Week 6 – part 5 : Rate Codes versus Temporal Codes

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Neuronal Dynamics:
Computational Neuroscience of Single Neurons

Week 6 – Noise models:

Escape noise

Wulfram Gerstner

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- √ **6.1 Escape noise**
  - stochastic intensity and point process
- √ **6.2 Interspike interval distribution**
  - Time-dependend renewal process
  - Firing probability in discrete time
- √ **6.3 Likelihood of a spike train**
  - generative model
- √ **6.4 Comparison of noise models**
  - escape noise vs. diffusive noise
- **6.5. Rate code vs. Temporal Code**
  - timing codes
  - stochastic resonance

Week 6 – part 5 : Rate Codes versus Temporal Codes

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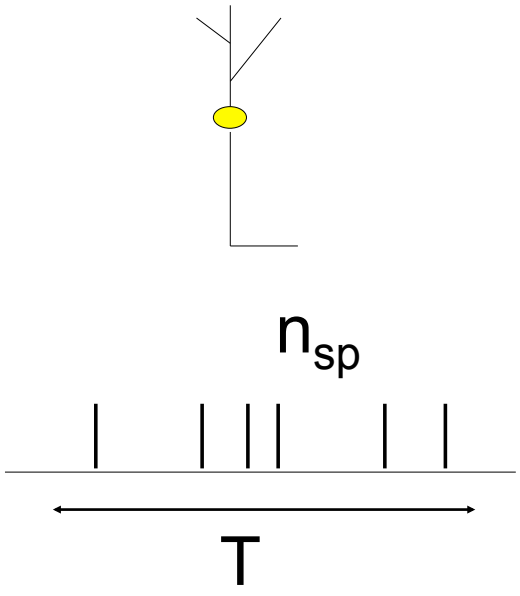
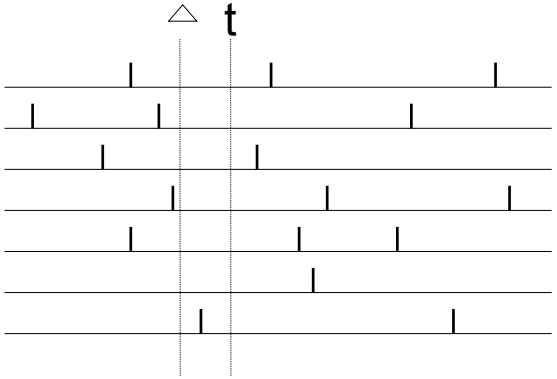
Neuronal Dynamics – 6.5 Rate codes versus temporal codes

