AUDITORY PROCESSING IN CHILDREN WITH HISTORY OF OTITIS MEDIA

Amala Agnes James

Reg. No. MSHM0101

A Dissertation Submitted in part fulfillment of Final Year M.Sc. (Speech and Hearing), University of Mysore, Mysore.

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MANASAGANGOTHRI
MYSORE - 570006

May - 2003

Dedicated to

My best friend
Jesus Christ.....
Silent Companion through
my lonely days

CERTIFICATE

This is to certify that this Dissertation entitled **"AUDITORY PROCESSING IN CHILDREN WITH HISTORY OF OTITIS MEDIA"** is a bonafide work in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student (Register No. MSHM0l0l).

Mysore

May, 2003

Dr. M. Jayaram
Director
All India Institute of Speech and Hearing
Mysore - 570 006

Certificate

This is to certify that this Dissertation entitled **"AUDITORY PROCESSING IN CHILDREN WITH HISTORY OF OTITIS MEDIA"** has been prepared under my supervision and guidance. It is also certified that this Dissertation has not been submitted earlier in any other University for the award of any Diploma or Degree.

Mysore

May, 2003

Asha Yathiraj

Dr. Asha Yathiraj
Reader and H.O.D.
Department of Audiology
All India Institute of Speech and Hearing
Mysore - 570 006

DECLARATION

This Dissertation entitled **"AUDITORY PROCESSING IN CHILDREN WITH HISTORY OF OTITIS MEDIA"** is the result of my own study under the guidance of **Dr. Asha Yathiraj,** Reader and H.O.D, Department of Audiology, All India Institute of Speech and Hearing, Mysore and not been submitted earlier in any other University for the award of any Diploma or Degree.

Mysore,

May, 2003 Reg. No. MSHM0101

ACKNOWLEDGEMENT

I express my sincere gratitude to my guide and my teacher Dr. Asha Yathiraj, HOD, Department of Audiology, for her constant support and guidance throughout this project.

I am thankful to Dr. M. Jayaram, Direaor, All India Institute of Speech and Hearing, Mysore for permitting me to carry out the study.

I thank Acharya Sir, for helping me out with the statistical analysis.

I thank Animesh Sir, Joby Sir and Kavita for helping me in the data collection.

I thank all the subjects who co-operated in the testing.

A special thanks to Demonstration School authorities and Gangothri School authorities for helping me in the data collection.

Appachan and Amma - Because of your blessings and support, I could grow till here.

Vimala Chechy, Thomaskutty, Chettan, Nirmala Chechy, Simon Chettan, Susan Chechy and Biju Chettan - I am lucky to have sisters and brothers like you - warm, wonderful and caring.

Angela - We share a special relationship. When I laugh, you laugh... when I cry, you cry....

Alphi, Amal, Jim, Alen, Maria and Lia-I love you all.

When I look back over the years,
There are a few people.
Who stand out in my mind,
The ones who have been
Truly significant in my life.
You are one of those
Very special people.

Rakhi - You are the kind of friend who has always given me a helping hand, when the going was rough. Ill always appreciate you for what you are and you will always be a permanent part of me.

Chandni, Mammu, Sandeep and Savitha -Though times may change and years may pass, one thing will never end ... . The special joy 111 always feel because you are my friend.

Kripal and Kunda -I am glad we are friends.

Delcy - Thank you for being with me, whenever I needed help.

Vimi - Some one who listens well and tries to understand, some one with cheering word, whenever spirit needs lift.

Vandana, Mili, Jessy, Rajani, Deema, Amy, Pooja, Mili, Regisha and **Shereen -**Enjoyed being with you.

Majun and Joshila - I am pretty lucky to have your care and affection.

I thank all my classmates for the moral support you have given me.

My sincere thanks to Softouch computers for doing the typing neatly.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The world is full of obvious things which nobody by any chance ever observes.

Arthur Conan Doyle.

Otitis media with effusion (OME) or middle ear disease, is one of the most common illnesses in young children (Northern & Downs, 2002). The widespread existence of recurrent otitis media (OM) and associated conductive hearing loss in children who are at a critical age for acquiring speech and language has recently received considerable attention. This is because of its possible relation to auditory processing and linguistic development (Clarkson, Eimas & Marean, 1989).

The first two to three years of life is generally recognized as a "critical period" for the development of speech and language. If otitis media is undetected for at least six months during infancy, the child will ultimately be handicapped because of a lack of structured auditory stimulation during critical period (Gottlieb, 2002).

Downs (1977) suggested that fluctuating conductive hearing loss during the critical period results in syndrome-like condition and she referred to it as an "Irreversible Auditory Learning Disaster". This in turn may adversely affect normal language development or may later give rise to learning disabilities.

Currently, OM-related conductive hearing loss is regarded by many as a form of auditory deprivation that involves periods of hearing loss (Clarkson, Eimas & Marean, 1989). The hearing loss caused by otitis media may range from negligible to 50 dB. The loss is worse in the lower frequencies at first. As fluid accumulates the hearing loss affects perception at all frequencies (Northern & Downs, 2002).

Normally speech is received at the cochlea at an average of 40-60 dB sound pressure level. Due to a conductive hearing loss, speech sounds reach the cochlea at about 10 dB or less, above the threshold. The speech sounds at the extremes of the frequency spectrum are weakest in intensity, and many of these sounds will be lost to the child with otitis media. The most vulnerable sounds are the stops, nasals and fricatives - the consonant sounds which carry much of the speech message. This situation would deteriorate further if the child were in a noisy environment. These features are important, not just to develop age appropriate lexical knowledge, but also for the development of a complex language structure. Deficiencies in detection of these transients may result in delayed acquisition of appropriate morphology and sentence structure (Bamford & Saunders, 1991).

One of the first reports on the developmental effects of early ear disease was made by the psychologist working with language learning problems (Eisen,1962, cited in Northern & Downs, 2002). He identified a child with auditory learning difficulties who had a history of otitis media in early childhood, starting in infancy . The child had normal hearing at the time of testing. He blamed the early otitis media for causing irreversible auditory language learning problem. He proposed a new syndrome called "quondam hard-of-hearing child" (at one time hard- of-hearing).

Needleman and Menyuk (1977, cited in Needleman, 1977), identified 20 children age 3-8 years with recurrent serous otitis media that had begun between birth and 18 months and continued for at least two years. They found the otitis media group to score significantly lower than the non otitis group in production of phonemes and words, in production of phonemes in connected speech, in the use of combinations of phonemes and word endings, and in varying morphologic contents. She pointed out that the phonologic skills that were deficient were necessary for reading skills and this fact may account for the educational retardation of the children who had early otitis media.

The impact of early otitis media on linguistic development remains an unresolved issue. Research in this area has yielded equivocal findings, which may be attributed to a variety of methodological limitations (Ventry, 1980). Hence, although many investigators have reported adverse effects of OM on speech and language development (Holm & Kunze, 1969, cited in Menyuk, 1979; Wallace, Gravel, Carton & Ruben, 1988), others have not found any adverse effects (Roberts, Burchinal, Davis, Collier & Henderson, 1991; Grievink, Peters, Bon & Schilder, 1993). Apparently, evidence of deficits in auditory perception after early otitis media effusion is not conclusive.

Objective of the study

The main objective of the study is to evaluate the auditory processing abilities in children with early histories of otitis media using the following tests:

- Duration pattern
- Recognition of speech-in-noise
- Dichotic CV

Further, using a questionnaire, the scholastic performance of the children will be determined.

Need for the study

Research on the auditory perception of children with early childhood otitis media, reveals that they may have auditory perceptual problems later in life (Holm & Kunze, 1969, cited in Menyuk, 1979; Needleman & Menyuk, 1977, cited in Needleman, 1977; Sak & Ruben, 1981). However there are studies that contradict this finding (Roberts, Burchinal, Davis, Collier & Henderson, 1991; Grievink, Peters, Bon & Schilder, 1993). Hence it is necessary to determine whether early history of otitis media would have an adverse effect on auditory perception or not. Further, Gupta and Khanna (1999) reported that there are 35 million episodes of acute otitis media annually among 70 million children in India by the age of 3 years. If early otitis media is found to have an adverse affect on the auditory perception of children, then appropriate measures need to be taken to prevent the occurrence of the condition or appropriate remedial measures need to be taken. Hence, there is a need to see if the presence of an otitis media in early infancy has any adverse affect in auditory perception and in school performance.

