Thresholding of Neural Signals to Optimize Decoding Accuracy

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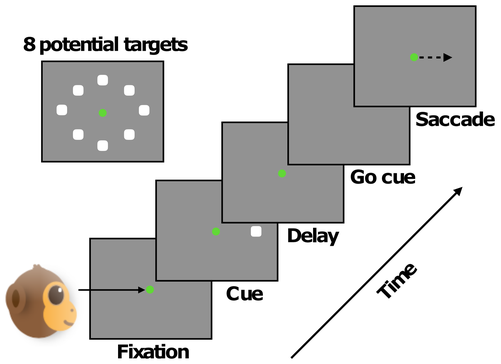
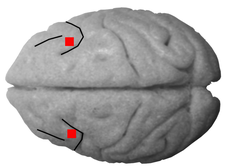
Motivation

- Brain-Computer Interfaces rely on large-population recordings to reliably decode signals encoded in neural activity
- Recording electrodes may record from multiple neurons on a single contact as well as noise, degrading available single-unit information
- **Question 1:** Is there a global threshold that optimizes decoding of the memory-guided saccade task?
- **Question 2:** By setting the threshold of each channel separately can decoding performance be improved?

Memory guided saccade task



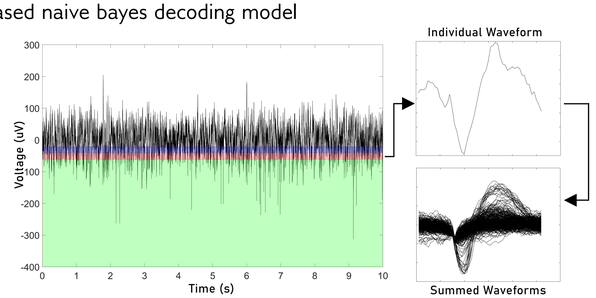
Bilateral intracranial prefrontal cortex recording



Dual Utah array (96 electrode) recordings in both hemispheres of dorsolateral prefrontal cortex (dlPFC) in one rhesus macaque

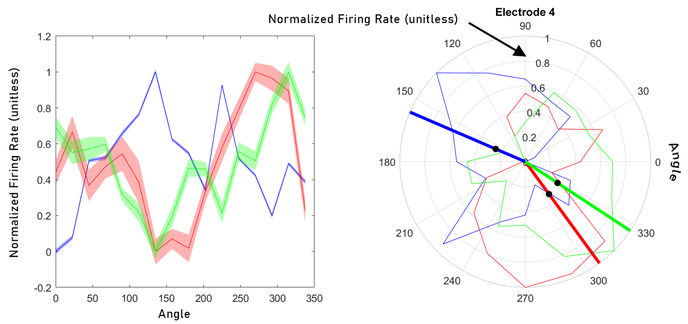
Spike times extracted via threshold crossing

Extracted spike times are sorted into several exclusive bins based on the maximum amplitude that the spike waveform achieves and summed together to create a firing rate based naive bayes decoding model

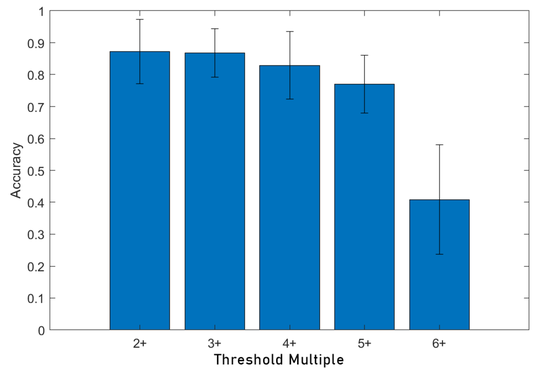


Tuning curves change with threshold

Keeping or discarding different amplitude bands from an electrode's recorded spikes can isolate individual neurons or multi-unit groups from the threshold crossing data. This can in turn reveal distinct tuning among those neurons



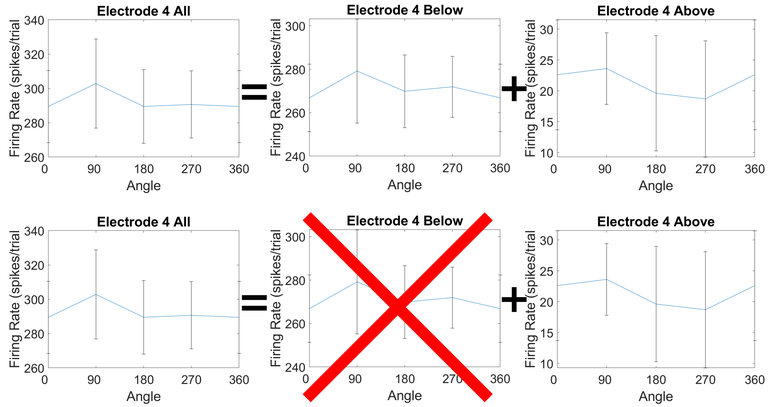
Decoding accuracy optimal within broad range



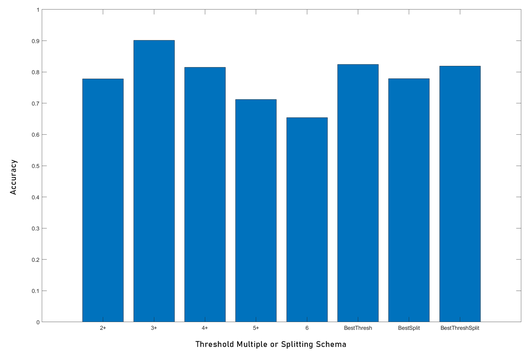
- Spikes are sorted into exclusive bins based on their largest amplitude reached. The baseline noise level of the channel is calculated as the median absolute deviation in microvolts of the first five seconds of the recording. The thresholds are then calculated as multiples of the noise level such that the threshold 2
- Contains spikes whose largest amplitudes were between 2 and 3 times the noise level, threshold 3 contained spikes with maximum amplitudes between 3 and 4 times the noise level, and so on. In the figure above, designations such as 2+ mean that all spikes in thresholds 2 and above were included.
- A naive bayes decoder was trained on the spike counts from the recorded data thresholded at specific multiples of the noise level. this model was then used to predict a held out test set from the same recording. Decoder performance is robust to changes in threshold for this task, with lower thresholds producing the best cross-validated results.

Individually thresholding channels did not increase decoding accuracy

- Separating electrode channels into multiple exclusive bins (see left column) creates additional pseudo-channels
- Pseudo-channels can either be recombined into high and low amplitude channels (splitting) or low amplitude channels can be discarded (rethresholding)
- Where to split or rethreshold can be set individually for each channel
- This selection affects the tuning of each pseudo-channel, which can affect the overall decoding accuracy



Deciding on a per-channel split/discard threshold proved to be a difficult problem



Conclusion

- Deciding on a threshold to record large-population neural activity at can affect overall decoding accuracy
- A wide range of relatively permissive global recording thresholds produced equivalent decoding accuracy in PFC
- Setting a recording threshold for each electrode can significantly change the electrode's tuning, but it is difficult to decide on a threshold selection scheme that increases decoding performance on a population level