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Tuning Ultrasound to Modulate Brain States

Scientists in the De Lecea and Pauly labs optimized ultrasound waveforms that non-invasively modulate brain circuits in freely moving mice. This approach allows targeted control of neural activity and behavior, creating a general framework for precise neuromodulation in a brain region agnostic manner.

Traditional ultrasound protocols vary across studies and often lack reproducibility. Some parameters activate neurons but also trigger nonspecific responses, while others are inconsistent across brain regions. To address this, the researchers used a coordinate descent method to optimize pulse frequency, compression, and intensity in several brain state regulating regions. They discovered that optimal excitatory and inhibitory waveforms are distinct but conserved across cell types, producing clear, site-specific behavioral effects such as locomotion or altered behavior. Importantly, optimized protocols outperformed non-optimized ones, demonstrating that tuning is essential for efficacy.

This work provides a broadly applicable strategy for designing ultrasound neuromodulation protocols. By matching parameters to specific neural targets, ultrasound can drive reproducible and selective changes in brain activity and physiology. The findings open new avenues for programming neural circuits and behaviors with non-invasive therapeutic precision.

Stage of Development

Preclinical

Applications

- Targeted seizure suppression
- Mood regulation

- Neurovascular conditioning

Advantages

- Non-invasive
- Tunable
- Bidirectional control
- Reversible
- Cell and brain region selective
- Clinical Trial Optimization

Publications

- **Murphy K., Farrell J., et al.** (2024). *Optimized ultrasound neuromodulation for noninvasive control of behavior and physiology.* Neuron.

Patents

- Published Application: WO2025090789

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