Effect of age on contralateral suppression of Oto-acoustic emissions and sentence perception in noise

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CERTIFICATE

This is to certify that this dissertation entitled "**Effect of age on contralateral suppression of oto-acoustic emissions and sentence perception in noise**" is a bonafide work submitted as a part of the fulfilment for the degree of Master of Science (Audiology) of the student registration number: 17AUD039. This has been carried out under the guidance of the faculty of this institute and has not been submitted to any other University for the award of any other diploma or degree.

Mysore
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CERTIFICATE

This is to certify that this dissertation entitled "**Effect of age on contralateral suppression of otoacoustic emissions and sentence perception in noise**" has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other University for the award of any other diploma or degree.

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DECLARATION

This is to certify that this dissertation entitled "**Effect of age on contralateral suppression of oto-acoustic emissions and sentence perception in noise**" is the result of my of study under the guidance of **Dr. Ganapathy M.K.,** Lecturer in Audiology, Department of Audiology, All India institute of Speech and Hearing, Mysore and has not been submitted to any other University for the award of any other degree or diploma

Mysore **Registration No. : 17AUD039**

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DEDICATING THIS DISSERTATION WORK TO

GOD ALMIGHTY

TO MY DEAR PARENTS

AND TO ALL THOSE WHO SEEK KNOWLEDGE IN THE FIELD OF AUDIOLOGY

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Abstract

Behavioural and physiological evaluations are non-invasive measures for understanding age related changes in human auditory system and in medial efferent (olivocochlear) pathways.

Objective: The main objective of this study was to study the effect of ageing on medial efferent system measuring the contralateral suppression of otoacoustic emissions (CSOAE) and sentence identification scores (SIS) in the presence of ipsilateral and contralateral noise. Further to probe into the correlation between CSOAE and shift in SIS in the presence of noise.

Method: The 60 participants of the study were divided into two groups (30 in each) based on their age – Group 1 (46-55 years) and Group 2 (56-65 years). All the participants in both the groups had pure tone threshold ≤ 20 dB at octave frequencies from 250 Hz to 4 kHz for AC and BC testing. TEOAE was measured with and without contralateral broadband noise (BBN) at 30 dB SL. Behaviourally SIS was also measured with and without contralateral BBN 30 dB SL for three ipsilateral signal to noise ratios (SNRs) of +5 dB SNR, 0 dB SNR and -5 dB SNR.

Results: The results indicated significant difference in the SIS scores with and without contralateral noise within both the groups at +5 dB SNR and 0 dB SNR. No significant difference was found for SIS with and without contralateral noise at above SNRs between the groups. Although there was a reduction in TEOAE amplitudes with and without contralateral noise in the Group 2 than Group 1, but the results were not significant statistically. Further no significant correlation was found between CSOAE and shift in SIS with contralateral BBN. However both behavioural and objective measures showed mean reduction between age groups indicating ageing effects in the efferent auditory system.

Conclusion: Influence of ageing is seen through the decline in speech in noise scores, deterioration in TEOAE amplitude and contralateral suppression of TEOAE across the two study groups. These indicate weakening of the medial efferent auditory system and thereby indicating speech perception difficulty found in elderly adults resulting due to ageing.

TABLE OF CONTENT

List of Tables

List of Tables

.

.

Chapter 1

Introduction

The outer hair cells (OHCs) in mammalian cochlea are very unique. The human cochlea has approximately 12,000 OHCs arranged in 3–5 rows along the basilar membrane, and around 3,500 inner hair cells (IHCs) arranged in a single row. “There are complete differences in the action of both of these hair cells” (Moller, 2006). “The function of inner hair cells is sensory transduction, while outer hair cells are mechanical in nature” (Moller, 2006).

While during an acoustic event, the “OHCs convert membrane voltage changes into mechanical force through their special properties known as mechanotransduction and electromotility”. These properties depend on a special motor protein called prestin and this is central for auditory functions such as cochlear amplification and fine tuning of the cochlear basilar membrane (Dallos et al, 1997). Efferent innervations of cochlea in mammals are provided by the olivocochlear bundles (OCB). In late 1970’s it became clear that the OCB actually consists of at least two fundamentally different sub systems. They are the medial and lateral olivocochlear bundles. First LOC (Lateral Olivocochlear Bundles) was described by Rasmussen (1946) and the MOC (Medial olivocochlear Bundles) was described by Guinan (1969).Both LOC and MOC arise from the superior olivary complex (SOC), the first nucleus in the auditory brainstem to receive binaural inputs. “The LOC and MOC can be differentiated by locations of their neurons in the SOC and their projections to different regions of the cochlea” (Guinan, Warr and Nobbis, 1983).

The “OHCs receive efferent projections from the central nervous system through medial olivocochlear neurons (MOC), located in the brainstem”. The cell bodies that make up the LOC are located in the lateral region of the SOC and they are thin, unmyelinated axons, which project to ipsilateral cochlea and terminate on afferent (Type 1) fibers of IHC's. "The neurons of the MOC have relatively thicker myelinated axons that project predominantly to the contra lateral cochlea, terminating on the cell bodies of OHC's" (Guinan, Warr and Nobbis, 1983). The efferent fibers act directly on outer hair cells while afferent fibers only affect the output of inner hair cells by controlling the neural excitation in the nerve fibers that leave inner hair cells (Moller, 2006).

Olivocochlear function in humans can be studied through different methods. Guinan was one who reviewed such methods since 1983. Otoacoustic emissions have been widely used as a non-invasive tool in order to evaluate the olivocochlear reflex,s pathway in animals as well as in humans. Since Buno & Murata's (1978, 1980) works, showed that" acoustic stimulation of one cochlea may modify afferent fibre responses in the contra lateral cochlea", experiments have indicated the possibility of studying the efferent olivocochlear system activity, by coupling a contra lateral stimulation to OAE recording, which involves a reduction of OAE amplitude in adults. This effect is called as "Contralateral suppression of OAE".

Suppression of OAE's refers to the reduction of the amplitude of the acoustic output measured at the tympanic membrane. "This reduction is small on the order of 1-4 dB SPL" (Berlin et al, 1993b, Collet et al 1990). "This effect is typically initiated soon after the introduction of the suppressing stimulus, & lasts as long as the stimulus is present, and disappears with the removal of the suppressor" (Liberman, 1996) and has been attributed to the activation of the OCB. "Clicks or tone pips that evoke TEOAEs can also be used to measure MOC effects" (Collet, 1990; Liberman, 1989).

The OAE suppression can be best achieved by using broadband noise to activate the MOC system. It also appears that similar effects can be obtained by using narrowband masking at a wide variety of frequency bands. These findings have been interpreted to mean that the MOC system suppression, at least measured by TEOAE's, but may not be frequency specific (Berlin et al, 1993).

"In humans the role of the auditory efferents in facilitating speech perception in noise" (De Boer et al., 2012; Kumar and Vanaja, 2004) and "mediating attention-related modulation of cochlear function" (e.g., Garinis et al., 2011a; Maison et al., 2001) has also been explored. Accordiing to Kawase and Liberman (1993) "the role of the auditory efferent system in the detection of speech presented under noisy conditions has been re-evaluated over the years with mixed results". Also they said that "almost every case the approach has been co-relational; i.e., "speech-in-noise performance in a group of individuals has been correlated with their own contralateral acoustical stimulus (CAS) induced changes in OAE magnitude".

