INTRODUCTION
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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 organizes and interprets sensory data he has received, on the basis of his past auditory experiences". The process that take place beyond the level of the VIIth 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 Perception" (Williamson & Alexander, 1975) (Cited in Williford & 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 Williford & 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. "Auditory processing involves 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 signals" (Lasky & Cox, 1983). Stark & Bernstein (1984) define it as "the neural processes involved in obtaining information 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 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 behaviour". "CAPD or APD is a general breakdown in auditory abilities resulting in diminished learning (e.g. comprehension) through hearing, even though peripheral auditory 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 limitations 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 of 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 agnosia, 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 overcome 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.