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Influence of ear side and gender on Distortion Product of normal hearing Iraqi population of age (21-30) years

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ABSTRACT

The goal of this study was to evaluate Distortion Product Otoacoustic emissions in the normal hearing subjects regarding to the following variables; ear side & gender. The purpose of this work is to study the influence of the ear side and gender on the distortion product Otoacoustic emission of normal hearing Iraqi population of age (21-30) years. The decision about whether a Distortion Product Otoacoustic Emission is present often depends on a visual assessment of the response along with certain objective criteria, such as DP1 level (amplitude) and the signal-to-noise ratio of the response compared to the noise. DPOAEs were considered present when the signal was at least 3 dB above the corresponding noise level. In the present study, the overall SNR for each tested ear was more than 3 dB SPL at the overall frequency bands. The findings from this study revealed an ear asymmetry and gender effect on the parameters of the DPOAEs (SNRs dB SPL &DP1 level dB) in Iraqi subjects. Right ears were found to produce higher DPOAEs-SNRs than left ears and The DPOAEs (DP1 level dB) in the right ears was higher than that in the left ears .The minimum value of the whole Signal-to-noise ratio (SNRs) recorded for all tested ears was above 3 dB SPL over frequency bands 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 and 8.0 kHz. The mean value of the whole SNRs in 56 ears was (10.53 dB SPL), ranged from 3.0 to 28.30 dB SPL. In females; the mean value of whole SNRs (11.27 dB SPL) was higher than that in males (9.8 dB SPL). The mean value of SNRs in the right ears female (11.38 dB SPL) was higher than that in the left ears female (11.16 dB SPL), while in male; the mean value of SNRs in the right ears male (10.08 dB SPL) was higher than that in the left ears male (9.52 dB SPL). The results show The minimum and the maximum value of the whole Distortion product (DP1 Level) recorded for all tested ears (56) was -10.7 and 25.6 dB respectively over frequency bands 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 and 8.0 kHz. The mean value of the whole DP1 level in 56 ears was (6.50 dB), ranged from (-10.7 to 25.6 dB). In females; the mean value of whole DP1 Level (7.72 dB) was higher than that in males (5.28 dB). The mean value of DP1 level in the right ears female (8.22 dB) was higher than that in the left ears female (7.23 dB), while in male; the mean value of DP1 level in the right ears male (5.58 dB) was higher than that in the left ears male (4.98 dB).

Introduction

Otoacousticemissions (OAEs) are narrow-band acoustic signals generated by the inner ear of normal hearing individuals, either in the absence of acoustic stimulation (spontaneous emissions) or in response to acoustic stimulation (evoked emissions)[1]. Types of otoacoustic emissions (OAEs): Spontaneous otoacoustic emissions (SOAEs)Sounds emitted without an acoustic stimulus (i.e., Spontaneously) [2, 3, 4 and 5],Transient otoacoustic emissions (TEOAEs) Sound emitted in response to an acoustic stimuli of very short duration; usually clicks but can be used tone –bursts [3], and Distortion ProductOtoacousticemissions (DPOAEs) Sound emitted in response to two –simultaneous tones of different frequencies [6 and 7].

Distortion Product Otoacousticemission (DPOAEs):

Distortion Product generation represents a nonlinear phenomenon that is characteristic of many physical systems. Such responses are generated by nonlinear elements that modify the signal, thereby creating additional frequencies. Distortion Product Otoacoustic emissions DPOAEs arise when the ear is stimulated acoustically by two sinusoidal signals primaries with appropriately chosen frequencies (f 1 , f 2) and stimulus levels (L1, L2) [8]. The stimulus for evoking DPOAEs consists of two tones, called primary tones, at frequencies f_1 and f_2 Hz (where $f_1<f$ and levels L_1 and L_2 dB SPL ($L_1 \geq L_2$). These tones produce a family of DPOAEs in the cochlea; the strongest emission has a frequency of $2f_1–f_2$,the two primary tones are usually chosen with a frequency ratio of $f_2/f_1 = 1.22$, because this combination produces a relatively high amplitude $2f_1 - f_2$ DPOAE over a range of primary frequencies and levels. All of the DPOAE studies used a fixedfrequency ratio (1.22) of the primary tones.

The outer hair cells (OHCs) stimulated by F1 and F2 frequencies stimulate a third set ofOHCs located between F1 and F2. The excitation of this third set of OHCs creates a separate tone, known as the Distortion Product as shown in Figure (1).

The generation of Distortion-Product otoacoustic emissions (DPOAEs), especially in humans, is adequately described by a two-source model [9 and10]. Source is thought to arise from the

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nonlinear interactions between the f_1 and f_2 primary tones, near the peak of the f_2 traveling wave (TW) [9] referred to this constituent as the "generator" or "distortion" component, while [10] described it as a "wave-fixed" component. This component is thought to travel both apically and basally within the cochlea,when the apically traveling segment arrives at the $2f_1{-}f_2$ DPOAE frequency place (f_{dp}) on the basilar membrane (BM), a second component, which is presumably generated by a coherent-reflection mechanism, travels basally to produce another DPOAE source referred to as the "reflection component" or a "place-fixed" component. Thus, the prevailing view is that lower-sideband DPOAEs (e.g., $2f_1{-}f_2$) conform to a two-source model with the emissions arising from two discrete locations associated with distinct mechanisms of generation.

