

Background

- Transcranial ultrasound (TUS) is low intensity megahertz mechanical vibrations delivered to the brain noninvasively.
- In animals, TUS modulates brain electrophysiology and behavior¹, and in humans, sensory discrimination and EEG².
- Mood in pain patients³ and healthy participants⁴ was altered via medical imaging ultrasound (at temporal or prefrontal cortex).

Can TUS affect mood and EEG with a device designed for brain stimulation?

- What are the optimal waveforms for humans?
- Optimal anatomical targets for mood effects?

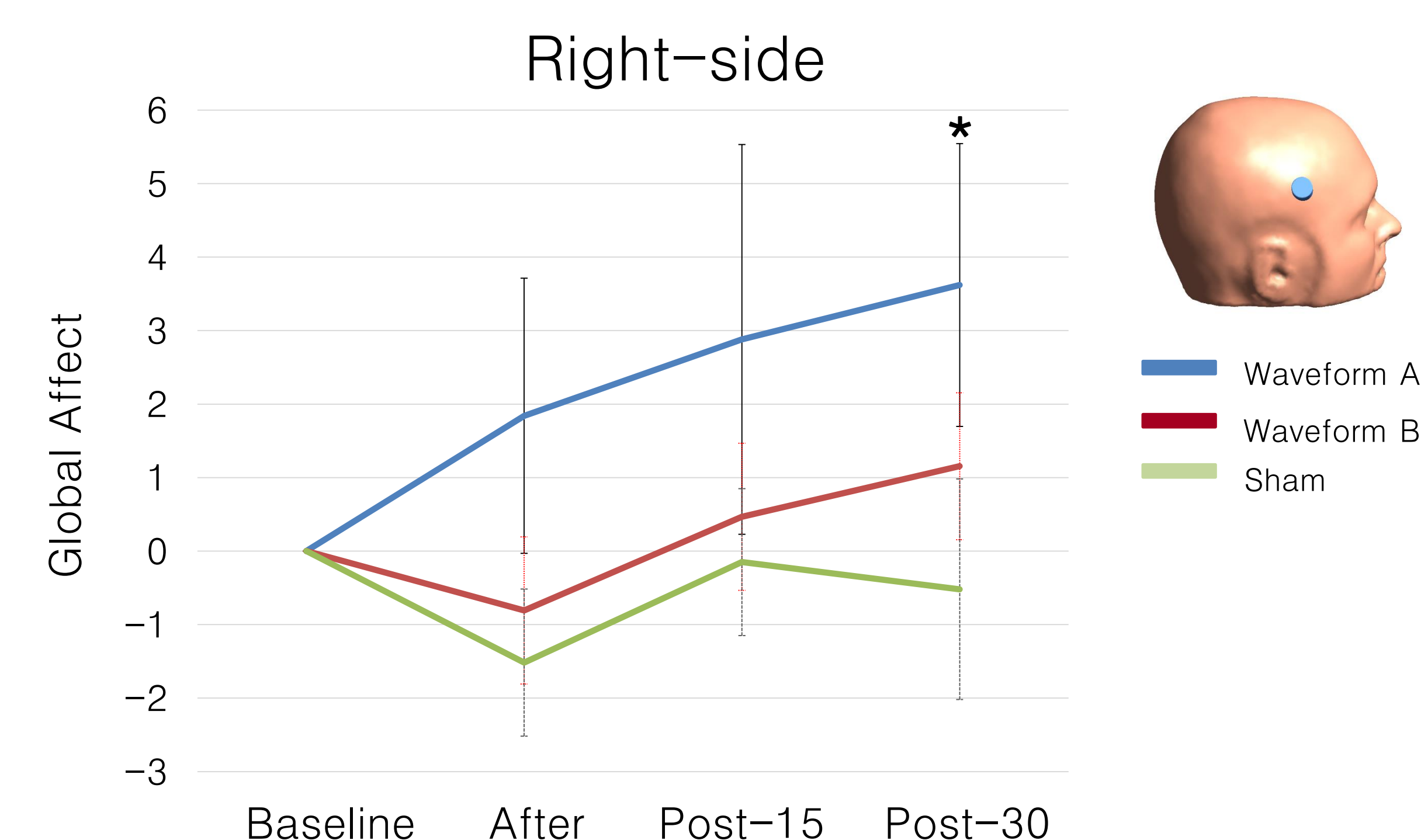
General Methods

- Exp. 1: TUS to right fronto-temporal (FT8) or vertex
- Exp. 2: left fronto-temporal cortex (FT7)
- Exp. 3: 64 channel EEG; TUS to F7 or F8
 - Fronto-temporal areas implicated in mood⁵
- Prototype ultrasound, Thync, LLC
- Waveform A:** 30 secs, 500 kHz; PRF 40 Hz
- Waveform B:** 10 min, 500 kHz, PRF 1000 Hz
- Sham:** Researcher and subject blind
- Physiology: EKG, GSR
- Visual Analogue Mood Scales (VAMS):
 - Global Affect: Increase = greater overall affect
- Data collection: baseline, immediately after, post- 15 & -30 minutes

