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Research Article

Effect of Visual Attention on Efferent Auditory System in Young Adults

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ABSTRACT

Introduction: The efferent auditory system is important for localization of sound source, auditory attention, protection of cochlea and speech perception.

Aim of the study: The present study attempted to find out the effect of different visual attention on efferent auditory system.

Subjects: Twenty young normal hearing adults were (Age range 18-35, Male-10, Female-10) participated in this study.

Methodology: Baseline DPOAE was recorded in all individuals. CS-DPOAE was recorded with 50 dB contra lateral white noise in three different visual conditions such as active attention, passive attention and closed eyes. The visual attention stimulus was delivered through brain workshop software. Amount of suppression values was compared among three different conditions across all the frequencies.

Results: Result of higher amount of suppression in all the frequencies in active visual attention indicates higher efferent system activity than other two conditions.

Conclusion: We conclude that the efferent system activity was higher during active visual attention so clinical CSOAE recording in closed conditions eliminate these attention effects.

Keywords: Visual Attention; Efferent Auditory System; Oto-Acoustic Emission (OAE); Contralateral Suppression of Oto-Acoustic Emission(CSOAE); Distortion Product Oto-Acoustic Emission (DPOAE).

INTRODUCTION

The auditory nervous system had both afferent and efferent auditory system. The afferent auditory system carries the acoustic impulses from cochlea to auditory cortex. Efferent system carries the efferent signals from auditory cortex. Efferent pathways can be found at every level of the afferent pathway and thus enable the brain to modify the processing of the ascending auditory information at various levels, regulating peripheral cochlear function and modulating signal processing at higher stages of the auditory pathway [1]. Not just inhibition or excitation but also the modulation and control of excitatory and inhibitory interactions in the auditory system.

The efferent auditory system can be divided into two systems. They are rostral efferent system and caudal efferent system. Rostral efferent consists of auditory cortex, medial geniculate body (MGB), and inferior colliculus and also loops connections between insula, superior colliculus and medial geniculate [2-5].Caudal efferent system includes the olivocochlear bundles which are divided in to two parts: lateral olivocochlear bundle (LOC) and medial olivocochlear bundle (MOC) [6].Lateral olivocochlear fibers Originates from lateral superior olivary nucleus and terminates at the inner hair cells. Mostly it projects ipsilateral fibers [7,8]

Attention

Attention is the cognitive process of selectively concentrating on one aspect of the environment while ignoring other things [18]. Attention is an active part of consciousness. Attention is not possible in the absence of consciousness but attention and consciousness are not same. The field of consciousness is vast and attention is one of its parts.

Example, I am reading the book at this time.

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During this activity book, table, note, chair, etc. all these are under my consciousness but my attention is on the words being read on the paper.

Attention depends upon External and Internal factors. External factors depend on Intensity or strength, Extension, Color, Movement, duration, Location, repetition, novelty and contrast of the stimulus. Internal factors depend on the freshness, interest, motive, desire, habit, and experience of the individuals [19].Active attention is requiring more consciousness and it is controlled by the both internaland external factors. The passive attention requires less consciousness to compare with active attention and it is controlled by the external factors [20,21].

The link between the otoacoustic emission and the neural control, make the question whether top-down control will modulate the hearing or not. In studying the effect of attention on the mechanics of the inner ear and efferent pathway, auditory attention more related to functioning of the inner ear. There is quite strong evidence for the effect of auditory attention on OAEs and their suppression. The results found that OAE amplitudes and suppression of OAE was more during active auditory attention to compare with normal quite condition [11, 22-25].

In day to day life, visual scenes typically contain more items than can be processed at any one time due to the limited processing capacity of the visual system. Visual attention refers to the cognitive operations that allow us to efficiently deal with this capacity problem by selecting relevant information and by filtering out irrelevant information [26].

Various studies hypothesized that visual attention also alters the function of cochlea and efferent auditory system. The first study to investigate the effect of visual attention on OAE was done by Puel, et al. ,The study found that the amplitudes of emissions were reduced in EOAE during selective visual task to compare with other conditions. Later, Ferber-Viart et al. Delano et al. ,Wittekindt, Kaiser and Abel, walsh et al. studies found that visual attention modifies the activity of efferent auditory system [27-34].

