COMS30017
Computational Neuroscience

Week 3 / Video 4 / Analysing spike data

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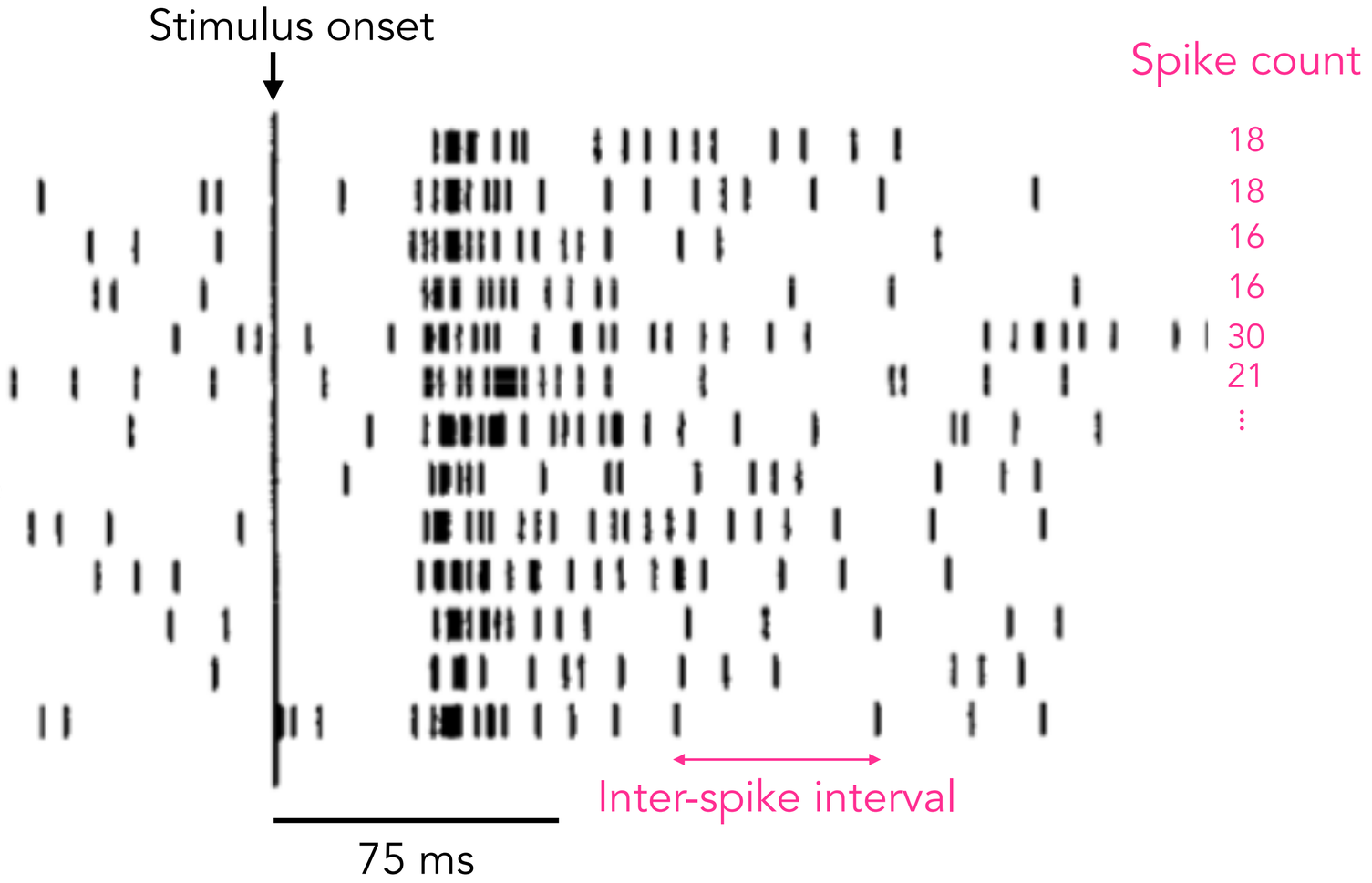
Intended learning outcomes

- Understand the basic analyses done on spike trains.
- Be able to explain the mathematics underlying CV, Fano Factor, Spike-triggered average.

