

Trigeminal neurons detect cellphone radiation: Thermal or nonthermal is not the question

Marino AA, Kim PY, Frilot li C. Trigeminal neurons detect cellphone radiation: Thermal or nonthermal is not the question. *Electromagn Biol Med*. 2016 Jul 15:1-9. [Epub ahead of print]

Abstract

Cellphone electromagnetic radiation produces temperature alterations in facial skin. We hypothesized that the radiation-induced heat was transduced by warmth-sensing trigeminal neurons, as evidenced by changes in cognitive processing of the afferent signals. Ten human volunteers were exposed on the right side of the face to 1 GHz radiation in the absence of acoustic, tactile, and low-frequency electromagnetic stimuli produced by cellphones. Cognitive processing manifested in the electroencephalogram (EEG) was quantitated by analysis of brain recurrence (a nonlinear technique). The theoretical temperature sensitivity of warmth-sensing neurons was estimated by comparing changes in membrane voltage expected as a result of heat transduction with membrane-voltage variance caused by thermal noise. Each participant underwent sixty 12-s trials. The recurrence variable r ("percent recurrence") was computed second by second for the Δ band of EEGs from two bilaterally symmetric derivations (decussated and nondecussated). Percent recurrence during radiation exposure (first 4 s of each trial) was reduced in the decussated afferent signal compared with the control (last four seconds of each trial); mean difference, $r = 1.1 \pm 0.5\%$, $p < 0.005$. Mean relative Δ power did not differ between the exposed and control intervals, as expected. Trigeminal neurons were capable of detecting temperature changes far below skin temperature increases caused by cellphone radiation. Simulated cellphone radiation affected brain electrical activity associated with nonlinear cognitive processing of radiation-induced thermal afferent signals. Radiation standards for cellphones based on a thermal/nonthermal binary distinction do not prevent neurophysiological consequences of cellphone radiation.

<http://www.ncbi.nlm.nih.gov/pubmed/27419655?dopt=Abstract>

Excerpts

A 1 GHz continuous-wave signal (a characteristic cellphone frequency) (Signal Forge Model 1000, Austin, TX) was amplified (Empower, Inglewood, CA) and fed to an electrically controlled timing switch that sent the signal to a patch antenna (Schmid et al., 2007) located 10 cm from the participant's right cheek or to a floor-level dummy antenna located 5 m away from the participant (Figure 1). The signal energized the patch antenna for 4 s and the dummy antenna for 8 s in successive 12-s trials. ...The unperturbed electric field measured at the location of the participant's cheek was 60 V/m (Extech, Nashua, NH). ... At 1 GHz, the far-field

approximation for the radiation from our patch (Schmid et al., 2007) was somewhere between 0.5 and 1.2 cm (Yang et al., 2000). Consequently, radiation from any antenna where the far-field approximation is applicable and the unperturbed electric field is 60 V/m would mimic our exposure conditions. At this field strength, the specific absorption rate calculated using conventional structural models and physiological assumptions is about 0.6 W/kg (less than half of the US-approved limit for cellphones). The maximum electric field measured 2 cm from a cellphone is about 400 V/m (Stewart, 2000). The public-health significance of chronic and subacute exposure to cellphone radiation is under scrutiny (Chu et al., 2011; Coureau et al., 2014; Hardell et al., 2013; Szykowska et al., 2014), and marked disagreements exist among the stakeholders as regards the public-health risks. Our work is directly pertinent to one aspect of the contentiousness, the assumption that there exists a binary distinction between so-called thermal and nonthermal biological effects associated with cellphone radiation. In that perspective, cellphone radiation is regarded as inherently nonthermal and consequently unable to cause any biological effects, health related or otherwise. The results reported here indicated that a standard cellphone radiating at a level well within approved emission limits will necessarily produce a physiological thermal effect triggered by heat deposited in the user's facial skin. Consequently, **cellphone safety cannot validly be predicated on the absence of thermal effects because they are never absent.**