The results of the previous studies are not uniform. The first contradictory result was found by avan et al. in 1992 reported that no significant difference in OAE amplitudes between the presence and absence of selective visual attention in both Distortion product OAE (DP-OAE) and stimulus-frequency OAE (SFOAE).Later in 2007 de boer et al showed that more reduction in CEOAE amplitudes in active auditory conditions but no significant changes in active and passive visual attention. De boer et al. concluded that no significant changes in OAE amplitude and amount of suppression during visual attention but it manifests only under more demanding conditions.

AIM OF THE STUDY

The aim of the study is to know the effect of visual attention on functioning of efferent auditory system by assessing contralateral suppression of distortion product otoacoustic emission (CS-DPOAE) in adults

SUBJECTS

Twenty voluntary normally hearing adults were (Age range 18-35, Male-10, Female-10) participated in thisExperimental study.Inclusion criteria includesnormal hearing sensitivity, DPOAE pass (SNR> 6dB) and normal vision. Exclusion criteria includesAbsent in DPOAE,Hearing loss, Central nervous system disorders, Medication that affect the central nervous system, Vision problem, Attention deficits, Neuropsychiatric diseases, Head trauma. All the testing was carried out in sound proof audiological setup, as per ANSI S3.1-1999 standards [35-37].

METHODOLOGY

Complete case history was gathered from the subjects. Otoscopic examination was carryout before audiological testing. Audiometric thresholds were measured using a calibrated Labat audiohubV.4 diagnostic audiometer. All the subjects' thresholds were below 15 dB all the frequencies from 250 to 8000 Hz. Tympanometry (226 Hz) and Acoustic reflexes were measured using a Resonance r26m middle ear analyzer to rule out middle ear pathology.

DPOAE

Distortion product otoacoustic emissions (DPOAEs) were done in all the subjects using the Sentiero diagnostic analyzer. DPOAE were measured for pure tone signals f1 and f2 at f2/f1 ratio of 1.22. The intensity of f1 and f2 was at 65 dB HL and 55 dB HL. The baseline DPOAE amplitudes were noted all the frequencies of 1 KHz to 8 KHz.

CS-DPOAE

During DPOAE recording the white noise was presented at 50 dB SPL using a MAICO MA53 dual-channel clinical audiometer via an insert ear phone to the subject's opposite ear. The CS-DPOAE recording was carried out for all the subjects in three conditions explained below using the same procedure.

1) No task : In this condition, all visual attention was eliminated. The subjects were simply sat comfortably in an arm-chair with their eyes closed.

2) Passive visual attention: This condition was passive visual attention. The subjects were simply sat comfortably in an arm-chair. The stimulus was displayed on a monitor in front of the subjects. The stimulus was silent repeating color videos and it displayed during the testing through brain workshop software.

3) Active visual attention: the subjects have identified the color match and position match on the stimulus during the CSDPOAE recording. The subjects were comfortably sat in an arm-chair. The stimulus was displayed on a monitor in front of the subjects. The stimulus was delivered from brain workshop software. The stimulus was continuously repeating with different colors in different position. The subject has to press the response button when the stimulus repeating same color (color match) and repeating same position (position match). Based on the subjects response percentage of scores were calculated and above 80 percentage scores are considered for this condition.

RESULTS

Comparision of three different conditions

The amount of suppression amplitude was calculated each condition by subtracting the DPOAE amplitude from each condition CS-DPOAE amplitude.The average amount of suppression values of three different conditions was compared in across the frequencies. The average amount of suppression was higher in all the frequencies in active visual attention to compare with passive visual attention and closed eyes condition (Figure 1).

Friedman test indicate that there is highly significant difference between three different conditions (Table 1).

Table 1: Mean amount of suppression, standard deviation and p value of Friedman test for among three different conditions such as closed eyes, passive and visual attention. (*statistically significance).