Studies have shown that the "performance in older adults is unaffected in quiet" (Pedersen, Rosenhall, &Møller, 1991; van Rooij, Plomp, & Orlebeke, 1989). Further, it is reported that majority of the population of older adults have reduced hearing and difficulty in understanding speech in different listening situations. This can be attributed to "histopathological changes in the cochlea such as cell degeneration with loss of supporting cells and hair cell loss at basal end of cochlea" (Willott, Parham, & Hunter, 1991). Thus there are structural (Shankar, 2010) and neurochemical (Caspary, Ling, Turner, & Hughes, 2008) changes which could lead to speech understanding deficits seen in older adults. Also studies have indicated that "the speech understanding problems in older adults is due to changes in the central auditory system (Divenyi & Haupt, 1997; Humes, 1996)".

It is reported that the pre-frontal cortex is the most affected (Shankar, 2010), with lateral pre-frontal region undergoing most atrophic changes (Kryla-Lighthallv& Mather, 2009). These age-related changes affect speech understanding, especially in presence of background noise (Kryla-Lighthall & Mather, 2009). Therefore these “neuro-chemical and central auditory system changes due to ageing possibly explains the speech understanding problems in older adults with no hearing loss (Horwitz, Dubno & Ahlstrom, 2002; Gilbertson & Lutfi, 2014)”. These central changes can be studied by studying the efferent system in older adults.

Kumar and Vanaja (2004) reported that “contralateral acoustic stimuli enhanced speech perception when ipsilateral signal to noise ratios was +10 dB and +15 dB”. This enhancement had significant positive correlation with contralateral suppression of OAE. But others have reported the reverse effect (eg: Micheyl, 1995; Garinis et al., 2011b). A strong negative correlation was reported by Bidelman & Bhagat (2015) between behavioral performance of SIN and magnitude of suppression of right-ear OAE, such that “lower speech reception thresholds in noise were predicted by larger amounts of MOC-related activity”. Also, de Boer and Thornton (2007) suggested that “the efferent system plays a role in speech perception through dynamic control of cochlear gain, influenced by attention or experience”.

1.1 Need for the study

Many researchers have shown that speech recognition and contralateral suppression of OAEs declines with increasing age. Early findings prove that “age-related functional deterioration in the medial olivocochlear (MOC) efferent system starts prior to age-related loss of OHCs (Fu et al, 2010)”. Castor et al. (1994) reported “a decreased influence of CAS (contralateral acoustic stimulation) on TEOAEs in a group of older adults (age range 70–88 years)”. Similarly, “Kim et al. (2002) found reduced medial efferent effects on DPOAEs in the middle-aged (38–52 yr olds) as compared to the young adult group without any significant difference in the baseline DPOAE levels”. This evidence suggests reduced contralateral suppression in even in middle aged adults also.

In older adults even with normal hearing sensitivity, speech understanding was reported to be poorer than younger individuals (Gelfand, Piper& Silman, 1986; Pichora-Fuller, Schneider & Daneman, 1995). From these studies it can inferred that ageing affects audibility and speech understanding abilities and that these hearing difficulties are not uniform among the older adults. Fu et al (2010) said that "olivocochlear bundles starts to degenerate before hearing loss due to presbycusis and speech identification in noise are reported to be affected in elder individuals irrespective of their normal pure tone thresholds". Some of the "age-related decline in speech perception can be accounted for by peripheral sensory problems but cognitive ageing can also be a contributing factor (Kim & Oh, 2013)".

Literature shows that clinically contralateral suppression of OAEs and Speech in noise testing is optimal way to measure and study the functioning of the olivocochlear bundle and medial efferent pathway. Also literature indicates a relationship between contralateral suppression of OAEs and Speech identification in noise i.e., abnormal reduction and absence of contralateral suppression indicates a poor speech identification in noise. Also different types of speech stimuli were used from non-sense syllable identification to continuous discourse identification by different authors. Studies report that the "speech in noise scores vary with the speech material used for testing (Anderson & Kalb, 1987)". Along with this the speech in noise testing may be carried out at varying SNRs and was found that identification scores improves with increment in SNRs (Cheesman & Jamieson,1996: Ellermeier & Hellbruck,1998). Thereby, the relationship between MOCB (medial olivocochlear bundles) and speech perception in noise may by varied by SNRs.

Thus the above findings of different studies suggest that contralateral suppression of OAEs can be used to predict speech identification in noise in an individual. Though contralateral suppression of OAEs is an objective tool that doesn't require behavioral responses, this can be used in difficult to test individuals as well to predict speech identification ability in noise. Thus there is a need to study the effect of ageing on efferent auditory system through contralateral suppression of OAEs and speech identification in noise test.

1.2 Aim:

The aim of the study is to evaluate the efferent auditory system in older adults.

1.3 Objectives of the study:

1. Effect of ageing on speech identification scores with and without contralateral stimulus
2. Effect of ageing on objective test of efferent auditory system (contralateral suppression of OAE)
3. Correlation of speech identification scores with contralateral stimulus and suppression of OAE in two older adult groups individuals

1.4 Hypothesis of the study

The assumed null hypothesis for the present study is, there will be no difference between behavioral and objective tests of auditory efferent system in adult groups.

Chapter 2

Review of Literature

The present study was carried out to understand the effect of ageing on efferent auditory system in older adults. To understand this, review of literature discusses what are the changes in the auditory system and its behavioural consequences.

2.1 Anatomical and physiological changes due to age in auditory system

Various anatomical and physiological changes have been archived in human body because of ageing. These changes are seen in the auditory system also which may or may not lead to hearing difficulties in older adults.

Anatomical and physiological changes occur in the auditory system with ageing. These changes can be seen in the outer ear, middle ear, inner ear, and the central auditory pathways. Barbera (2012) reported “changes in the outer ear due to ageing include enlargement of the pinna, hair growth in the outer ear - on the tragus and lower helix mainly in males, increased scaliness, dryness and pigmentation spots”. They also reported loss of elasticity in the ear canal, and narrowing or collapse of the ear canal is common, leading to conductive hearing loss (Barbera, 2012). “Production of excessive wax, with poor epithelial migration is also common in older adults” (Miyamato, 1995). Most of these changes do not affect hearing, but may interfere with use of hearing aid and while taking ear impressions for making ear moulds.

Wiley, Nondahl, Cruickshanks, and Tweed (2005) have reported that “changes in the middle ear due to ageing resemble arthritic changes and loss of elasticity as in other parts of the body”. Wiley et al. (2005) reported that “the tympanic membrane appears to become rigid, thinner and less vascular with increase in age". Rawool and Harrington (2007) suggested that "the middle ear system may become sloppy with rheumatoid arthritis in the lenticular process with advancing age". The arthritic changes also include calcification and thinning of incudomalleolar and incudostapedial joints (Rosenwesser, 1964). Additionally, "atrophy and degeneration of the fibers of muscles and ligaments of the ossicles has also been reported" (Rosenwasser, 1964). It is obvious that the middle ear undergoes anatomical changes with age. However, this has little physiological consequence leading to changes in the Behavioural test results. However, significant deficit of middle ear transformer function has not been reported with age (Wiley, Cruickshanks, Nondahl, & Tweed, 1999).

