Faces/Houses Decoder

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Introduction

- We decided to use the Faces/Houses dataset which consists of a visual recognition task with and without added noise.
- The main analysis was focused around different noise levels, the ECoG data, key-press and the true label.
- We wanted to compare model's results between trials in different conditions and to subjects' performance.
- Main question: **Can face or house stimuli of different noise levels be distinguished using ECoG data even when patients themselves make a mistake?**
- Additionally we investigated which brain regions are important for distinguishing faces and houses in the clean condition.

Literature

Gramfort, A., Luessi, M., Larson, E., Engemann, D. A., Strohmeier, D., Brodbeck, C., ... & Hämäläinen, M. (2013). MEG and EEG data analysis with MNE-Python. Frontiers in neuroscience, 267.

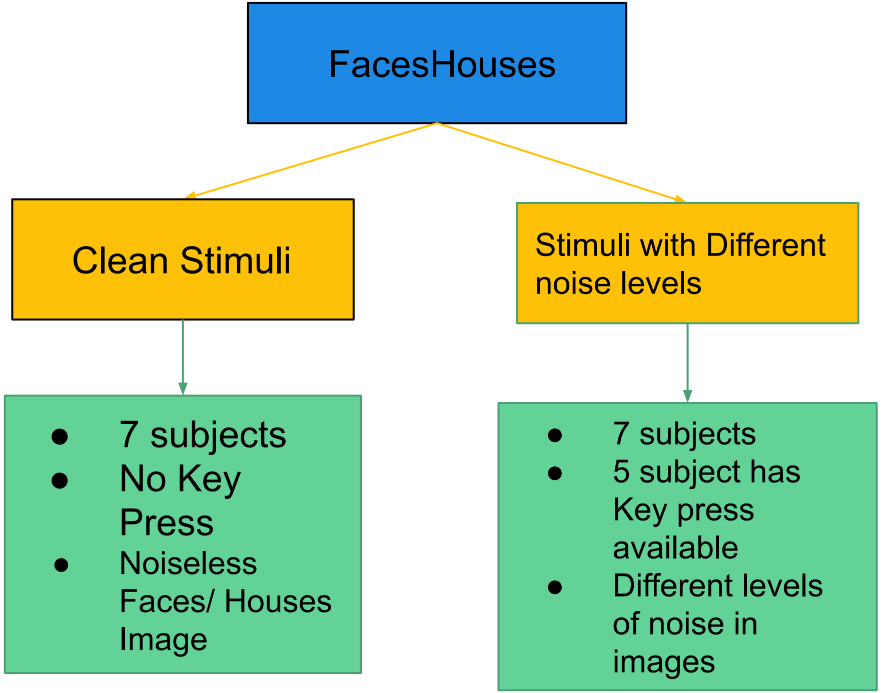
Miller, K. J., Hermes, D., Pestilli, F., Wig, G. S., & Ojemann, J. G. (2017). Face percept formation in human ventral temporal cortex. Journal of neurophysiology, 118(5), 2614-2627.

Miller, K. J., Hermes, D., Witthoft, N., Rao, R. P., & Ojemann, J. G. (2015). The physiology of perception in human temporal lobe is specialized for contextual novelty. Journal of neurophysiology, 114(1), 256-263.

Miller, K. J., Schalk, G., Hermes, D., Ojemann, J. G., & Rao, R. P. (2016). Spontaneous decoding of the timing and content of human object perception from cortical surface recordings reveals complementary information in the event-related potential and broadband spectral change. PLoS computational biology, 12(1), e1004660.

Dataset Overview

- The subjects of this experiment are epilepsy patients.
- There are two experiments. The first one used clean stimuli and the second one used images (faces/houses) with different level of noise.
- If the keypress was given within 200ms of the image that was shown to the patient, then the response (keypress) is mapped to the prior image.