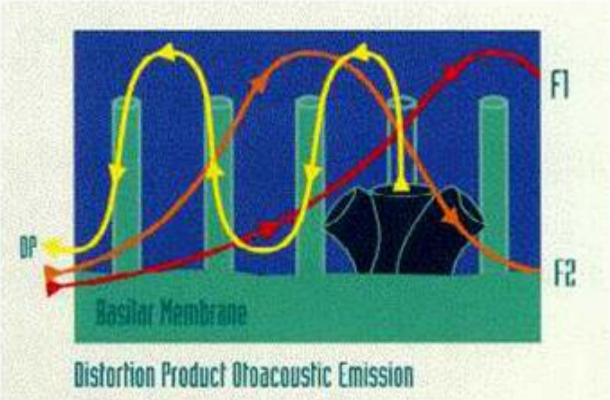

Figure 1

The vast majority of physiological and psychophysical studies involving DPOAEs concentrate on the 2 f 1- f 2 distortion product, principally because it usually represents the strongest DPOAE and therefore the easiest one to measure. OAEs, including DPOAEs, originate in the inner ear and, in most mammals, have been linked to outer hair cell Motility and receptor potential [11].The $2f_1 - f_2$ DP-grams were generated as part of a larger research protocol conducted during various experiments in the Infant Auditory Research Laboratory (USC Medical Center) over 5 years.

Materials and methods:

The study was performed in specialized center of, hearing and speech in Baghdad.

Subjects

The data were obtained from a sample of 28 adults male and female aged 21–30 years, without any hearing abnormalities or any risk factors for familiar hearing loss and with good general health. All subjects had normal otoscopic results, audiometric and tympanometricparameters. There was no history of ontological diseases or ototoxic drug use among the studied subjects. None of the subjects reported that they were frequently exposed to intense leisure noise.

Procedure

Otoacoustic emissions (OAEs) are influenced by the fact that the stimulus must be transmitted to the cochlea via the middle ear and the response must be detected in the ear canal, so it is important to study the interaction of middle ear status and emission properties.

To confirm the normal outer/middle ear status of all the groups, routine procedures were used. Audiometer over a frequency range of 250 Hz-to-8000Hz and a tympanometry were performed to assess hearing ability in all subjects. All investigations were performed in low sound noise, and both ears of all subjects tested consecutively in a random order.

Pure-Tone Audiometry

Each ear was examined with an otoscope prior to audiometry testing to determine if there are any blockages in the ear canal due to ear wax or other materials.

Audiometer (ATMOS SCREEN 20K-Denmark) was used to test the threshold hearing level of each ear. The results were recorded on a graph called an audiogram as shown in figure (2). An audiogram is a plot of threshold intensity versus frequency. The intensity scale in hearing level (HL) measured in (dB) increases downwards.

In a normal ear, most thresholds were approximately zero dB HL. Points below zero dB HL on the scale denoted louder threshold levels, whereas those above, expressed in negative decibels (-dB) with respect to the zero level, were less intense levels.

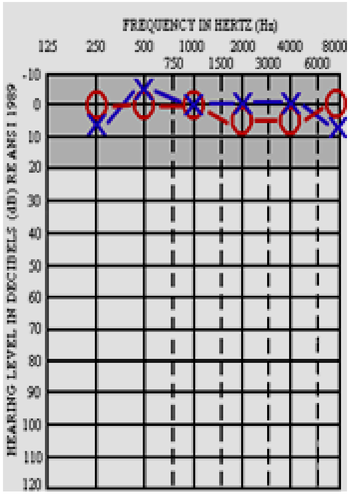

Figure 2. Audiogram for a subject with normal hearing

Tympanometry: is an electronic and acoustic measurement technique to assess middle ear status. It is a routine clinical procedure that involves measures of acousticimmittance in the ear canal as air pressure in the canal is varied above (+) and below (-) atmospheric level in the ear canal. (Acoustic immittance is a general term referring to either acoustic impedance or acoustic admittance).

Calibration: All OAEs and tympanometric measurements were performed by (Madsen Capella's-OAE/middle ear analyzer-GN Otometrics, Denmark) as shown in figure(3).The probe system contains; manometer (pump) varies air pressure against tympanic membrane (controls mobility), speaker introduces 226 Hz probe tone, and microphone measures loudness in ear canal. The probe was calibrated before each test session. The calibration was standardized according to the manufacturer recommendations [12] (ANSI S3.39.1987) (American National Standard Institute). Calibration process was performed by measuring the acoustic immittance of standard test cavity of known and specified volume (conformed by the manufacturer). The enclosed volume of air in a test-cavity is directly related to the admittance offered by the cavity. The acoustic admittance or acoustic impedance value indicated by the monitor of the instrument must be equal to the known value for fixed test-cavity volume over the range of interest. At a probe frequency of 226 Hz, a hand-walled cavity of 1 cm^3 offers an acoustic admittance of approximately 1 acoustic mmho. The computer-based instruments provide for correction of calibration errors through software commands.