The changes in the cochlea due to ageing are mainly due to histopathological changes. "The histopathological changes in organ of Corti with ageing include cell degeneration with loss of supporting cells" (Willott, & Lister, 2003). Willott, Parham, and Hunter (1991) reported that "loss of hair cells starts at the basal end and begins with outer hair cells (OHC)". Further, they noted that the OHCs are less in older adults (>70 years of age) and that collapse of outer and inner hair cells are independent. In contrast, it has been eminent that "older adults who have hair cell damage near the base of the cochlea are associated with high frequency hearing loss ; whereas, hair cell loss in the most apical portions did not have significant shift in low frequency thresholds (Willott et al., 1991)".

The loss of OHCs with ageing is reported to be associated with reduction in spectral resolution capacity of the inner ear with ageing (Frisina & Frisina, 1997). Otte, Schuknecht, and Kerr (2015) demonstrated a relation between ageing and loss of ganglion cells. They reported that a "progressive loss of about 2000 neurons per decade with significant decline seen from 41 years of age". Further, they suggested that age-related loss in the ganglion cells is greater near the base of the cochlea. Suzuki et al. (2006) reported "atrophy of the spiral ganglion cells in individuals above 50 years of age". Several histopathological studies have revealed that “neural degeneration can occur before and/or independent of sensory loss” (Otte, Schuknecht, & Kerr, 2015; Suzuki et al., 2006). Willott et al. (1991) noted loss of nerve fibres in one turn of the cochlea or in all turns without loss of hair cells. Suzukaand & Schuknecht (1988) reported that “less than 20% of the subjects showed unaffected pure-tone thresholds with loss of ganglion cells”.

Increase in audiometric thresholds were noted when total ganglion cells was less than 20,000 (Otte, Schuknecht, & Kerr, 2015). “Neuronal changes have also been reported with increasing age. These include affected neural synchrony with reduced amplitude of the action potential” (Caspary, Schatteman, & Hughes, 2005), “longer neural recovery time” (Walton, Frisina, & O’Neill, 1998) and “decrease in number of neurons with changes in synapses between inner hair cells (IHCs) and the auditory nerve”(Caspary, Schatteman, & Hughes, 2005; Clinard, Tremblay, & Krishnan, 2010).

These consequences of changes in the peripheral auditory system are seen also throughout the central auditory nervous system. In addition, the central auditory nervous system (CANS) undergoes changes with ageing. “Changes in both CANS and peripheral auditory system due to ageing will contribute to the processing problems experienced by older adults, mostly in temporal domain” (Frisina & Walton, 2006).

2.2. Speech identification in adults

Age-related hearing loss (presbycusis) is characterized by:

- an poorer hearing threshold
- poor speech understanding in a noisy environment,
- slowed central processing of acoustic information, and
- Impaired localization of sound sources.

(Kim, 2013).

Presbycusis affects the older adults' quality of life; also Kim said that "hearing loss in the elderly contributes to social isolation, depression, and loss of self-esteem". People who present with normal hearing (within normal limits) but have supra-threshold auditory deficits are not uncommon. Multiple terms have been used to describe these deficits including: central presbycusis, auditory disability with normal hearing, obscure auditory dysfunction (OAD), King-Kopetzky Syndrome, auditory dysacusis, central auditory processing disorder (CAPD) or auditory processing disorder (APD), idiopathic discriminatory dysfunction, hidden hearing loss (HHL), cochlear synaptopathy (CS), and HDs, among others (Beck et al, 2018).

Gordon-Salant and Fitzgibbons (1993) reported that"ageing alone contributes to the diminished speech identification performance in elderly adults. Studies have shown that "the performance of older adults is unaffected in quiet" (Pedersen, Rosenhall & Moller, 1991; van Rooij, Plomp & Orlebeke, 1989). However, "the perception in older adults is significantly affected for speech in degraded condition or in the presence of background noise even in individuals with normal heari'ng sensitivity (Dubno, Lee, Matthews,& Mills, 1997; Gelfand, Piper & Silman, 1986)". "Most of the elderly individuals experience difficulty in understanding speech when in noise, or at a faster rate, or when the amount of information is loaded even if they do not have hearing loss (Gordon-Salant, 2005)".

Pichora-Fuller, Schneider & Daneman (1995) reported "reduced speech understanding in elderly individuals, even without any clinically significant elevation of pure-tone thresholds". According to Gelfand, Piper, & Silman (1986), "even though older adults have normal hearing thresholds their speech understanding problem cannot be explained by mere peripheral hearing loss alone". Snell (1997) have reported "poor temporal resolution in older adults” and these “temporal deficits may lead to speech perception deficits which was indicated on time compressed speech tests where older adults showed poorer scores when compared to younger counterparts” (Letowski & Poch, 1995). Also the scores for time time compressed speech tests were drastically affected when presented in background noise (Tun, 1998).

Abdala (2014) also compared “the difference in performance for tasks such as vowels, consonants and word in sentence identification in the presence of noise among teenagers, young adults, middle aged adults and older adults”. The result was also “deterioration in performance with increase in age beyond middle age. Also found no correlation between speech scores and age in individuals greater than 60 years of age”. Similarly for a study by Billings, Penman, McMillan & Ellis (2015), “significantly lower sores for sentence in the presence of speech noise for older adults compared to young adults”. Also in the same study, a significant main effect of SNR which was varied from -10 dB to 35 dB was also reported for both the groups.

All these study results indicates affected speech perception in older adults with or without hearing loss. The efferent stimulation through contralateral acoustic stimulation is dependent upon the type of contralateral stimulus

2.3. Effect of ageing on SOAEs and contralateral suppression.

Bright (1997) reported “decrease in prevalence of spontaneous otoacoustic emissions (SOAEs) in adults older than 60 years”. Further, it was reported that the total number SOAEs decreased with age. Similar results were also reported by Stover and Norton (1993). However, studies have revealed that “only about 40 to 60% of the normal hearing individuals have SOAEs” (Jedrzejczak, Kochanek, Pilka, & Skarzynski, 2016).

SOAEs are not found in a single consistent frequency i.e., different individuals show different SOAE frequencies with the response spectrum. Also contralateral stimulation has indicated a shift in the emission frequency and reduction in amplitude as well. Hence, using SOAEs to validate the effects of ageing may seem inappropriate.

2.4. Effect of ageing on DPOAE and contralateral suppression

The distortion-product OAEs (DPOAE) reflect the non-linear response properties of the human cochlea (Bowman, Eggermont, Brown, & Kimberley, 1998). Uchida et al. (2008) hypothesized that "the DPOAE levels decline due to ageing independent of hearing loss, and that men are more affected than women". Lonsbury-Martin, Cutler, and Martin (1991) reported decrease in DPOAE amplitudes due to ageing.

Jacobson, Kim, Romney, Zhu, and Frisina (2003) also noted a decline in DPOAE amplitude due to effects of ageing. They further noted that reduced contralateral suppression of DPOAE at low frequencies preceded the decline in DPOAEs with age. Jupiter (2009) noted that "use of DPOAEs serve as a potential tool to identify older adults at-risk for hearing loss and also to monitor them with otoacoustic drugs". These studies verify that DPOAE measurements in older adults may give early indication of cochlear damage due to ageing and aid in monitoring their hearing.