A brief description of the historical setting for the work described here seems appropriate. In 1981, we concluded that the biological effects of environmental-strength electromagnetic fields (EEFs) on animals and humans were real (Becker and Marino, 1982), rather than the result of inconspicuous errors in experimental design, execution, or data analysis (Michaelson, 1982; Schwan, 1971), and we hypothesized that the prototypical effect was an emergent property of the organism's stress-response system that followed EEF transduction, rather than a direct cellular or subcellular phenomenon (Bawin and Adey, 1976; Blank and Goodman, 2009). The hypothesis entailed the idea that EEF bioeffects were energetically possible, not forbidden by physical law (Adair, 1991; Weaver et al., 1998). We demonstrated that low- and high-frequency EMFs altered the stress-response system (Bell et al., 1991; Marino et al., 1977; Marino et al., 1979; Marino et al., 1980; Marino et al., 2001; Marino et al., 2000), that transduction occurred in the head (Marino et al., 2003a, 2003b), and that low-frequency transduction could be understood as a direct Coulomb force on aggregates of sugar molecules attached to the gates of ion channels in sensory neurons (Kolomytkin et al., 2007). But that transduction mechanism was precluded at cellphone frequencies by the mechanical inertia of the responding aggregates. Here we showed that an indirect process in which Coulomb forces on atomic charges generated heat that altered the open time of ion-channel gates in sensory neurons could explain

transduction of cellphone radiation. Taken as a whole, the various experimental studies support the original hypothesis that the prototypical process by which EEFs (including but not limited to cellphone radiation) are linked to human disease consists of sensory transduction and a chronic stress response resulting from neuroendocrine-immune interactions.

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Acute Exposure to Terrestrial Trunked Radio (TETRA) has effects on the electroencephalogram and electrocardiogram, consistent with vagal nerve stimulation

Burgess AP, Fouquet NC, Seri S, Hawken MB, Heard A, Neasham D, Little MP, Elliott P. Acute Exposure to Terrestrial Trunked Radio (TETRA) has effects on the electroencephalogram and electrocardiogram, consistent with vagal nerve stimulation. *Environ Res.* 2016 Jul 12;150:461-469. doi: 10.1016/j.envres.2016.06.031. [Epub ahead of print]

Abstract

BACKGROUND: Terrestrial Trunked Radio (TETRA) is a telecommunications system widely used by police and emergency services around the world. The Stewart Report on mobile telephony and health raised questions about possible health effects associated with TETRA signals. This study investigates possible effects of TETRA signals on the electroencephalogram and electrocardiogram in human volunteers.

METHODS: Blinded randomized provocation study with a standardized TETRA signal or sham exposure. In the first of two experiments, police officers had a TETRA set placed first against the left temple and then the upper-left quadrant of the chest and the electroencephalogram was recorded during rest and active cognitive processing. In the second experiment, volunteers were subject to chest exposure of TETRA whilst their electroencephalogram and heart rate variability derived from the electrocardiogram were recorded.

RESULTS: In the first experiment, we found that exposure to TETRA had consistent neurophysiological effects on the electroencephalogram, but only during chest exposure, in a pattern suggestive of vagal nerve stimulation. In the second experiment, we observed changes in heart rate variability during exposure to TETRA but the electroencephalogram effects were not replicated.

CONCLUSIONS: Observed effects of exposure to TETRA signals on the electroencephalogram

(first experiment) and electrocardiogram are consistent with vagal nerve stimulation in the chest by TETRA. However given the small effect on heart rate variability and the lack of consistency on the electroencephalogram, it seems unlikely that this will have a significant impact on health. Long-term monitoring of the health of the police force in relation to TETRA use is on-going.

<http://www.ncbi.nlm.nih.gov/pubmed/27419367?dopt=Abstract>

Highlights

- Two provocation experiments of Terrestrial Trunked Radio (TETRA) in healthy volunteers.
- In one experiment, chest exposure to TETRA had significant effect on the electroencephalogram (EEG).
- Chest exposure to TETRA also induced changes in heart rate variability (HRV).
- Pattern of effects on the EEG and HRV suggestive of vagal nerve stimulation.
- Physiological effects of short-term TETRA exposure warrants further investigation

Excerpts

Terrestrial Trunked Radio (TETRA) is an open standard telecommunications system for private mobile radios used by the emergency services, utility companies and the military in more than 100 countries. TETRA employs time division multiplexing such that the radio frequency (RF) signal (380-395 MHz) is transmitted in a series of bursts (timeslots) with a pulse rate of 17.6 Hz (Challis, 2007 and MTHR, 2007). This pulsing may induce an extremely low frequency (ELF) modulation of the magnetic field at 17.6 Hz in addition to, and synchronized with, the pulse-modulated RF electromagnetic fields (EMF). The UK's Independent Expert Group on Mobile Phones (Stewart Report) concluded in 2000 that '...as a precautionary measure, amplitude modulation around 16 Hz should be avoided, if possible, in future developments in signal coding' (IEGMP, 2000).

