CONTRALATERAL SUPPRESSION OF OAES
AND
SPEECH - IN - NOISE : EFFECTS OF
AGE, GENDER AND EAR

Reg. No. M2k21

A dissertation submitted as part fulfillment for the final year
M.Sc (Speech and Hearing) to University of Mysore

ALL INDIA INSTTITUE OF SPEECH AND HEARING

MYSORE-570006

MAY-2OO2

DEDICATED TO

THE FIELD OF

AUDITORY RESEARCH

&

TO MY PARENTS,

FOR MAKING IT POSSIBLE TO

EMBARK ON THIS JOURNEY

CERTIFICATE

This is to certify that this dissertation entitled **"CONTRALATERAL SUPPRESSION OF OAES AND SPEECH - IN - NOISE: EFFECTS OF AGE, GENDER AND EAR"** is a bonafide work in part of fulfillment for the degree of Master of Science (Speech and Hearing) of the student (Register No.M2K21)

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May, 2002

Aditi: You helped me discover my self. You are the wind beneath my wings.Thanks a lot. Through thick and thin, uphill and downhill,there you are, every time I look beside me...You mean the world to me.

Amit: You are priceless. I shouldn't be able to find a friend like you even in Utopia. No words will suffice to thank you as 1 want to.Thanks for always being there, and showing me just how much you care.

Puru, ABR & ANS : for adding a dash of colour to life. Wishing you guys best of everything.

Tyagi: Our freindship has seen a lot of " Dhoop-Chchaon"...You'll always be a Friend...All the Very Best in whatever you do.

Thank You God...
You 've given me the
perseverence to do this.

CERTIFICATE

This is to certify that this dissertation entitled **"CONTRALATERAL SUPPRESSION OF OAES AND SPEECH - IN - NOISE'.** EFFECTS OF AGE, GENDER AND EAR" has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in any other University for the award of any diploma or degree.

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To my family, without whom I wouldn't be here. I love you.

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BIBLIOGRAPHY

DECLARATION

This dissertation entitled **"CONTRALATERAL SUPPRESSION OF OAES AND SPEECH - IN - NOISE: EFFECTS OF AGE, GENDER AND EAR"** is the result of my own study under the guidance of **DR. C.S. VANAJA** Lecturer in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore and not been submitted in any other University for the award of any degree or diploma.

Mysore,

May, 2002 **Reg.** No. **M2K21**

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CHAPTER I

INTRODUCTION

Many advances have been made in auditory physiology in the last decade. It is now well established from anatomic viewpoint that the cochlea receives two part efferent inputs. However, the functional role of these auditory efferent fibers in hearing is still a matter of debate. Nevertheless, continued attempts to understand the function of the efferent olivocochlear system by researchers in animals and humans have clearly identified interesting properties of medial efferent fibers, many of which have clinical relevance. They include the following:

- Protective function against acoustic stimulation. (Patuzzi and Thompson, 1991, cited in Sahley, Nodar and Musiek, 1997).

- Modulation of auditory sensitivity (Wiederhold and Kiang, 1970).

- Frequency and intensity discrimination (Capps and Ades, 1968, cited in Sahley, Nodar and Musiek, 1997)

- Improvement of signal detection in noise (Liberman, 1988, cited in Sahley, Nodar and Musiek, 1997; Micheyl and Collet, 1996).

This finding that the inhibitory function of medial olivocochlear bundle (MOCB) could lead to an improvement in coding of signals embedded in noise suggest an anti-masking role of the MOCB (Dolan and Nuttal, 1988), which has recently received further support (Liberman and Guinan, 1998).

Zeng, Lehmann, Soni and Linthicum (1994) reported that the presence of MOCB activity improved the perception of speech sounds in noise. Girand et al., (1997) also reported that, in normal hearing subjects, activity of MOCB evoked through contralateral noise enhanced the speech in noise intelligibility. However, this improvement was absent in de-efferented ears of vestibular nurectomized patients. A Study by Kumar (2001) supports this hypothesis that the efferent system augments speech perception in noise. Results showed significant improvement in the speech identification scores (SIS) in presence of contralateral acoustic stimulation (CAS) in normal children. However, no improvement in SIS was observed in children with learning disorder. Veuillet, Khalfa and Collet (1999) also reported significant reduction in MOC functioning in learning disorder children.

A majority of the investigations regarding the overall significance of the descending olivocohlear pathways have been based on physiological data obtained following medial efferent stimulation. Since these investigations reflect the clinical relevance of MOCB fibers, attempts have been made to assess their functioning noninvasivley through contralateral suppression of otoacoustic emissions (CSOAEs) (Collet et al., 1990, cited in Veuillet, Khalfa and Collet, 1999). Contralateral suppression of otoacoustic emissions refers to a reduction in the amplitude of otoacoustic emissions recorded in one ear upon stimulation of the other ear. This effect is attributed to alternation of cochlear micromechanics by medial olivocohlear bundle, which is activated by contralateral acoustic stimulation. (Buno, 1978, cited in Maison, Micheyl and Collet, 1999).

Studies have also found correlation between contralateral attenuation of evoked otoacoustic emissions and the detection of signal in presence of noise. (Micheyl and Collet, 1996; Kumar, 2001). Micheyl and Collet (1996) reported that greater the contralateral suppression of evoked otoacoustic emissions the better was the detection performance in noise. It was also reported that OAE contralateral suppression appeared to be statistically related to behavioral detection performance only in the condition in which contralateral noise is present in the contralateral ear or when background noise is binaural (Micheyl and Collet, 1996). Kumar (2001) also found positive correlation between the shift in speech identification scores due to contralateral acoustic stimulus and the contralateral suppression of otoacoustic emissions. This indicates the involvement of olivocochlear bundle in speech perception in noise.

NEED FOR THE STUDY

A review of literature shows that there is a relationship between contralateral suppression of otoacoustic emissions and speech perception in noise i.e., abnormally reduced or absent contralateral suppression indicates poor speech perception in noise. This in turn suggests that contralateral suppression of otoacoustic emission can be used to predict an individual speech understanding capacity in noise. As contralateral suppression of otoacoustic emission is a non invasive physiologic measure which does not require any voluntary response it may be easier to administer this on difficult to test children on whom behavioral test cannot be administered.

However, the use of contralateral suppression of otoacoustic emissions as a classical tool for predicting speech perception in noise requires established normative data across age groups. Thus there is a need to study the effect of age on the relationship between contralateral suppression of otoacoustic emission and speech perception in noise. A review of literature also reveals that OAE amplitude shows asymmetry between two ears (Collet, 1993; Kumar, 2001) and is also different in the two genders (Robinette, 1992). Thus there is a need to study how these factors i.e., age, gender and ear affect the relationship between Contralateral suppression of OAEs and speech perception in noise.

AIM OF THE STUDY

The present study was designed to observe the effect of age, ear and gender on:

- Speech identification scores (SIS) in quiet, in presence of ipsilateral noise only and in presence of both ipsilateral and contralateral noise.
- TEOAE amplitude in absence and presence of contralateral broadband noise.
- Correlation between shift in speech identification and OAE amplitude due to contralateral acoustic stimulation.

CHAPTER II

REVIEW OF LITERATURE

This chapter reviews literature on various aspects of the role of auditory medial efferent fibers in the identification of speech in noise under the following headings:

- Anatomy of Medial olivocochlear bundle (MOCB)
- Investigation of MOCB functions.
- Functional role of MOCB.
- Role of MOCB in the identification of speech in noise.

Anatomy of medial olivocochlear bundle (MOCB):

The history of medial olivocochlear bundles (MOCB) has been marked by two main periods (Maison, Micheyl and Collet, 1999). In 1946, Rasmussen (cited in Maison et al., 1999) gave the first description of a group of nerve fibers coming from the superior olivary complex (SOC), crossing the midline at the level of the fourth ventricle and making synapses into the cochlea. In 1960, he supplemented his description by reporting a second group of olivocochlear fibers, which reach the cochlea without crossing the midline. Fifteen years later, Warr and co-workers (cited in Maison et al., 1999) who distinguished two types of olivocochlear fibers according to cell body location, proposed a new classification. First type corresponds to lateral efferent fibers, the cell bodies of which are situated in the, lateral superior olivary nucleus. These unmyelinated fibers make synapse with radial afferent fiber dendrites (Liberman, 1980, cited in Maison et al., 1999), mainly on the ipsilateral side. The second type consists of medial olivocochlear fibers (MOC), the cell bodies of which are located around the preolivary nuclei of the SOC. The projections of these myelinated fibers are mainly contralateral and make direct synaptic contact with basolateral membrane of the cochlear outer hair cells (Liberman and Brown, 1986, cited in Maison et al., 1999). These projections are tonotopically organized, with density of innervation decreasing from base to apex (Brown, 1989, cited in Maison et al., 1999). The olivocohlear bundle pathway is also illustrated in figure 1, given below.

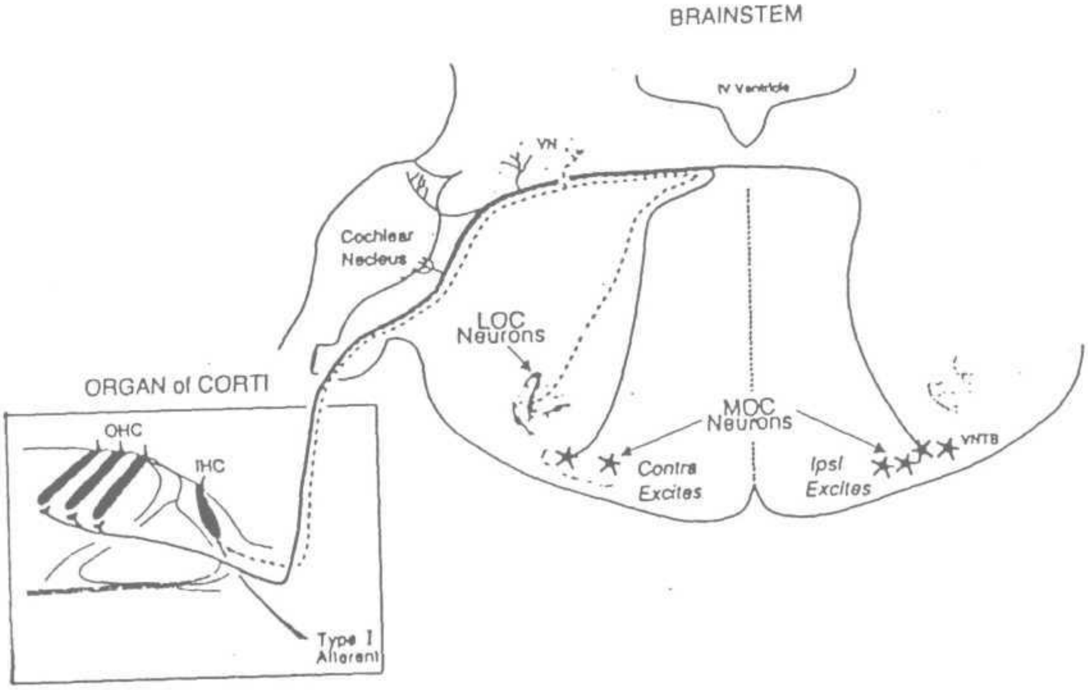


Figure 1. Schematic representation of the brainstem origins, course and organ of corti terminations of the olivocochlear systems, (adapted from John and Santos-Sacchi, 2001).