DPOAE levels are generally lesser in the older age group compared to the younger adults and that "contralateral suppression turned down with age for the middle-aged and old groups. In addition, contralateral suppression in the 1 to 2 kHz range was greater than in the 4- to 6-kHz range for all ages, but especially for the old group" (Kim S, Frisina DR, Frisina RD, 2002). These findings advocate that a functional drterioration of the MOC system with age precede OHC degeneration. Moreover, "the MOC system maintains better function in the 1 to 2 kHz range than in the 4 to 6 kHz range as a function of age" (Karger, 2002).

Both “BBN and NBN are effective contra lateral stimuli in the suppression of DPOAEs. Suppressive effects of BBN have been measured for DPOAEs from 0.5 to 5 KHz” (Moulin et al 1993). BBN appears to have the maximum effect on DP among 1 KHz and 3 KHz. “NBN is most effective in suppressing DPOAEs when the center frequency of the noise is close to that of the DPOAE and the DPs are in the range of 1-2 KHz” (Croze et al 1993). Noise bands at center frequencies amid 250 and 750 Hz were not found to be efficient suppressor of DPOAEs.

Abdala, Dhar and Luo (2013) reported that “MOC activation with contralateral stimulation reduced the reflection more than distortion component of the DPOAE”. Distortion is abridged by approximately 5% to 18% of baseline amplitude on average across frequency; reflection, between 10% to 34% on average. According to them “few older individuals exhibited enhanced DPOAE amplitude with contralateral stimulation and were termed as atypical elders in their study”.

2.5. Effect of ageing on TEOAE and contralateral suppression

According to Shera and Guinan (1999) "unlike DPOAEs, which are generated in the cochlea by two mechanisms, TEOAEs are generated by low to moderate stimulus levels by only one cochlear mechanism ,which describes that the TEOAE magnitude changes with the presence of CAS”. Subject age and intensity of contralateral noise level are two important variables to consider in the measurement of OAEs and interpretation of the efferent-mediated suppression effect.

Stenklev and Laukli (2003) reported that “the prevalence of transient or click evoked OAEs decreased with age”. In addition, the response level and reproducibility decreased with age. Further, they stated that the results were significant statistically but not clinically significant in terms of wave reproducibility.

However, Prieve and Falter (1995) in their study reported that “there was no significant difference in transient evoked OAE levels between young and older adults having normal hearing”. These studies point out that the transient evoked OAEs may not serve as a tool to study the effects of ageing.

When the level characteristics of TEOAEs and distortion product OAEs as a function of age was studied , it clearly indicated that “when the degree of peripheral hearing loss is rigorously controlled, there is no direct effect of advanced age on the level of OAEs” (Strouse et al, 1996; Parthasarathy, 2000).

“Evaluating the suppression effect on OAE level as a function of age at varying levels of CBBN is one of the few ways to determine the efferent activity of the MOS that is implicated in the ability to hear in noisy backgrounds” (Liberman, 1989; Musiek and Hoffman, 1990; Micheyl and Collet, 1996).

When clicks are used to elicit TEOAEs during efferent-mediated suppression measurement, broadband stimuli are considered most effective (Berlin et al, 1993b). Collet et al (1990) and Veuillet et al (1991) evaluated the suppression effect to linear clicks for 60 to 63 dB peak SPL while CBBN level was presented ranging from 0 to 50 dB SPL. No significant impact were found for noise levels below 30 dB SPL. When “click intensity is held constant, the level of the suppression effect increases as a function of increases in the suppressor noise level “(Hood et al, 1996).

According to Kalaiah, Noronah, Kharmawphlang, Nanchirakal (2017)“largest suppression of TEOAE was found for white noise”. In contrast, speech babble elicited least suppression of TEOAE. For amplitude-modulated noise, the quantity of suppression increased with modulation frequency of noise. Among real-life noise signals, he reported that the suppression was largest for cafeteria noise compared with traffic noise.

Collet et al, (1990) found significant suppression effect, close to 3 dB, was observed for broadband noise levels between 30 and 50 dB SPL. In addition, the suppression effect varied considerably in degree but was consistently present in normal-hearing subjects.

Parthasarathy (2002), in his study with subjects in the age range below 60 years, found a raise in the CBBN intensity level from 40 to 50 dB HL resulted in an increase in the mean suppression from 0.5 to 1 .0 dB, and "the overall mean suppression level increased from 0.5 to 3 .5 dB SPL with an increase in the level of CBBN from 40 to 70 dB HL". In contrast, "for subjects between 60 and 69 and 70 and 79 years of age, with an increase in the CBBN from 40 to 70 dB HL, the mean suppression effect increased from 0.5 dB to 0.9 dB SPL". In this study, for subjects in the age range between 60 to 79 years, an increase in CBBN levels from 40 to 70 dB HL resulted in a minimal increase in suppression from 0.5 to 0 .9 dB SPL.

Similarly, Castor et al (1994), using "linear clicks with 30 dB SL contralateral white noise, reported an equivalent attenuation of TEOAEs close to 2.17 dB in the 20 to 39 years age group and 0.36 dB in the 70 to 78 years age group". These minor disparities in results are attributable to the methodological differences in computing the suppression effect.

The amount of MOC system suppression on OAE's is a function of the intensity level of the noise in the contralateral ear. As the level of the noise increases, so does the amount of suppression (Berlin et al 1993; Collet et al 1990) The time period for which most suppression takes place is usually 8 to 18 ms range (post stimulation), at least for TEOAE's (Berlin et al, 1993). Suppression effects are greater if the OAE stimulus is less than 65dB SPL. "Higher intensities are more resistant to suppression effects of the MOC bundle" (Hood, Hurley, Leonard, and Berlin, 1996).

The results from these literatures have shown that a continuous BBN can activate the MOCS and differentially suppress the TEOAEs as a function of age. Although direct comparison of suppression effects of the current with other studies is difficult because of the differences in subject ages, suppressor noise levels, eliciting stimuli levels, and the type of clicks, the conclusion of the present study are in good agreement with previous results.

Although OAE levels are correlated with age, hearing thresholds, click intensity, and intensity of the CBBN (Collet et al, 1990; Berlin 1993b; Stover and Norton, 1993; Hood et al, 1996), important factors controlling OAE levels are not completely understood.

Thus, it appears that the efferent control of OHCs may become functionally impaired with aging. The inefficiency of the MOCS might, in part, explain the increasing difficulties of speech understanding in noise with aging.

2.6. Middle ear muscle reflex and contralateral suppression of OAE.

Though there exists a chance that the middle ear muscle reflex (MEMR) is activated in an OAE test, it is tough to decide if the alter in OAE level was because of initiation of the MOC activity, or of the MEM reflex, or a blend of both (Guinan et al., 2003; Goodman et al., 2013). "Changes in improvement level past a measure sum were ascribed to changes in middle ear impedance brought about by MEMR activation by the contralateral acoustic stimulation(CAS)" (Goodman et al., 2013; Boothalingam and Purcell, 2015; Lichtenhan et al., 2016; Mertes and Goodman, 2016). In the current study contralateral acoustic stimulation was 30dB SL, which is well below the level to possibly generate an acoustic middle ear reflex. However, click stimuli themselves were neither not really known whether elicited MEMR nor were controlled to avoid evoking the MEMR. So it is likely that there was MEMR activation in both the with and without CAS conditions because of the clicks, however not because of the presentation of contralateral stimuli.

