Brief Conceptual Review for HW1

Intro to Computational Neuroscience
Section 4

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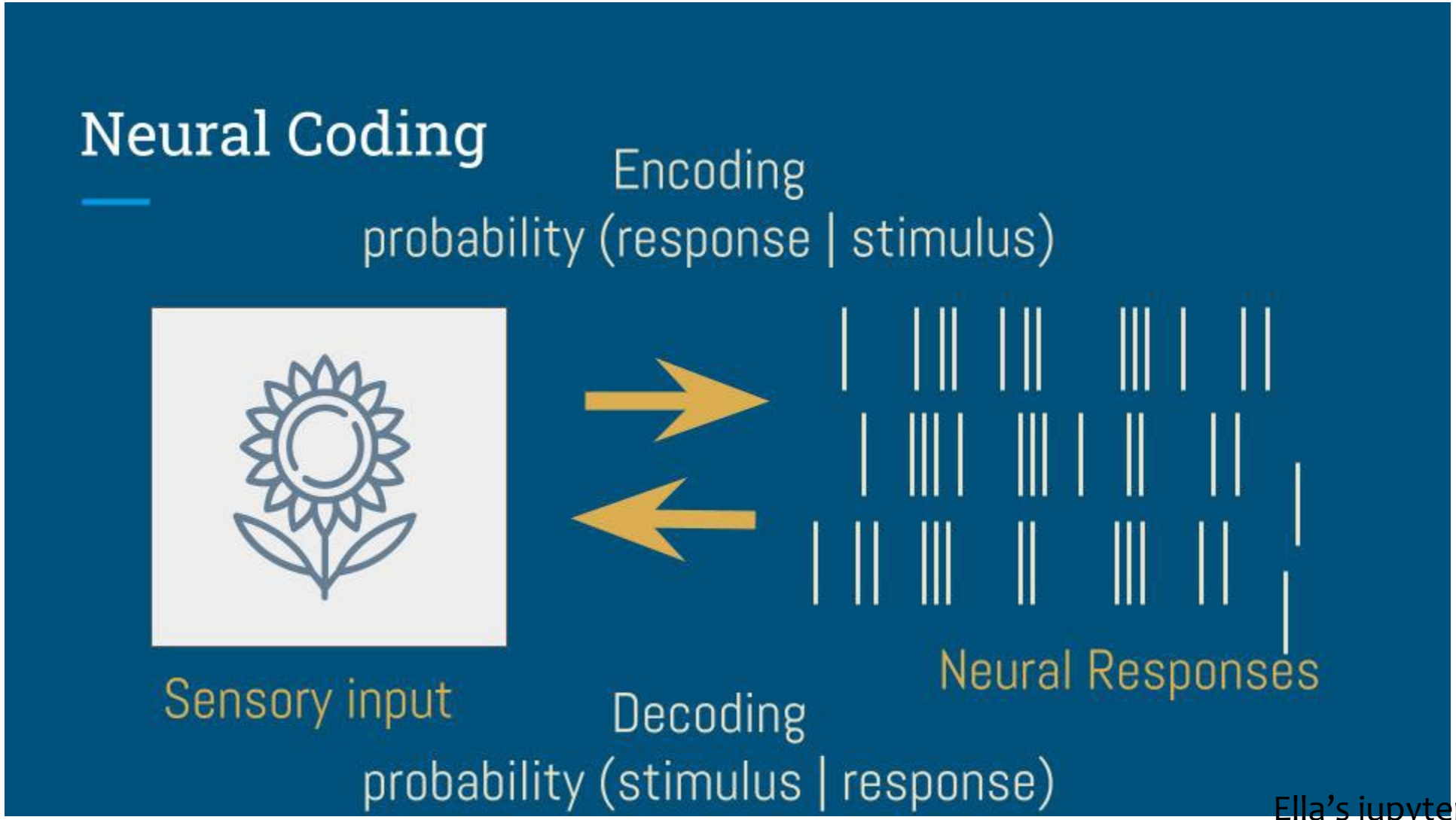
Our Question

- In a neural system, we want to know what the neurons "care about" in the environment.
  - Problem 1, Auditory cortex neuron ~ auditory input.
  - Problem 2, Medial Entorhinal Cortex neurons ~ location, speed, body configuration.

