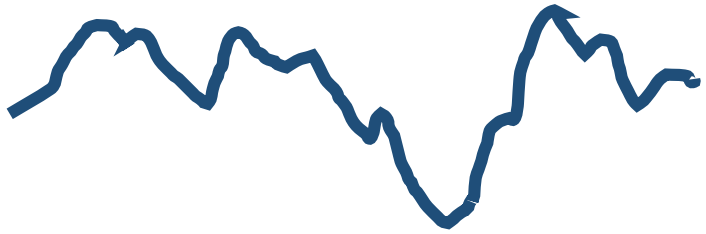
Decoding stimulus information from neural activity: part 2

Bi23: Methods in Neural Data Analysis

2/22/2019

Neural decoding

Stimulus feature **(x)**

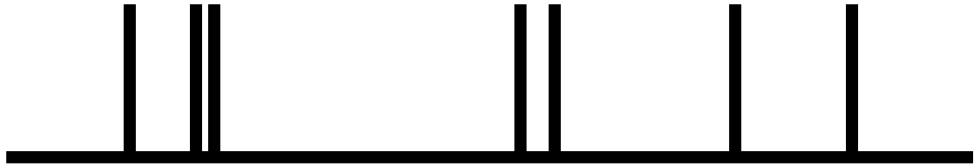


time →

Decoding model

P (x | y)

Recorded spikes **(y)**



time →

Given the observed spiking "y", what stimulus/behavior "x" is present?

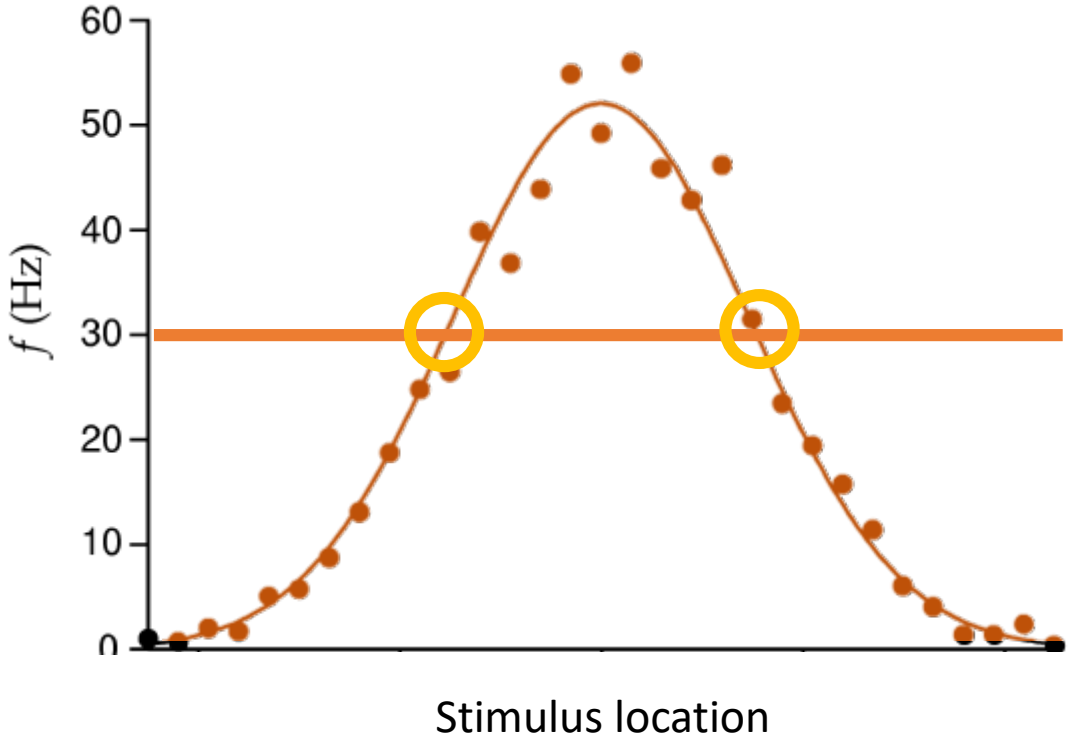
Decoding from a single neuron

?

