

DOES ACUTE EXPOSURE TO THE ELECTROMAGNETIC FIELD EMITTED BY A MOBILE PHONE INFLUENCE VISUAL EVOKED POTENTIALS?

A pilot study

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SUMMARY

To search for a potential negative influence on the central nervous system (CNS) of the electromagnetic field emitted by a mobile phone, the authors performed a pilot experimental study of the influence of a single short acute exposure to the GSM mobile phone Motorola 8700, using visual evoked potentials (VEP) examination as an electrophysiological marker of CNS dysfunction. The study group consisted of 20 healthy volunteers. The duration of exposure was 5 minutes. The output power of the device was 1.5 W when the antenna was pulled up. Five parameters of VEP were evaluated by means of multifactorial ANOVA. Confounding effects of age, sex, and of the call in itself were taken into consideration. No statistically significant influence of the above-described exposure to the electromagnetic field emitted by the mobile phone on latencies or amplitudes of VEP was observed.

Key words: mobile phone, electromagnetic fields, visual evoked potentials

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INTRODUCTION

Potential changes in the functioning of the central nervous system (CNS) induced by exposure to the electromagnetic field emitted by mobile phones are supposed to be functional and reversible (at least at the beginning). To search for such subtle CNS changes we consider psychological and electrophysiological methods as adequate means. Concerning the electrophysiological methods, electroencephalography (EEG) and evoked potentials examination (EVP) come into consideration as the first choice.

EEG was used for the purpose by Hietanen (1) and Thuroczy (2). However, we did not find in the available literature any report on EVP. Therefore, we decided to try the EVP examination in search of potential CNS changes induced by exposure to the electromagnetic field emitted by a mobile phone. There are various modalities of EVP. We chose visual evoked potentials examination (VEP) for the following reasons: 1. The VEP are generated in the occipital lobe cortex which is in close proximity of the mobile phone antenna (3). 2. Cortical structures are in general much more sensitive to various influences than subcortical or brainstem structures. 3. From a practical point of view, the VEP examination is easier and faster to perform than that of other EVP modalities (e.g. somatosensory evoked potentials or the wave P300 examination).

before and after having used a mobile phone. The exposure had the scenario of a crossed trial.

Subjects

Inclusion criteria: Experimental subjects were healthy volunteers recruited among our workmates, friends or relatives. Both sexes were represented equally.

Exclusion criteria: 1. History or presence of an illness that could influence VEP.

2. Visual acuity worse than 5/7.5 at least on one eye, not corrected by glasses.

3. Atypical or poorly reproducible evoked complex in the first examination of VEP without exposure.

A total of 20 subjects were included in the study. Table shows the characteristics of the group under study.

Table 1. Characteristics of the group under study

	N	Age (years)
Females	10	22 - 57, 41 ± 12
Males	10	19 - 70, 43 ± 18
Total	20	19 - 70, 42 ± 15

VEP Examination

The VEP examination was performed with Neuromat 2000 (Dantec). Stimulation: TV system, monocular, full field black and white checkerboard pattern reversal, stimulator field size 12° x 9°, square size 70', average luminance of the screen 20 cd/m², contrast between light and dark squares 69%, frequency of stimulation 1.5 Hz. Bioelectrical activity was recorded from the derivation O_z-F_z. Bandwidth of the amplifier

MATERIAL AND METHODS

Study Design

We performed an experimental study of the influence on VEP of a single short acute exposure to the electromagnetic field emitted by a mobile phone. The study was based on the comparison of VEP results in a group of healthy volunteers

Table 2. The experimental scenario

Session	VEP		Five minute call with mobile	VEP	
1.	1.	2.	on / off	3.	4.
2.	1.	2.	off / on	3.	4.

1–100 Hz; sweep 300 ms; 200 epochs were averaged. Sensitivity 1–2 μ V/D. Latencies of the waves N1, P1, N2, and amplitudes N1P1, and P1N2 were evaluated.