Big Picture



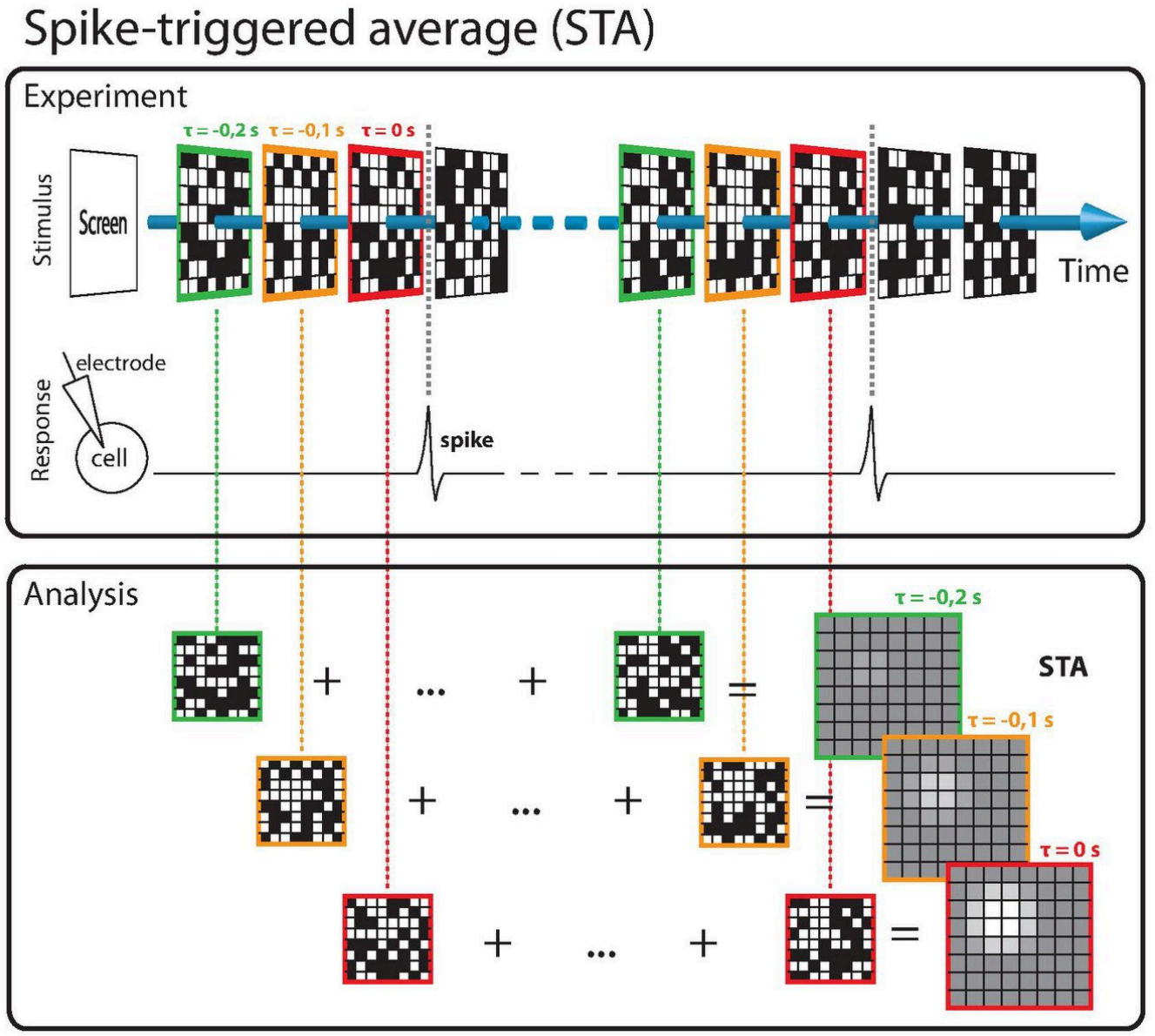
Ella's jupyter book

What's in our pocket?

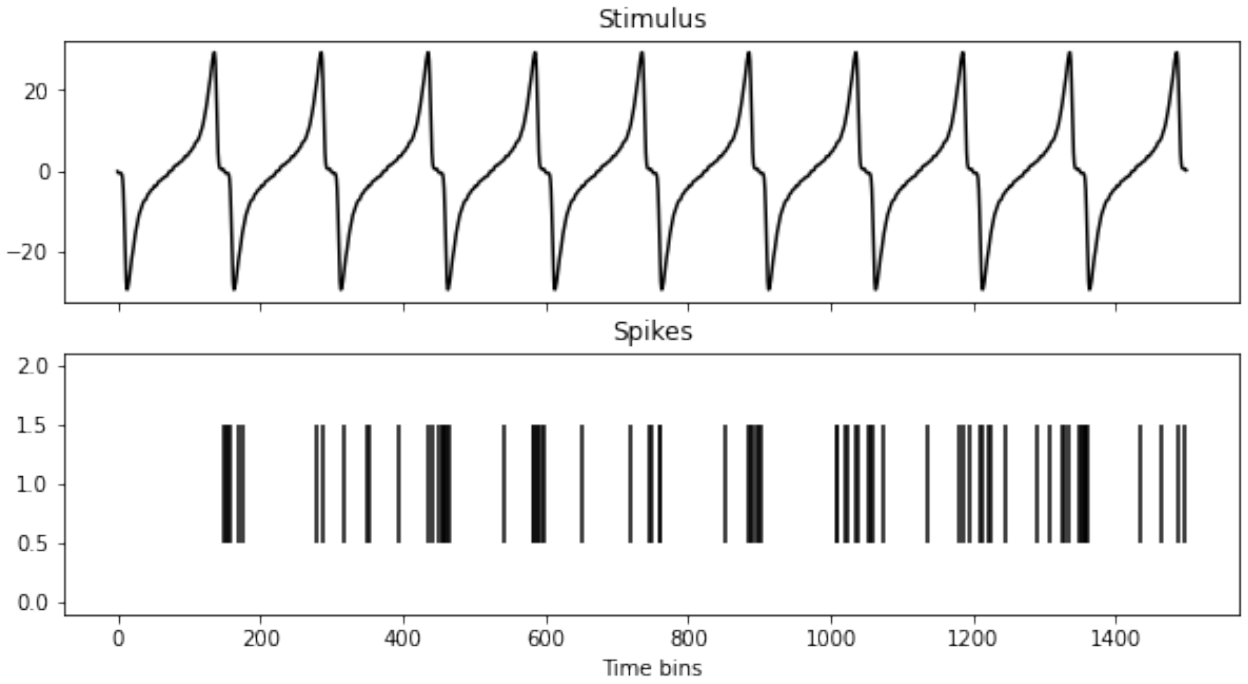
- Spike triggered average
  - Tools: Align the environment to spikes, and average it.
- Encoding: Linear Nonlinear model
  - Tools: generalized linear model, likelihood, MLE, optimization
- Decoding: Linear decoding
  - Tools: regression, cost function, least square

