to be significantly higher at the 0.01 level of confidence.

In a study by Putter-Katz et al. (2002) listening skills were compared before and after a structured intervention program for a group of children with APD. They took 20 children between 7 years and 11 months and 14 years and 4 months of age for the study and divided them into two groups. Group I consisted of 11 children who had poor scores on the Speech-In-Noise test but normal scores~bn the dichotic tests while Group II consisted of 9 children who had depressed scores on both tests. All participants underwent an auditory processing evaluation using conventionally recommended measures to assess the functional integrity of the auditory system. The treatment program extended for one 45-minute treatment session per week extending over a 4-month period (i.e., 13-15 sessions). The APD management program focused on environmental modifications, remediation techniques and compensatory strategies. The main goal of environmental modification and teaching suggestions included counselling about the nature of APD and importance on keeping the learning environment highly redundant, recommendations to decrease background noise, use preferential seating and use a tape-recorder in lectures. The compensatory strategies included auditory closure, speech reading, assistive listening devices and metacognitive awareness enhancement. Parental involvement was also instrumental towards success. Remediation techniques aimed to improve 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 and divided attention tasks. Treatment tasks were built hierarchically as a function of language complexity and different levels of background noise and competing speech.

The results revealed a significant improvement for the right ear scores for the Speech-In-Noise test in Group I following treatment. No differences were found for the performance accuracy scores of the left ear before and after treatment. No differences were also observed for the pre and post treatment performance accuracy scores of Group I in the dichotic listening tasks. However the pre and post scores for Group II was significantly different for each test in the battery following intervention, except the short competing sentences test for the right ear.

The study revealed that the auditory function of the children participating in the study demonstrated some improvement following intervention, as indicated by improved performance on speech-in-noise and competing sentences tasks. In addition, the authors report that these improvements were corroborated by parents and teachers of the children, who reported improvement in overall listening behaviours and abilities at home and in the classroom.

Temporal based training:

Tallal and Piercy (1973, 1974 and 1975, cited in Ferre, 2002) observed that children with language impairments were much poorer than their peers at perceiving tone order for short duration tones separated by very short inter-stimulus interval and at perceiving initial portions of speech stimulus. They concluded that when either duration of the tone or initial portion of the speech signal was prolonged, normal perception occurred.

Two treatment programs developed in response to deficit in central auditory temporal processing skills are Sloan's Phonemic Training Program (1986) and the Fast ForWord Program developed by Tallal and colleagues (Scientific Learning Corporation, 1997, cited in Ferre, 2002).

In general several studies have reported improvement in academic and language skills following CAPD intervention, indicating the generalization of activities to non-therapy situations (Shapiro and Mistal 1985, cited in Ferre, 2002; Chermak, Crutis, Seikel ,1996, cited in Ferre, 2002; and Tallal, 1997, cited in Ferre, 2002).

NEED FOR THE STUDY

1. The need for the present study was felt since 3-7% of all school aged children exhibit some form of Learning Disability (Bellis, 1996). According to Silverman and Metz (1973, cited in Keith, 1977) atleast 10-15% of the school population in the United States fit these criteria out of which only 1.4% to 2.6% are in special classes. In India it has been found that the percentage of children found to have dyslexia ranges from 3% (Ramaa, 1985) to 7.5% (Nishi Mary,

1988, cited in Ramaa, 2000). The difference in the findings of the various studies was probably due to the method used to determine the presence of the problem. Most often than not these children go unidentified and drop out of school because of poor academic performance. However, with specific training there is a possibility that these children might improve in their auditory perceptual abilities and thus perform better academically. Hence, the present study was undertaken, to check for the efficacy of an auditory training procedure in children diagnosed with an APD.

2. The study is required to know whether training children on the deficits that they manifest during assessment would help improve their auditory processing abilities.
3. Limited resources are available about the activities carried out for the intervention of auditory processing disorders in children. The outcome of the study will help professionals, teachers or parents of the APD child to provide the adequate (or atleast basic) auditory training required for the child to show an improvement in auditory processing skills.
4. Children with learning disability are often known to have CAPD problems. Such children find it extremely difficult in a classroom situation as well as in any listening situation that is noisy. It is reported in literature that such children with intensive training may improve in their auditory processing ability (Willeford and Burleigh, 1985; Bellis, 1996; Sloan, 1995; Chermak and Musiek, 1997). However, reports of the outcome of such training programmes

have been limited. There is a need to see if intensive training would bring about an improvement in auditory perception.

AIMS OF THE STUDY

The present study aimed at:

1. Developing material for the purpose of screening evaluation and management for children with APD.
2. Utilizing the developed material to correctly screen and identify children who might be 'at risk' for an APD.
3. To provide a training programme, according to the profile of deficits exhibited as per the baseline or primary evaluation.
4. To check for the efficacy of the training programme in improving the auditory processing skills of APD children.
5. To develop guidelines for parents and teachers which they can carry out easily.

METHOD

The present study was conducted in five stages:

- **Stage one** involved the development of material for screening, diagnostic evaluation and therapy for children with auditory processing difficulties.
- **Stage two,** involved screening of children using a questionnaire, to determine whether they had an auditory processing disorder or not.
- **Stage three** involved obtaining a base line performance, using diagnostic tests, of the children having auditory perceptual problems and age and sex matched normal children.
- In **stage four,** children with auditory perceptual problems were given therapy with the developed material.
- **Stage five** comprised the post therapy evaluation.

Subjects

The subjects comprised of five children who formed the experimental group and five who formed the control group.

Experimental group:

Subjects were selected based on the following criteria:

- Fluent English speaker in the age range of 7 to 12 years

- Normal pure tone AC and BC thresholds from 250-8000 Hz and 250 Hz-4000 Hz respectively.
- Normal speech recognition thresholds (SRT).
- No history of ear discharge
- Normal immittance findings
- No speech problems
- Normal IQ
- Should have symptoms of auditory processing problems based on the "Screening checklist for auditory processing" (SCAP) developed as a part of this project.
- Failed on one or more of the following test(s) for auditory processing disorders:
    - Speech-in-noise test
    - Dichotic CV test
    - Duration Pattern Test
    - Auditory Sequencing Test

Control group:

The control group was selected based on the same criteria adopted for the experimental group except that the children should have no symptoms of auditory processing problems based on the "Screening Checklist for Auditory Processing" (SCAP)

Instruments

- A calibrated two-channel audiometer with facility for CD/Tape input
- A calibrated immittance instrument
- An audio CD player to present tests for auditory processing disorders

Material

- The "Screening Checklist For Auditory Processing" (SCAP)
- The cassette version of the dichotic CV test developed by Yathiraj, (1999)
- For the speech-in-noise test, the word lists developed by Rout and Yathiraj (1996) were used along with speech noise.
- Duration pattern test developed in Audiolab version II
- Auditory sequencing test developed as a part of this project
- Training material for the therapy programme.

Environment

All the above diagnostic tests were carried out in a two-room sound-treated suite. The training was carried out in a distraction free environment.

Procedure

The procedure for carrying out the five different stages of the study was as described below.

Stage one: ***<u>Development of material</u>***

Material for Screening:

A screening checklist was developed in English titled "Screening Checklist for Auditory Processing"(SCAP). It was developed based on knowledge of professionals and literature such as the Fisher's Auditory Problems Checklist (Fisher, 1985, cited in Willeford and Burleigh, 1985), the Children's Auditory Performance Scale (CHAPPS) (Smoski, 1990) and other checklists available on the internet like the CAPD Symptoms and Subtypes Checklist (Paton) and the CAPD checklist (The Speech, Hearing and Learning Center, Inc, Greenville, South Carolina).

