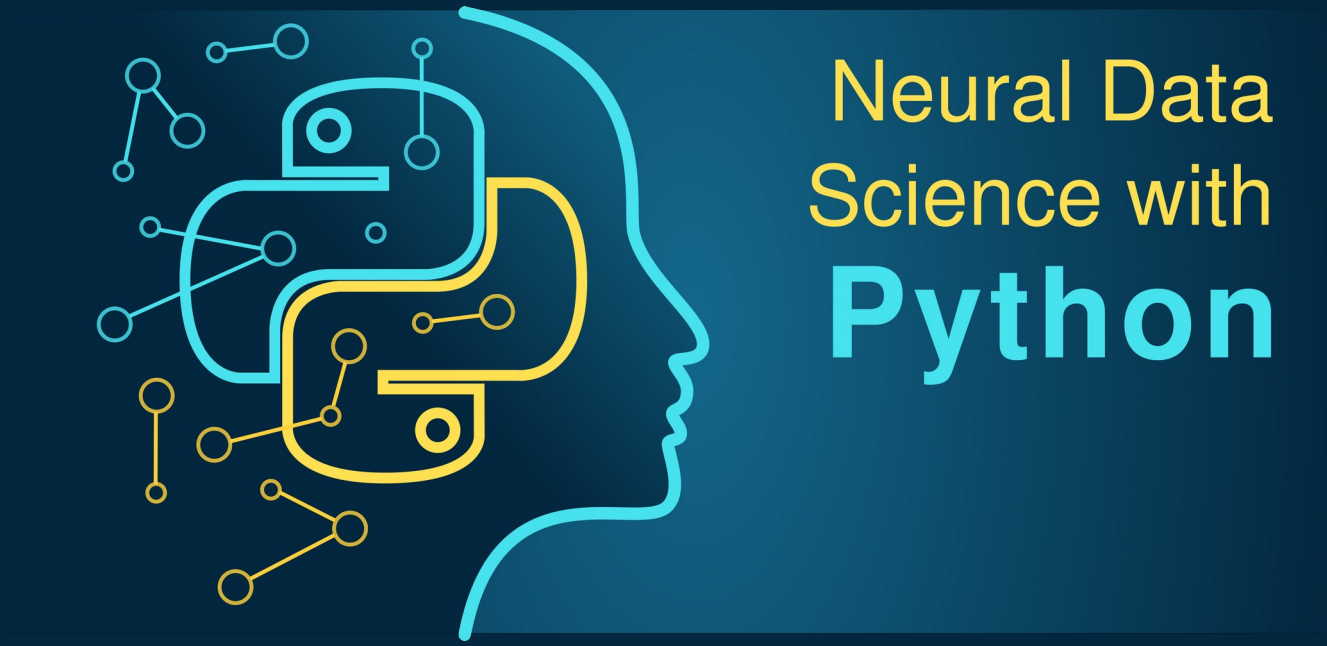


L11: End-of-Course Projects - Selection and Realization

Michael Graupner

SPPIN – Saint-Pères Institute for the Neurosciences

Université Paris Cité, CNRS

Aim of the End-of-Course project

- **Time for your emancipation** : realize a small-scale project using python on your *own* or in a *team of two*
- **Apply/solidify your knowledge** : use the knowledge/expertise acquired in course and extend it and apply it to a specific scientific project/question
- **Extend your understanding :** dive in-depth into a scientific topic and question

Expected from you for the project work

- **Work independently :** after a kick-off meeting with the project organizer, you should strive to advance without further interaction (unless you are completely stuck)
- **Get involved in the project/question :** Use all available resources to learn about the underlying science, the scope of the question and how to implement the project realization.

Tips for advancing the project

- **Set yourself small, achievable goals :** advance in small steps, go only further once your achieved your goal.
- **Start to work on the project as early as possible :** Learn about the project early and identify the challenges. Thinking about the project for a longer period of time will improve your result.
- **Spread your work on the project :** Committing small time periods here and there will avoid the deadline rush which is often not creative/productive.

Tips for programming

- **Check at every step what you are doing :** look at results at each step and visualize: Does it make sense?
- **Validate your code if you have a reference or ground-truth :** use your code to run an example for which you know the outcome. Do you get the expected result?
- **Look back at the course material for help and example implementations :** the techniques used have been discussed in the course, this should be your first reference
- **Use the internet to get help :** Be precise in your question and key-words; common sites for useful help : *stackoverflow, askubuntu, github, ChatGPT*.

Tips for the project jupyter-notebook

- evaluation will be based on the **jupyter-notebook** which you developed while working on the project
- besides the python code, the jupyter-notebook should be annotated (with explanations and comments) and contain the following

Title	Should be concise and precise	maximal 2 lines
Abstract	What did you do in a nutshell? Question – Method(s) – Results	1 paragraph
Introduction	What is the question?	2-3 paragraphs
Annotate the python code	Describe concisely what your aim to do with each code snippet	
Results	Explain, interpret your results; figures should have captions explaining them (labels too!)	
Discussion	What does it all mean?	2-3 paragraphs
References	Whose work did you refer to?	

Tips on preparing the presentation

- Do not prepare slides ! the presentation and discussion will be solely based on the jupyter-notebook
- follow the logic :

  Question – Method(s) – Results
- stick to the 10 min presentation duration (hard limit): requires training
- in case you worked as a team : present the project *together*
- do not go into the details of the python code, rather provide the general purpose

Timeline of the project

- **Nov 24th, '23** (today) : introduction, presentation of possible projects
- **Dec 1st, '23** : final determination of who (teams) works on which project
- soon after **Dec 1st** : meet the tutor and get introduced to the project (you have to set up the meeting yourself)
- between **Dec 1st, '23** and **Jan 7th (23h59), '24** : work on the project, try to spread the work during that period (~2-3 full days of work are required)
- **Jan 7th (23h59), '24** : submit the project jupyter-notebook file
- **Jan 11th , '24, 9h00-14h00** : project presentation/discussion in front of jury, each student/team of two has 10 min for presenting their project + 5 min of questions

