Individual differences in neuroanatomy predict neurostimulation related multitasking gains in older adults

Kevin Jones, Theodore Zanto, Avery Ostrand, Wan-Yu Hsu, Adam Gazzaley

Neuroscape, University of California, San Francisco

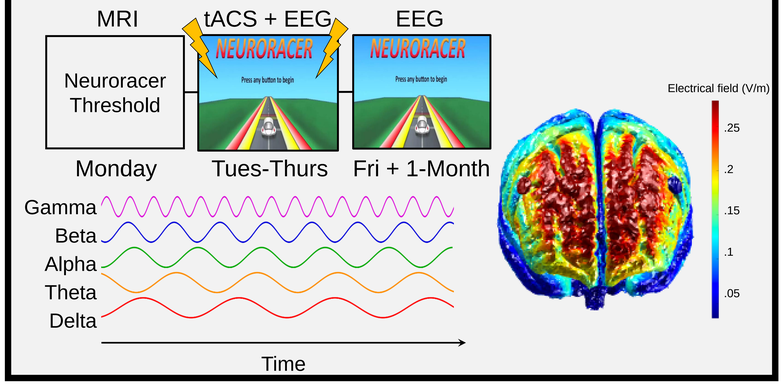
Background

- Longitudinal multitasking training is effective for older adults[1].
  - Gains associated with increased prefrontal cortex (PFC) theta (4-7 Hz) power and phase locking values (PLV).
- Applying theta transcranial alternating current stimulation (tACS) to the PFC improves multitasking in younger adults[2,3].
- Research, rehabilitation, and commercial applications of tACS result in unreliable cognitive outcomes.

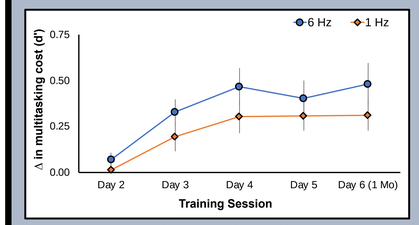
Can we reliably enhance multitasking training gains in older adults with PFC tACS?

Methods

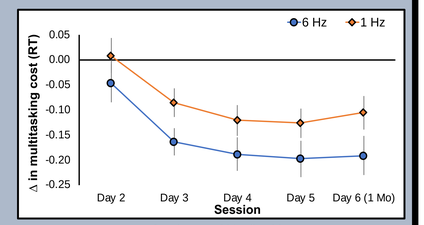
- Healthy older adults (60-80 years old)
- Baseline MRI
- 3 Neuroracer training days
- Online theta (6 Hz) or control frequency tACS (1 Hz)
  - F3 and F4 electrode placement at 1 mA
  - 8 blocks of Neuroracer + tACS
  - 8 blocks of Neuroracer + EEG
  - Follow up session one month after training
- Neuroelectrics 32-channel dual tACS/EEG
- Model tACS induced electrical field on structural scans



Theta tACS improves training gains



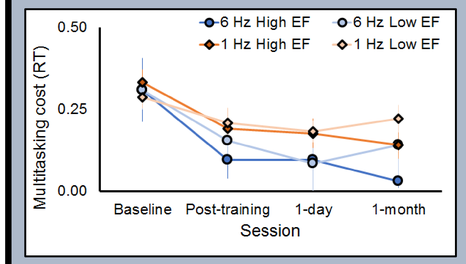
Session $p < .001$, $\eta^2 = .06$
Group $p = .17$

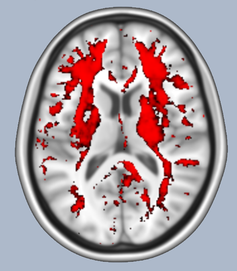


Session $p < .001$, $\eta^2 = .06$
Group $p = .05$, $\eta^2 = .11$

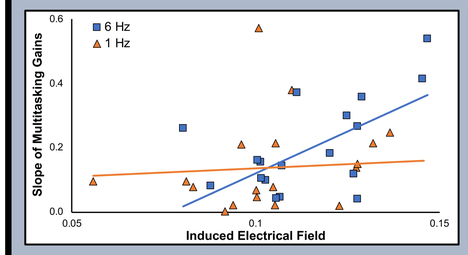
Higher tACS electrical field predicts gains

1. Model T1 and T2 scans using ROAST[4]
2. Fit electrical field (EF) model and scans to MNI space
3. Correlate training gains with EF mag