The SCAP comprises 12 questions concerning the symptoms of deficits in auditory processing (Appendix 1). It consists of three aspects, auditory perceptual processing, auditory memory and other miscellaneous symptoms. The checklist was scored on a two point rating scale as "Yes/No". Each answer marked "Yes" carried 1 point and each "No" was marked 0. Children who scored more than 50% (i.e. 6 or more, out of 12) were considered to be "at risk". The cut-off criterion to consider a child as "at risk" was kept high in order to increase the sensitivity of the checklist. The checklist was designed to be administered by the parent of the child or the class teacher.

Material for diagnostic evaluation:

An Auditory Sequencing Test using the material from the "Monosyllabic Speech Identification Test in English for Indian Children" (Rout and Yathiraj, 1996) was developed. The length of the word sequence increased from a three-word sequence to an eight-word sequence. Each sequence group has been referred to as a token. There were two tokens in the 3 and 4 word sequences and four tokens each in all the other sequences (i.e. 5, 6, 7 and 8), as described in table 1. The interval between words in each sequence was 500 ms. the inter-stimulus interval was 5 seconds for the 3, 4, and 5 word sequences and increased to 7 seconds for the 6, 7, and 8 word sequences.

Table 1: The sequences and tokens of the auditory sequence test

SI. No.	Sequence Type	Number of tokens	Example
1	3-word sequence	2	Cap, shirt, leaf
2	4-word sequence	2	Head, man, watch, tree
3	5-word sequence	4	Goat, jug, shoe, nose, milk
4	6-word sequence	4	Wash, ball, school, hand, cup, duck
5	7-word sequence	4	Lock, drink, snake, pen, frog, tree, goat
6	8-word sequence	4	Shoe, girl, horse, drink, mug, snake, foot, sleep

The words were recorded in a Pentium IV computer. The recorded material was then edited using the "Creative Mixer Sound Blaster 16" software. Scaling of the signals was done using the "AudioLab" software to ensure that the intensity of all sounds was brought to the same level.

Material for therapy: (Appendix 2)

The therapy material was developed in English. The vocabulary and material used was appropriate to the age level of the children. The material was selected from books and from caregivers of children. The material included activities for phoneme synthesis, auditory integration, auditory separation & recognition of low redundancy speech, auditory memory (recall and sequencing) and duration pattern recognition.

Material for auditory integration:

Auditory Closure and Dichotic Offset Training comprised the auditory integration activities. The auditory closure activities included missing word exercises at the sentence and phrase levels, missing syllable and missing phoneme exercises at the word level. The material was developed at varying levels of difficulty.

For the Dichotic Offset Training, dichotic material using words, phrases and sentences was developed. Each pair of dichotic stimuli was approximately of the same length. The lag was varied starting with gross offset lags (where the stimuli were presented one after the other) and proceeding to simultaneous presentation (where both stimuli were presented together). The hierarchy of the items was prepared ranging from easy activities (with redundant cues) to more difficult activities (with lesser redundant cues).

Material for auditory separation & recognition of low redundancy speech:

This involved preparing speech material in the presence of different levels of noise. Material such as words, phrases, sentences and paragraphs were used. This material was presented at different signal-to-noise ratios. The S/N ratios varied from +20 dB to -10 dB. As with the auditory integration task, the material was prepared in increasing levels of difficulty, so that the children were trained first with the easier task and then proceeded to the more difficult task. Initially phrases and sentences were presented at a +20 dB S/N ratio. As the children became proficient at performing the task the S/N ratio was decreased. A similar procedure was carried-out for words.

Material for auditory memory:

Auditory memory was enhanced using memory activities. These activities were also in hierarchy of difficulty from easy to difficult. The caregivers were also counseled regarding the use of acronyms, mnemonics and other memory enhancing devices for improvement of sequencing abilities.

Material for duration pattern recognition:

Training of duration pattern recognition using non-verbal stimuli such as pure tones was done. This training was also done for verbal stimuli i.e. for short versus long vowels in isolation and word level.

Stage two: <u>Screening of children using a Questionnaire</u>

The SCAP was administered to children from various schools located nearby. Eight schools were visited and approximately 3000 children were administered the SCAP from standard II till standard VII. The class teachers were oriented regarding how to administer the checklist and identify the children who were "at risk". These teachers then administered the checklist since they were familiar with the children. . The checklist was scored as mentioned earlier.

Stage three: <u>Obtaining the baseline performance</u>

The children who failed the checklist were tested for the presence of auditory processing problems using the following tests:

a. The Dichotic CV Test: The cassette version of the Dichotic CV test (Yathiraj, 1999) was used. The children were tested at the 0 msec-lag condition with the signal being presented at 70 dB HL through headphones. The recorded material was routed through a two-channel audiometer. Subjects were asked to repeat what was heard in both ears. Both single correct and double correct responses were noted.

b. The Speech-In-Noise Test (SPIN): The Speech-In-Noise test was administered using the "Monosyllabic Speech Identification Test In English For Indian Children" (Rout and Yathiraj, 1996) in the presence of background speech noise. The signals were presented monotonically to each ear at 0 dB S/N ratio at 40 dB SL (reference SRT). A recorded version of the speech test was used. Each ear was tested independently. Percent correct scores were computed.

c. Duration pattern test: The Duration Pattern test was presented using the Audiolab version-II software. Thirty sets of items were administered through a two-channel audiometer at 40 dBSL. Each ear was tested independently. The listener was instructed to indicate the pattern of the sounds presented in terms of their length. The percent correct score for each ear was computed.

d. Auditory sequencing test: The Auditory Sequencing test in English was used to determine the auditory sequencing abilities of the children. The signals were presented at comfortable level through a sound field speaker. The subject was seated 1 meter away from the speaker at 0° azimuth. The children were instructed to repeat the words in the correct order. A score of one was awarded for every correct word that was recalled. An additional score of one was awarded if the words were recalled in the correct sequence. The final score was converted to a percent score, separately for recall and for sequence.

After administration of the tests, five children who tested positive for auditory processing disorders were selected as the experimental group for the study. The scores obtained for the various tests were tabulated and formed the baseline assessment for each individual child. In addition five children who passed the SCAP were also evaluated on all the diagnostic tests except the dichotic CV test. They were not evaluated on the latter test since normative data for the test (Krishna and Yathiraj, 2001) was available.

Stage four: ***<u>Therapy for Auditory training</u>***

Using the material developed (Appendix 2), the five experimental group children were trained for thirty sessions. Each session lasted for a duration of 45 minutes. Deficit specific intervention was carried out as per the baseline assessment. The activities for the therapy programme were planned as per the auditory processes that were found to be deficient. A summary of the plans is included in the table 2.

Table2: Therapy activity based on process deficiency

Test Failed .	Process	Therapy
Dichotic CV	Auditory integration	Auditory closure and Dichotic offset training
Speech-in-noise	Low redundancy speech and auditory separation	Noise desensitization
Duration Pattern Test	Duration pattern recognition	Duration pattern training for verbal and non verbal stimuli
Auditory Sequence Test	Auditory memory and sequencing	Memory games and memdry enhancing devices
	Phonemic Synthesis	Phonetic training for syllabification and segmentation tasks

Children having problems in more than one process were given training in each area found to be deficient. The therapy program started with the easier lessons and progressed to the more difficult lessons. All children underwent phoneme synthesis training.

In addition to the training provided to the children during the therapy sessions, they were given activities to be carried out at home with the help of the parent who accompanied them for the therapy. The parents were also instructed as to how the activities could be carried out at home.

Monitoring progress during therapy: The children were tested once in fifteen sessions to check for progress in their performance. In addition, feedback was obtained from their schoolteacher or family members regarding the progress of the child in terms of auditory performance, attention skills and overall behaviour in the classroom.

