

Neural Prosthesis Seminar

Direct Brain Interfaces for Memory Restoration

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DeGrace Hall, Room 312
Case Western Reserve University



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Abstract

Human episodic memory encoding fluctuates in its efficiency from moment to moment, leading to variability in the ability to store information for later retrieval. Oscillatory brain activity both during and prior to an event predicts later memory, suggesting that direct manipulation of brain activity through stimulation can be used to modulate memory function. We tested this hypothesis in two different studies involving direct brain recording and stimulation in patients with epilepsy undergoing intracranial monitoring with implanted electrodes.

In the first study, open-loop direct brain stimulation was successfully used to modulate human memory encoding in 36 patients (Ezzyat et al. 2017). Interestingly, the effect of stimulation depended on the state of the brain immediately prior to stimulation delivery. Stimulation applied during poor encoding states significantly increased memory performance, while stimulation applied during good encoding states significantly impaired memory. These results suggested that stimulation might consistently increase memory performance if timed to coincide with poor memory states, which we tested in a subsequent study.

In the second study, closed-loop neurostimulation was delivered to 25 subjects, with stimulation timed to arrive only during poor encoding states (Ezzyat et al. 2018). We used a subject-specific multivariate classifier trained on previous record-only electroencephalographic data to decode the probability of memory success for each item and triggered stimulation if the classifier indicated that later recall was unlikely. Stimulation significantly increased memory performance relative to a matched non-stimulated control condition when applied to lateral temporal cortex, while it significantly impaired performance when applied to other areas of the brain including medial temporal lobe.

These data indicate that closed-loop neurostimulation applied to superficial cortical areas can be used to enhance memory performance. Based on these results, Nia Therapeutics is developing active implantable devices to treat memory dysfunction in patients with traumatic brain injury.

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