Conclusion

We found evidence for a significant TETRA-induced change in the EEG in our first experiment and the hypothesis arising from this that TETRA might affect HRV was supported in our second experiment by a measurable reduction in pNN50, a marker of parasympathetic (i.e. vagal) influence, during chest exposure, although the EEG effect was not replicated. The change in pNN50 was small, comparable to the difference seen between opening and closing the eyes,

and as such, it seems unlikely that it poses any serious health risk. Nevertheless, the fact that physiological effects were found in humans during short-term exposures to levels of TETRA signal that were conservatively defined to exclude such influences is a novel finding worthy of further investigation and further studies with chest exposure to TETRA-RF should be undertaken. Long-term monitoring of the health of the police force in relation to TETRA use is on-going (Elliott et al., 2014).

Symptoms in Swiss adolescents in relation to exposure from fixed site transmitters: a prospective cohort study

Anna Schoeni, Katharina Roser, Alfred Bürgi and Martin Rösli. Symptoms in Swiss adolescents in relation to exposure from fixed site transmitters: a prospective cohort study. *Environmental Health*. 2016. 15:77. DOI: 10.1186/s12940-016-0158-4.

Abstract

Background. There is public concern regarding potential health effects of radiofrequency electromagnetic fields (RF-EMF) emitted by fixed site transmitters. We therefore investigated whether self-reported general well-being in adolescents is affected by RF-EMF exposure from mobile phone base stations (downlink) and broadcast transmitters (TV and radio). **Methods.** In a prospective cohort study, 439 study participants aged 12-17 years, completed questionnaires about their self-reported well-being and possible confounding factors at baseline and one year later. Exposure from fixed site transmitters at home and school was calculated by using a geospatial propagation model. Data were analysed using a mixed-logistic cross-sectional model of a combined dataset consisting of baseline and follow-up data and a longitudinal approach where we investigated whether exposure at baseline (cohort analysis) or changes in exposure between baseline and follow-up (change analysis) were related to a new onset of a symptom between baseline and follow-up. All analyses were adjusted for relevant confounders. **Results.** Mean exposure (median; 75th) for broadcast transmitters, downlink and total exposure at baseline were 1.9 $\mu\text{W}/\text{m}^2$ (1.0 $\mu\text{W}/\text{m}^2$; 2.8 $\mu\text{W}/\text{m}^2$), 14.4 $\mu\text{W}/\text{m}^2$ (3.8 $\mu\text{W}/\text{m}^2$; 11.0 $\mu\text{W}/\text{m}^2$) and 16.3 $\mu\text{W}/\text{m}^2$ (5.8 $\mu\text{W}/\text{m}^2$; 13.4 $\mu\text{W}/\text{m}^2$), respectively. In cross-sectional analyses no associations were observed between any symptom and RF-EMF exposure from fixed site transmitters. In the cohort and change analyses only a few significant associations were observed including an increased OR for tiredness (2.94, 95%CI: 1.43 to 6.05) for participants in the top 25th percentile of total RF-EMF exposure from fixed site transmitters at baseline, in comparison to participants exposed below the median and a decreased OR for exhaustibility (0.50, 95%CI: 0.27 to 0.93) for participants with an exposure increase between baseline and

follow-up.

Conclusions. In this cohort study, using a geospatial propagation model, RF-EMF exposure from fixed site transmitters was not consistently associated with self-reported symptoms in Swiss adolescents. The few observed associations have to be interpreted with caution and might represent chance findings.