Stage five: ***<u>Post Therapy Evaluation</u>***

After the completion of the therapy program the tests used for the baseline evaluation were administered to determine the post therapy evaluation. The procedure to evaluate the children was the same as that used earlier, except that different lists of the same tests were used. In addition, the parent and the class teacher of each child were questioned regarding the concentration, auditory performance in the presence of noise, ability to spell on dictation, academic performance and general behaviour.

The data obtained in stages three and five were tabulated. The obtained data was subjected to statistical analysis using paired t-test for the significance of difference between pre and post-test scores. The comparison was made between each of the following tests:

- The dichotic CV test
- The Speech-in-noise test
- Duration pattern test
- Auditory sequencing test

RESULTS AND DISCUSSION

The five children who failed the SCAP were evaluated on the following tests:

- Dichotic CV
- Speech-in-noise
- Duration Pattern Test
- Auditory sequencing test
    - Recall
    - Sequence

The mean performance of these children on these tests was compared to the normative data obtained by Krishna and Yathiraj (2001) for the dichotic CV test and age matched normal hearing children, who had passed the SCAP, for the remaining tests. The 't' test indicates that their baseline performance was significantly lower than the scores of the control group for all the tests except for the duration pattern test as well as lower than the norms obtained by Krishna and Yathiraj (2001). This is evident from table 3. The significant difference was not noted for the duration pattern test since only two of the five children in the experimental group had relatively low scored on this particular test. Though this difference was not significant, the mean scores for the experimental group was lower than that of the control group.

Table 3: Mean, SD and t-value for the significance of difference between the experimental group and the control group for the DPT, SPIN and AST

Tests	Groups	Mean	SD	T Value
Dichotic CV	Experimental	8.64	4.37	—
	Norms	14.24	4.25	
DPT	Experimental	67.00	15.87	-.59 NS
	Control	72.00	10.36	
SPIN	Experimental	46.00	12.40	-4.50**
	Control	77.60	9.63	
AST (Recall)	Experimental	26.64	11.64	-3.85**
	Control	48.72	5.36	
AST (Sequence)	Experimental	7.26	3.57	-3.92**
	Control	15.32	2.88	

NS: Not significant at the 0.01 level

**: Significant at the 0.01 level

The baseline test indicated that each of these children failed on different tests and had each child had specific auditory perceptual problems. The specific tests that these children fail are depicted in table 4.

*

Table 4: Pre and post therapy scores of the experimental group on the dichotic CV, SPIN, DPT and AST (recall and sequence)

Subjects	Dichotic CV		SPIN		**DPT**		AST (Recall)		AST (Sequence)	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
1	16.66	46.66	44	**62**	**50**	62.5	32.69	59.61	3.84	18.65
2	16.66	60	40	**88**	42.5	70	25.96	69.23	3.84	20.19
3	16.66	46.66	46	**78**	68.5	82.5	23.1	54.8	4.8	18.46
4	33.33	53.33	54	**66**	65	82.5	34.61	61.54	17.3	33.65
5	33.33	43.33	44	**64**	82.5	85	33.65	59.62	9.61	21.15

* Scores significantly lower when compared to age matched normals

Following the deficit specific therapy, the children were once again evaluated on the same tests to check the efficacy of the therapy program. Table 4 gives the improvement in the raw scores and table 5 indicates the mean, standard deviation (SD) and significance of difference of means of the pre and post therapy evaluations. From table 4 it is evident that the improvement was relatively larger for subject 2 and 3, for most of the tests. Though all the parents were instructed to follow-up the therapy program with home training activities, the quantum of home training given to each child varied. The parents of subjects 2 and 3 provided the children with a lot more home training activities when compared to the other subjects. The home training was greatest for subject 2 who showed the maximum improvement. Thus it can be construed that greater improvement can be obtained if the therapy program is followed with a rigorous home training program.

Table 5: Mean, standard deviation (SD) and significance of difference of means of the pre and post therapy evaluations.

Test	**Pre-therapy mean scores**	**Post-therapy mean scores**	't'
Dichotic CV double correct scores	23.33 % (SD = 9.13)	50.00 % (SD = 6.67)	4.78**
Speech-in-noise	45.6 % (SD = 5.18)	71.6%(SD = 11.08)	4.07*
Duration pattern test	62.20 % (SD = 16.62)	76.5 % (SD = 9.78)	3.229*
Auditory Sequence test - Recall scores	30.00 % (SD = 5.25)	60.96 % (SD = 5.15)	9.56**
Auditory Sequence test - Sequence scores	7.88 % (SD = 5.78)	22.42 % (SD = 6.37)	16.05**

** = Significant at the 0.01 level
** = Significant at the 0.05 level

Table 5 reveals that there was a statistically significant improvement in the auditory perceptual abilities of the children following the deficit specific therapy program. The difference was significant at the 0.01 level for the double correct score of the dichotic CV test and the auditory sequence test. Both the recall scores and the sequence scores of the latter test was found to be significant at the 0.01 level. The remaining two tests, i.e.the duration. Pattern Test and the

Speech-!n-Noise test had a significant difference at the 0.05 level. The mean improvement was greatest for the auditory recall test (31%) followed by the dichottc CV test and the speech-in-noise test where the improvement was 26%. The improvement was approximately 14% for the duration pattern test and auditory sequence tests.

To check for generalization of the skills that the children had acquired during the therapy program, their parent and school-teacher were interviewed. Four of the five children were reported to have improvement in the following skills:

- Auditory attention even in the presence of background noise
- Spelling
- Ability to complete class notes on time
- Self confidence
- Ability to interact with peer group

Chermak and Musiek (1997) is of the opinion that the efficacy of therapy for central auditory processing problems should not rely solely upon improvement in performance on tests of central auditory function, but include documented change in related functional skills at home, work, or school. Ferre (2002) noted that the changes should be in evident in both objective (e.g., pre therapy and post therapy measures of skills) and subjective (e.g., listener and perception of disability, teacher observation and parent reports measures. In the present study the enhancement in auditory skills following therapy is evident based on the test that were used to assess the improvement as well as in the real life situations which was reported by the parents and class teachers of the children.

This information was not obtained for the fifth child, as the parent and the teacher were not available to conduct the interview after the therapy program. However, when a different professional evaluated this child during one of sessions, it was noted that the child had generalized the perceptual activities to other general activities such as dictation.

The above findings indicate the positive effect that deficit-specific therapy has in the auditory perceptual abilities of children identified to have APD. In the literature relatively few studies have been conducted to evaluate the effect of therapy on auditory perception in children having auditory perceptual problems.

In a study by English, Martonik and Moir (2003) it was observed that by providing auditory stimulation to the left ear only, improved left ear dichotic deficits as measured by the dichotic digits test. They hypothesized that providing left ear auditory stimulation improved dichotic listening skills in typically developing children. However, they did not train the children using simultaneous presentation of stimulus to both ears. In the present study all the children had equal performance in the two ears and hence it was not considered necessary to provide stimulation to any one ear separately.

In an earlier study by Katz, Chertoff and Sawusch (1984) they provided therapy to subjects who had lowered scores on a Staggered Dichotic Digit test which was similar to the Staggered Spondaic Word test (SSW) developed by Katz (1962). An improvement in the test score was noted after giving the children fifteen one-hour sessions of dichotic-offset training. The authors did not however find an improvement in the scores for the phonemic synthesis test, the SSW and the SPIN. They suspect that a battery of auditory training tasks is likely to be more beneficial than training any single skill and hence the improvement was noted only in the staggered dichotic digit test.

The findings of Katz, Chertoff and Sawusch (1984) are in consensus with the findings of the present study where it was found that training children using a Dichotic Offset tasks improved their Dichotic CV scores. It however cannot be concluded that this improvement was solely due to the dichotic offset training. There is a possibility that this improvement could be on account of the other training given to the children, which included auditory closure, noise desensitisation therapy, phoneme synthesis training, and training for auditory memory.