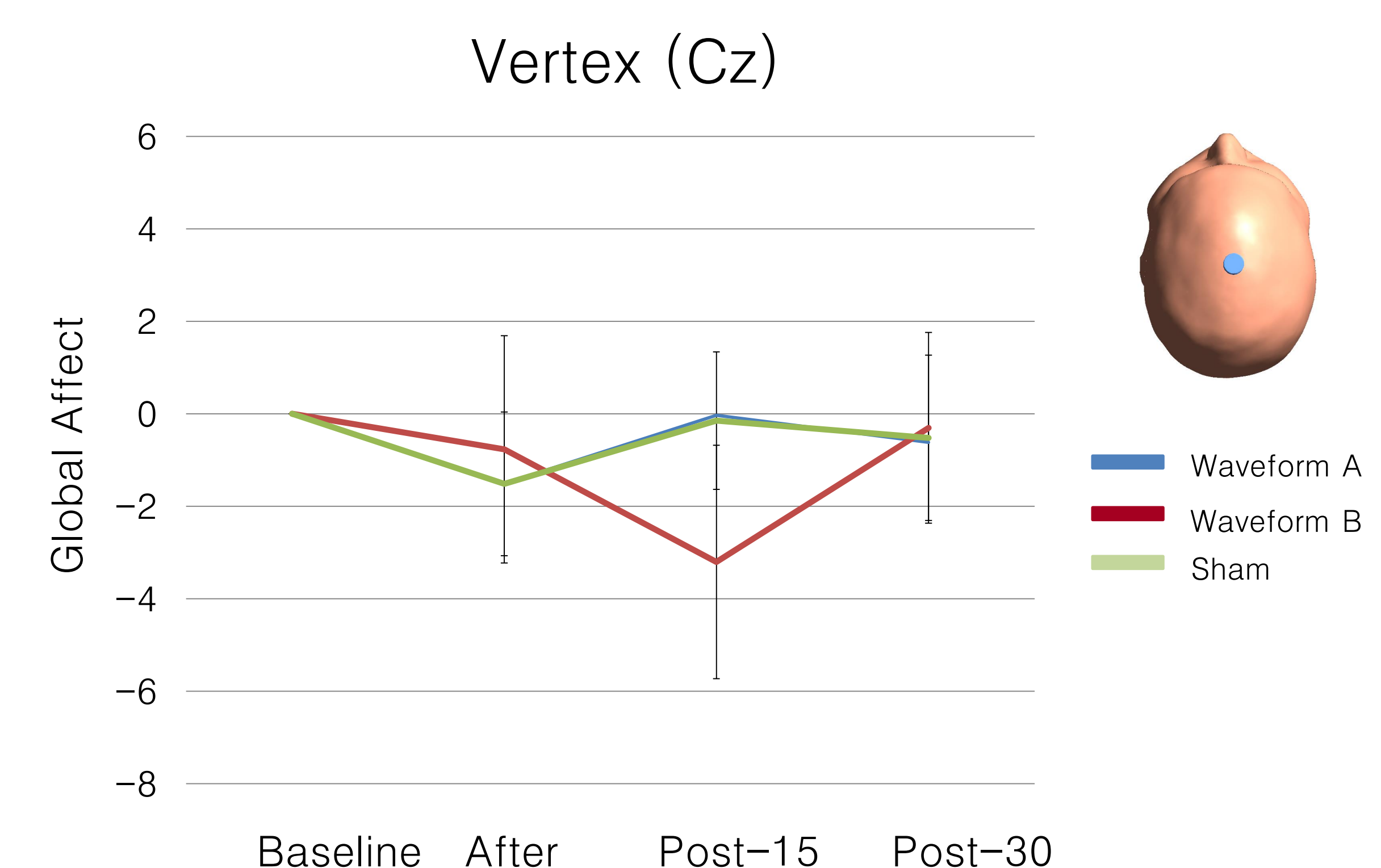


Experiment 1

- Right-side (FT8), Vertex; n = 147
- Waveform A, Waveform B, Sham
- No physio. (EKG, GSR) effects
- Location x Waveform X Time interaction



