

CELLULAR PHONES EFFECTS ON OTOACOUSTIC EMISSIONS

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ABSTRACT

A study on bioelectromagnetic effects induced by the use of TACS phones, evidencing a variation of the natural response of the auditory system is presented. This study was performed applying a method based on the registration of the evoked otoacoustic emissions (transient and distortion products). The experimental results show that modulated electromagnetic fields modify the distortion products in about all the examined subjects.

INTRODUCTION

The increasing use, in the last years, of portable cellular phones by people has stimulated several scientists to incoming studies in order to verify if there is some hazard for the human health depending on electromagnetic pollution.

Before to establish if the use of TACS cellular phones may be dangerous for man, it is useful to know the bioelectromagnetic interactions related to the SAR at frequencies and power used by cellular phones. Actually several studies are oriented to the determination of the SAR as, for example, reported in [1],[2],[3].

In order to study the interaction mechanisms it is important to identify some biological response stimulated by electromagnetic exposition.

This work presents a study on bioelectromagnetic effects induced by the use of TACS phones, evidencing a variation of the natural response of the auditory system. The study was performed applying a method based on the registration of the evoked acoustic emissions (transients and distortion products).

The otoacoustic emissions (OAE) are low amplitude signals generated into the cochlea and their presence is an indication of the normal contractile and osmotic activity of the outer hair cells [4].

The OAE recording is the most objective, simple, speedy and non invasive audiologic procedure to evidence the possible alterations induced by electromagnetic exposure.

EXPERIMENTAL SETUP

The measurement system is based on a piezoelectric emitter/receiver, therefore the absence of conducting electrodes avoids any artifact depending on electric currents induced by fields as can occurs, for example, with the electrodes used in the measure of evoked potentials.

The experimental activity was performed using a system (ILO 88 and ILO 92 by Otodynamics) for recording the click-evoked emissions and the distortion product otoacoustic emissions. The click-evoked emissions were recorded by means of non linear stimulus (3 clicks of equal amplitude and polarity followed by a click of

opposite polarity and triple amplitude) of 80 μ s duration with a repetition rate of 50 Hz and at an intensity of 80-85 dB SPL (sound pressure level). Each response consisted of an average of 260 sweeps.

The analysis was performed through the default procedure (II order high pass filter, with cutoff at 330 Hz, and a low pass IV order filter with cutoff at 10.6 kHz). The response was kept valid when the stimulus spectrum stretched from 1 to 4 kHz, its stability was greater than 75% and its reproducibility, understood as the percentage of superposition of two responses, greater or equal to 70%. The distortion products have been obtained using two stimuli tones with a ratio between the frequencies $f_2/f_1 = 1.22$ and amplitudes $A_1=A_2$ from 70 dB SPL down to the threshold, as suggested in [5]. The distortion products at the frequency $2f_1-f_2$ were therefore examined.

In order to analyze the effects, for each experiment were carried out the DP-gram (distortion product gram) and the DP growth functions. For each DP gram the stimuli tones were varied across a wide range of frequencies, maintaining a constant f_2/f_1 ratio, and the $2f_1-f_2$ distortion products were plotted as a function of the f_2 frequency stimulus. For the DP growth functions the intensity of the two stimuli tones is decreased and the amplitude of $2f_1-f_2$ distortion products was plotted versus the f_2 stimuli intensity.

The exposition to the electromagnetic field was obtained using a commercial TACS cellular phone (MICROTAC II by Motorola), operating at 897.5 MHz with an irradiated power of about 500 mW, modified as follows [6]:

- the earphone was removed so the subject under test received only the acoustic signals emitted by OAE system, in absence or in presence of the electromagnetic radiation;

- the keyboard was removed and a remote control for the phone was realized.

Such a system allowed us to perform experiments excluding artifacts depending on the knowledge of the irradiation periods from subjects examined.

In order to evidence the effects of CW exposure, click-evoked emissions were recorded.

On the contrary, to analyze the effects due to modulated electromagnetic fields, the distortion products were examined when FM field was irradiated modulating the RF signal at 1 kHz.

RESULTS

Evoked acoustic emissions were recorded in a sound proof cabin on 25 normally hearing subjects.

The click-evoked emission analysis do not evidence any significant variation in the response when the subject is exposed or not to the electromagnetic radiation. The analysis of the growth functions has shown a significative difference between subjects irradiated and not irradiated with FM modulated field. The mean of differences, versus f_2 amplitude, of the distortion products