The neurons within the medial superior olivary complex or trapezoid body, sends axons either to the contralateral (70%) or to the ipsilateral (30%) cochlea and synapse with the basal pole of outer hair cells (Pujol, 1994). MOC fibers can either be seen as the feedback branch of a cochleo-cochlear loop or as the component of an inter-cochlear link (Maison et al., 1999). This can be explained with the fact that there is an existence of direct projections from the cochlear nucleus (CN) into the SOC (Robertson and Winter, 1988, cited in Maison et al., 1999). Because these projections are crossed, MOC fibers having their cell bodies on one side are excited by acoustic stimulation presented to the other side. Also, a majority of MOC fibers project to the contralateral cochlea. As a result, MOC fibers mainly project onto the cochlea from which they indirectly derive their inputs (Liberman, Dodds and Pierce, 1990 cited in Maison et al., 1999) or otherwise stated MOC fibers form a clean "feedback" loop (Maison et al, 1999). This has an important implication in studies involving the contralateral evoked otoacoustic emissions (CEOAEs) suppression effect, that MOCB activation is likely to be qualitatively similar, but substantially weaker than ipsilaterally induced activation (Maison et al., 1999).

In conclusion, results from various studies have now established that efferent olivocochlear system is divided anatomically, into lateral efferent and medial efferent fibers. Also, the MOC fibers form a feedback branch of a cochleo-cochlear loop.

Investigation of MOCB functions:

The function of the medial olivocochlear system is presently best investigated, both in humans and in the experimental animals, by monitoring changes in otoacoustic emissions (OAEs) brought about by contralateral acoustic stimulation (Berlin et al., 1993, cited in Collet et al., 1994). Since OHCs receive a rich medial efferent innervation and OAEs are a normal by product of cochlear amplifier activity and reflect OHC integrity, they provide appropriate index of changes in cochlear function as MOC fibers are activated. (Abdala, Ma and Sinniger, 1999). The OAEs are recorded in one ear in the presence and in the absence of a contralateral acoustic stimulation (CAS). Three types of OAEs have been used viz., spontaneous OAEs (Mott, Norton, Neely and Warr, 1989, cited in Collet et al., 1994) transient evoked OAEs with linear clicks (Collet, 1993), non linear clicks (Collet et al., 1994), tone pips (Berlin et al., 1993, cited in Collet et al, 1994) and acoustic distortion product OAEs (Abdala et al., 1999). The contralateral auditory stimulation can be a pure tone (Berlin et al., 1993, cited in Collet et al., 1994), clicks (Veuillet, Collet, and

Duclaux, 1991, cited in Collet, 1994); narrow band noise (Veuillet et al., 1991, cited in Collet et al, 1994) or broad band noise (Veuillet et al., 1991, cited in Collet et al, 1994)

Since 1990, the literature has become richer regarding the contralateral suppression of TEOAEs. A number of factors have been identified which affect the amount of suppression observed in normal subjects. Some of the important factors include intensity of contralateral stimulus, type and bandwidth of the contralateral stimulus, intensity of the stimulus evoking OAEs and age of the subject.

The contralateral acoustic stimulus (CAS) level is an important variable in the interpretation of efferent mediated suppression effect. The physiological data indicates that in human adults, TEOAEs show an average reduction of 3.37 dB with presentation of moderate levels of broad band noise in the contralateral ear (Veuillet et al., 1991, cited in Abdala et al., 1999). Greater the contralateral auditory stimulus intensity greater is the decrease in amplitude of TEOAEs. However there is inter-subject variability in the amount of suppression observed, but a majority of normal-hearing subjects show efferent-mediated suppression effect over some time period of the response (Parthasarathy, 2001). Berlin et al., (1993), cited in Parthasarathy, (2001) showed that a few subjects exhibit suppression effects of as much as 5 to 10 dB over time periods between 8 and 18 msec. Otoacoustic emission amplitude begins to fall as soon as noise become perceptible in the contralateral ear. (Collet. 1993). Ryan, Kemp and Hinchcliffe (1991) have shown that as the level of broadband noise (BBN) increases from 0 to 70dBSL, the amplitude of TEOAE falls and the phase lead becomes greater.

Hood, Berlin, Hurley, Cecola and Bell (1996) , cited in Parthasarathy (2001) measured the CAS intensity effect in normal hearing subjects. TEOAEs were recorded in response to linear clicks between 50 and 70 dB peakSPL in 5 dB steps while continuous white noise was presented at 10 dB above or below the click level. The results reveal that independent of click intensity level, the suppression of TEOAEs increased from a mean suppression of 0.33 dB, when the contralateral suppressor noise was lOdB below the click, to a mean suppression of 1.38 dB when the suppression noise was 10 dB above the click intensity level. This suggests that the intensity of CAS has an effect on the suppression of TEOAEs (Collet, 1993).

Studies have also shown that for TEOAEs and DPOAEs the suppression effect is greatest when the level of the ipsilateral stimulation is lowest (Veuillet et al., 1991,cited in Collet et al., 1994). Hood et al., (1996), cited in Parthasarathy, (2001) also showed that when the ipsilateral click stimulus level was kept at or below the suppressor noise level; the suppression effect was significantly greater. Veuillet et al (1991), cited in Collet et al., (1994) also showed that TEOAEs have greater suppression when the ipsilateral stimulus level is low, suggesting that MOCB function best at low ipsilateral stimulation level. Several other investigations (Veuillet et al., 1991, cited in Collet et al., 1994) have shown that this suppression effect is not related to artifacts caused by middle ear muscle contraction or crossover from the contralateral stimulus ear. This is supported by the fact that suppression is present in subjects without middle ear acoustic reflexes but is absent in subjects who have undergone a vestibular neurectomy (Williams, Brookes and Prasher, 1993).

It has been reported in literature that broad band noise is the most effective stimulus for the contralateral suppression (Collet et al., 1990,cited in Maison et al., 1999). Norman and Thornton (1993) investigated the influence of stimulus bandwidth on contralateral EOAE attenuation. Their results revealed that the contralateral EOAE suppression affect increased with the contralateral stimulus bandwidth. A study by Maison, Micheyl and Collet (1999) suggested a greater effectiveness of increase in bandwidth on the upper than on the lower side of the center frequency of the noise. Maison, Micheyl and Collet (1999) explained this observation of increased MOCB activation with increased stimulation bandwidth by the spatial integration properties of certain neurons in the cochlear nucleus (CN). Onset units have large tuning curves, with occasionally inhibitory lateral bands in their response maps. These units are able to carry out spatial integration of several auditory nerve fiber responses of different best frequencies (Maison et al., 1999). Thus, simple models of MOCB activation mechanisms including peripheral band pass filtering, within-channel compression and across channel summation by the afferent paths may account for the fact that MOCB activation increases with stimulus bandwidth, whether or not the overall energy is kept constant (Maison et al., 1999). Veuillet, Collet and Morgon (1992), cited in Collet (1993) have shown white noise contralateral stimuli to be less effective at EOAE frequencies around 4 kHz suggesting a more fragile cochlear area. At higher and lower frequencies, contralateral auditory stimulation reduces the other components.

Subject's age is another important variable in the measurement of OAEs and interpretation of efferent mediated suppression effect. Morlet, Collet, Salle and Morgon, (1993) found that BBN presented contralaterally had no effect on TEOAE amplitude for a group of premature neonates ranging in conceptional age from 33 to 39 weeks. However, other investigators have observed contralateral suppression of TEOAEs in term born neonates and even in some premature subjects. (Godforth, Hood, and Berlin, 1997, cited in Abdala et al., 1999). Abdala et al., (1999) reported that significant suppressive effect on DPOAE amplitude can be seen when broad band noise (BBN) is presented contralaterally. The magnitude and pattern of contralateral suppression in term-born neonates is comparable to that of adults suggesting that medial efferent effect on cochlear function is matured by 40 weeks gestation. However the data obtained on premature babies in the study by Abdala et al., (1999) suggest that earlier a baby was born, the more likely it is they will show non-adult like expressions of efferent function (i.e. contralateral enhancement of DPOAE amplitude instead of contralateral suppression). The extent of prematurity at birth apparently influences the medial efferent system function more than maturational status, indicating that early birth is, in and of itself, disruptive to formation of normal functioning of the system (Abdala et al., 1999).

In human adults with healthy ears, TEOAEs have an average reduction of 3.7 dB with presentation of moderate levels of BBN in contralateral ear (Veuillet et al., 1991, cited in Abdala et al., 1999). The suppression is reported to be consistent in human adults. Castor, Veuillet, Morgon and Collet (1994) cited in Parthasarathy, (2001) reported an age-related decline in the suppression of TEOAEs in the presence of continuous CBBN at 30dBSL. The suppression level with a CBBN was significantly smaller for subjects in the age range of 70 and 88 years, than in subjects between 20 and 39 years. However, interpretation of their findings was likely to be confounded by an age-related high frequency hearing loss for subjects between 70 and 88 years. Parthasarathy (2001) reported that subjects in the age range between 60-79 years of age showed a minimal increase in suppression ranging from 0.5 to 0.9 dBSPL when the CCBN level was increased from 40 to 70 dBHL. However, subjects in the age range of 20-59 years showed a significantly high suppression effect on TEOAE with the magnitude of a suppression increasing from 0.5 to 3.5 dBSPL with increase in the CBBN level. Thus the results of this study suggest that there is an interaction between the effect of intensity of CAS and age on the magnitude of contralateral suppression.

