Examining the relationship between individual differences in Paired Associative Magnetic Stimulation and Inter-hemispheric Propagation Time.

Yarden Viktor Dejorno, Uri Alyagon, Avraham Zangen.

Introduction:

- Cortico-cortical Paired Associative Magnetic Stimulation (PAS) is a bi-focal, noninvasive, paired magnetic stimulation based on the Hebbian principle
- By Hebbian principle - successive stimulation of two cortical areas using a specific Inter-Pulse-Interval (IPI) influences the connectivity between them[1,2].
- PAS directed to the frontal areas of the hemispheres, using an IPI of 8-ms influences inter-hemispheric connectivity and activity power depicted using EEG[3].
- There is importance of precise spike timing as well as synaptic strength for activity- induced modification of central synapses[4].

Research objective:

To explore the relationship between individual differences in inter-hemispheric propagation time to PAS efficiency.

Procedure:

- Twenty-four healthy participants underwent 9 weekly PAS sessions using different IPI durations (4,8,16,32-ms or sham) and directions (L-R, R-L).
- Resting-state EEG have been measured before and after PAS.
- Inter-hemispheric propagation time between the frontal stimulation sites (electrodes F3 and F4) was estimated using the pre-stimulation phase-delay time (13-16 Hz) between the two areas[5,6,7], averaged across sessions.
- PAS-induced alternations were calculated as the change (post- pre) in the alpha band (8-15 Hz) activity in power of those two sites[3].
- The optimal IPI have been defined individually for each subject as the one inducing the maximal effect in PAS induced change at LR-RL contrast.

Results:

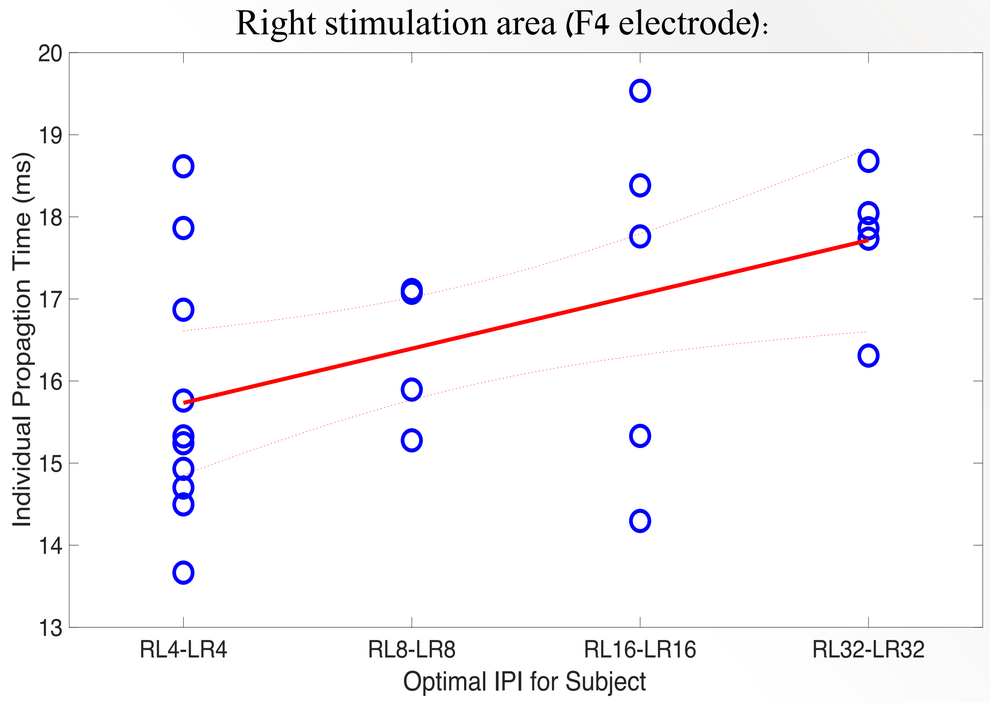


Figure: Association between inter hemispheric propagation time and optimal IPI. Scatter plots of linear correlation between propagation time and optimal IPI in the right (upper panel, electrode F4) and left (upper panel, electrode F3) stimulation areas.

- Significant positive correlation was observed under the right stimulation area (r= 0.4914, p= 0.0147).
- No correlation was observed under the left stimulation area (r= 0.0147, p= 0.8516).

Discussion :

- The findings suggest that individual differences in inter-hemispheric propagation time influence the efficiency of PAS; Longer propagation time require longer IPI to produce optimal effect.
- Further randomized controlled trial is needed to conclude if individual adjustment of IPI may improve PAS effectivity.

References:

1. Song, S., Miller, K. D., & Abbott, L. F. (2000). Competitive Hebbian learning through spike-timing dependent synaptic plasticity. Nature Neuroscience, 3(9), 919-926.
2. Müller-Dahlhaus, F., Ziemann, U. & Classen, J. Plasticity Resembling Spike- TimingDependent Synaptic Plasticity: The Evidence in Human Cortex. Front. Synaptic Neurosci. 2, (2010).
3. Zibman, S., Daniel, E., Alyagon, U., Etkin, A., & Zangen, A. (2019). Interhemispheric corticocortical paired associative stimulation of the prefrontal cortex jointly modulates frontal asymmetry and emotional reactivity. Brain Stimulation, 12(1), 139-147.
4. Bi, G. Q., & Poo, M. M. (1998). Synaptic modifications in cultured hippocampal neurons: dependence on spike timing, synaptic strength, and postsynaptic cell type. Journal of neuroscience.
5. Boeijinga, P. H., & da Silva, F. L. (1989). A new method to estimate time delays between EEG signals applied to beta activity of the olfactory cortical areas. Electroencephalography and clinical neurophysiology, 73(3), 198-205.
6. Thatcher, R. W., North, D. M., & Biver, C. J. (2008). Development of cortical connections as measured by EEG coherence and phase delays. Human brain mapping, 29(12), 1400-1415.
7. Sato, S., K. Nishio, and Yoichi Ando. "Propagation of alpha waves corresponding to subjective preference from the right hemisphere to the left with changes in the IACC of a sound field." Journal of Temporal Design in Architecture and the Environment 3.1 (2003): 60.