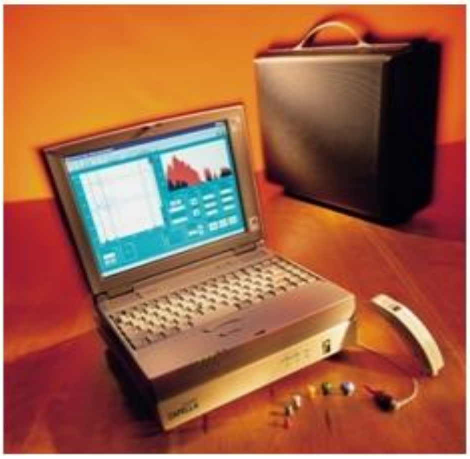

Figure 3. All OAEs and tympanometric measurements were performed by (Madsen Capella's-OAE/middle ear analyzer-GN Oto metrics, Denmark.

Tympanogram: The probe tip was precisely inserted into one ear of the subject where the tip of the probe faced the drum and the path to the tympanic membrane was not blocked as shown in Figure (4). Then the probe turns on with a pump speed 200 dapa/sec, the pressure in the ear canal varying between +200 to -400 dapa. The tympanogram provides information regarding the compliance of the middle ear system (how well sound passes through the eardrum to the middle ear system), ear canal volume, and middle ear pressure. Compliance is plotted vertically on the tympanogram, and is measured in (ml) or (mmho).

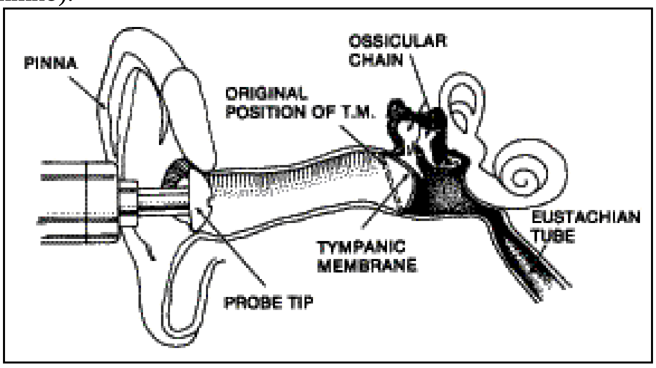

Figure 4. The probe tip introduces into the ear canal

Maximum compliance of the middle ear system occurs when the pressure in the middle ear cavity is equal to the pressure in the external auditory canal. This compliance (static acoustic admittance) is represented by the highest peak of the curve on the graph. Pressure is indicated on the horizontal axis of the graph and is measured in decaPascal. The normal tympanometric amplitude values should be >0.2 acoustic mmho for infants and >0.3 acoustic mmho for children as shown in Figure (5) [13].

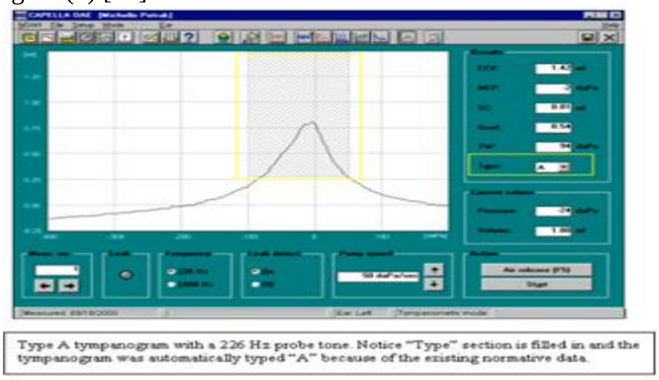

Figure 5. A tympanogram of normal hearing ear

Otoacoustic Emissions (OAEs): Otoacoustic emissions divided into many types according to the nature of the acoustic stimulus used to elicit them. This study was used Distortion product Otoacoustic emissions Gram (DPOAEs gram).

Distortion Product Otoacoustic Emissions gram (DPOAEs gram)

The DPOAE measurements performed by the OAE module present two simultaneous pure tone signals to the ear to be tested, and measure the resulting sound pressure level in the external ear during presentation. Each of the two signals is delivered by a separate transducer in the probe. The DPOAEs module provides for stimulation by each of 9 different frequency pairs(0.5,0.75 ,1.0,1.5,2.0,3.0,4.0,6.0,8.0)kHz at fixed ratio1.22. Each of these pairs has as its geometric mean one of the standard audio logical frequencies. The two primary frequencies are positioned approximately one sixth of an octave on either side of the corresponding audio logical frequency. DPOAE, and 226 Hz probe tone Tympanograms were obtained from the subjects using a MadsenCapell'a- GN- Oto Metric Denmark. A protocol used to the acquisition of DPOAE response was (nonlinear) mode. This protocol has many advantages such as, decreases time test and reduces the amount of low frequency noise contaminations.