To summarize, a review of literature shows that efferent mediated suppression is influenced by age, CBBN level, and also by ipsilateral click stimulation level.

Functional role of Medial Olivocochlear Fibers:

The functional role of the auditory efferent in hearing is still a matter of debate. Since the study by Buno (1978), cited in Collet, (1993) and Murata et al., (1980), cited in Collet, (1993), it has been agreed that acoustic stimulation of one cochlea can alter afferent nerve-fiber responses in the contralateral cochlea in both animals and humans. Eventhough the functional role is not so clear, continued attempts to understand the functions of the efferent olivocochlear system by researchers in animals and humans have clearly identified interesting properties of medial efferent fibbers, many of which have clinical relevance. These interesting functions are

- Protective function against acoustic stimulation.
- Modulation of auditory sensitivity.
- Frequency and intensity discrimination.
- Modulation of signal detection in noise.

Protective function against acoustic stimulation:

Previous studies have provided strong evidence that the efferent pathways to the mammalian cochlea can protect the cochlea from damage caused by loud sounds (Cody and Johnston 1989, cited in Sahley et al., 1997). This hypothesis is based on the experimental work of animals showing a diminution of the PTS in case of acoustical or electrical stimulation of the olivocochlear bundle (OCB) during noise exposure and an increase of the PTS after section of OCB. However, Liberman, (1990), cited in Sahley et al., (1997) was not able to replicate the results. These investigations suggest that activation of the medial efferent serves a protective function (" toughening") in the mammalian auditory periphery (Patuzzi and Thompson, 1991, cited in Sahley et al., 1997). Cody and Johnstone (1982), cited in Sahley et al., (1997) demonstrated that the whole nerve action potential (Nj) in guinea pigs following monaural acoustic overstimulation was significantly reduced, from 12.7dB to 5dB, when a frequency matched acoustic stimulus at a lower stimulus intensity is delivered to the contralateral ear. This frequency specific temporary threshold shift (TTS) suggested that the activation of contralateral medial efferent system reduce the susceptibility of the cochlea to the effects of acoustic trauma. However, other researchers have pointed out that there are certain ambiguities to the mechanism underlying such effects. (Liberman, 1992, cited in Sahley at al, 1997).

Modulation of Auditory Sensitivity:

The activation of medial efferent neurons by the delivery of a contralateral stimulus (BBN) has been shown, to result in discharge suppression within primary auditory neurons in animals. (Wiederhold and Kiang, 1970). Clinical investigations in human subjects have also demonstrated suppression of the auditory nerve compound action potential following the delivery of a contralateral auditory stimulus (Folson & Owsley, 1987,cited in Sahley et al., 1997). In view of the preferential innervation of OHCs by descending medial efferent fibers (Liberman et al., 1990, cited in Sahley et al., 1997), the prevailing view has been that stimulation of medial efferent alters IHC sensitivity indirectly by altering the mechanical properties of organ of corti. Subsequently auditory sensitivity is also changed (Brownell, 1990, cited in Sahley et al., 1997). Based on this evidence, it was proposed that medial efferent system regulates the length, tension and stiffness of OHCs along their longitudinal axis, providing a gain control for the active, non-linear biomechanics of the cochlear partition (Kim, 1984, cited in Sahley et al., 1997) for low intensity auditory stimuli (i.e., 45dB to 55dBSPL or 30 to 40 dB above threshold).

Frequency and intensity discrimination:

There is some evidence to suggest that medial efferent fibers transaction may impair the frequency resolving capacity of the auditory system (Capps and Ades, 1968, cited in Sahley et al., 1997). Focussed ultrasonic lesions of the medial efferent fibers in monkeys resulted in an increase in the frequency difference (threshold) needed to maintain a 75% level of correct discrimination performance. These results suggested that efferent transection produces marked deficits in frequency discrimination performance.

Igarshi and associates (1979) reported that transaction of the midline efferent olivocohlear bundle in the cat fails to produce changes in the suprathreshold (75 dBSPL) intensity discrimination limen for a 10 kHz pure tone, compared to a preoperative values of 3.64 dB of difference limen. The interpretation of these remains equivocal because the animals had bilaterally intact cochlea and were tested in a sound field.

Modulation of signal detection in noise:

It has been reported that the OCB is involved in the detection of signal (tone or speech) in noise in animals and humans. (Igarashi, Alford, Nakai and Gordon, 1972., Micheyl and Collet., 1996, Girand et al., 1997, Zeng, Lehmann, Soni and Linthicum, 1994). These findings indicate that inhibitory function of efferent system could lead to an improvement in coding of signals embedded in noise (Libermann, 1988, cited in Sahley et al., 1997). This also suggests that efferent system aid in masking.

Micheyl and Collet (1996) found that greater the contralateral EOAE attenuation effect, the better the detection performance of signal in presence of noise. Such an observation raises the question as to how a system that inhibits the auditory periphery (reduction in compound action potential of the auditory nerve and auditory afferent fiber discharge, (Wiederhold, and Kiang 1970) can finally enhance detection performance. Neurophysiological studies on the influence of OCB stimulation on auditory-nerve (AN) fibers have suggested a positive involvement of the OCB in perception in noise compatible with its inhibitory function on AN fibers. The OCB-induced change in AN activity that could explain enhanced detection in noise with OCB stimulation is the antimasking effect which has been demonstrated for both shock-evolved and sound-evoked OCB activity (Kawase, Delgutte and Libermann, 1993, cited in Micheyl and Collet., 1996).

Role of MOCB in the identification of speech in noise:

Libermann and Guinan (1998) have described how anti-masking effects of the middle ear muscles (MEM) and olivocochlear efferent neurons affect feedback control of the auditory periphery. According to them the anti-masking properties of the MEM and MOC systems are based on different mechanisms and complement each other in the sense that the MEM system helps to control masking from low frequency noise while the MOC system helps with medium and high frequency noise. Addition of noise can raise the thresholds ANFs in two fundamentally different ways. These two mechanisms have been called "excitatory masking" and "Suppressive masking". (Liberman and Guinan, 1998). Neurophysiological studies have shown that the MEM reflex can decrease the masking of high frequency signals by low frequency noise (i.e., the upward spread of masking) also known as suppressive masking.. The MOC reflex is believed to minimize masking of high-frequency transient signals by high frequency continous noise, also known as excitatory masking.

Excitatory masking (Fig. 2a) is illustrated by the effect of the high frequency noise "masker" on the response of the high-CF fiber to a "signal". In the absence of noise, the signal is within the fiber's response area (dashed tuning curve). Thus in the absence of noise, the fiber responds to the signal by increasing its discharge rate, as schematized by the train of action potentials in the "Noise off' column. However, the noise bands also contains energy at frequencies and levels to which the fiber responds, as illustrated by overlap between the noise spectrum and the dashed tuning curve. Thus, while the noise is on, the fiber responds vigorously for the duration as shown by the long spike train in the "noise on" column. This noise driven excitation raises the fiber's threshold to tones so that the signal no longer elicits a response when the noise is on. This "excitatory masking" occurs for two reasons. First, the excitation of the fiber by the steady noise is like increasing its background discharge rate. Thus, for a tone signal to cause a "response" it must elicit an additional increase in rate, and its level must be higher than normal. This has been called the "line-busy" effect. The second reason for excitatory masking is that ANFs become fatigued by continuos stimulation by noise and when fatigued, they are less responsive to an additional transition signal such as the tone burst.

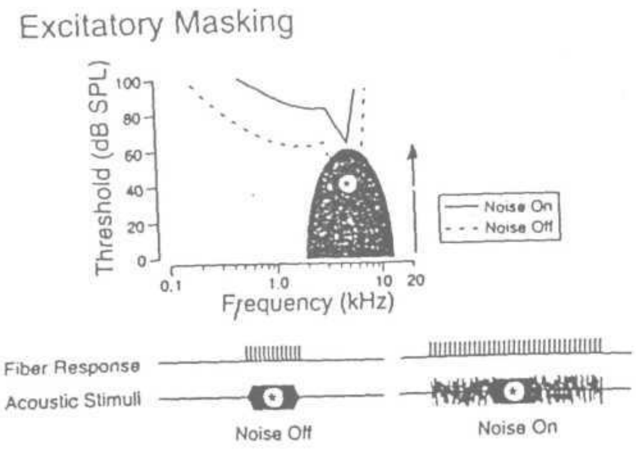


Figure 2(a): Shows the tuning curve of the fiber in quiet and in excitatory masking, (adapted from Liberman and Guinan, 1998).

The mechanism underlying this fatigue or adaptation as it is also called probably involves depletion of chemical neurotransmitter from the synapse between IHC and ANF. This transmitter that can only be synthesized and packaged at a limited rate, on continuos stimuli such as masking noise decrease the response to transient stimuli such as tone bursts. In this situation, even though the signal is still within the masked response area the increment in rate, which it elicits, is very small. Such as small rate change will be difficult for the central nervous system to detect, and small differences in the sound level of the signal will also be difficult to detect.

Stimulation of MOCs decreases the steady response to the noise, thereby increasing the response to the signal transient because the degree of adaptation is reduced. This type of antimasking is illustrated in figure 2b. The resulting increment in response to the signal will be easier to detect and the ability to discriminate suprathreshold stimuli in noise will be improved. However, masked thresholds may not be improved.