As with the present study Putter-Katz et al. (2002) also observed an improvement in, both ears of their twenty subjects who underwent therapy to improve speech perception in the presence of noise. They noted an improvement of approximately 10% following the therapy in children who had deficit only in the speech-in-noise test. This difference was statistically significant in the right ear but not in the left ear. In the children who had a deficit in both speech-in-noise and the dichotic sentence tests, the improvement was 15% following therapy. In the present study the improvement was much larger (26%), following therapy. The difference in findings is probably due to the variation in the therapy schedule. In the study carried out by Putter-Katz et al. (2002), the children received only 13-15 sessions of therapy which was conducted once a week, while in the present study the children received 30 sessions of therapy, five days a week. This could account for the greater improvement in the scores in the present study.

In a single-subject study of the efficacy of the Fast ForWord program, Seats (1998, cited in Ferre, 2002) examined pre-training and post-training electrophysiological and behavioural measures of central auditory function. The program had tasks that include discrimination, analysis and identification of speech sounds as well as temporal ordering of stimuli. However no significant improvement was noted on the subject's performance on tests of temporal patterning or recognition of time-compressed speech skills, which were hypothesised to improve following training because of their dependence on temporal aspects of speech. This finding is in contradiction with the results of the present study where a statistical improvement was noted in the children in the duration pattern test following therapy that focused on improving duration perception using nonverbal and verbal material (table 5).

The majority of the literature on memory problems in individuals with auditory processing problems focuses on kind of problem and the strategies that can be used to enhance memory (Flavell and Wellman, 1977, cited in Chermak and Musiek, 1997; Medwetsky, 2002). Information on the improvement noted in memory following therapy is limited. The present study highlights that with systematic therapy focusing on enhancing auditory memory, children with such problems can be helped considerably.

From these findings it can be concluded that providing deficit specific therapy to children having auditory perception problems, would result in an improvement in their performance not only during the therapy program but also in a real life situation.

CONCLUSION

Five children who failed the SCAP test and who were identified to have auditory processing problems based on four diagnostic tests (Dichotic CV, Speech-in-noise, Duration Pattern Test, Auditory sequencing test - Recall & Sequence) were given thirty sessions of therapy for the deficits that they demonstrated. The scores obtained by these children prior to therapy was compared with that of age and sex matched controls who had passed the SCAP. It was found that the scores of the experimental group were significantly lower than that of the control group for all the tests, except the duration pattern test. There was no significant difference in the Duration Pattern Test for the two groups since only two of the children in the experimental group had lower scores. Despite the scores not being statistically significant, the mean scores was lower in the experimental group.

The performance of the experimental group prior to and following the thirty sessions of therapy was assessed on the four diagnostic tests. Further, the parent and class teacher of each of the children were interviewed following the therapy to note any change in the performance of the children in terms of their listening skills as well as their general behaviour. There was a significant improvement in the children for all the tests that were administered, indicating that providing children with deficit specific therapy does bring about an improvement in their auditory performance. The interview with the parents and the class teachers of the children revealed that there was a generalization of the skills that were taught during the therapy to the home and school situations. Thus it can be concluded that children with children with an auditory processing problem can be helped if they are given rigorous training to improve their perception.

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APPENDIX-I

THE SCREENING CHECKLIST FOR AUDITORY PROCESSING (SCAP)

Yathiraj and Mascarenhas (2002).

Developed as part of the project titled " Effect of auditory stimulation of Central Auditory Processes in children with CAPD" at the Department of

Audiology,

ALL INDIA INSTITUTE OF SPEECH AND HEARING,
Manasagangothri, Mysore 570 006

Name: Age/Sex: Date:

School Class: Class Teacher:

Medium of instruction:

Language(s) spoken at home:

Home Address & Telephone no:

Father's Occupation: Mother's Occupation:

PLEASE PLACE A TICK (/) MARK AGAINST THE CHOICE OF ANSWER THAT IS MOST APPROPRIATE.

SI. No.	Questions	Yes	No
1	Doesn't listen carefully and doesn't pay attention to instruction (Requires repetition of instruction).		
2	Has a short attention span for listening (approximately 5-15 minutes).		
3.	Easily distracted by background sound.		
4.	Has trouble recalling what has been heard in the correct order.		
5.	Forgets what is said in a few minutes.		
6.	Has difficulty in differentiating one speech sound from another.		
7.	Has difficulty following verbal instructions and tends to misunderstand what is said, which other children of the same age would understand.		
8.	Slow or delayed response to verbal instructions or questions.		
9.	Has difficulty relating what is heard with what is seen.		
10.	Poor performance for listening tasks, but performance improves with visual clues.		
11.	Has a pronunciation problem (Mispronunciation of words).		
12.	Performance is below average in one or more subjects such as social studies, 1/ II language.		

APPENDIX - II

Auditory Training Material For Children with APD

This manual has been developed to help train auditory processing abilities in children with such problems. The manual is easy & comprehensible and adaptable to the home situation. Professionals, teachers and/or parents may use it. It has been developed in English & should be used by children who are fairly fluent in the language.

The manual consists of 5 sections. Section I deals with the training of sounds of the English alphabet. Activities involving playing with sounds (blending & segmenting of sounds into words & vice-versa) come under this section.

Section II deals with training for auditory integration. In this section training is given for the ability to integrate two messages given separately to two ears so that they both may be attended to. Auditory closure or the ability to complete a message using intrinsic & extrinsic redundancy has also been included in this section.

Auditory memory or the ability to recall & sequence auditory signals, comprises section III. Activities in the form of memory games come under this section

Section IV deals with Noise Desensitization, which is an important part of training for APD children, especially in the classroom situation.

Finally section V consists of training for temporal sequencing activities using verbal & non- verbal stimuli have been incorporated.

The manual is a guideline for the professional/teacher & or parent. Training for APD is not a short-term achievement but a long-term ongoing process which has to be carried out regularly & extensively. Activities other than what is mentioned in the manual are over, may be included to help train the APD child.

SECTION I

Phonemic synthesis

Objectives

To be able to improve or teach the letter / sound association of the alphabet. To be able to break words into its constituent sounds and also to be able to blend sounds to make words.

Note: The more complicated words in English need to be taught with spelling rules. (For further reference: Hornsby and Shear, 1990: *Alpha to Omega: The A-Z of teaching reading, writing and spelling).*

Training for phonemic synthesis

Step 1: Letters

Make flash cards of all the letters of the English alphabet (A-Z). It would be preferable to make the letter associated with the sounds by having the word pictographically represented.

For example:

A > Apple > Ant

The first sound of the word should indicate the sound of the letter

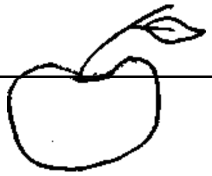
(A -» as --> | aent|)

Step 2: The first instruction to be given to the child is the distinction between the name of a letter and its sound. Each letter of the English Alphabet has a name and a sound.

For example: "a" is its name and /as/ as in ant, is its sound,

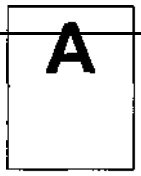
"b" is its name and /b/ as in ball is its sound

Step 3: Write a letter of the alphabet on a flashcard with a picture representing the letter drawn on the reverse side. Initially the picture can be shown and the child has to produce the first sound of the picture.

For Example:  /ae/ when they see an apple

/b/ when they see a ball

Gradually when the child is familiar with the sounds of the letters, they may associate the sound with only the letter, without the word.