Amount of suppression	Closed eyes		Passive		Active		p value
	Mean	SD	Mean	SD	Mean	SD	
1 KHZ	1.4	0.63	1.5	0.67	2.66	0.83	.000*
1.5 KHz	1.56	0.77	1.74	0.92	2.46	1.1	.000*
2 KHz	1.52	0.91	1.8	0.88	2.37	1.18	.000*
3 KHz	1.56	0.62	1.86	0.77	2.68	1.27	.000*
4 KHz	1.8	0.64	1.67	0.9	3.1	1.67	.000*
5 KHz	1.67	0.65	1.99	0.77	2.77	1.13	.000*
6 KHz	1.62	0.68	1.9	0.74	3.02	1.14	.000*
8 KHz	2.43	0.63	2.88	1.01	4.33	1.3	.000*

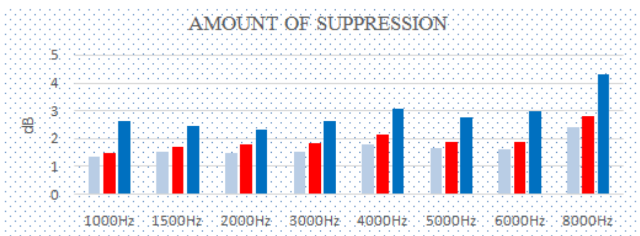

Figure 1: Comparison of average amount of suppression values across the frequencies among three different conditions.

Comparison between the conditions

The average amount of suppression values compared between groups (closed eyes vs. passive, closed eyes vs active and passive vs. active) respectively.

Table 2: Mean amount of suppression, standard deviation and p value of Wilcoxon signed rank test for between closed eyes and passive visual attention. (* statistically significance).

Amount of suppression	Closed eyes		Passive		p value
	Mean	SD	Mean	SD	
1K Hz	1.4	0.63	1.5	0.67	.129
1.5 KHz	1.56	0.77	1.74	0.92	.026*
2 KHz	1.52	0.91	1.8	0.88	.020*
3 KHz	1.56	0.62	1.86	0.77	.000*
4 KHz	1.8	0.64	1.67	0.9	.000*
5 KHz	1.67	0.65	1.99	0.77	.000*
6 KHz	1.62	0.68	1.9	0.74	.000*
8 KHz	2.43	0.63	2.88	1.01	.007*

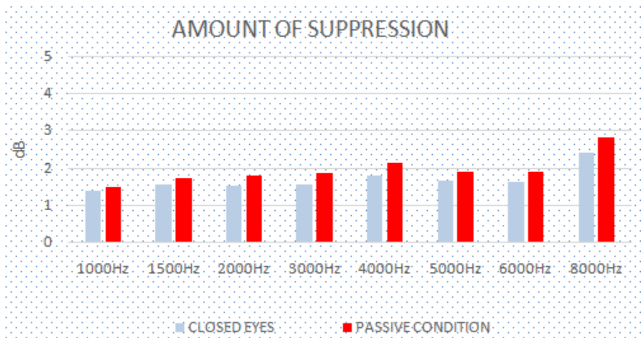

Figure 2: Comparison of average amount of suppression across the frequencies between closed eyes and passive visual attention task.

Table 3: Mean amount of suppression, standard deviation and p value of Wilcoxon signed rank test for between closed eyes and active visual attention. (* statistically significance).

Amount of suppression	Closed eyes		Active		p value
	Mean	SD	Mean	SD	
1 KHZ	1.4	0.63	2.66	0.83	.000*
1.5 KHz	1.56	0.77	2.46	1.1	.000*
2 KHz	1.52	0.91	2.37	1.18	.000*
3 KHz	1.56	0.62	2.68	1.27	.000*
4 KHz	1.8	0.64	3.1	1.67	.000*
5 KHz	1.67	0.65	2.77	1.13	.000*
6 KHz	1.62	0.68	3.02	1.14	.000*
8 KHz	2.43	0.63	4.33	1.3	.000*

Wilcoxon sign rank test indicates that statically significance difference between these groups respectively (Tables 2-4 and Figures 2-4).

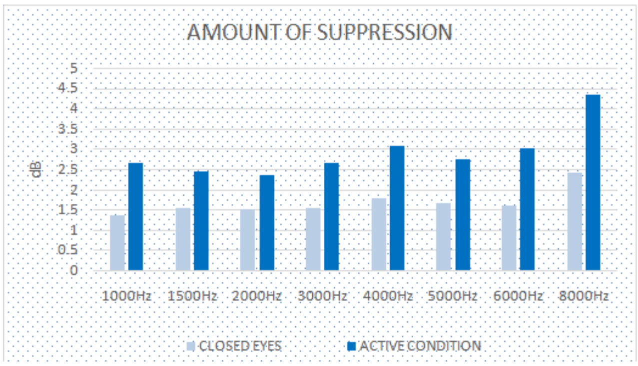

Figure 3: Comparison of average amount of suppression across the frequencies between closed eyes and active visual attention task.

