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# Bio-inspired Sonar System for Brain Stimulation to Transfer Sensorial Information

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## Extended Abstract

Mammals such as rats and bats decode ultrasound (US) waves up to 120 kHz by converting mechanical waves into bioelectrical signals, called action potentials, which travel through the acoustic pathway in the auditory system and are processed in the brain. In this work, we present a neural stimulation technique based on biomimetic sonar, which is able to generate electrical signals taken from ultrasound (US) waves in the air, transferring sensorial information into the brain. We investigated the possibility of creating an electrical neural signal able to directly stimulate a specific cerebral area in the same way as biological action potential, which bypasses sense organs. The electrical signal used during experimentation was generated by a bio-inspired custom sonar and was used to stimulate rat brain tissue *in vivo*.

Our system consists of two hemi-cylindrical piezo-film (PVDF) transducers, one used as transmitter and the other as receiver of US signals. The transmitter generates US waves at 55 kHz with a voltage of up to several hundred volts and was realized with a power operational amplifier, a step-up transformer, and coaxial cables that prevent environment interference which could disturb the generated signal (Fiorillo et al, 2011).The received echo is then processed by a pre-amplifier, a band-pass active filter and finally a precision rectifier. The unipolar signal emulates the action potential that is generated along the acoustic pathways in the auditory system.

To evaluate the efficacy of the technique, the amygdala was used as stimulation site which is employed to generate electrical kindling in epilepsy research (McIntyre et al, 2008). Five bipolar stainless steel electrodes were implanted into the baso-lateral nucleus of the left amygdala in male Wistar rats for stimulation and five cortical electrodes were positioned for EEG recordings (Russo et al, 2011).The electrical stimuli were characterized by single pulses of 1 ms and a frequency of 20Hz (time duration of 10 minutes over 30 minutes of stimulation). Each pulse was the rectified output with 1V in amplitude and 55 cycles at 55 kHz (Fiorillo et al, 2013).A time delay was present after which the spike-wave discharges were recorded and when stimulation ended the EEG pattern became regular. The neural output was recorded every time electrical stimulation was in act.

We were able to demonstrate that information arising from US waves, processed by our bio-inspired sonar system, influences the neural signal and obtains an EEG response depending on the same signal and the area stimulated. The spike-wave discharges verified that our device is able to generate a modulating signal which can stimulate the amygdala, and the time delay was attributed to the stage necessary for the brain to elaborate the signal and transfer it from the amygdala to the cortex.

Further investigation will be devoted to the transfer of coded information related to the external environment directly into the brain, bypassing sense organs; this will be attempted using converted US electrical signals. This technology can be applied to investigate the treatment of pathologies which involve diseases of deep sense organs.

## References


Fiorillo A.S., Pullano S.A. (2011). Ferroelectric Polymer for Bio-Sonar Replica. In: Ferroelectrics – Applications, MickaëlLallart, editor. Rijeka: Intech, pp. 75-94.

Fiorillo A.S,Pullano S.A,Critello C.D,Citraro R., De Sarro G. , Russo E.(2013). Measurements of rat brain activity originating from ultrasound waves in air. IEEE International Symposium on Medical Measurements and Applications (MeMeA), pp. 233 – 23.

McIntyre D.C., Gilby K.L. (2008). Mapping seizure pathways in the temporal lobe. Epilepsia, vol. 3, pp. 23-30.

Russo E., Citraro R., Scicchitano F., De Fazio S., Perrota I., Di Paola E.D., Constanti A., De Sarro G. (2011) . Effects of early long-term treatment with antiepileptic drugs on development of seizures and depressive-like behavior in a rat genetic absence epilepsy model. Epilepsia, vol. 52, pp. 1341-1350.