For example: 

/ae/ when they see an A

Ibl when they see B

Step 4: Digraphs

In this step, consonant digraphs may be introduced. These are |sh|, |ch|, |th| (thumb), |th| (the), |ph| (phone), |wh| (what). These sounds are also taught in the same way.

Step 5: Short Vowels

In this step introduce the vowels with their names a, e, i, o, u. Now, the sounds that have been taught to them should be introduced as their short sounds. They also have long sounds that shall be learnt about later.

Step 6: Consonant Blends

When the sounds are correctly identified more than 90% of the time, move onto the next step of consonant blends. The method of teaching is the same as before with the use of flashcards.

Step 7: Long vowels

Initially, the vowels were introduced only with their short sounds. Now introduce the long sound of the vowels. The long sound of a vowel is nothing but the name of the vowel, (i.e. when the name itself forms the sound of a vowel in a word, it is a long vowel).

Activity 6: Sound Riddles

In this activity there are some particular instructions in which the child has to drop and add sounds to derive new words.

SECTION II

BINAURAL INTEGRATION

Dichotic Offset Training

Objective:

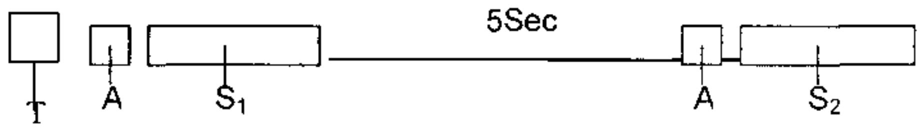
The main objective is to be able to train the child to differentially integrate the two different stimuli, which are separately given to both ears.

Material:

The activities for training require a tape recorder along with the prerecorded speech stimulus. Make lists of words, (20 words per list) phrases or sentences and yes/ no questions (10 each). There should be a minimum of at least 8 lists. The material should have speech sounds of all frequencies and should be age appropriate in terms of vocabulary and grammatical complexity.

Stepi: Record four lists of phrases, yes/no questions and words. The time gap between two stimuli of each list should be approximately 5 seconds. Between lists the interval should be approximately 10-15 seconds. The title of the list should precede it. Before recording the stimulus, ensure that alerting stimuli like a clap or bell ring precedes the stimulus as shown in figure 1.

Figure 1:



T-Title of the list (e.g. Sentence list A, Word list A)

A - Alerting stimulus (e.g. Bell)
S - stimulus

When the cassette is ready with at least 4 lists each of pre-recorded stimuli (i.e. 4 lists of phrases, question and words) the activity may begin.

Step 2: The activity ideally requires a two-channel audiometer. Live voice selection should be chosen for one channel and CD/Tape input selection for the other. The activity should be carried out at a comfortable level of loudness (i.e. 40dBSL). Adjust the signal so that the VU meter deflection in both channels equals zero and does not overshoot.

Note: If audiometers are unavailable, the activity may be adapted to the home situation. In this situation seat the child on a stool. On one side of the child place a CD/Tape recorder at approximately 45 degrees from the child's ear. At exactly the same angle, seat yourself on the other side and then proceed with the activity. Make sure that the loudness level of the recorded material and the live voice should sound alike in loudness.

Instruction: Instruct the child to answer the yes / no question in a full sentence (e.g. Is your hair black? Ans.: Yes, my hair is black.) or repeat the phrase / word as appropriate.

Auditory Closure

Objective:

To train the child to utilize intrinsic and extrinsic redundancy to fill in distorted portions of the auditory signal and recognize the whole message.

Auditory closure plays an important role in everyday listening activities. The activities for auditory closure include methods of improving access to information through activities from sentence to phoneme level.

Step 1: Pre-requisite activities for missing word exercise

Before the activity for missing word may be initiated the child needs to be taught the concept of rhyming words. Ask the child to close his/ her eyes, and listen carefully. Read out a part of a simple poem.

For example: Jack & Jill went up the hill;

Then ask the child "Which word in the line sounds just like Jill?"

Similarly read other familiar, rhyming lines of poems like "Twinkle Twinkle", "Baa baa black sheep" etc. in which rhyming words are easily spotted.

1

Step 2: Multiple choice

In this step, say aloud a word (Call it the keyword). Then give a choice of 3-4 words out of which, one or more than one word may rhyme with the keyword. Ask the child to choose the word/ words that rhymes with the key word.

Note: This activity can be incorporated for training phonemic synthesis also.

For example: Shop: hop, hat, ship.

SECTION III

Auditory Separation and low redundancy

Objective

To train the child to listen to the important or relevant sound i.e., speech and to ignore the unwanted sound or noise.

Material:

Activities for separation require speech material in the form of questions, short paragraphs, short stories, phrases and words. The equipment required is a tape recorder with recorded noise. The noise may be recorded for a duration of at least six minutes. It may be the recording of traffic noise; six or more people talking continuously i.e. speech babble; household noise like the grinding mixer, the cooker whistle, vessels clanking or else it may be the presence of a television or any such background competing sound.

Note: The noise should be continuous for approximately six minutes not an intermittent recording of noise.

Instruction: For Story or paragraph: Listen carefully to what is read. Ignore the other noise that is present and concentrate on what is read. When I have finished reading, I shall ask you questions that you have to answer.

For phrases and words: Listen carefully to what is read and repeat what I say. Ignore the noise that is present

Step 1: The speech stimulus should be presented in various levels of difficulty. The activities should start with easier tasks such as reading of short paragraphs or stories that are familiar. Such material has additional semantic and other redundant cues that make the task easier. Later on more difficult material (mentioned in Step 5) may be used. Simultaneously along with the speech material present a competing stimulus (noise TV, tape recorded noise) at a level obviously lower than that of the speech (approximately +20dB S/N ratio). Since the speech signal is louder, the task should not be too difficult to perform.

Step 2: When the passage / story is complete, stop the noise. Now ask the child to answer questions based on the passage / story. When the task is easy enough for the child to score over 80%, move to the next step.

Step 3: Repeat step one, using a different story. However, do not switch off the noise while asking the questions.

Step 4: Increase the level of the noise till it is perceptually equal in loudness to the stimulus (0 dB S/N ratio). Now repeat the same procedure as was described previously. Again the same criterion for the responses may be acceptable.

Step 5: The final step is in the presence of noise the loudness of which is higher than the signal (approximately +10 dB S/N ratio). For example, the TV at a loud volume. Again repeat the same task. If the child is able to correctly answer or repeat 80% of the stimulus then move to the next stage.

Note: At each of the above steps, do not use a same familiar story or passage.

Step 6: This stage is more difficult. The stimuli used are unfamiliar stories, phrases and isolated, unrelated words. Now repeat the same procedure as delineated in steps 1, 2, 3 and 4. However when the repetition task is being done do not interrupt the noise. The repetition of the phrase and the word may be done while the noise is still on.

Note: There shouldn't be contextual cues available when the stimuli are presented.

For example:

	For phrases	For words
	1. Today is Sunday	1. Ball
	2. I have no school	2. Bat

SECTION IV

AUDITORY MEMORY [Recall and sequencing]

Objective

Memory facilitates language learning and speech perception. The main objective of auditory memory activities is to improve the ability for sequence and recall. Some of the activities are:

Activity 1: Memory Chain

Select a concept.

Instruction: Start contributing items appropriate to the concept. The activity would require at least two participants or more. One is the child and the other may be the therapist, parent or teacher. Each person should add one item of his own after having first repeated the item of the previous person (s) in the order that they were said.

For example: Concept: Places

Child: Bangalore.

Therapist/Parent: Bangalore, Calcutta.

Child: Bangalore, Calcutta, Nagpur.

Step 2: To further increase the difficulty of the game, we may involve the sound training experience in it too (Activity may be included in Phonemic Synthesis

Activities also). In this we begin the new word with the final sound of the previously uttered word.