Excerpts

We are aware that exposure to fixed site transmitters is of minor relevance in comparison to exposure from wireless devices operating close to the body such as a mobile or cordless phone. According to the dose estimations by Roser et al. [16], the far-field exposure from fixed site transmitters contributed on average 0.7 % to the cumulative brain dose and 2.3 % to the cumulative whole body dose. Or expressed differently, the mean dose for the brain in our study sample obtained from mobile phone base stations (downlink exposure) for 24 h corresponds to a mobile phone call of 2.6 s on the GSM (2nd generation Global System for Mobile Communications) network or of a 6.1 min call on the UMTS (3rd generation Universal Mobile Telecommunications System) network. Concerning the exposure to the whole body, 24 h downlink exposure from mobile phone base stations corresponds to a 15.0 s call on the GSM network or to a 34.2 min call on the UMTS network.

Conclusions

Exposure from fixed site transmitters was low in our study area (≤ 0.38 V/m). In cross-sectional analyses no associations between self-reported symptoms and RF-EMF exposure was observed. In the change analyses a decrease of exhaustibility was found for total RF-EMF increase and an improvement in concentration for increase in downlink exposure, whereas in the cohort approach an association between modelled RF-EMF exposure from fixed site transmitters and tiredness and concentration difficulties in Swiss adolescents was seen. Given the high number of analyses conducted in this study, the observed associations need confirmation before firm conclusions can be drawn.

<http://ehjournal.biomedcentral.com/articles/10.1186/s12940-016-0158-4>

Effect of radiofrequency radiation from Wi-Fi devices on mercury release from amalgam restorations

Paknahad M, Mortazavi SM, Shahidi S, Mortazavi G, Haghani M. Effect of radiofrequency

radiation from Wi-Fi devices on mercury release from amalgam restorations. J Environ Health Sci Eng. 2016 Jul 13;14:12. doi: 10.1186/s40201-016-0253-z. eCollection 2016.

Abstract

BACKGROUND: Dental amalgam is composed of approximately 50% elemental mercury. Despite concerns over the toxicity of mercury, amalgam is still the most widely used restorative material. Wi-Fi is a rapidly using local area wireless computer networking technology. To the best of our knowledge, this is the first study that evaluates the effect of exposure to Wi-Fi signals on mercury release from amalgam restorations.

METHODS: Standard class V cavities were prepared on the buccal surfaces of 20 non-carious extracted human premolars. The teeth were randomly divided into 2 groups (n = 10). The control group was stored in non-environment. The specimens in the experimental groups were exposed to a radiofrequency radiation emitted from standard Wi-Fi devices at 2.4 GHz for 20 min. The distance between the Wi-Fi router and samples was 30 cm and the router was exchanging data with a laptop computer that was placed 20 m away from the router. The concentration of mercury in the artificial saliva in the groups was evaluated by using a cold-vapor atomic absorption Mercury Analyzer System. The independent t test was used to evaluate any significant differences in mercury release between the two groups.

RESULTS: The mean (\pm SD) concentration of mercury in the artificial saliva of the Wi-Fi exposed teeth samples was $0.056 \pm .025$ mg/L, while it was only $0.026 \pm .008$ mg/L in the non-exposed control samples. This difference was statistically significant ($P = 0.009$).

CONCLUSION: Exposure of patients with amalgam restorations to radiofrequency radiation emitted from conventional Wi-Fi devices can increase mercury release from amalgam restorations.

Open Access Paper: <http://jehse.biomedcentral.com/articles/10.1186/s40201-016-0253-z>

Terahertz Radiation: A Non-contact Tool for the Selective Stimulation of Biological Responses in Human Cells

Ibtissam Echchgadda, Jessica E. Grundt, Cesario Z. Cerna, Caleb C. Roth, Jason A. Payne, Bennett L. Ibey, Gerald J. Wilkink. Terahertz Radiation: A Non-contact Tool for the Selective Stimulation of Biological Responses in Human Cells. IEEE Transactions on Terahertz Science and Technology. 6(1): 54-68. 2016.