List of End-of-Year Project proposals

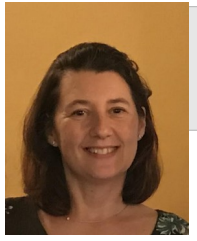
- 16 diverse projects are listed here : https://github.com/mgraupe/NeuralDataSciPy2023/blob/main/EndOfYearProjects.md

- go through the list and **pick out three proposals ranked by your order of preference** : **send** this list together with your team configuration to Michael **until Wednesday Nov 29th, noon**, Michael will get back to you with proposals of project attributions

- each project has contact person (Karine, Jonas, Marcel, Heike, or Michael) with whom you should fix a kick-off meeting soon to get more details and information about the project

- own project ideas are possible and welcome but should be discussed with Michael Graupner beforehand

The five project tutors



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Heike Stein, ENS
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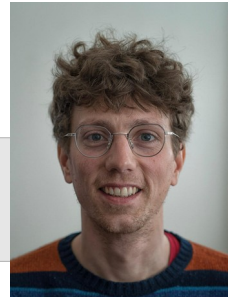
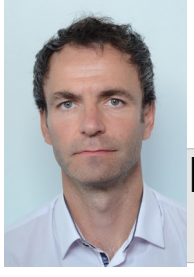
Marcel Stimberg, Institute de la Vision
marcel.stimberg@inserm.fr



Jonas Ranft, ENS
jonas.ranft@ens.psl.eu

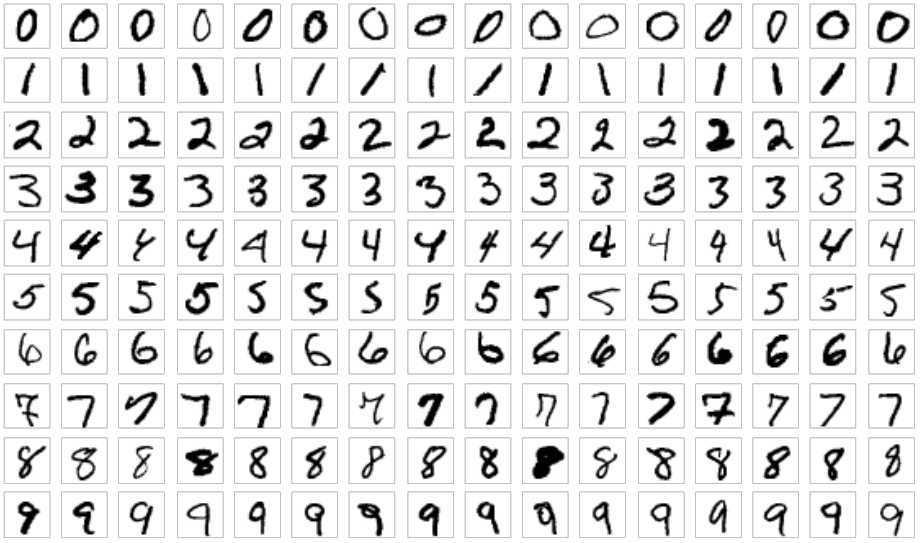


Michael Graupner, Université Paris Cité
michael.graupner@u-paris.fr

P#1: Testing classifier performance on hand-written digits

- *classification project* : train classifier to recognize hand-written digits

MNIST handwritten digit database



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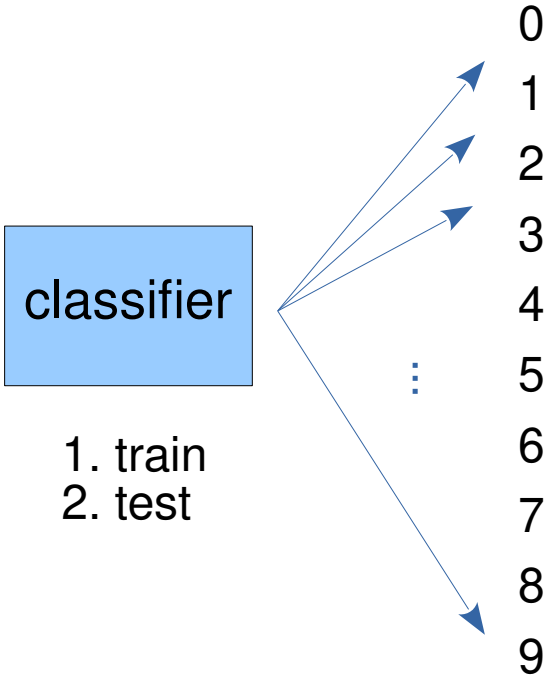
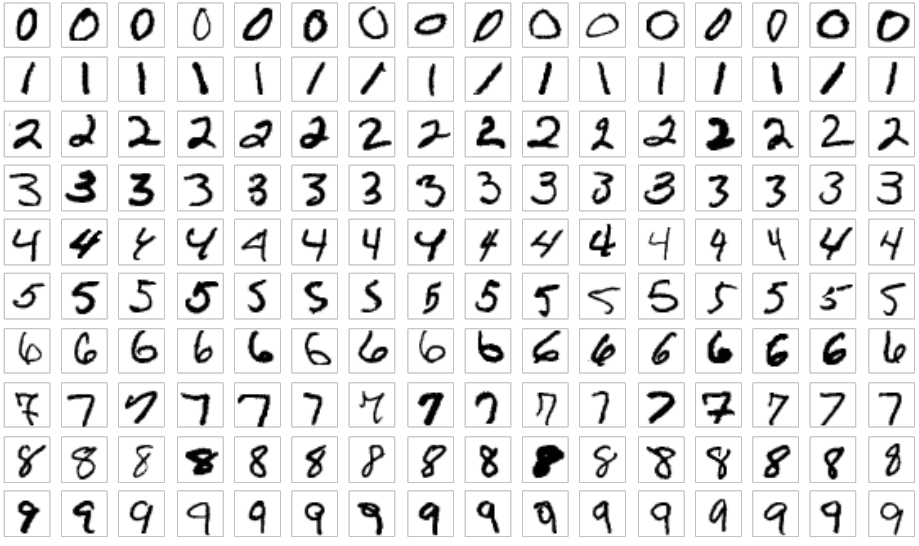