Distortion Product measurements were performed in a quiet room to minimize the effect of the external noise. Acoustic probe tip was inserted deeply into each ear canal and monitor the consistency of the probe fit during the (DP OAEs) recording. The probe contains twospeaker's sound generator, filter and recording microphone. The speaker delivers the stimulus to the ear canal while the microphone samples the emission following stimulus presentation as shown in figure (6).The microphone output was subjected to fast Fourier Transform (FFT) for signal processing. The identification of the DPOAES against the background noise was based upon recordings obtained after spectral averaging of 1000 sweeps (i.e. Fast Fourier Transforms) at frequency range from 0.5 kHz to 8 kHz. Filtering occurs to reduce the internal body noise and external environment noises.

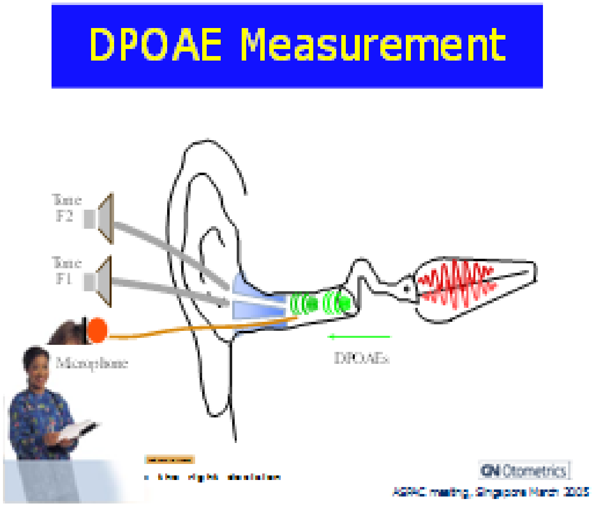

Figure 6.DPOAEs Measurement

The criteria employed to consider the presence of the responses in Distortion product Otoacoustic emissions were: response amplitude orDP1 level,(signal to-noise ration) (SNR) equal or superior to 3 dB SPLfromnoise level dB, noise level dB .these statistics area are shown in Figure (7).

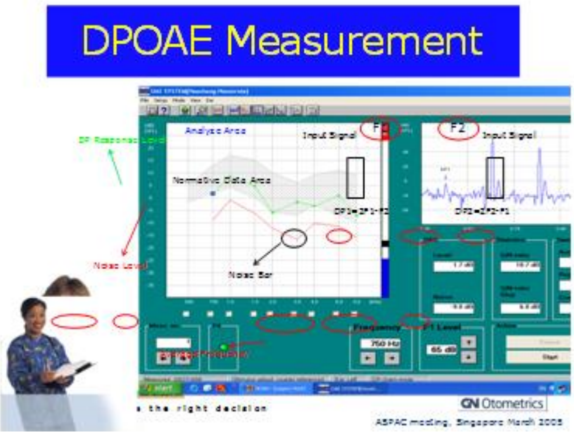

Figure 7. The statistics area of (DPOAEs) measurement

Results and discussion:

Only normal hearing subjects were enrolled in this study. Data taken for subjects are shown in Tables (1 to 9). The data in Tables (1 to 4) included the values of Distortion Product parameters (DP1 level and SNR) for Right and Left ear male (MR and ML), the data in Tables (5 t0 8) included the values of Distortion Product parameters (DP1 level and SNR) for Right and Left earfemale (FR and FL) measured for all normal hearing subjects. The total number of subjects which completed all testes was 28subjects with age from (21-30) years, 28 subjects contained 13 female and 15male. The mean value of age for females was 25.0 and for males 23.86. The group was consisted of a number of the ears in both females and males, the total number of the ears was 56,included 26 ears in females and 30 ears in males.

The minimum and the maximum value of the whole Distortion Product (DP1 Level) recorded for all tested ears (56) was -10.7 and 25.6dBrespectively over frequency bands 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 and 8.0 kHz. The mean value of the whole DP1 level in 56 ears was (6.50 dB), ranged from (-10.7 to 25.6 dB).In females; the mean value of whole DP1 Level (7.72 dB) was higher than that in males (5.28 dB). The mean value of DP1 level in the right ears female (8.22 dB) was higher than that in the left ears female (7.23 dB), while in male; the mean value of DP1 level in the right ears male (5.58 dB)was higher than that in the left ears male (4.98 dB).