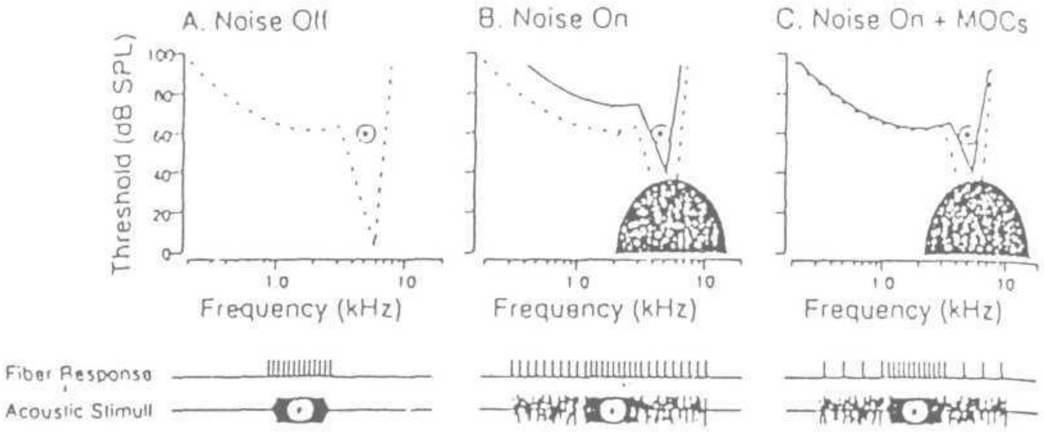


Figure 2(b): Shows the anti-masking effects of the MOC reflex, (adapted from Liberman and Guinan, 1998)

It is important to note that the MOC system does not suppress the noise more effectively than the signal because the noise is broad band whereas the signal is narrow-band. Rather, the important difference is that the "noise" is continuos whereas the signal is transient.

The MOC reflex acts to minimize the response to long-lasting stimuli (which becomes 'noise' if present for well beyond the time required to decode and react to them), while maximizing the response to novel stimuli. The MOC system will not aid in the detection or discrimination of continous tones in continous noise. The MOC reflex also cannot contribute large anti-masking effects for low-frequency noise, because MOC effects are very small in the low-frequency regions of the cochlea as shown in the figure 2(c).

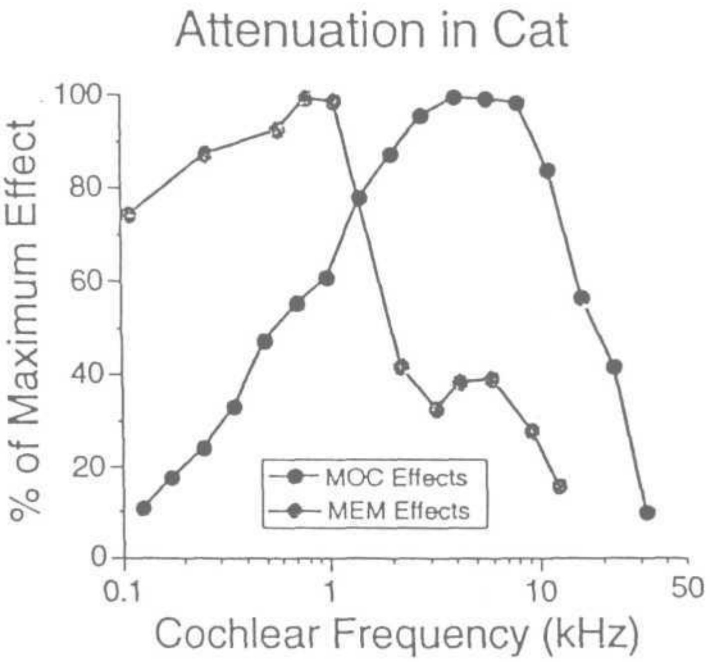


Figure 2(c): Comparison of the relative strength of MEM and MOC peripheral effects as a function of frequency, (adapted from Liberman & Guinan, 1998)

Micheyl and Collet (1996) investigated the involvement of auditory efferent in hearing -in-noise in humans. Olivocochlear bundle (OCB) function was assessed in terms of contralateral attenuation of evoked OAE i.e., the reduction in EOAE amplitude elicited by 30-dBSL contralateral broad band noise. The detection thresholds for 1 and 2 kHz tone pips embedded in 50 dBSPL BBN were measured. EOAEs were measured in the same ear with and without contralateral BBN of 30 dBSPL. The results indicated that the contralateral attenuation of EOAEs correlated significantly with detection threshold for 2 kHz tone pips embedded in noise. It also correlated with shift in threshold at 1 kHz and 2 kHz induced by contralateral acoustic stimulation. This suggest that the OCB is involved in the detection of tones in noise only when noise is present in the contralateral ear or when background noise is binaural.

Electrophysiological studies by Warr and Guinan (1979), cited in Liberman and Guinan (1998) and Liberman (1988), cited in Liberman and Guinan (1998) have shown that maximum OCB functioning occurs when noise is present in both ears simultaneously, as is the case most of the time in natural environment. The fact that binaural noise is necessary for large OCB effects to arise could explain the discrepancies between studies, such as those which suggest an involvement of the OCB in perception in noise (Micheyl & Collet, 1996) and others in which no OCB- mediated effect is found. (Scharf et al., 1994, cited in Micheyl and Collet, 1996., Igarshi et al., 1972).

Zeng et al (1994) studied the effects of vestibular neurectomy on pure tone intensity discrimination and speech perception in noise in six subjects, by comparing performance in the surgery ear and the non-surgery ear and when available between the pre and post-operative conditions. It is assumed that MOCB are severed during vestibular neurectomy. Five of the six subjects had normal or near normal pure tone average thresholds (>30dBHL). Broadband noise was used for intensity discrimination and speech spectra shaped noise was used in speech reception threshold measurement. Both types of noise were presented binaurally at several different levels, whereas tone or speech was varied adaptively based on patient's response. Preliminary results showed that loudness dynamic range is not affected by surgery and also intensity and speech perception in noise was significantly worsened after the surgery in some subjects but not others. Thus, Zeng et al., (1994) concluded that in cases where MOCB was severed the perception of speech in noise became poor.

Girand et al. (1997) investigated speech perception in noise in vestibular neurectomized patients and in normals. In normals, contralateral noise improved speech intelligibility in noise and this was correlated with magnitude of contralateral suppression of OAE. This improvement was absent in de-efferented ears of vestibular neurectomized patients.

A study by Kumar (2001) reinforces this hypothesis that the efferent system augments speech perception in noise. Results showed that contralateral noise significantly improved the speech identification scores (SIS) at +10dB and +15dB signal-to-noise ratio, but not in children with learning disorder. More shift in SIS scores was seen at +10db SNR and +15dB in normal children, and this shift showed a positive correlation with the physiological measures of OCB (CSOAE). Subjects with learning disorder showed absent CSOAEs and there was no improvement in the SIS scores in the presence of contralateral noise. An investigation by Veuillet et al (1999) also reported significant reduction in MOC functioning in learning disorder children.

Thus a review of literature emphasizes the need for evaluation of the functioning of OCB in the test battery approach, especially while evaluating those with difficulty in hearing - in - noise. However, the use of CSOAEs as a classical tool for predicting speech perception in noise requires established normative data across age groups. Thus, there is a need to study the effect of age, gender and ear on speech perception in noise.

CHAPTER III

METHOD

This study was undertaken to study the effect of age, gender and ear on the functioning of medial olivocochlear bundle through psychoacoustical and physiological experiment.

Subjects:

A total of 70 subjects were taken for the study. The subjects were divided into three groups based on their ages. Table 1 indicates the number of males and females subjects in different age groups.

Group	**No. of Subject**	**Age Range**	**Male / Female**
Group 1	**20**	**6-8** yr.	10/ 10
Group II	**20**	8-10 yr.	10/10

Table 1: Shows the number of subjects and males and females in the three different age groups.

All the subjects had normal hearing i.e., thresholds no more than 15dBHL at octave frequencies between 250Hz to 8000Hz and normal results on immittance evaluation. Subjects with any history of otologic or neurologic disorders were not included in the study.

Equipment:

1. **Psychoacoustic experiment:** Two channel clinical audiometer, ORBITER 922 with TDH 39 headphones housed in MX-41/AR ear cushions with audiocups were used for pure tone and speech audiometry. Speech stimulus was presented through the audiometer using two channel cassette deck [Philips AZ 2160(Version 2.0)]. Broad band noise was fed through the insert receiver of the same audiometer, and was used as contralateral acoustic stimuli (CAS) to activate the efferent system.
2. **Physiologic experiment:** A calibrated immittance meter, GSI-33 middle ear analyzer (version -2), was used to assess the middle ear functioning of the subjects. Click evoked otoacoustic emissions was measured using ILO292 Echoport plus. Broad band noise fed through insert receiver of a calibrated audiometer, GSI-16, was used as contralateral acoustic stimuli to activate the efferent system.

Material:

For all the subjects, speech stimuli consisted of 2 half lists of speech identification test developed by Rout (1996) for Indian English speaking children. The material was recorded by Yathiraj (2000). Two randomized sets were recorded for each list. A calibration tone was recorded at the beginning of each list.

Test Environment:

All the testing was carried out in an acoustically treated air-conditioned room with adequate illumination. Pure tone audiometry and speech identification test was carried out in a two-room suite whereas tympanometry and otoacoustic emission measurements were carried out in a single room.

Test Procedure:

All the subjects were screened for hearing loss and middle ear dysfunction. Subjects who met the criteria specified earlier were selected for the study.

Psychoacoustic Experiment: Speech identification score were obtained at 50dBHL in quiet and with a signal to noise ratio of + 10dB. This was carried out in the presence and absence of contralateral BBN at 30dBSL (Re: threshold of noise). Verbal responses were obtained from the subjects.

Physiological Experiment: Otoacoustic emissions evoked by clicks presented at 80dBpeak SPL were recorded. The probe with a foam tip was positioned in the external ear canal and was adjusted to give flat stimulus spectrum across the frequency range. The response was acquired using the standard non-linear differential averaging technique to minimize stimulus and other artifacts. The two-averaged TEOAE waveforms of each memory buffer, composed of 260 accepted click trains, were automatically cross-correlated and used to determine the reproducibility of the measure TEOAEs by the software. Responses were accepted when the reproducibility was 80% or greater. Stimulus stability was maintained at greater than 80 percent. TEOAEs were recorded with and without continous CBBN stimulation at 30dBSL (Re: threshold for noise). Care was taken to ensure that the position of the probe was not altered.

The data obtained was tabulated and suitable statistical analysis was carried out to investigate the aims of the study.