P#2: Exploring existence of clusters in hand-written digits

- *clustering project* : explore number of distinguishable clusters in hand-written digits

MNIST handwritten digit database



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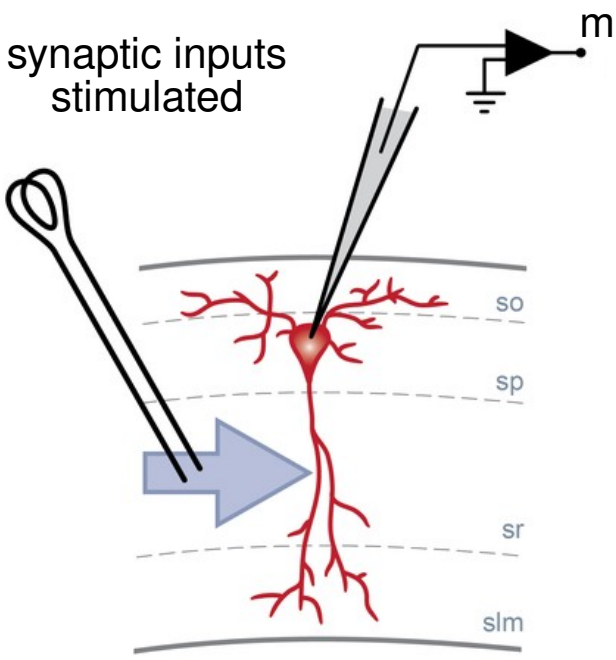
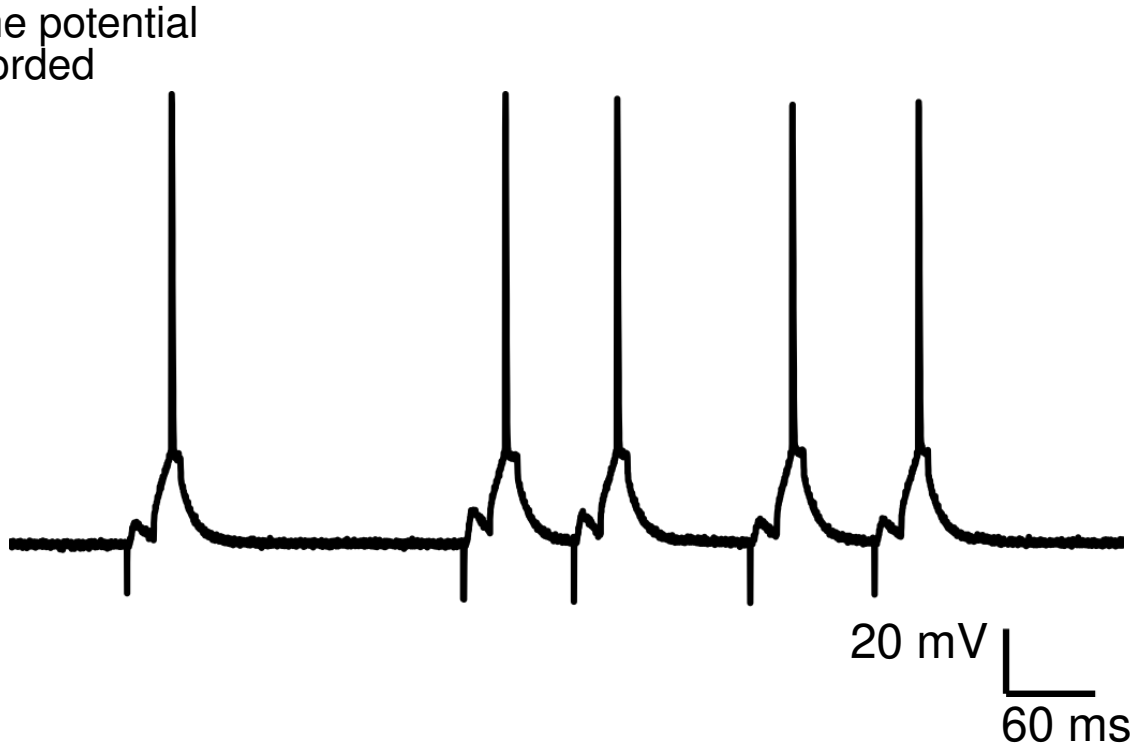
clustering algorithm → investigate existence and number of distinct clusters in the data-set

P#3: Extracting and analyzing spike-times from membrane potential recording

- *time-series analysis* : extract pre- and postsynaptic action potentials



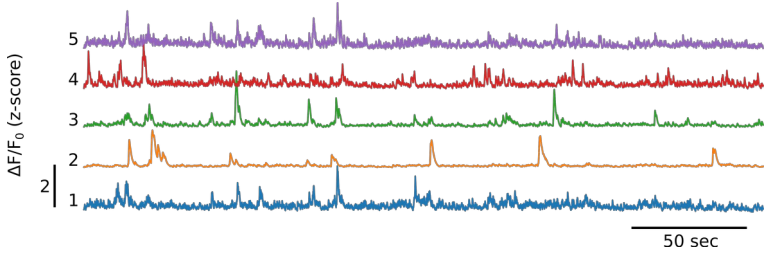


P#4: Calculate head-direction tuning curves of presubicluar neurons from calcium imaging

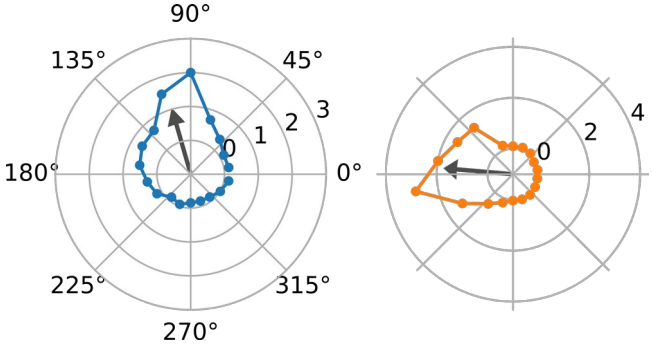
- *calcium imaging analysis* : compute the histogram and determine preferred head-direction