2.7. Ear effect on contralateral suppression

Study by Glattke et al. (1994), cited in Glattke and Robinette (1997) had shown that "the response amplitude of TEOAE was slightly more in the right ears than for the left ears" but was not statistically significant. Similar results were also reported by Priene and Falter (1995), Sharad & Vanaja (2004). This suggests that "the cochlear mechanism is more active in the right ears supported by studies related to more SOAEs in the right ear compared to the left ear" (Lamprecht et al., 1998). The regular finding in these studies was a higher amount of suppression in the right ear compared to the left ear. Urnau & Tochetto (2012) study had right-handed individuals and the clarification given was in relation to handedness of the medial olivocochlear system. But Kaipa and Kumar (2016) reported no significant effect of handedness on MOCB function.

Even though there are mixed results in literature the subjects in the current study tested for contralateral suppression and also for speech identification in noise in right ear only.

Thus from the above literature reviews it is understood that speech recognition (Gelfand, Piper& Silman, 1986; Gordon- Salant & Fitsgibbons (1993); Pichora-Fuller, Schneider & Daneman, 1995; Kim & Oh, 2013; Abdala, 2014), OAE amplitudes (Parthasarathy, 2002; Stenklev and Laukli (2003; Abdala & Dhar,2012: Abdala & Kalluri, 2017) and contralateral suppression of OAEs decline with increasing age (Castor et al., 1994; Kim et al., 2002; Fu et al., 2010) and this shows the feasibility of using contralateral suppression of OAEs and speech in noise testing as an optimal way to measure and study the functioning of the medial medial oliovocochlear efferent pathway.

Thereby, indicating a need to study the effect of ageing on efferent auditory system through speech identification in noise test, TEOAE test evaluation and contralateral suppression of TEOAE.

Chapter 3

Method

The study was done to evaluate the effect of ageing on the medial efferent system based on findings of behavioural and objective tests.

3.1 Subjects:

A total of 60 subjects participated in the study. They were divided into two groups based on age.

Group 1: consisted of 30 participants in the age range >45 to 55 years with hearing sensitivity within normal limits.

Group 2: consisted of 30 participants within the age range >55 to 65 years with normal hearing sensitivity.

3.2 Subject Selection Criteria

Inclusion criteria

The participants in Group 1 and Group 2 were included with audiometric thresholds ≤ 20 dBHL from 250 Hz to 4 kHz frequencies for air conduction (AC) and bone conduction (BC). Participants included had ‘A’ type tympanogram with acoustic reflexes present at 1 kHz.

It was ensured that all the participants had no history of otological problems, noise exposure and neurological issues.

3.3 Instrumentation

A calibrated dual channel clinical audiometer, Grason Stadler Inc.-61 (GSI-61),with Telephonics TDH-39 supra-aural headphones was used for estimating the air conduction thresholds. Radio ear B-71 bone vibrator was used for bone conduction thresholds estimation. The same GSI-61 audiometer was used to present contralateral broadband noise for TEOAE suppression testing.

A calibrated middle ear analyzer, GSI tympstar (GSI-USA) was used for tympanometry and reflexometry.

Speech material was presented through a laptop connected to a two channel clinical audiometer.

Transient evoked otoacoustic emissions (TEOAEs) and Contralateral Suppression were recorded using a Otodynamics ILO 292 version 6.0 OAE equipment. Contralateral noise was given through ER-3 insert earphones connected with the audiometer.

3.4 Test environment

All tests were carried out for each individual in an air-conditioned acoustically treated double- room setting. The noise levels in these rooms were ensured to be within permissible limits (ANSI S 3.1 1991).

3.5 Procedure

3.5.1 Behavioural testing

An initial otoscopic examination was carried out to rule out the presence or absence of wax in the external ear and status of the tympanic membrane. Pure tone audiometry was done based on Modified Hughson-Westlake (Carhart & Jerger, 1959) procedure for octave frequencies 250 to 4000 Hz. Thresholds were obtained using TDH 39 air conduction headphone and for bone conduction B-71 bone vibrator was used.

Test material:

Test material developed by Geetha & Kumar (2014), was used for speech identification. Speech material consists of 25 homogenous lists with 10 sentences in each list Speech material was mixed with speech noise at– 5, 0 and +5dB SNRs and was presented through a laptop connected to a two channel clinical audiometer. A calibration tone recorded at the beginning of each list was used to adjust the deflection of the VU meter to 0 while presenting the material. Verbal responses were obtained from the subjects.

3.5.1.1 Speech Identification tests

Speech identification scores were obtained at the level of 50 dBHL for the following conditions:

In quiet (no noise will be given in either of the ears): During this testing the subjects were made to sit comfortably in a seat and were asked to repeat the words heard over the headphones.

In the presence of ipsilateral Speech noise: Here, along with the speech stimulus, speech noise was presented to the same ear (ipsilateral) and the subjects were asked to ignore the noise and repeat the words heard over the headphone. Speech stimuli were presented at 50dBHL along with ipsilateral noise in signal to noise ratios (SNRs) of -5, 0 and +5 dB SNRs.

In the presence of ipsilateral and contralateral noise: Here, contralateral broad band noise (BBN) of 30 dBSL (ref: threshold of noise) was presented along with the above three SNR conditions (i.e., -5, 0 and +5 dB SNRs**).** The contralateral noise was presented through the headphone 500 ms before the onset of sentences and was turned off 500 ms after each sentence was completed.

The order of the presentation of stimuli was randomized to avoid the order effect. Every correct word in each sentence was scored as 1 and the corresponding percentage was calculated. Based on the obtained results, effect of contralateral stimuli on speech identification scores was analysed.

3.5.2 Objective testing

3.5.2.1 Transient evoked otoacoustic emissions (TEOAEs)

Participants were instructed to be seated on a chair and to be quiet during testing procedure. Transient evoked otoacoustic emissions (TEOAEs) were recorded using a Otodynamics ILO Version 6 OAE equipment. The standard protocol, with default settings, for measurement of contralateral suppression was used. In the protocol, 80 dB peSPL click stimuli were delivered to right ear. A total of 260 OAE sweeps are used. Global and half-octave band values of OAE response levels and signal-to-noise ratios (SNRs) were used for analysis. All recordings had an SNR of at least 3 dB for global values and 2 dB in half-octave bands frequencies from 1 to 4 kHz.

3.5.2.2 Contralateral Suppression testing

The same procedure as above were repeated in the presence of contralateral BBN (left ear) at 30 dBSL (reference was threshold of noise in that ear) which was presented through the insert ear phone. Care was taken to ensure the position of the probe to be the same during both the recordings.

Finally, contralateral suppression of TEOAE was calculated by taking the difference in amplitude measured without noise and with contralateral noise. That is, CS (in dB) = TEOAE (– CAS) -TEOAE (+CAS)

[-CAS: Without contralateral acoustic stimulation; +CAS: With contralateral acoustic stimulation].