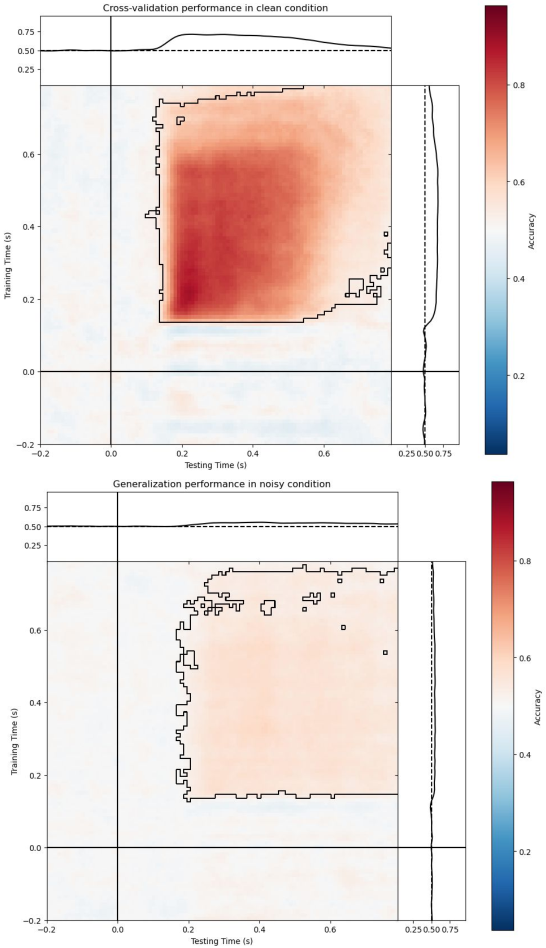


Dataset Info

- Sample rate is always 1000Hz.
- ECoG data has been notch-filtered at 60, 120, 180, 240 & 250Hz.
- Two samples have been exempted from noisy image experiment because there are no keypresses.
- In Clean stimuli experiment, images have been shown for 400ms and then 400ms of Inter stimulus Interval (ISI).
- In the Noisy image experiment, images have been shown for 1000ms and there is no Inter stimulus Interval (ISI).

Pipeline

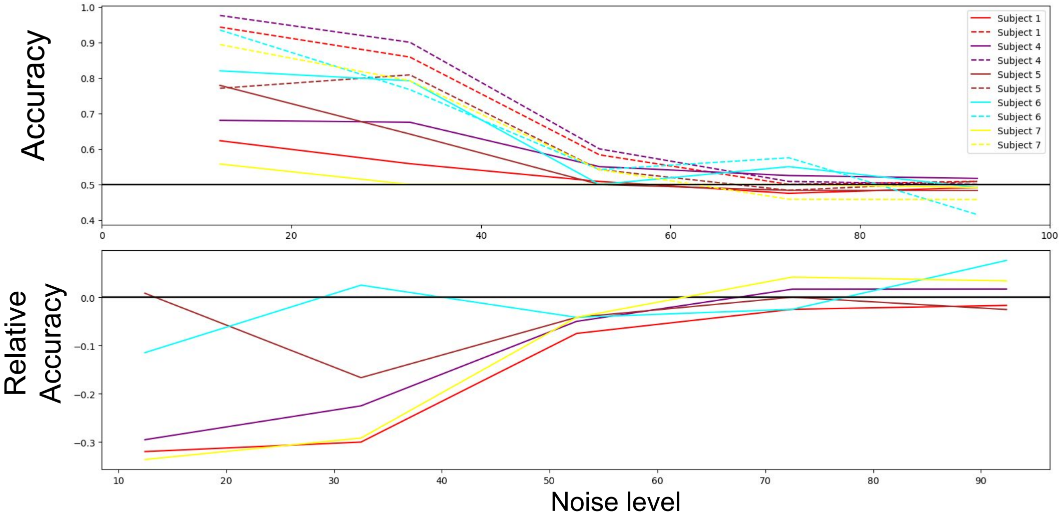
- Data were notch-filtered at harmonics of 60 Hz and z-scored to standardize across channels.
- A band-pass filter was applied at 10-50Hz.
- Normalization based on training set median and quartile range.
- Logistic regression model was trained on clean data and applied on noisy data to predict the stimulus category of the data.
- Classification is significant in the 200-800 ms window for both clean and noisy data.