recordings with miniscope in presubiculum

calcium traces



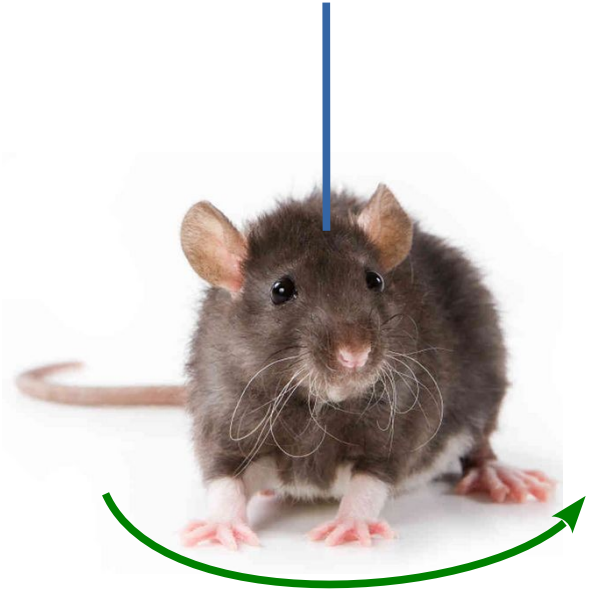
head-direction tuning curves



P#5: Calculate head-direction tuning curves of presubicluar neurons from electrophysiological recordings

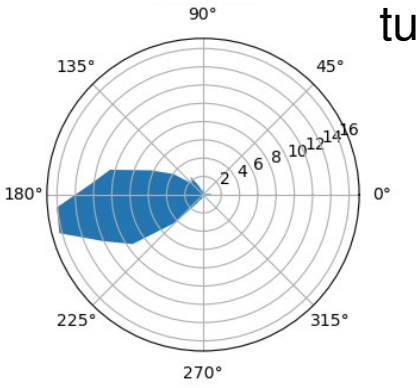
- *spike train analysis* : calculate tuning curves, preferred direction, spiking statistics

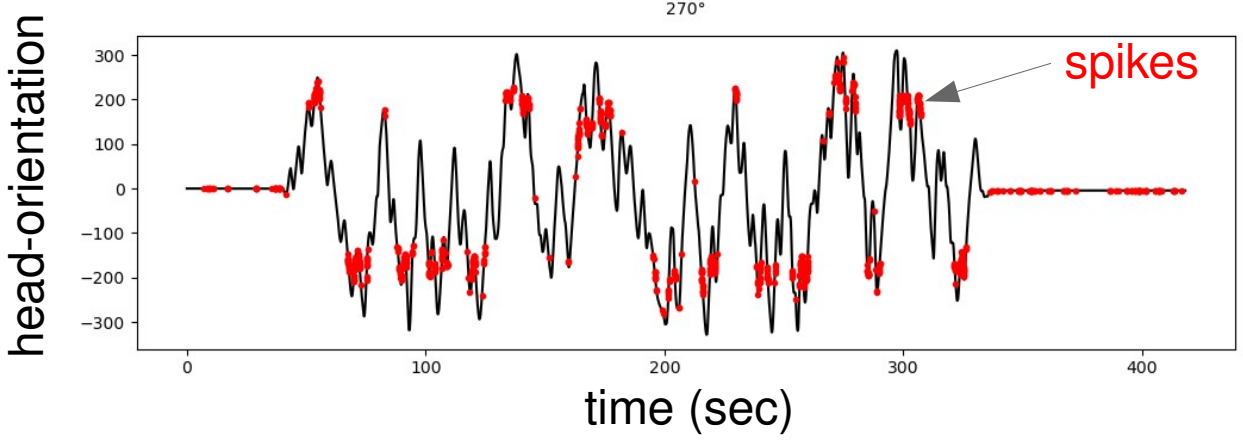
neuropixel probe
in presubiculum



mouse is passively rotated

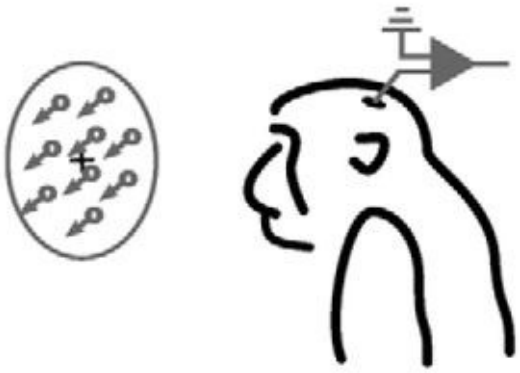
tuning curve



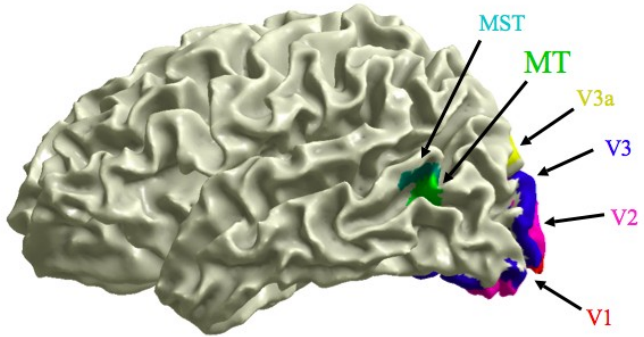


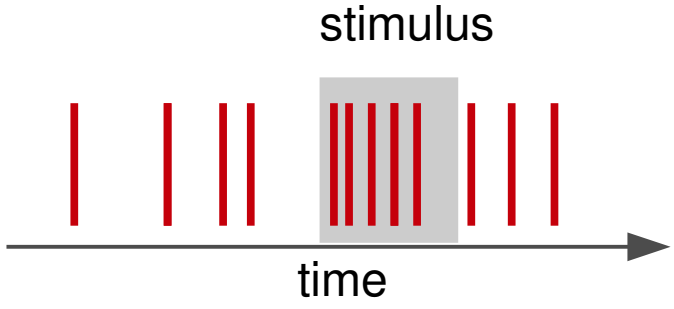
P#6: Compute tuning curves of monkey visual cortex neurons