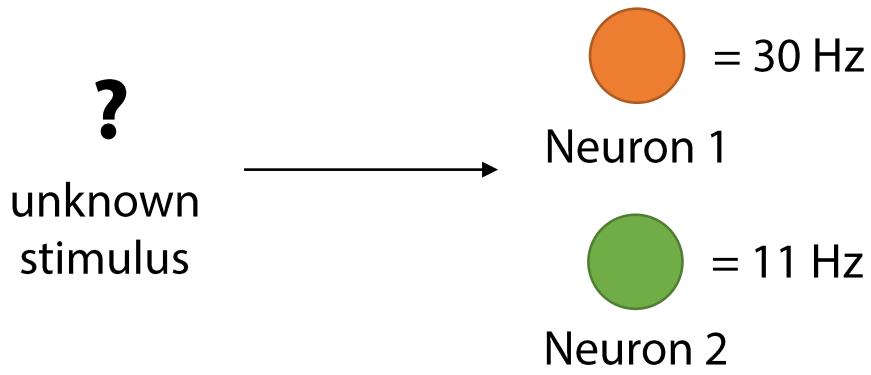
unknown stimulus

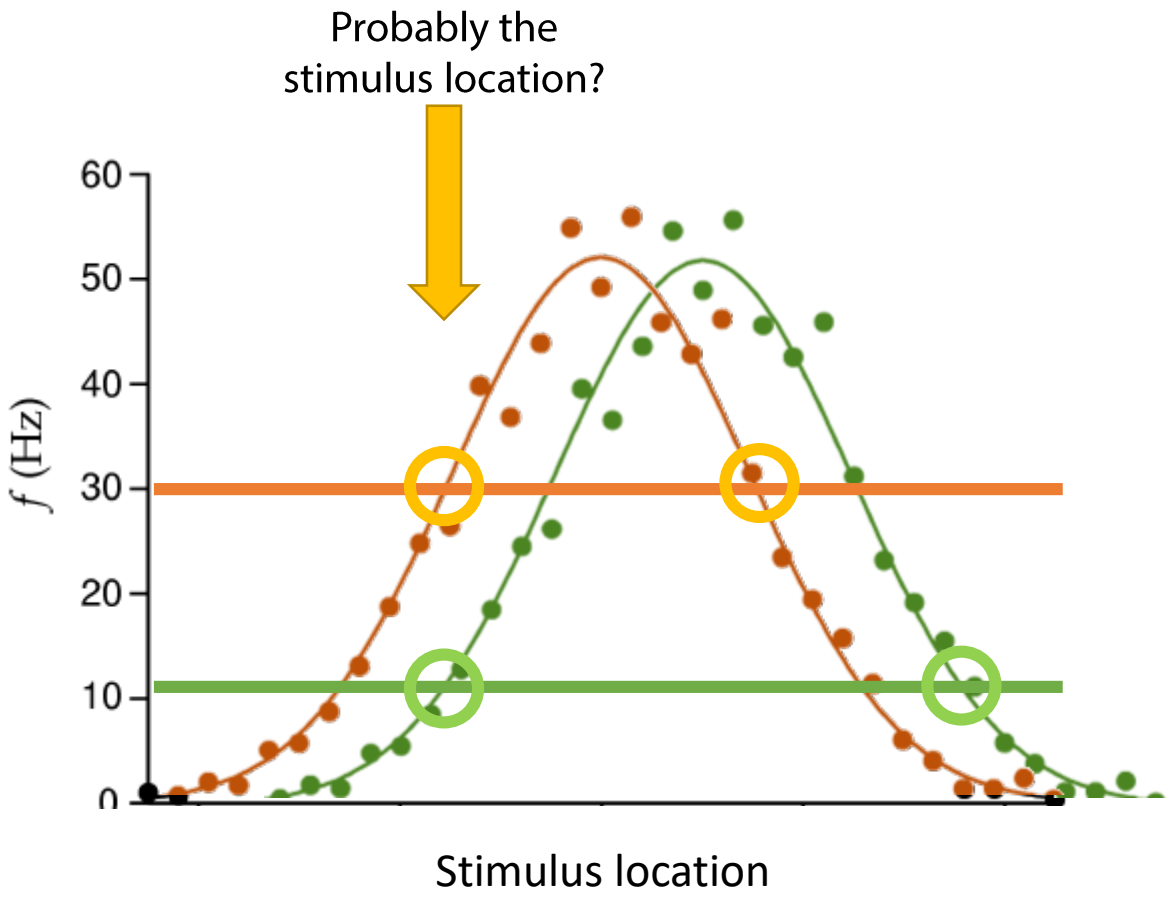
= 30 Hz

Neuron 1



Decoding from multiple neurons





A Bayesian perspective on decoding

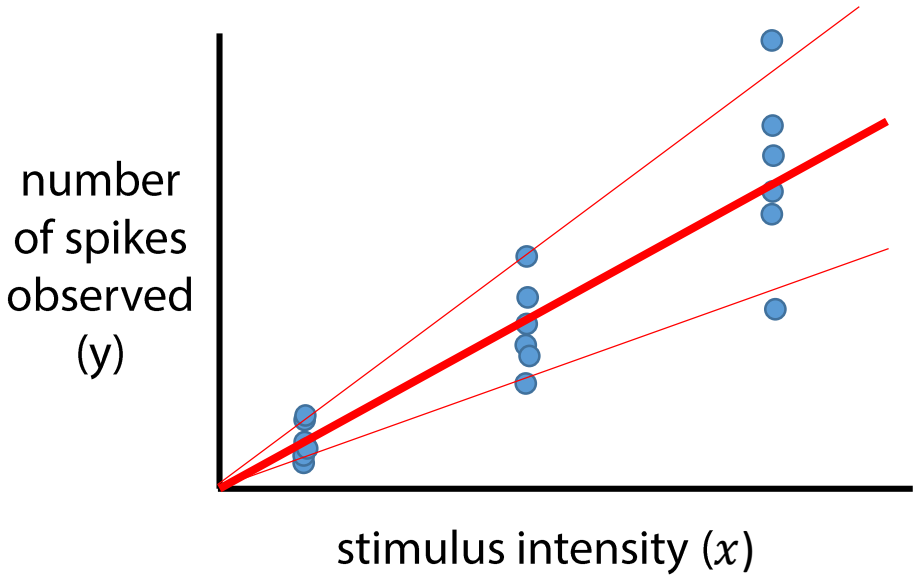
Likelihood $P(y|x,\theta)$

stimulus "x"
spiking "y"
parameter(s) "θ"

"How likely it is the neuron fires *k* spikes given which stimulus the animal saw."

