

1 Lecture 1: Introduction

There is a diversity of methods currently used in Neuroscience:

1. Psychophysics
2. EEG/ERP
3. MEG
4. MRI/fMRI
5. Single neuron recordings and multiple neuron recordings

We can also consider whether methods are invasive (directly interferers with neurons[?]) or non-invasive.

Psychophysics

Psychophysics is a sub-discipline of psychology dealing with the relationship between physical stimuli and their perception. It is interested in measuring thresholds of perception, detection, discrimination. Measures illusions, reaction times, effects of training, group differences, effect of substance intake etc. It is non-invasive.

Models

A tool of neuroscience is mathematical and computer models which are used to understand how the brain works. The aims are

1. What? Description: unify data in a single framework
2. How? Understand mechanisms
3. Why? Interpretive model: Understand principles underlying functions
4. Make predictions - guide experiments and better data analysis

2 Lecture 2: Neurons

Definition: Dendrites

receive inputs from other cells

Definition: Axon

transfers signal to other neurons

Definition: Synapse

Contact between pre and post synaptic cell. Efficiency of transmission can vary over time.

Definition: Ion channels

There are ion channels across the membrane, allowing ions to move in and out with selective permeability (mainly Na^+ and K^+ , Ca^{2+} and Cl^-)

2.1 Electrophysiological recordings

There are two types: intracellular recordings where a sharp electrode is placed inside the neuron patch electrode, sealed to the membrane and is used to view the V_m . *Extracellular* where the electrode is placed near a neuron to view action potentials often in Vivo (possible awake animal). Was common to observe one neuron at a time, now use of arrays of electrodes is beginning.

2.2 Describing neurons activity

One of the aims of neuroscience is to describe the activity of a neuron and what it responds to. For example, we can observe a neuron where visual stimuli is changing orientation. We can measure spike sequence, number of spikes or rate. The variability of this is large and thus needs to be averaged over many trials.

Definition: Tuning curves

You modify an aspect of the stimulus and measure the r_j (spike count rate)

3 Lecture 3: Encoding**Definition: Encoding problem**

What is the relationship between stimuli in the world and the activity of the brain? $P(r|s)$

Beyond simply just measuring the average spike count, we can use tools from probability theory: stochastic(random) processes. The spike count r on one trial is considered as a random variable. The probability of getting n spikes is given by a probability distribution. For this we need the mean and variance. Noise of the model is often described as Poisson, or Gaussian with a variance proportional to the mean.

3.1 Poisson distribution

Is the probability of a spike count occurring in a fixed period of time, knowing average spike count $f(s)$. The assumption is that the generation of each spike is independent of all other spikes.

$$P(n = k|s) = \frac{e^{-f(s)} f(s)^k}{k!}$$

3.2 Questions

Slide 5 "Experiments show that the variance of the spike count is linearly related to the mean spike count". Humans are attempting to advance themselves by looking closer at the human brain. Effectively, to advance, we are learning to understand ourselves and how the brain works. This creates a problem - could computers and our technology be inhibited by our own brain? The best way for everyone to reach a better understanding is to all share knowledge.

4 Coursera: Neurobiology

Dendrites: Inputs in ESPS: Excitatory post-synaptic potential. If you receive enough of these it creates a spike action potential. Axons: output of neuron

5 Glossary

Definition: Psychophysics

Investigates the relationship between physical stimuli and sensations and the perceptions they affect