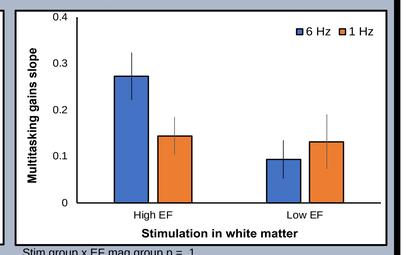




6 Hz: EF Mag correlation with training gains ($p < .02$)
1 Hz: no significant voxels

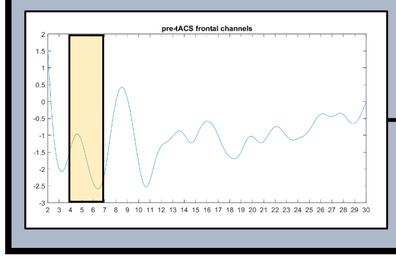


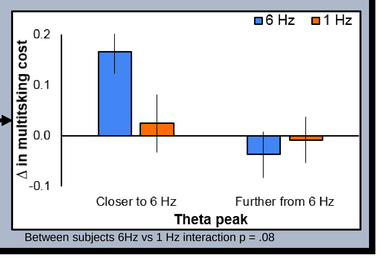
6 Hz: $r = .71$ $p < .001$, 1 Hz: $p = .75$, $r = .08$



Stim group x EF mag group $p = .1$
High v low EF Mag $p = .047$, $\eta^2 = .21$

Individual theta peak predicts tACS efficacy

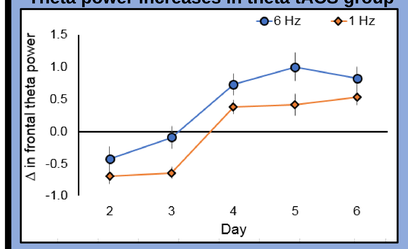




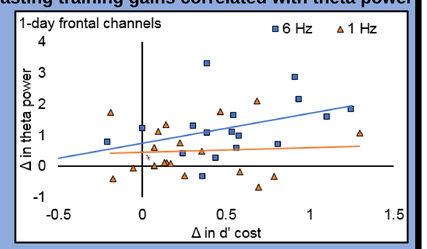
Between subjects 6Hz vs 1 Hz interaction $p = .08$

EEG Metrics

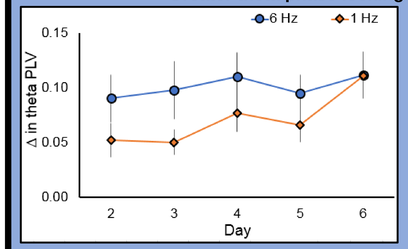
Theta power increases in theta tACS group

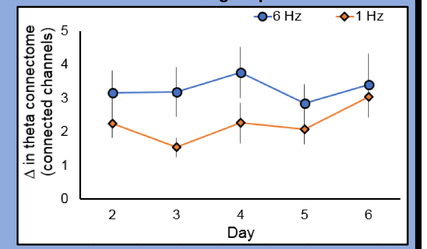


Lasting training gains correlated with theta power

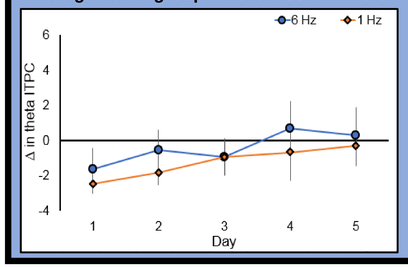


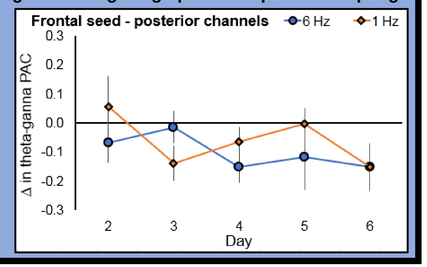
Greater theta phase locking + phase connectome in 6 Hz group





No significant group differences in ITPC or theta-gamma long-range phase-amplitude coupling





Conclusions

- Theta tACS paired with cognitive training improved cognitive control in healthy older adults.
- Increases in theta power correlated with training gains.
- Participants with the greatest tACS-induced EF change had the greatest training gains.
- Matching frequency and dose of stimulation per individual may lead to more reliable cognitive outcomes.

1. Anguera et al, *Nature* (2013) 2. Hsu et al. *Plos One* (2017) 3. Hsu et al. *Brain Stimulation* (2019) 4. Realistic vOlumetric Approach to Simulate Transcranial Electric Stimulation, Huang et al, *IEEE* (2018)

Contact: kevin.jones2@ucsf.edu