Single-trial classification of EEGs during visual and auditory stimulus

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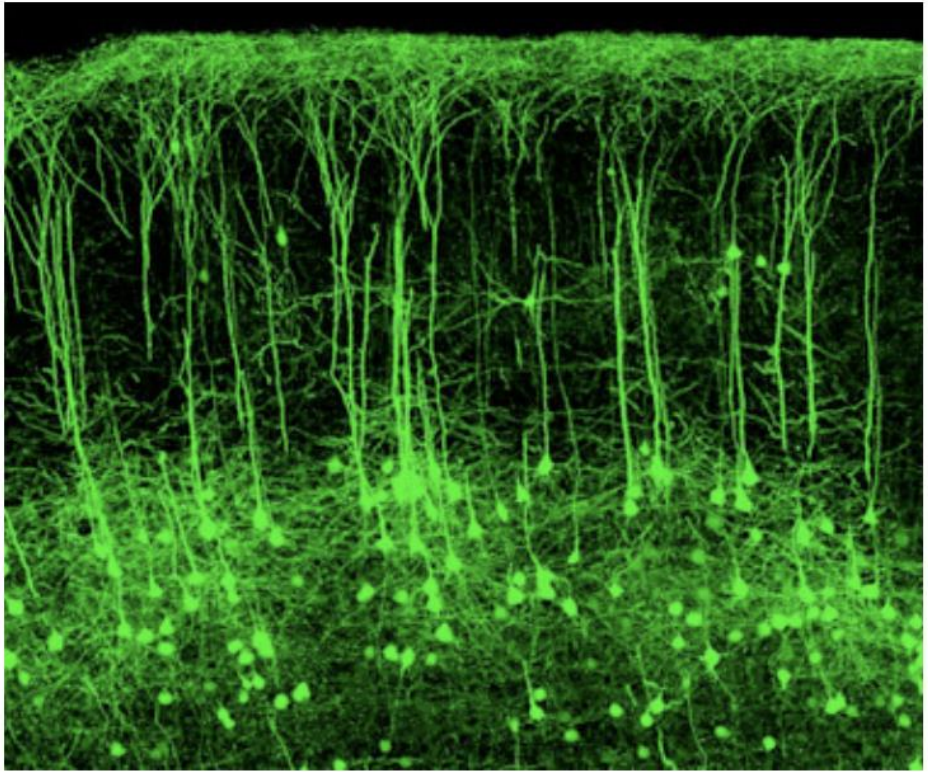
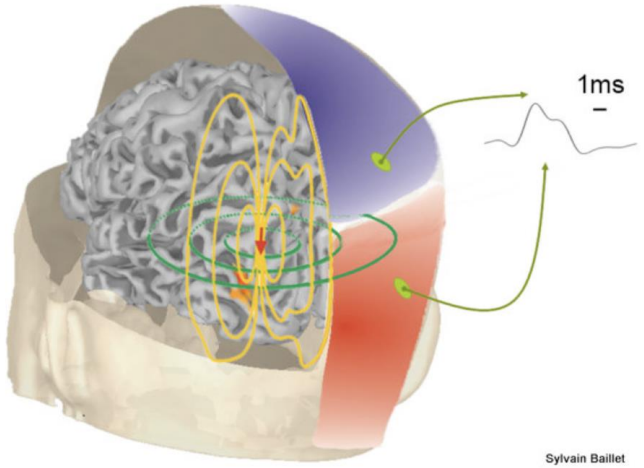


yellow fluorescent protein
Dr. Fu-Ming Zhou
https://www.uthsc.edu/neuroscience/imaging-center/



Averaging removes any signal that is NOT perfectly time-locked to trial start

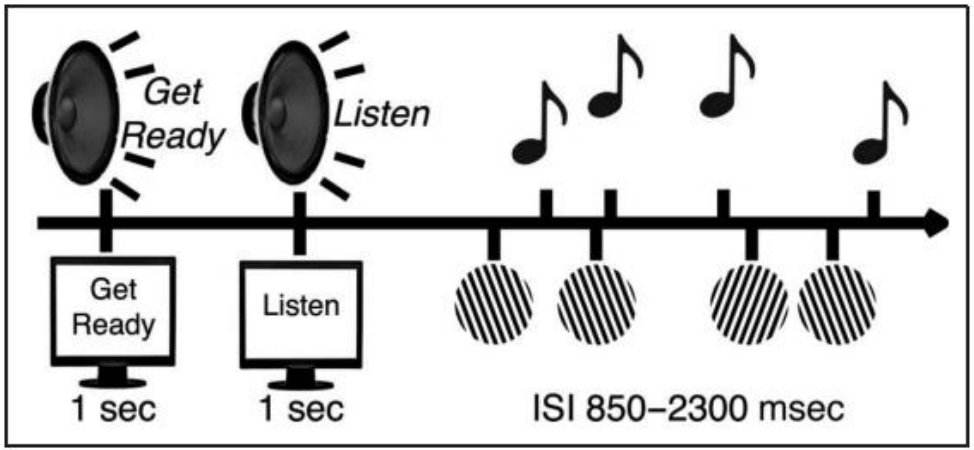
- If we AVERAGE many trials, we can reduce increase SNR
- But only capture truly time-locked signal
- Different tasks can have different time-locked brain response
- **But averaging can remove some real signal (consider averaging time-points of ocean waves)**
- **NO WAVES (unless perfectly time-locked)**

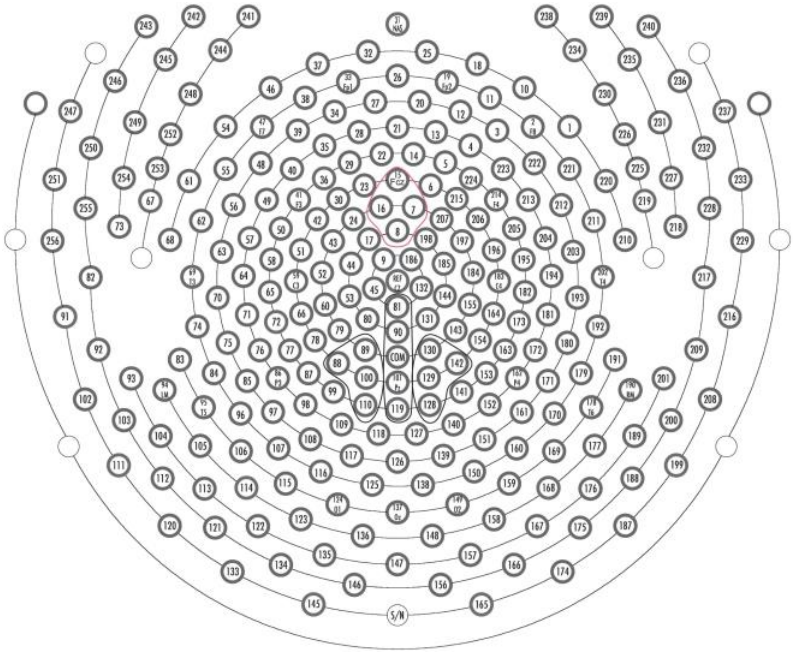
http://passyworldofmathematics.com/mathematics-of-ocean-waves-and-surfing/