REVIEW

Otitis media with effusion occurs most frequently in early childhood. When a child has otitis media with effusion (OME), fluid is present in the middle ear cavity, which can persist for several weeks or even months after the onset of an OME episode (Roberts, Dollaghan, Schwartz, Gravel & Hunter, 2001). The presence of fluid in the middle ear generally results in a hearing loss. As the ear volume in the middle ear decreases, the stiffness of the ear drum increases and the sensitivity to low frequency sound decreases. This hearing threshold further deteriorates across all frequencies, as the air in the middle ear cavity is replaced by fluid (Bamford & Saunders, 1991).

Conductive hearing loss may impair auditory perception of speech. Hence, children with recurrent bouts of middle ear disease during the first year of life may be considered to be at risk for delayed language development (Harsten, Nettelbladt, Schalen, Kalm & Prelliner, 1993). Northern and Downs (2002) considered the first year and a half as the most critical period for speech and language development.

According to Katz (1978), a conductive hearing loss is like an ear plug in that it restricts the sounds of the environment from stimulating the cochlea, thereby depriving the auditory system of normal activity. The effects of deprivation, may be far reaching and no doubt involve the retrocochlear system and the brain. The greater the hearing loss and the longer the period of deprivation the more extreme the retrocochlear signs. Even after the mechanical blockage has been removed, abnormal auditory function may persist. The adverse effects of OME in central auditory processing abilities can be attributed to the fluctuating hearing loss over the period of time when the auditory nervous system is immature. This may results in a permanent dysfunction (Keith, Lawless & Cotton, 1981).

Various authors have conducted research on the effect of conductive hearing loss on the different abilities of the individual. The following section reviews the effect of fluctuating conductive hearing loss on the following:

I. Auditory perceptual abilities

a. Sound symbol association

b. Perception of speech in degraded conditions

i. Effect of noise on speech perception

ii. *Effect of filtered speech on perception*

iii. Effect of time compressed speech on perception

c. ***Binaural interaction***

i. Rapidly alternating speech perception

ii. Effect on binaural fusion

iii. Effect on binaural MLD

d. Dichotic listening

e. Phoneme perception

II. Language abilities

III. Scholastic skills

I. Effect of fluctuating conductive hearing loss on auditory perceptual abilities

Various studies have been conducted to examine the effect of recurrent middle ear disease in early childhood on auditory perception abilities. The studies evaluate different auditory perceptual aspects such as sound symbol perception, perception of degraded speech, binaural interaction, dichotic listening and phoneme perception.

a. Effect of fluctuating conductive hearing loss on sound symbol association

Updike and Thornburg (1992) investigated the auditory processing ability in a group of 6-7 year old children who had atleast three episodes of middle ear disease during the first 3 years of life and compared them with a group of children who had no history of middle ear problems. All children had normal hearing thresholds at the time of testing. They administered the Goldman-Fristoe-Woodcock sound symbols test battery (GFW) which includes sound mimicry, sound recognition, sound analysis, sound blending and sound symbol association. The conductive hearing loss group performed significantly worse than normals on sound mimicry, sound analysis and sound blending. They suggested that the conductive hearing loss group did not perform upto their potential on the auditory perceptual tests, owing to their early exposure to chronic otitis media and assumed auditory deprivation. This finding is in agreement with that of Brandes and Ehinger (1981) who found children aged 7 to 9 years with a history of atleast three episodes of middle ear problems before the age of 2 years performed poorly on sound symbol perception tests.

Results of these investigations suggests that early middle ear pathology may produce secondary effects that can persist well beyond the episodes of temporary conductive hearing loss.

b. Effect of fluctuating conductive hearing loss on the perception of speech in degraded situations

The speech perception of children who had otitis media, has been investigated in various degraded conditions. The following section discusses the findings of these studies.

i. Effect of noise on speech perception

Normal ears can readily extract meaningful speech from background noise. This function is considered to be a central auditory phenomenon. Identification of speech-in-noise may reveal children with an auditory learning disability and reflects an inability to hear comfortably in the presence of ambient speech (Welsh, Welsh & Healy, 1996).

The relationship between bilateral OME at 2-4 years of age and performance at 7.5 - 8 years of age using speech-in-noise test was assessed by Schilder, Snik, Straatman and Broek (1994). The children were grouped according to the duration of bilateral OME at preschool age. A significant effect of OME was found on the speech-in-noise test. The children who suffered from OME at preschool age but who were free from this condition at a later age were able to compensate for early auditory deprivation. However, the children who experienced OME most persistently upto the age of 8 years showed a marked deficit in speech recognition in a situation of background competition. This indicates that maturation of this aspect continues after the age of four. Jerger, Jerger and Lewis (1981, cited in Schilder, Snik, Straatman &

Broek, 1994) came to similar conclusion in their study of development of speech perception in competitive conditions in children with otitis media.

Jerger, Jerger, Alford and Abrams (1983) described developmental functions for the Paediatric Speech Intelligibility (PSI) word and sentence materials presented in quiet and in competition for normal children and children with recurrent otitis media. The ages of the subjects ranged from 24 to 56 months. The age of OME onset ranged from 2 weeks to 36 months and the documented OME episodes per year was seven. In normal children, developmental functions for PSI speech materials showed earlier development of performance in quiet than in competition as well as early development for words than for sentences (competing condition). In children with otitis media, developmental functions were normal for both words and sentences in quiet and for sentences in competition. However, developmental functions were grossly abnormal for words in competition. In other words, their results suggested degradation of the acoustic phonetic information important to word understanding, but preservation of the global information important to sentence comprehension.

Further Jerger et al., (1983) found that children with recurrent OME in the age range of 24-26 months exhibited delay in the growth of PSI performance. The performance difference between quiet and competing conditions resolved with increasing age, however in the 39-56 months old group, the difference between performance in quiet versus competition was 0%. The authors concluded that recurrent conductive hearing loss appears to be associated with temporarily arrested development of word understanding in competition in some children.

In an early experiment Dobie and Berlin (1979) also found that specific aspects of speech cannot be perceived during episodes of otitis media. They analysed filtered speech waveforms to simulate the typical hearing loss (20 dB) of children with otitis media. Spectral analysis suggested degradation of brief utterances and high frequency information, but preservation of vocalic and temporal information. They found that brief utterances in connected speech such as 'are' and 'to' were likely to be lost. They suggested that plural endings and related final-position fricatives might not be heard. If the phonetic segments which are not perceived are also morphological markers, this imperception results in semantic ambiguity and cause confusion to the child who is acquiring semantic knowledge. This leads to wider consideration of the effects of hearing the phonetic units of speech inconsistently. This study indicates the components of speech which may be heard inconsistently both during attacks of otitis media and between attacks.

Similar findings have also been reported by Gravel and Wallace (1992), Moore, Hutchings and Meyer (1991) and Pillsbury, Grose and Hall (1991). They too found that the performance on competitive listening task was consistently affected by a history of OME.

Though it is evident from these studies that the recurrent episodes of OM during early childhood affect the speech perception in noisy situations, a few investigators could not find any deficits.

Welsh, Welsh and Healy (1996) investigated the long term effects of conductive hearing loss occurred during the first 4 years of life and persisted for 1 year. They noted little impairment in speech-in-noise test. The authors concluded that the long term impact of verbal recognition with the masking effect of simultaneous noise seems to be negligible.

Keith, Lawless and Cotton (1981) evaluated the perception of speech in noise in a group of children with documented middle ear effusion that required surgical treatment. Children were 7-9 years old and acquired OME between their second and fourth years of life. Results found no significant difference on the speech-in-noise test. The authors suggested that the children who receive effective medical or surgical care of their persistent OME may be less apt to acquire disorders of central auditory abilities, since their conductive hearing loss was minimized. Central auditory deficits may be more inclined to occur in otitis-prone children who acquire OME in the first few months of life when the auditory system is still developing.

It is evident from the above studies that the speech recognition in background competition is a task, very sensitive to auditory deprivation. While some studies do report of poorer performance in speech-in-noise test in children who had a history of OME, others do not. This can be due to variations in the age of onset of otitis media in the subjects, the duration of the problem and the treatment which they have taken.

ii. Effect of filtered speech on perception

The natural intelligibility of speech is degraded by limiting its frequency content. Such stimuli are perceived with difficulty by listeners with temporal lobe lesions. This test is thus employed in the assessment of central auditory dysfunction. However, a strong maturational effect and widely varying individual scores have been reported by Willeford (1977, cited in Bamford & Saunders, 1991). It is thus difficult to use this measure as a measure of neuromaturational ability (Bamford & Saunders, 1991).

Various investigators have used the filtered speech material to evaluate the auditory processing abilities in children who had early history of otitis media. The results varies depending upon the material used in the study.

It is reported that in a test using speech material with attenuation in the higher frequency, subjects who had history of OME before the age of 4 years demonstrated poor performance. 51% of the subjects failed in the particular test. The authors proposed that as a consequence of the middle ear disease, there is a sufficient deleting of sound image, particularly related to the less intense components which permanently results in an incomplete verbal image in the central area of reception and auditory skills (Welsh, Welsh & Healy, 1983).