Posterior $P(x|y,\theta)$

"How likely it is the animal saw a certain stimulus given the observed neuron's spiking."



(a Poisson GLM) :

Predicted spike distribution $y \sim Poiss(\lambda)$

Underlying spike rate $\lambda = \theta x$

A Bayesian perspective on decoding

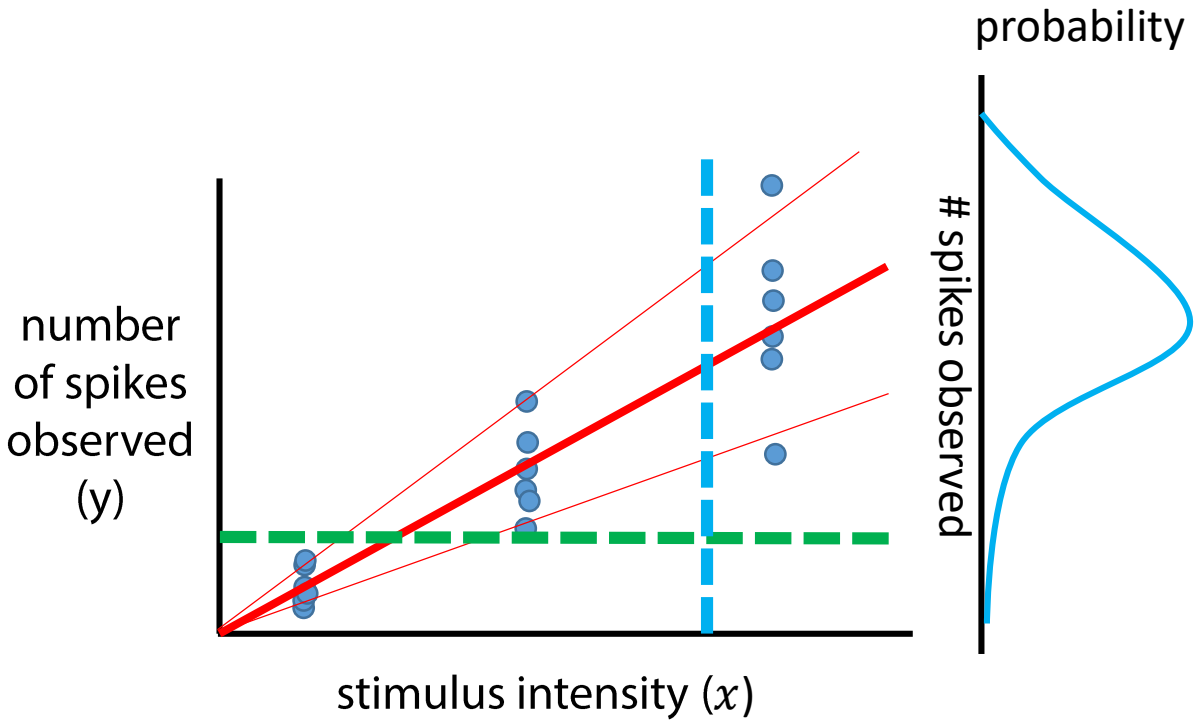
stimulus "x"
spiking "y"
parameter(s) "θ"

