Neural Data Analysis

URP 2024, CiCi Zheng, 07/10/24

Agenda Today

Part 1 (45 min):

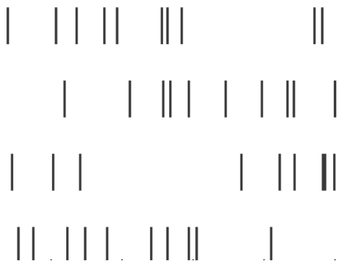
- Explore multivariate data in neural behavioral experiments

Part 2 (45 min):

- Introduce classical models for neural encoding

Some common problems in neuroscience

Stimulus, ***x***



Neural response, ***y***

Depending on the brain region and the input:

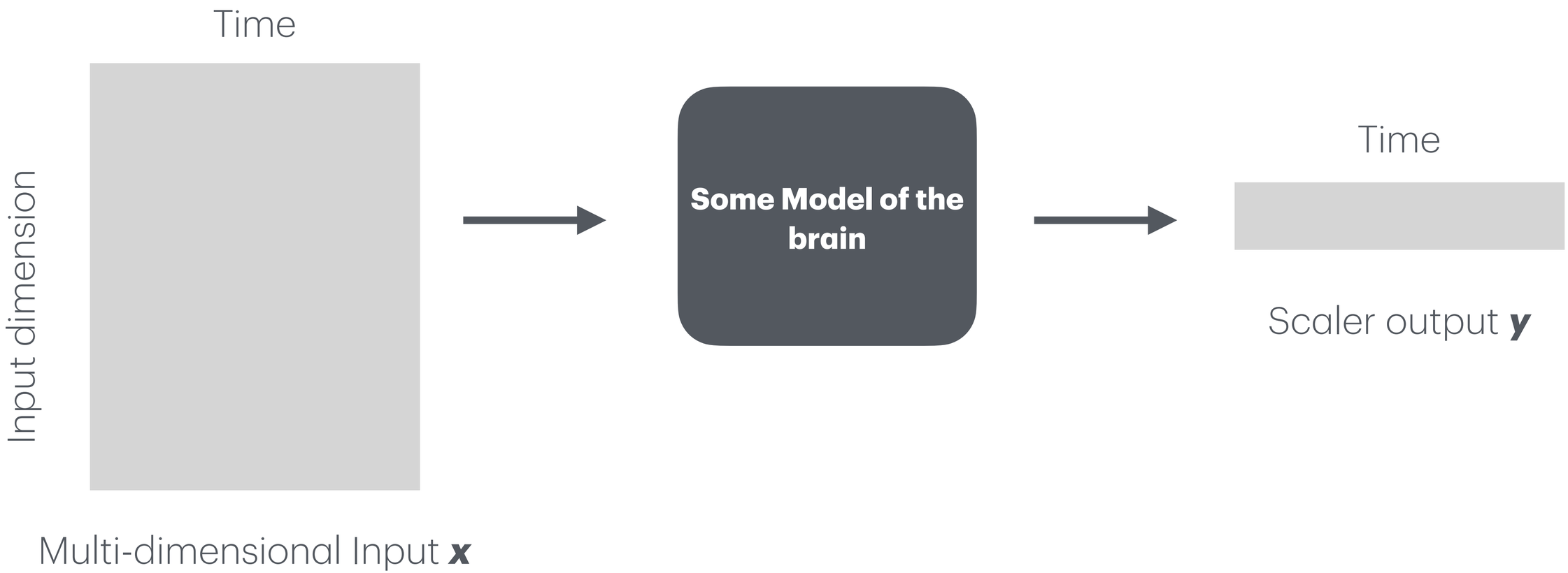
"A horse!"

"Position and speed"

"Place the bet!"

... ...