Abstract

Collective motions of water and of many biological macromolecules have characteristic time

scales on the order of a picosecond. As a result, these biomolecules can strongly absorb terahertz (THz) radiation. Due to this absorption, THz radiation can exert a diverse range of effects on biological structures. For example, THz radiation has been shown to impact the structure, functional activity, and dynamics of macromolecules such as DNA and proteins. THz radiation can affect several gene expression pathways and, consequently, can alter various biochemical and physiological processes in cells. Indeed, THz radiation has been shown to influence the expression of several genes within different cell types. However, a complete view of the global transcriptional responses and the intracellular canonical pathways specifically triggered by THz radiation has not been elucidated. In this study, we performed a global profiling of transcripts in human cells exposed to 2.52 THz radiation and compared the exposure responses to a thermally-matched bulk-heating (BH) protocol. Our results show that both THz radiation and BH induce a significant change in the expression of numerous mRNAs and microRNAs. The data also show that THz radiation triggers specific intracellular canonical pathways that are not affected in the BH-exposed cells. This study implies that THz radiation may be a useful, non-contact tool for the selective control of specific genes and cellular processes.

<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7361772>

Comparison of average global exposure of population induced by a macro 3G network in different geographical areas in France and Serbia

Huang, Y., Varsier, N., Niksic, S., Kocan, E., Pejanovic-Djurisic, M., Popovic, M., Koprivica, M., Neskovic, A., Milinkovic, J., Gati, A., Person, C. and Wiart, J. (2016), Comparison of average global exposure of population induced by a macro 3G network in different geographical areas in France and Serbia. *Bioelectromagnetics*. doi: 10.1002/bem.21990.

Abstract

This article is the first thorough study of average population exposure to third generation network (3G)-induced electromagnetic fields (EMFs), from both uplink and downlink radio emissions in different countries, geographical areas, and for different wireless device usages. Indeed, previous publications in the framework of exposure to EMFs generally focused on individual exposure coming from either personal devices or base stations. Results, derived from device usage statistics collected in France and Serbia, show a strong heterogeneity of exposure, both in time, that is, the traffic distribution over 24 h was found highly variable, and space, that is, the exposure to 3G networks in France was found to be roughly two times higher than in Serbia. Such heterogeneity is further explained based on real data and network architecture. Among those results, authors show that, contrary to popular belief, exposure to 3G EMFs is dominated by uplink radio emissions, resulting from voice and data traffic, and average

population EMF exposure differs from one geographical area to another, as well as from one country to another, due to the different cellular network architectures and variability of mobile usage.

<http://onlinelibrary.wiley.com/doi/10.1002/bem.21990/abstract>

Quality Matters: Systematic Analysis of Endpoints Related to "Cellular Life" in Vitro Data of Radiofrequency Electromagnetic Field Exposure

Simkó M, Remondini D, Zeni O, Scarfi MR. Quality Matters: Systematic Analysis of Endpoints Related to "Cellular Life" in Vitro Data of Radiofrequency Electromagnetic Field Exposure. *Int J Environ Res Public Health*. 2016 Jul 12;13(7). pii: E701. doi: 10.3390/ijerph13070701.

Abstract

Possible hazardous effects of radiofrequency electromagnetic fields (RF-EMF) at low exposure levels are controversially discussed due to inconsistent study findings. Therefore, the main focus of the present study is to detect if any statistical association exists between RF-EMF and cellular responses, considering cell proliferation and apoptosis endpoints separately and with both combined as a group of "cellular life" to increase the statistical power of the analysis. We searched for publications regarding RF-EMF in vitro studies in the PubMed database for the period 1995-2014 and extracted the data to the relevant parameters, such as cell culture type, frequency, exposure duration, SAR, and five exposure-related quality criteria. These parameters were used for an association study with the experimental outcome in terms of the defined endpoints. We identified 104 published articles, from which 483 different experiments were extracted and analyzed. Cellular responses after exposure to RF-EMF were significantly associated to cell lines rather than to primary cells. No other experimental parameter was significantly associated with cellular responses. A highly significant negative association with exposure condition-quality and cellular responses was detected, showing that the more the quality criteria requirements were satisfied, the smaller the number of detected cellular responses. According to our knowledge, this is the first systematic analysis of specific RF-EMF bio-effects in association to exposure quality, highlighting the need for more stringent quality procedures for the exposure conditions.