Spike trains

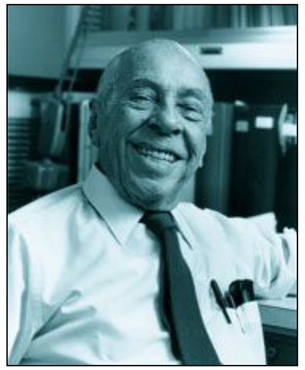
- Shown right is a “raster plot” from a single neuron recording in monkey visual cortex.
- Each tick is a spike.
- Each row plots the neuron’s spike train vs time for a differential repeated ‘trial’.
- The visual stimulus is identical in each case but the neuron’s response has a high degree of trial-to-trial variability.
- The inter-spike interval and the spike count are two measures of neural response.



[Motter, *J Neurophysiol*, 1993]

Analysing spiking data

- Fano factor
- Coefficient of variation
- Peri-stimulus time histogram (PSTH)
- Spike-triggered average (STA)



Ugo Fano

Fano Factor

- The Fano Factor is a statistical measure of the *dispersion* of a probability distribution.

- In neuroscience it is typically used to quantify the variability of spike trains.

- It the variance of the spike count divided by the mean spike count:

$$F = \frac{\sigma^2}{\mu}$$

- Importantly it usually applied to the **spike counts** over some time interval (not the interspike intervals).

Coefficient of variation (CV)

- A different measure of variability is the coefficient of variation (CV).
- It is the standard deviation of the interspike interval divided by the mean interspike interval:

$$CV = \frac{\sigma_{ISI}}{\mu_{ISI}}$$

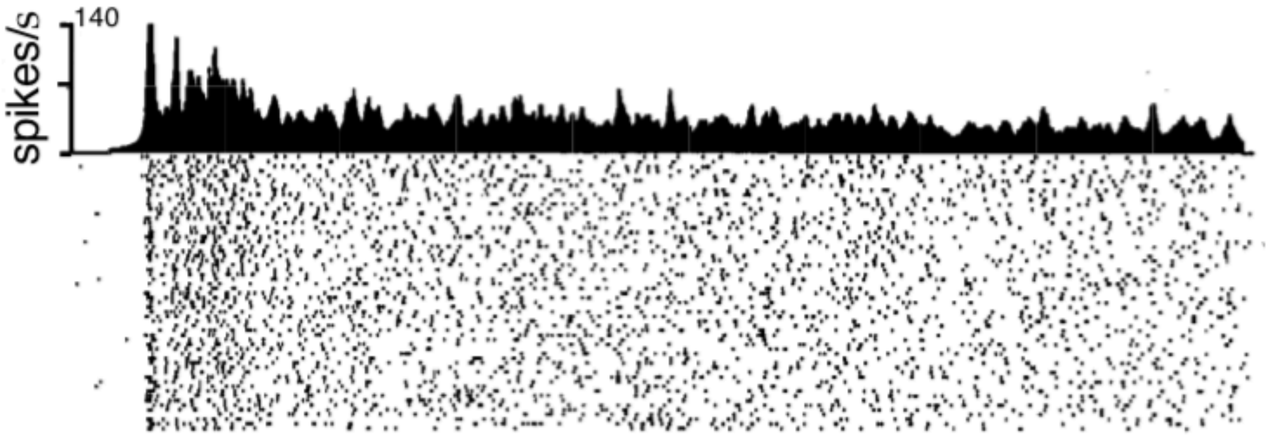
- In contrast to the Fano Factor, it is usually applied to the **interspike intervals** (not the spike counts).

Peri-stimulus time histogram (PSTH)

- Neural responses to stimuli are variable, meaning they are not always identical from trial to trial (repeated presentations of the same stimulus).

- The peri-stimulus time histogram is one way to represent the average spike response across trials.

- The idea is:
  - Superimpose the neuron's spike responses from multiple trials.
  - Bin time into small intervals (e.g. 2 ms).
  - Histogram the spike counts in each time bin.