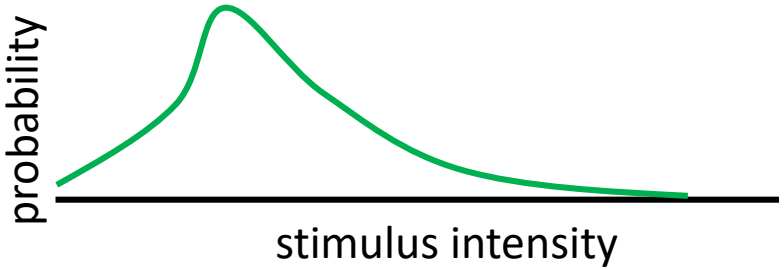
Likelihood $P(y|x,\theta)$

"How likely it is the neuron fires *k* spikes given which stimulus the animal saw."

Posterior $P(x|y,\theta)$

"How likely it is the animal saw a certain stimulus given the observed neuron's spiking."





A Bayesian perspective on decoding

Likelihood $P(y|x,\theta)$

stimulus "x"
spiking "y"
parameter(s) "θ"

"How likely it is the neuron fires *k* spikes given which stimulus the animal saw."

Posterior $P(x|y,\theta)$

"How likely it is the animal saw a certain stimulus given the observed neuron's spiking."