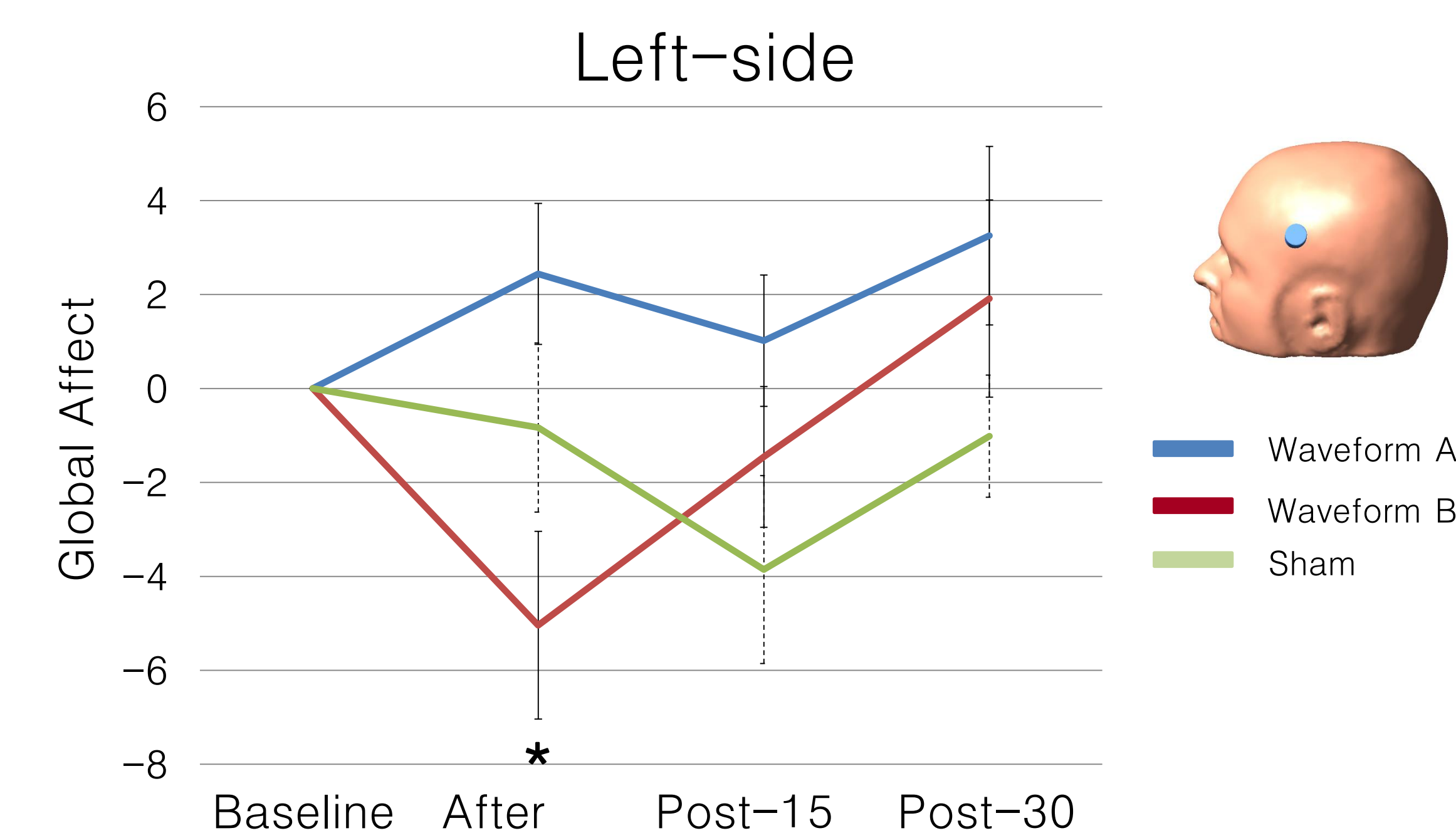
Global affect was increased relative to sham with Waveform A only at right fronto-temporal area.



No changes in global affect with vertex stimulation.