[Dayan & Abbott, 2001]

Spike-triggered average

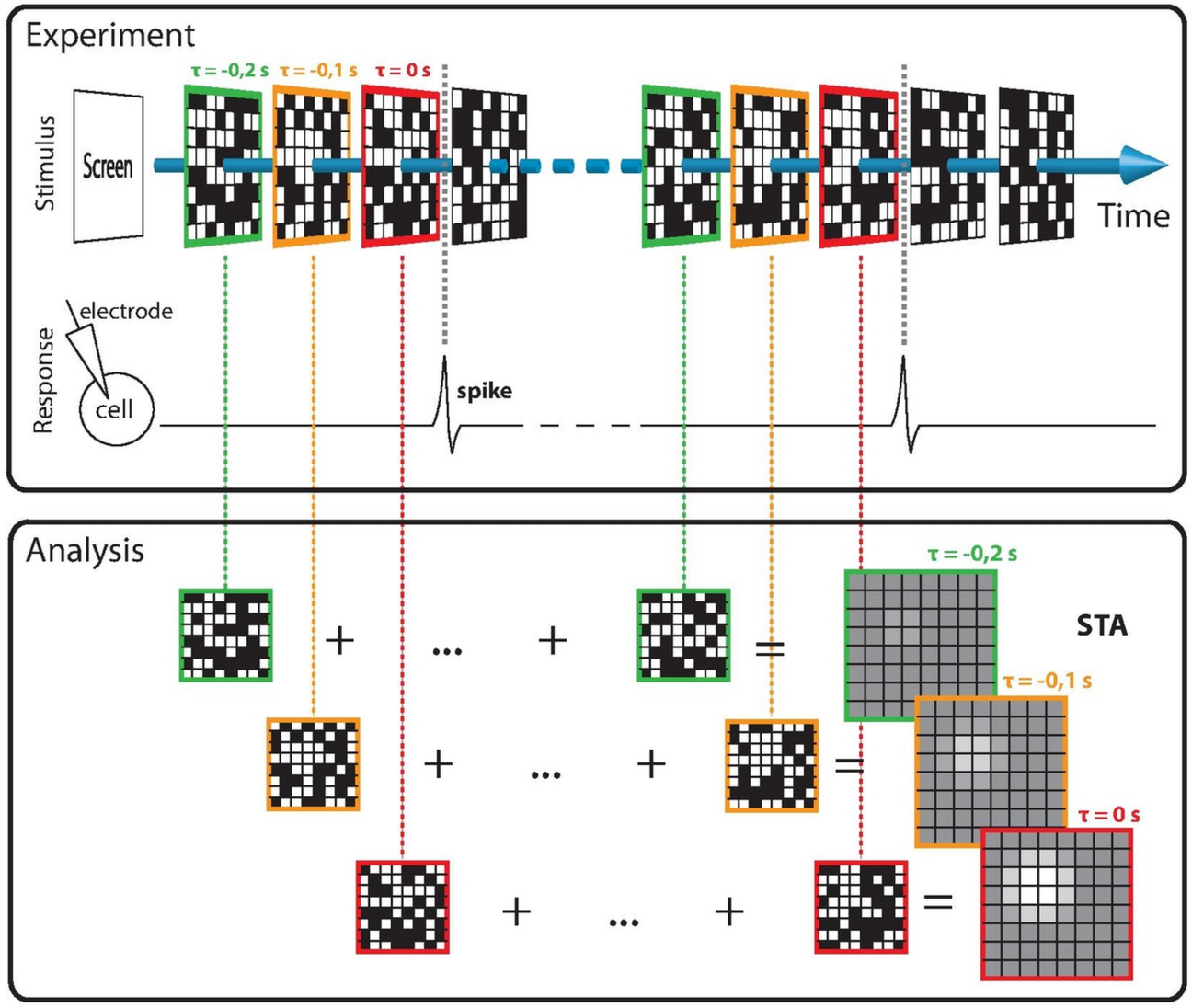
- Another way of analysing the data is to ask the question: what aspect of the stimulus caused the neuron to spike?

- One way of quantifying this is the spike-triggered average stimulus:

$$S(\tau) = \frac{1}{N} \sum_{i=1}^{N} s(t_i - \tau)$$

where $s(t)$ is the stimulus value, t_i's are spike times and τ is a time interval.

Spike-triggered average (STA)



https://upload.wikimedia.org/wikipedia/commons/2/2c/Illustration_diagram_for_the_Spike-triggered_average.pdf

Summary

- Spike trains are unusual objects for analysis.
- Neuroscientists have adopted several statistical measures for quantifying them and their relation to external variables (e.g. sensory stimuli).