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Pico-Tesla TMS and Epilepsy

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COLUMN ARTICLE

The pico-Tesla (pT) (1pT=10^{-12} Tesla) external transcranial magnetic stimulation (pT-TMS) electronic device is a modified helmet containing up to 122 coils which are arranged in 5 array groups, so as to cover the 7 brain regions (frontal, vertex, right and left temporal, right and left parietal and occipital) of the subject [1]. It is designed to create pT-TMS range modulations of magnetic flux (intensity: 1-7.5 pT), in the alpha frequency range (8 - 13Hz) of each epilepsy patient. The pT-TMS device [1] was configured for each individual to generate a square wave (so as to resemble the firing activity of neurons in the brain) modulated magnetic field at the individual's mean peak alpha frequency - generated in the subject's occipital lobe (Figure 1).

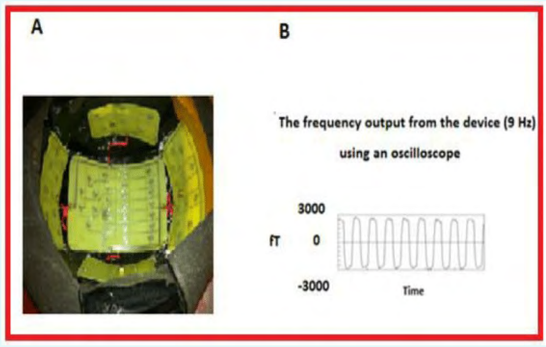

Figure 1: A) The configuration of the stimulation coils within the helmet of the electronic device. B) The frequency output from the electronic device which has calibrated to 9Hz.

In a number of studies, we suggested that pT-TMS to patients has some quantifiable benefit, demonstrated that MEG recordings in patients with seizures disorders showed significant abnormal MEG activity often in the absence of EEG abnormalities [2-7]. Thus, using external weak pT-TMS we were able successfully to attenuate seizure activity in a cohort of over 100 patients with various forms of epilepsy. Specifically, using the electronic device [1] we were able to increase the abnormal (2 - 7Hz) frequencies of the brain activity towards frequencies of less than or equal to those frequencies of the alpha frequency range (8 - 13Hz) of each patient [2-7]. All patients were referred from Neurologists from Greece, England and USA. Biomagnetic measurements were performed using a whole-head 122-channel MEG device (Neuromag-122, Neuromag Ltd. Helsinki, Finland). The research was approved by the Research Committee of the Democritus University of Thrace. Informed consent was obtained from all individual participants included in the study. The subjects were at rest with eyes closed in order to avoid artifacts and to enhance alpha rhythm during the MEG.

A software program was developed in our lab in order to detect the amplitude of the primary dominant frequency of the power spectra of the MEG recordings obtained from each epilepsy patient and channel after the application of Fast Fourier Transform (FFT). Then we were interested in the alpha rhythm of the patient in order to calibrate the electronic device [1] and in the primary dominant frequency of his/her MEG power spectra in the (2 - 7Hz) band. Since epileptic foci emit coherent magnetic activity, we have attempted to influence these foci with the pT-TMS

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electronic device. The coils of the device were constructed to emit back to the brain of the patients magnetic fields with proper field characteristics (magnetic field amplitude: (1 - 7.5pT) and frequency: the alpha-rhythm of each patient 8 - 13Hz). The application of pT-TMS is resulted to decrease the maximal magnetic power from these areas and an attenuation of the seizure activity. Exposure of an organism or biological material to magnetic fields has been reported to induce mutagenic, immunological, metabolic, endocrine, morphological, developmental, behavioral and anticonvulsant effects. On a cellular level, the consequences of magnetic fields on seizure activity may be related to alterations in properties and stability of biological membranes and their transport characteristics including their intra- and extra cellular distributions and flux of calcium ions. The 2nd day's examination with the MEG showed that their spectrum was almost like normal with absent most of the high abnormal frequencies in the 2 - 7Hz frequency band. All epilepsy patients were evaluated clinically and with the MEG the 10th day after the first application of the pT-TMS in our lab. Most of the patients reported a progressive worsening to their pretreatment status. To determine if the responses elicited in our lab were reproducible, it was advised the patients to apply at home and for one month daily pT-TMS treatment nightly (23.00 pm) following the instructions given to their relatives. After one month, the examination by the clinicians it was shown that in average 70% of the all epilepsy patients had MEG records with a reduction in their abnormal power spectrum and their symptoms improved without daily seizures.

In conclusion, this method of the pT-TMS has some possible effects to be considered as a non-invasive safe and efficacious modality in the managing the symptoms of epilepsy patients.

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