A common formulation



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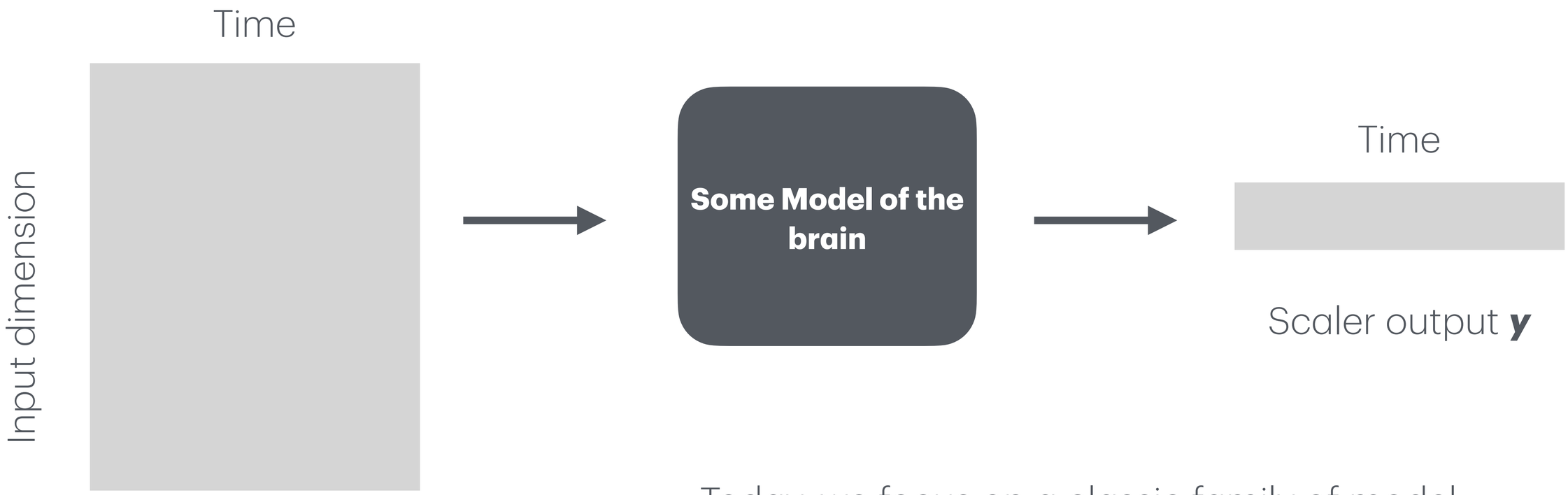
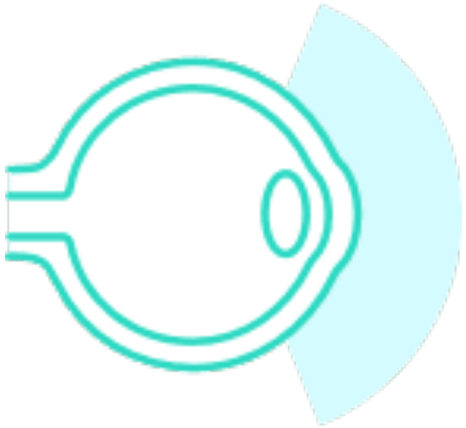


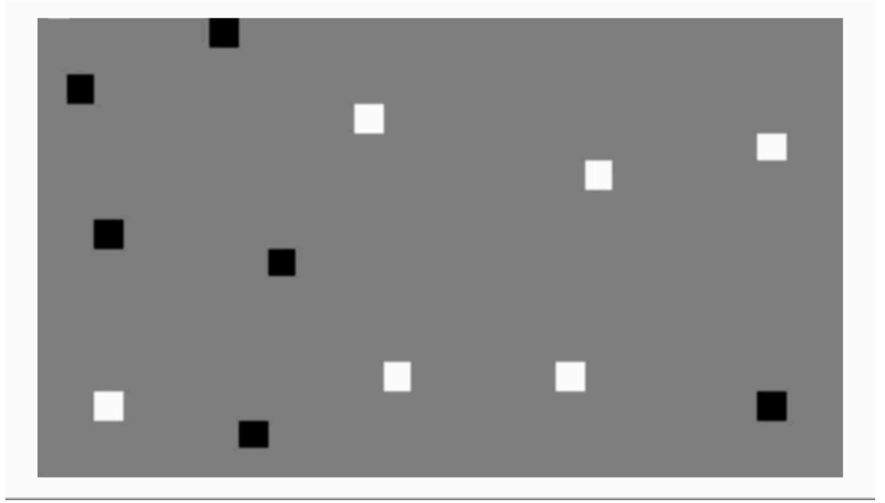
Multi-dimensional Input ***x***

Today, we focus on a classic family of model which can handle many output forms: the **generalized linear models** (GLMs)

An example research question:

“How temporally precise is our early visual system at tracking/encoding the luminous signals?”