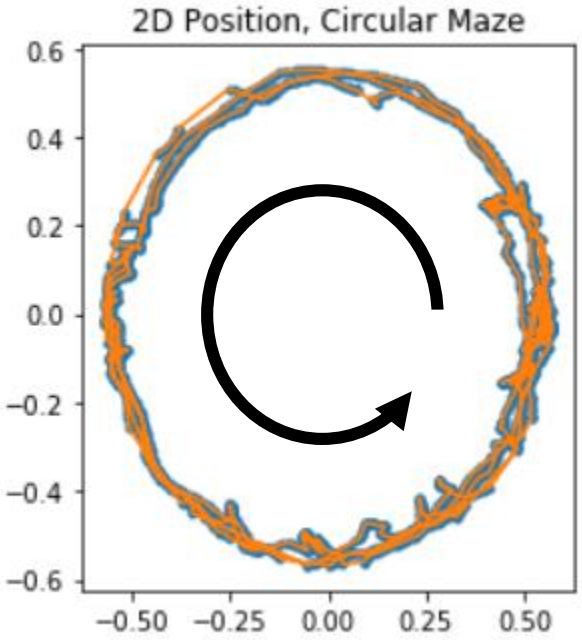
Bayes' theorem

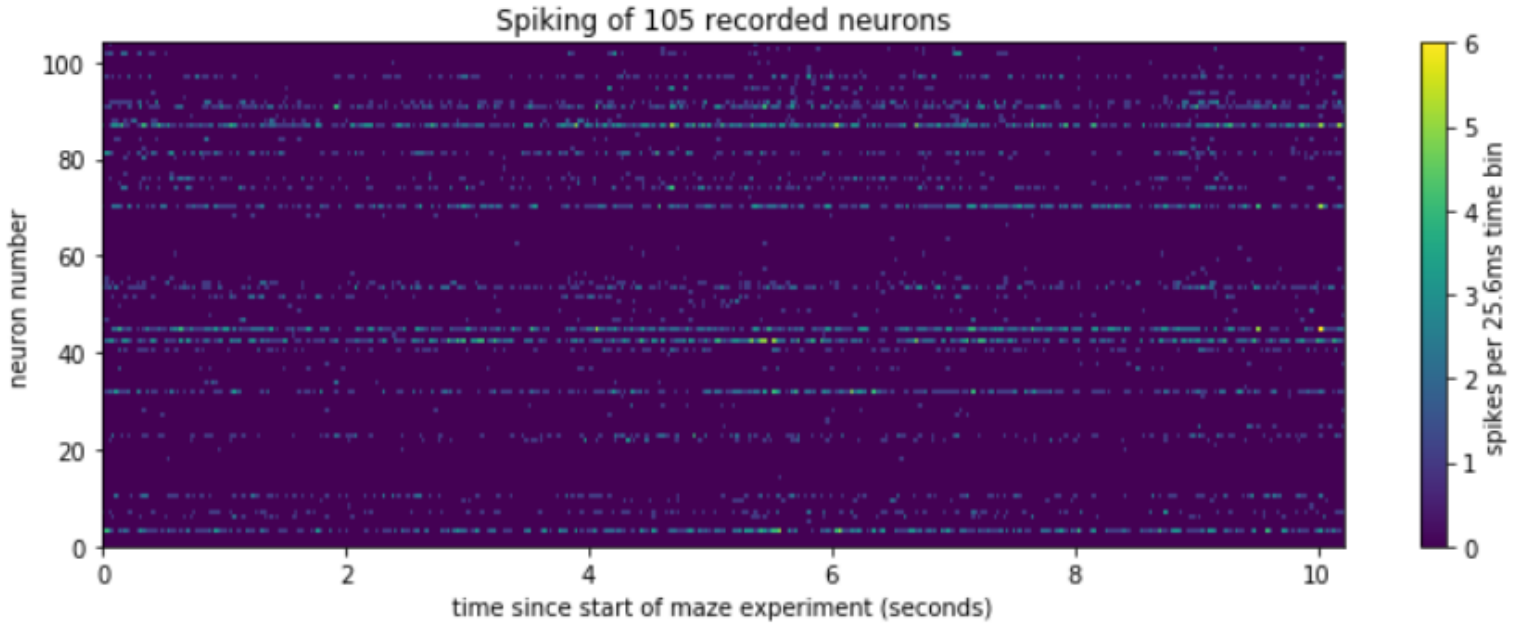
$$P(x|y,\theta) = \frac{P(y|x,\theta)\,P(x)}{P(y)}$$

Prior over stimuli

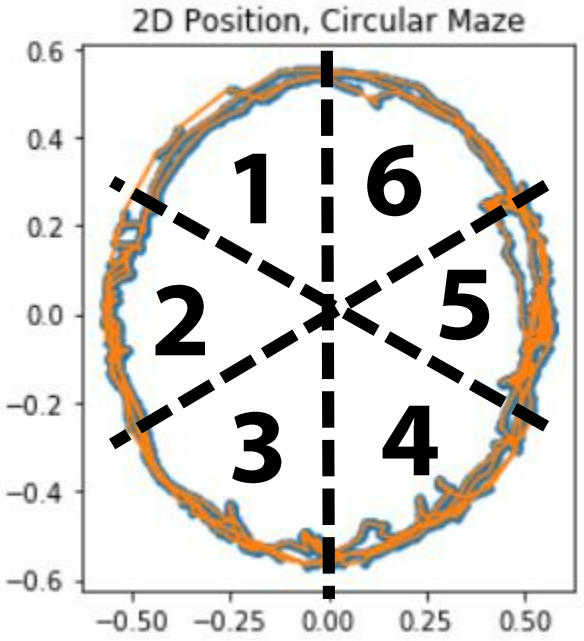
"Evidence"
(usually omitted)

