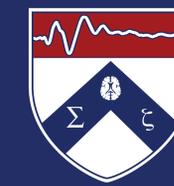


Decoding and Optimizing Episodic Memory

Joseph H. Rudoler, James P. Bruska, Nicholas B. Diamond, David J. Halpern, Matthew Dougherty, Brandon Katerman, Woohyeuk Chang, and Michael J. Kahana
University of Pennsylvania, Department of Psychology, Philadelphia, PA 19104



Computational Memory Lab
UNIVERSITY of PENNSYLVANIA



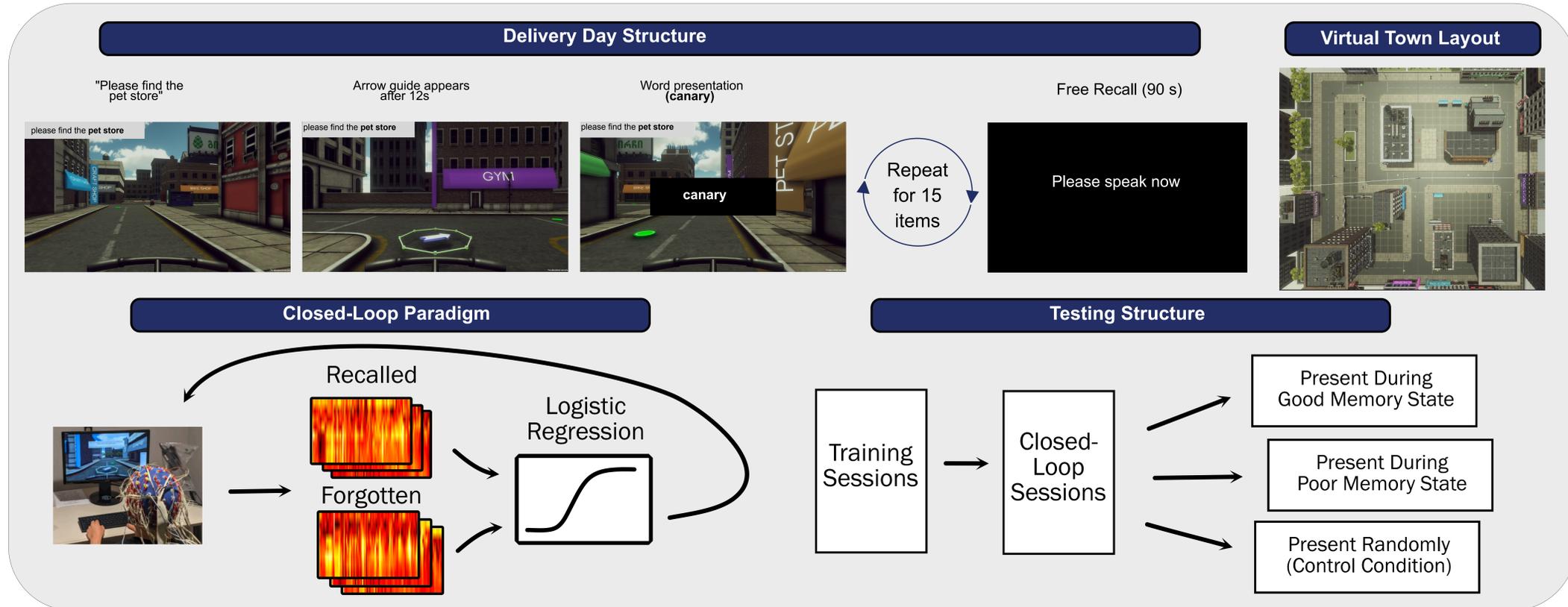
How can we leverage EEG to enhance memory performance?

Scalp EEG can be used to classify memory success from neural activity (Li et al., 2022; Weidemann et al., 2021)

Closed-loop stimulation: there is evidence that real-time classification of brain state is an effective tool for timing memory-enhancing electrical stimulation for epilepsy and TBI patients (Ezzyat et al., 2018)

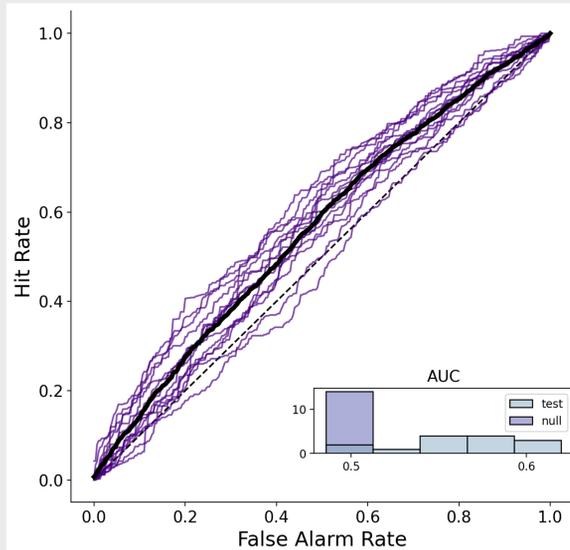
Timing with respect to certain neural features influences memory encoding (Fell et al., 2011; Burke et al., 2015)

We seek to improve the memory of healthy participants with a non-invasive, closed-loop procedure: Optimizing timing so participants learn when they are in good memory states