Experimental Methods - Brain voltage

Subject task:

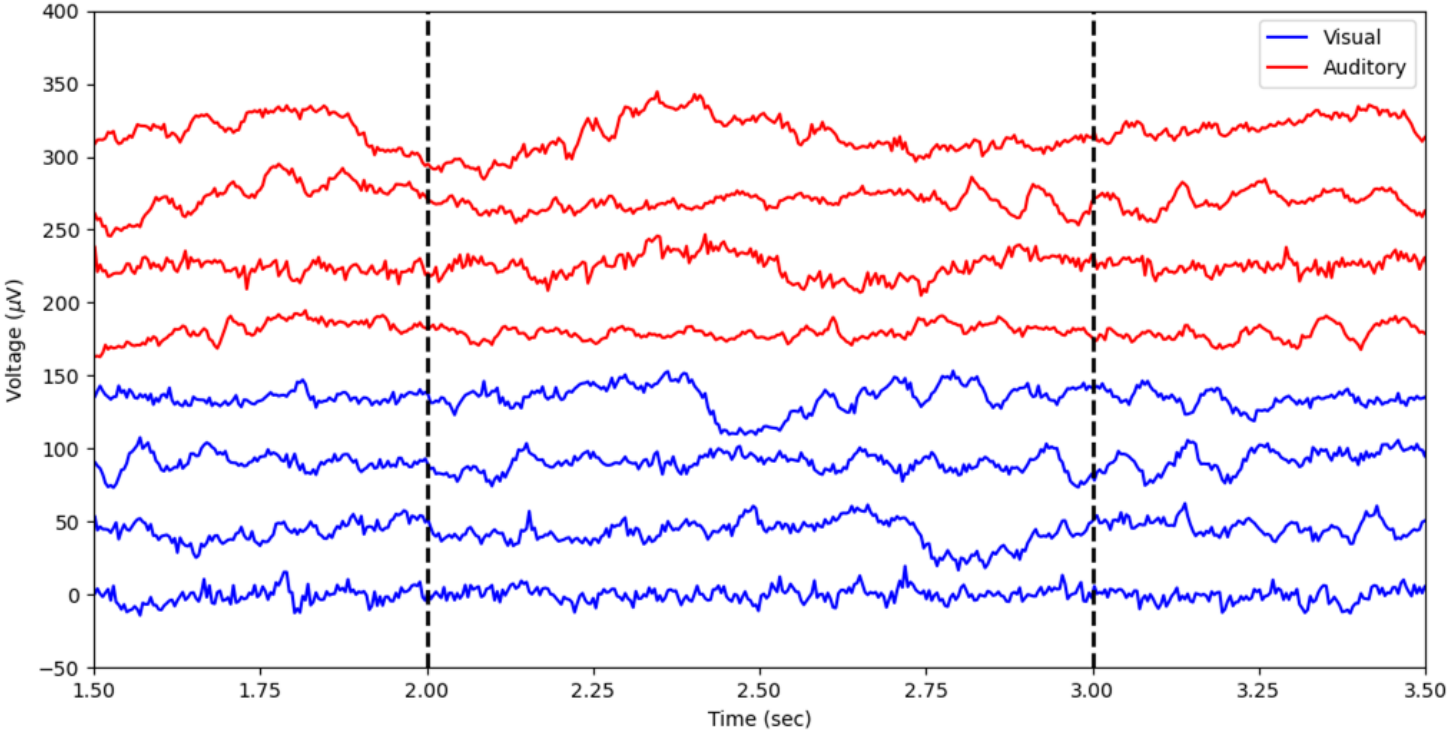
- When task was **listening**, then subject would **ignore the objects**.
- When task was **watching**, then subject would **ignore the sounds**.