Decoding position from the hippocampus

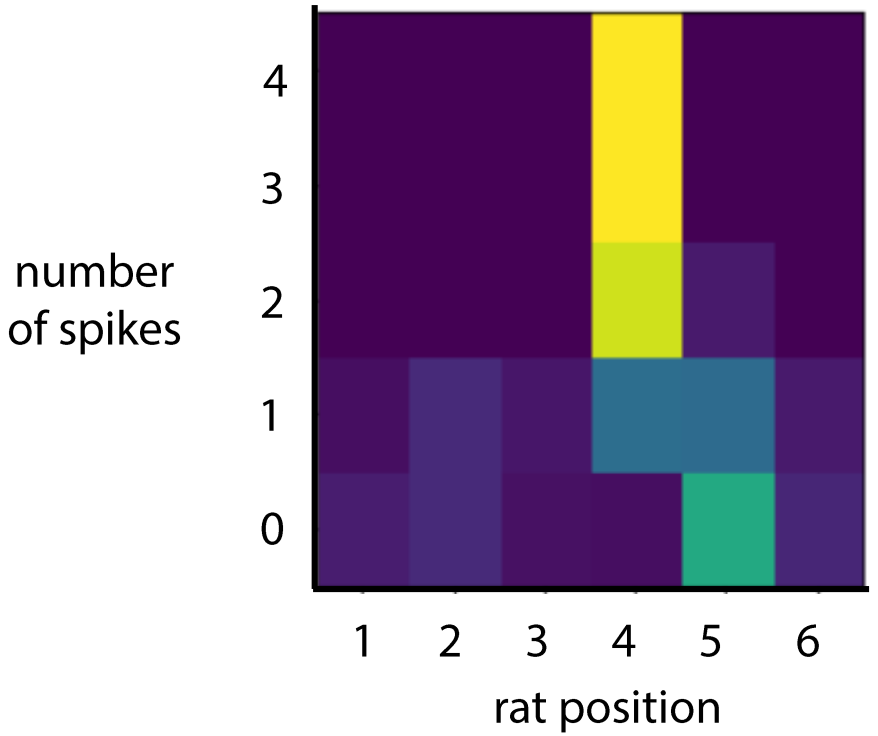




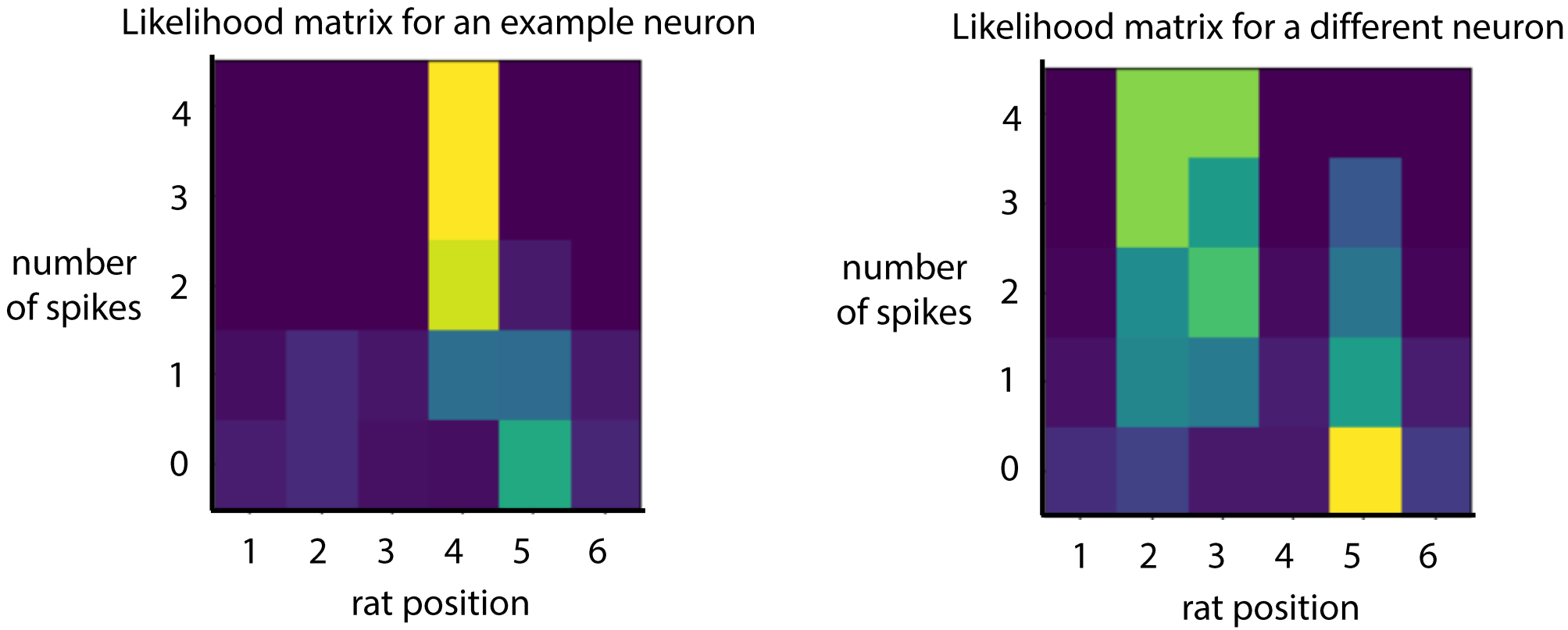
Computing the likelihood for one neuron



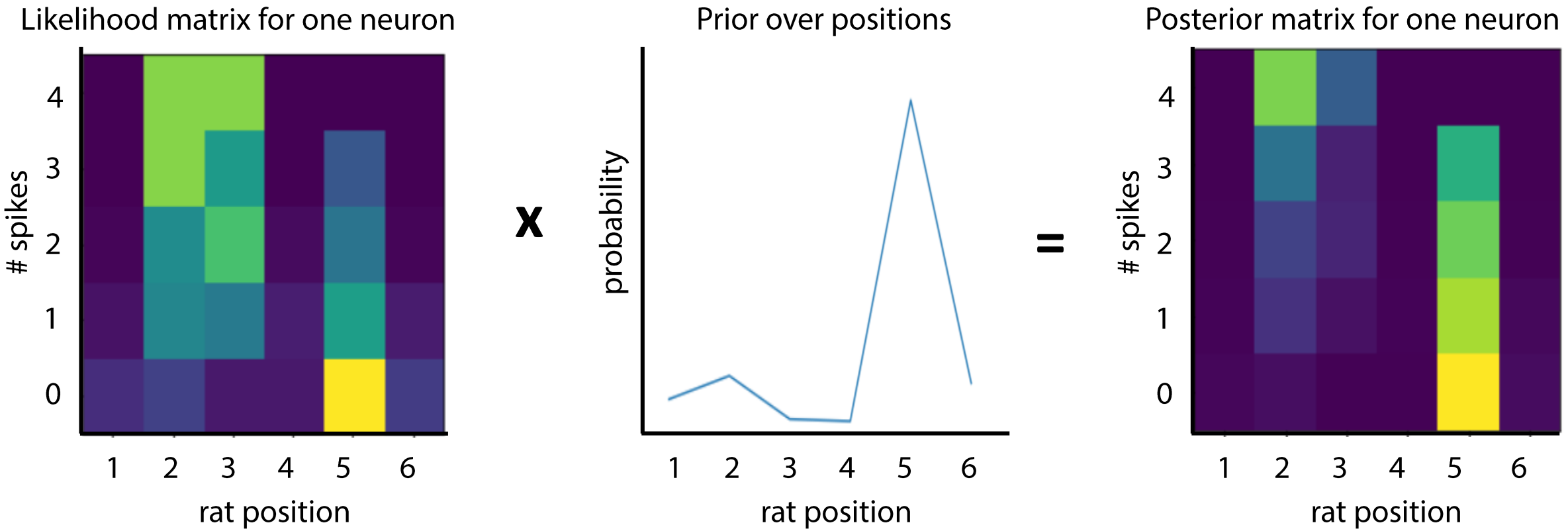
Likelihood matrix for an example neuron



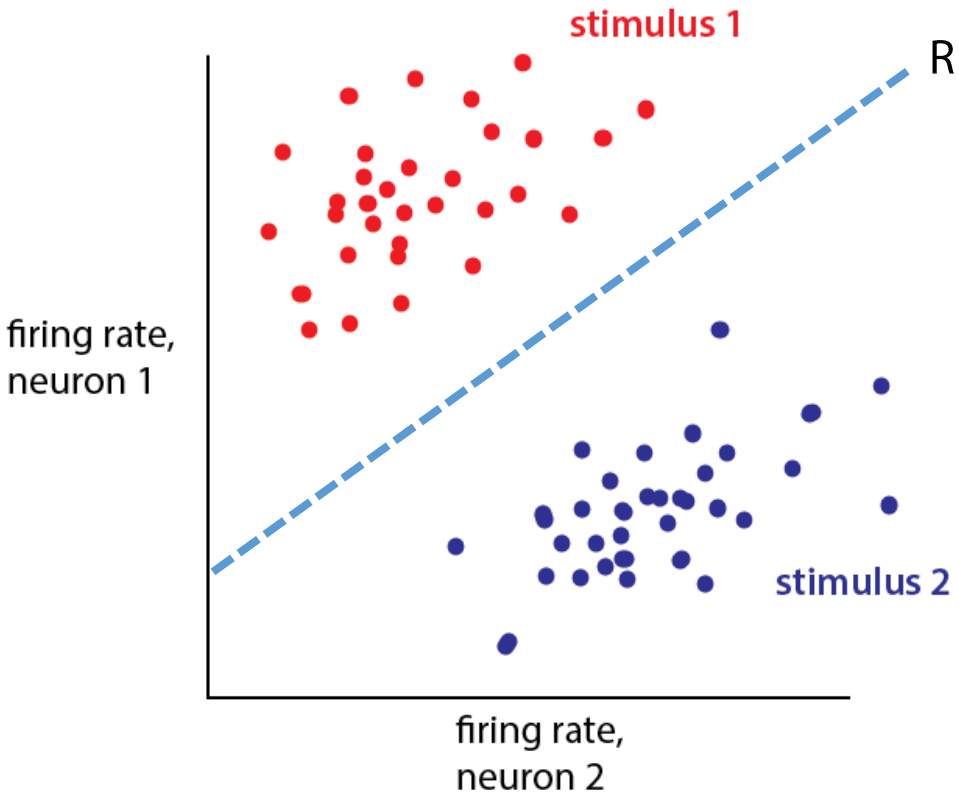
Interpreting the likelihood