CHAPTER IV

RESULTS & DISCUSSIONS

The data obtained from the three age groups were analyzed using SPSS 10.0 version. Three-way analysis of variance (ANOVA) was done to investigate the effect of age, gender and ear on the following:

1) Speech identification scores (SIS) in different Conditions
2) Amplitude of transient evoked otoacoustic emission in the presence and absence of CBBN.
3) Correlation between shift in SIS and OAE amplitude induced by contralateral acoustic stimulation (CAS).

The results obtained in the present study are discussed in context of existing literature in this chapter.

Speech Identification scores:

EFFECT OF AGE:

Results of this study indicate that there was a significant influence of age on speech identification scores. Table 2 shows the mean and standard deviations (SD) of speech identification scores in three conditions, i.e. in quiet [SIS (Q)], in presence of ipsilateral noise only [(SIS (I)] and in presence of both ipsilateral and contralateral noise [SISI(C)]. The mean and SD of shift in speech identification scores due to contralateral acoustic stimulation is also Shown in Table 2.

The mean values for speech identification scores within each condition suggest that speech identification scores improve as a function of age. This is depicted in figure 3.

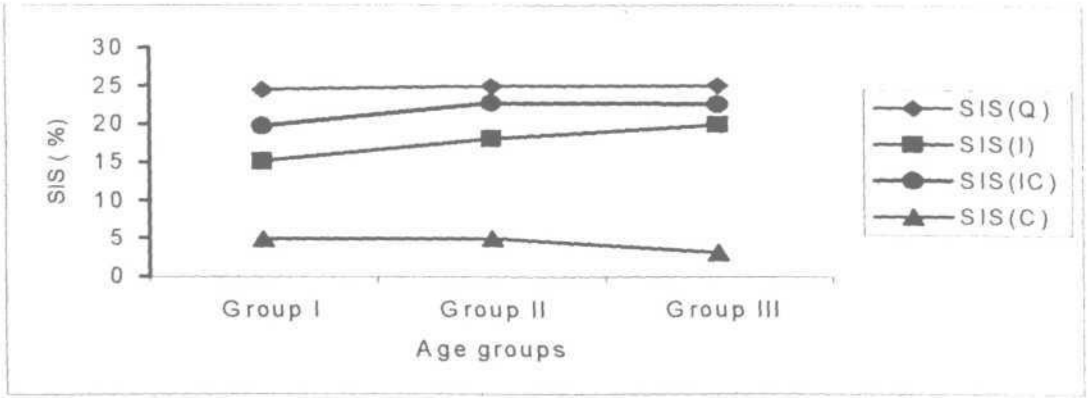


Figure3: Shows the mean for the SIS in different conditions for the different age groups.

ANOVA revealed that age has an effect on the speech identification scores in quiet (F= 11.22, p < .001). Post-hoc Duncan test revealed that the speech identification scores in quiet for group I, was significantly different from that of group II and group III. However there was no significant difference between scores of group II and group III

SIS/AGE	Group I		Group II		Group III	
	Mean	SD	Mean	SD	Mean	SD
SIS(Q)	24.40	1.29	24.92	.26	25.00	.00
SIS(I)	15.06	3.57	18.02	2.03	19.83	2.80
SIS(IQ	19.67	2.79	22.67	1.52	22.53	2.20
SIS(Q	4.88	3.85	4.97	2.64	3.08	2.80

Table 2: Mean and SD for the SIS in different conditions

This result thus suggests that the performance of children on speech identification in quiet reach adult value by lOyears of age. This is in accordance with the report of Elliott et al (1979). According to Elliott et al (1979), there is a developmental changes in speech understanding in quiet across the 5-to 10-year of age range and by the age of lOyears, performance of normal children achieves a level that typifies adult performance.

Investigations by several researchers into the developmental time course of speech recognition have demonstrated systematic improvement in performance as child matures to adolescence (Elliott 1979; Elliott et al, 1979; Hnath-chisolm, Laipply and Boothroyd, 1998). The underlying sources that explains these improvements are far from clear; they have been attributed to factors like growth of vocabulary or increase in phonemic categories, maturation in decision making process, attentional and short term memory demands, or articulation improvement (Boothroyd, 1970,cited in Eisenberg et al., 2000, Hnath-Chisolm et al., 1998). Anatomical studies demonstrate that the human auditory cortex continues to develop until adolescence (Moore, Guan and Wu, 1997 cited in Eisenberg et al, 2000) and hence there may be an improvement in the performance of the child on speech identification task.

However the results of the present study are in contradiction with that of Rout (1996) who emphatically suggests that there is no significant age effect. This difference in results may be attributed to difference in testing procedures. Rout (1996) conducted his study on subjects in a narrow age-range (6-8yrs) and used a picture identification task, as contrasted with the 6-10yrs and 18-30yrs age-groups and a verbal repetition task used in this study.

Significant age effect was found for speech identification scores in the presence of ipsilateral noise only ($F= 37.26$, $p > .001$), in presence of both ipsilateral and contralateral noise ($F= 7.02$, $p < .001$), and also for shift in speech identification scores due to contralateral acoustic stimulation ($F=6.63$, $p < .001$). Post-hoc Duncan tests revealed that there was a significant difference for speech identification scores in the presence of ipsilateral noise for all the three groups. For speech identification scores in presence of both ipsilateral and contralateral noise, post hoc Duncan test revealed, that scores of group 1 were significantly different from that of group II and group III. These results clearly suggest that younger children were significantly less accurate than older children and adults in recognizing speech in presence of ipsilateral noise.

Improved scores were obtained on contralateral acoustic stimulation in younger children, although the scores were poorer than the older children and adults. Also, the noteworthy point is that the performance of older children approximated that of adults on contralateral stimulation. These results suggest that stimulation of medial efferent pathway enhances the speech identification in presence of ipsilateral noise and it can also be speculated based on the results that this property of medial efferent system improves with age.

The shift in speech identification scores on contralateral acoustic stimulation was more for group II, followed by group I and was less for group III. This increased shift in the speech identification scores can be attributed to relatively poor performance of these subjects on the speech identification task with ipsilateral noise only, rather than a gross inference of better medial olivocochlear functioning in these subjects.

Effect of Gender:

The mean and SD value for males and females in the three age groups for speech identification scores in different conditions and for shift in speech identification scores due to contralateral acoustic stimulation are shown in Table 3. The mean values are also illustrated in Figure 4.The statistical analysis reveals significant gender difference for speech identification scores in quiet ($F= 11.82$, $p< .001$) for children in the Group I only. Both males and females obtained 100 % speech identification scores in quiet for the group III and there was no significant gender difference for the group II.

Rout (1996) did not find any gender difference in younger age group (6-8yrs). This difference in results can again be attributed to the difference in the test procedures used in both the studies. Rout (1996) used a picture identification task, as contrasted with a verbal repetition task used in this study. Since it has been demonstrated that from early infancy.

females have superior linguistic performance compared to males in speech production as well as speech perception, their response on verbal repetition task may have been better compared to males. (Dubno, Lee, Matthews and Mills, 1997).

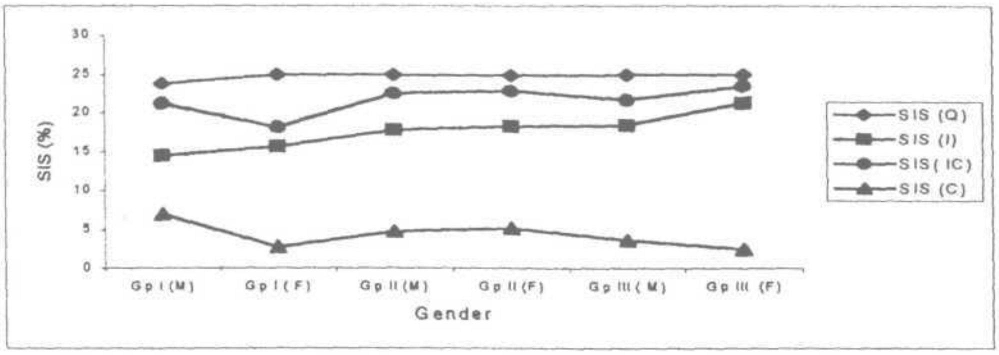


Figure 4: Shows the mean values for the SIS indifferent conditions for males and females for all the three age groups.

Significant gender difference in the speech identification scores in presence of ipsilateral noise only (F=10.23, p < 05) and in presence of both ipsilateral and contralateral noise (F=. 10.97, p< 001) was also found.

SIS/SEX	**Group I**				**Group II**				**Group m**			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
SIS(Q)	23.80	1.64	25.0	.00	24.95	.22	24.9	.30	25.00	.00	25.00	.00
SIS(l)	14.45	4.46	15.67	2.32	17.80	2.06	18.25	2.02	18.43	2.80	21.23	2.02
SIS(IC)	21.20	2.14	18.15	2.56	22.50	1.53	22.85	1.53	21.63	2.51	23.43	1.38
SIS(C)	7.00	3.34	2.77	3.16	4.75	2.35	5.20	2.90	3.66	3.24	2.50	2.19

Table 3: Mean and SD for the SIS in different conditions and for shift in SIS due to CAS for males and females.

Except in group I, for speech identification scores in presence of both ipsilateral and contralateral noise, was better for females when compared to males.

For speech identification scores in presence of ipsilateral noise females were found to perform better than males in all the three age groups. These results of the present study are in accordance with study done by Gatehouse (1994). According to Gatehouse (1994), males need more intensity to "just follow" speech in quiet as well as in noise compared to females.

It can also be speculated from this study that females have better auditory processing abilities in presence of background noise compared to males. This can be because of females using both the hemispheres for processing compared to males. The inference to the above mentioned speculation is made from the results of an investigation by Kansaku, Yamaura and Kitazawa (2000) who reported that females use the posterior temporal lobe more bilaterally during linguistic processing of global structures compared to males.

Effect of Ear:

Table 4 depicts the mean and SD values for right and left ear in the three age groups for Speech identification scores in different conditions and for shift in speech identification scores due to contralateral acoustic stimulation. The mean values are also illustrated in Figure 5.

No significant difference was found for speech identification scores in quiet (F=. 07; p> .05), in presence of ipsilateral noise only (F= .08, P> .05) and in presence of both ipsilateral and contralateral noise (F= 1.49,P> .05). Descriptive statistics also shows that there is not much of a difference in the mean values for speech identification scores in quiet for both left and right ear.