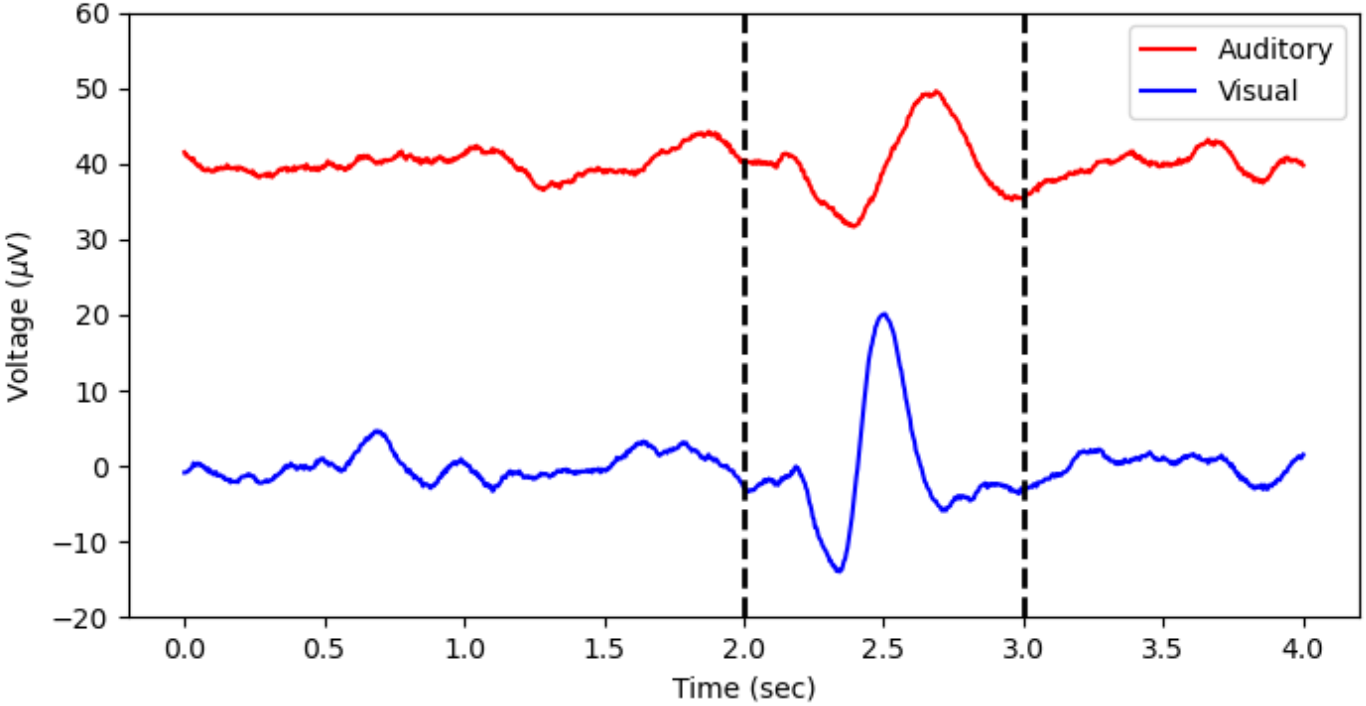


Lenartowicz et al, J. Cog. Neuro (2014).