Experimental Scenario

Each proband was examined twice at an interval of about two weeks. In each session VEP were examined four times in a row. A call with the mobile phone apparatus GSM Motorola 8700 was set between the second and the third VEP examination. A five minute duration of the call was chosen, corresponding to an average duration of a common phone call. During that time the proband read into the mobile phone a text from a newspaper. The device was held in the right hand and its antenna was pushed in. The phone was switched on in one session and off in the other. The order of "on-off" was randomized. With the mobile phone "on" another phone apparatus in the room was called, through which the connection was being checked. The intensity of the signal in the examination room was expressed as the number of bars in the icon on the mobile phone display. The proband was aware of whether the mobile phone was "on" or "off". The scenario of the experiment is summarized in Table 2.

Statistical Evaluation

Results of VEP examination obtained by the stimulation of the right eye were evaluated. Eight values of each VEP parameter measured on one person were considered as a balanced block of dependent values. Fitting of the distribution of VEP parameters with normal distribution was tested with the Kolmogorov-Smirnov test. The following variables were evaluated:

A. *Predictive variable*: exposure to the electromagnetic field (mobile phone switched on or off).

B. *Dependent variables*: 1. the wave N1 latency, 2. the wave P1 latency, 3. the wave N2 latency, 4. the amplitude N1P1, 5. the amplitude P1N2.

C. *Confounding variables*: 1. age, 2. sex, 3. mobile "on" in the first or in the second session, 4. the order of the VEP examination in the given session (first or second).

Multifactorial analysis of variance was used. The influence of the following factors was evaluated: age, sex, mobile phone "on" or "off", test before and after using the mobile phone, the order of repeated VEP examination within the scope of one VEP test, the order of the session in which the device was "on", and interactions of the above-mentioned factors. The H_0 hypothesis was formulated that the means of VEP parameters before and after using the mobile phone "on" and "off" were equal. This issue was tested by the interaction between factors: mobile phone "on" or "off" versus VEP before or after calling. The influence of age and sex on this interaction was tested with the multiple regression.

RESULTS

The influence on VEP of exposure to the electromagnetic field emitted by the mobile phone was tested in the statistical model as the interaction between factors: 1. mobile phone on

Table 3. The influence on VEP parameters of exposure to the electromagnetic field emitted by a mobile phone

Parameter	Influence of the exposure to electromagnetic field	
	F	p
Latency N1	1.70	0.194
Latency P1	0.00	0.944
Latency N2	0.32	0.575
Amplitude N1P1	2.46	0.119
Amplitude P1N2	0.76	0.385

Table 4. Correlation with age and sex of the influence on VEP parameters of the exposure to the electromagnetic field emitted by a mobile phone

Parameter	Correlation of the influence of exposure to elmag field with			
	age		sex	
	B	p	B	p
Latency N1	1.61	0.181	-2.52	0.944
Latency P1	1.65	0.287	-0.81	0.986
Latency N2	2.01	0.391	23.5	0.743
Amplitude N1P1	0.08	0.530	1.44	0.704
Amplitude P1N2	0.02	0.888	2.85	0.561

or off, and 2. VEP examination before or after the phone call. The F-values and corresponding significances of this interaction for individual VEP parameters from ANOVA tables were summarized in Table 3. It can be seen that exposure to the electromagnetic field had no significant effect on any VEP parameter.

The question of whether there is a correlation between an influence on VEP parameters of exposure to the electromagnetic field and the age or sex of the exposed subjects was tested by multiple linear regression. The B-values and their corresponding p-values for the correlations are summarized in Table 4. As can be seen, no statistically significant correlation was observed.

DISCUSSION

To search for any potential negative influence on the CNS of electromagnetic field emitted by mobile phone, we used VEP as an electrophysiological marker of CNS dysfunction. We compared five VEP parameters before and after calling with a mobile phone for five minutes. To differentiate the influence on VEP of the electromagnetic field from any influence of the call in itself, we repeated the same procedure before and after calling with the mobile phone "off". If the electromagnetic field induced changes in CNS functioning detectable by means of VEP, the difference between values of one or more VEP parameters before and after calling with the mobile phone "on" should significantly differ from the difference of values of the parameter before and after the dummy exposure, i.e. calling with the mobile phone "off". The corresponding hypothesis was tested by multifactorial ANOVA.

It is apparent from the results of ANOVA (Table 3) that under the described experimental conditions the electromagnetic field emitted by the mobile phone induced no statistically significant changes in any of the five VEP parameters evaluated. This result was not influenced by age or sex of the experimental subjects (Table 4).

Limitations of the study:

1. The number of our probands (20) was relatively small. Therefore the power of our study to differentiate between a supposed small effect and no effect was low.