However, for speech identification scores in the presence of ipsilateral noise the speech identification scores are better for the right ear. On contralateral acoustic stimulation the performance was found to be improved and was more for left ear. Significant ear difference was found for shift in speech identification scores due to contralateral acoustic stimulation (F= 5.67, P< 001).

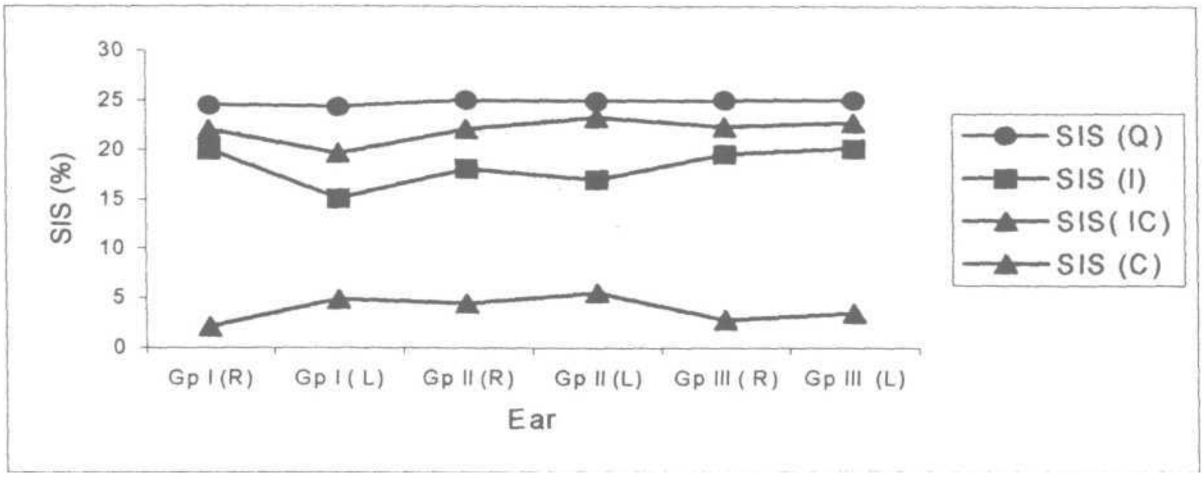


Figure 5: Shows the mean values for the SIS indifferent conditions for right and left ear for all the three age groups.

The variability was more in right ear compared to left ear for shift in speech identification scores due to contralateral acoustic stimulation.

5IS/EAR	**Group I**				**Group n**				**Group III**			
	Right		**Left**		**Right**		**Left**		**Right**		**Left**	
	Mean	**SD**	Mean	SD	Mean	SD	Mean	SD	Mean	SD	**Mean**	**SD**
SIS(Q)	24.45	.94	24.35	1.59	24.95	.22	24.90	.39	25.00	.00	25.00	.00
SIS(I)	20.00	5.10	15.02	3.60	18.05	2.01	17.0	2.10	19.56	2.97	20.10	2.64
SIS(IC)	22.00	9.70	19.65	3.18	22.10	1.48	23.25	1.37	22.33	2.27	22.73	2.14
SIS(C)	2.06	4.90	4.87	3.13	4.40	1.98	5.55	3.12	2.73	3.27	343	2.23

Table 4; Mean and SD for the SIS in different conditions and for shift in SIS due to CAS for both right and left ear.

It is unclear why and how the performance of left ear was better than that of right ear in the present study. Nevertheless, absence of significant ear difference for the contralateral suppression of otoacoustic emissions, led to the speculation that efferent inhibition may have been more effective for left ear for the speech identification task and thus aiding in better performance. This speculation support the notion proposed by Mc Fadeen (1993) that the amount of efferent inhibition is relatively less for right ear compared to left ear.

Interaction of effects of age, gender and ear:

Two-way ANOVA revealed a significant interaction between age and gender for speech identification in quiet, and in presence of both ipsilateral and contralateral noise (F= 12.68, p < .001; F= 6.81,p<. 001). The improvement in speech identification scores in quiet with age was greater for males when compared to females. For speech identification scores in presence of both ipsilateral and contralateral noise, the improvement in scores was found to be more for females compared to males as the age advanced. No significant interaction effect was found between age and ear or ear and gender. Three- way ANOVA revealed no significant interaction effect between the age, gender and ear on speech identification scores in all the three cases.

OTQACOUSTIC EMISSIONS:

Another intriguing aspect of the result lies in the influence of age, gender and ear on transient evoked otoacoustic emissions and contralateral suppression of otoacoustic emission amplitude.

Effect of Age:

The results of the present study indicate significant effect of age on TEAOE amplitude in quiet and on contralateral acoustic stimulation. Mean and SD scores for amplitude of TEOAE in the presence and absence of CBBN are shown in Table 5. The mean values for the same are also illustrated in Figure 6. The TEOAE response in absence and presence of CBBN obtained from 6-year old female is shown in figure 7 and figure 8 respectively.

In general the TEOAE amplitude in presence and absence of CBBN is lower in the group II compared to that of the group I and group III. Results of ANOVA revealed a significant effect of age on the TEOAE amplitude, both in quiet and in presence of CBBN (F=3.62, p > .05; F= 3.43, p< .05).

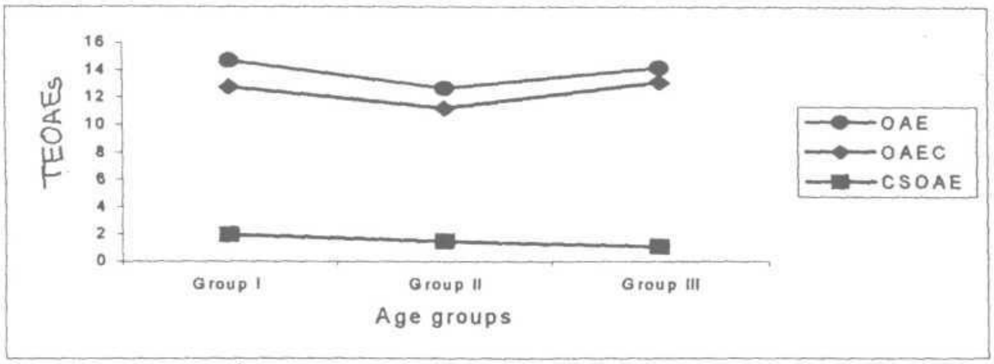
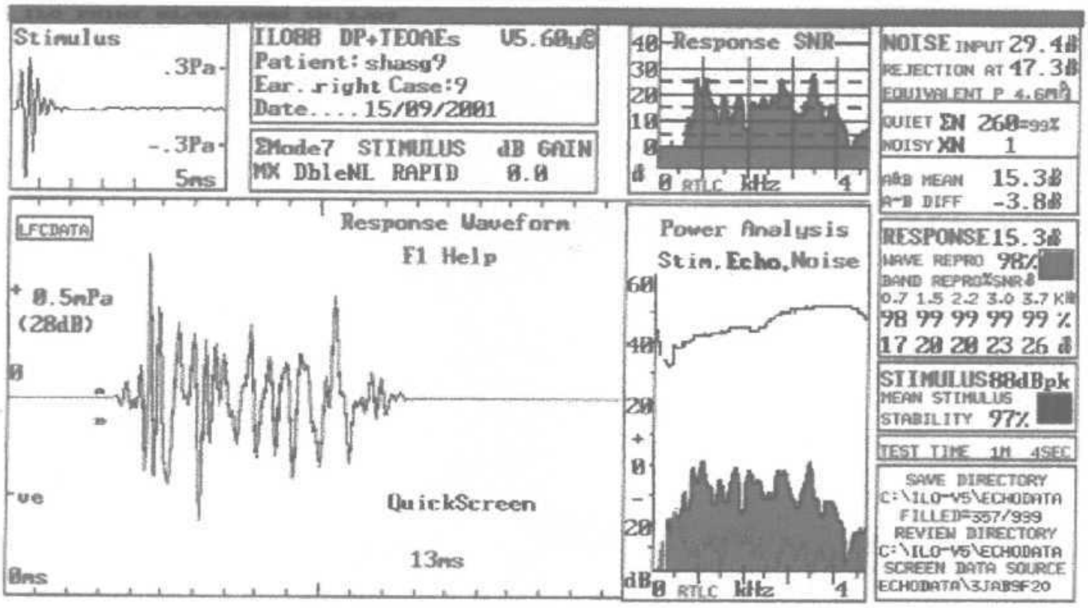


Figure 6: Shows the mean values of OAE amplitude in different conditions for different age groups.

Post hoc Duncan test revealed a significant difference in the TEOAE amplitude (in presence and absence of CBBN) of group II from that of group I and group III. The variability was also less in the group II compared to that of group I and group III for both the conditions.

OAE/AGE	Group I		Group II		Group III	
	Mean	SD	Mean	SD	Mean	SD
OAE	14.65	3.52	12.66	2.74	14.16	4.11
OAEC	12.74	3.48	11.22	2.98	13.09	4.13
CSOAE	1.91	1.86	1.44	.96	1.06	1.33

Table 5: Mean and SD for OAE amplitude in presence and absence of OAE and for suppression in amplitude due to CAS.



