

Age Related Changes in Fine Structures of DPOAE

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ABSTRACT

DPOAEs reflect the outer hair cells integrity and cochlear functions, when used appropriately it is an effective diagnostic tool. In this current study DPOAE fine structures among various age groups have been compared which would help in the explanation of the basilar membrane mechanism across various age groups.

Keywords: DPOAE, Fine Structures, Age Related Changes, Otoacoustic emissions (OAE)

INTRODUCTION

Otoacoustic emissions (OAE) are sounds which are generated by normal cochlea at outer hair cells (OHC) either spontaneously or in response to acoustic stimulation and detected at the level of Tympanic membrane(TM) with a microphone. OAEs are a pre-neural phenomenon that occurs at the level of the cochlea. Distortion Product OAEs (DPOAEs) are produced when two tones interact on the basilar membrane. With the greatest amplitude of the response is at around the $2f_1-f_2$ frequency, where f_1 and f_2 are the two frequencies that are presented simultaneously to the same ear (Lonsbury-Martin & Martin, 1990). DPOAEs are dependent on the level of presentation of these tones, and an input-output (I/O) function can be obtained by keeping the stimulus frequency and frequency ratio constant. The relation between these two measures becomes stronger depending on the frequency of the signal [reviewed in (Rasetshwane, Neely, Kopun, & Gorga, 2013; Rasetshwane et al., 2015)] and when repeated estimates are combined in a multivariate analysis. As reported in literature, fine structure (FS) of DPOAE has certain clinically useful properties DPOAE

fine structure is directly linked to the health of the cochlea in sudden hearing loss the DP fine structure might indicate some slight damage, although the threshold as measured in the clinical audiogram had already recovered. In adults, most noticeable amplitude decrease has been reported from birth to months after the neonatal period, maturation of DPOAE fine structure and individual distortion components that produce fine structure has been preliminarily explored (Dhar and Abdala, 2007). The present study attempted to study the DPOAE fine structures ($2F_1-F_2$) in frequency range of 2-4Khz which better explain basilar membrane mechanism across different normal hearing age groups.

MATERIALS AND METHODS

Participants: Four different age groups comprising 15 individuals in each group. Individuals with bilateral normal hearing sensitivity were considered as represented in Table 1.

Table 1: The fine frequency structure of the $2f_1-f_2$ DPOAE was examined across four different age groups.

GROUP	AGE RANGE	No. OF SUBJECTS
1	10-20	15
2	21-30	15
3	31-40	15
4	41-50	15

Inclusive criteria:

- Individuals had a pure tone average (PTA, an average of pure tone thresholds at 500 Hz, 1 kHz, 2 kHz, and 4 kHz) of less than 15 dB HL.
- All of the participants had not reported of having any middle ear disorder/pathology, otological complaints, noise exposure, ototoxic medications, diabetes /hypertension.

Instrumentation: Oscope
Audiometer GSI 61.
GSI tymptstar 16.
ILO-292 v 5.0.

(All instruments were calliberated according to standards provided in the manuals)

Protocol used in the present study

F1/F2 (frequency ratio of two primaries)
: 1.22

L1(intensity of the first primary)
: 65dB SPL

L2(intensity of the second primary) :
50dB SPL

Frequency range : 2-4 kHz

No of points/ octave : 17

Test Environment : Noise level
<50bBA

Test Procedure: All subjects underwent otoscopy, tympanometry, reflexometry, pure tone audiometry. Each patient was then seated comfortably and was advised to avoid body movements such as coughing, yawning etc.

The correct size of the ear tip was securely inserted into the ear for an air tight seal, ear canal resonance & probe fit was checked automatically. DPOAE were recorded from 500-8000Hz, at 4 points / octave. If DPOAEs were present in all frequency then DPOAE fine structure was obtained for each ear separately. DPOAE fine structure frequency 2- 4KHz was used because at low frequencies noise floor was more and above 4KHz hearing loss was seen in elderly age group. Two trials were taken for each ear to check the repeatability.

Statistical Analysis: The comparison of the DPOAE Input-Output function was done using two variables, the first being the slope

of the I/O functions, and the second being the area under the curve. These variables were compared between the different age groups. These data were subjected to statistical analysis to determine the mean, standard deviation and statistical level of significance using ANOVA. The DPOAE fine structure using 17 points per octave were measured bilaterally in the frequency range of 2-4 KHz with an unequal stimulus level 65/50 (L1/L2). The frequency ratio (F2/F1) of the two primaries was held constant at 1.22.

The following were measured for all the subjects;

1. Comparison of mean intensity for DPOAE fine structure for each frequency for bilateral ears among all age group.
2. Comparison of total mean intensity among age groups.
3. Comparison of the following :
 - Ear effect
 - Subject effect which include age, ear and Age + Ear
 - Total maxima and minima in each group

Coefficient of repeatability: Correlation coefficient for repeatability was computed using Karl Pearson's product moment correlation coefficient, which showed a good correlation and repeatability was found in terms of the DPOAE amplitude for all age groups.