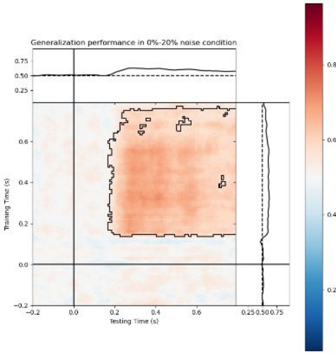


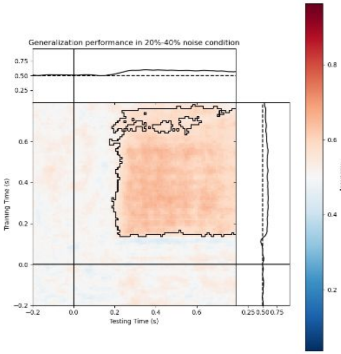
Results

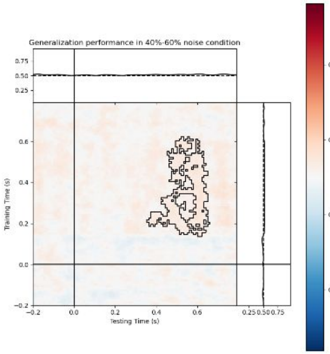
Post hoc analysis revealed:

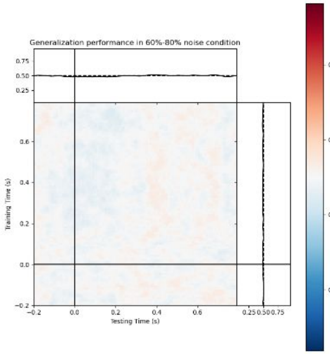
- BA 18 (V2), 19 (V3, V4, V5), and some areas in temporal gyrus as well as Parahippocampal and fusiform gyri contributed most to classification.