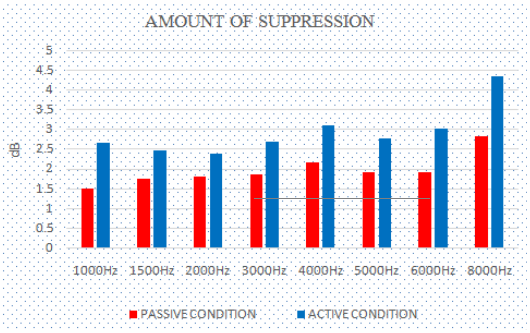

Figure 4: Comparison of average amount of suppression across the frequencies between passive and active visual attention task.

Amount of suppression	Passive		Active		p value
	Mean	SD	Mean	SD	
1 KHZ	1.5	0.67	2.66	0.83	.000*
1.5 KHz	1.74	0.92	2.46	1.1	.000*
2 KHz	1.8	0.88	2.37	1.18	.000*
3 KHz	1.86	0.77	2.68	1.27	.000*
4 KHz	1.67	0.9	3.1	1.67	.000*
5 KHz	1.99	0.77	2.77	1.13	.000*
6 KHz	1.9	0.74	3.02	1.14	.000*
8KHz	2.88	1.01	4.33	1.3	.000*

Table 4: Mean amount of suppression, standard deviation and p value of Wilcoxon signed rank test for between passive and active visual attention. (*statistically significance).

DISCUSSION

Visual attention influence on Moc

The results of our study found the significant difference between the three different conditions. The amount of suppression was higher in all frequencies during active visual attention than other two conditions. The differences among three conditions were about 1–2 dB.The Amount of suppression values depend on the activation of efferent auditory system. The results suggest that efferent auditory system activity is higher during the active visual attention than the other conditions. It indicates that visual attention influences the activity of efferent auditory system. Attention primarily affects the reflexive response of the MOC efferent system. The differences among three different conditions reported here can be attributed to the reflexive MOC system having been deferentially activated during thesethree different conditions by the efferent flow from auditory cortex to superior olive.

That is, cortico-olivary efferent pathways are able to modulate the level of activity in the MOC reflex. Specifically, the cortico-olivary efferent flow is greater during active attention than other two conditions, and that makes MOC strength greater, cochlear-amplifier strength weaker, and amplitude compression less than during other conditions.

Possible alternative explanations

The changes in the amount of suppression may due to activation of middle-ear reflex (e.g., Goodman and Keefe; Henin et al.). Themiddle-ear reflex was deferentially activated during visual attention and inattention conditions. The middle-ear reflex is activated due to the MOC influence and it can alter the OAE recordings. That is, the top-down influences that we have been assuming were acting on the MOC network were acting (also or instead) on the middle-ear reflex. We have no direct evidence contradicting this form of the alternative explanation because no simultaneous or auxiliary measurements were obtained of the middle-ear reflex for our subjects (beyond screening for "normal" tympanometry).

Another possible alternative explanation for our experimental differences across visual attention conditions is that during the visual attention conditions most of our subjects simply became more restless and thus noisier and thus had more amount of suppression. This is an implausible explanation for several reasons. First, our behavioral tasks did require that the subjects attend visual stimulus and the subject has to press the response button when the stimulus repeating same color (color match) and repeating same position (position match).

FUTURE RECOMMENDATIONS

The effects of visual attention on efferent auditory system results are not uniform. Hence to confirm these results more studies

The amount of visual attention was measured through the subjective measures. Alternatively to measure the amount of visual attention can measure through the objective tests.

CONCLUSION

In this present study we found that the visual attention can alter the activity of efferent auditory system. Higher activity of the efferent system can increase the speech perception abilities. During the active visual attention may get better speech perception ability than non-visual attention condition. From this study we conclude that visual attention can increase the activity of efferent auditory system so clinical CSOAE recording in closed eye condition eliminate these attention effects. Furthermore, studies are required to confirm these visual attention effects on efferent auditory system.

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