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Original Research Article

Stimulus and Subject Factors Affecting Contralateral Suppression of Acoustic Reflexes

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ABSTRACT

Contralateral Suppression of Acoustic Reflex is used as a diagnostic tool to measure the functioning of the medial efferent auditory system. The study assessed the effect of different reflex eliciting signals and the ear and gender effect on contralateral suppression of acoustic reflexes. A clinical observational design was used to achieve the objective. 30 normal hearing subjects between age group of 17-30 years were randomly selected. A comparison between baseline acoustic reflex threshold and amplitude (at 10 dB SL) with the presence and absence of 40 dB SL white noise in the contralateral ear was recorded. The results of the study showed that there was suppression of acoustic reflex threshold and reflex amplitude for 500Hz, 1000 Hz, and 2000 Hz, low band noise, high band noise, broad band noise and clicks. However, there was no significant difference in the amount of suppression of acoustic reflex threshold and reflex amplitude across stimuli, gender and across left and right ears. The result of the study shows that there is no effect of different stimuli on contralateral suppression of acoustic reflexes. In addition, there was no ear effect and gender effect on contralateral suppression of acoustic reflexes. Further studies with all the stimuli on hearing impaired population are essential to know whether the method can be used for a larger clinical population.

Key words: Contralateral Suppression of Acoustic Reflex Threshold, Contralateral Suppression of Acoustic Reflex Amplitude, Stimulus effect, Ear Effect, Gender Effect, Medial efferent system.

INTRODUCTION

The efferent auditory system has a vital role in human auditory perception. The medial efferent system plays important role in localization of sound source, [1] auditory attention, [2,3] protection of cochlea against acoustic injury, [4,5] improved detection of acoustic signals and improved speech perception in presence of noise. [2,6] The medial olivocochlear bundle (MOCB) originates from the nuclei in the medial olivary nucleus. These are myelinated fibers which directly innervate the outer hair cells. [7] The medial efferent fibers project predominantly to the contralateral ear and they are readily stimulated than the lateral efferent fibers. The functional and clinical role of medial efferent system is still unclear. However, the basic function of medial efferent system, in general, is the suppression of the afferent activity. It is well established that acoustic stimulation of one cochlea can change afferent responses in the opposite ear mediated by medial efferent system. [8-10]

Outer hair cells are innervated directly by the medial efferent system. Thus, the outer hair cells are directly modulated by the medial efferent system. The medial efferent system functioning is generally assessed using contralateral suppression of otoacoustic emissions (OAE) where there is a reduction of amplitude of OAE in the order of 1-4 dB due to a suppressor stimulus. [11] The noise presented to the opposite side reduces the movement of outer hair cells in the contralateral ear. This inhibition induced by the efferent system causes reduction in OAE amplitude. The absence of suppression is usually indicative of abnormal functioning of medial efferent system. The abnormal medial olivocochlear bundle (efferent) functioning seen in individuals with learning disability, [12] auditory neuropathy spectrum disorder, [13] (central) auditory processing disorder and aging effects. [14]

Contralateral suppression of acoustic reflexes can be an additional tool which can be used to assess the functioning of efferent system. [9] Kumar and Barman [9] reported that contralateral suppression of acoustical reflex may be used as an indicator to check the functioning of the efferent system at high intensity input levels. Contralateral suppression of acoustic reflex can be determined by the decrease in the amplitude, or, the increase in the threshold of the middle ear muscle reflex in the presence of a suppressor stimulus in the contralateral ear. Contralateral suppression of acoustic reflex threshold (CSART) or contralateral suppression of acoustic reflex amplitude (CSARA) is more widely applicable on the clinical population as middle ear stapedial reflex are resistant till 60dB of sensorineural hearing loss. In addition, studies also suggest that test re-test reliability of contralateral suppression of otoacoustic emissions is poor. [15] Kumar, Methi and Avinash [15] recommended that contralateral suppression of DPOAE shouldn’t be used clinically to assess the medial efferent system. In addition, evaluation of the medial efferent system by contralateral suppression of OAE warrants normal cochlear functioning. The test cannot be used even in individuals with mild to moderate hearing loss. Thus, contralateral suppression of acoustic reflexes can be a powerful tool which can be used in individuals hearing loss. There is limited reported literature on assessment of efferent system using acoustic reflexes. However, the effects of other reflex eliciting stimuli such as noise of different bandwidths and clicks are not studied yet. There are no studies on difference in the amount of suppression across different reflex eliciting stimuli. There is also dearth of literature regarding gender effect and ear effect on CSART and CSARA. Thus, the present study attempts to determine the effect of different reflex eliciting signals such as pure tones (500 Hz, 1 KHz and 2 KHz), Noise (Broadband noise, Low band noise and High band noise) and clicks on CSART and CSARA. It also checked for the presence of any ear or gender effect on CSARA and CSART.

