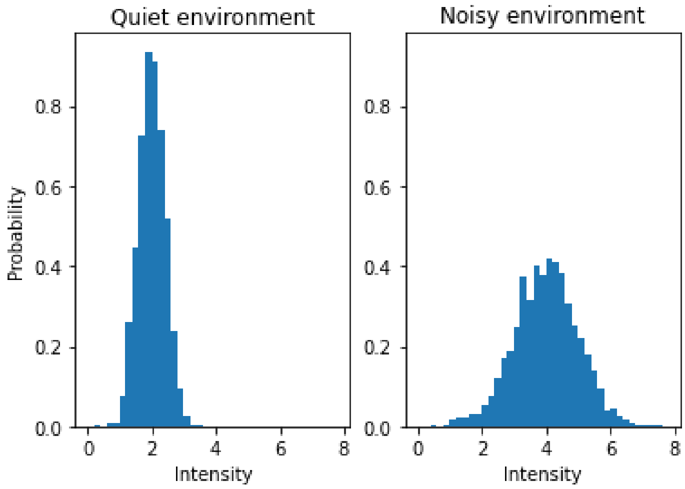
Informatics 1 Cognitive Science – Tutorial 7

Matthias Hennig

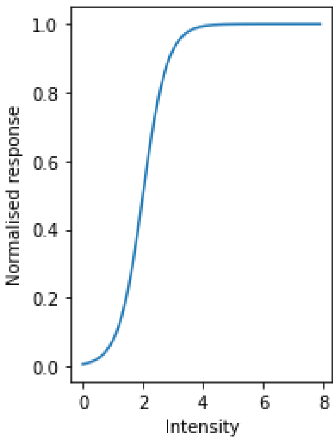
Week 8

Part 1

In the lectures you have seen that neurons in the visual system primarily respond to changes in visual stimuli. This is true for all sensory systems, neurons usually signal changes rather than producing a constant output that corresponds to the intensity of an ongoing, unchanging stimulus.
Neurons can only produce a limited range of outputs as their firing rates range from zero spikes to a maximum of usually around 30 to 50 spikes per second. This limits the ability of a neuron to encode sensory inputs.
Let's consider a simple situation where a neuron is sensitive to the intensity of a stimulus (say the amplitude of a sound). Now we consider what happens when the overall distribution of amplitudes changes, for instance when we move from a quiet into a noisy environment:



The transfer function of a neuron, which describes the normalised spike rate as a function of the stimulus intensity, may be described by a logistic function. An example looks as follows:



Questions

1. Is the transfer function shown above better suited to encode stimuli in the quiet or noisy environment? Why do you think this is the case?

2. Neurons can adapt their transfer function (either through intrinsic mechanisms, or through network effects) to changing input statistics. How should this transfer function change to capture the inputs in the other environment?

3. If this adaptation takes place in the early sensory system, the brain never receives any information about the absolute magnitude of the stimuli. However, we usually can tell if we're in a quiet or loud environment, or if it is bright sunlight or cloudy. How is this possible?

Part 2

The mathematician George Box is reported to have said that "All models are wrong, but some are useful". In the lectures so far you have seen a wide range of models, ranging from abstract models of language and categories all the way done to models of single neurons in the brain. According to James McClelland , "The essential purpose of cognitive modeling is to allow investigation of the implications of ideas, beyond the limits of human thinking." (see *The place of modeling in cognitive science*, Topics in Cognitive Science, 2009). So let's discuss how useful models are in cognitive science.

Questions

1. Make a list of different models the course has covered so far.

2. Choose a model and come up with an experiment to access one or several quantities the model aims to describe. While all these models are related to the brain in some way, the experiments will likely differ substantially. How?

3. Now discuss how these models can be useful (given they are all wrong anyway). What is the role of a good model? How can a "wrong" model be useful?

4. Finally, we can ask if more complex models are more useful, since they are of course more expressive. Is it true that "the best model of a cat is a cat"? (this quote has been attributed to Norbert Wiener, and it goes on "...and ideally the same cat")