For example:

Child: Bangalore - *lxl*

Therapist/Parent: Roam - /m/

Child: Madrid-*161*

Step 3: In this step 2-3 specific concepts are used and the words are to be named/recalled in a specific order. Play the game in the same manner.

For example: Concepts: Places, animals and vehicles

Child: Bangalore

Therapist/Parent: Bangalore, Cow

Child: Bangalore, Cow, Santro

Therapist/Parent: Bangalore, Cow, Santro, Mysore

Step4: In this step too, 2-3 specific concepts are used. The words however are to be named/recalled in a random order. Play the game in the same manner.

For example: Concepts: Places, animals and vehicles

Child: Bangalore

Therapist/Parent: Bangalore, Santro

Child: Bangalore, Santro, Mysore

Therapist/Parent: Bangalore, Santro, Mysore, Cow

Some of the themes that may be interesting: Names of places, Wild animals, Domestic animals, , Vehicles, School items,

Names of Books, Personalities etc.

Activity 2: Word Heard

Step 1: Read aloud a poem or a story

Step 2: Make a list of words, some of which appeared in the matter read aloud from the story or the poem and some of which didn't.

Step 3: Now, read aloud the list of words that has been prepared by you with words that belong and do not belong to the story.

Instruction: Ask the child to recall, only those words which belonged to the story.

Activity 3: Sound Heard

Read aloud a poem or a story in which a specific speech sound is repeated many times.

Instruction: Ask the child to recall, how many times a particular sound occurred in the material. Then ask the child to try and recall only those words that began with the specific sound.

Activity 4: Topsy - Turvy sentence

Step 1: The activity may be applicable to children with an adequate amount of language. Jumble the order of words in a sentence and read it aloud only once.

Instruction: Listen carefully and correct the sentence.

For example: name is my Kareena

Ans: My name is Kareena

Step 2: Gradually increase the complexity of the sentence, as the child is able to perform at a level of more than 80%.

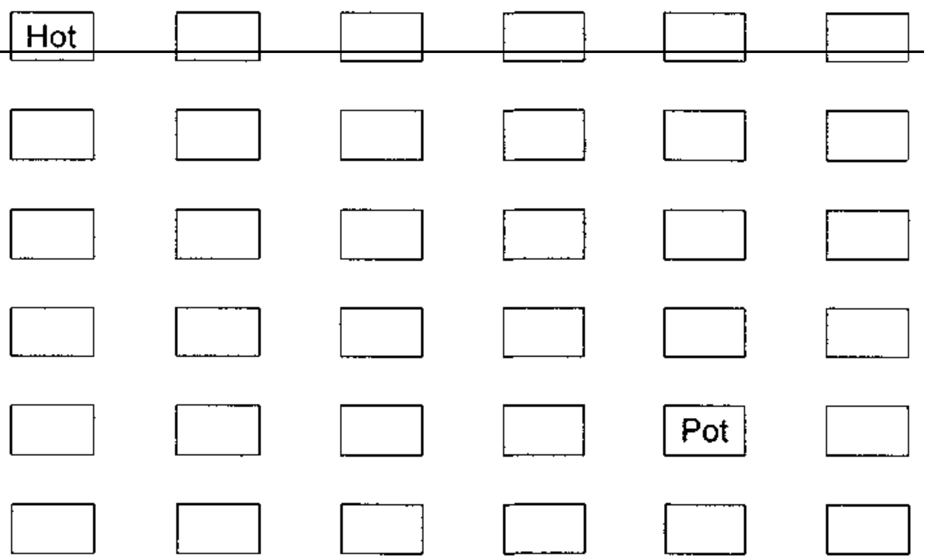
For example: boy wild chased the small dog the

Ans: The wild dog chased the small boy.

Activity 5: Memory cards

Make little cards with rhyming words written on them and place them face down. Now, play the memory game by lifting cards, reading them aloud and trying to match it from memory with a rhyming word.

For example:



Activity 6: Word Recall

This activity is easy. Give a long list of words in any order. Within that list have a list of words belonging to some particular concept. Now, after the words have been read, ask the child to recall as many words as he/she can that belong to that particular concept and that were said aloud.

Note: This activity can also be adapted to school curriculum subjects like science and social studies.

SECTION V

Duration Pattern Recognition

Activity 1:

Initially tasks involving nonverbal stimuli are used.

If Audiometers are available for use, then use pure tones. Other wise make use of a musical instrument e.g. keyboard or flute. Vary the duration and produce a pattern of three tones so that the child has to say what pattern occurred. Let the difference in duration be easily recognizable,

i.e. Long-Long-Short

Gradually shorten the inter stimulus time and produce the patterns.

When the child is able to correctly identify more than 80% of the patterns correctly introduce verbal stimuli.

Activity 2:

The Activity for Verbal stimuli is similar to that used in the Phonemic Synthesis Activity: Short versus Long Vowel

AUDIOLOGICAL PROFILE OF CHILDREN WITH SUSPECTED AUDITORY PROCESSING DISORDER

(Paper presented at 2003 ISHACON at Chennai)

Dr. Asha Yathirai. HOD (Audiology), AIISH, Mysore

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All India Institute of Speech and Hearing , Mysore

Won the best paper award in Audiology

APPENDIX-III

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Abstract

3-7% of all school aged children exhibit some form of an Auditory Processing Disorder (Bellis,1996). Most often these children go unidentified and drop out of school. In the present study a checklist to screen for the presence of an auditory processing disorder was developed. Eight children who were suspected to have an auditory processing disorder, based on the checklist were evaluated using four different CAPD tests to confirm the presence or absence of the problem. The tests included the Dichotic CVTest, the Speech-in-Noise Test (SPIN) , the Duration Pattern Test(DPT) and an Auditory Sequencing Test(AST). In addition, eight age and sex matched children who passed the checklist, were also evaluated, using the same tests. An audiological profile of these children is described

The dynamic and complex acoustic characteristics of real-world speech signals and the distractive nature of background noise make real-word spoken language processing the most powerful and probably the most demanding activity of the central auditory nervous system (CANS). Therefore, background listening conditions, temporal processing demands and listeners' abilities to effectively use linguistic-contextual information, determine every day receptive communication success or failure (Chermak andMusiek, 1997).

Many auditory processes, such as attention, localization, discrimination, closure, association, memory, are involved in the appropriate perception of an acoustic event (Handel, 1989, cited in Chermak and Musiek , 1997). Most of these processes are interdependent and involve both the peripheral and central systems. Usually, the more complex the acoustic task in listening, the more the central system becomes involved.

The definition of central auditory processing disorders (CAPD) provided by the Central Auditory Processing (CAP) Ad Hoc Committee of the American Speech Language Hearing Association (ASHA, 1990, cited in Johnson, Benson, and Seaton, 1997) and the task force on CAP Consensus Department (ASHA, 1996, cited in Johnson, Benson, and Seaton, 1997) is " A CAPD is an observed deficiency in one or more of the following behaviours: Sound localization and lateralization, auditory discrimination, auditory pattern recognition, temporal aspects of audition, auditory performance decrements with competing acoustic signals and/or auditory performance decrements with degraded acoustic signals. This definition is complex and may not be easily understood by teachers and parents. A more functional definition for the educational audiologist to use may be that a CAPD is a deficit in "what is done with what is heard" (Johnson, Benson, and Seaton, 1997).

Children with auditory processing disorders (APD) typically demonstrate one or more of the following: deficits in foreground-background discrimination, poor auditory attention, limitations in memory, as well as delays in receptive language development {Matkin, 1982 cited in Katz, (1985)}. APD's also include: poor integrative skills (e.g., binaural fusion), reduced ability to sequence auditory information, difficulty with phonics (associating auditory symbols with visual symbols) and problems with time altered speech or speech that has other forms of reduced redundancy (Katz and Wilde, 1985, cited in Katz 1985).