3.6. Statistical Analysis:

The data was subjected to the Shapiro Wilks test of normality. The result revealed that the data do not follow normal distribution (i.e., $P < 0.05$) and hence non parametric tests were administered. The statistical tests administered are as follows:

1. Descriptive statistics were performed to examine the central tendency and variation of amplitude in TEOAE with and without contralateral BBN and speech identification scores with and without contralateral BBN.
2. A non parametric Mann Whitney U test was carried out to compare Group 1 and Group 2 in terms of amount of suppression and variation in speech identification scores.
3. Wilcoxon sign rank test was administered to check difference in sentence identification score with and without contralateral noise at +5 dB SNR, 0 dB SNR and -5 dB SNR and to compare amplitude of TEOAEs with and without contralateral BBN.
4. Spearman’s rank correlation test was administered to check for correlation between contralateral suppression of OAE and shift in speech identification scores in the presence of contralateral BBN.

Chapter 4

Results

The data obtained from the two age groups were analyzed using SPSS 21.0 version. The aim of the study was to investigate the effect of ageing on sentence identification in the presence of contralateral noise and on efferent auditory system using contralateral suppression of OAE.

The sentence identification scores were measured at different conditions keeping speech level constant at 50 dBHL such as:

- in quiet (SpQ),
- in presence of ipsi speech noise at +5 dB SNR (SI5).
- in presence of ipsi speech noise at 0 dB SNR (SI0).
- in presence of ipsi speech noise at -5 dB SNR (SIM5).
- in presence of ipsi speech noise at +5 dB SNR with contralateral BBN at 30dBSL(SIC5).
- in presence of ipsi speech noise at 0 dB SNR with contralateral BBN at 30 dBSL(SIC0).
- in presence of ipsi speech noise at -5 dB SNR with contralateral BBN at 30 dBSL(SICM5).

The measures used for analysis of TEOAE are global amplitude of OAE and amplitudes of OAEs at different frequencies: 1 kHz, 1.5 kHz, 2 kHz, 3 kHz, and 4 kHz with and without contralateral noise at 30 dBSL (ref: threshold of noise).

The data scores between the two groups were compared namely

Group 1: 46- 55 years and Group 2: 56-65 years.

The data is subjected to the Shapiro Wilk's test of normality. The result revealed that the data do not follow normal distribution (i.e., $p < 0.05$). A non parametric Mann Whitney U test is carried out to compare Group 1 and Group 2.

4.1 Comparison of sentence identification scores with and without contralateral noise

Comparison of sentence identification scores with and without contralateral noise was done within group and between groups.

4.1.1 Comparison of sentence identification scores with and without contralateral noise within group 1.

For group 1 descriptive statistics were carried out to find the mean, median and standard deviation of sentence identification scores with and without contralateral noise with ipsi +5 dB SNR, 0 dB SNR and -5 dB SNR. The same is shown in table 4.1.

Table 4.1

Mean, median and standard deviation of sentence identification scores with and without contralateral noise at different SNRs within Group 1.

Group 1	SpQ	SI5	SI0	SIM5	SIC5	SIC0	SICM5
Mean	100	98.33	90.31	61.66	96.46	87.29	62.9
SD	0	3.46	10.09	11.22	6.01	10.66	12.36
Median	100	100	92.19	62.50	100	90.62	64.06

Descriptive statistic results of sentence identification score indicates that there was a difference in the mean values of with and without contralateral noise conditions at different SNRs within Group 1.

Wilcoxon sign rank test was administered to check difference in sentence identification score with and without contralateral noise at +5 dB SNR, 0 dB SNR and -5 dB SNR within Group 1.

Table 4.2

Test statistics (|Z|) and significance values for comparison SIS with and without contralateral BBN within Group 1.

	|Z|
SI5 and SIC5	2.481*
SI0 and SIC0	2.122*
SIM5 and SICM5	0.663

* p value <0.05

Results indicate that there was a significant difference in the sentence identification scores with and without contralateral noise conditions at +5 dB SNR, 0 dB SNR but not at -5 dB SNR within Group 1.

4.1.2 Comparison of sentence identification scores with and without contralateral noise within group 2.

For Group 2 descriptive statistics were carried out to find mean, median and standard deviation of sentence identification scores with and without contralateral noise with ipsi +5 dB SNR, 0 dB SNR and -5 dB SNR. The same is shown in table 4.3.

Table 4.3:

Mean, median and standard deviation of sentence identification scores with and without contralateral noise at different SNRs within Group 2.

Group 2	SpQ	SI5	SI0	SIM5	SIC5	SIC0	SICM5
Mean	99.58	97.81	86.46	59.48	95.41	82.71	57.5
SD	1.6	3.59	11.56	11.41	7.37	12.27	13.44
Median	100	100	90.62	62.5	100	82.81	56.25

Descriptive statistic results of sentence identification score indicates that there was a difference in the mean values of with and without contralateral noise conditions at different SNRs within Group 2.

Wilcoxon sign rank test was administered to check difference in sentence identification score with and without contralateral noise at +5 dB SNR, 0 dB SNR and -5 dB SNR within Group 2.

Table 4.4:

Test statistics (|Z|) and significance values for comparison SIS with and without contralateral BBN within Group 2.

	|Z|
SI5 and SIC5	2.831*
SI0 and SIC0	2.516*
SIM5 and SICM5	0.843

* p value <0.05

Results indicate that there was a significant difference in the sentence identification scores with and without contralateral noise conditions at +5 dB SNR, 0 dB SNR but not at -5 dB SNR within Group 2.

4.1.3 Comparison of sentence identification scores with and without contralateral noise between groups.

Descriptive statistic results of sentence identification score indicates that there was a difference in the mean values of with and without contralateral noise conditions at different SNRs between the two groups.

Table 4.5:

Mean median and standard deviation of sentence identification scores with and without contralateral noise at different SNRs between the groups.

SIS	Group 1			Group 2		
	Mean	SD	Median	Mean	SD	Median
SI5	98.33	3.46	100	97.81	3.59	100
SI0	90.31	10.09	92.19	86.46	11.56	90.62
SIM5	61.66	11.22	62.50	59.48	11.41	62.5
SIC5	96.46	6.01	100	95.41	7.37	100
SIC0	87.29	10.66	90.62	82.71	12.27	82.81
SICM	62.9	12.36	64.06	57.5	13.44	56.25

The descriptive statistic results of sentence identification score indicates that there was a decrease in the mean values in contralateral noise conditions at different SNRs compared to only ipsilateral noise in both the groups except at -5 dB SNR with and without contralateral BBN in Group 1.

Mann-Whitney U test was administered to compare Sentence identification scores with and without contralateral BBN between groups and the results are as shown in Table 4.6.

Table 4.6:

Test statistics (|Z|) and significance values for comparison SIS with and without contralateral BBN between groups.

	|Z|
SI5	0.531
SI0	1.312
SIM5	0.402
SIC5	0.323
SIC0	1.430
SICM5	1.351

p values > 0.05

The result showed no significant difference between the two groups as shown in table 4.6.

4.2. Comparison of TEOAE amplitude between both the groups

Table: 4.7

Mean and standard deviation of TEOAEs with and without contralateral noise at different SNRs between the groups.