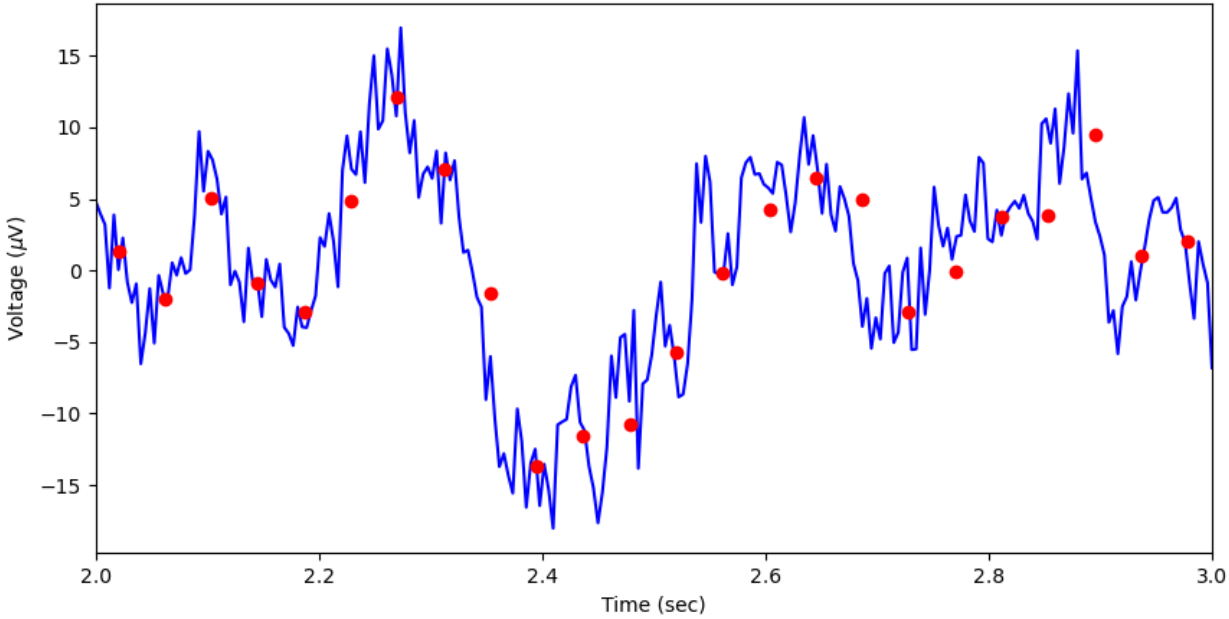
Visualizing the Raw Data



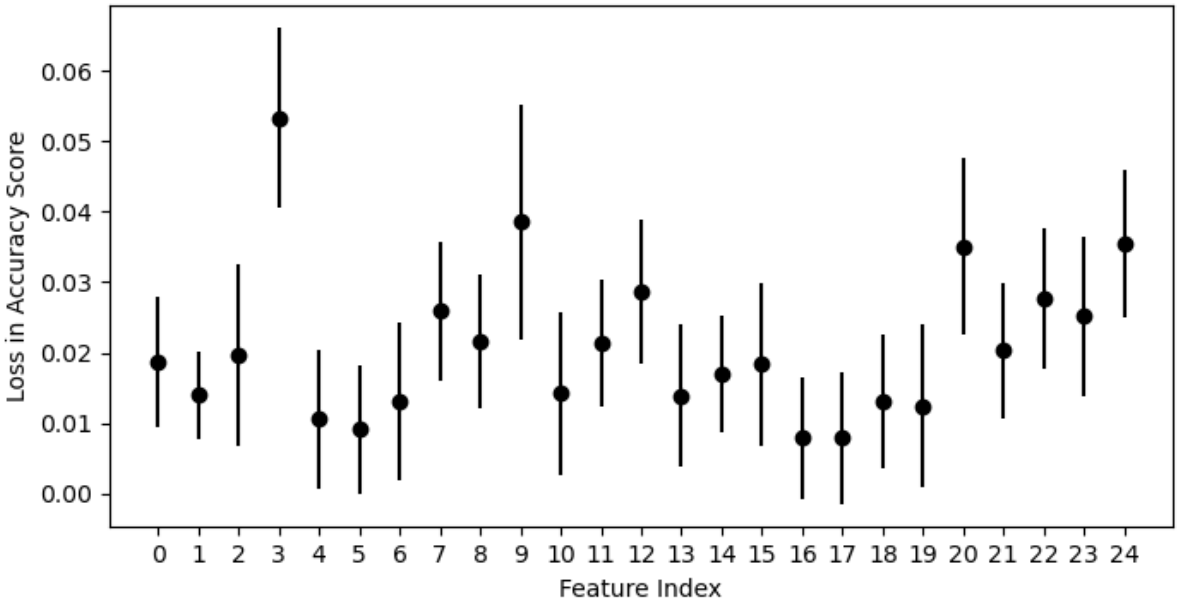
Averaging Over Trials



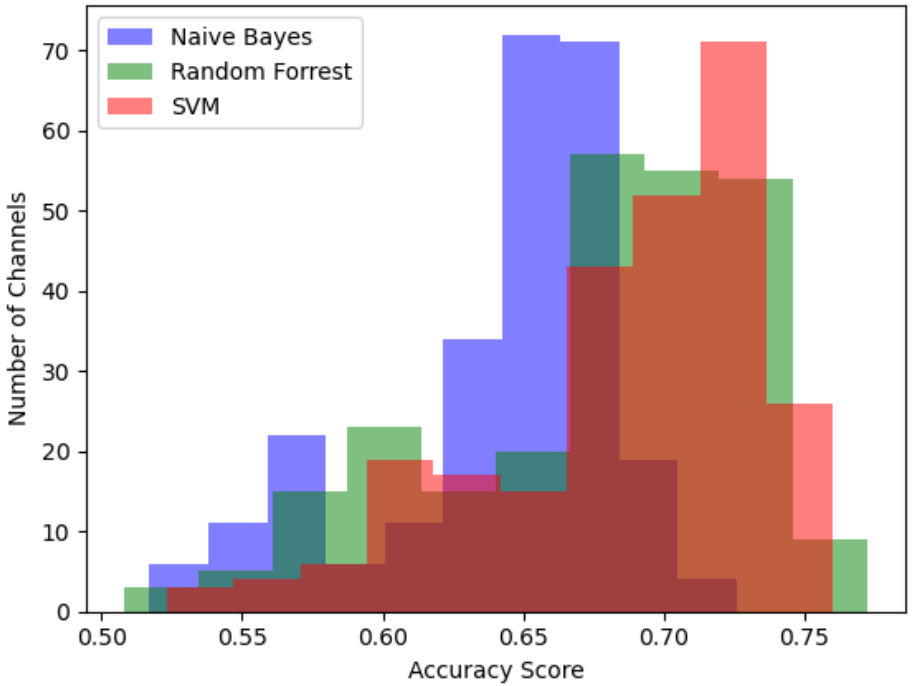
Feature Engineering



What part of the signal is most important?



Comparison of several ML models across all 256 Channels (single-trial single-channel classification)

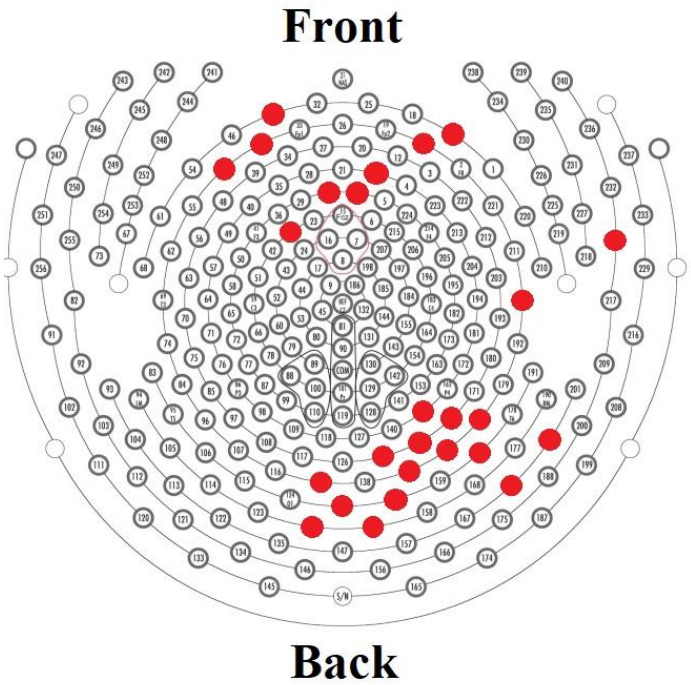


- Support Vector Machines (SVM) have the highest average accuracy score across the channels.
- Tuning the hyper parameters of all channels minimally affected the statistics of these distributions.
- However, tuning the hyper parameters of the individual channels could be used to improve the accuracy score.

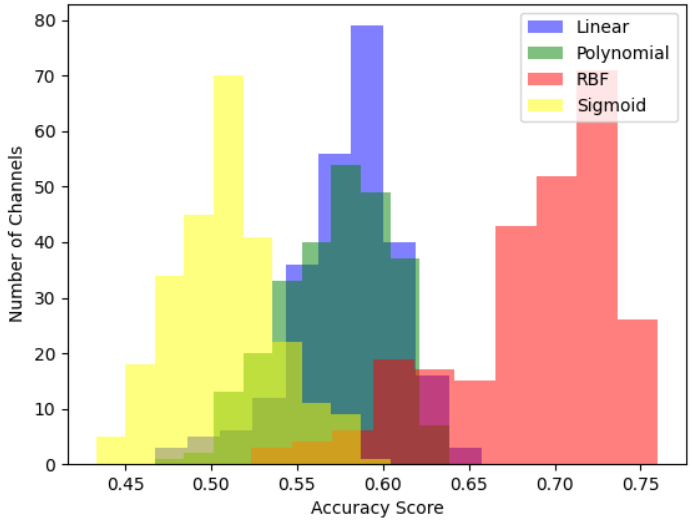
Accuracy score depends on channel location

- The most accurate channels (> 74% accuracy) were located on the front and back of the head.

- The front and back of the head are the primary locations for auditory and visual processing, respectively.