Input: "full-field flicker”

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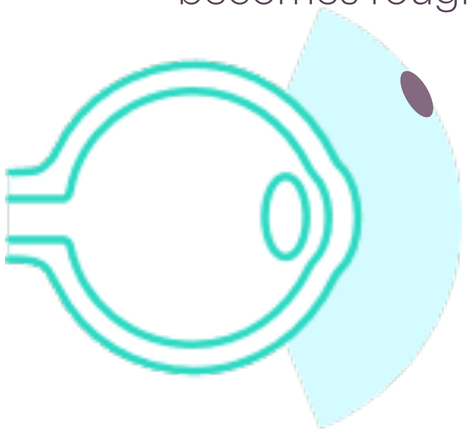
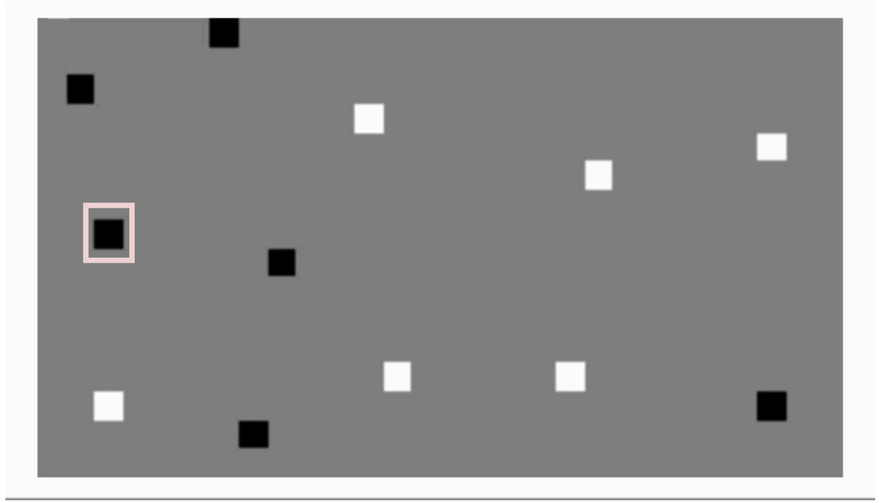
Focus on one retinal ganglion cells' center receptive field, input becomes roughly 1D





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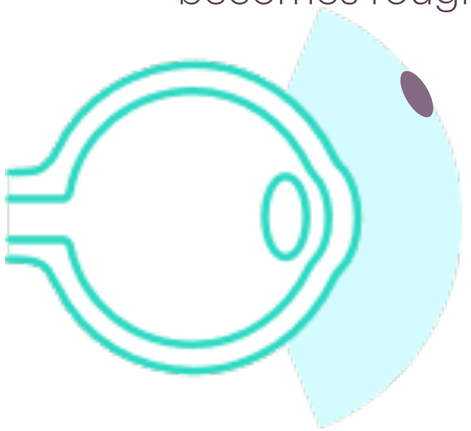
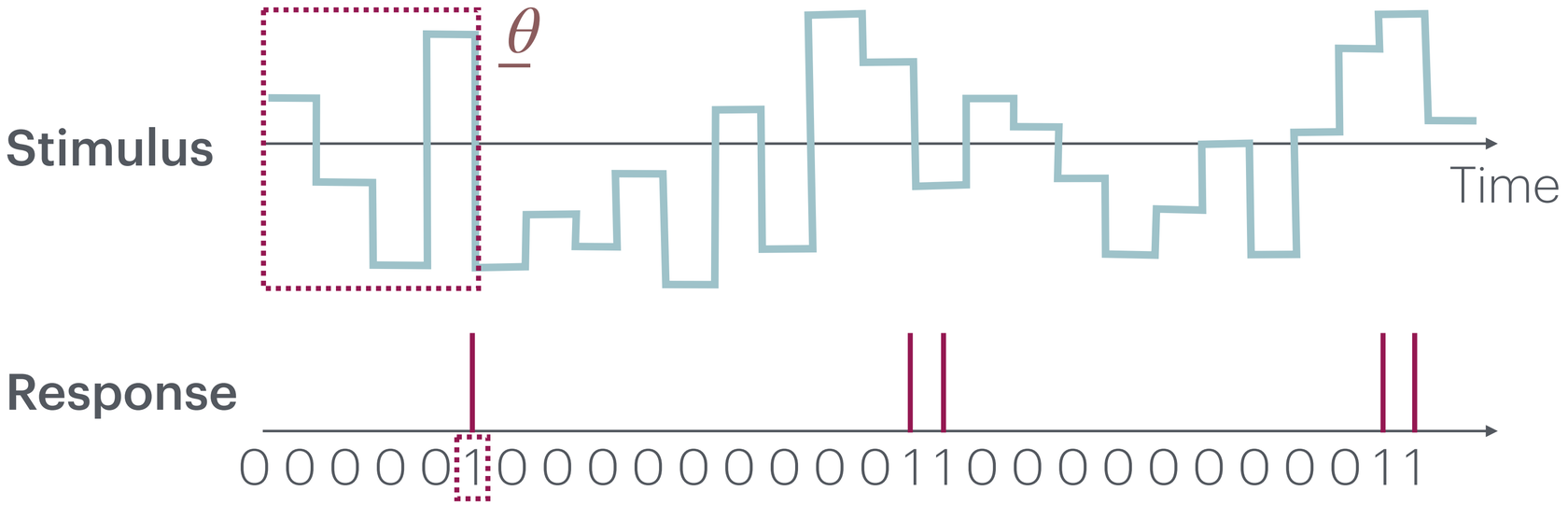