Intensity: The responses obtained are measured in terms of intensity (dB). They should be within the reference to call as normal. The figure 9 is an example showing the amplitude of DPOAE Fine structure. Intensity varies among subjects.

Noise floor: Noise floor is the amount of noise in dB. The difference between the response and noise level should be greater than 6dB. In figure 8, the red shaded area represents the noise level.

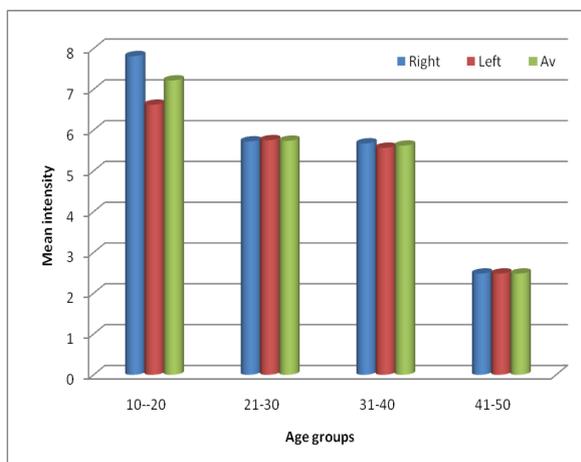
Number of peaks (Maxima & Minima): The initial point from the response is taken as the reference to calculate maxima and minima. Next point can be either increase in

intensity or decrease in intensity. In the figure 9 represents the example of no of maximas and minimas.

RESULTS

Comparison of mean intensity for DPOAE fine structure for each frequency for bilateral ears among all age group: DPOAE fine structure was obtained for different age range for frequency range of 2 kHz to 4kHz. The mean intensity was analyzed for each age group. A total of 1020 ears were analyzed in each group including both right and left.

AGE	EAR	Mean	Std.Deviation	N
10-20	R	7.8127	4.15107	510
	L	6.6224	4.79694	510
	Total	7.2175	4.52281	1020
21-30	R	5.7228	4.99195	510
	L	5.7520	4.42511	510
	Total	5.7374	4.71448	1020
31-40	R	5.6731	4.87927	510
	L	5.5663	4.26883	510
	Total	5.6197	4.58228	1020
41-50	R	2.4812	4.26328	510
	L	2.4824	3.61309	510
	Total	2.4818	3.94964	1020
Total	R	5.4223	4.96322	510
	L	5.1057	4.57104	510
	Total	5.2640	4.77315	1020



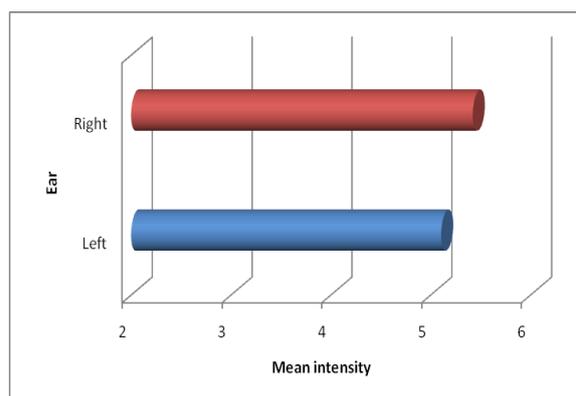
Graph 1: Represents the mean intensity among 10-20, 21-30, 31-40 and 41-50 yrs age groups. Blue coloured bars represents right ear, red coloured bars represents left ear and green coloured bars represents average of both right and left ears.

From the above graph it is clear that the mean intensity of 7.81dB for Right ear and 6.6dB for left ear for group 1 is higher than other groups. The mean intensity for group 2 is about 5.72dB for right ear and 5.75dB for left ear. The mean intensity for

group 3 is about 5.67dB for right ear and 5.56dB for left ear. The mean intensity for group 4 is about 2.48dB for right ear and 2.48dB for left ear.

Ear effect

DPOAE amplitude was calculated as a whole differentiating between right and left ear for all 60 subjects. The following graph shows the ear effect on DPOAE fine structure amplitude.



Graph 2: Above graph represent the ear effect for all subjects in DPOAE fine structure amplitude

On the whole DPOAE intensities were higher in the right ear for all age groups. Statistical analysis using ‘f’ test was carried out at 0.05 level of significance to statistically verify the significant differences in DPOAE intensities between the ears and it was found that statistically at 0.05 level of significance there was significant ear effect among all age groups.

Tests of Between-Subjects Effects for intensity

One way ANOVA was carried out for subject effect i.e., for age, ear & age + ear effects for all age groups. with more significant difference in present study for the variable “AGE” compared to other variables. Hence it can be said that age has an effect on DPOAE fine structure.