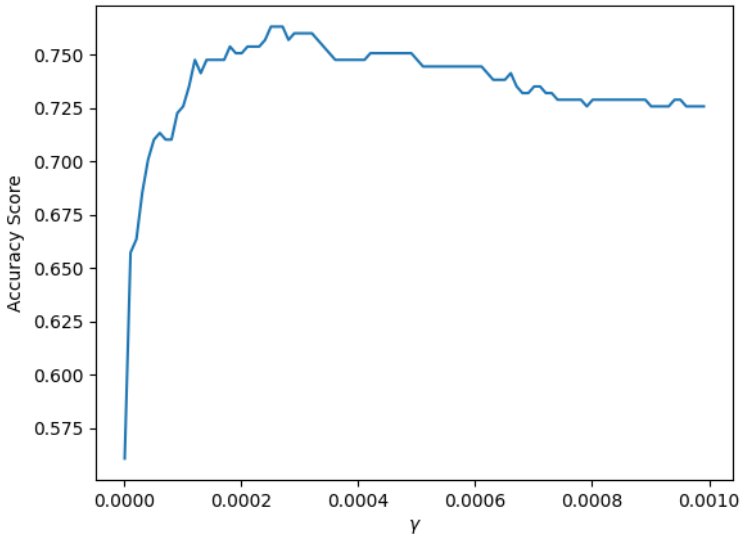


Comparing Kernels in SVM

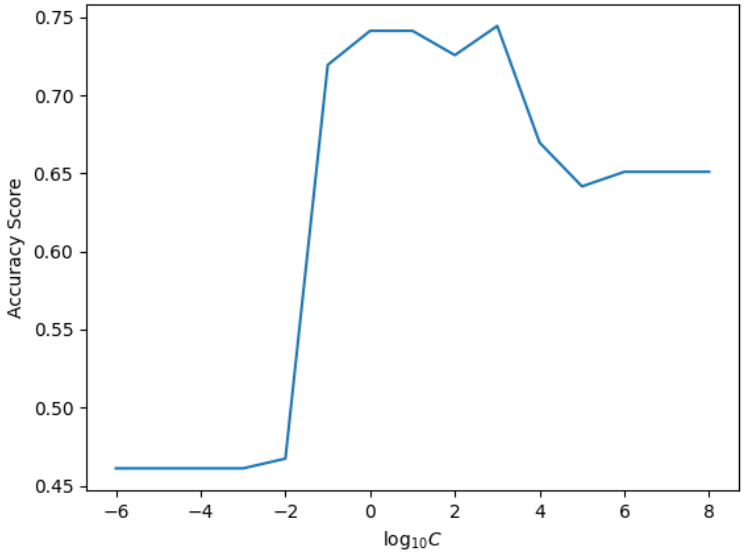


- RBF unsurprisingly performs better than the other kernels
- Here the default values of the hyperparameters were taken for each model

Tuning Hyperparameters

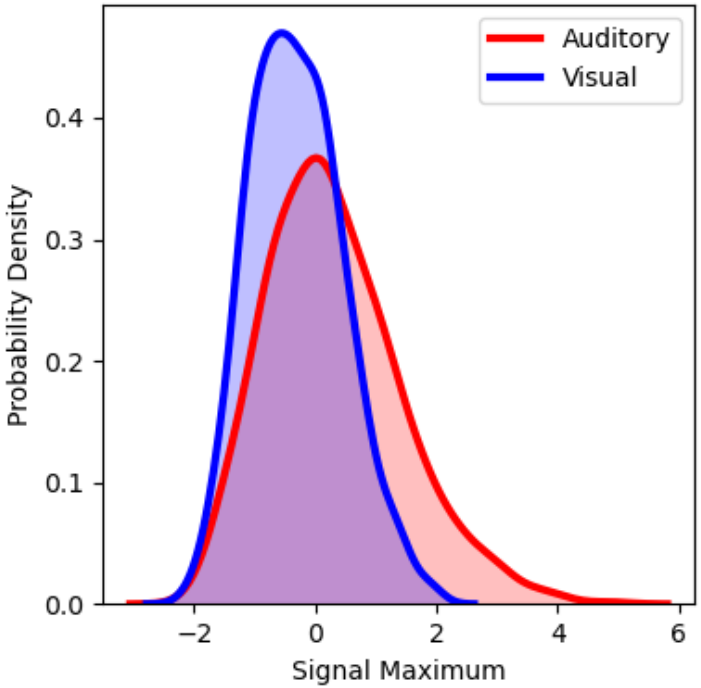


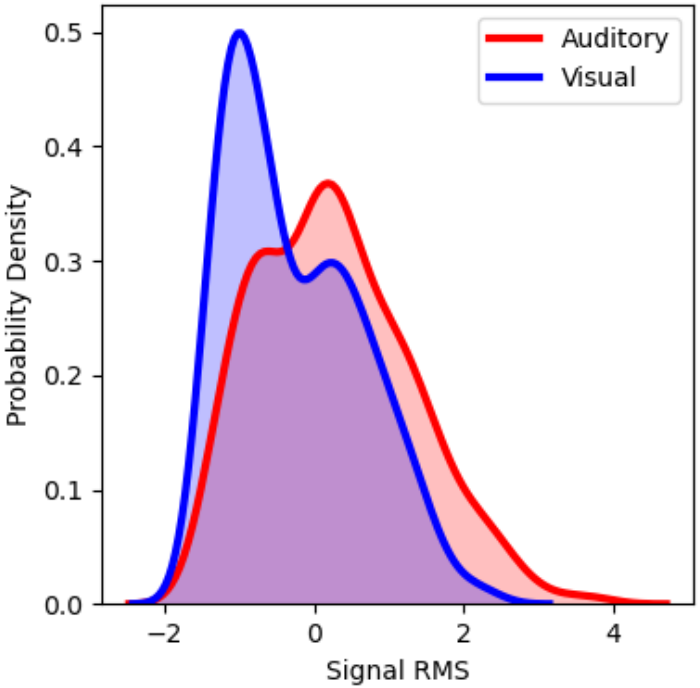
$$\exp\left\{-\gamma\|x-y\|^2\right\}$$



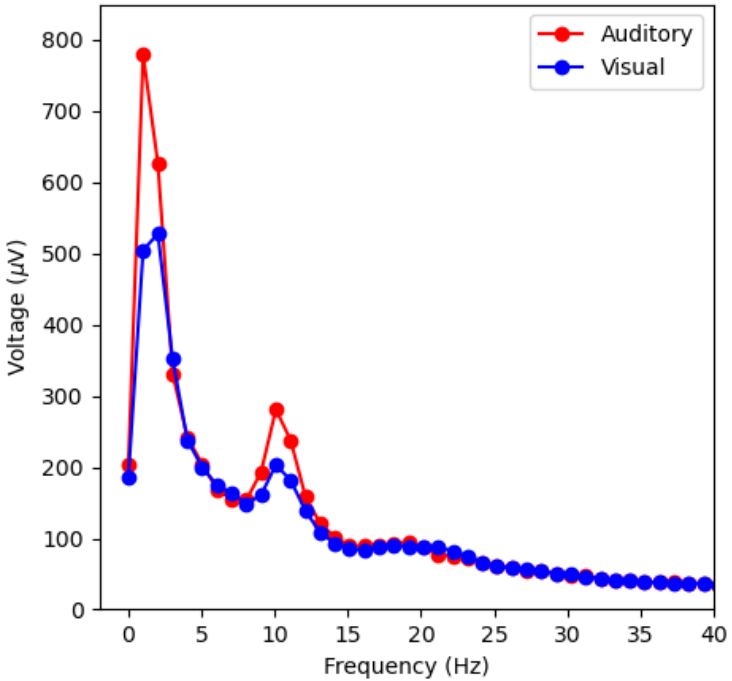
$$\min\left\{\|w\|^2 + C\sum_i \xi_i\right\}$$