Conclusions

Taking it together, our analysis shows that in vitro cellular response after exposure to RF-EMF—Considering apoptosis and cell proliferation separately and both combined in a group of "cellular life"—have no significant association to any of the relevant exposure parameters, such as frequency, exposure duration, or SAR value. Only cell lines showed a statistically significant

higher association with cellular response, as compared to primary cell cultures. The most relevant result in the present study is the negative association between outcomes of cellular responses and the quality of the experimental procedures, specifically to the exposure conditions. The more the quality criteria requirements were satisfied, the smaller the number of cellular responses that were detected, with a dramatic drop in the number of responses at the highest possible quality criteria number (<2% in more than 100 experiments). Our study provides evidence that the accurate control of the exposure and experimental procedures is crucial. Therefore, we suggest the definition of an appropriate Standard Operating Procedure (SOP) for EMF research (at least for the investigation of non-thermal RF-EMF effects) or a rigorous definition of a unified “best practice”, such as the MIAME procedure for gene expression microarray experiments [121]. We think that our analysis provides robust results investigating the association of several RF-EMF experimental conditions to selected biological endpoints. Moreover, the results shows that improving the experimental quality by means of appropriate procedural protocols might allow addressing controversies in EMF research more clearly.

<http://www.ncbi.nlm.nih.gov/pubmed/27420084?dopt=Abstract>

Effects of combined radiofrequency field exposure on amyloid-beta-induced cytotoxicity in HT22 mouse hippocampal neurones

Lee JS, Kim JY, Kim HJ, Kim JC, Lee JS, Kim N, Park MJ. Effects of combined radiofrequency field exposure on amyloid-beta-induced cytotoxicity in HT22 mouse hippocampal neurones. *J Radiat Res.* 2016 Jun 20.

Abstract

Alzheimer's disease (AD) is the most common progressive and irreversible neurodegenerative disease and it is caused by neuronal death in the brain. Recent studies have shown that non-ionizing radiofrequency (RF) radiation has some beneficial cognitive effects in animal models of AD. In this study, we examined the effect of combined RF radiation on amyloid-beta (A β)-induced cytotoxicity in HT22 rat hippocampal neurons. Treatment with A β suppressed HT22 cell proliferation in a concentration-dependent manner. RF exposure did not affect cell proliferation, and also had a marginal effect on A β -induced suppression of growth in HT22 cells. Cell cycle analysis showed that A β decreased the G1 fraction and increased the subG1 fraction, indicating increased apoptosis. Accordingly, A β increased the annexin V/propidium iodide (PI)-positive cell fraction and the degradation of poly (ADP ribose) polymerase and caspase-3 in HT22 cells. However, RF alone and the combination of A β and RF did not affect these events significantly. A β increased reactive oxygen species (ROS) generation, thereby suppressing cell proliferation. This was abrogated by N-acetylcysteine (NAC) treatment, indicating that A β -

induced ROS generation is the main cause of suppression of proliferation. NAC also restored A β -induced annexin V/PI-positive cell populations. However, RF did not have a significant impact on these events. Finally, A β stimulated the ataxia telangiectasia and Rad3-related protein/checkpoint kinase 1 DNA single-strand breakage pathway, and enhanced beta-site amyloid precursor protein expression; RF had no effect on them. Taken together, our results demonstrate that RF exposure did not significantly affect the A β -induced decrease of cell proliferation, increase of ROS production, or induction of cell death in these cells.

<http://www.ncbi.nlm.nih.gov/pubmed/27325640?dopt=Abstract>

Excerpt

There are fierce debates about the effect of RF-EMFs on public health, specifically on the brain. Some studies have shown that long-term use of mobile phones could affect the occurrence of brain tumors [2, 3, 12]. However, other studies indicate that RF-EMF exposure is not related to the incidence of brain tumors and does not have any impact on the biological systems in brain [13-15]. Recently, the impact of RF-EMFs on neurodegenerative disease, especially on AD, has received much attention. RF exposure reduced brain AD deposition by preventing A β aggregation, which had a beneficial effect on cognitive impairment in AD mice [7]. This effect might be explained by the elevation of transthyretin via RF, because transthyretin sequesters A β and prevents the formation of A β plaques in the brain [8]. In addition, Banaceru et al. reported that RF exposure improved the cognitive behavior of 3xTg-AD mice [9]. However, Jiang et al. insist that RF exposure has a negative impact on AD by inducing A β overexpression in rats [11]. In this study, we tried to define the effect of RF-EMFs on A β -induced toxicity in HT22 rat hippocampal neurons. Our data indicate that A β treatment inhibited cell proliferation and induced partial apoptosis by increasing intracellular ROS levels along with partial induction of apoptosis in HT22 cells. However, short-term exposure to RF-EMFs did not have any significant effect on the impact of A β in these cells.