Experiment 2

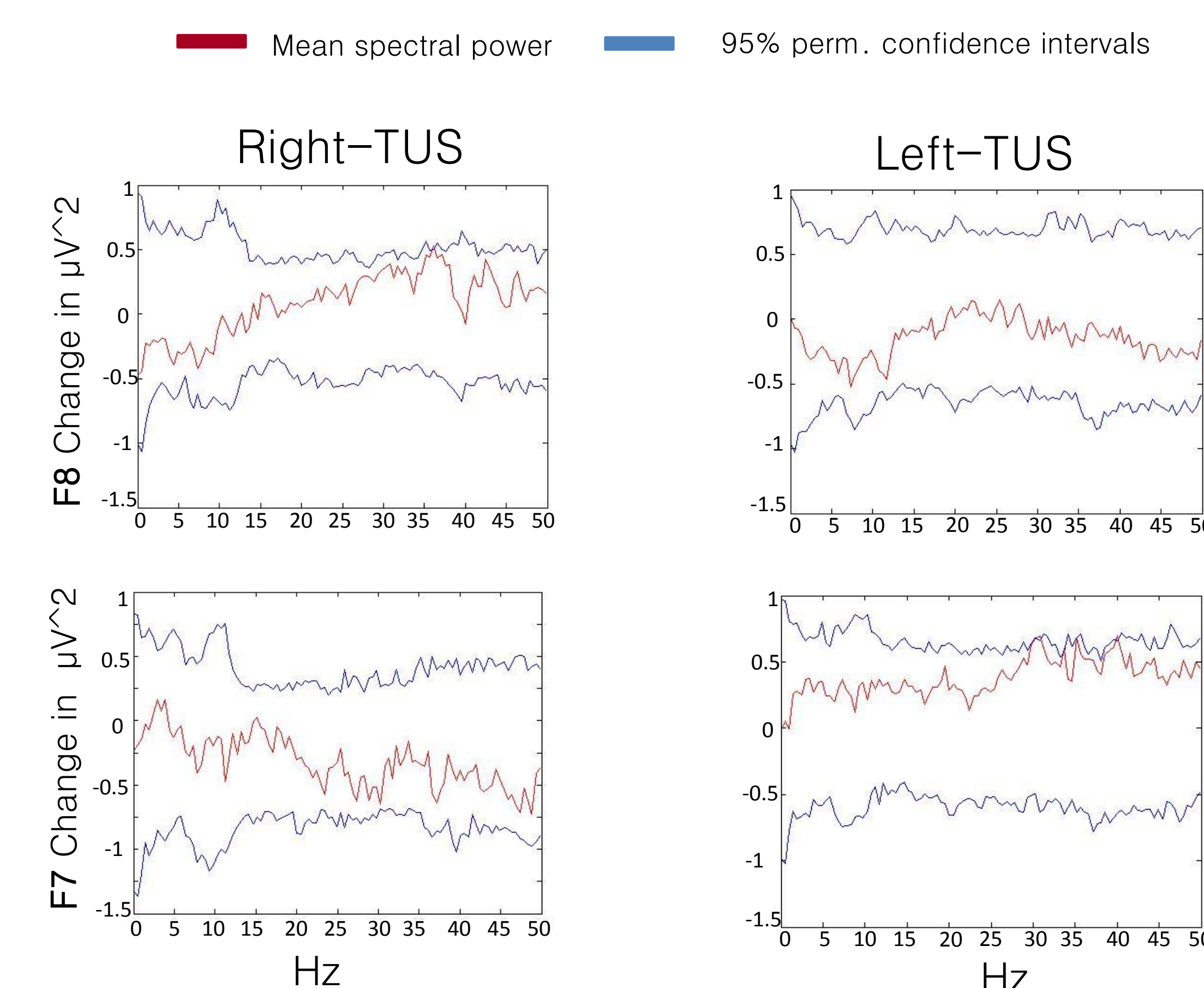
- Left-side (FT7) only; n = 64
- Waveform A, Waveform B, Sham
- No physio. (EKG, GSR) effects



Global affect decreased following stimulation with Waveform A stimulation on the left-side.