It is hypothesized that children with OME who were adequately treated, may exhibit only temporary delay rather than permanent deficits in auditory abilities. Keith, Lawless and Cotton (1981) confirms this hypothesis by administering low-pass filtered speech (filtered at 1kHz with an 18 dB/octave rejection rate) monaurally at 50 dBHL to a group of children in the age range of 7-9 years, who underwent surgical treatment for OME. The children acquired OME between the 2-4th years of life. Children in the age group of seven years, performed poorer than the normal children in the control group. In contrast, the children in the age group of nine years performed similar to the children in the control group.

Schilder, Snik, Straatman and Broek (1994) were not able to demonstrate a significant difference between the subjects with a history of OME (during the age 2-4 years) and the normal control group on a low pass filtered speech test. For the test, selected monosyllables were low pass filtered with cut off frequency of 1kHz and a slope of 24 dB per octave. The test was administered when the children were 7.5 - 8 years of age. This finding is contrary to that reported by Keith, Lawless and Cotton (1981).

Although the studies are not conclusive, most of the studies indicate that subjects who had an early history of otitis media may have difficulty in integrating the speech components and to perceive the high frequency components of speech, i.e. consonants.

iii. Effect of time compressed speech on perception

In this task speech is "speeded up" but with the frequency factor held constant. Accelerated speech at 60% is usually recognized without difficulty in normally functioning ears, but persons with central auditory pathway disorders find difficulty to recognise the accelerated speech (Bamford & Saunders, 1991).

Studies have indicated the negative impact of OME on the ability to understand time altered speech. Welsh, Welsh and Healy (1996) utilized the test developed by Beasley, Schwimmer and Rintelmann (1972) and evaluated monaural compressed speech in children of the age range 6-11 years who had OME during the first 4 years of life which persisted for at least one year. This test contained CNC (consonant-nucleus-consonant) monosyllabic words. Spectral components were intact without frequency distortion. Only the duration of exposure was modified. The subjects exhibited a statistically significant deviation from the normative data on compressed speech. From this study it can be noted that children with early history of OME many find difficulty in situations where rapid processing is essential.

c. Effect on binaural interaction

Binaural interaction can be assessed through different tests like binaural fusion test, rapidly alternating speech perception test and binaural masking level differences.

i Rapidly alternating speech perception (RASP) test

This test relies upon the shifting of verbal stimulus from one ear to the other several times in a time frame of one second, thereby exposing the perceptual ear to time limited incomplete sound package of information. The rapidly alternating sentence task itself requires mature processing of syntax in conjunction with an auditory memory load, making it primarily a test of language maturity (Bamford & Saunders, 1991).

Welsh, Welsh and Healy (1983) reported that this test is insufficiently challenging to identify a problem, since 90% of their subjects who had intermittent history of OME passed this test. Further, they commented that the deficit is sufficiently subtle that it does not appear due to the competence of the system. Their data did not suggest a central hearing deficit. Most of their subjects developed OME beyond 2½ years and the author's data do not give information about duration of conductive hearing loss. They speculated that there is a direct temporal relationship to the degree of disability and that short intervals of conductive hearing loss interspersed with longer periods of normal hearing may be inadequate duration to effect a central disorder.

ii. Effect on binaural fusion

The speech signal presented to the subject is split in such a way that neither portion contains sufficient part of the speech spectrum to allow recognition. When both portions are presented simultaneously, one to each ear, the message is 'fused' to give a representation of the whole. This test requires the central interaction and integration of incomplete verbal stimuli (by frequency separation) presented bilaterally (Mueller & Bright, 1994).

Schilder, Snik, Straatman and Broek (1994) evaluated the binaural interaction in Dutch children in the age range of 7.5 - 8 years who had OME at 2-4 years of age. They band-pass filtered the Dutch PB lists in two ways: (1) One band with central frequency of 400 Hz, a bandwidth of 100 Hz and a slope of 12 dB per octave; and (2) another band with a central frequency of 200 Hz, a band width of 220 Hz and a slope of 12 dB per octave. The low frequency band was presented to one ear and the high frequency band to the other. The scores of this test showed that early persistent OME has an adverse effect on auditory perception. However, it was not statistically significant. All the children in the study had received necessary medical and educational intervention. This factor may have obscured some effects of OME that could well surface in less privileged societies.

Welsh, Welsh and Healy (1983) reported a severe impairment in the binaural function in a group of children at age 7.5 - 8 years who had a history of OME before the age of 4 years. 77% of the subjects failed in that particular group.

Thus it can be concluded that early history of OME has an adverse effect on the binaural integration at later ages. However, with the use of appropriate intervention, the problem can be reduced.

iv. Effect on binaural masking level difference (MLD)

The phenomenon of masking level difference is a binaural effect, which facilitates selective listening to a specified signal in a noise background. The phenomenon occurs when the phase relationship of a signal presented to the two ears is different to that of a noise simultaneously presented to the two ears (Schoeny, & Talbott, 1994).

The binaural hearing of children with and without history of otitis media of age 8.3 years has been determined by Moore, Hutchings and Meyer (1991) through assessing their binaural MLD's. The children had more than 5 episodes of OME before the age of 5 years. Some children in the OM group had small (15-25 dBHL) sensitivity deficits in one or both ears. The mean binaural MLD of the OM children was significantly lower than that of non-OM children. The result was consistent with the hypothesis that auditory experience in early life can modify binaural processing in the human brain. The developmental disorders experienced by OM children may be the result of neurological changes within the primary central auditory pathway. The authors suggested that the small binaural MLDs in the OM group may be associated with these children having difficulties detecting and attending to signals in noisy environments.

Pillsbury, Grose and Hall (1991) investigated MLD in a group of children having no known history of ear disease and a group of children having a history of otitis media with effusion and hearing loss. In the OME group MLDs were measured both before and 1 and 3 months after the placement of pressure equalization tubes. The MLDs were often abnormally small in the OME group after surgery, when hearing loss was present. Significantly, MLDs sometimes remained abnormally small after surgery even after hearing returned to normalcy.

Hogan, Meyer and Moore (1996) retested the MLD in two groups of teenagers who were originally tested 6 years earlier. Members of one of these groups had atleast 5 episodes of OM before the age of 5 years. The other group had no known history of OM. The mean MLD of the OM group, at 6-12 years of age, was significantly lower than that of the controls. The same subjects at ages 12-18 years, were tested and authors found no difference between the mean MLDs of the OM and control groups. These results show that the reduced MLD that occurs following OM in infancy can recover in later childhood.

Other researches have also reported that MLD recovers to normal level before or during the teenage years in subjects who had recurrent OME in early childhood (Stephenson, Higson & Haggard, 1995; Hall, Grose & Pillsbury, 1995).

Research has shown that the mature cerebral cortex is capable of reorganization in response to lesions of the sensory, periphery or to changes of sensory experience. Some of this reorganization takes place immediately, but the major effects seem to require several weeks to months or even years of altered sensory input to appear (Moore 1994, cited in Hogan, Meyer & Moore, 1996).

The effect of early asymmetric hearing loss in children (between the ages 2 and 4 years), owing to OME, on binaural hearing was assessed by Stollman, Snik, Schilder and Broek (1996). All children had normal hearing at the time of testing and they were about 12 years of age. They reported that children's MLD values were within normal range. Their study too did not support the presence of long term auditory processing deficits induced by early asymmetric OME. There is a possibility that they have evaluated the children after the recovery to normalcy which has been reported by Stephenson, Higson and Haggard (1995) and Hall, Grose and Pillsbury, (1995).

Stollman et al., (1996) explained that OME in most cases cause a fluctuating conductive hearing loss, which indicates that there is an intermittent, partial auditory deprivation of the impaired ear. Binaural stimulation via bone conduction (eg. own voice) can have effects on auditory deprivation due to a conductive hearing loss. The average hearing loss with otitis media is typically 20-40 dB HL which means that some auditory input of extraneous sounds is possible, although binaural hearing will probably be compromised. Finally, the time between the period with OME episodes and the actual testing time was fairly long in this study. According to the authors, the effects of early OME on auditory processing have been found in short term evaluations but to a lesser degree on a long term.

In general, the difficulties seen in OM group in detecting and attending to signals in noisy environments can be attributed to small binaural MLD's in them.

d. Effect of fluctuating conductive hearing loss on dichotic listening tasks

Dichotic listening test have been used to study language processing in the brain and has gained a reputation as a valid and reliable measure of hemisphere specialisation and language lateralization. The typical performance pattern is a right ear advantage (REA) for verbal stimuli and a shift to left ear advantage (LEA) for non verbal stimuli such as emotion content and musical instruments. It is also a valid procedure for the assessment of auditory selective attention (Bryden, 1988).