- Let's consider random discrete input for the demo:



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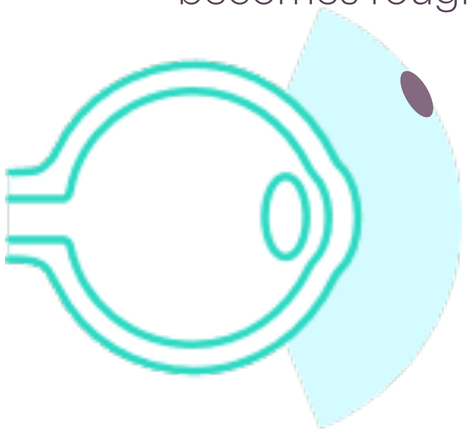

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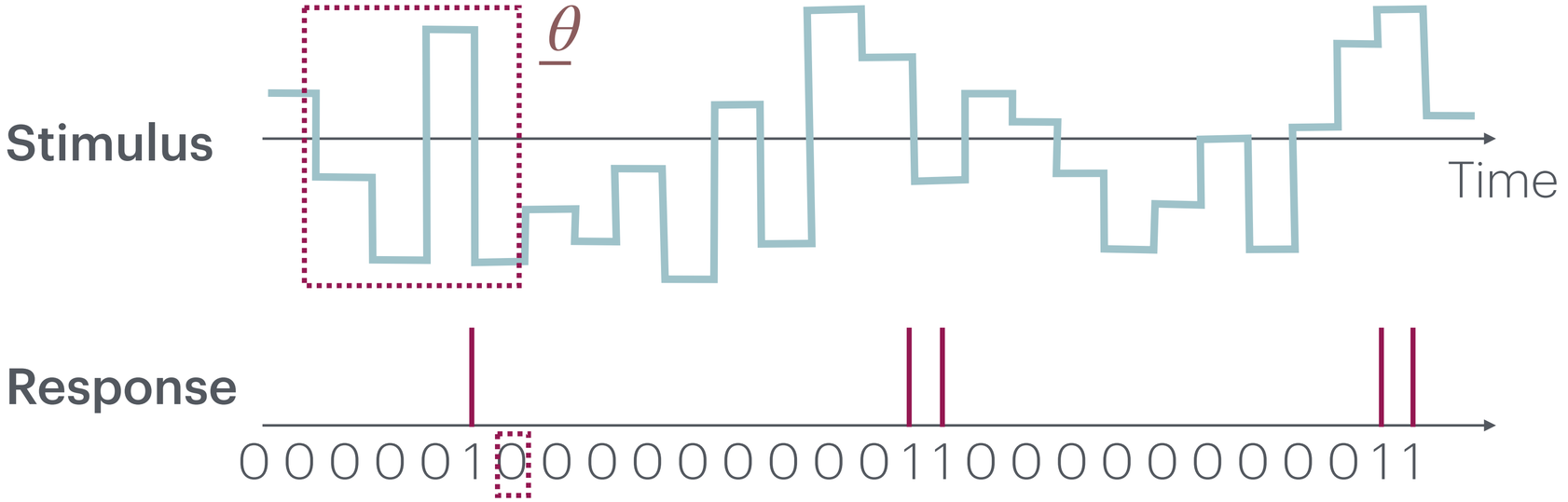