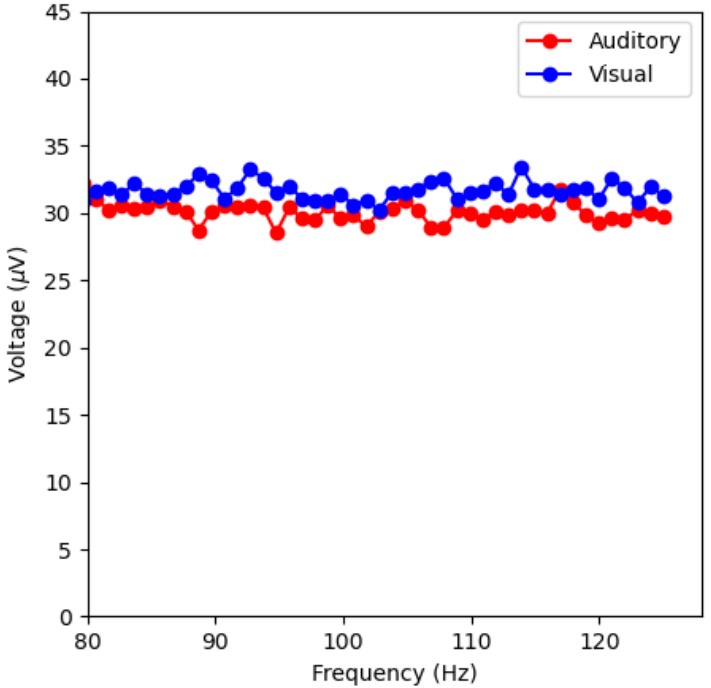
More Feature Engineering (Signal Statistics)





Frequency Domain





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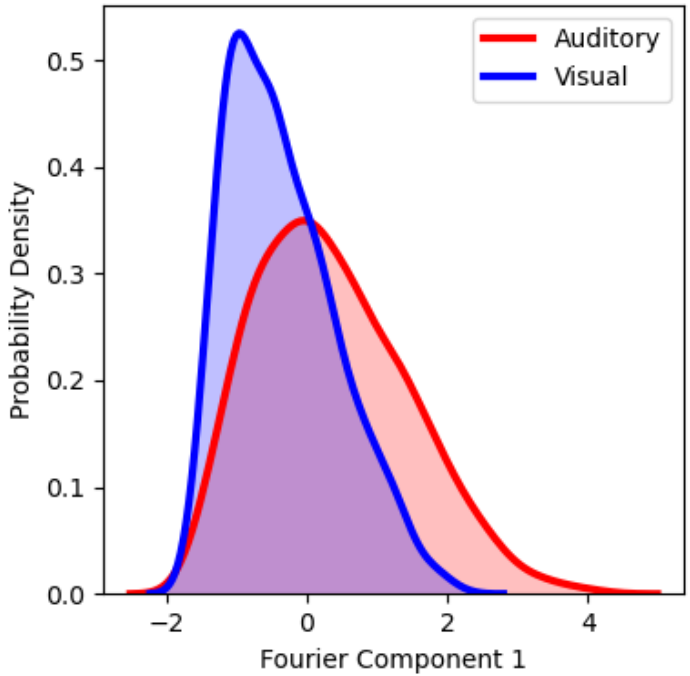
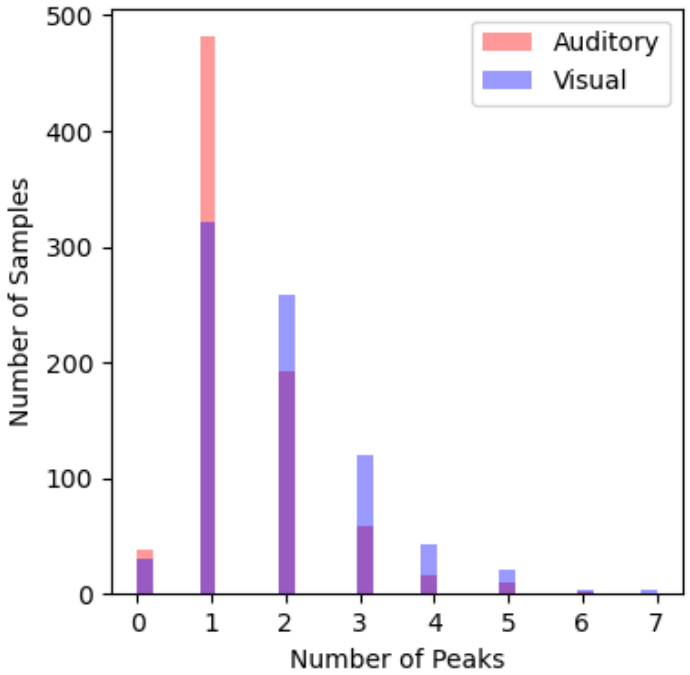
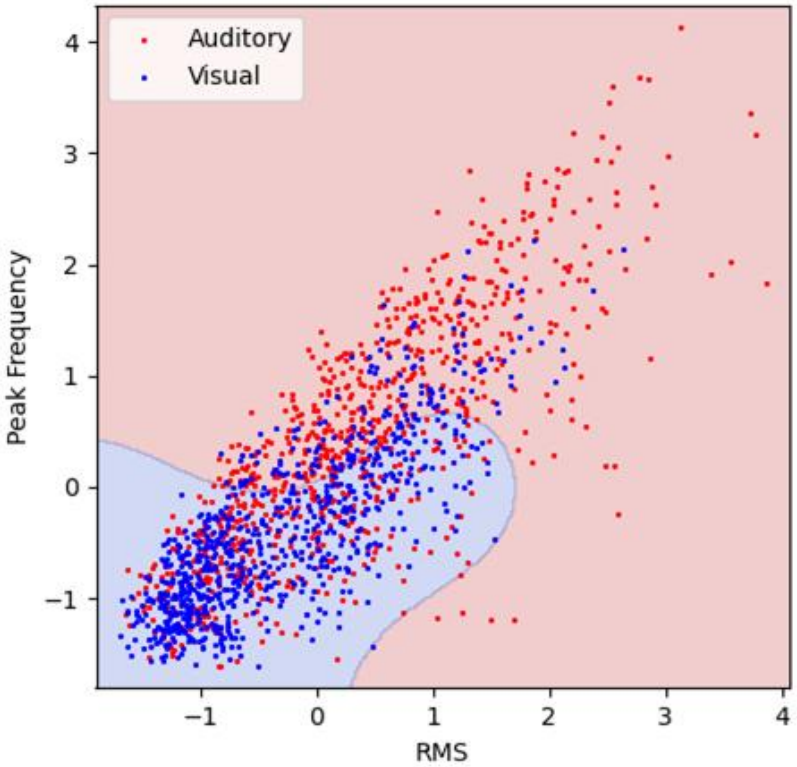


