UNIVERSITY OF NORTH DAKOTA
BIOMEDICAL ENGINEERING

Enhancing rTMS Therapy with Innovative Coil Design: using Constructive Interference for Deeper Brain Penetration

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Background:

Repetitive Transcranial Magnetic Stimulation (rTMS) is a non-invasive neuromodulation technique that utilizes magnetic pulses to modulate brain activity, offering therapeutic potential for various neurological and psychiatric disorders. Magnetic pulses generated by an electromagnetic coil that is placed near the scalp, pass through the skull, inducing electrical currents in underlying brain tissue. The induced currents can either excite or inhibit neural activity, all depending on the parameters of stimulation, such as pulse frequency, intensity, and duration.

Despite its promise, traditional rTMS coil designs often face challenges in achieving optimal depth of penetration and spatial focality. Constructive interference emerges as a compelling solution to enhance the precision and efficacy of rTMS therapy. By combining magnetic pulses from multiple coils in a synchronized pattern, constructive interference can amplify and focus the magnetic field within targeted brain regions.

Methods:

Our design aims to optimize the applications of rTMS by utilizing a novel configuration of three cylindrical coils arranged in an equilateral triangle for optimized neuromodulation. By strategically positioning the coils, we intend to achieve constructive and deconstructive interference patterns, enhancing precision and efficacy in targeting specific brain regions. Through computational modeling, we aim to demonstrate the effectiveness of our three- coil design in creating constructive interference and its potential for therapeutic applications.

Conclusion:

Our study explores the potential of constructive interference in rTMS applications. Through computational modeling and initial experimental investigation, we have observed promising effects that suggest strategic implementation of constructive and deconstructive interference can enhance the precision of neuromodulation. These preliminary findings suggest that the application of constructive interference represents a promising direction for optimizing rTMS therapies, warranting further exploration and validation in future studies.

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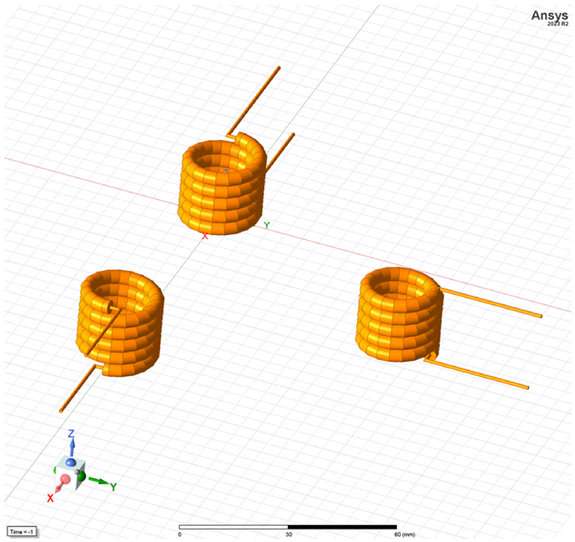
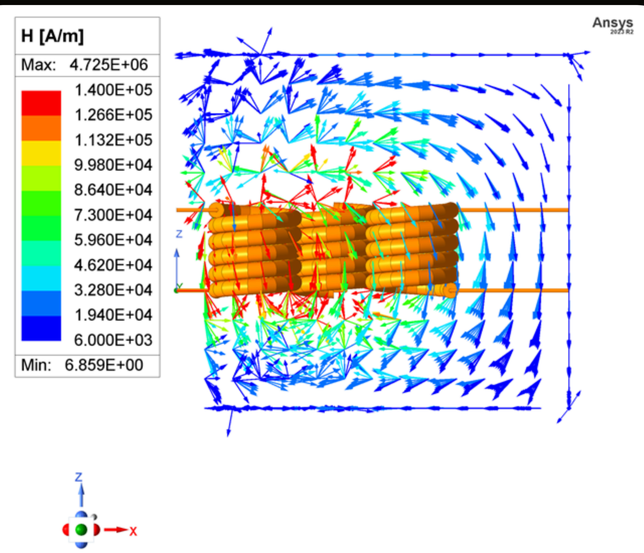
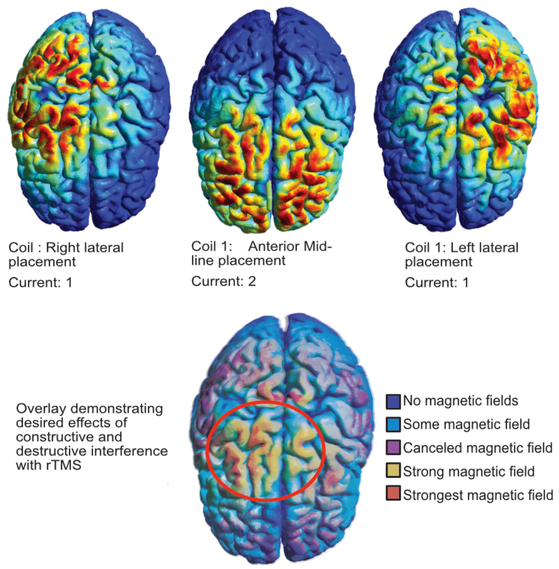
When interference isn't a bad thing



Three coil design placed in an equilateral triangular configuration made in Ansys Maxwell



Visual of constructive interference taking place in the equilateral configuration of our three coils in Ansys Maxwell



Overlay of the three coil placements in SimNIBS to demonstrate our goal of constructive interference

Biot-Savart Law

$$B(r) = \frac{\mu_0}{4\pi}\int_C \frac{Idl \times r'}{|r'|^3}$$

Ampere's Law

$$\int B * dl = \mu_0 I$$

Two of the equations that were used when doing our calculations