Cross-hemispheric Connectivity Benefits Cognition in Normal Aging and MCI

Mariam Hovhannisyan[1,2], Olga Lucia Gamboa Arana[1,3,4], Daisy K Banta[1,2], Courtney A Crowell[2,3], Amanda Szymanski[1,2], Marty G Woldorff[1,3,4], Simon W Davis[1,2,3]
[1]Center for Cognitive Neuroscience, Duke University, Durham, NC, USA; [2]Department of Neurology, Duke University School of Medicine, Durham, NC, USA.
[3]Department of Psychiatry and Behavioral Sciences, Duke University, Durham, NC [4]Department of Psychology and Neuroscience, Duke University, Durham, NC

the electric dinosaur

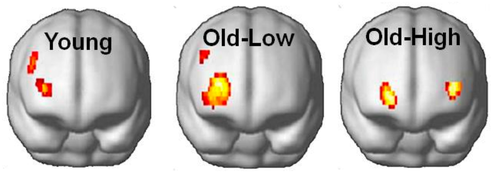
Background

The left and right cerebral hemispheres collaborate to complete complex cognitive tasks and healthy older adults often take advantage of this mechanism to offset the deleterious effects of aging on cognition[1].

Bilateral patterns of fMRI and EEG activity are associated with increases in memory and attention, suggesting a compensatory mechanism[2].

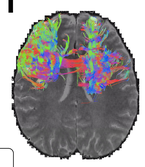
Most of these theories are based on correlational data. Here we use bilateral TMS delivered online to PFC to answer the following questions:

Is it beneficial for the hemispheres to work together? Can we test this causally with TMS? Does bilateral connectivity mediate performance on memory and attention tasks?

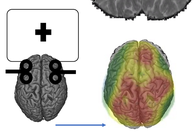


Study Design

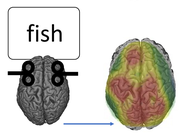
Session 1
DTI Targeting @ Cross-hemispheric sites



Session 2
rTMS @ Target Site during rest



Session 3
rTMS @ Target Site during task

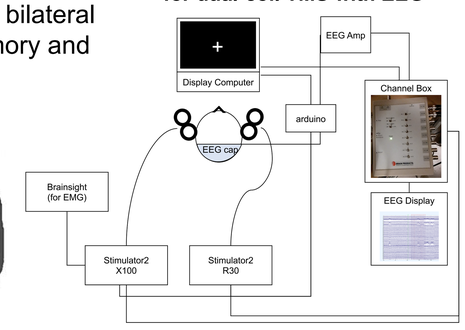


MRI session: 42 participants had structural scans, including high-resolution DTI. Ss complete NIH toolbox/MoCA/NACC outside of the scanner.

TMS + EEG (non-task): Of those 42 participants, 13 of them underwent TMS-EEG procedures.

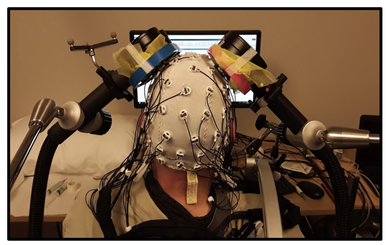
TMS + EEG (task): 13 participants underwent the same TMS-EEG procedures while they performed domain judgement encoding task followed by a memory task.

Wiring Diagram for dual-coil TMS with EEG




coil spacer for EEG

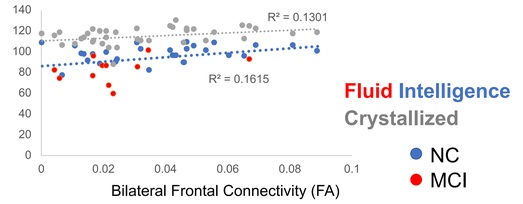

sham extension



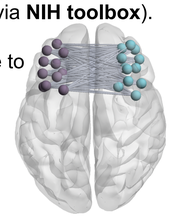
Does bilateral connectivity mediate memory performance?

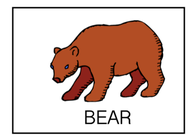
Structural connectivity

Bilateral connectivity in frontal regions predicts performance selective to fluid (but not crystallized) intelligence scores. These effects are largely driven by relationships working memory tasks and not any other task (via **NIH toolbox**).

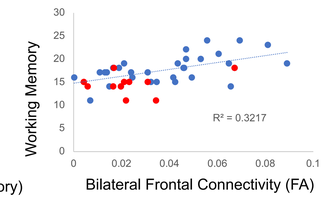


Effects are selective to Bilateral **Frontal** Connectivity.