To detect true-positive OAEs responses relevant signal-to-noise (SNRs) criteria must be used. DPOAEs were considered present when the signal was at least 3 dB above the corresponding noise level, [14 and 15]. In the present study, the overall SNR for each tested ear was more than 3 dB SPL at the overall frequency bands. The findings from the present study revealed an ear asymmetry effect on DPOAEs in Iraqi subjects. Right ears were found to produce higher DPOAEs-SNRs than left ears and The DPOAEs level (DP1) in the right ears was higher than that in the left ears .The minimum value of the whole Signal-to-noise ratio (SNRs) recorded for all tested ears was above 3 dB SPL over frequency bands 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 and 8.0 kHz. The mean value of the whole SNRs in 56 ears was (10.53 dB SPL), ranged from 3.0 to 28.30 dB SPL.In females; the mean value of whole SNRs (11.27dB SPL) was higher than that in males (9.8 dB SPL). The mean value of SNRs in the right ears female (11.38 dB SPL) was higher than that in the left ears female (11.16 dB SPL), while in male; the mean value of SNRs in the right ears male (10.08 dB SPL) was higher than that in the left ears male (9.52 dB SPL).

The results were agreement with the fact of interest is that, in humans, OAEs exhibit sex differences[16]. DPOAES Responses are higher in females than they are in males[17 and18].As noted above, whenever sex differences exist at birth, they cannot be attributable to then-current differences in the levels of sex hormones, so it is common to assume that these differences are after effects of earlier differences in development [19]. In that spirit, the best-documented sex differences during prenatal development is the differential exposure to androgens in male and female fetuses. To be specific, one reasonable explanation is that prenatal androgen exposure acts to weaken the cochlear amplifier in males and thus weaken their OAEs [20].

The right ear advantage has been reported in the auditory processing literature for more than 50 years [21]. The essence of the right ear advantage discussion says that the left hemisphere is dominant for speech and language processing and the contra lateral auditory pathways are stronger. Therefore, when sounds from the right ear sent to the left hemisphere (via contra lateral pathways) a right ear advantage is often apparent regarding speech, language, and dichotic presentation of language-based sounds, particularly in younger people

Conclusion:

1-DPOAEs have considerable clinical relevance because it can be obtained in almost normal subjects.

2-Signal to noise ratio (SNR) equal or more than (3.0 dB SPL) at frequency bands (0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 and 8.0 KHz) can be taken as an indicator of DPOAEs responses compared to the noise floor.

3-The present investigations have found a gender effect in DPOAEs obtained from 28 Iraqi subjects age (21-30 years). A gender effect was clearly observed, with females displaying higher DPOAEs compared with males.

4-The presence of DPOAEs in right ear is more than that in left ears.

5-The gender and ear side effects might be attributed to the anatomic and physiologic difference in ear canal and/or middle ear between the females and males as well as between the right And left ears.

Table (1) DP1 Level (dB) for Right ear male

Freq / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.2	13.1	10.9	9.8	9.2	9.1	13.2	13.2	13.1
2	1.2	6.4	12	13.8	10.7	3.6	12.8	23.1	17.0
3	4.5	7.1	14.5	15.3	9.6	4.9	12.3	20.3	8.5
4	-1.2	0.1	1.5	7.7	7.5	11	13.8	12.9	17.1
5	-5.9	3.1	7.3	8.6	5.7	-11.1	4.9	-3.2	2.1
6	-6.6	-6.1	-5.3	2.9	5.0	2.5	4.8	16.3	13.8
7	-4.1	9.2	11.4	15.3	11.7	6.5	7.6	9.8	3.0
8	14.7	-0.8	-3.1	-3.6	2.0	5.1	6.7	2.8	7.8
9	-10	-5.0	-8.9	-4.1	4.7	0.6	6.4	9.5	4.4
10	0.3	9.4	15.1	15.6	11.2	7.4	11.4	5.3	11.8
11	-1.6	3.3	4.8	8.1	2.7	8.4	15.5	25.3	25.6
12	17.8	-2.0	9.7	17.7	11.5	5.9	15.7	18.2	16.0
13	-1.6	-10.1	-9.6	-9.2	-10.4	-10	-2.9	3.0	-1.3
14	3.9	0.6	6.4	6.7	-3.0	-6.6	-2.5	-6.5	-7.4
15	-3.4	2.2	7.5	5.4	-1.3	-0.9	8.1	13.3	4.9
average	0.81	2.03	4.95	7.33	5.12	2.45	8.52	10.95	9.09

Table (2) DP1Level (dB) for Left ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
1	9.3	13.5	12.8	2.0	-0.3	10.6	15	11.7	10.0
2	0.8	6.8	14.3	13.5	11.5	11.1	15.3	24.1	12.0
3	-2.6	-2.5	8.7	11.8	0.4	1.3	8.1	10.4	3.1
4	6.7	4.2	6.9	8.1	7.4	4.9	12.7	17.3	18.8
5	-2.9	2.0	9.8	8.7	-4.2	2.0	1.1	-8.9	-8.8
6	-7.1	-5.0	6.5	6.2	-0.1	1.3	9.5	13.4	8.7
7	7.3	1.5	5.2	9.5	8.0	13.4	11.3	4.8	-2.7
8	2.1	7.9	8.9	8.1	1.6	6.4	14.4	9.5	2.7
9	-8.4	-0.2	-4.7	-0.5	4.1	6.8	4.0	3.9	-6.1
10	-3.3	7.9	15	16.5	9.9	11.7	12.6	17.6	21.4
11	6.6	-0.6	2.2	2.1	2.6	5.5	11.6	18.1	7.4
12	-1.0	5.7	9.8	13.2	10.3	13.9	14.0	5.7	5.3
13	-10.0	-9.0	-4.4	-4.9	-9.5	-10.9	-1.7	1.5	0.7
14	1.7	5.4	7.3	6.2	-5.7	-4.0	-2.0	4.3	17.3
15	-10.0	1.0	4.8	-0.9	-9.9	-8.7	3.8	10.0	-1.2
average	-0.72	2.57	6.87	5.97	1.75	4.35	8.65	9.56	5.90

