Recurrent Neural Networks Improve Classification of Episodic Memory Encoding

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Learning Objectives

By the conclusion of this session, participants should be able to:

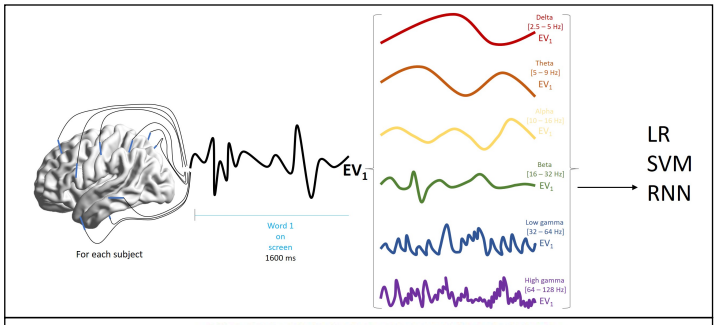
1. note the improvement in classification accuracy deep learning affords closed-loop stimulation devices
2. understand the use of recurent factor elimination in the design of closed-loop stimlation devices and in predicting memory loss following epilepsy surgery

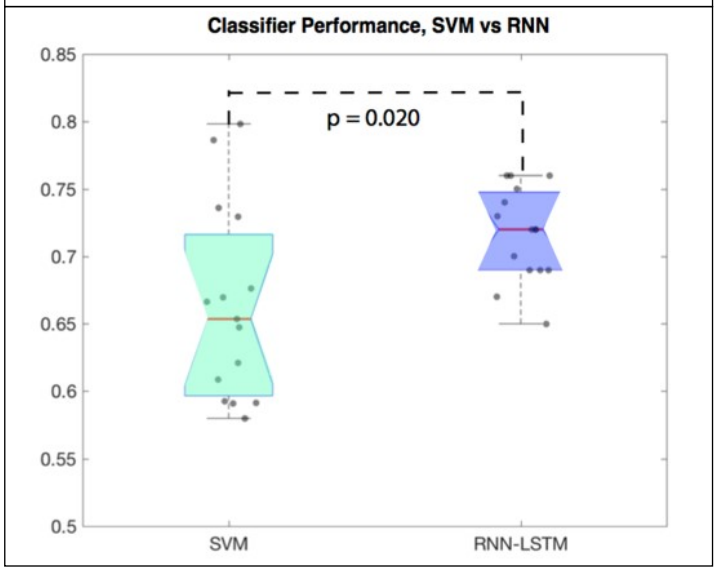
Introduction

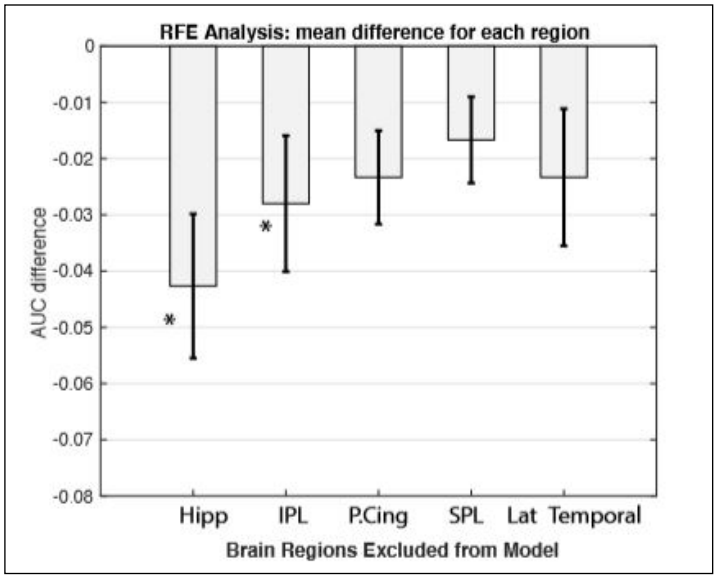
Closed-loop brain stimulation devices have demonstrated promise in improving episodic memory. However, such devices rely on accurate classification of real-time electrophysiological correlates of memory-related brain activity as either conducive or non-conducive to successful episodic encoding. We compared the classification accuracy of a recurrent neural networks (RNNs) paradigm to that of our group's previously reported highest performing machine learning classifier-support-vector machines (SVM) with t-distributed stochastic neighbor embedding (tSNE). Also, by withholding information recorded from various brain regions from the SVM/tSNE classifier, we predicted the impact of tissue resection during epilepsy surgery on episodic memory performance following the operation.

Methods

Fifteen patients with medically refractory epilepsy were implanted with intracranial electrodes. All had contacts in the dominant hemisphere of five common brain regions-the hippocampus, precuneus, posterior cingular gyrus, lateral temporal cortex, and posterior lateral temporal cortex. While implanted, patients participated in an episodic memory task (free recall). EEG







Results

RNNs significantly outperformed the SVM/tSNE model as demonstrated by their respective area under the receiver operating characteristic curve values (RNNs = 0.72, SVM/tSNE = 0.68, p=0.0026). When oscillatory information from each of the five regions was withheld from the SVM/tSNE classifier in turn, hippocampal information loss resulted in the greatest decline in classification accuracy (corrected p=0.02).

Conclusions

Improving the classification accuracy of closed-loop stimulation devices through use of RNNs has the potential to boost the memory improvements seen with their use. Also, harnessing machine learning to quantify the relative importance of each region to classifier performance provides a novel way of predicting memory loss after tissue resection in epilepsy surgery.

References

Xia M, Wang J, He Y (2013) BrainNet Viewer: A Network Visualization Tool for Human Brain Connectomics. PLoS ONE 8: e68910.