Studies on the impact of long-term exposure to these events are needed to reach a final conclusion.

Passenger Exposure to Magnetic Fields due to the Batteries of an Electric Vehicle

Pablo Moreno-Torres Concha; Pablo Velez; Marcos Lafoz; Jaime R. Arribas. Passenger Exposure to Magnetic Fields due to the Batteries of an Electric Vehicle. IEEE Transactions on Vehicular Technology. 65(6):4564-4571. Jun 2016.

Abstract

In electric vehicles, passengers sit very close to an electric system of significant power. The high currents achieved in these vehicles mean that the passengers could be exposed to significant magnetic fields (MFs). One of the electric devices present in the power train are the batteries. In this paper, a methodology to evaluate the MF created by these batteries is presented. First, the MF generated by a single battery is analyzed using finite-elements simulations. Results are compared with laboratory measurements, which are taken from a real battery, to validate the model. After this, the MF created by a complete battery pack is estimated, and results are discussed.

Conclusion

Passengers inside an EV could be exposed to MFs of considerable strength when compared with conventional vehicles or to other daily exposures (at home, in the office, in the street, etc.). In this paper, the MF created by the batteries of a particular electric car is evaluated from the human health point of view by means of finite-elements simulations, measurements, and a simple analytical approximation, obtaining an upper bound for the estimated MF generated by a given battery pack. These results have been compared with ICNIRP's recommendations concerning exposure limitation to low-frequency MFs, finding that the field generated by this particular battery pack should be below ICNIRP's field reference levels, and conclusions concerning the influence of the switching frequency have been drawn. Finally, some discussion regarding other field sources within the vehicle and different vehicles designs has been presented. Due to the wide variety of both available EVs and battery stacks configurations, it is recommended that each vehicle model should be individually assessed regarding MF exposure.

<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=7297855>

Effects of 3 Hz and 60 Hz Extremely Low Frequency Electromagnetic Fields on Anxiety-Like Behaviors, Memory Retention of Passive Avoidance and Electrophysiological Properties of Male Rats

Rostami A, Shahani M, Zarrindast MR, Semnanian S, Rahmati Roudsari M, Rezaei Tavirani M, Hasanzadeh H. Effects of 3 Hz and 60 Hz Extremely Low Frequency Electromagnetic Fields on Anxiety-Like Behaviors, Memory Retention of Passive Avoidance and Electrophysiological Properties of Male Rats. *J Lasers Med Sci*. 2016 Spring;7(2):120-5. doi: 10.15171/jlms.2016.20.

Abstract

INTRODUCTION: The effects of electromagnetic fields on biological organisms have been a controversial and also interesting debate over the past few decades, despite the wide range of

investigations, many aspects of extremely low frequency electromagnetic fields (ELF/EMFs) effects including mechanism of their interaction with live organisms and also their possible biological applications still remain ambiguous. In the present study, we investigated whether the exposures of ELF/EMF with frequencies of 3 Hz and 60 Hz can affect the memory, anxiety like behaviors, electrophysiological properties and brain's proteome in rats. METHODS: Male rats were exposed to 3 Hz and 60 Hz ELF/EMFs in a protocol consisting of 2 cycles of 2 h/day exposure for 4 days separated with a 2-day interval. Short term memory and anxiety like behaviors were assessed immediately, 1 and 2 weeks after the exposures. Effects of short term exposure were also assessed using electrophysiological approach immediately after 2 hours exposure. RESULTS: Behavioral test revealed that immediately after the end of exposures, locomotor activity of both 3 Hz and 60 Hz exposed groups significantly decreased compared to sham group. This exposure protocol had no effect on anxiety like behavior during the 2 weeks after the treatment and also on short term memory. A significant reduction in firing rate of locus coeruleus (LC) was found after 2 hours of both 3 Hz and 60 Hz exposures. Proteome analysis also revealed global changes in whole brain proteome after treatment. CONCLUSION: Here, some evidence regarding the fact that such exposures can alter locomotor activity and neurons firing rate in male rats were presented.

<http://www.ncbi.nlm.nih.gov/pubmed/27330708?dopt=Abstract>