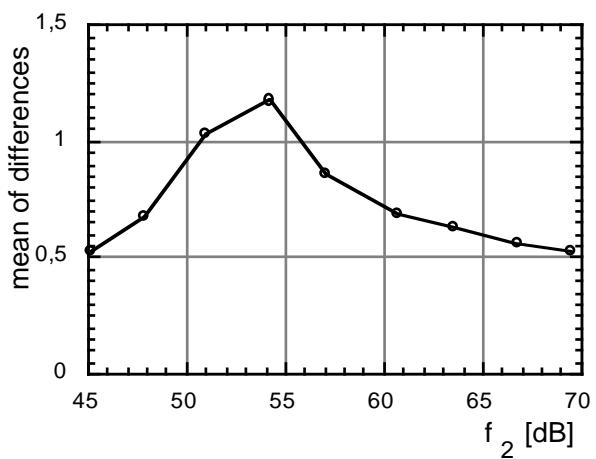


Figure 1 - Mean of differences versus intensity of f_2 stimuli acoustic of the distortion products $2f_1-f_2$ intensity for subject exposed or not a modulated microwaves

$2f_1 - f_2$ between subjects irradiated or not irradiated is shown in fig. 1. On the average, the growth function related to irradiated people with modulated microwave is greater than that one observed for not irradiated people at all the intensity stimuli with a 54.2 dB SPL peak intensity.

The experimental results show that modulated electromagnetic fields modify the distortion products in about all the examined subjects.

The histogram of fig. 2 reports the number of subjects showing predetermined intensity differences of the distortion products $2f_1-f_2$ between records in presence of radiation or not, at a stimulation intensity of 54.2 dB SPL. This histogram shows a prominence of the positive deviation.

In order to know the level of significance we applied the paired version of the Student t test because the data are related to two sets of measurements on the same subjects.

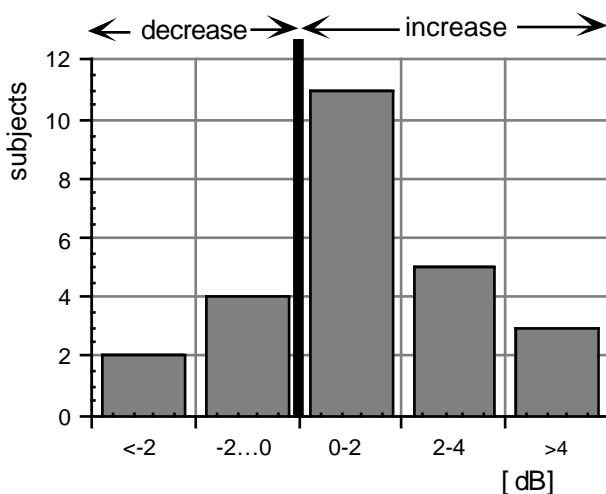


Figure 2. Number of subjects having differences (dB) on the intensities of the distortion products between irradiated and non irradiated growth functions at a stimulation intensity of 54.2 dB.

In Tab. 1 are reported results of the Student t test for the 54.2 dB intensity level of the acoustic stimuli. The probability value is

sufficiently low to enable us to reject the null hypothesis at the about 1% ($p=0,0128$) level and accept the alternative hypothesis that the electromagnetic field FM modulated influence the evoked otoacoustic emissions of the twenty five subjects.

We have also performed the distribution analysis using the mean value and the STD value of the distortion products in the subjects exposed or not in correspondence of the 54.2 dB SPL intensity acoustic stimuli.

Tab. 1 - Student t test - Paired values

Irradiated subjects	Non irradiated subjects
mean: -3,0956	mean: -1,7578
std: 7,4185	std: 7,5476
Student t value: -2,7005	
Probability: 0,0128	

The draw of the Fig. 3 shows the result of the analysis: the continue line represents the normal distribution of people not exposed to

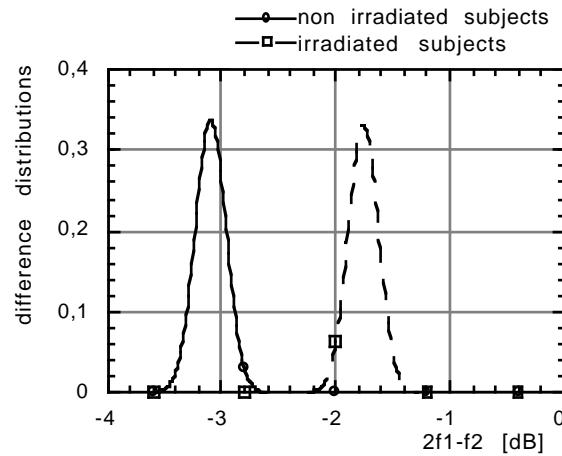


Figure 3. - Distribution of subjects exposed or not to modulated electromagnetic fields versus distortion products intensity.

electromagnetic fields radiated by the phone, while the dashed line refers to normal distributions of exposed subjects.

In the above figure it is evident that the two distributions are clearly divided confirming an effect induced by the radiation.

CONCLUSIONS

The otoacoustic emissions, evoked by clicks, do not have evidenced any alteration in presence of electromagnetic field.

On the contrary the frequency modulated electromagnetic emission of the TACS modify the distortion products intensity.

Therefore the presence of a biological response using TACS cellular phones suggests us the opportunity of closely examining the studies in this field in order to verify if may occurs some hazardous effect for man.

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