Research has shown that early hearing deficits may effect the development of the receptive language centre, resulting in a larger and more developed area for verbal processing. This is evident from the study of Klausen, Moller, Holmefjord, Reiseter and Asbjornsen (2000). They assessed the lasting effect of early bilateral OME on dichotic listening performance in 19, nine year old children. All children had been treated for OME with ventilation tubes. 15 of them were right handed. The test material consisted of six stop consonants (b, d, g, k, t, and p) combined with the vowel to create six CV syllables, (ba, da, etc). The syllables were combined to make 36 CV syllable pairs. The syllable pairs were presented simultaneously in both ears, one sound in each ear. Each child was presented with three tasks, i.e., free recall (FR), attention right (AR) and attention left. Results indicated that children in the OME group showed a more pronounced right ear advantage than the controls, but a lack of attentional modulation, when tested with dichotic listening tests compared with the control group. Although the study was small, they found lasting effects of OME on the ability to perceive and focus attention on auditory events.

In an earlier study, Schilder, Snik, Straatman and Broek (1994) were not able to demonstrate a significant effect of early OME on dichotic listening tests. They administered dichotic speech tests in a group of Dutch children of the age 7.5 - 8 years. They had OME at 2-4 years of age. They presented a series of 2x3 monosyllable words with simultaneous onset times dichotically. Children with a history of persistent OME performed poorly but the difference was not significant. The authors explained that since the onset of OME was between 2-4 years of age, the auditory system would have developed before this age and this reduced the adverse effects of OME. The importance of first few months of life has also been reported by Keith, Lawless and Cotton, (1981).

A few researchers have examined binaural integration, using the staggered spondaic word test (SSW). Keith, Lawless and Cotton (1981) administered 49 items of SSW to a group of children who had undergone medical treatment for OME in early life. They presented the signal at 50 dBHL. The results indicated that there was no significant difference between the experimental and the normal group. The results indicate that there may not be any auditory perception problems in children who are adequately treated for OME in early life.

e. Effect of otitis media on phoneme perception

History of poor hearing in children with otitis media may lead to poorly established phonological representations. This inturn, could negatively affect their ability to identify and discriminate between speech sounds. Additionally, weak phonological coding abilities may result in poor lexical organization, which could be manifested in difficulties with word retrieval and semantic processing. Two experiments on the effect of speech perception in short term verbal memory in children with and without history of bilateral OME during the first year of life was investigated by Mody, Schwarts, Gravel and Ruben (1999). Children were tested at the age of 9 years and all had normal hearing at the time of testing. They examined the influence of phonetic features similarity on short term memory using four nonsense syllables |sj|, |zj|, |kj| and |gj|. The stimuli were presented in pairs and the children were required to repeat the paired syllables. The results indicated that the error patterns were similar for both groups. It suggests that their general coding and retrieval of these stimuli were comparable. The more frequent transposition of phonetic information by the OM-positive group suggests that their phonological coding of the items was less firmly established than that of the OM-negative group. The poorer attention and recall of the stimulus items by the OM-positive group suggests that these children had representations that were under-specified in working memory, which would make them relatively insensitive to phonetic characteristics of stimuli.

In the second experiment, Mody et al., (1999) investigated whether the poorer performance of OM-positive children noted in the previous experiment was on account of their weaker encoding of phonetic distinctions or a failure to recall the temporal order of the stimulus items. They used four synthetic speech syllables, |ba|, |da|, |sa| and |ʃa| for identification and temporal order recall tasks. The stimuli were presented in syllable pairs. The procedure consisted of three tasks: an identification training task, a temporal-order-judgement task with a long inter stimulus Interval (ISI) (400 msc) and the temporal-order-judgment task at short ISI (100, 50 and 10 msc). Both the OM positive group and OM negative group made more errors when the syllable pairs were differentiated by only one feature - place of articulation |ba| - |da| and |sa| - |ʃa|. They made almost no errors in their identification and temporal order judgements when speech token pairs were differentiated by multiple features (i.e. |ba| - |sa| and |da| - |ʃa|). The overall weaker performance of the OM positive group indicates that they are less accurate than OM negative group in their coding of phonetic feature distinctions in working memory.

Both groups found |sa| - |ʃa| to be a harder contrast than |ba| - |da| on the identification task. This difference in performance on |sa| - |ʃa| relative to |ba| - |da|

was greater for the OM positive group than for OM negative group on the temporal-order-judgment task at the long ISI. The hearing loss associated **with otitis media** may make the discriminability of a pair of voiceless sounds like |sa| - |ʃa|, differing only in place of atriculation, more difficult than a voiced placed contrast (|ba| - |da|) for a listener. This findings are supported by Dobie and Berlin's study (1979) which points to the vulnerability of high frequency low intensity sounds with regard to hearing loss associated with OM.

Deficits at the level of phonological processing and verbal working memory can have consequences that extend to higher linguistic levels. An inability to store unfamiliar sound patterns while more permanent records are being constructed could disrupt the phonological loop in working memory and thereby affect a child's ability to learn new words (Gathercole & Baddeley, 1993, cited in Mody, Schwartz, Gravel & Ruben, 1999).

Roberts, Dollaghan, Schwartz, Gravel and Hunter (2001) reported that children with OM had particular difficulty in processing speech sound categories that have little energy such as the voiced stop consonants (|p|, |t| and |k|) and strident sounds (|s|, |sh| and |th|) since threshold shifts from 0 to 20 or 30 dB can affect perception of these sounds. They observed that at ten months of age, children who had more episodes of OME had more bilabial consonants and fewer fricatives than children without an OME history. At two years of age, children with OME had more variety of consonants at all positions and more consonant-vowel-consonant productions than children without OME history. The authors suggested that the speech and language deficits associated with OME may be subtle and may appear to have no clinical implications for some children. However, for vulnerable children, atypical early auditory experience may possibly have significant impact on language acquisition.

The ability of 5 years old children to perceive differences in voice onset time (VOT) was investigated by Clarkson, Eimas and Marean (1989) in naturally produced speech. Three groups of children whose hearing was within normal limits at the time of the experiment were tested on identification and discrimination tasks. The first group had children with normal language abilities and no history OME. The children in the second group had histories of severe, recurrent OME but normal language abilities and the third group had children with histories of severe OME and delays in the acquisition of linguistic competence. The stimuli were two sentence - "She is not thinking of the BATH (PATH)". The final words, BATH and PATH were excised from each sentence and used to form a series of stimuli that varied in VOT. The children had to discriminate as well as identify the material. They reported that compared to the control group, the third group showed marked difference in their ability to identify and discriminate speech patterns. Their perception was less categorical, as well there was less of peak in the discrimination function at the region of the phoneme boundary. The performance of the second group fell between the other two groups with deficits being more pronounced in the discrimination task than in the identification task. The results shows that a history of severe, recurrent OM during the early years of childhood markedly interferes with the processing of voicing information in young children afflicted with more language disabilities. This is true despite the absence of any permanent conductive hearing loss. The results supported the idea that episodes of OM can produce periods of sensory depivation that alter the perceptual abilities.

Though, the adverse effects of OME on different auditory perceptual abilities are not conclusive, it is evident from the review that frequent history of otitis media before the age of one year results in different auditory processing deficits. Therefore history of early OM may have long term effects that place a child at risk for poor academic performance.

II. Effect of early OME on language skills

Otitis media during infancy may interfere with certain prelinguistic skills that are critical to the normal development of linguistic abilities at later ages. Recent research indicates that there are dramatic changes in speech perception abilities during prelinguistic period, as the infant moves from language general to language-specific processing of speech. These developmental changes in speech perception abilities are fully dependent on appropriate auditory input (Rvachew, Slawinski, Williams & Green, 1999).

The effect of OME on emerging language was examined in a group of one year old children by Wallace, Gravel, Carton and Ruben (1988). Outcome measures at one year include the Bayley Scales of Infant Development and Sequenced Inventory of Communication Development Receptive and Expressive Scales. No significant difference was detected on the receptive scale. However, the otitis positive group exhibited significantly lower expressive language scores than the otitis free group. It suggests that impairments in language expression may be evident as early as one year of age in children with OM.

Rvachew, Slawinski, Williams and Green (1999) investigated the impact of OM on the development of canonical babble in children who experienced atleast one episode during the period birth through six months of age, in comparison with children who did not have OM during this period. The results showed a consistently lower rate of canonical syllable production among children with early onset OM, when compared to children with later onset OM, during the period 6 through 18 months of age. In addition, a relationship between canonical babbling ability and expressive vocabulary size was observed at 18 months of age. This study demonstrates that early-onset OM has an impact on phonetic development during infancy.