Table (3) Signal Noise Ratio SNRs (dB) for Right ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	6.4	14.5	9.1	10.2	10.5	6.2	11.3	8.0	3.0
2	5.0	11.0	7.0	20.4	16.8	13.1	20.6	27.3	13.6
3	6.7	12.5	10.9	6.5	11.0	11.1	12.3	6.6	3.3
4	7.9	7.0	14.2	13.6	15.6	17.7	20.0	12.2	17.1
5	7.6	6.6	7.4	15.8	6.3	7.7	11.8	9.9	9.7
6	7.0	6.7	8.7	6.9	10.1	9.9	7.9	16.3	7.1
7	7.1	6.5	15.4	19.0	15.8	16.2	15.5	9.6	6.3
8	7.6	4.0	6.9	9.2	8.0	10.8	13.5	4.0	5.6
9	4.9	6.2	7.3	6.0	7.8	7.1	12.1	9.8	8.0
10	9.1	12.6	11.3	17.1	18.2	14.4	15.9	7.4	7.6
11	8.4	9.0	9.4	12.7	14.8	17.8	20.9	28	20.3
12	6.6	4.7	5.7	6.7	6.9	7.4	11.0	6.1	10.5
13	4.0	4.1	3.4	6.5	4.7	5.0	10.2	8.2	4.0
14	4.8	6.5	10.2	8.3	9.2	8.3	4.5	4.0	6.3
15	7.3	6.9	15.9	7.1	8.6	14.2	8.6	14.6	12.6
average	6.69	7.92	9.52	11.06	10.95	11.12	13.07	11.46	9.0

Table 4. Signal Noise Ratio SNRs (dB) for Left ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	12.2	19.8	12.9	11.9	8.5	11.0	12.0	8.0	10.0
2	6.5	9.9	11.7	14.0	7.9	9.3	8.4	4.6	3.3
3	4.0	7.3	11.7	9.4	8.0	7.5	13.6	9.0	3.0
4	8.7	7.3	11.7	13.2	17	16.5	15.2	20	11.5
5	3.8	6.2	9.1	16	9.3	14.1	14.6	5.2	6.1
6	3.0	6.6	13.1	11.0	6.5	11.5	15.4	15	8.5
7	6.8	8.9	7.2	10.7	6.4	11.9	10.3	6.9	6.8
8	7.8	7.3	8.6	7.4	6.5	10.3	13	6.8	4.6
9	5.8	8.7	5.7	4.0	11.6	11.8	9.7	9.8	3.0
10	8.1	7.5	18.8	23.4	19.2	12.8	8.9	20.6	12.5
11	8.3	10.6	8.9	8.8	10.4	13.9	17.3	8.8	6.0
12	8.1	4.3	16.5	9.0	6.6	9.1	10.2	11.0	3.1
13	3.0	4.3	6.1	6.2	6.1	8.5	13.7	5.0	3.0
14	6.5	11.8	15.2	8.9	6.3	6.1	11.9	8.4	8.7
15	6.6	8.3	9.4	6.2	7.8	8.1	14.6	7.6	6.2
average	6.61	8.58	11.10	10.67	9.20	10.82	12.58	9.78	6.42

Table 5. DP1 Level (dB) for Right ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	1.7	2.6	8.9	2.4	4.5	12.5	18.5	23.9	20.1
2	-9.1	0.8	0.6	5.4	0.4	-1.0	-0.1	11.2	14.3
3	2.3	5.8	8.8	14.5	11.1	16.2	16.4	9.5	7.4
4	-4.4	3.8	8.1	15.2	8.2	5.1	18.9	25.6	25.6
5	-9.0	0.5	-4.9	12.8	14.1	12.7	14.2	5.1	-3.6
6	-5.3	-4.2	-0.1	10.9	5.6	9.3	9.5	11.7	19.8
7	-3.6	5.3	11.3	12.8	13.9	12.9	18.8	23.6	7.6
8	-0.8	9.9	12.7	16.2	6.6	12.4	11.7	18.0	15.1
9	6.5	0.0	4.5	4.5	3.0	-6.6	0.5	3.1	-4.3
10	-10.4	-1.4	3.6	7.5	4.4	9.6	8.9	22.6	24.0
11	-0.4	6.3	5.5	7.3	-0.5	6.5	18.7	21.9	15.0
12	-8.8	5.0	5.1	10.6	9.0	11.1	16.8	16.0	9.1
13	10.9	6.1	5.1	8.1	10.3	12.8	17.7	18.8	13.3
average	-2.3	3.11	5.32	9.86	6.96	8.70	13.11	16.30	13.0