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ILO88 DP+TEOAEs   V5.60y©
Patient: shasg9
Ear. right Case:9
Date....15/09/2001
ΣMode7  STIMULUS  dB GAIN
MX DbleNL  RAPID   0.0
NOISE INPUT 29.4dB
REJECTION AT 47.3dB
EQUIVALENT P 4.6mPa
QUIET ΣN 260=99%
NOISY XN   1
A&B MEAN   15.3dB
A-B DIFF   -3.8dB
RESPONSE 15.3dB
WAVE REPRO 98%
BAND REPRO%SNRdB
0.7 1.5 2.2 3.0 3.7 KHz
98 99 99 99 99 %
17 20 20 23 26 dB
STIMULUS 88dBpk
MEAN STIMULUS
STABILITY 97%
TEST TIME  1M  4SEC
SAVE DIRECTORY
C:\ILO-V5\ECHODATA
FILLED=357/999
REVIEW DIRECTORY
C:\ILO-V5\ECHODATA
SCREEN DATA SOURCE
ECHODATA\3JAB9F20
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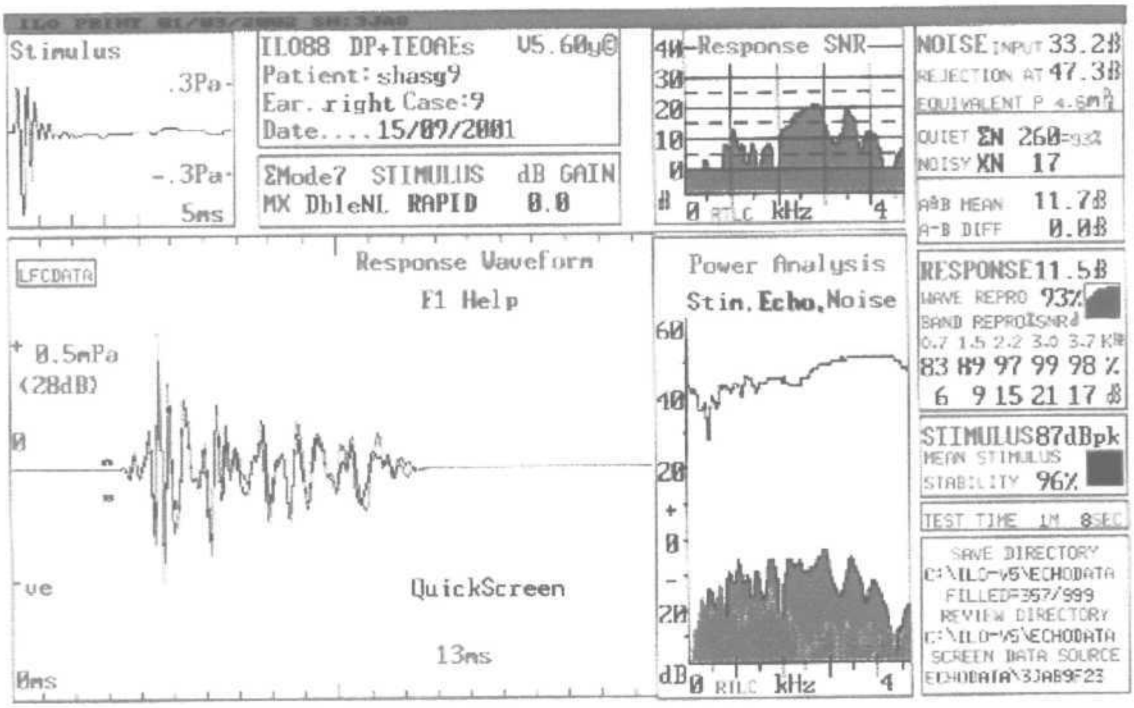
Figure 7: TEOAE response obtained in quiet from a 6-year old female.



```
ILO88 DP+TEOAEs   V5.60y©
Patient: shasg9
Ear. right Case:9
Date....15/09/2001
ΣMode7  STIMULUS  dB GAIN
MX DbleNL  RAPID   0.0
NOISE INPUT 33.2dB
REJECTION AT 47.3dB
EQUIVALENT P 4.6mPa
QUIET ΣN 260=93%
NOISY XN  17
A&B MEAN   11.7dB
A-B DIFF    0.0dB
RESPONSE 11.5dB
WAVE REPRO 93%
BAND REPRO%SNRdB
0.7 1.5 2.2 3.0 3.7 KHz
83 89 97 99 98 %
 6  9 15 21 17 dB
STIMULUS 87dBpk
MEAN STIMULUS
STABILITY 96%
TEST TIME  1M  8SEC
SAVE DIRECTORY
C:\ILO-V5\ECHODATA
FILLED=357/999
REVIEW DIRECTORY
C:\ILO-V5\ECHODATA
SCREEN DATA SOURCE
ECHODATA\3JAB9F23
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Figure 8: TEOAE response obtained in presence of CBBN from a 6-year old female.

Such a pattern indicated that there is no clear relationship between TEOAE amplitude with age, although there is an age-effect. This is also seen for contralateral suppression of otoacoustic emission.

For contralateral suppression of otoacoustic emissions, the results suggest more suppression for the youngest age groups and relatively less suppression for older age groups. Post-hoc Duncan test revealed that there is a significant difference in the amplitude of contralateral suppression of otoacoustic emissions between group I and group III. However the suppression amplitude of group II did not differ significantly from group I and group III. The variability was found to be however more for group I compared to other two groups.

Although the difference is slight, the finding here was that there is more suppression of TEOAEs in younger age group. Similar evidence of a more effective efferent system was also shown by the scores on the psychoacoustical task. These results in general support the notion that the human auditory system demonstrates some kind of continuous maturational changes and are thought to occur primarily at the neural level (Morlet et al., 1996, cited in Bellis, 1996). There is a variety of age-dependent morphological changes that occur in the brain and influence auditory behavior, the most prominent of which is degree of myelination (Romand, 1983, cited in Bellis, 1996). The formation of myelin, although begins during fetal development it continues until maturity. Therefore, the time span of myelination is directly related to the development of sensorimotor and cognitive development (Lecours, 1975, cited in Bellis, 1996).

The development of neural connections in the mammalian cochlea exhibits some classical features that are classically found in the nervous system during their synaptogenesis process. It has been suggested in the literature that the maturation process in the auditory system continues in terms of afferent branching, presence of multiple synaptic bodies, direct efferent contacts with the inner hair cells, axosomatic medial efferents synapse with the outer hair cells (Pujol, Rebillard and Lenoir, 1998). These continuous change in the morphological characteristics of cochlear innervations, as part of the developmental phase could account for its physiological properties as observed in the present study. Given the fact that neuromaturation of the central auditory nervous system continues for several years following birth, it would be expected that those behavioral auditory phenomena and processes that rely upon auditory system integrity would follow a maturational course consistent with the physiological neuromaturation of the system. (Bellis, 1996).

Effects of gender:

Table 6 shows the mean and SD scores for TEOAE in absence and presence of CBBN and also of the suppression of TEOAE amplitude due to the CAS. The mean values for the same are shown in Figure 9.

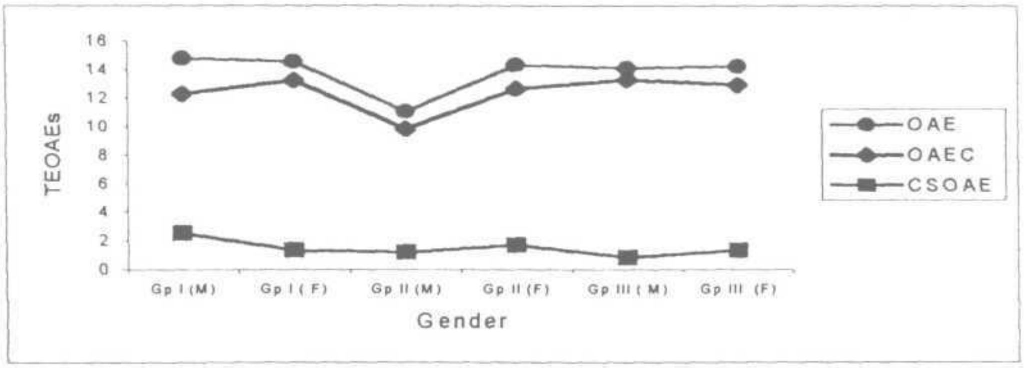

Figure 9: Shows the mean for the OAE amplitude in different conditions for the male and females for the three age groups.

As can be seen from the Figure7, the TEOAE amplitude is higher in females compared to males for the group II and group III, whereas for the group I, the TEOAE amplitude was slightly more for males compared to females. This finding is in accordance with the previous studies (Robinette, 1992). Glattke et al (1994), cited in Glattke and Robinette, (1997) recorded TEOAEs in normal hearing subjects aged from 2 to 83 years. He reported that measures of response amplitude were significantly more robust for females than for male subjects.

These results support the notion that development of cochlear active mechanism in human differs between gender (Morlet et al., 1996, cited in Bellis, 1996). This is also evident from the fact that females are more likely than males to have spontaneous otoacoustic emissions (SOAEs). As Lamprecht-Dinnesen et al (1998) summarized, this gender difference could be from males having longer cochleae; from females having more number of outer hair cells than males; from the small ear canal volume in females leading to easier-to-detect SOAEs or from some genetic factor.

OAE/SEX	**Group>I**				**Group n**				**GroupIII**			
	Males		**Females**		**Males**		**Females**		**Males**		**Females**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	Mean	**SD**	**Mean**	**SD**
OAE	14.78	3.99	14.53	3.07	11.03	2.22	14.30	2.21	14.10	**4.35**	14.21	3.93
OAEC	12.27	4.09	13.21	2.77	9.82	2.54	12.62	2.77	13.28	4.50	12.91	3.80
CSOAE	2.51	2.35	1.31	.91	1.20	.81	1.68	1.07	.82	1.70	1.30	.77

Table 6: Mean and SD for OAE amplitude in presence and absence of OAE and for suppression in amplitude due to CAS for males and females.

Statistical analysis failed to show any significant gender difference for TEAOE amplitude in presence of noise (F= 3.41, p> .05) and for the contralateral suppression of TEOAEs (F=. 11, p > .05). Nevertheless, descriptive statistics suggest that TEOAEs amplitude in presence of contralateral acoustic stimulation and contralateral suppression of otoacoustic emissions were larger in females when compared to males. However this observation was excepted. In group III, males were found to have larger TEOAE amplitude in presence of noise compared to females and in group I, males were found to have more contralateral suppression compared to females.

In general these results suggest that the inhibition by medial efferent system on its activation is more effective in females when compared to males. This can also- be related to the fact that high speech identification scores were observed for females when compared to males on contralateral acoustic stimulation except for group I.

EFFECT OF EAR:

Table 7 shows the mean and SD scores for TEOAE in absence and presence of CBBN and also of the suppression in TEOAE amplitude due to the CAS. The mean values for the same are shown in Figure 10 also.

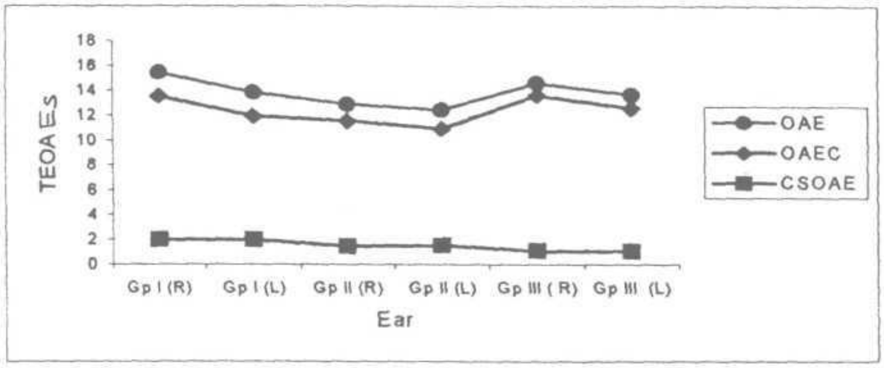

Figure 10: Shows the mean for the OAE amplitude in different conditions for the right and left ears.

Figure 10 depicts that the OAE amplitude is higher in the right ear compared to the left ear. However the statistical analysis failed to show any significant difference between the ear for any of the groups (F=2.95, **p** > .05).

OAE/EAR	Group I				Group n				Group III			
	Right		Left		Right		Left		Right		Left	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
OAE	15.46	3.32	13.85	3.61	12.92	2.96	12.41	2.55	14.64	4.24	13.67	3.98
OAEC	13.55	3.43	11.93	3.42	11.53	3.11	10.91	2.89	13.61	4.32	12.58	3.94
CSOAE	1.90	2.41	1.92	1.13	1.39	1.13	1.49	.79	1.08	1.24	1.03	1.44

Table 7: Shows the Mean and SD for the OAE amplitude in different conditions for the right and left ears for the three age groups.

The variability was also found to be more in the right ear compared to the left ear with an exception of the first group where the variability was slightly higher in the left ear. Similarly, for TEOAE amplitude in presence of contralateral broadband noise larger amplitude was seen in the right ear compared to the left ear and also there was more suppression of TEOAEs in right ears compared to the left ear except for group I. However, statistical analysis failed to show any significant difference between the ears for TEOAE amplitude in presence of contralateral noise ($F= 3.36$, $p > .05$) and for contralateral suppression of TEOAE ($F= .067$, $p > .05$).

A study by Glattke et al (1994), cited in Glattke and Robinette, (1997) showed that response amplitude of TEOAE was slightly more robust for the right ears than for the left ears. Similar results were reported by Priene and Falter (1995). The results of the present study are in accordance with these studies. This suggests that cochlear mechanism is more active in right ears compared to left ears. This notion is supported by studies related to SOAE. Many investigations have concluded that that the prevalence of SOAEs is more in right ear compared to left ear (Lamprecht- Dinnesen et al, 1998)