3 rate codes

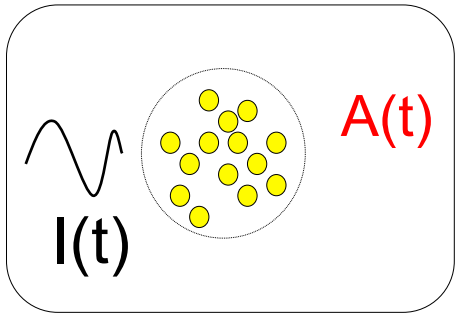


Temporal averaging



$$PSTH(t) = \frac{n(t;t+\Delta t)}{K\,\Delta t}$$

Trial averaging

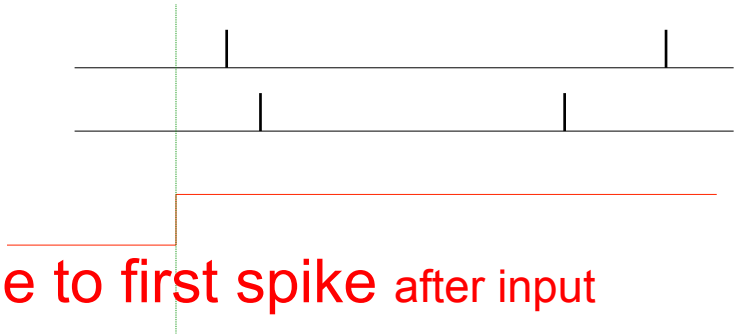


$$A(t) = \frac{n(t;t+\Delta t)}{N\Delta t}$$

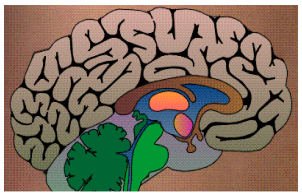
population averaging

Neuronal Dynamics – 6.5. Temporal codes

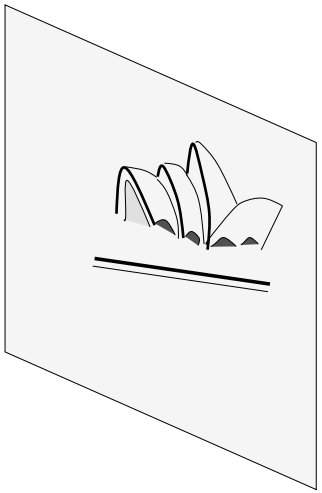
The problem of neural coding: temporal codes



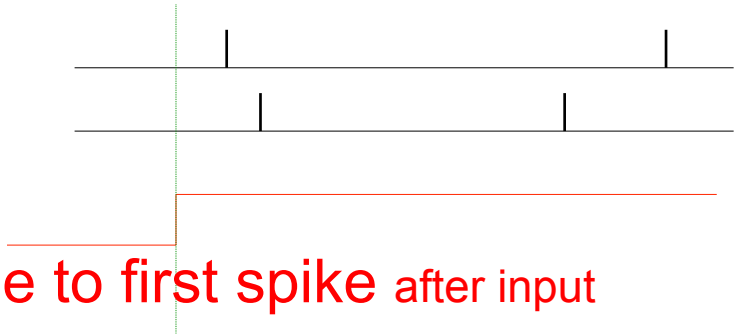
Time to first spike after input



Brain

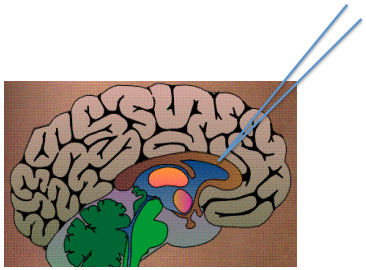


Neuronal Dynamics – 6.5. Temporal codes

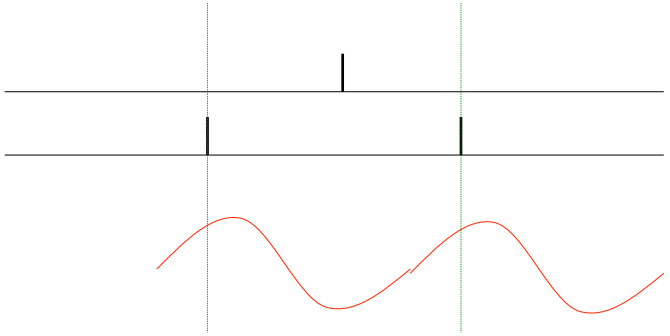


Time to first spike after input

Spike timing codes:
-time-to-first spike
-phase code



Brain



Phase with respect to oscillation

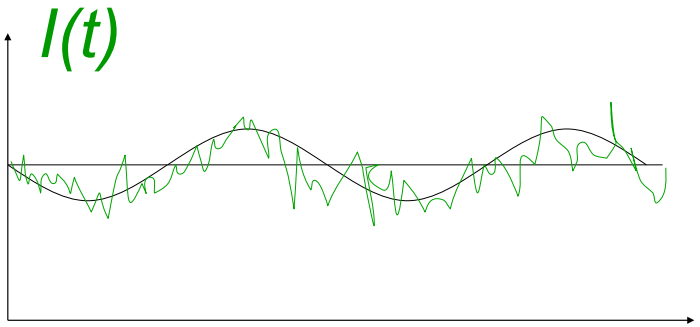
Neuronal Dynamics – 6.5. Stochastic Resonance

