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This responds to your Freedom of Information Act (FOIA) request dated October 6, 2007, for a copy of "Neuronal Entrainment for Non-Lethal Applications."

The requested document is enclosed.

Fees will be assessed upon completion of the last document processed under your October 6, 2007 request.

Any questions concerning this matter should be directed to Mrs. Bobbie Cave at (703) 432-3934 or bobbie.cave@usmc.mil.

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Neuronal Entrainment for Non-Lethal Applications

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June 29, 1998

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Abstract

Staff of the Oak Ridge National Laboratory (ORNL) propose to undertake a rapid (12 month) and decisive proof-of-principle measurement program designed to determine the potential for high-strength electromagnetic fields to be useful as a stunning agent in non-lethal technologies. All work during the first year will be done with a small animal, mouse or rat, and will be limited to a proof-of-principle experiment.

If this proof-of-principle experiment is successful, follow-on work not included in this proposal will provide more detailed characterization of the parameters of effects, target size scaling parameters, and methods by which these electromagnetic fields may be directed to targets.

Relevance to Program

High strength electromagnetic fields have the theoretical potential to ***incapacitate personnel*** by entrainment of brain neuron firing. At question is whether or not the technology requirements will be prohibitive for reasons of size, energy, collateral damage or concurrent permanent injury to the targeted human. Answers to these questions will only be forthcoming as more is learned about the actual susceptibility of animals to potential modalities of high-strength electromagnetic fields.

It is well known that animals absorb radiofrequency energy, resulting in heating. *The active biophysical mechanism in the proposed work is* ***not heating*** *but rather lowering the firing potential of neurons, or triggering them to discharge.* The proposed concept offers the potential for graded force, or tunability based on the proportion of neurons affected. This proportion, in turn, is thought to be associated with the parameters of exposure. Several potential levels of effect are possible, ranging from the disruption of short-term memory (e.g., what happened during the past 5-10 seconds) to total loss of control of voluntary bodily functions. Work in this initial proposal will be limited to the latter objective.

Background

From the past work of two of the authors (Gailey and Easterly 1994), it is estimated that sufficiently strong internal fields can be generated within the brain to trigger neurons. Estimates are that 50 to 100 kV/m free field of very sharp pulses are required to produce a cell membrane potential of approximately 2 V; this would probably be sufficient to trigger neurons or make them more susceptible to natural triggering.

Recent evidence of this potential for causing neuronal triggering is manifest in the clinical use of externally applied magnetic fields in pain and epilepsy therapy, and in the treatment of depression by stimulation of the brain. The use of externally applied magnetic fields obviates the need for skin electrodes in traditional electrotherapies and thereby reduces the painful effects of electrical currents at the skin-electrode interface.

Technical Approach

Work in this proposal is focused on answering the questions: (1) Can high-strength electromagnetic fields be used to disrupt voluntary motion in animals? (2) What profile does the dose-response curve follow for different modalities of exposure?

Based on preliminary calculations, a generating device will be assembled and tested for the range of anticipated parameters. An exposure chamber will be constructed for mice which will contain a restraint apparatus suitably insulated from the electrodes. The test for effect will be developed around a simple measure such as the ability of the mouse to right itself after exposure, and the time of recovery. More subtle measures will be used for studies involving short-term memory, but this will be after the first year's effort which will be a proof-of-principle for neural disruption.

Technical Risk

There is more likely to be a distribution in recovery times after neuronal entrainment than in susceptibilities to the technology. If the proof-of-principle experiment is successful, it is most likely that all humans will be susceptible to the technology. With regard to recovery, the best model at present, for which we do have information, is from experience with photic-induced epileptic individuals or possibly from experience with the new form of very low current electroconvulsive shock therapy. In individuals who experience these situations, the recovery time is variable, up to hours.

Although there are no experimental data using the proposed technology that might be incorporated into safety considerations, some related clinical observations are available. It is known from numerous clinical observations that, while photic-induced seizures and the newer low current electroconvulsive therapy cause retrograde amnesia (short-term), they do not affect

the cognitive function and the personality structure. This experience supports the notion that those events themselves, and by implication an externally induced loss of voluntary control, such as we are proposing, does not produce any organic or functional damage to the brain.

Deliverables

Deliverables shall be in the form of proof-of-principle data and, if positive, a feasibility assessment including an experimental program designed to provide the basic biological data needed to insure effectiveness as a stun device on humans and for use in disrupting short-term memory, as well as for the design and testing of prototype devices for generation and aiming of the electromagnetic energy. Work in this project will be reported on quarterly with formal written reports, and, presentations, if necessary.

Cost Estimate : 12 Months

Materials:	$ 55K
Labor:	
Direct	$275K
Subcontract	$ 20K
Total:	$350K

Reference

P. C. Gailey and C. E. Easterly, "Cell Membrane Potentials During Exposure to EMP Fields", *Electro- and Magnetobiology* **13(2)** 159-166 (1994).