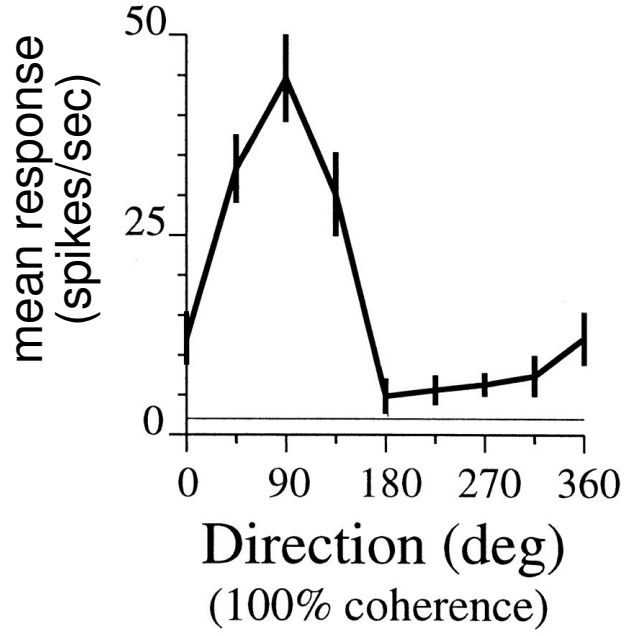
- *spike train analysis* : calculate tuning curves, PSTH, calculate spiking statistics



tetrode recording in visual area MT of awake fixating monkey

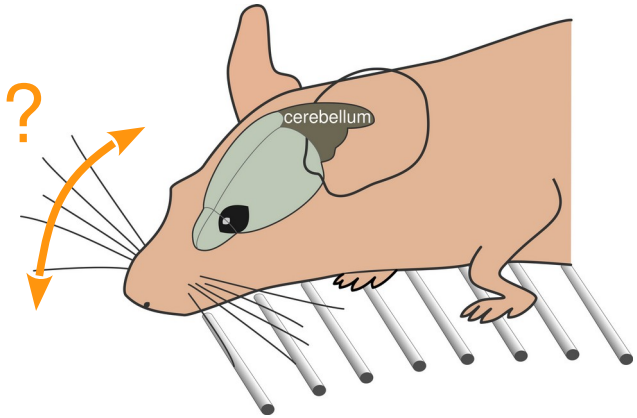






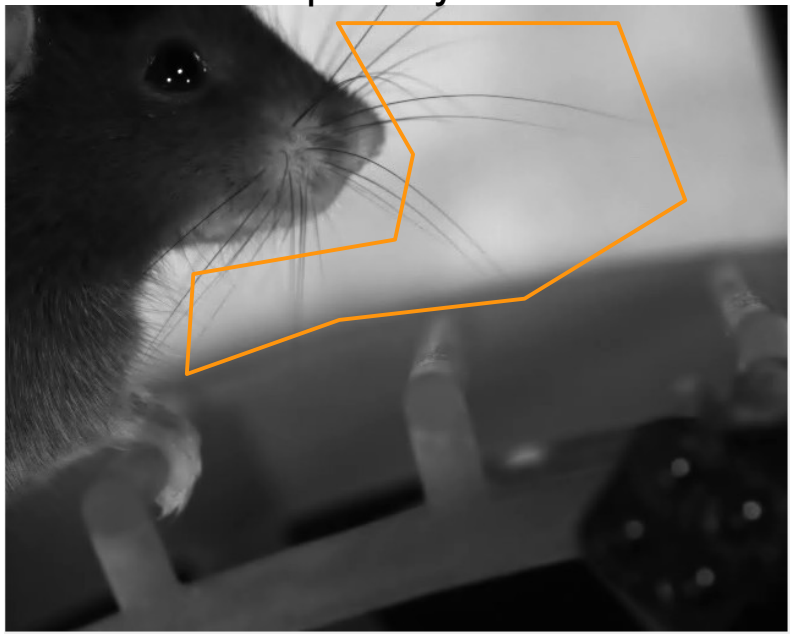
P#7: Extract whisking activity from mouse video recordings

- video analysis : extract motion index of whisker activity



What is the dynamics of the whiskers during locomotion on the wheel ?

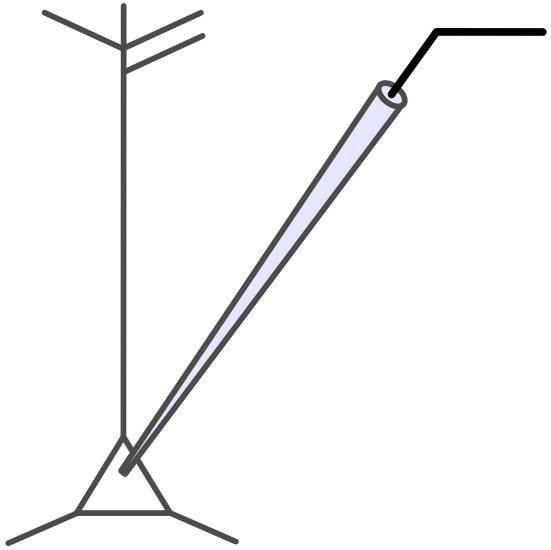
Define region of interest and quantify motion



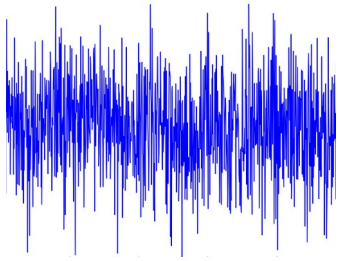
P#8: Leaky-Integrate-and-Fire model with refractory period

- *model simulation*: numerical integration of a differential equation, spike analysis