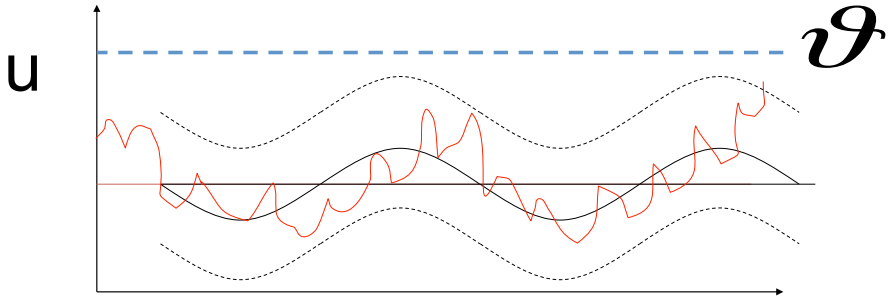
Stochastic Resonance: changing the noise level

$$I(t) = I_0 \cos(\omega t)$$

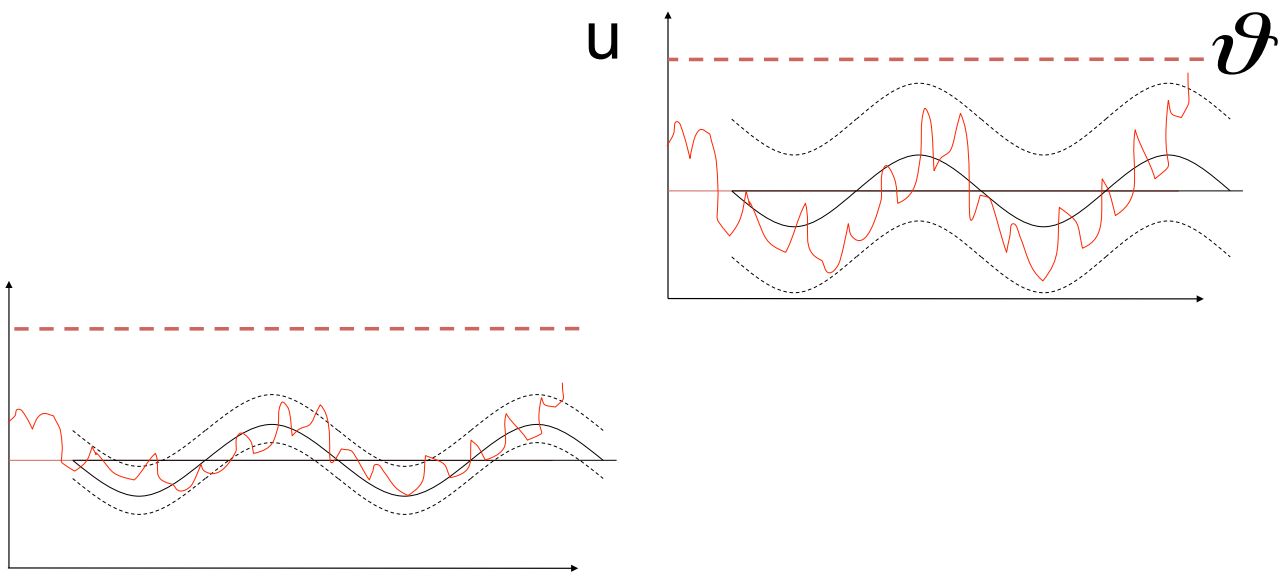
$$I^{noise}(t) = \sigma \xi(t)$$

Sinusoidal input
+ noise
+ threshold

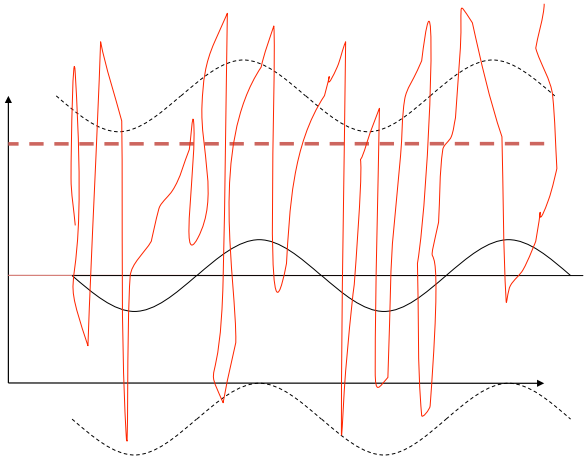




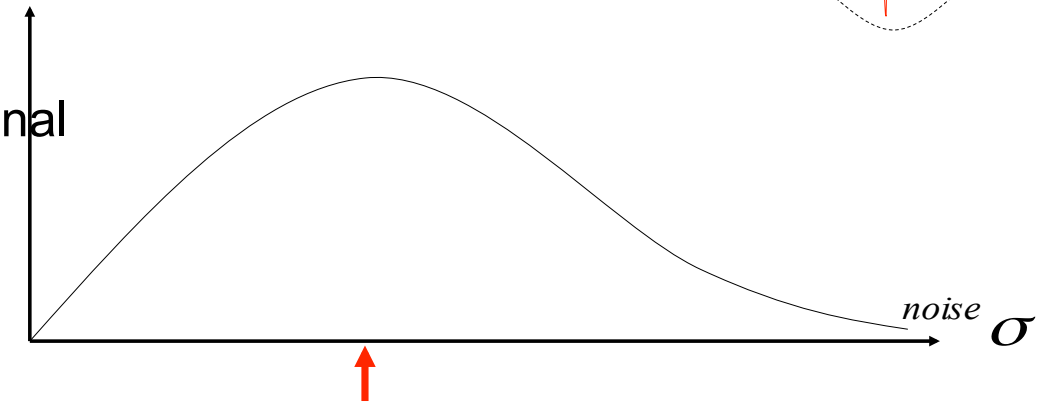
Neuronal Dynamics – 6.5. Stochastic Resonance



Compare:
Gammaitoni, L., et al. (1998).



Transmission
of periodic signal



Neuronal Dynamics – 6.5 Rate codes versus temporal codes

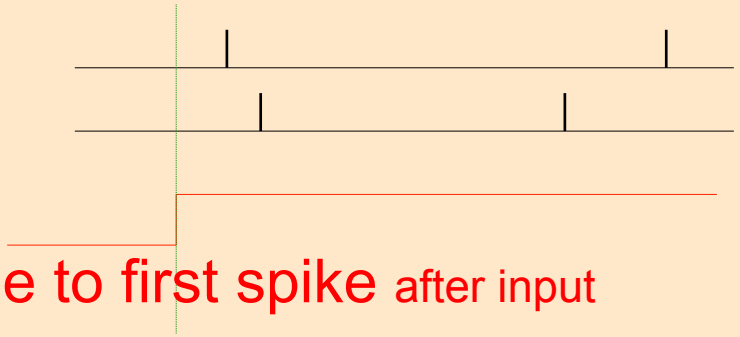
-Rate codes

- population rate

-Temporal Codes

- time-to-first spike
- phase of spike
- stochastic resonance

Neuronal Dynamics – Homework assignment 6.2



Time to first spike after input

With deterministic model
With Poisson model
With noisy IF (escape noise)

Neuronal Dynamics weeks 5+6– References and Suggested Reading

Reading: W. Gerstner, W.M. Kistler, R. Naud and L. Paninski,
Neuronal Dynamics: from single neurons to networks and models of cognition. Ch. 7-9*:* Cambridge, 2014
OR W. Gerstner and W. M. Kistler, Spiking Neuron Models, Chapter 5, Cambridge, 2002

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