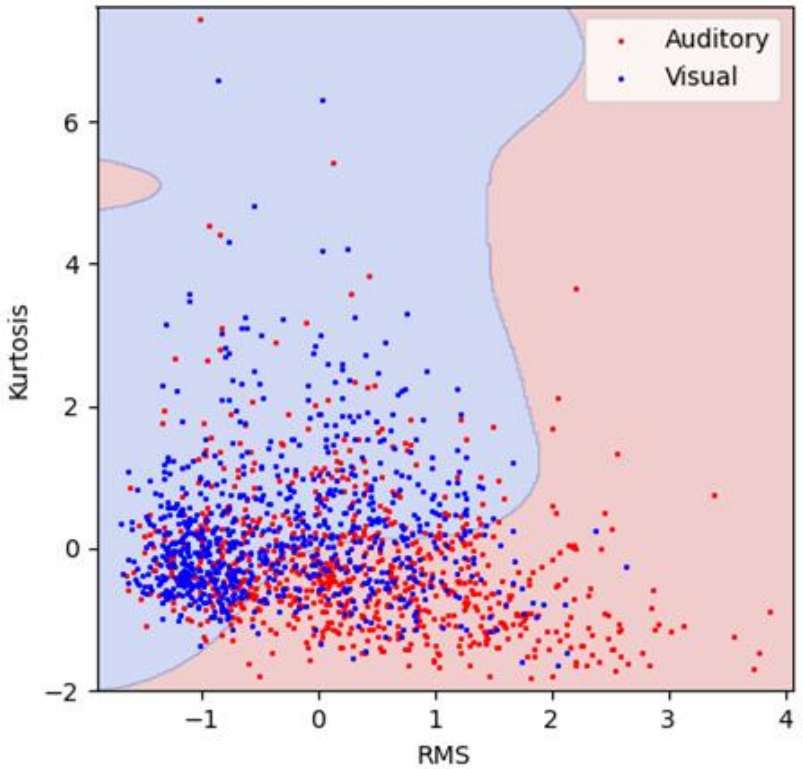


SVM Decision Boundary (Just 2 Features)

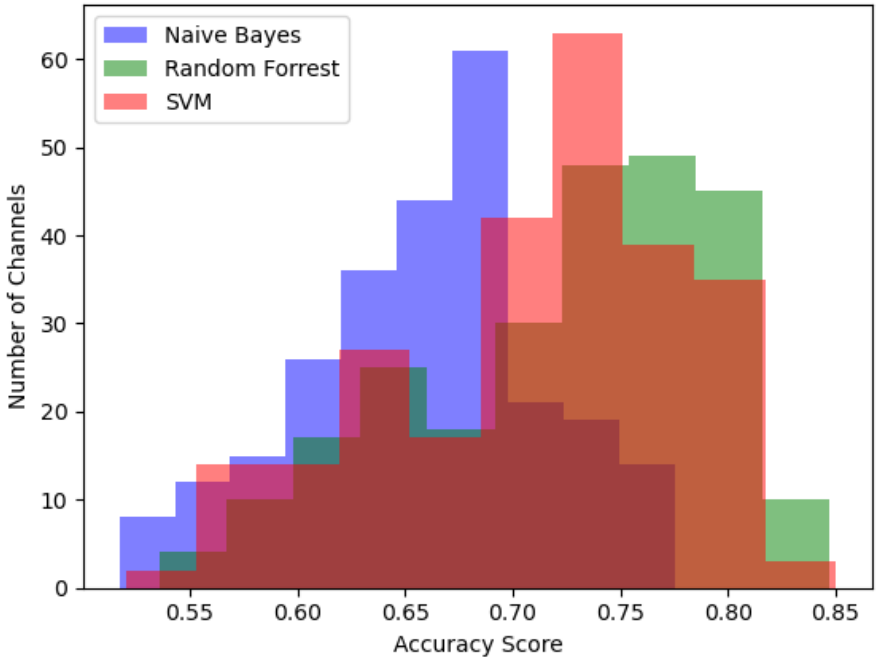
Accuracy Score = 0.68



Accuracy Score = 0.65



Accuracy Scores over all 256 Channels for an 8-Feature Model (single-trial single-channel classification)