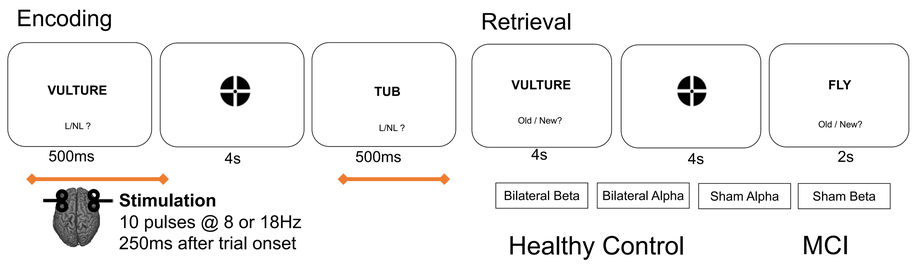




Size Sorting Task
(A measure of Working Memory)

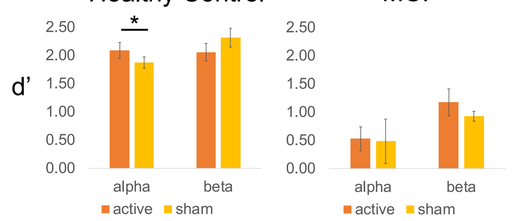


TMS-induced effects on behavior & neurophysiology

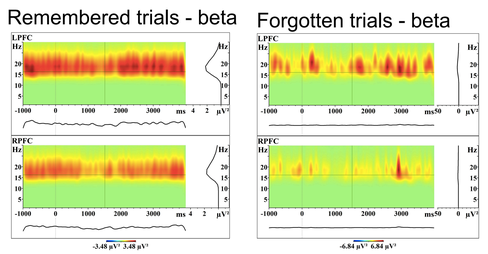


In our sample of healthy older adults (n=14) and MCI (n=4), memory varied by TMS condition.

Memory accuracy (d') appeared to show a selective benefit for bilateral **alpha** TMS in HCs (t = 2.11, p = 0.051), and bilateral **beta** TMS in MCIs.



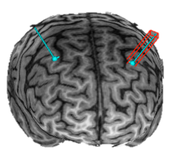
Neurally, time-frequency analyses from EEG in HCs of remembered and forgotten trials reveals strong subsequent memory difference selective to the beta band.



Can we find reliable neurophysiology from bilateral TMS?

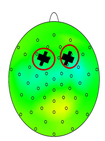
Non-task Conditions		
Bilateral beta	Bilateral alpha	Sham bilateral alpha
Unilateral beta	Unilateral alpha	Sham unilateral alpha

Task Conditions x2		
Bilateral beta	Bilateral alpha	Sham bilateral alpha

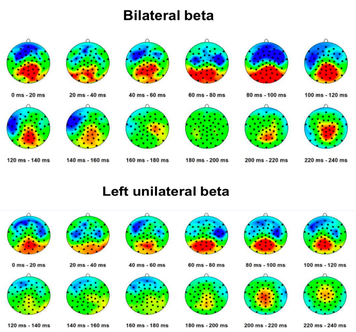


We used neuronavigation via Brainsight to locate the middle frontal gyrus of individual MRIs.

Two stimulation frequencies:
Beta = 18 hz
Alpha = 8 hz



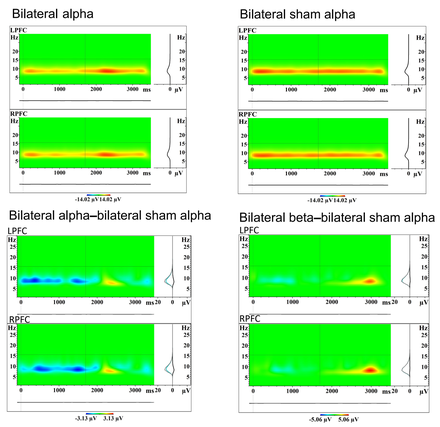
Event-related Potentials



Topographic maps showing a clear difference between bilateral and unilateral conditions in the stimulated region when driven at beta.

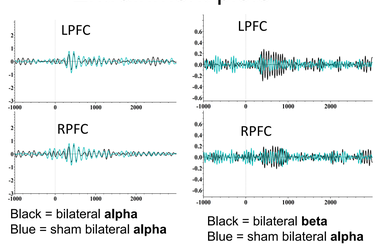
Topographic maps showing a clear difference between bilateral and sham condition in the stimulated region when driven at alpha.

Time-frequency plots



Time frequency plots show differences between real and sham conditions in frequency bands of interest, but no effect of TMS entrainment.

Entrainment plots



Summary

Our study, thus far, helps to confirm the hypothesis that bilateral connectivity patterns mediate attention and memory tasks, and clarify the interdependence between these forms of cognition in older adults.

References

[1] Cabeza, R. 2002. Hemispheric asymmetry reduction in old adults: The HAROLD Model. *Psychol. Aging* 17: 85–100.
[2] Davis SW, Murphy DM, Luber BL, Lisanby SH, Cabeza R. Frequency-specific neuromodulation of local and distant connectivity in aging and episodic memory function. *Human Brain Mapping*. 00:00–00

Funded by NIA grant K01-AG053539