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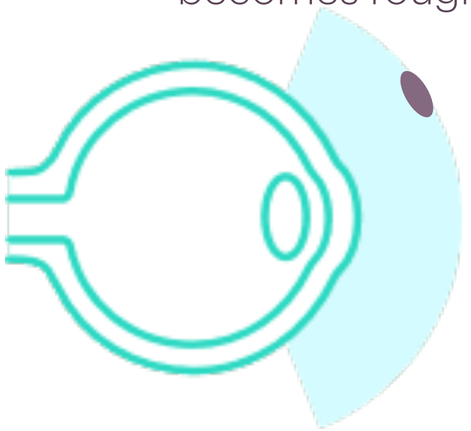

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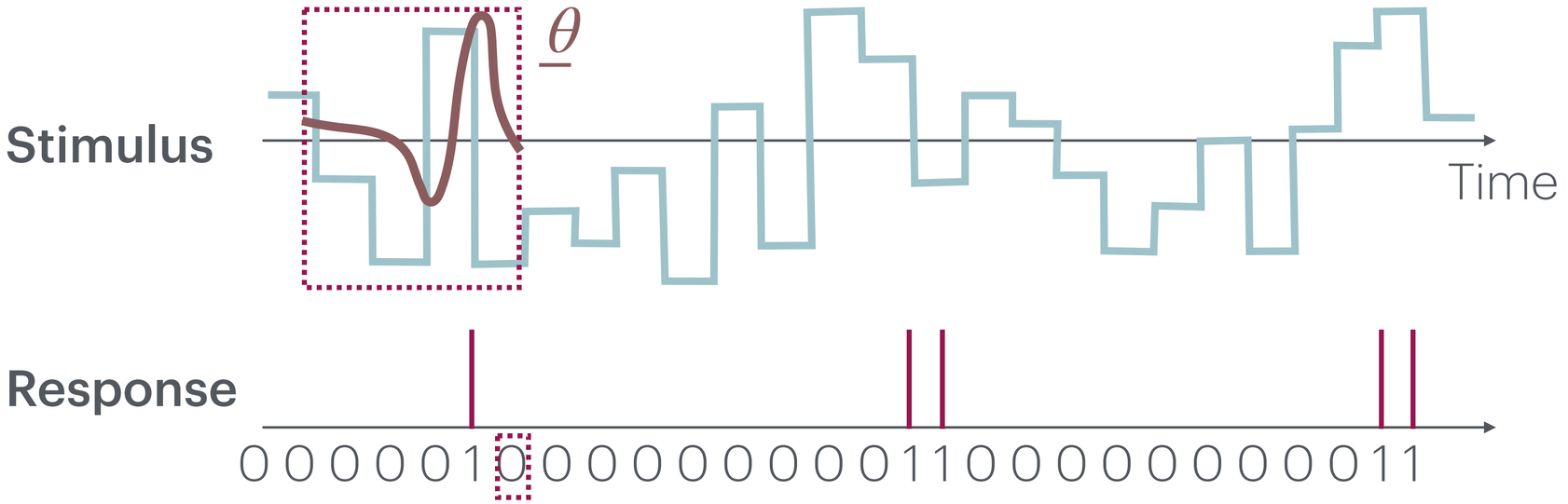

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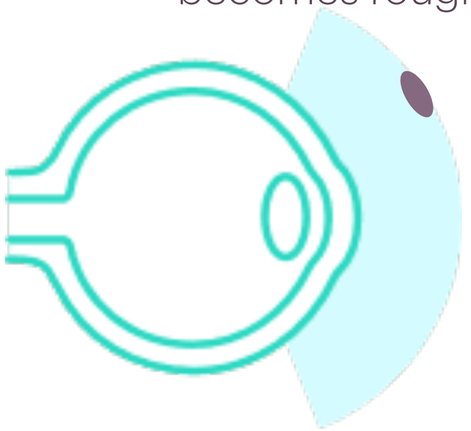