Finitzo and Friel Patti (1987, cited in Menyuk, 1992) studied infants from 6 months-36 months. They reported a minimal response level of 32 dB for children with OM at 500 Hz and 2 kHz. Some of the infants in the study could hear the pure tones but could not localize them. They hypothesized that even when long standing OM resolves, the affected infant may have difficulty in responding to and localizing sound in the environment.

The same researchers in 1990, reported that at 18 and 24 months both receptive and expressive, language scores were significantly related to hearing at 6 to 18 months of age. Further, it was found that within this population hearing thresholds for infants from 6 to 12 months of age were significantly related to receptive scores at 12 months of age. At 18 and 24 months both receptive and expressive scores were significantly related to hearing at 6 - 18 months of age. Hearing, in turn, was related to frequency of occurrence and the duration of otitis media.

It is been reported that children who had histories of OME did not parallel their peers in phonological production at age three (Paden, Matthies & Novak, 1989, cited in Menyuk, 1992). They had inadequate production of velars, liquids, consonant clusters, and postvocalic singleton obstruents (syllable final or word final consonants). These are sounds in positions in words where the energy is reduced.

Many researchers could not establish a significant relationship between early OME experience and later language development (Roberts, Burchinal, Davis, Collier, & Henderson, 1991; Gravel & Wallace, 1992; Harsten, Nettelbladt, Schalen, Kalm & Prelliner, 1993; Grievink, Peters, Bon & Schilder, 1993).

The difference in the results can be due to variations in the test used and depends on whether they have taken treatment for OM or not. The tests may not be sensitive to assess the patterns of language deficits that accompany prolonged OME in early childhood.

Even though controversy exists we can conclude that children who had history of early OME are at a high risk for sustaining delays in the acquisition of spoken language and may be impeded in the acquisition of educational skills requiring age appropriate linguistic competence (Bamford & Saunders, 1991).

III. Effects of OM on scholastic skills

Learning process deficits are thought to be major factors in learning disabilities. Speech and hearing problems among the learning disabled are taking their place with reading deficiency as one of the central intellectual problems exhibited by the learning disabled child. One specific contributing agent to such problems may, for some children, be middle ear infections during the early phase of language learning. Such infections could irreversibly disrupt development (Masters & Marsh, 1978).

Holm and Kunze (1969, cited in Menyuk, 1979) suggested that the fluctuations of hearing acuity during the developmental period when language is being acquired was enough to produce language problem that later affected academic achievement.

It was reported by Masters and Marsh (1978) that 25% of learning disabled students showed evidence of middle ear pathology based on impedance audiometry results.

In 1956, the Scottish Council for Research in Education published results of a study on over 300, 11-12 years old children with histories of middle ear disease, who showed evidence of significant educational retardation compared with children with histories of normal hearing (quoted by Ling, 1972, cited in Bamford & Saunders, 1991). Ling (1972, cited in Bamford & Saunders, 1991) himself showed children with middle ear disorders to be retarded by about one year in the skills of reading and mathematics.

The relationship between early otitis media status and later academic performance was assessed by Gravel, Wallace and Ruben (1995). Fourteen children aged 6 years received screening for educational risk status and formal measures of academic performance. These children had been followed prospectively from birth for their otitis media status. Seven children had otitis media (recurrent episodes bilaterally) at the age of one, while the other seven were considered otitis free. Academic status was related to early hearing acuity (as determined by repeated ABR assessment). The otitis media group and otitis free children in this sample did not differ on standard measures of beginning reading and mathematical skills. However, differences in abilities underlying reading (visual - auditory learning) and in teacher's ratings of children's competence in academic skills and overall school functioning were noticed.

Dalzell and Owrid (1976) reported that children with history of OME had less problems in academics by the time they reached secondary school but their problems had by no means completely disappeared.

In general these findings suggest an important relationship between hearing acuity in the first year of life and later academic performance. It appears that children with poorer hearing, secondary to frequent OM episodes in early life are at risk for academic difficulties, particularly in skill areas that are dependent on auditory - attentional abilities.

It can be construed that early OM affects hearing sensitivity and as a consequence affects later ability to attend to and / or process auditory information, particularly in background competition. Such skills are important to optimal school performance.

The review of literature reveals that children with a history of recurrent OME in the first year may demonstrate long term deficits in different aspects of higher order processing. In turn they may be at risk for academic difficulties. Evidences from the study are not conclusive with the majority of research indicating that the children do have a persisting problem after the resolving of the otitis media. A few studies, however reported the contrary. Hence the present study is taken up to evaluate the auditory processing abilities in children with a history of early otitis media and compare their performance with a group that did not have a history of otitis media.

METHOD

The objective of the study was to evaluate the auditory processing abilities in children with a history of early otitis media and compare their performance with a group that did not have a history of otitis media

Subjects: The study involved an experimental and a control group.

The experimental group comprised of 12 Kannada speaking children in the age range of 7-11 years who had a history of otitis media before the age of one year (continuously for 2-3 months). Among them seven subjects had bilateral history of otitis media and five subjects had unilateral history of otitis media. All subjects had normal hearing at the time of testing and did not have any middle ear pathology.

The control group consisted of 12 age and sex matched children with normal hearing and did not have any history of otitis media.

Instrumentation

The audiological testing was carried out using a two channel clinical audiometer Madsen 0B922 version 2.23, coupled to acoustically matched ear phones (TDH-39) with MX-41/ AR ear cushions and a bone vibrator (Radio ear B-71). The instrument was calibrated as per ANSI standards (1996, cited in Frank, 2000).

The immittance audiometry was performed through GSI-33 immittance meter.

For carrying out duration pattern test, a Pentium IV computer with Audio Lab version II software was used.

The dichotic CV test and speech-in-noise test were carried out using a Philips AZ2160V CD radio cassette tape recorder.

Test environment

All the tests were carried out in a sound treated double room. Ambient noise levels were within permissible limits as recommended by ANSI (1991, cited in Wilber, 1994).

Test material

The tests used to evaluate the auditory perceptual process of the children were.

- Duration pattern test
- Recognition of speech-in-noise
- Dichotic CV test

The dichotic CV test was administered using the test material developed by Yathiraj (1999), at AIISH, Mysore. The taped version of the test was used.

The recognition of speech-in-noise was done using "The speech identification test in Kannada for children" (list-1) developed by Vandana (1998). The two half lists, consisting of 25 stimuli each were used for testing. The CD recorded version of the speech test was used.

The duration pattern test was presented using the Audio Lab version-II software. The test consists of 30 stimuli and each stimulus consisted of three tones having a different duration patterns.

Test procedure

Pure tone testing : To ensure that the subjects had normal hearing, pure tone testing was done. Pure tone thresholds for air conduction and bone conduction were obtained for the frequencies from 250 Hz - 8 kHz and 250 Hz - 4 kHz respectively.

Immittance testing : To rule out middle ear pathology, immittance testing was done. Both tympanometry as well as reflexes were checked.

Dichotic CV **test**

The taped version of the dichotic CV test was played on a Philips AZ2160V CD radio cassette tape recorder. The output from the tape recorder was sent to the two channel clinical audiometer (Madsen 0B922). One track of the tape was fed to the tape input of the audiometer while the other track was fed to the auxiliary input of the audiometer.

The 1kHz calibration tone, recorded in the tape , was used to adjust the VU meter to zero in both channels. The list with a 0 msec lag condition was used. The output from the audiometer was presented at 70 dBHL through ear phones. The children were asked to repeat the two CV's heard among six alternatives. A total of 30 stimuli were presented.

Responses were scored interms of single correct and double correct scores. A single correct score was given when the subject reported the syllable presented to any one ear correctly. A double correct score was given when the subjects reported the syllables presented to both ears correctly.

Speech-in-noise testing

The CD recorded version of the speech test was played through Philips AZ2160V CD radio cassette tape recorder. The output from the CD player was sent to the CD input of the clinical audiometer Madsen 0B922 .

The VU meter of the audiometer was adjusted to zero using the 1 kHz calibrated tone that was recorded on the CD. Speech noise was presented in the same ear as the speech signal at 0 SN ratio. Both the signals were presented at 40 dBSL through the audiometer (relative to the average of best thresholds of two speech frequencies from 500 Hz to 2 kHz) fletcher,1950, cited in Tillman & Olsen, 1973). Each ear was tested independently.

The children were asked to repeat the stimuli and the responses were recorded on a scoring sheet. Each correct responses was given a score of one and an incorrect response a score of zero.