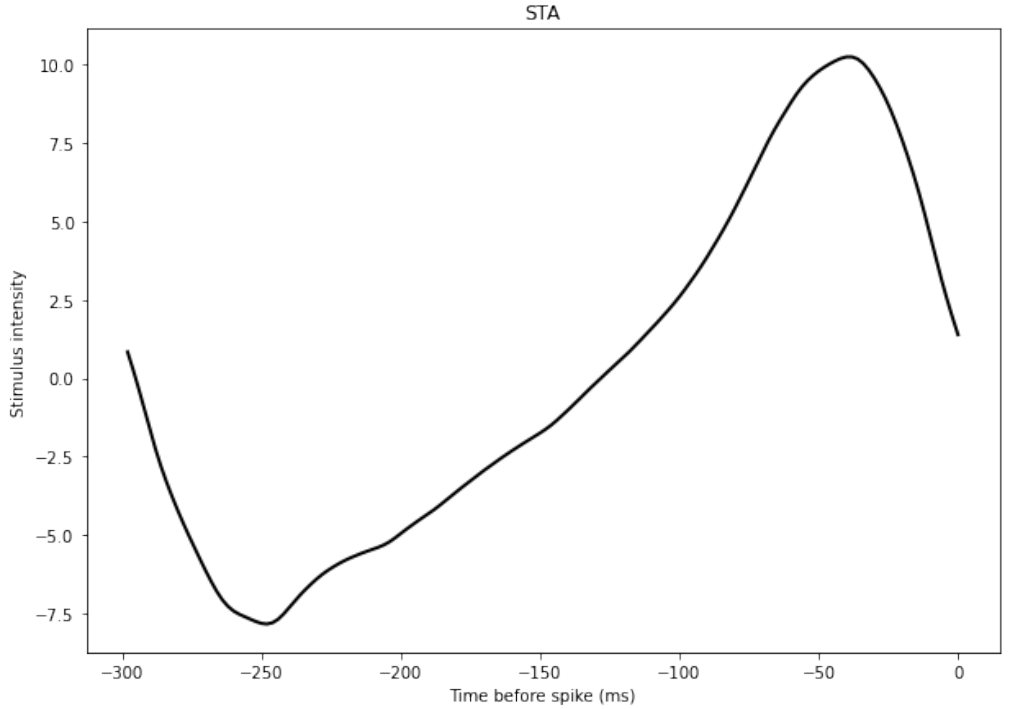
STA

- (Problem 1, f, g)
- Average the (stimulus) context of a spike
  - Movie frames, sound waves, spectrogram, location ……
- What's the requirement for stimulus to use STA?
  - Independent and identially distributed (i.i.d.)
  - White noise



A Counter Example





Natural stimuli are highly correlated, hard for STA to work! (think about face and eyes)

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Encoding model: LNP

- Build the model, mapping features to firing rate using linear nonlinear function. (**Prob 2b**)

$$f: features, kernel \rightarrow spike\ rate$$

$$P(spike|rate) = Poisson(rate)$$

$$P(spike = k|\lambda) = \frac{e^{-\lambda}\lambda^{k}}{k!}$$

Encoding model: LNP

- Calculate the negative log likelihood, use the model above, (**Prob 2c**)

$$\mathcal{L}(kernel; features, spike) = -\log P(spikes|rate)$$
$$= -\log P(spikes|f(featuers, kernel))$$

Encoding model: LNP

- MLE: Infer parameters by minimize the NLL, Prob 2d

$$\hat{\theta} = \arg\max_{\theta} \mathcal{L}(\theta; x, y)$$
$$\hat{\theta} = \arg\min_{\theta} -\log \mathcal{L}(\theta; x, y)$$

- In our case

$$kernel = \arg\min_{kernel} \mathcal{L}(kernel; features, spike)$$

- In Python, `scipy`

$$\text{minimize}(\mathcal{L}, args = (features, spike))$$

- Interpret the result, (Prob 2e)