

**Week #7 (March 11 & 16) Computational approaches**

“Can theory, math and computers tell us anything interesting and new about Neuroscience?”

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In Wednesday’s lecture, we will discuss if, how and when theoretical models can help us understand cortical function. In the first part, we will focus on a few landmark examples of theoretical models at the single neuron level (integrate-and-fire neurons and multi-compartmental models) and at the circuit level (the perceptron and Hopfield networks). In the second part, we will focus on a few models that have been proposed to explain the responses of neurons in different parts of visual cortex.

Prior to Wednesday, you may be interested in reading:

Sejnowski, T., C. Koch, and P. Churchland (1988) "Computational neuroscience". *Science*, **241**:1299-1306.

On Monday we will discuss a computational paper that aims to model object recognition. The paper focuses on how to achieve position and scale invariance in visual object recognition.

Riesenhuber, M. and T. Poggio (1999) "Hierarchical models of object recognition in cortex". *Nat. Neurosci.* **2**:1019-1025.

While you read the paper, you may want to think about the following questions:

- i) What is the difference between “bottom-up” and “top-down” processes?
- ii) How can these two types of processes be distinguished at the physiological level?
- iii) What can this model explain and what can’t this model explain?
- iv) What kind of trade-offs are there between abstract models and realistic simulations? How realistic does a model need to be to help us understand visual cortex (e.g. do we need to consider the neuronal shape and distribution of ion channels or can we just use blocks for each visual area or is there something in between?)
- v) What other forms of visual invariance should we be able to account for and what kind of models may explain robustness to other object transformations?
- vi) Can we do “neurophysiology” in computational models? What would be the advantages and the disadvantages?

Your assignment this week is to write a referee’s report on the Riesenhuber & Poggio paper.