Duration pattern test

The Audio Lab version II software was used for the duration pattern test. The software was loaded on a Pentium IV processor. The output from the computer was connected to the auxiliary / tape input of the clinical audiometer, Madsen 0B922. The output from the audiometers was presented at 40 dBSL. Each ear was tested independently. The children were asked to describe the stimuli as either short or long in the correct sequences.

The response of the subjects was fed in the computer using the Audio Lab Version II software. The scores were calculated automatically by the software interms of percentage.

Questionnaire administration : Using a questionnaire (Appendix) the past history and scholastic performance of the subjects were obtained. An interview technique was used and one of the parents answered the questionnaire. The responses were recorded by the experimenter.

Analysis

The scores obtained on the various tests were tabulated. The analysis of the raw data was done using independent t-test.

RESULTS AND DISCUSSION

The study was carried out to evaluate the auditory processing ability in twelve children who had histories of early otitis media with effusion (OME) and to compare them with age and sex matched control subjects.

The experimental group involved two groups i.e., seven children who had bilateral history of OME and five children who had unilateral history of OME.

The analysis was done using the independent t-test for the following:

1. Subjects with bilateral history of OME Vs. control subjects for
   a. Duration pattern test (DPT)
   b. Speech-in-noise test (SPIN)
   c. Dichotic CV test
      - Single correct scores for right ear
      - Single correct scores for left ear
      - Double correct scores
2. Subjects with unilateral history of OME (abnormal ear scores) Vs. control subjects for
   a. Duration pattern test
   b. Speech-in-noise test
   c. Dichotic CV test
      - Single correct scores
      - Double correct scores

3. Subjects with unilateral history of OME (abnormal ear) Vs. normal ear for

   a. Duration pattern test

   b. Speech-in-noise test

   c. Dichotic CV test - Single correct scores

4. Subjects with unilateral history of OME (abnormal ear scores) Vs bilateral history of OME for

   a. Duration pattern test

   b. Speech-in-noise test

   c. Dichotic CV test
      - Single correct scores
      - Double correct scores

The scores for the duration pattern test was calculated in terms of percentage while the raw score were calculated for the speech-in-noise test and dichotic CV test (double correct and single correct scores).

1. Subjects with bilateral history of OME Vs. control subjects

The mean and the standard deviation (SD) values for the duration pattern scores, the speech-in-noise and dichotic CV test scores were calculated. The independent't' value was calculated and tabulated in table 1.

Table 1 : Mean, SD and 't' value for the bilateral OME group Vs. control group

Test	Subjects	N (number of ears)	Mean	SD	t - value
DPT	E	14	32%	17	8.54*
	C	24	68%	8	
SPIN	E	14	7.35	3.99	7.418*
	C	24	14.29	1.75	
Dichotic CV: single correct scores (Rt)	E	7	14.14	4.22	4.59*
	C	12	22.91	3.89	
Dichotic CV: single correct scores (Lt)	E	7	13.85	4.87	2.94*
	C	12	19.75	3.79	
Dichotic CV: double correct scores	E	7	5.85	6.46	3.72*
	C	12	15.14	1.34	

* Significant at 0.01 level
E = Experimental group
C = Control group

The results indicate that there was a significant difference between the experimental and control subjects at the 0.01 level, with the control group getting higher scores in the three tests in which they were evaluated. This includes the duration pattern test, speech in noise test and dichotic CV test. For the dichotic CV test the difference was significant for the single correct as well as the double correct scores. The standard deviation was more in the experimental group compared to the control group indicating more dispersed scores in the three tests.

From the poorer performance of the experimental subjects in the duration pattern test, it is evident that children who had bilateral history of OME early in childhood may have deficits in the temporal ordering skills. However, there is a dearth of information on the duration pattern test in children with history of early

OME. Research evaluating duration pattern perception in children with otitis media has not been given much importance.

Their lower performance in the speech-in-noise test indicates that they have problems in auditory separation or low redundancy tasks. Welsh, Welsh and Healy, (1996); Schilder, Snik, Straatman and Broek (1994) and Jerger, Jerger, Alford and Abrams (1983) have reported that children who had OME in early childhood, performed poorly in recognition of speech in noisy environments. Thus it can be interpreted that the children with OME during the critical period of speech and language development exhibit difficulty in detecting and attending to signals in noisy environment.

The dichotic listening test assessed the binaural separation and binaural integration ability. The poor performance of the experimental subjects both in single correct scores and double correct scores suggest that the children with a history of early OME can have lasting effects on binaural integration and separation abilities. Moller, Holmefjord, Reiseter and Asbjornsen (2000) support the findings of the present study. They too found a lack of ability to attentional modulation in a group of children who had bilateral history of OME in early childhood, when tested in dichotic listening situations.

Hence, based on the results, it can be concluded that OME in both ears during early childhood may affect different auditory processing abilities in children at later ages, including auditory separation and integration.

2. Subjects with unilateral history of OME Vs. control subjects

In the experimental group the mean and the standard deviation values for the scores in the three tests were calculated in the ear which had a history of OME. This was compared with the scores obtained by the control group to determine the significance of difference. The independent 't' value was calculated for the above variables and tabulated in table 2.

Table 2 : **Mean, SD and 't' value for the unilateral OME group Vs control group**

Test	Subjects	Number of ears	Mean	SD	t - value
DPT	E	5	22.8%	10.20	7.22*
	C	10	67%	11.56	
SPIN	E	5	5.8	3.34	5.89*
	C	10	13.9	2.02	
Dichotic CV single correct scores	E	5	9.8	3.96	3.518*
	C	5	19.8	4.96	
Dichotic CV double correct scores	E	5	1.20	1.64	9.18*
	C	5	13.8	2.58	

E = Experimental group C = Control group
* = Significant at 0.01 level

Results indicate that children with unilateral history of otitis media in the early childhood also performed poorly in the three tests. The children had significantly poorer scores in the ear which had a history of OME when compared to the scores obtained by the control group. The difference was statistically significant at the 0.01 level. Three of the children could perceive only one stimulus at a time in the dichotic CV test. At times they perceived the stimulus in one ear, while at times it was in the other ear. Hence three of the subjects got zero double correct scores in the test. The range in double correct scores in the test was 0-3. While in the normal control group, the range was 11-18. The control group obtained scores similar to what has been reported by Krishna (2001).

Supporting evidence can be drawn from animal studies. It is reported that a unilateral conductive hearing loss at an early age can lead to structural changes in brainstem neurons (Anderson, 1985). Researchers, have shown reduction of dendritic length in brainstem auditory nuclei following unilateral conductive loss (Smith, Gray & Rubel, 1983, cited in Anderson, 1985). Hence, it is evident that history of unilateral otitis media during the critical period of language development can lead to structural changes in brainstem neurons. In turn, this may affect the auditory processing abilities. So it can be construed that an unilateral history of OME during the first year of life, lasting for a duration of 2-3 months, also has a deleterious effect on the auditory processing abilities.

3. Subjects with unilateral history of OME : Abnormal ear scores Vs. Normal ear scores

The mean and the standard deviation (SD) values for the duration pattern scores, speech-in-noise scores and dichotic CV test single correct scores were calculated for abnormal ear and normal ear of the same subject independently. The independent 't' value was used to compare the ear with a history of OME with the normal ear of the same subject. The obtained scores are tabulated in table 3.

Table 3 : Mean, SD and 't' value for abnormal ear Vs. normal ear of the subject with unilateral history of OME

Test	Subjects	Number of ears	Mean	SD	t - value
DPT	Abnormal ear	5	22.80%	10.20	1.09 NS
	Normal ear	5.	29.80%	10.05	
SPIN	Abnormal ear	5	5.8	3.34	0.97 NS
	Normal ear	5	7.6	3.78	
Dichotic CV single correct scores	Abnormal ear	5	9.80	3.96	3.75*
	Normal ear	5	16.80	1.30	

* = Significant at 0.01
NS = Not significant

The results indicate that the ear with a history of OME which occurred for a duration of two to three months, performed poorer than the normal ear of the same subject. While the difference was statistically significant at the 0.01 level in the dichotic CV test (single correct scores), the difference was not statistically significant for the duration pattern test and in the speech-in-noise test. Despite there being no statistical difference in the latter two tests the scores were lower in the ear with a history of otitis media. It can be construed that a unilateral hearing loss affects binaural integration to a greater extent and does not affect perception of duration and auditory separation to the same extent.

This is consistent with the findings of previous study by Snik, Teunissen and Gremers (1993, cited in Schilder, Snik, Straatman & Broek, 1994). They reported of a relationship between speech recognition abilities and early conductive hearing loss in patients successfully operated for unilateral congenital ear anomalies. Despite normal speech-in-quiet performance, speech recognition in noise, in the operated ear, remained below the level of the normal contralateral ear.