MATERIALS AND METHODS

Participants: Thirty individuals (15 males and 15 females) between the age of 17-30 years (mean age: 19.2) participated in the study. All the participants had pure tone thresholds within 15 dB HL from 250 Hz to 8000 Hz. None of the subjects reported previous history of use of ototoxic drugs, long/short term exposure to high level noise, or otological/neurological diseases. An informed consent was taken from all the participants of the study. All tests were carried out in sound treated audiometric rooms with permissible noise levels standards of ANSI S3.1-1999 (R 2013).

Procedure: Pure tone air conduction (AC) and bone conduction (BC) thresholds were estimated using Modified Hughson and Westlake procedure. [16] AC thresholds were obtained for pure tones from 250 Hz to 8 kHz and BC thresholds from 250 Hz to 4 kHz in octave frequencies. Unaided speech identification scores were obtained for phonemically balanced words developed for adults in Kannada by

Yathiraj and Vijayalakshmi, [17] Recorded word lists were routed from a PC through a 2 channel diagnostic audiometer (Piano Inventis) through TDH 50 headphones at 40 dBSL (re: Speech Recognition Threshold).

Baseline Measurement: GSI-Tympstar (version 2) middle ear analyzer was used to assess the middle ear functioning and suppression. A tympanogram was recorded for all participants prior to the measurement of acoustic reflex. The acoustic reflex threshold (ART) was determined at 500Hz, 1 KHz, 2KHz, low band noise (LBN), high band noise (HBN), broad band noise (BBN) and clicks for both right and left ears in 1dB steps in each individual with 226Hz probe tone. In addition, the reflex amplitude was noted down at 10 dB SL with respect to reflex threshold obtained for all the stimuli.

Measurement of CSART and CSARA: Without altering the probe placement, ART and reflex amplitude at 10 dB SL (ref: ART) were established again for 500Hz, 1 KHz, 2 KHz, low band noise (LBN), high band noise (HBN), broad band noise (BBN) and clicks for both right and left ears in 1 dB steps in each individual with 226 Hz probe tone stimuli in the presence of white noise in the contralateral ear. The threshold for white noise was found using the calibrated Piano Inventis audiometer and the contralateral noise was presented through the ER-3A insert receiver at 40 dBSL. The frequency spectrum of BBN was 125Hz to 4000 Hz through audiometer and middle ear analyzer. It was ensured that the intensity of white noise was less than the ART for BBN in the contralateral ear for all the participants. The order of presentation of stimuli and the ear tested was randomized.

Statistical analysis: The results were analyzed using Statistical Package for Social Sciences (SPSS) version 17 software. Paired Samples t-test and Mixed ANOVAs were done to determine statistical differences across different parameters of the study.

RESULTS

The results of the study showed that there was elevation of ART and reduction in the reflex amplitude with contralateral noise. The mean and SD of ART and reflex amplitude with and without noise for all the stimuli is shown in table 1. Paired sample t-test with and without noise showed that there was a significant difference ($p < 0.05$) for all the stimulus conditions in CSART. However, CSARA showed significant difference ($p < 0.05$) at 2 KHz, HBN, BBN and clicks. There was no significant difference ($p > 0.05$) in CSARA at 500 Hz, 1000 Hz and LBN.

Table 1: Mean and SD of ART and acoustic reflex amplitude with and without noise for all the test stimuli

Stimuli Used	ART without noise		ART with Noise		Acoustic Reflex amplitude without noise		Acoustic Reflex amplitude with noise	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
500 Hz	83.96	5.30	87.01	6.14	0.095	0.03	0.081	0.03
1000 Hz	81.32	5.28	84.64	5.74	0.098	0.03	0.091	0.02
2000 Hz	84.54	6.51	87.72	6.13	0.102	0.04	0.082	0.03
LBN	75.21	5.12	78.53	5.67	0.106	0.03	0.102	0.03
HBN	78.88	7.83	83.46	6.67	0.075	0.03	0.088	0.04
BBN	74.36	6.56	79.83	11.06	0.096	0.04	0.104	0.04
Clicks	88.05	7.05	92.43	7.18	0.074	0.03	0.086	0.03

The amount of suppression for CSART and CSARA was calculated for all the seven stimulus conditions. The mean and SD of suppression values for CSART are shown in figure 1. The mean and SD of suppression values for CSARA are shown in figure 2.