TEOAE	Group 1		Group 2	
	OAE	OAEN*	OAE	OAEN*
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Global	9.55(3.82)	8.71(.394)	7.78(3.16)	7.09(2.96)
OAE1	2.90(5.19)	0.83(5.17)	2.80(3.68)	-0.83(4.88)
OAE1.5	4.86(4.46)	3.91(4.59)	0.94(5.67)	2.11(3.35)
OAE2	2.15(4.13)	1.44(4.09)	-4.06(6.02)	-0.44(5.58)
OAE3	-0.893(6.09)	-1.46(5.84)	-6.59(6.96)	-4.36(5.46)
OAE4	-2.13(6.72)	-2.67(6.84)	-3.21(4.21)	-4.22(5.96)

*OAEN – Otoacoustic emission with contralateral noise

The descriptive statistics results for TEOAE amplitude between the two groups revealed reduction in TEOAE amplitude with age across the groups but the difference was statistically significant which is shown in table 4.7 for descriptive statistics and in table 4.8 for test statistics (|Z|) .

Mann-Whitney U test was administered to compare TEOAE amplitude with and without contralateral BBN between groups and the results are as shown in Table 4.6.

Table 4.8:

Test statistics (|Z|) and significance values for comparison of TEOAE amplitudes with and without contralateral BBN between groups.

TEOAE	|Z|
OAE	1.590
OAEN	1.279
OAE1	0.961
OAEN1	0.614
OAE2	1.390
OAEN2	1.280
OAE3	1.906
OAEN3	1.775
OAE4	2.647
OAEN	2.936

p values > 0.05

4.3 Comparison of contralateral suppression of TEOAE

Comparison of contralateral suppression of TEOAEs was done between groups.

4.3.1 Comparison of contralateral suppression of TEOAEs between groups.

Descriptive statistics were carried out to find the mean, median and standard of contralateral suppression of TEOAE.

Table 4.9:

Mean, median and standard deviation of contralateral suppression of TEOAEs between groups

CSOAE	Group 1			Group 2		
	Mean	SD	Median	Mean	SD	Median
Global	0.836	0.681	0.700	0.683	0.983	0.750
1 kHz	0.820	1.704	0.600	0.440	1.800	0.70
1.5 kHz	0.956	1.028	1.000	0.693	1.066	0.800
2 kHz	0.710	1.044	0.500	0.533	1.452	0.600
3 kHz	0.566	1.476	0.650	0.506	1.756	0.200
4 kHz	0.536	0.730	0.700	0.446	1.616	1.100

CSOAE: contralateral suppression of otoacoustic emission.

Results showed decreased mean values of contralateral suppression of TEOAE across all frequencies in group 2 compared to group 1. The same is shown in the table 4.9.

Mann-Whitney U test was administered to compare difference in contralateral suppression of TEOAE between the groups.

Table 4.10:

Test statistics (|Z|) and significance values for comparison of TEOAE with and without contralateral BBN between groups.

CSOAE	|Z|
CSOAE_G	0.133
CSOAE1	0.104
CSOAE1.5	0.504
CSOAE2	0.037
CSOAE3	0.474
CSOAE4	1.705

p values > 0.05

The results indicate no significant difference between the two groups in contralateral suppression at all frequencies as shown in table 4.10.

4.4. Correlation between contralateral suppression of TEOAE and shift in SIS in the presence of contralateral BBN.

Spearman's rank correlation test was administered to check whether there is any correlation between contralateral suppression of TEOAE and shift in SIS in the presence of contralateral BBN.

Table 4.11:

Correlation coefficient and significance value (p) for contralateral suppression of OAE and shift in SIS with contralateral BBN for Group 1.

Group 1	Correlation coefficient
CSOAE and ShiftSI5	-0.372
CSOAE and ShiftSI0	-0.142
CSOAE and ShiftSIM5	0.232

p value >0.05

For group 1 result indicate that there is no significant correlation. The same is depicted in Table 4.11.

Table 4.12:

Correlation coefficient and significance value (p) for contralateral suppression of OAE and shift in SIS with contralateral BBN in Group 2.

Group 2	Correlation coefficient
CSOAE and ShiftSI5	0.003
CSOAE and ShiftSI0	-0.120
CSOAE and ShiftSIM5	-0.305

p value >0.05

For group 2 results indicate that there is no significant correlation. The same is depicted in Table 4.12.

Chapter 5

DISCUSSION

5.1. Effect of ageing on speech perception in noise

The first objective of the study was to probe into the effect of ageing on speech identification scores with and without contralateral stimulus. There were 30 participants each in both the groups named Group 1 (age ranged from 46 to 55 years) and Group 2 (age ranged from 56 to 65 years). Both the groups had participants with hearing sensitivity within normal limits upto 4 kHz. Sentence identification scores in the presence of ipsilateral speech noise at different SNRs (+5 dB SNR, 0 dB SNR and -5 dB SNR) without and with contralateral broad band noise (BBN) were administered.

The study results indicated no significant effect of age on speech identification score. But the mean speech identification scores were getting poorer in both the adult groups as the SNR decreases from + 5dB to -5 dB along with contralateral BBN stimulation. Kim S, Ma S, Lee J, & Han W (2018) also reported deterioration of sentence recognition in noise as the SNR was reduced from +6 to 0 dB. If the study were compared with a much younger group there could have been a statistically significant difference.

Further, at 0 dB and -5 dB SNRs the sentence identification scores improved when the contralateral BBN was presented than in ipsilateral noise condition alone in few individuals in both the adult groups. This improvement was seen in 15% of participants at 0 dB SNR and 50% of participants at -5 db SNR in Group 1 and in 28% of participants at 0 dB SNR and 34% of participants at -5 dB SNR in Group 2. This kind of finding was also reported consistently by Kumar and Vanaja (2004) for word identification in contralateral noise test for children at +15 and +10 dB SNRs. They reported “the improvement in attribution to the activation of MOC pathways with contralateral noise". These results are indicative of intact/functioning efferent auditory system in few older adults. Further, in individuals who did not have improvement in the scores could be indicative of age related deterioration of auditory efferent system. Also these results indicates that the deterioration may not be taking place in similar fashion.

Similar results were also indicated by different authors in the literature as well. Abdala et al (2014) showed a decline in speech scores up to 60 years and thereafter it was plateau. His result was, deterioration in performance with increase in age beyond middle age (40-58 years). Billings, Penman, McMillan & Ellis (2015), showed "significantly lower sores for sentence in the presence of speech noise for older adults compared to young adults". Also in the same study, a significant main effect of SNR which was varied from -10 dB to 35 dB was also reported. In the current study even though we do not see a statistically significant difference, the mean scores shows difference in performance between Group 1 and 2. Also there was more number of individuals in Group 1 whose performance with contralateral noise was better.

"Reduced temporal acuity and cognitive decline in the elderly has been accounted as one reason for the decline in the speech scores with age" (Fitzgibbons & Gordon-Salant,1996; Pichora-Fuller, Schneider, McDonald, Pass, & Brown, 2007). "Listening in dips phenomena is the one that occurs while listening in noise indicating the temporal modulation cues" (Assman & Summerfield, 2004). These declined temporal abilities are attributed to the poor speech perception in noise as the noise masks the temporal cues and deteriorates performance more (Assmann et al., 2008). "gnitive load being more required in case of background noise also is an influential factor "(Zekveld, Kramer & Festen, 2011) and "reduced neural efficiencies" (Werff & Burns, 2011) deteriorating listening in noise ability in older individuals.