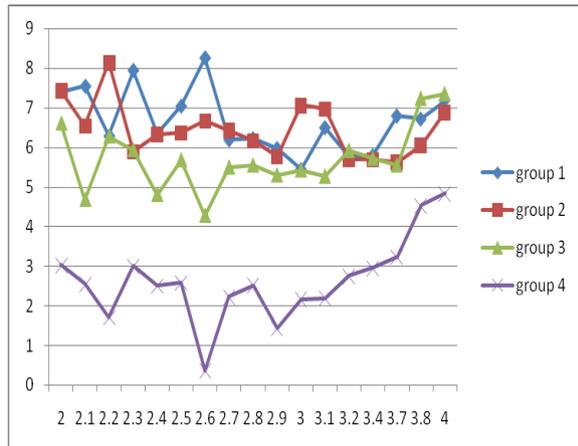
Table 2: The table shows the mean square, f test and significance for Age, Ear and Age + Ear for amplitude.

Source	Mean Square	F	Sig
Age	4048.576	205.00	0.000
Ear	102.297	5.108	0.023
Age*Ear	87.374	4.424	0.004

Among the three sources, the AGE factor is more significant.

Comparison of Maximas and Minimas among age groups:

The initial point from the response is taken as the reference to calculate maxima and minima. Next point can be either increase in intensity or decrease in intensity. The mean maximas and minimas were compared among age groups.



Graph 3: Represents the number of maximas and minimas for each age range.

From the above graph it is clear that for group 1 there are 5 maximas and 4 minimas. Group 2 has 3maximas and 4 minimas. Group 3 has 3 maximas and 4 minimas. Group 4 has 2 maximas and 3 minimas. It is also noted that for Group 4 flattening of response was seen in higher frequencies.

DISCUSSIONS

Intensity change across different age groups for DPOAE fine structure was measured. And found the existence of linear correlation between amplitude and age; As age increases amplitude decrease. For the group 41-50 yrs the intensity is less and flattening of fine structure in 4KHz region and for the group 11-21yrs the intensity is more in terms of dB.

This was found in literature also.

Amplitude diminishes significantly throughout childhood, but the most noticeable decrease is birth to months after the neonatal period. Study done by Bonfils et.al, 1992; Lasky et.al,1992; Brown et.al,

1995 showed that larger DPOAE amplitudes for children versus adults He and Schmiedt investigated the effects of aging and threshold on the prevalence of FS using equilevel stimulus levels of 50 dB SPL and frequency steps of 1/32 octave.

The authors compared FS in four groups of human subjects:

- (1) Young with normal hearing,
- (2) aged with normal or near-normal hearing,
- (3) aged with more severe hearing loss above 2 khz, and
- (4) Young with hearing similar to those of the normal or near normal hearing aged group (total n = 34).

A statistically significant averaged difference in mean peak-to-valley depth in FS between young and aged normal hearing subjects only in the 3 kHz region (with lower values for the aged group) was found But in present study it has been showed that there is a significant difference in terms of amplitude from 2-4KHz. Better response obtained for the right ear . Similar findings in literature was found but are not statistically significant.(Lonsbury-Martin 1997).But there is no reports regarding ear effect in the literature on DPOAE fine structure. Hence it can be conclude that Age factor has a significant effect on DPOAE fine structure.

CONCLUSION

The present study was aimed at comparing DPOAE fine structure across different age groups. 60 normal hearing individuals of different age groups 15 of each age group, tested separately for right and left ear were taken for the study. ILO 292 was used to check the DPOAEs and DPOAE fine structure. DPOAE fine structure was measured in the frequency range of 2-4KHz. The intensity levels of the primary tones f1 and f2 were 65 and 50dB SPL respectively. The testing was carried out in a quiet room with noise levels of approximately 50dBA. Trials were repeated in order to check for repeatability.

Following parameters comparisons were made:

- Amplitude of DPOAE fine structure between age group
- subject effect which includes Age , Ear and AGE + Ear
- Ear effect on DPOAE fine structure

Good repeatability was found in terms of the DPOAE amplitudes in all age groups.

The mean amplitude was measured across age range. The maximum mean amplitude is obtained for the age range 10-20 yrs and least for 41-50 yrs of age. And from all the analysis it can be concluded that as age increases the mean amplitude of DPOAE fine structure decreases significantly. Comparing the subject effect of which factor being more effect the DPOAE fine structure which include Age, Ear and Age+Ear. The results showed that Age factor is more significant than others. And there is a significant difference among age range. When ear effect among age range was compared. A significant difference between ears was found. That is mean amplitude for right ear was more among all the subjects, showing right ear advantage.

All the above changes in the responses that is lower amplitude, higher noise levels and flattening of fine structure in high frequency region (4KHz) might indicate the presence of mild pathology which can develop later in life. Hence fine structure can serve as a more sensitive tool for the detection of slight cochlear damage in certain cases than the DPOAE level alone. However, a prospective clinical study involving more subjects would be required to evaluate this possible application.

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