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Low-frequency electric field modulation of neural activity in a chronic seizure model

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Low-frequency (<<100Hz content) electrical fields have been demonstrated to modulate neural activity both in slice preparation as well as in acute animal experiments (1). Such modulation is advantageous over pulse stimulation for use in neural prosthetics both because it has an excitatory and inhibitory, graded effect and because with proper instrumentation can be done with minimal recording artifact. Therefore, this mode of interaction is ideal for use with continuous feedback controllers. We present here the first demonstration of electric field modulation in chronically implanted animals.
All work was carried out under IACUC approval. Sprague-Dawley rats (300g) were anesthetized and implanted with iridium-oxide coated stimulation and recording electrodes located in various parts of the hippocampus, along with stainless steel cranial screw electrodes (N=5 rats). Tetanus Toxin (5 ng in 1ul) was injected into the right ventral hippocampus to induce spontaneous seizures, which are observed with a peak rate of ~30/day in weeks 2-4 after implantation. Custom recording hardware was used to provide high fidelity recordings of neural activity with minimal stimulation artifact.
Direct modulation with electric fields was observed in response to periodic low frequency (9-15 Hz) sinusoidal stimulation. Clear entrainment of activity was transiently observed in recordings of hippocampal activity contralateral to the stimulation both at seizure onset and termination. In addition, observations of interaction include seizure occurrence reduction under various stimulation protocols.
These results are a step in the development of an implantable, closed-circuit stimulation controller with the ultimate goal of electronic seizure suppression.
(1) Richardson et al., Epilepsia 44(6):768-777, 2003.
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