2. The intensity of the signal in our examination room was weak, corresponding to the degree "2" on the mobile phone display. That was advantageous from the perspective of our study because the output of the mobile phone was high: approximately 1.5 W when the antenna was pulled up. (When the antenna was pushed in, the output was a little bit lower.) Anyhow, it is conceivable that five minute exposure was too short to induce changes in the CNS functioning and further studies with longer exposure are desirable.

The interpretation of the negative results of our study must take into consideration the above-mentioned limitations. We did not observe any significant influence on VEP of the acute five minute exposure to the electromagnetic field emitted by a mobile phone. However, we cannot exclude that VEP changes could be detected if we increased the number of exposed subjects or if we prolonged the exposure.

Even if the electromagnetic field really had no influence on VEP, this would not necessarily mean the absence of any influence of the electromagnetic field on the CNS. It is not possible to exclude that the exposure to the electromagnetic field could induce such changes in the CNS functioning for which the VEP examination would not be an adequate marker.

Finally, we have to stress that our study was designed to search for effects of an acute single exposure and consequently it says nothing about potential untoward effects of repeated or chronic exposure.

Acknowledgments

The authors thank Ing. Jan Musil, CSc., and MUDr. Pavel Chýle for critical reading of the manuscript and Mrs. Lydie Hamsová for skilled technical assistance.

The study was supported by grants IGA MZ ČR 3497-3 and COST 244 bis.

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Received February 3, 1998

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Salivary gland secretions provide a better environment for pathogen transmission. Arthropod saliva contain components interacting with the hosts haemostatic mechanisms as platelet aggregation inhibitors, vasodilators and inhibitors of coagulation factors. Diverse antihemostatic compounds may yield new drugs relevant to control of vectors.

Chapter 5 is devoted to **Arthropod Modulation of Host Immune Response**. Haematophagous arthropods are faced with a complex array of host responses that can inhibit bloodmeal acquisition – haemostatic mechanisms reduce availability of blood for ingestion, antibody and specifically sensitized cells interfere with blood acquisition. On the other hand, arthropod countermeasures inhibit host haemostasis with anti-haemostatic and vasoactive activities and modulate host immune responses. Salvia of the blackflies, sand flies and mosquitoes may impact antibody and cell-mediated defences. Salivary glands extracts from ticks reduce effector functions of NK cells.

Chapter 6 examines the **Digestion and Fate of the Vertebrate Bloodmeal in Insects**. Of the estimated 1 to 10 million species only 300 to 400 are regular blood feeders. Described is design of the midgut and associated structures of various insect groups in relation to the bloodmeal digestion, to the production and role of peritrophic matrix (= peritrophic membrane), to the meal size and to the distribution of major constituents of host blood, and their utilization for insect development.

Chapter 7 focuses on **Immune Responses to Fleas, Bugs and Sucking Lice**. All three orders are solenophagous, feeding from small blood vessels. In these groups blood-feeding

evolved independently. There are differing chemical mediators which can increase blood-feeding efficiency and decrease danger from host behavioural or physiological response. In particular groups described are specificity, salivary components, and host responses, namely hypersensitivity reactions, clinical signs, kinetics of blood cells, and more.

Chapter 8 considers problems of **Immune Responses to Mosquitoes and Flies**. Discussed are natural immune responses to haematophagous dipteran parasites, namely the hypersensitivity, immune responses to resistant hosts and modulation of host responses. Vaccination against haematophagous species may stimulate immune responses which affect feeding, fecundity and survival. Also vaccination against myiasis flies may become a major aim of research in human as well in veterinary areas.

Chapter 9 centers attention upon **Immunology of the Tick-Host Interface**. Tick feeding induces a complex array of host immune responses and ticks have developed a sophisticated arsenal of immunomodulatory measures. Tick-borne viruses, rickettsiae, bacteria and protozoa increase the complexity of these relationships. Host immunoregulatory and effector pathways stimulated by tick feeding involve antibodies, complement, cytokines, antigen-presenting cells, mast cells, basophils, eosinophils, B- and T-lymphocytes, and bioactive molecules. Host genetic composition determines immune response capabilities. Understanding of host-tick immune interactions is essential with regard to the medical importance of ticks and tick-borne diseases.

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