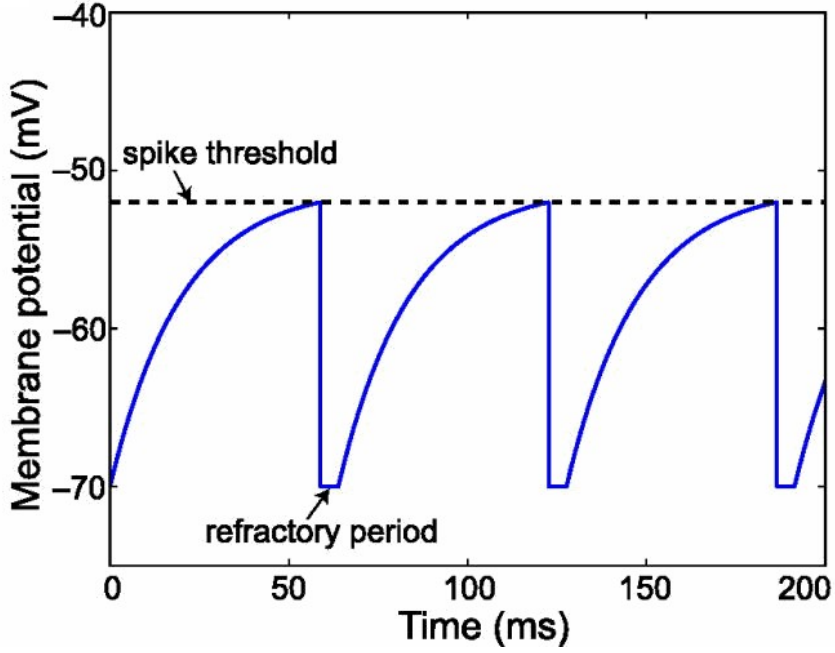
Single neuron model



Noisy input



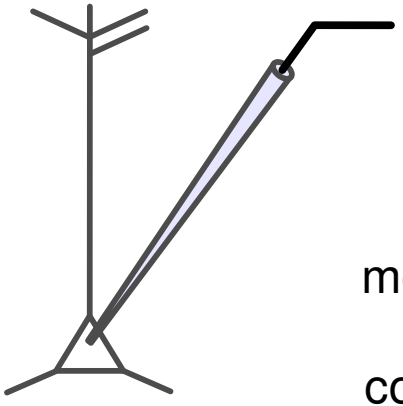
Leaky-Integate-and-Fire Model



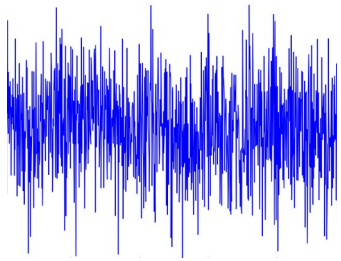
P#9: Exponential-Integrate-and-Fire model

- *model simulation*: numerical integration of a differential equation, spike analysis

Single neuron model

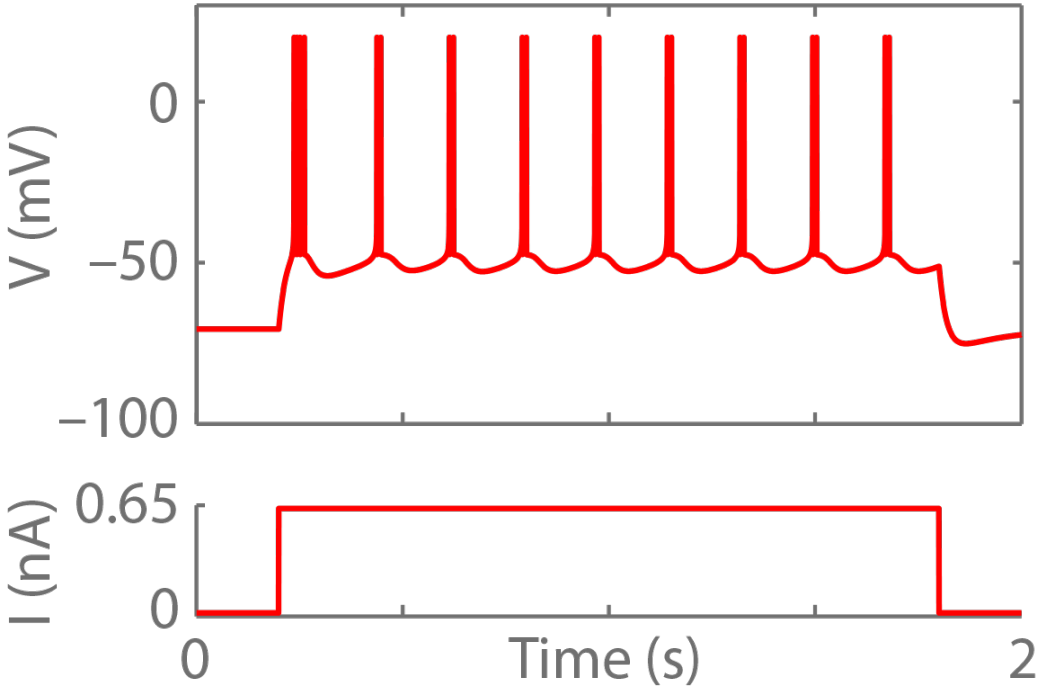


Noisy input



model captures better the spike initiation compared to the leaky integrate-and-fire model

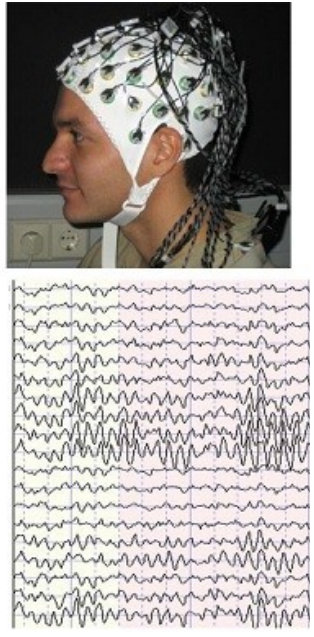
Exponential-Integrate-and-Fire



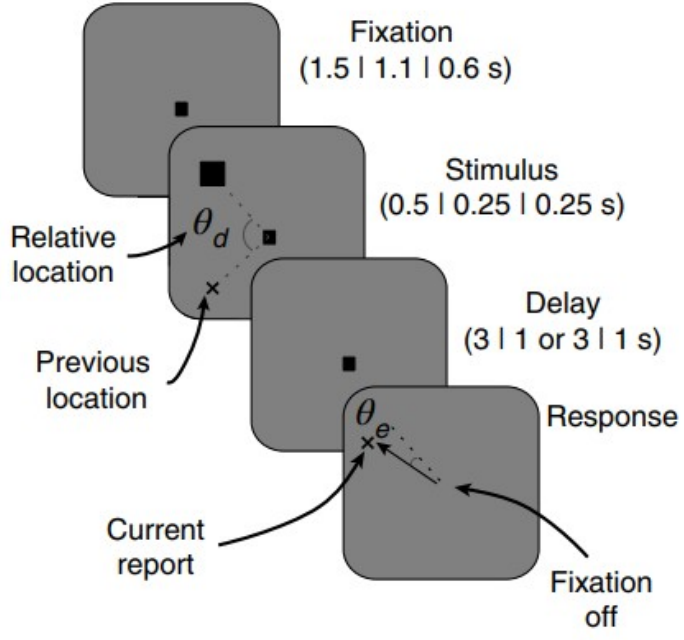
P#10: Decode working memory content from EEG recording