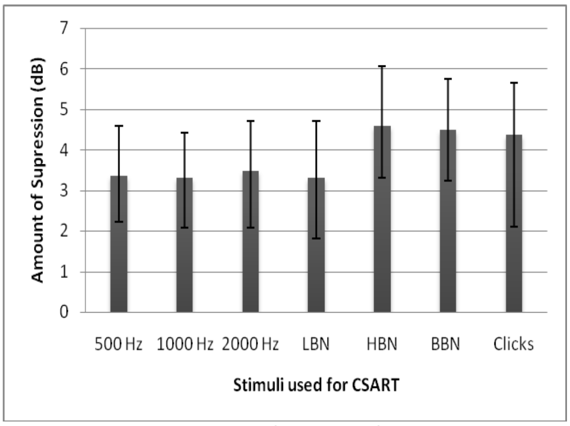

Figure 1: Mean and SD of amount for CSART across different stimuli

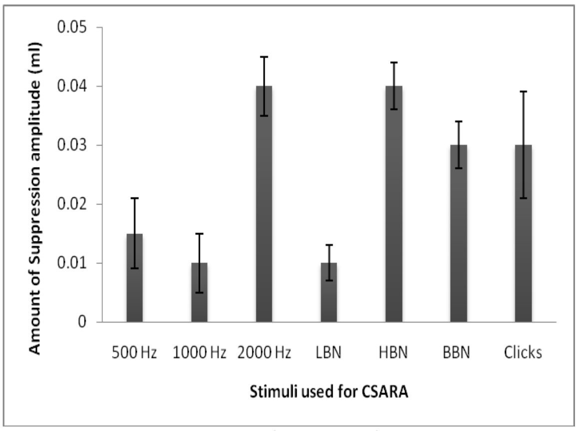

Figure 2: Mean and SD of amount for CSARA across different stimuli

It was also attempted to determine whether there was difference in amount of suppression of CSART across gender and across ears. The mean and SD of suppression values for CSART across stimuli for males and females are shown in figure 3. The mean and SD of suppression values for CSART across stimuli for right and left ear are shown in figure 4.