Computing the posterior



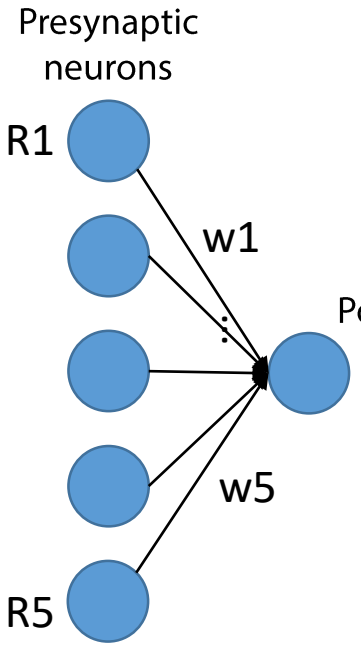
Binary decoding



$R1 = w * R2 + b$

$R1 > w*R2 + b \rightarrow$ **stimulus 1**

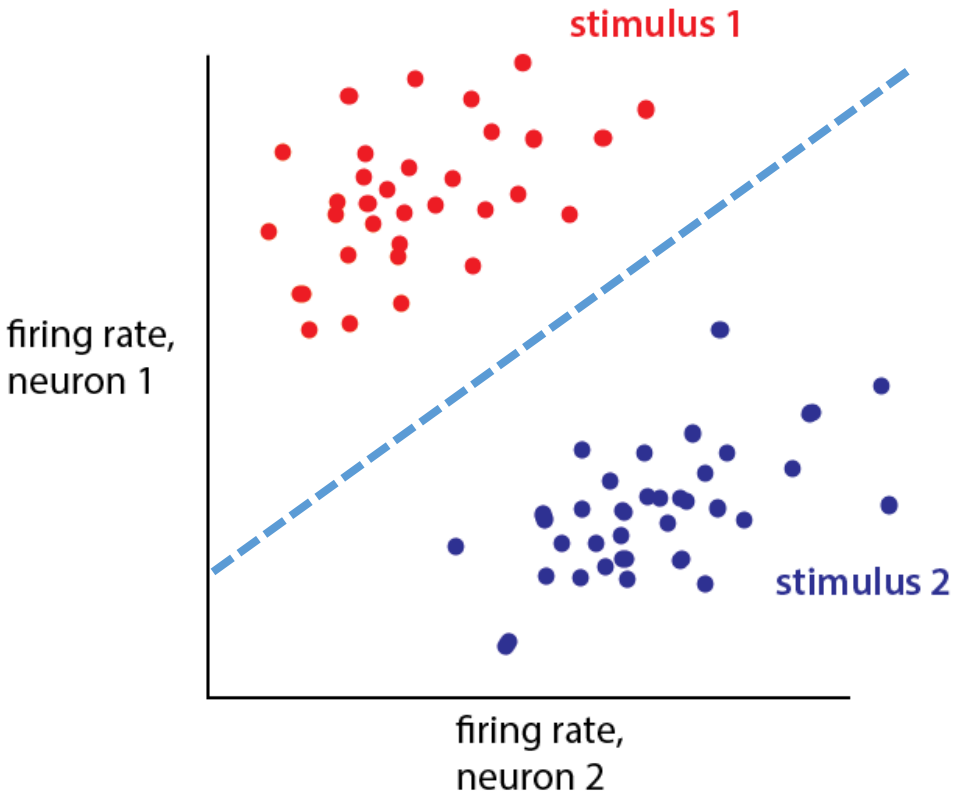
$b < w*R2 - R1$



***Spike if*:**

$w1*R1 + w2 * R2 + \ldots + w5 * R5 > b$

Binary decoding: Fisher's Linear Discriminant Analysis



Goal: find *w*'s to maximize separability (*S*):

$$S = \frac{\sigma^2_{\text{between}}}{\sigma^2_{\text{within}}}$$

$$= \frac{(\vec{w} \cdot \vec{\mu}_1 - \vec{w} \cdot \vec{\mu}_0)^2}{\vec{w}^T \Sigma_1 \vec{w} + \vec{w}^T \Sigma_0 \vec{w}}$$

$$\vec{w} \propto (\Sigma_0 + \Sigma_1)^{-1} (\vec{\mu}_1 - \vec{\mu}_0)$$