Urban Lab

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The nature of olfactory stimuli

Mori, K. 1995
The mouse olfactory system

Main olfactory epithelium
- Olfactory sensory neurons

Main olfactory bulb
- Mitral cells – the primary targets of sensory neurons
Olfactory bulb circuitry

Input from ~ 10,000,000 olfactory receptor neurons converge on glomeruli

~2000 glomeruli

~50 Mitral cells/glomerulus receive essentially identical excitatory input

100,000 mitral cells project to ~ 100x more neurons in olfactory cortex
How many neurons do we need?
Does it depend on which neurons?
Mitral cells respond differently to the same constant current input

Padmanabhan and Urban 2010
Mitral cells respond differently to fluctuating inputs.
Constructing and analyzing simulated population responses (SPRs)

• Homogeneous SPR: Collect spike trains evoked across trials in which a single cell was repeatedly injected with the same stimulus current.

• Heterogeneous SPR: Collect spike trains evoked across trials in which different neurons were repeatedly injected with the same stimulus current.

\[ I(x; r) = H(x) - H(x|r) \]

Method of Osborne et al 2008
Effects of blocking Kv1.X channels
Effects of blocking Kv1.X channels
Is this biophysical diversity a feature or a bug?

• Does diversity allow populations of neurons to do a better job encoding information about stimuli?
  – Are neurons diverse in how they respond to stimuli?
  – Model the behavior of individual neurons
  – Which collections of these model neurons do the best job of representing information about a stimulus.
Generalized Linear Models fit to individual neurons
GLMs of individual mitral cells accurately predict spike trains
Diversity in GLM parameters
Stimulus reconstruction from single neurons
Stimulus reconstruction with homogeneous vs heterogenous populations
Reconstructing multiple stimuli shows that there are generalist and specialist populations.
Greedy Search graphical schematic

**Iteration step 1**

- Find neuron with lowest average decoding error.

**Iteration step 2**

- Find neuron to add which decreases error the most given the first neuron.
Greedy Search Results

- Optimal populations: n = 1, 2, 3, ... n = 10
- GLM parameters: PC 1, PC 2
- Population diversity, Stimulus diversity, Post-spike diversity
- Random, Winning, Homogeneous
- Population count vs. Number unique neurons
Conclusions

• Neurons, even neurons of a given “type” differ in their intrinsic biophysical properties
• These differences can contribute to encoding information about stimuli
• “Winning” populations consist of a mixture of redundant and diverse populations.
• How do alterations in diversity affect function?
BRAD PITT
MONEYBALL
JONAH HILL  PHILIP SEYMOUR HOFFMAN
COLUMBIA PICTURES PRESENTS: A SCOTT ROBIN/MICHAEL DE LUCA/RAHUL JHA Prod. Art by BRUNNETE MILLER
MONEYBALL "MICHAEH DANA" KARHU NALCIA MALMING AND CHRISTOPHER HOFFMAN ARE "AG MIMI SIMS" ANDREW NELLY PESSER "SCOTT ROBIN ANDREW NASCH SUNDAY KINNELL MARK BANSHI "CHRIS MICHAEL HENTS BRUNNETE MILLER" "SISI SUNN" "SUNN NELLY PESSER" ""SUNN NELLY PESSER" "SUNN NELLY PESSER" "SUNN NELLY PESSER" "SUNN NELLY PESSER"
THIS FALL
WHAT ARE YOU REALLY WORTH?