- *decoding a time series* : train a linear classifier on time-series data, use cross-validation

Human EEG recording



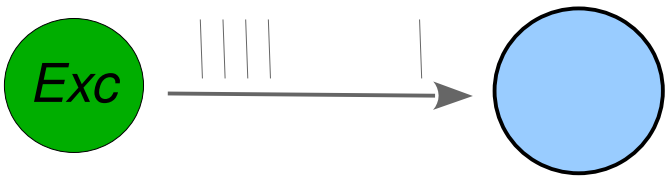
Working memory task



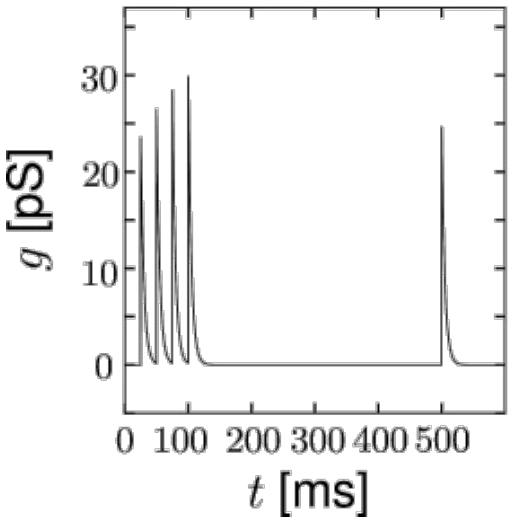
Train a decoder on the EEG data to predict where the stimulus occurred

P#11: Short-term synaptic plasticity

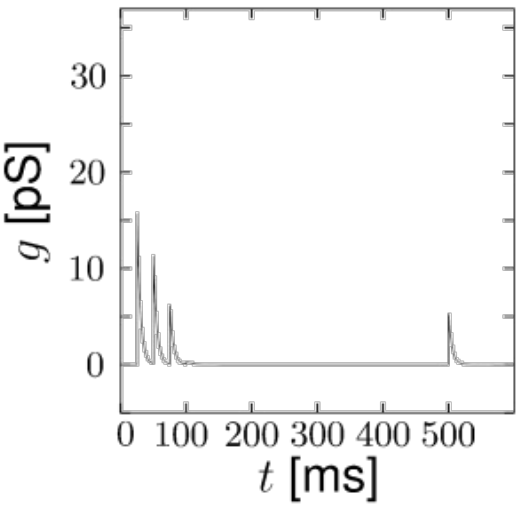
- *two neuron simulation :* synaptic transmission changes, use Brian



facilitating synapse



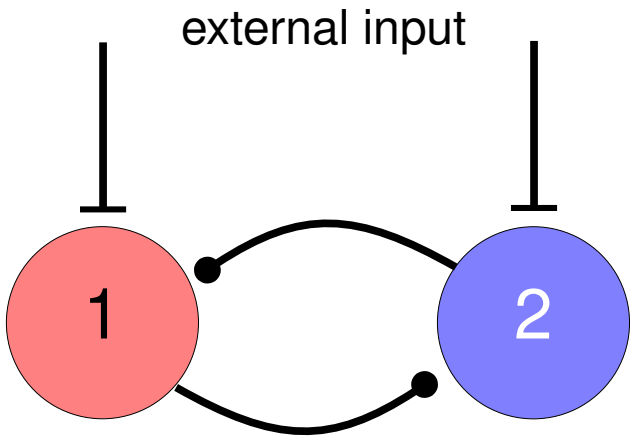
depressing synapse



P#12: Coupled oscillators

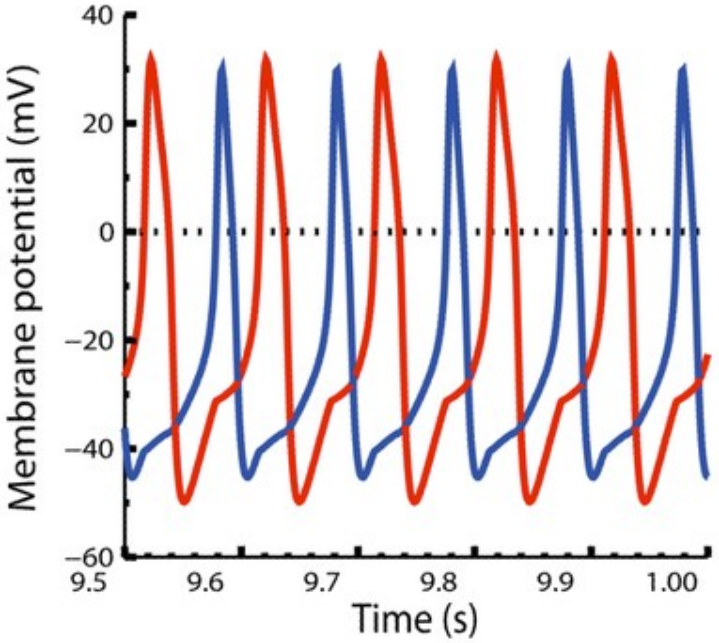
- *2-neuron network simulation* using Brian

implement network of 2 connected neurons
and explore activity as function of
synaptic connection