It can be noted that though the ear with unilateral history of OME returns to normalcy in terms of pure tone thresholds, it performed poorer than the normal contralateral ear on auditory processing ability measures.

4. Subjects with Unilateral history of OME (abnormal ear scores) Vs. subjects with bilateral history of OME

The mean and the standard deviation (SD) values for the three tests carried out in the ear with a history of OME, in the subjects with a unilateral hearing loss, was compared with the subjects who had a history of bilateral otitis media. The subjects were matched interms of age and sex. For the dichotic test the subjects were matched in terms of ears. The independent t-value was calculated and tabulated in table 4.

Table 4 : Mean, SD and 't' value for subjects with unilateral OME Vs subjects with bilateral OME

Test	Subjects	Number of ears	Mean	SD	t - value
DPT	Unilateral OME	5	22.08%	10.20	1.42 NS
	Bilateral OME	10	32.60%	16.28	
SPIN	Unilateral OME	5	5.80	3.34	1.41 NS
	Bilateral OME	10	7.90	3.78	
Dichotic CV single correct scores	Unilateral OME	5	9.8	3.96	1.709 NS
	Bilateral OME	5	14.0	3.80	
Dichotic CV double correct scores	Unilateral OME	5	1.20	1.64	1.55 NS
	Bilateral OME	5	5.85	6.46	

NS = Not significant

It is revealed from the results that the unilateral OME subjects performed poorer than the bilateral subjects on all the three tests. However, this difference was not statistically significant at 0.01 and 0.05 levels.

Studies conducted on animals have demonstrated that a more dramatic reorganization of the auditory system (particularly at the level of brainstem) occurs in unilateral than bilateral auditory deprivation (Trahiotis, 1992, cited in Gravel & Tocci, 1998; Moore, Hutchings, King & Kowalchuk, 1989, cited in Gravel & Tocci, 1998). Hence, it is evident that the early unilateral episodes of OME can have a more adverse effects than bilateral episodes of OME on auditory processing. These findings suggests that adequate medical care should be given even in the case of unilateral persisting OME.

Results of the questionnaire

Using the questionnaire (Appendix) the past history and scholastic performance of the subjects were noted. Out of the twelve children, one child with a history of unilateral OME was reported to have articulation problems (i.e., substitution) of |l| for |r| and his scholastic performance was average. The other eleven children did not have a report of any scholastic or speech problems and all performed above average in the school.

It is evident from the results of the present study that though the scholastic performance was not affected, the children in the experimental group exhibited deficits in auditory processing abilities. This suggests that these children might have developed some compensatory strategies inorder to compensate for their auditory perceptual deficits. Most of the lessons taught to-the children till the primary class (5^{th} grade) are written on the board for the children to copy. It is after this stage that teachers begin to dictate notes. Hence, it can be posited that the children of the experimental group, were not under the pressure of depending solely on their auditory perceptual skills. Thereby they did not exhibit any scholastic difficulties. This finding is contrary to that of Needleman and Menyuk (1977, cited in Needleman, 1977), Dalzell and Owrid (1976) and Gravel, Wallace and Ruben (1995) who reported of educational retardation in children who had early OME.

From the above finding it can be summarized that:

1. Subjects with bilateral or unilateral history of OME performed significantly poorer in duration pattern test, speech-in-noise test and dichotic CV (single correct scores and double correct scores) when compared normal age and sex matched children.
2. In the subjects of unilateral OME, the ear with the history of OME had poorer scores than the normal contralateral ear. The difference was not statistically significant on the duration pattern test and on the speech-in-noise test, while the difference was significant on the dichotic CV single correct scores. This finding reveals the greater impact of early unilateral OME on the binaural integration abilities.
3. Subjects with a unilateral history of OME scored poorer than subjects with a bilateral history of OME in all the tests. However, the difference was not

statistically significant. This indicates the deleterious effects of a unilateral OME on auditory perception.

4. Though the experimental group did have an auditory perceptual problem, they did not have any difficulty in their scholastic skills. Subjects probably compensated using visual cues, thus compensating for their auditory perceptual deficits.

These findings suggest an important relationship between the history of otitis media in the first year of life, which persists for a duration of two to three months and later auditory processing abilities. It appears from the result of present study that children with frequent otitis media episodes in early life are at risk for deficits in auditory processing skills, that are dependent on auditory - attentional abilities. Hence, it is essential that necessary steps be taken to identify the presence of middle ear problem as early as possible. This should be followed up with appropriate remedial measures.

SUMMARY AND CONCLUSION

Cosiderable attention has been drawn towards children having a conductive hearing loss during critical age for acquiring speech and language because of its possible relation to auditory processing and linguistic development (Clarkson & Eimas, 1989). Roberts, Burchinal, Davis, Collier and Henderson (1991) suggested that a child with otitis media often experiences mild to moderate fluctuating conductive hearing loss and thus receives partial or inconsistent auditory input, making speech more difficult to detect. This may impair the discrimination and central processing of speech and thus cause the child to encode information inefficiently, incompletely or inaccurately into the database from which language develops.

From the review, it is evident that the impact of early otitis media on auditory perception remains as an unresolved issue. Hence the present study was undertaken to evaluate the auditory processing abilities in twelve children with early histories of otitis media and to compare them with a matched control group that did not have a history of OME. The experimental group involved seven subjects with the bilateral history of early OME and five subjects with unilateral history of early OME (before the age of one year). The duration pattern test, the speech-in-noise test and the dichotic CV test were used to assess the auditory processing abilities. Further, using a questionnaire, the scholastic performance and their past history was assessed. Scores were calculated for the tests and analysed using independent t-test.

The results revealed that the subjects with bilateral or unilateral history of OME exhibited significantly poorer performance in all the three tests, indicating the deficits in temporal ordering skills, auditory separation tasks and auditory integration skills.

In the subjects with a unilateral hearing loss, the ear with the history of OME performed poorer than the normal ear on the three tests. The performance was significantly different only on the dichotic CV single correct scores, suggesting the grater impact of early unilateral OME on the binaural integration abilities.

The subjects who had unilateral history of OME had poorer scores than the subjects with bilateral history of OME. Though this difference was not statistically significant, this finding suggests that unilateral history of OME can have more adverse effects on the auditory perception than bilateral history of OME.

From the questionnaire administered it was noted that only one child with unilateral history of OME reported articulation problem and the performance in the school was average, while the other children performed above average. Despite having an auditory perceptual problem, the children were probably able to compensate using other strategies such as using visual cues, to cope in school. Hence they did not have any scholastic problems.

From the above results, it is evident that the children with otitis media in early childhood are at risk for developing an auditory processing problem. This problem may persist even after the otitis media has resolved and continue to exist even when they are older. Hence it is essential that necessary steps be taken to identify the problems as early as possible, no matter whether it is unilateral or bilateral. This should be followed up with appropriate remedial measures.

REFERENCES

Anderson, K.L. (1985). A case study of central processing following longstanding unilateral conductive hearing loss. *The Journal of Auditory Research,* 25, 201-213.

Bamford, J., & Saunders, E. (1991). *Hearing impairment, auditory perception and language ability* (2nd ed.). London : Whurr Publishers Ltd.

Beasley, D.S., Schwimmer, S., & Rintelmann, W.F. (1972). Intelligibility of time compressed CNC monosyllables. *Journal of Speech and Hearing Research,* 15, 340-350.

Brandes, P.J., & Ehinger, D. M. (1981). The effects of early middle ear pathology on auditory perception and academic achievement. *Journal of Speech and Hearing Disorders,* 46, 301-307.

Bryden, M.P. (1988). Correlates of the dichotic right-ear effect. *Brain and Language,* 24,313-319.

Clarkson, R.L., Eimas, P.D., & Marean, G.C. (1989). Speech perception in children with histories of recurrent otitis media. *Journal of the Acoustic Society of America,* 85(2), 926-933.

Dalzell, J., & Owrid, H.C. (1976). Children with conductive deafness. A follow-upstudy. *British Journal of Audiology,* 10, 87-90.

Dobie, R.A. & Berlin, C.I. (1979). Influence of otitis media on hearing and development. *Annals of Otology Rhinology and Laryngology,* 88, 48-53.

Downs, M.P. (1977). The expanding imperatives of early identification. In F.H. Bess (Ed.), *Childhood deafness : Causation, assessment and management* (pp. 95-106). New York: Grune & Stratton, Inc.

Frank, T. (2000). Basic instrumentation and calibration. In R.J. Roeser., M. Valente, and H.H. Dunn (Eds.), *Auditory Diagnosis* (pp. 213-225). New York : Thieme Medical Publishers Inc.

Gottlieb, M.I. (2002). *Chronic otitis media - Speech / language Disorders, Learning Disabilities : IS There A Link?.*Retrieved March 3, 2003, from http://www.humed.com/otitis/~l.htm.