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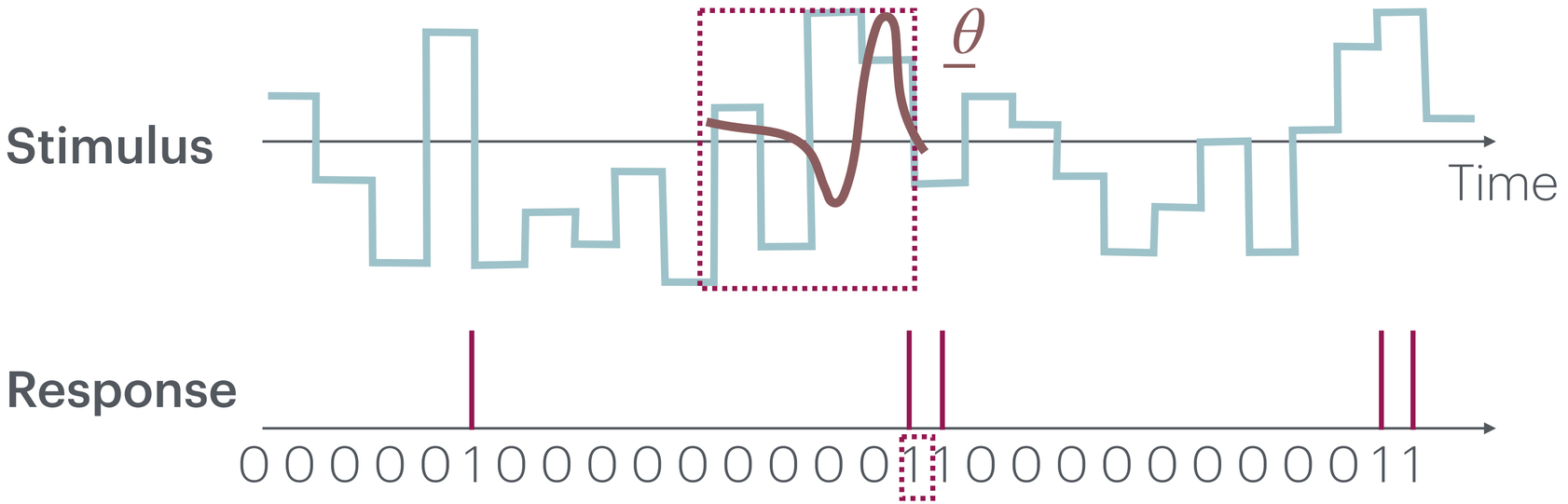

Firing rate $y_t = \underline{\theta}^T \underline{x}_t = \sum_{i=0}^{d-1} \theta_i x_{t-i}$

Linear filter Vector of past stimuli in window *d* at time *t*

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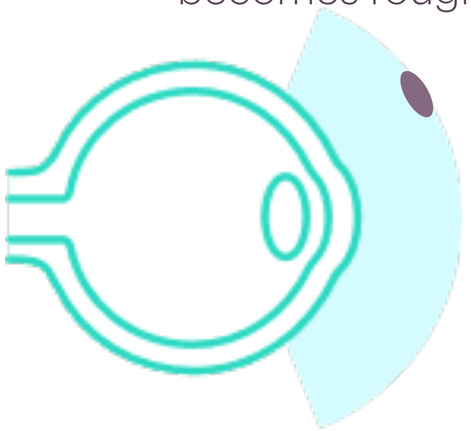