5.2. Effect of age on contralateral suppression of TEOAE

The findings of this study showed of presence of TEOAE suppression in both the adult groups. The mean amount of suppression in dB was 0.836 (SD= 0.70) for Group 1 and 0.683 (SD=0.750) for Group 2. The descriptive statistics reveals a reduced suppression of TEOAEs in the Group 2 compared to the Group 1 for the global response and also in frequencies 1, 1.5, 2, 3 & 4 kHz. However the test of significance (Z values) indicated no significant difference between the two groups ($p>0.05$). Further mean TEOAE amplitude also were reduced in Group 2. Here too the statistical analysis does not show significant difference between the groups.

Stenklev and Laukli (2003) reported that “the prevalence decrease in amplitude of transient or click evoked OAEs with increase in age”. In addition, the response level and reproducibility decreased with age. Further, they stated that the results were statistically significant but not clinically significant in terms of wave reproducibility. However, Prieve and Falter (1995) in their study reported that “there was no significant difference in transient evoked OAE levels between young and older adults having normal hearing”. These studies point out contradicting results of transient evoked OAEs.

Parthasarathy (2001) had tested for the amount of TEOAE suppression with increasing age and also found a reduction in suppression amplitude in participants with mean age more than 60 years. He attributed this to the deteriorated functioning of MOC (medial olivocochlear) pathways. Similar results were also reported in a study by Castor et al. (1994) and SungHee Kim et al (2002). In the study by Maruthy, Kumar & Gnanateja (2017) indicated a reduction the suppression amount of OAE with age which was in consensus with the current study though statistical significance between the two groups were absent. The standard deviations of the suppression were high, which may be the reason for no statistical significance. For this including more number of samples would be an option to understand suppression in ageing. Also including a much younger adult group for comparison could have given an ageing effect.

5.3. Correlation of contralateral suppression of TEOAE and Speech identification in noise

A weak correlation between the contralateral suppression and SIS shift with contralateral noise was reported in the study. It is reported that increased MOC efferent activity upon increasing contralateral stimulation level should, on average, exhibit an improvement in performance of signal detection in the presence of noise (Narne & Kalaiah, 2018). Contrary to expectation, the results revealed a weak correlation between MOC activity and speech perception. Giraud et al (1997), Kumar & Vanaja (2004), Sunghee Kim et al (2006), and Abdala et al (2014), have reported a positive correlation between Speech in noise scores and MOCB functioning. Similar results are also reported in literature especially "for older adults for DPOAE inhibition depicted as the decline in the functioning of MOC bundles leading to poor speech perception" (Uchida et al. (2008).

Bhagat and Biedelman (2015) reported a strong negative correlation between behavioral performance of SIN and magnitudes of right-ear TEOAE suppression. They reported lower speech reception thresholds in noise were predicted by larger amounts of MOC-related activity. Kim et.al, (2006) showed weak relation between MOC reflex strength and speech perception in 25 individuals in the age range of 18-75 years using DPOAEs. Wagner et.al, (2008) also reported no correlation for speech reception threshold and MOC reflex for subjects in the age range of 19.7-41.7 years using DPOAEs.

Here in the present study no significant improvement in speech identification scores was found in both the groups with contralateral broadband stimulation. Though both the groups showed suppression in TEOAE amplitude with contralateral noise, but this activation of MOC was not enough to enhance the speech perception indicating poorer MOC activation in older adults. Thereby in line with difficulty in speech perception in noise condition found commonly in elder population, the study also confirms that the efferent auditory system is important for understanding speech in the presence of noise.

As there was no statistical significant difference the assumed null hypothesis for the present study that there will be no difference between behavioral and objective tests of auditory efferent system in adult groups is accepted.

So the influence of ageing demonstrated through the decline in speech in noise scores, deterioration in TEOAE amplitude and contralateral suppression of TEOAE over the two study groups. It is an indicator that explains the weakening of the medial efferent auditory system and thereby indicating speech perception difficulty found in elderly adults resulting from ageing of the system.

Implication of the study:

The study clearly points out reduction in the functioning of efferent auditory system in older adults. This points out for a need to develop norms for older adults and use the behavioural and objective tests for routine audiological evaluation. The results also indicate on use of assistive listening devices for older adults who have listening problems in noisy places.

Chapter 6

SUMMARY & CONCLUSION

Ever since OAEs where first defined by Kemp (1978, 1979) there has been growing interest in their clinical application to the problem of identifying the presence of hearing loss. TEOAEs are found in 98% of normal-hearing individuals (Figueiredo, 2003). Anatomical abnormalities of the outer ear canal or the middle ear (in this study all subjects had type A tympanometry curves and the acoustic reflexes were present), issues with equipment, and noise are some of the factors that may explain absence of TEOAE (Lopes & Carlos, 2005).

Two groups of participants in the range of 46 to 65 yrs were included in the study. Both the groups included 30 individuals each who were individuals with normal hearing sensitivity. The first group ranged in age from 46 to 55 years and the second group ranged in age from 56 to 65 years. Amplitude of TEOAEs was measured with and without contralateral BBN at 30 dBSL and the amount of suppression was calculated. Speech identification scores were obtained at ipsilateral +5 dB SNR, 0 dB SNR and -5 dB SNR with and without contralateral stimulus condition.

The data obtained was analysed using statistical package of Social Science (SPSS) software version 21. The results revealed that there was a significant difference in sentence identification scores (SIS) with and without contralateral stimulus at both +5 dB SNR and 0 dB SNR in both the groups.

In both the groups the mean scores declined as ipsilateral signal to noise ratio reduced from +5 dB SNR to -5 dB SNR and also with both ipsilateral and contralateral noise. In Group 1 the reduction for SIS was from 98.3 % to 61.66 % for ipsilateral noise and from 96.46 % to 62.9 % for both ipsilateral and contralateral noise. Whereas in Group 2, the reduction for SIS was from 97.81 % to 59.48 % for ipsilateral noise and from 95.41 % to 57.5 % for both ipsilateral and contralateral noise.

Even though no statistical significant differences were seen for the objective tests the TEOAEs amplitude were lesser in the Group 2 compared to the Group 1. The mean global TEOAE amplitude for Group 1 with and without contralateral BBN noise was 9.55 dB and 8.71 dB respectively whereas in Group 2 the mean global TEOAE amplitude with and without contralateral BBN noise was 7.78 dB and 7.09 dB respectively.

The contralateral suppression of TEOAEs, both the adult groups showed suppression of TEOAEs in the presence of contralateral BBN. There was no significant difference in terms of contralateral suppression of TEOAEs between both groups. But the mean values of the contralateral suppression for Group 1 (mean: 0.836, SD: 0.681) was more than Group 2 (mean: 0.683, SD: 0.983). These indicate the older adults the suppression is reduced and could be reason for their reduced speech understanding in noise.

No significant difference between the groups could be due to high standard deviations of the suppression values. For this including more number of samples would be an option to understand suppression in ageing. Also including a much younger adult group for comparison could have given a ageing effect. However, the results point out to reduced speech in noise and overall reduced levels of TEOAE and contralateral suppression of TEOAE indicate age related deterioration of the MOC pathways.

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