Gravel, J.S., & Tocci, L.L. (1998). Setting the stage for universal new born hearing screening. In L.G. Spivak (Ed.), *Universal New born Hearing Screening.* (pp. 1-27). New York : Thieme Medical Publishers Inc.

Gravel, J.S., & Wallace, I.F. (1992). Listening and language at 4 years of age : Effects of early otitis media. *Journal of Speech and Hearing Research,* 35, 588-595.

Gravel, J.S., Wallace, I.F., & Ruben, R.J. (1995). Early otitis media and later educational Risk. *Acta Otolaryngologica,* 115, 279-281.

Grievink, E.H., Peters, S.A.F., Bon, W.H.J., & Schilder, A.G.M. (1993). The effects of early bilateral otitis media with effusion on language ability : A prospective cohort study. *Journal of Speech and Hearing Research,* 36, 1004-1012.

Gupta, A., & Khanna, K. (1999). Economic value of breast feeding in India. Retrieved January 4, 2003, from http://www.bpni.org/egi/economicvalue.asp.

Hall, J.W., Grose, J. H., & Pillsbury, H.C. (1995). Long term effects of chronic otitis media on binaural hearing children. *Archieves of Otolaryngology - Head & Neck Surgery,* 121, 847-853.

Harsten, G., Nettelbladt, U., Schalen, L., Kalm, O., & Prelliner, K. (1993). Language development in children with recurrent acute otitis media during the first three years of life. Follow-up study from birth to seven years of age. *The Journal of Laryngology and Otology,* 107,407-412.

Hogan, S.C., Meyer, S.E., & Moore, D.R. (1996). Binaural unmasking returns to normal in teenagers who had otitis media in infancy. *Audiology & Neuro-Otology,* 1, 175-185.

Jerger, S., Jerger, J., Alford, B.R., & Abrams, S. (1983). Development of speech intelligibility in children with recurrent otitis media. *Ear and Hearing,* 4 (3), 138-145.

Katz, J. (1978). The effects of conductive hearing loss on auditory functions. *American Speech and Hearing Association,* 20, 879-886.

Katz, J., Basil, R.A., & Smith, J.M. (1963). A staggered spondaic word test for detecting central auditory lesions. *Annals of Otology Rhinology* and *Laryngology,* 72, 906-917.

Keith, R.W., Lawless, K.H., & Cotton, R.T. (1981). Auditory processing abilities in children with previous middle ear effusion. *Annals of Otology Rhinology and Laryngology,* 90, 543-545.

Klausen, O., Moller, R., Holmefjord, A., Reiseter, S., & Asbjornsen, A. (2000). Lasting effects of OME on language skills and listening performance. Acta *Otolaryngologica,* Suppl. 543, 73-76.

Krishna, G.(2001). Dichotic CV Test Revised : Normative Data on children. Unpublished Independent Project, University of Mysore, India.

Masters, L., & Marsh, G.E. (1978). Middle ear pathology as factor in learning disabilities. *Journal of Learning Disabilities*, 11, 54-57.

Menyuk, P. (1979). Design factors in the assessment of language development in children with otitis media. *Annals of Otology Rhinology and Laryngology*, 88, Suppl. 60, 78-89.

Menyuk, P. (1992). Relationship of otitis media to speech processing and language development. In J. Katz., N. Stecker, & D. Henderson (Eds.), *Central Auditory Processing: A Trans disciplinary view* (pp. 187-198). St. Lousis: Mosby Year book Inc.

Mody, M., Schwartz, R.G., Garvel, J.S., & Ruben, R.J. (1999). Speech perception and verbal memory in children with and without histories of otitis media *Journal of Speech Language and Hearing Research*, 42, 1069-1079.

Moore, D.R., Hutchings, M.E., & Meyer, S.E. (1991). Binaural masking level differences in children with a history of otitis media. *Audiology*, 30, 91-101.

Mueller, H.G., & Bright, K.E. (1994). Monosyllabic procedures in central testing. In J. Katz (Ed.), *Hand Book of Clinical Audiology* (pp. 222-238). Baltimore : Williams and Wilkins.

Needleman, H. (1977). Effects of hearing loss from early recurrent otitis media on speech and language development. In B.F. Jaffe (Ed.), *Hearing loss in Children* (pp. 640-649). Baltimore : University Park Press.

Northern, J.L., & Downs, M.P. (2002). *Hearing in children* (5th ed.). Lippincott: Williams and Wilkins.

Pillsbury, H.C., Grose, J.H., & Hall, J.W. (1991). Otitis media with effusion in children : Binaural Hearing before and after corrective surgery. *Archieves of Otolaryngology - Head & Neck Surgery,* 117, 718-723.

Roberts, J.E., Burchinal, M.R., Davis, B.P., Collier A.M., & Henderson, F.W. (1991). Otitis media in early childhood and later language. *Journal of Speech and Hearing Research,* 34, 1158-1168.

Roberts, J.E., Dollaghan, C, Schwartz, R.G., Gravel, J., & Hunter, J.L. (2001). *Otitis media* : Implications for language development and auditory processing disorders. Retrieved November 4, 2002, from http://www.humed.com/otitis/~2.htm.

Rvachew, S., Slawinski, E.B., Williams, M., & Green, C.L. (1999). The impact of early onset otitis media on babbling and early language development. *Journal of the Acoustic Society of America,* 105(10), 467-475.

Sak, R.J., & Ruben, R.J. (1981). Recurrent middle ear effusion in childhood : Implications of temporary auditory deprivation for language and learning. *Annals of Otology Rhinology and Laryngology,* 90, 546-551.

Schilder, A.G.M., Snik, A.F.M., Straatman, H., & Broek, P.V.D. (1994). The effect of OME at preschool age on some aspects of auditory perception at school age. *Ear and Hearing,* 15(3), 224-230.

Schoeny, Z.G., & Talbott, R.E. (1994). Non speech procedures in central testing. In J. Katz (Ed.), *Handbook of Clinical Audiology* (pp. 212-221). Baltimore : Williams and Wilkins.

Stephenson, H., Higson, J., & Haggard, M. (1995). Binaural hearing in adults with histories of otitis media in childhood. *Audiology,* 34, 113-123.

Stollman, M.H.P., Snik, A.F.M., Schilder, A.G.M., & Broek, P.V.D. (1996). Measures of binaural hearing in children with a history of asymmetric otitis media with effusion. *Audiology & Neuro-Otology,* 1, 175-185.

Tillman, T. W., & Olsen, W.O. (1973). Speech Audiometry. In J. Jerger (Ed.), *Modern Developments in Audiology* (pp. 37-70). London : Academic Press Inc.

Updike, C, & Thornburg, J. (1992). Reading skills and auditory processing ability in children with chronic otitis media in early childhood. *Annals of Otology Rhinology and Laryngology,* 101, 530-537.

Vandana, S. (1998). The speech identification test for Kannada speaking children. Unpublished Independent Project, University of Mysore, India.

Ventry, I.M. (1980). Effects of conductive hearing loss : Fact or Fiction. *Journal of Speech and Hearing Disorders,* 45, 143-156.

Wallace, I.F., Gravel, J.S., Carton, C.M.M., & Ruben, R.J. (1988). Otitis media and language development at 1 year of age. *Journal of Speech and Hearing Disorders,* 53,245-251.

Welsh, J.J., Welsh, L.W., & Healy, M.P. (1983). Effect of sound deprivation on central hearing. *Laryngoscope,* 93, 1569-1575.

Welsh, J.J., Welsh, L.W., & Healy, M.P. (1996). Early sound deprivation and long term hearing. *Annals of Otology Rhinology and Laryngology,* 105, 877-881.

Wilber, L.A. (1994). Calibration, Puretone, Speech and Noise Signals. In J. Katz (Ed.). *Handbook of Clinical Audiology* (pp. 73-97). Baltimore : Williams and Wilkins.

Yathiraj, A. (1999). Dichotic CV test-revised. Developed at All India Institute of Speech and Hearing, Mysore, India.

APPENDIX

Questionnaire

Name : Age / Sex

Class :

1. Your child had a history of ear discharge before the age of one year ?
2. If yes, how many times has the child had ear discharge and what was the duration of episode?
3. Has the child undergone medication for the problem?
4. Which is the medium of instruction in the school ?
5. How is the performance of the child in the school?
6. Does the child find difficulty in any particular subject ? (if any, specify)
7. Does the child have problems in understanding speech in noisy situations?
8. Does the child have problem in following the teacher's instructions in school?
9. Does the child have difficulty in paying attention or concentration in any particular activity?
10. Does the child have any problems of misarticulation? (if any specify).
11. Does the child have any memory problems?