EVALUATING THE SUBSEQUENT MEMORY EFFECT AS PREDICTIVE OF MEMORY

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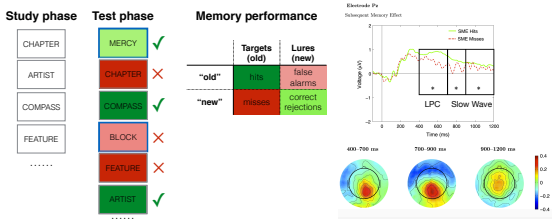
The Subsequent Memory Effect

- Difference in brain activity during the *study* phase that relates to subsequent memory success during the *test* phase[1].



Chen et al. (2014)

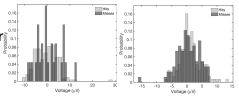
- Often described as identifying brain activity that is *predictive* of memory success[2].
- But memory is influenced by many factors outside of study as well[3].

Predictive Subsequent Memory Effect

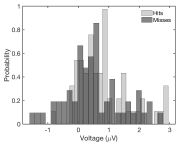
- Difference in the average signal for hits and misses does not test for actual prediction.

How to predict memory for individual trials?

LPC amplitudes: individual trials for two random participants.



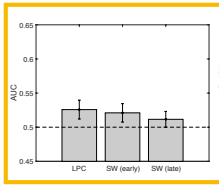
Mean LPC amplitudes across all participants.

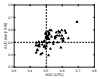


- Classification rule: LPC (or Slow wave) amplitude is greater for hits than misses.

Each trial set as the cutoff at a time.

AUC can be from **0.5** (random) to **1** (perfect).





t-test for AUCs against chance (0.5):
t(63) = 3.67, p<0.001 for LPC
t(63) = 3.04, p<0.005 for early SW
t(63) = 1.95, p=0.06 for late SW.
95% CI for AUCs:
LPC *[0.51 0.54]*, early SW *[0.51 0.53]* and late SW *[0.50 0.52]*.

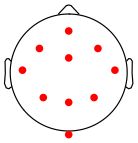
Multivariate Brain Activity During Study

- Multivariate activity: access to more information from the study phase.

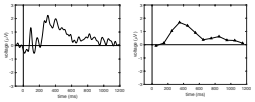
Classifiers: linear discriminant analysis (LDA) and linear support vector machine (SVM). *10 fold* cross validation, *stratified* samples.
Performance: average AUC across 10 folds.
Class imbalance: Behaviourally, hits were more frequent than misses [mean: 175.48 (hits); 49.52 (misses)]. This could lead to biased learning.

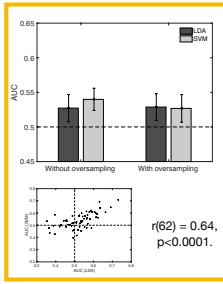
Feature selection:

12 representative electrodes that span the recording coverage.



Averaged voltage over 100~ms time bins, from 0--1,200 ms post-stimulus onset.

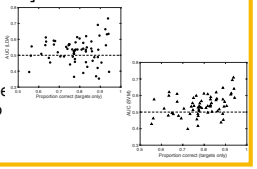




t-test for AUCs against chance (*0.5*):
t(63) = 2.79, p<0.05 for LDA; *t(63) = 5.03, p<0.0001* for SVM. *95% CI* of the AUCs: *[0.51 0.55]* for LDA; *[0.52 0.56]* for SVM.

r(62) = 0.64, p<0.0001.

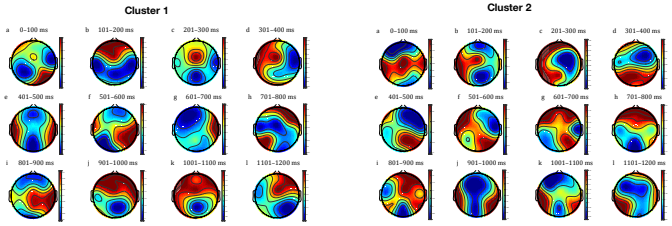
Also possible, greater the no. of hits, better the SNR for the classifier to pick up on.



Analysis of the Multivariate Features

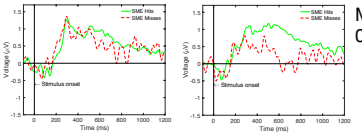
Which features were deemed more important by the classifier?

- For LDA, the coefficient of each feature estimates its importance.
- Cluster analysis with k-means algorithm on the LDA weights.
- A set of 2 clusters were found, 19 in cluster 1 and 23 in cluster 2.



- Topographic plots for the LDA weights (range scaled).

Cluster 1 Cluster 2



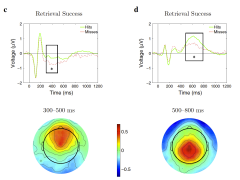
Mean AUC for cluster 1 = 0.59, for cluster 2 = 0.55.
Mean proportion of hits for cluster 1 = 0.80, for cluster 2 = 0.77.

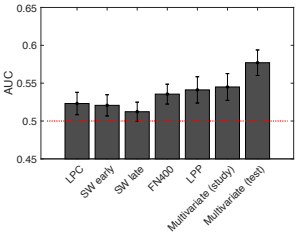
Study ERPs at electrode Pz for the two clusters.

Discussion

- LPC or the SW could predict memory for individual trials. But with a very small effect size.
- Multivariate pattern classification can offer moderate increases to this size.
- Possible improvements: non-linear classifiers, spectrograms?
- Alternatively, the small effects could be due to factors that influence memory outside of study.
- For example, activity at test.

Test ERPs at electrode Fz and P3 respectively.





- t-test for AUCs against chance (0.5): t(63) = 5.31, p<0.001 for FN400, t(63) = 4.62, p<0.001 for LPP, 95% CIs = [0.52 0.55] and [0.52 0.56] respectively.
- Multivariate test activity produced significantly better prediction than multivariate study, t(63) = 2.68, p<0.05.

References

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