Table 6. DP1 Level (dB) forLeft ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	-4.0	7.3	2.9	6.7	15.0	6.3	14.8	18.6	11.4
2	3.6	11.1	15.8	17.1	11.2	10.0	15.7	19.3	23.1
3	-1.6	7.7	13.8	13.4	14.5	9.8	4.2	6.1	3.9
4	13.1	3.0	12.0	13.8	8.4	-0.6	16.8	21.6	16.8
5	-9.7	-6.6	-5.3	9.5	8.1	8.2	11.2	6.8	-3.3
6	0.3	-3.5	9.0	13.0	10.4	11.0	14.7	13.4	5.5
7	-2.9	11.6	10.4	7.2	5.3	9.0	15.9	24.3	20.6
8	-10.7	-8.7	-3.2	-6.3	-0.3	5.4	1.7	-3.2	-0.2
9	-8.1	-9.8	10.9	5.1	-0.4	-4.2	8.3	-2.2	6.6
10	-10.7	0.0	4.1	10.6	12.6	11.1	4.7	20.1	22.1
11	-6.5	4.2	6.9	3.5	3.0	7.4	13.3	18.5	4.6
12	-10.2	0.1	5.1	11.4	11.6	10.8	19.1	24.5	23.4
13	2.6	8.0	7.0	10.1	11.3	10.5	13.4	1.0	-2.7
average	-2.12	1.87	6.87	8.85	8.51	7.28	11.83	13.36	10.13

Table 7. Signal Noise Ratio SNRs (dB) for Right ear female.

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	9.5	9.1	8.9	10.1	7.7	20.3	17.3	20.5	4.5
2	9.0	6.1	6.5	8.1	11.8	11.9	7.4	14.6	6.7
3	6.5	12.5	8.6	16.0	18.1	10.6	21.6	11.2	13.4
4	6.7	11.4	10.9	20.6	7.9	14.6	17.6	8.8	10.5
5	4.2	6.3	6.2	16.5	23.6	21.0	21.1	8.2	4.0
6	5.0	6.5	6.6	16.1	13.9	18.7	12.4	6.3	6.7
7	4.0	14.2	14.3	12.4	12.7	18.5	24.5	23.3	6.5
8	7.0	15.3	14.4	21.2	13.4	20.0	17.6	13.6	7.0
9	10.2	6.4	12.8	7.1	10.3	8.5	8.9	7.1	3.0
10	3.8	7.0	7.7	9.3	10.8	16.4	16.3	18.1	6.3
11	7.3	8.7	11.9	13.3	6.8	19.0	13.5	6.5	6.1
12	4.2	6.3	7.0	7.1	11.7	17.9	19.1	8.8	6.7
13	9.8	11.0	9.8	6.1	6.1	17.3	18.4	15.6	8.8
average	6.70	9.29	9.66	12.60	11.90	16.5	16.59	12.50	6.73

Table 8. Signal Noise RatioSNRs (dB) for Left ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.5	8.6	4.0	11.4	13.9	16.5	13.3	13.1	3.0
2	8.1	8.0	10.9	19.8	18.6	13.0	19.2	14.0	12.4
3	6.8	11.5	16.1	19.4	23.8	18.2	7.2	12.5	10.1
4	9.0	6.5	9.9	13.9	8.4	10.3	18.1	13.1	7.1
5	3.0	3.0	3.4	12.7	12.8	21.3	17.1	9.5	3.3
6	4.2	6.6	17.3	10.7	12.9	17.8	20.9	7.5	6.8
7	5.6	14.4	11.0	10.3	13.8	18.2	23.3	28.3	16.1
8	3.0	6.4	7.6	7.9	9.3	7.2	8.1	-0.4	3.3
9	6.1	6.3	17.8	11.6	15.0	9.9	16.6	6.1	6.2
10	3.0	7.5	8.4	15.1	20.3	18.2	13.0	21.1	7.7
11	3.6	6.6	16.1	10.3	8.6	11.9	10.8	10.6	6.7
12	3.2	6.7	9.6	9.4	7.8	11.6	18.5	23.2	11.0
13	8.0	15.4	15.5	17.6	11.1	12.7	14.2	5.0	3.0
Average	5.23	8.26	11.35	12.29	13.56	14.36	15.40	12.58	7.43

Table 9. Comparison between average of DP1level and SNR for females and males at each frequency