A number of Central Auditory Tests, either behavioural or electrophysiological, have been used successfully in identifying APD in children with learning problems [Bornstein and Musiek, 1992; Jerger, Martin and Jerger, 1987; Ferre and Wilbur, 1986 cited in Chermak and Musiek, (1997)]. Chermak and Musiek, (1997) reported that it is valuable to select tests that assess different processes. Two lesser efficient tests that evaluate different processes would be better than two highly efficient tests that evaluate the same process.

No single test of CAP can be expected to challenge the variety of functions required by the CANS in different listening situations. Therefore, it is necessary to use a test battery approach (Dempsey, 1983, cited in Chermak and Musiek, 1997). The underlying conceptualization and philosophical approach one has regarding CAP will determine testing procedures used for evaluation. Chermak (1992) suggested that pediatric evaluations for CAPD include tests in the following areas: auditory neuromaturational level (i.e. auditory localization, binaural synthesis, Binaural separation, resistance to distortion); tests of temporal processing; dichotic tests; monaural low redundancy tests; analysis of metalanguage; checklists of auditory performance. Chermak (1992) recommended that a CAP evaluation minimally include at least one test of temporal processing, one dichotic test and one monaural low redundancy test. If a child performs poorly in any one area, another test should be administered to evaluate that skill more completely.

Both screening and diagnostic test procedures play a role in assessing the central auditory systems (Musiek, Gollegly Lamb and Lamb, 1990). This is especially true for children with learning problems. A problem with simply trying to find the most sensitive/specific battery for identifying those with CAPD is that these tests will not necessarily help in determining the person's specific problems and / or needs. Parents, teachers and speech language pathologists what to know what the child's problems are and what needs to be done. It is important to provide the specific guidance for management that CAP tests can offer. Therefore, CAP testing needs to incorporate tests that not only allow the identification of a child or adult with CAPD in a timely cost effective manner but also derive a composite profile of that individual. In summary, a CAP test battery should encompass the following goals;

Determine if a CAPD problem exists and if so, determine the severity and the nature of the various underlying difficulties.

Provide findings and interpretation that guide recommendations for management of the problem.

In central auditory evaluation, screening procedures are used primarily to help make an appropriate referral for a complete diagnostic workup (Chermak and Musiek, 1997). However screening tests may not have the complexity to test a variety of auditory / language processes, a trait critical to appropriate diagnosis. These tests may also lack the reliability or validity that in-depth batteries or longer tests have; screening tests may lack flexibility to appropriately test certain patient populations (Chermak and Musiek, 1997).

Hence, behavioural tests remain the mainstay of evaluating the CANS. Although many aspects of CANS assessment must be considered, behavioural test results are the key to the diagnosis of CAPD in adults or children.

The Speech-In-Noise test is a monaural low redundancy test in which a conventional monosyllabic word list is used with an ipsilateral competing noise (Mueller, 1987, cited in Katz, 2002). Katz and Burge, 1971 {(cited in Katz (2002)} proposed speech-in-noise procedures in the evaluation of central auditory problems. They found a large percentage of children with learning disability had difficulty when faced with a speech-in-noise task whether it was dichotic or diotic.

Dichotic CVs have been used for the evaluating central auditory functions in adults and children (Berlin et al., 1968). They confirmed that patients with confirmed brain lesions as well as children with APD perform poorly when double correct responses were calculated.

Studies also show that temporal processing is an underlying key component of testing central auditory function (Bornstein and Musiek, 1984; Pinheiro and Musiek, 1983 cited in Chermak and Musiek , 1997). The duration pattern test (DPT) is one such test. It has been reported that some children may exhibit normal speech and language development yet display significant difficulties in reading and spelling as a result of poor phonologic awareness skills which may be attributed to underlying temporal processing deficits (Merzenich et al., 1996 cited in Chermak and Musiek , 1997) poor phonologic categorization / working memory (Apel and Swank, 1999; Nittrouer, 1999 cited in Chermak and Musiek , 1997) or a combination of both. The efficacy of inclusion of temporal processing tests in most central auditory test batteries has been strongly supported by both animal and human studies (Musiek, 1984; Musiek and Baran, 1981; Colavita, 1972; Neff, 1961 cited in Chermak and Musiek , 1997).

Another stage in auditory processing is the short-term memory during which the information that has been processed is within an individual's conscious awareness. Information can be stored in STM for approximately 2 seconds (Massaro, 1975cited in Katz, 2002) Miller 1956, (cited in Katz, 2002) found that the typical adult STM span familiar stimuli such as digits and common household objects was 7+2 units. Also it is likely that when stored percepts are activated by incoming stimuli, their activated units, in turn, lower the activation thresholds of other units to which they have become linked. Research indicates that the processing of target words is speeded up by word primes (Cowan, 1996 cited in Katz, 2002). Consequently, if links are well organized, incoming stimuli will be processed accurately and efficiently and be quickly transferred to the long term memory (Norman, 1979 cited in Katz, 2002).

The need for the present study was felt since 3-7% of all school aged children exhibit some form of Learning Disability (LD) (Bellis, 1996). According to Myklebust and Boshes (1969) and Silverman and Metz (1973, cited in Keith, 1997) at least 10-15% of the school population in the United States fit these criteria out of which only 1.4% to 2.6% are in special classes. Therefore most often than not these children go unidentified and drop out of school because of poor academic performance. Hence the present study was undertaken to be able to refer, by a quick screening test, those seemingly at risk for an APD. There is a need to note whether children who fail a screening checklist also fail diagnostic tests that assess APD. Further, it is a well-known fact that children with auditory processing do not show identical profiles. Hence, profiling these cases is necessary in order to differentially classify these children. The information from the diagnostic tests will of considerable use in determining the management strategies that have to be with these children.

The present study aims at developing a checklist for screening of children with APD; making a profile of these children based on the results of the checklist and the diagnostic evaluation and correlating the characteristics exhibited by these children using the checklist with their performance on the diagnostic tests.

Method

The present study was conducted in three stages:

Stage one involved the development of a checklist for children with auditory processing difficulties.

In **stage two,** screening of children using the questionnaire to determine whether they have an auditory processing disorder was carried out.

Stage three involved administration of the tests for CAPD to confirm whether the children had APD or not as per the screening checklist.

<u>Subjects</u>

The subjects comprised of eight children for the experimental group and eight for the control group.

Experimental Group:

The subjects for the experimental group were selected based on the following criteria:

- Fluent English speaking children in the age range of 7 to 12 years
- Normal pure tone AC and BC thresholds from 250-8000 Hz and 250-4000 Hz respectively, confirmed by a routine pure tone screening
- No reported history of ear discharge as reported
- Normal immittance findings according to the immittance assessment
- No reported speech problems
- Normal IQ verified by a detailed psychological assessment

  Symptoms of auditory processing problems based on the "Screening Checklist for Auditory Processing" (SCAP)

Control Group:

The control group was selected based on the same criteria adopted for the experimental group except that the children should have no symptoms of auditory processing problems based on the "Screening Checklist for Auditory Processing" (SCAP)

<u>Instruments</u>

A calibrated two-channel audiometer with facility for tape and CD input (Madsen OB922)

A calibrated immittance instrument (GSI 33)

An audio CD player and a tape recorder to present tests for auditory processing disorders

(Philips AZ2160V).

Pentium IV computer with Audiolab software Version II

Material

The Screening Checklist for Auditory Processing that has been developed (Appendix 1)

The Dichotic CV Test (Yathiraj, 1999)

The Speech-in-Noise test (SPIN) [The speech material developed by Rout (1998) was used along with speech noise]

Duration Pattern Test (Audiolab Version II)

Auditory Sequencing Test (Yathiraj and Mascarenhas, 2002)

Environment

All the tests were carried out in a two-room sound-treated suite, in a distraction free environment.