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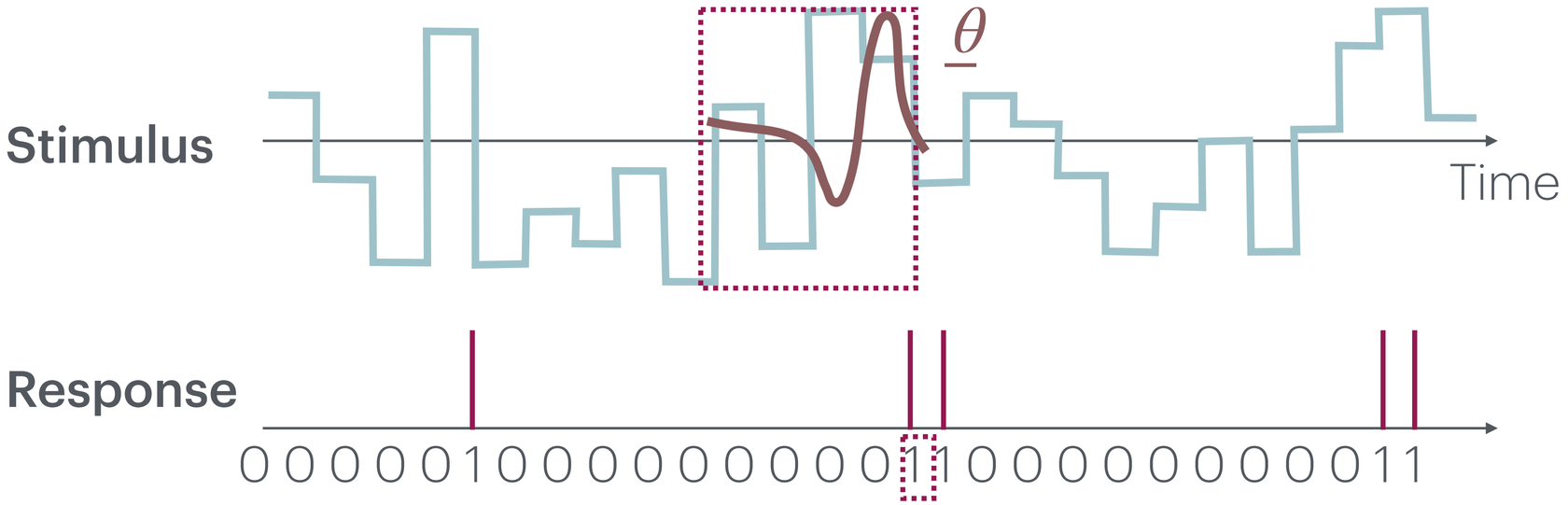
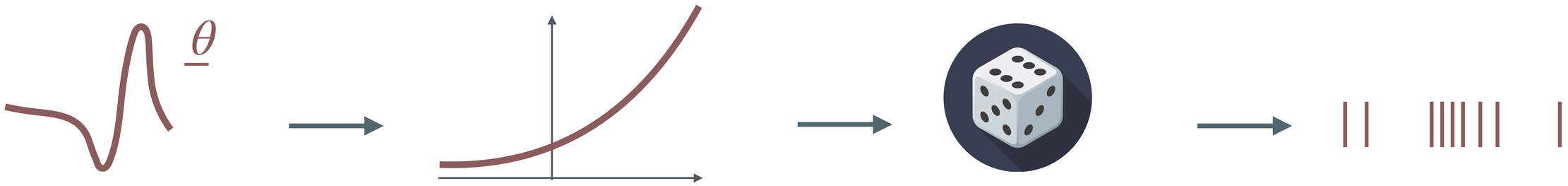


A slightly more sophisticated model would take into the account of output being 1) discrete; 2) non negative — the Poisson GLM model

$$y_t = \underline{\theta}^T \underline{x}_t = \sum_{i=0}^{d-1} \theta_i x_{t-i}$$

Poisson GLM



Stimulus filter

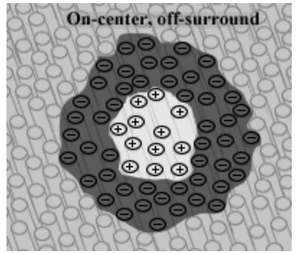
Non- linearity

Stochastic spiking

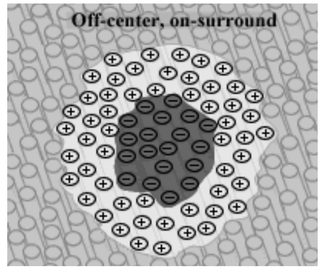
Spikes

Let's look at some real neural data!

(Uzzell & Chichilnisky, 2004)

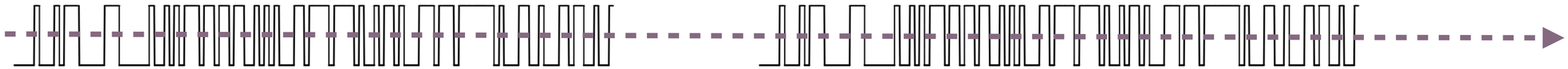


ON



OFF

Stimuli



Response