No.	Frequency KHz	DP1Level FR dB	DP1Level FL dB	SNR FR dB	SNR FL dB	DP1Level MR dB	DP1Level ML dB	SNR MR dB	SNR ML dB
1	0.5	-2.3	-2.12	6.7	5.23	0.82	-0.72	6.69	6.61
2	0.75	3.11	1.87	9.29	8.26	2.03	2.57	7.92	8.58
3	1.0	5.32	6.87	9.66	11.35	4.95	6.87	9.52	11.10
4	1.5	9.86	8.85	12.60	12.29	7.33	5.97	11.06	10.67
5	2.0	6.96	8.51	11.90	13.56	5.12	1.75	10.95	9.20
6	3.0	8.70	7.28	16.51	14.36	2.45	4.35	11.12	10.82
7	4.0	13.11	11.83	16.59	15.40	8.52	8.65	13.07	12.58
8	6.0	16.30	13.36	12.50	12.58	10.95	9.56	11.46	9.78
9	8.0	13.0	10.13	6.75	7.43	9.09	5.90	9.0	6.42
	average	8.22	7.39	11.38	11.16	5.69	4.98	10.08	9.52

Reference:

[1] Kemp, D.T. (1978): Stimulated acoustic emissions from within the human, Arch Otorhinolaryngology. 224: 37-45.

[2]Penne, M.J; Glotzbach, L; Huang, T. (1993): Spontaneous otoacoustic emissions: Measurement and data. Hear. Res. 103: 28-34.

[3]Cheng, J. (1993): Time-frequency signal representation of transient evoked otoacoustic emissions via smoothed pseudo winger distribution, (report 12g "Dept of technical audiology, karolinska Institution Stockholm"). PP. 1-18.

[4]Martin, G.K; Probst, R.; Lonsbury-Martin, BL. (1990): Otoacoustic emissions in human ears; normative finding ear hear. 11: 106-120.

[5]Talmadge, G.L; Long, G.R.; Murphy, W.J.; Tubis, A. (1993): "New off-line method for detecting spontaneous otoacoustic emission in human subjects. Hear. Res. 71: 170-182.

[6] Brown, A.M.; Kemp, D.T. (1984): Suppressibility of the $2F_1$-F_2 stimulated acoustic emissions in gerbil and man. Hear Res. 13: 29-37.

[7] Jaramillo, F.; Markin, V.S.; Hudspetch, A.J. (1993): Auditory illusion and the single hair cells. Nature. 364: 527-529.

[8]Probst, R., Lonsbury-Martin, B. L., and Martin, G. K. ~1991!. ‘‘A review ofotoacoustic emissions,’’ J. Acoust. Soc. Am. 89, 2027–2067.

[9]Kalluri, C. A. Shera, (2001). "Distortion-product source unmixing,A test of the two-mechanism model for DPOAE generation," J.Acoust. Soc. Am. 109, 622-637.

[10] Fahey, B. B. Stagner, B. L. Lonsbury-Martin, G. K. Martin,(2000), "Nonlinear interactions that could explain distortion productInterference response areas," J. Acoust. Soc. Am. 108, 1786-1802.

[11]Dallos, P; Gorey, ME (1991): The role of outer hair cell motility in Cochlear tunning. CurrOpinNeurobiol. 1: 215-220.

[12] American National Standards Institute (ANSI), (1996), American National Standard specification for Instruments to Measure Aural Acoustic Impedance and Admittance (Aural Acoustic Admittance), ANSI S3. 39-1987. New York: ANSI.

[13] American Speech – Language – Hearing Association (ASHA), (1997): Guidelines for Audiologic Screening. Rockville Pike, MD: ASHA.

[14] Lonsbury-Martin, F. P. Harris, B. B. Stagner, M. D.Hawkins, and G. K. Martin, (1990b), "Distortion-product emissions158 in humans, I. Basic properties in normally hearing subjects," Ann.Otol. Rhinol.Laryngol, 99, Suppl. 147, 3-14.

[15]Lonsbury-Martin, G. K. Martin, and M. L. Whitehead, (2001), "Distortion product otoacoustic emissions," in Otoacoustic Emissions Clinical Applications, edited by M. S. Robinette and T.J. Glattke (Thieme, New York), pp. 83-109.

[16] McFadden, D. (1998): Sex differences in the auditory system. Der Neuropsychol. 14: 261-98.

[17] McFadden, D. (1993): A speculation about the parallel ear asymmetries and sex differences in hearing sensitivity and otoacoustic emissions, hear Res. 68: 143-51.

[18] McFadden, D. &Shubel, E. (2003): The relationships between otoacoustic emissions and relative lengths of fingers and toes in humans, hormones and behavior. 43: 421-429.

[19] Nelson R.J. (2005): An introduction to behavioral endocrinology (3rd Ed.) Sunderland, MA: Sinauer.

[20] McFadden, D.; Westhafer, J.G.; Pasanen, E.G.; Carlson, C.L. and Tucker, D.M. (2005): Physiological evidence of hypermasculinization in boys with the inattentive type of attention – deficit / hyperactivity disorder (ADHD), Clinical Neuro Science Research. 5: 233-245.

[21] Gadea, M; Espert, Chirivella, J. (1997): Dichotic listening: Elimination of the Right Ear Advantage under a Dual Task Procedure, Applied Neuropsychology,Vol. 4.