Regarding contralateral suppression of TEOAEs, a study by Khalfa, Micheyl, Veuillet and Collet, (1998), cited in Veuillet et al., (1999), revealed that medial olivocochlear bundle is more effective in the right ear than in the left ear. The results of the present study are in support of this study. This asymmetry between the two ears reinforces the notion of peripheral auditory lateralization. Similar findings were also reported by Kumar (2001). In 1993, Me Fadeen proposed lateral asymmetries and sex and ear difference in the 'strength' of the efferent inhibition delivered to individual cochleas. Specifically, it was proposed that the amount of efferent inhibition is relatively less in right ears and in females than in left ears and males. These results were found only in group I, where more suppression was seen in males and in left ears.

Interaction effects of age, gender and ear:

Two-way ANOVA revealed significant interaction between effects of age and gender for transient evoked otoacoustic emissions (F=3.27, p<. 001). It was observed that there was greater reduction in amplitude of TEOAEs with increase in age for females. There was no significant interaction between effects of age and ear or ear and gender for amplitude of TEOAEs with and without CBBN. Three-way ANOVA also revealed no significant interaction between effects of age, gender and ear.

Correlation between SISC score and CSOAE amplitude:

Finally the noteworthy point that must be dealt is the correlation between the shift in speech identification scores due to contralateral acoustic stimulation and the contralateral suppression of otoacoustic emissions. The correlation analysis performed with contralaterally induced shift in TEOAE as an independent variable and shift in SIS as the dependent variable. For this, Pearson product moment correlation was calculated. The analysis revealed statistically significant positive correlation (r = .428, p< .001). This positive correlation indicates the involvement of OCB in speech perception in noise. These results are in accordance with the previous studies (Micheyl and collet, 1996; Zeng et al, 1994; Kumar, 2001).

Study by Zeng et al., (1994) and then by Girand et al., (1997) also suggested the notion that, in normal hearing subjects, activity of medial olivocochlear fibers evoked through contralateral noise enhanced the speech in noise intelligibility. However, this improvement was absent in de-efferented ears of vestibular neurectomized patients. Neurophysiological studies also have shown that olivocochlear bundle stimulation enhances the auditory nerve fiber (ANFs) responses to brief tones in presence of noise (Winslow and sachs, 1988, cited in Micheyl and Collet, 1996).

The feedback suppression of MOCB pathway can have enhancing effects on ANFs responses by the decompression of rate level functions. In the presence of noise, ANF responses adapts to steady masker and an adapted ANF is less responsive than an unadapted one (Smith, 1978). Such compression in the rate level functions affect the coding of changes in the stimulus parameters. The activation of OCB may suppress the response to steady masker and decrease the adaptation effect. Thus, it is indirectly increases the ANF response to stimulus (Kawase and Liberman, 1993, cited in Micheyl and Collet, 1996). Reducing the ANF discharge rate at low stimulus levels, the OCB could elicit a decompression of rate level functions, thereby partly restoring the sensitivity of ANFs to changes in stimulation; levels in background noise (Winslow and Sachs, 1988, cited in Micheyl and Collet, 1996). Since variation in intensity and frequency are the major cues for speech perception this decompression effects will enhance the speech identification scores (Kumar, 2001). The results of the present study also supports the hypothesis, that, MOCB enhances the signal coding in noise not because the signal is narrow band and noise is wide band, rather because the noise is constant and the signal is time varying.

Thus the results of the present study indicates that there is a significant influence of age on the olivocochlear bundle functioning and related psychophysical performance in humans. The present study also confirms the hypothesis, that MOCB functioning is important for perception in noise, there by suggesting a possible role of cochlear efferent fibers in hearing.

CHAPTER V

SUMMARY & CONCLUSIONS

Continued attempts by researchers to understand the functioning of the efferent olivocochlear system, has led them to the identification of interesting properties of medial efferent fibers many of which have clinical relevance. One such finding is that the inhibitory function of medial olivocochlear bundle could lead to an improvement in coding of signals embedded in noise (Micheyl and Collet, 1996). A review of literature shows that there is a relationship between contralateral suppression of otoacoustic emissions and speech perception in noise. This suggests that contralateral suppression of otoacoustic emissions can be used to predict an individuals speech understanding capacity in noise. However, the use of contralateral suppression of otoacoustic emissions as a classical tool for predicting speech perception in noise requires established normative data across age groups. Hence, the present study was set up in this direction and aimed at investigating the effect of age, gender and ear on:

- Speech identification scores in quite, in presence of ipsilateral noise only and in presence of both ipsilateral and contralateral noise.

a Transient evoked otoacoustic emission amplitude in absence and presence of contralateral broadband noise.

a Correlation between shift in speech identification scores and transient evoked otoacoustic emission amplitude due to contralateral acoustic stimulation.

To study this, psychophysical (estimation of speech identification scores) and physiological (measurement of transient evoked otoacoustic emission) experiment was carried out for subjects in three different age groups. Group I (6-8yrs) and group II (8-

lOyrs) had twenty subjects each, out of which ten were males and ten were females. Group III (18-30yrs) had thirty subjects, out of which fifteen were males and fifteen were females. Speech identification scores were measured in three conditions, quite, + 10dB signal to noise ratio with and without contralateral noise. Physiological measures of olivocochlear bundle were carried out by measuring contralateral suppression of otoacoustic emissions. The data obtained from the three age groups were analyzed using SPSS 10.0 version. Three-way analysis of variance was carried out to investigate the effect of age, gender and ear. For correlation Pearson-product moment correlation was calculated. The following conclusions were drawn from the study

I) Speech identification scores within each condition improve as a function of age.

II) Significant gender difference is present in the performance of speech identification task in all the three conditions. In general, females have better performance when compared to males.

III) Significant ear effect is seen only for shift in speech identification scores due to contralateral acoustic stimulation. Scores of left ear were found to be better than the right ear.

IV) There is a significant interaction between age and gender for speech identification in quiet and in presence of both ipsilateral and contralateral noise.

V) There is no clear relationship between transient evoked otoacoustic emission amplitude either in quiet and in presence of noise with age.

VI) There is a significant influence of gender on transient evoked otoacoustic emissions amplitude only in quiet. In general, females have larger transient evoked otoacoustic emissions amplitude and more suppression compared to males.

evoked otoacoustic emissions amplitude and more suppression compared to males.

VII) Though statistically, not significant, the amplitude of transient evoked otoacoustic emissions is larger and suppression of otoacoustic emissions is greater in right ear when compared to that of left ear.

VIII) There is a significant interaction between effects of age and gender for transient evoked otoacoustic emissions.

IX) There is a significant positive correlation between the shift in speech identification scores and transient evoked otoacoustic emissions amplitude due to contralateral acoustic stimulation. This indicates the involvement of olivocochlear bundle in speech perception in noise.

Thus, the results of the present study show that there is a significant influence of age on the speech identification and transient otoacoustic emissions in absence and presence of contralateral noise. The present study also shows that irrespective of age, stimulation of medial efferent fibers improve the perception of speech in noise. Thus the norms for contralateral suppression of transient otoacoustic amplitude obtained in the present study can be used to make an inference regarding the speech perception abilities of the clinical population, especially of children with suspected central auditory processing difficulties or auditory-based language disorders. In this respect, the present study certainly constitutes a step toward the study of more developmental trends related to speech perception on activation of medial efferent fibers and its clinical relevance.

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