Procedure

The entire procedure of developing the screening checklist, administration of the checklist and administration of the APD tests was carried out, as mentioned earlier, in three stages.

Stage One: Development of the screening checklist

The checklist "Screening Checklist for Auditory Processing"(SCAP) was developed in English. It consists of twelve questions concerning deficits in auditory processing (Appendix 1). The checklist consists of three aspects; Auditory perceptual processing, auditory memory and other miscellaneous symptoms. The checklist is scored on a two point rating scale as "Yes/No". Each answer marked "Yes" carries 1 point and each "No" is marked 0. Children who score more than 50% (i.e. 6 or more, out of 12) are considered to be "at risk".

Stage two: Administration of SCAP

The subjects who were selected according to the subject selection were administered the Screening Checklist for Auditory Processing. Eight children who failed the screening checklist, with a score of more than 50 %, were selected as the experimental group and administered further detailed evaluation. Eight subjects who passed the screening checklist were selected as the control group.

Stage three: Diagnosis of Auditory Processing Disorder (APD)

The children who fail the checklist were tested for APD using the following diagnostic tests for the assessment of CAPD.

The Dichotic CV Test: The cassette version of the Dichotic CV test (Yathiraj, 1999) was used. The children were tested at the 0 msec-lag condition with the signal being presented at 70 dB HL through headphones. The recorded material was routed through a two-channel audiometer. Subjects were asked to repeat what is heard in both ears. Both single correct and double correct scores were recorded.

The Speech-In-Noise Test (SPIN): The Speech-In-Noise test was administered using the wordlist of the "Monosyllabic Speech Identification Test In English For Indian Children" (Rout, 1996) in the presence of background speech noise. The signals were presented monotonically to each ear at 0 dB S/N ratio at 60 dB HL. A recorded version of the speech test was used. An oral response was obtained from the children. Each ear was tested independently. The percentage of correct responses was noted.

Duration pattern test: The Duration Pattern Test was presented at 40 dBSL using the Audiolab version-II software. The stimuli were routed through a two-channel audiometer. Each ear was tested independently with thirty stimuli. The listener was instructed to indicate the pattern of the sounds presented in terms of their length. The percent correct score for each ear was computed.

Auditory Sequencing Test: The auditory sequencing test in English, which has been developed as part of the project titled "Effect of auditory stimulation of central auditory processes in children with CAPD" by Yathiraj and Mascarenhas (2002-03), was used to determine the auditory sequencing abilities of the children. The test uses material from the "Monosyllabic Speech Identification Test In English For Indian Children" (Rout, 1996). Twenty items were developed with four items as practice items and sixteen test items. The test was scored for sequencing and recall. For the present study, only the sequencing score are considered. The final score was calculated as a percent score. The signals were presented at a comfortable loudness level through the speakers of a computer. The children were .instructed to repeat the words in the correct order. The responses were scored as recommended in the test.

Results And Discussion

The results obtained from the experimental group and the control group with the SCAP and the diagnostic tests were tabulated. Statistical analysis was carried out for the following:

I. The chi square test for the significance of difference was computed for the scores obtained with SCAP and with the detailed diagnostic assessment for the experimental group.

II. The t-test for the significance of difference was carried out between the control and experimental group for Duration Pattern Test (DPT) Speech-in-noise Test (SPIN) and Auditory Sequencing Test (AST)

III. Comparison of the Dichotic CV with the normative data

I. SCAP versus Diagnostic tests

Table 1: Significance of difference between SCAP and the Diagnostic tests for the control group

SCAP	Diagnostic tests	X2
42.30	40.84	2.85 **NS***

1.67	1.18	NS*

*NS Not significant at 0.01

The scores obtained for the SCAP were computed into a percent score. Similarly for ease of statistical computation the scores of the behavioural diagnostic tests were also converted to percent scores. The mean percent score was calculated for the behavioural diagnostic tests. The Chi square test for the significance of difference was calculated between the SCAP and the behavioural diagnostic tests. The results revealed that there is no significance of difference for the two tests at one degree of freedom. This indicates that the SCAP was as effective in correctly identifying those children with APD as were the diagnostic tests. The SCAP took not more than two minutes to be answered by the school teachers. Hence, it would be a useful and quick method to screen children who might have an APD. It is best that a teacher who is familiar with the class performance of the child answer the checklist.

II. Control versus experimental groups for DPT, SPIN and AST

It was not possible to test all of the 8 subjects for the 4 tests since four children did not report back for testing. Hence, only four children out of eight were tested for the DPT and AST. Three of the four subjects tested with all the diagnostic tests (DPT, SPIN, AST, Dichotic CV) failed them all. Three of the remaining four children who were evaluated with SPIN and Dichotic CV failed both, while one passed both. Three of the four subjects tested with all the diagnostic tests (DPT, SPIN, AST, Dichotic CV) failed them all. Three of the remaining four children who were evaluated with SPIN and Dichotic CV failed both, while one passed both. The means and standard deviation for the scores obtained for the DPT, SPIN and AST were computed for the experimental group and the control group. The t-test for the significance of difference revealed a significant difference at the 0.01 levels between the two groups for all the three tests as can be seen from Table 2.

Table 2: Mean, SD and t-value for the significance of difference between the experimental group and the control group for the DPT, SPIN and AST

Tests	Groups	Number	Mean	SD	T Value
DPT	Experimental	4	54.25	9.39	-3.111*
	Control	8	74	10.75	
SPIN	Experimental	8	50.25	12.06	-5.946*
	Control	8	80.50	7.83	
AST	Experimental	4	3.12	3.32	-6.148*
	Control	8	14.06	2.70	

* Significant at the 0.01 level

The results are in accordance with studies conducted by { Musiek (1984) and""" Musiek and Baran (1981) cited in cited in Chermak and Musiek , 1997 }who also found that children with APD performed poorly in temporal ordering tasks when compared with normal children. {Katz and Burge (1971) cited in Katz, 2002} found a large percentage of cases with APD had difficulty when faced with a speech-in-noise task whether it was dichotic or diotic. {Apel and Swank (1999) and Nittrouer (1999) cited in Chermak and Musiek , 1997 } reported that children with reading and writing difficulties have poorer working memory. Similar findings have also been found in the present study where all four children who were evaluated had poor auditory sequencing abilities.

111. Performance on Dichotic CV

Table 3: Means and SD for Dichotic CV in the present study and for the norms

Group	Mean	SD
Experimental group	7.23	5.39
Norms (Krishna & Yathiraj, 2001)	14.24	4.25

The Means and SD for the Dichotic CV test obtained for the experimental group was compared with the normative data of Krishna & Yathiraj (2001). The results indicate that the scores obtained fell well below those obtained by Krishna & Yathiraj (2001). The variability was also more in the present study. Berlin (1983 cited in Katz, 1985) also noted that patients with confirmed brain lesions as well as children with APD perform poorly when double correct responses were calculated.

Conclusion

The present study indicates that with the use of the Screening Checklist for Auditory Processing (SCAP), in children who possibly have an auditory processing problem can be quickly and easily identified. The fact that there was no significant difference between the SCAP and the diagnostic tests substantiates its utility.
The diagnostic tests run on the experimental group highlights that not all children who fail the SCAP have identical results on the diagnostic tests.

The present study indicates that children who fail on the SCAP should be evaluated on a battery of tests that identify different processing deficits. These diagnostics tests would enable develop a profile of the auditory processing problems of each individual child. Not all children identified as having APD have identical auditory processing profiles. This profile of each child would help in further management.

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