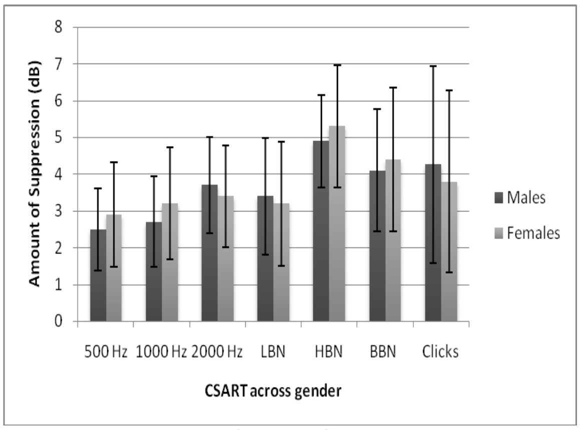

Figure 3: Mean and SD of amount for CSART across gender for different stimuli

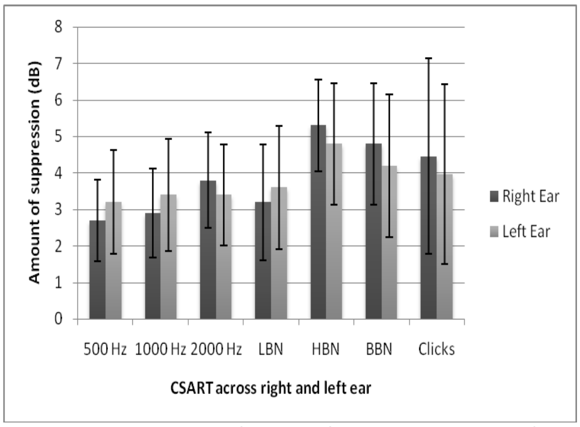

Figure 4: Mean and SD of amount for CSARTacross ear for different stimuli

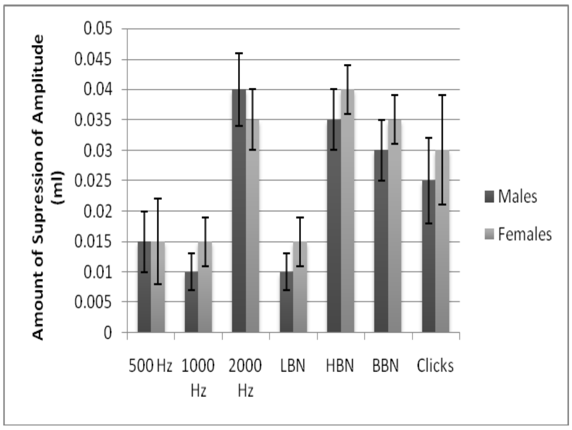

Figure 5: Mean and SD of amount for CSARA across gender for different stimuli

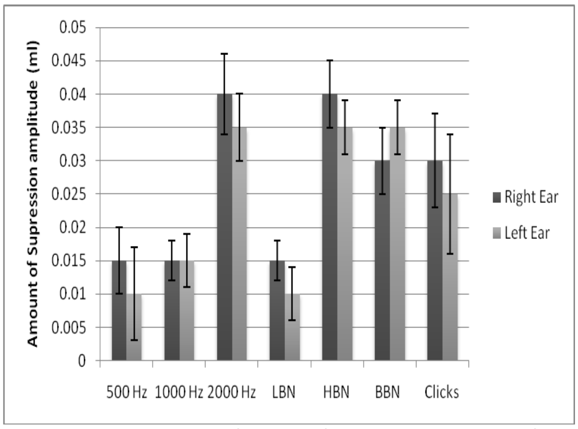

Figure 6: Mean and SD of amount for CSARA across ear for different stimuli

The difference in amount of suppression of CSARA across gender and across ears was also determined. The mean and SD of suppression values for CSARA across are shown in figure 5. The mean and SD of suppression values for CSART across are shown in figure 6.

Mixed ANOVAs were done considering suppression (ART and amplitude) as within subject factor and gender as between subject factor. The results showed that there was no significant main effect of suppression for ART [F (13, 364) = 1.33, $p > 0.05$] and suppression of reflex amplitude [F (13, 364) = 0.758, $p > 0.05$] across different reflex eliciting stimuli. There was also no significant main effect of gender for suppression of ART [F (1, 28) = 1.84, $p > 0.05$] and reflex amplitude [F (1, 28) = 1.84, $p > 0.05$]. There was also no significant interaction between gender and suppression of ART [F = (13, 364) = 0.408, $p > 0.05$)] and suppression of reflex amplitude [F = (13, 364) = 1.061, $p > 0.05$)]. The result suggests that the amount of suppression for ART and reflex amplitude doesn't change across the reflex eliciting stimuli. The result also suggested that there was no ear effect and gender effect on CSART and CSARA.

DISCUSSION

The elevation in the ART and reduction in the reflex amplitude can be attributed to the inhibition caused because of efferent system. The activation of medial olivocochlear bundles leads to release of inhibitory neurotransmitters which causes electrical/mechanical changes in the cochlea. It is well known that medial efferent system inhibits the auditory nerve responses by reducing the basilar membrane motion. [18,19] These alterations in the basilar membrane motion and reduction in neurotransmitter release by inner hair cells [20] because of efferent inhibition could cause elevation in ART and reduction in amplitude with contralateral noise. The reduction in acoustic reflex amplitude at high levels especially at 2 KHz, HBN, and BBN supports the hypothesis that efferent system is helpful in protecting the cochlea from loud sounds. [5]

The results of the study also showed that suppression of ART and reflex amplitude was present even for noise stimuli. It is well known that the acoustic reflex threshold obtained using BBN is 15-20 dB lower than ART for tones. [21,22] The reflexes for BBN are present even when the hearing loss is 60-70 dB HL as the noise-tone difference increases at higher degree of loss. This adds an additional option to use BBN, HBN or LBN to check efferent system as it can assist in assessment individuals with hearing loss. However, the CSART and CSARA must be done on clinical population with different degree of hearing loss before it can be used clinically. In addition, the test-retest reliability of contralateral suppression of acoustic reflexes should also be determined before it can replace contralateral suppression of OAE. The study also showed that there was no gender effect and ear effect on functioning of medial efferent system. This suggests that medial efferent system functioning in suppression of acoustic reflexes doesn't vary across gender. There can be individual variations in the amount of suppression but it didn't vary across ears in the present study. This result is in consensus with previous reports on OAE which suggest that there is no ear and gender effect on suppression. [23,24]

CONCLUSIONS

The present study shows that variety of stimuli (tones and noise) can be used in contralateral suppression of acoustic reflexes to determine the efferent system functioning. The study showed that there is no ear and gender effect on contralateral suppression of acoustic reflexes. It is understood that acoustic reflexes are more resistant to hearing loss especially using broadband noise compared to OAE. Thus, further studies determining CSART and CSARA using tones and noise in clinical population are essential. In addition, studies on test-retest reliability are also needed before contralateral suppression of acoustic reflexes can be used more clinically.

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