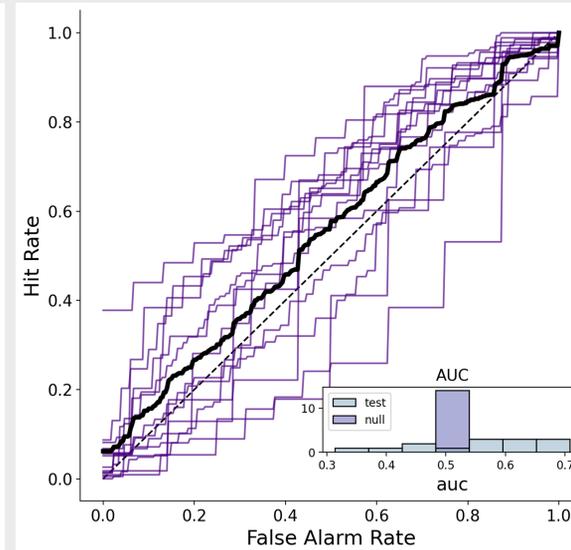


Classifying memory success in a naturalistic task

Training Sessions (cross-validated)

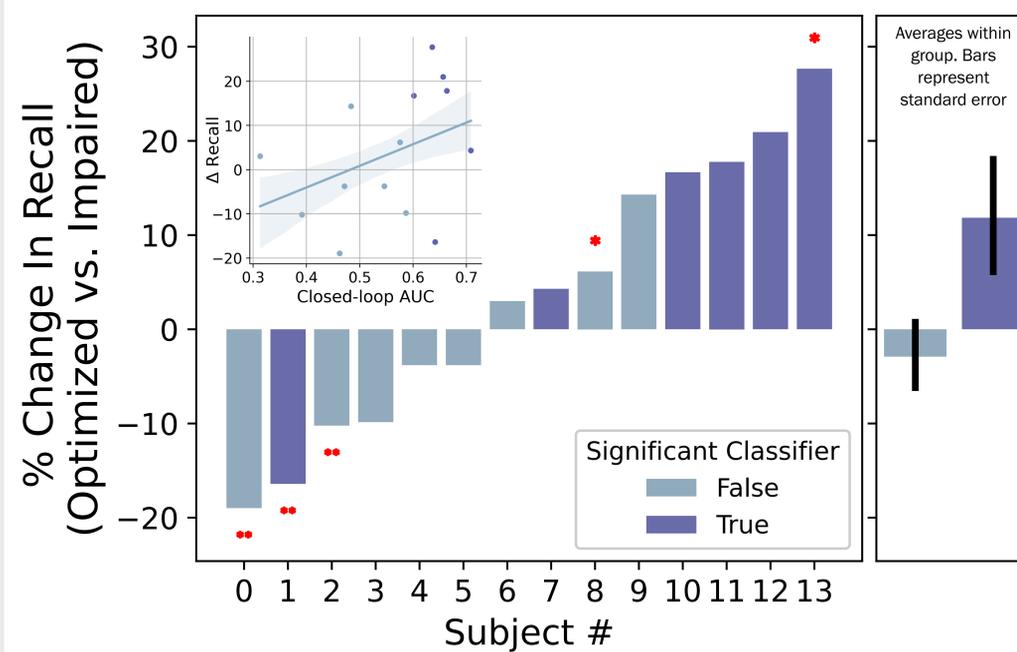


Closed-Loop Sessions (control lists)



Significance of classifier generalization from training to closed-loop determined by permuting labels to generate a null distribution of AUC's. Type II error rate fixed at 5%. 6/14 subjects had classifiers that scored above chance.

Does optimizing timing improve memory performance?



One-sample t-test comparing observed differences to a null of zero was not significant for either group (for good classifiers: $T(6)=1.83, p=0.12$; for poor classifiers: $T(8)=0.78, p=0.46$).

Memory improvement significance computed using Fisher's exact test within subject.

There is a weak correlation between classification and memory improvement ($R = 0.38, p=0.17$)

Conclusions

- Classifiers can distinguish between good and bad memory encoding states
- Classifier output can be used to modify task behavior in real time based on neural features from scalp EEG
- Optimizing task timing based on brain state yields mixed results, with some subjects showing memory improvements
- Optimization may be dependent on classification success

Note: data collection is still ongoing

References

Li, Y., Pazdera, J.K., Kahana, M.J. (2022). "EEG Decoders Track Memory Dynamics." *In Review*.
Weidemann, C.T. and Kahana, M.J. (2021). "Neural Measures of Subsequent Memory Reflect Endogenous Variability in Cognitive Function." *JEP:LMC*. 47(4), 641-651.
Ezzyat, Y. et al. (2018). "Closed-loop stimulation of temporal cortex rescues functional networks and improves memory." *Nature Communications*, 9(1), 365.
Fell, J. et al. (2011). "Medial Temporal Theta/Alpha Power Enhancement Precedes Successful Memory Encoding: Evidence Based on Intracranial EEG." *Journal of Neuroscience*. 31(14), 5392-5397
Burke, J. F., Merkow, M., Jacobs, J., Kahana, M. J., and Zaghoul, K. (2015). Brain computer interface to enhance episodic memory in human participants. *Frontiers in Human Neuroscience*, 8, 1055.