Induction and Quantification of Plasticity in Human Cortical Networks

Yuhao (Danny) Huang BS; Corey J. Keller MS; Christopher Honey MD, PhD; Maria Fini; Victor Du MD; Fred A Lado; Ashesh Mehta MD, PhD

Department of Neurosurgery and Neurology, Hofstra Northwell School of Medicine, and Feinstein Institute for Medical Research, Manhasset, NY

CNS 2017 ANNUAL MEETING BOSTON, MASSACHUSETTS OCTOBER 7–11, 2017

Introduction

Functional neurosurgery is increasingly used to treat neuropsychiatric disorders. However, the fundamental principles underlying how, when and where plasticity is induced after electrical stimulation in the human brain are largely unknown.

Methods

Direct intracranial electrical stimulation of 10Hz and 1Hz were applied to 4 human subjects undergoing intracranial monitoring. Brain excitability measurements were quantified using the pre/post stimulation cortico-cortical evoked potential (CCEP), which provide direct measurements of oligosynaptic connections in the human brain.

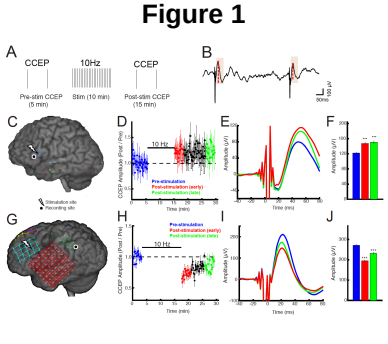
Results

In each subject, 10Hz repetitive stimulation elicited CCEP changes that outlasted the stimulation protocol in a small proportion of regions probed. Findings were primarily evident within 50ms of the CCEP response. 1Hz and 10Hz stimulation protocols demonstrated opposing plasticity effects. For each patient, regions showing plasticity were anatomically closer to the stimulation site and functionally elicited higher amplitude and shorter latency CCEPs compared to non-modulated regions.

Results (Continued)

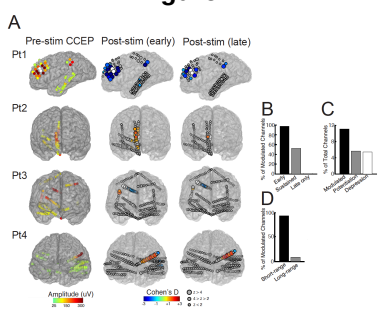
Classifier built using pre-stimulation amplitude, latency or distance correctly identified region of modulation with >80% accuracy. Finally, we demonstrate the induction phase, captured from intratrain-recordings, partially reflect plasticity effects observed in pre/post CCEPs.

Figure 1



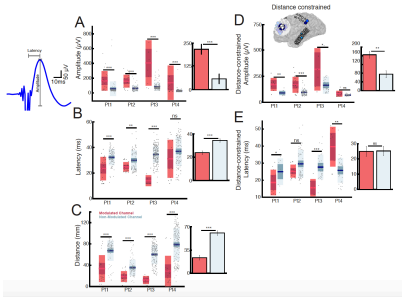
Repetitive stimulation elicited changes in the cortico-cortical evoked potentials (CCEPs) that outlasted the stimulation by at least five minutes.

Figure 2



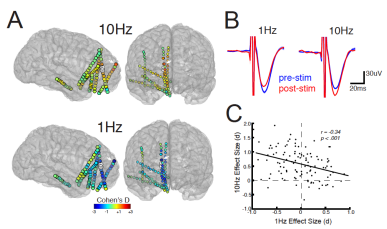
Repetitive stimulation elicited changes in the cortico-cortical evoked potentials (CCEPs) that outlasted the stimulation by at least five minutes.

Figure 3



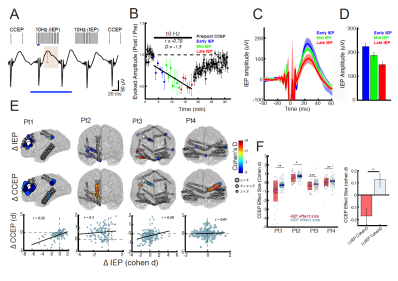
Repetitive stimulation elicited changes in the cortico-cortical evoked potentials (CCEPs) that outlasted the stimulation by at least five minutes.

Figure 4



The direction of plasticity differed for 1Hz and 10Hz repetitive stimulation

Figure 5



Intra-stimulation evoked potential (IEP) dynamics partially reflect plasticity observed following stimulation.

Conclusions

Repetitive stimulation induces predictable changes that outlast stimulation in regions anatomically and functionally connected to the stimulation target. These plasticity effects are partially captured by excitability changes that occur during the stimulation period. This work provides avenues for optimization of stimulation site and the development of novel closed-loop brain stimulation strategies.

Learning Objectives

1)Describe the characteristics of cortical response following focal repetitive electrical stimulation

2)Identify the anatomical and functional predictors for plasticity change following electrical stimulation

References

1) Keller CJ, Honey CJ, Entz L, Bickel S, Groppe DM, Toth E, Ulbert I, Lado FA, Mehta AD (2014) Corticocortical evoked potentials reveal projectors and integrators in human brain networks. J Neurosci 34:9152-9163.