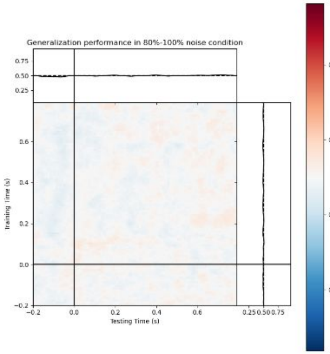




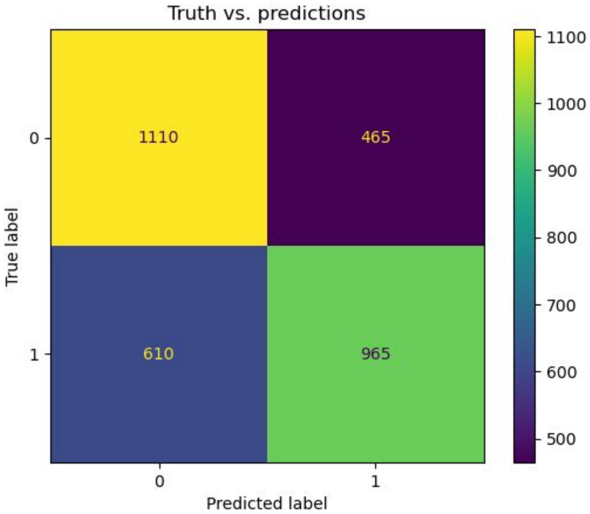






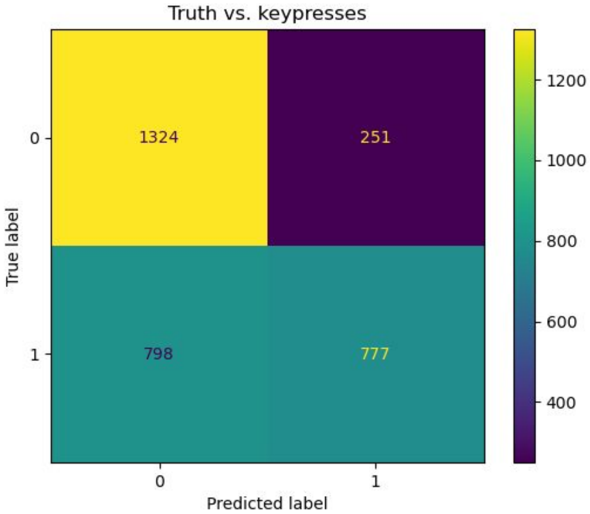


Model predictions



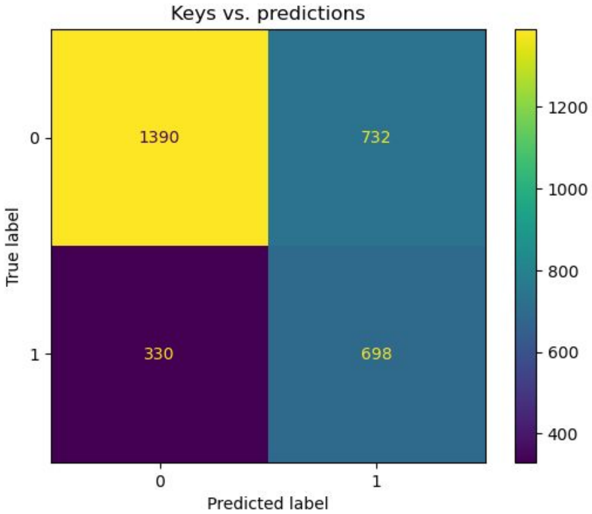
For faces:
Precision: 965/(965+465) = 67.5%
Recall: 965/(965+610) = 61.3%
F1: 64.25%

Subject keypresses



For faces:
Precision: 777/(777+251) = 75.6%
Recall: 777/(777+798) = 49.3%
F1: 59.68%

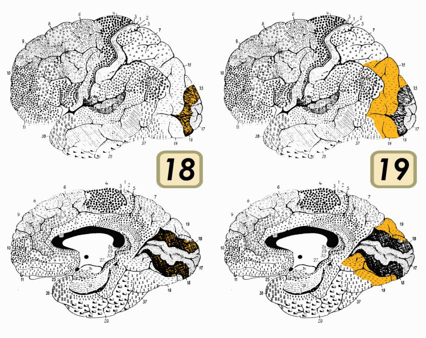
Subjects vs. model



Conclusions

So, what does that *mean*?

- 1 model **outperformed** its corresponding subject for certain noise levels.
  Subjects and models have comparable accuracies overall, especially on high noise levels, but mostly answered differently on the same trials.
  <u>Did we answer our main question?</u>
- The best **time window** is between 0.2 and 0.8 seconds after stimulus onset.
- **Signal power** and **time-frequency data** are almost equal in their predictive abilities for this kind of classification.(But using signal power is much faster)
- Electrodes on some specific **brain regions** contribute a lot to the classification(e.g. Brodmann areas 18 and 19).
  Are those regions also involved in similar tasks in humans?(yes)



Limitations & Future Research

- The **electrode mapping** does not match across patients and limits the generalizability of the results as well as restricts the analysis of important brain regions.
- **Key-presses only correspond to identifying a face**. It is unknown if no keypress is due to confusion or actual house identification. This also does not allow analysis of reaction time for both stimuli, and adds a severe bias towards houses.
- We did not have the **original pictures**, so no encoding for us!
- Better/different **feature extraction and selection** methods should be considered. Time-frequency feature importance could also be looked into.
- It would be useful to **train on different noise levels** to check the difference in feature importance, and whether **auxiliary areas** are involved when processing noisy faces/houses.
- **Statistical analysis** of the data could be improved.