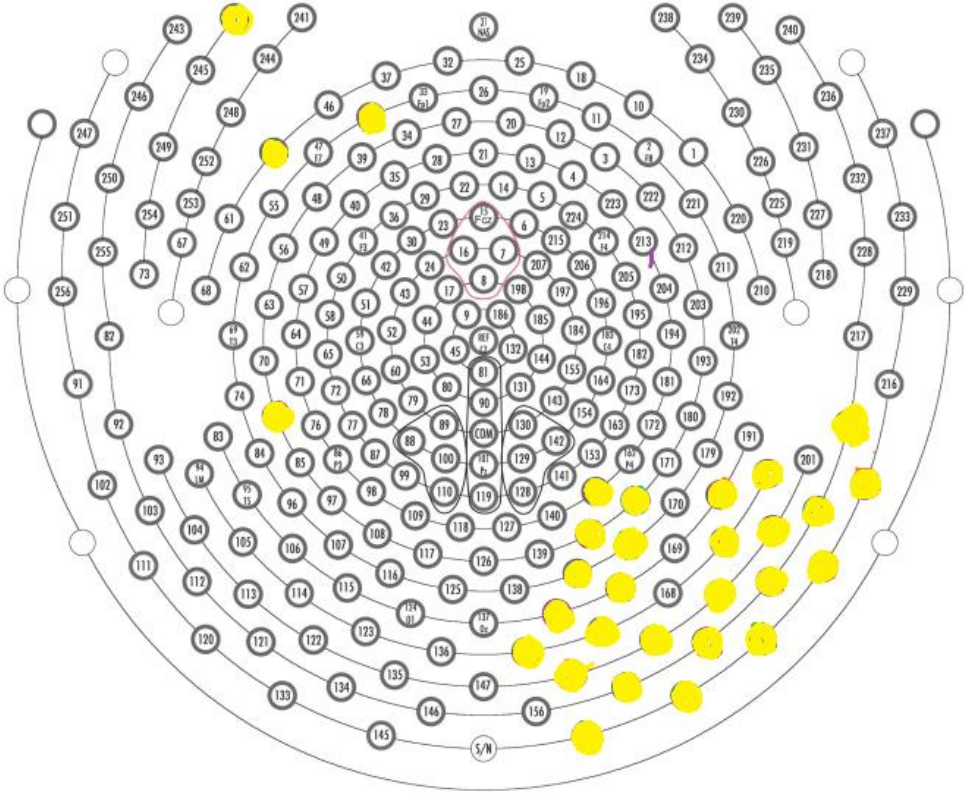


- Features:
  - 3 key Fourier components
  - Avg. of high frequencies
  - Signal maximum
  - RMS
  - Kurtosis
  - Number of peaks
- SVMs and random forests produced comparable accuracy scores.
- All methods produced higher accuracy for the 8-feature model, than the previous model.

- The best accuracy score we could obtain was 90%, using 2 of these highlighted channels (one on the front and one on the back of the head)

- Combining the 2 top performing channels overall did not improve the accuracy

- Adding a third channel from another location lowered the accuracy score

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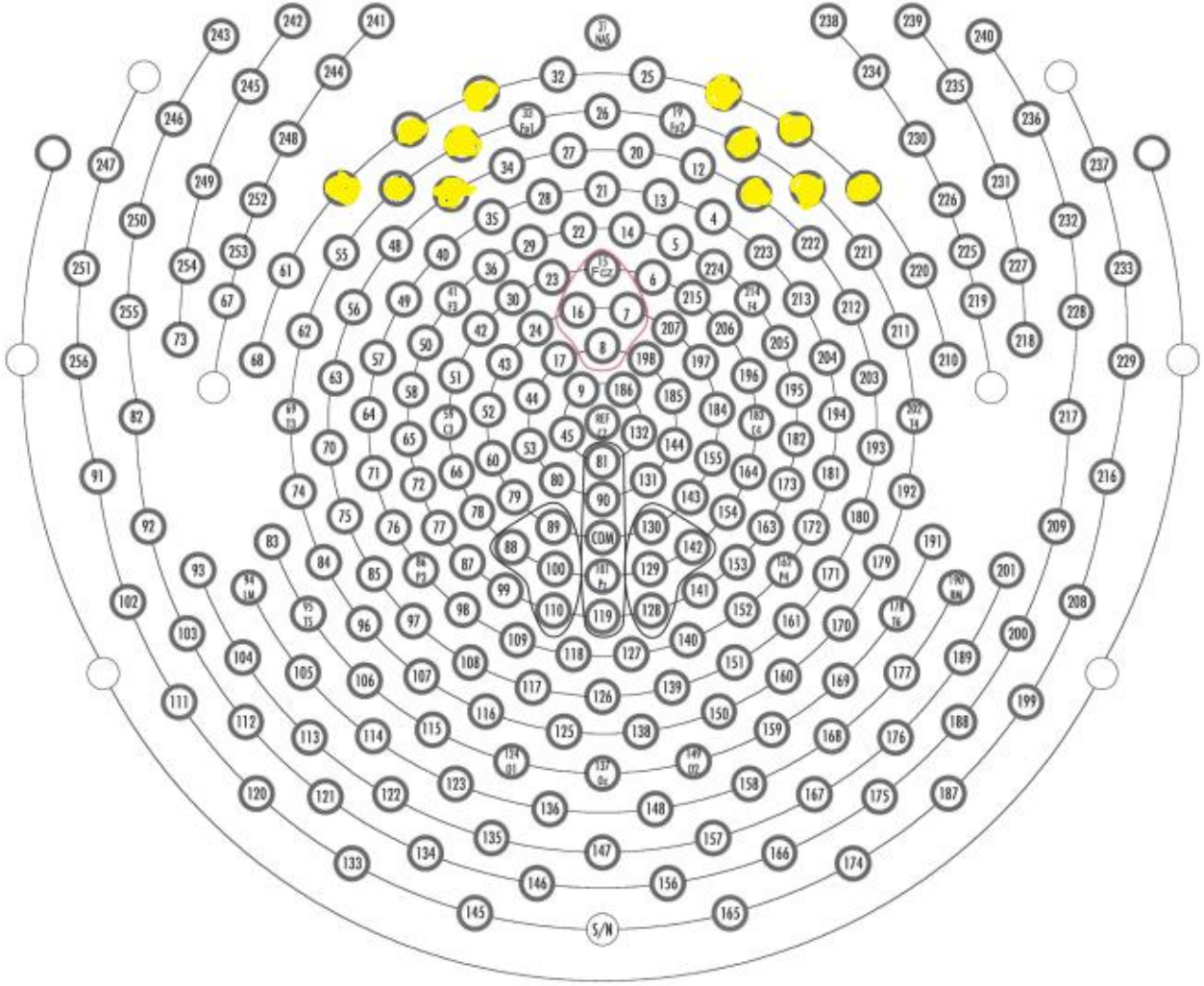
NAS
Fp1
Fp2
F3
F4
C3
C4
P3
P4
O1
O2
LM
RM
T5
T6
Fz
Cz
Pz
COM
S/N

Future Directions?

Questions: other tasks, other intentions,
Diagnoses and states of consciousness?

CAVEATS: eye-blinks/muscle artifacts could be used in addition to brain signal!