Experiment 3 (EEG)

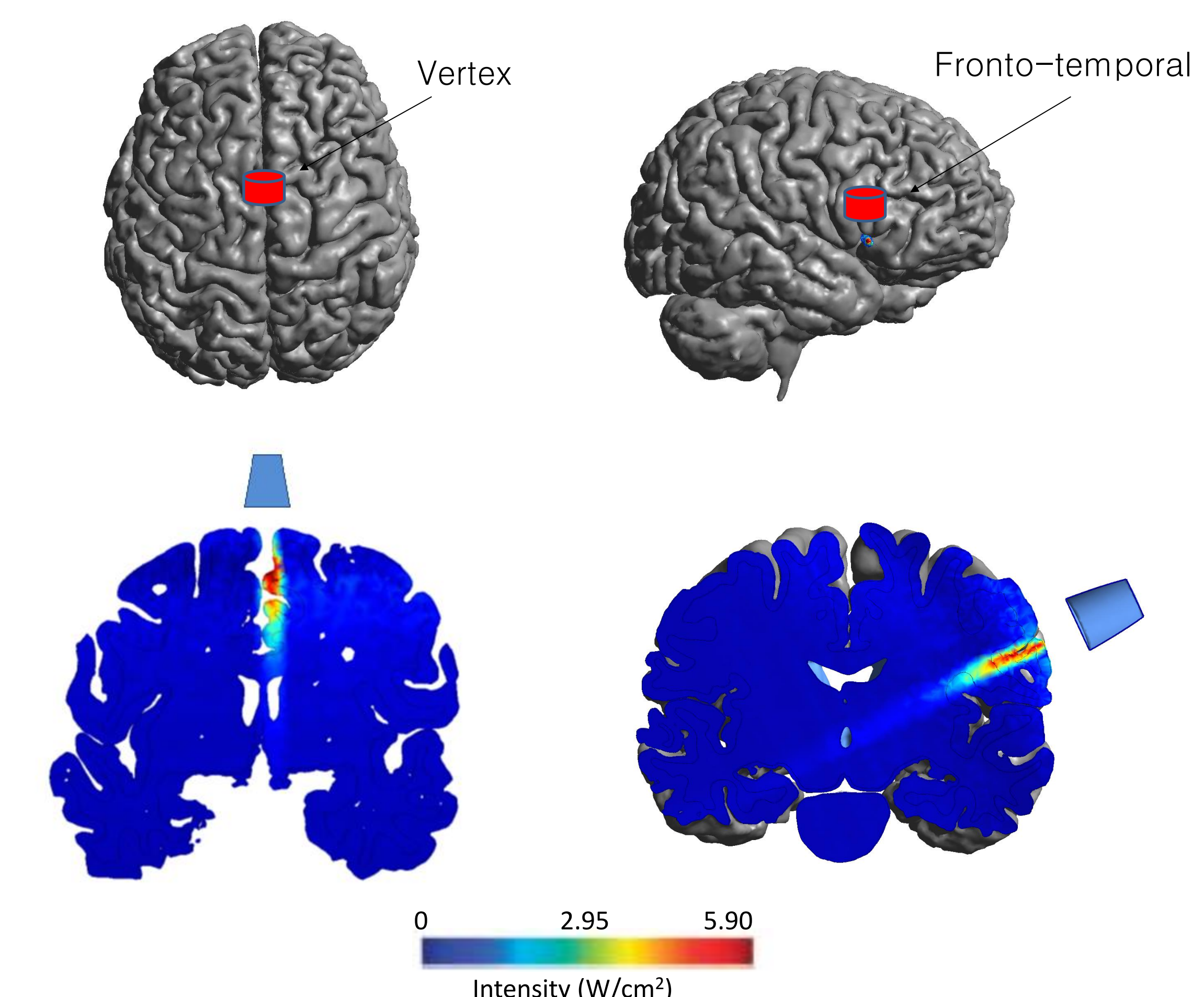
- TUS (Waveform A) at F8 or F7
- Effects Post-30 min – Baseline



High-frequency EEG power increased 30 min after stimulation at the stimulation site (F8 & F7).

Anatomical Targets

- Acoustic intensity field of the TUS beam
- Realistic head models (FEM), whole head MRI



Summary: Brief TUS exposure to fronto-temporal cortex increases global affect scores; TUS increases EEG power at the site of stimulation.

Discussion

- Waveform A superior in humans: Different neuroanatomy relative to animals?
- TUS might have stimulatory or inhibitory effects with Waveform A.
 - TUS at multiple locations, F8³ or FT8 (here), along a network implicated in mood/emotion⁵ increases positive affect.
- Mood and EEG effects strongest ~30 min. after TUS; suggests sustained effects.
- TUS for neurotherapy?
 - Increased positive affect and nonattachment: implications for depression, OCD, anxiety?

References

- Tyler, et al. (2008) *PLOS One*.
- Legon et al., (2014). *Nature Neuroscience*.
- Hameroff et al., (2012). *Brain Stimulation*.
- Sanguinetti et al., (2013). *SPR Poster*.
- Habel et al., (2005). *Neuroimage*.