

Decoding Visual Stimuli from Recordings in Inferior Temporal Cortex

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The Problem: We are interested in how visual stimuli translate into neuronal activation patterns in inferior temporal (IT) cortex. Specifically, given electrical signals from electrodes in IT, is it possible to decipher what objects the animal is seeing at a given moment?

Motivation: The question of how information is encoded in the brain remains a tantalizingly unsolved problem in neuroscience. In this project we are looking at how information is encoded specifically in IT, the last purely visual area of the ventral visual pathway. Neurons from IT are thought to respond best to complex stimuli. However, the actual underlying neural encoding of information in IT is unknown. Understanding the “neural code” will help us to better understand how information is processed in this region.

Previous Work: Electrophysiologists have been exploring the activity of individual neurons in the macaque brain for several decades now [3]. For an overview of object recognition by IT, see [1]. There is some suggestion of topography in the neuronal representation based on the work of Tanaka and colleagues [2]. However, we still lack a thorough understanding of feature selectivity in IT and how it arises from the combined activity of neurons in earlier visual areas, local interneurons and feedback connections.

Approach: We are currently examining electrophysiological data collected from neurons (individual recordings) in Macaque IT. For each recording, the monkey is shown a number of stimuli belonging to one of 8 object groupings, i.e. face, food, etc. Neural data is analyzed in a certain way, i.e. by counting spikes, and then a classifier, such as an SVM or Fisher’s Linear Discriminant, is trained on the neural data. The idea is that such a system can shed insight into how information is encoded in IT. Preliminary results indicate that spike counts (averaged firing rates) divided into varying size bins, and inter-spike intervals (on individual neurons) may both be used to decode information in IT. Future work will involve the analysis of different types of neural encodings, electrophysiological data from local field potentials (in addition to the spike analysis as performed previously), and data from multiple neurons recorded simultaneously.

Difficulty: Preliminary results indicate that we can decode the input stimuli with 80% accuracy if working with 32 randomly placed electrodes. Given that preliminary results are fairly positive (in terms of decoding information) for both firing rate and ISI codes, finding which code is actually applied in biology may be a difficult problem. There are numerous other firing codes that can be tested, and perhaps even firing codes that we have not thought of that may be responsible for object recognition in the brain. Furthermore, determining which type of classifier is best to use for this analysis may be a computationally intensive task.

Impact: Understanding how information is encoded in IT may shed light on how information is encoded and processed in other regions of the brain as well. This understanding may also give us insight into how the brain is able to perform visual object recognition tasks so efficiently.

Future Directions:

- I) Analysis of local field potentials
- II) Extension to multiple (simultaneous) electrode recordings
- III) Compare between MUA (multi-unit activity) and SUA (single unit activity)

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