no connection, exc. synapses, inh. synapses

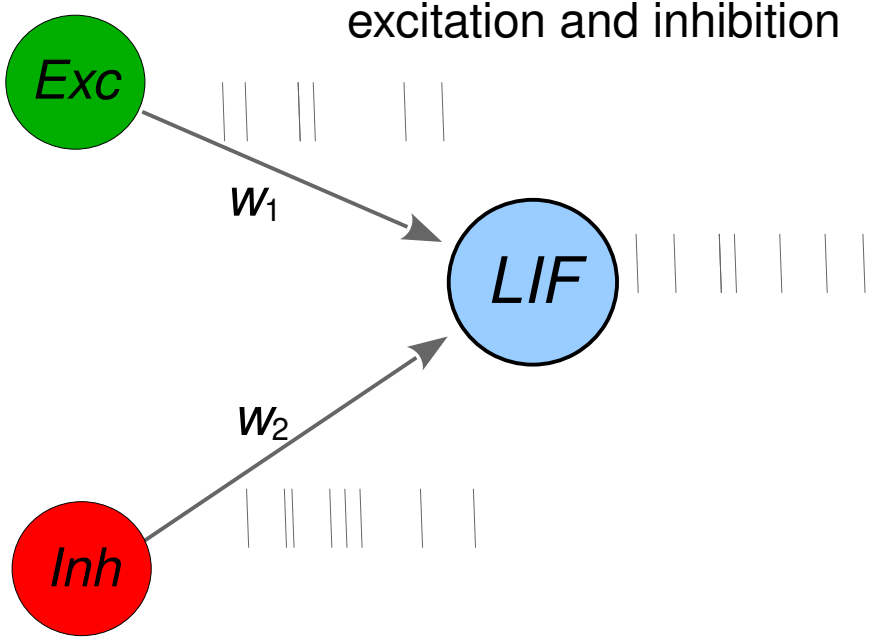
explore temporal relationship of
the activity between
both neurons



P#13: Interplay of excitation and inhibition

- *single neuron simulation in Brian* : analyze input and spike output of a single neuron

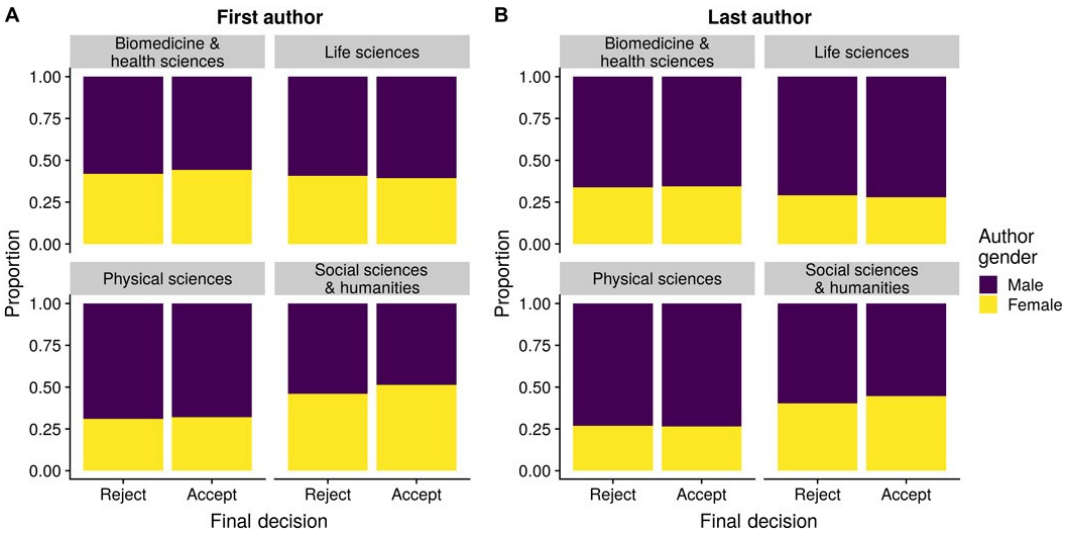
implement a leaky-integrate-and-fire neuron model in Brian receiving excitation and inhibition



→ Explore how the excitatory and inhibitory synaptic inputs shape the spike output of the neuron

P#14: Author position and gender bias

- *Bioinformatics* : literature search based project, query Pubmed

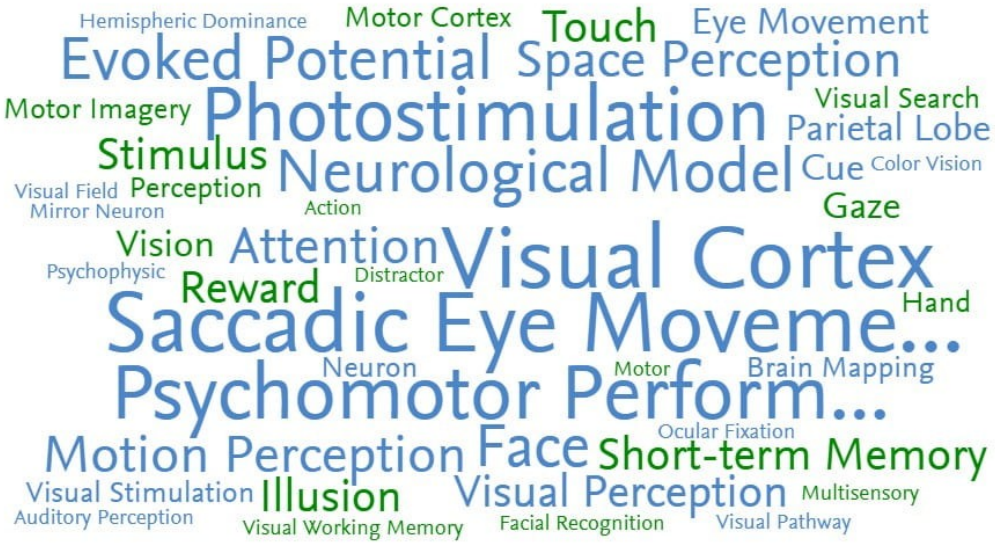


[Squazzoni et al. Science 2021]

Study the gender ratio of first and last authors and how this ratio developed over the last 20 years.

P#15: Research trends in neuroscience

- *Bioinformatics* : literature search based project, query Pubmed

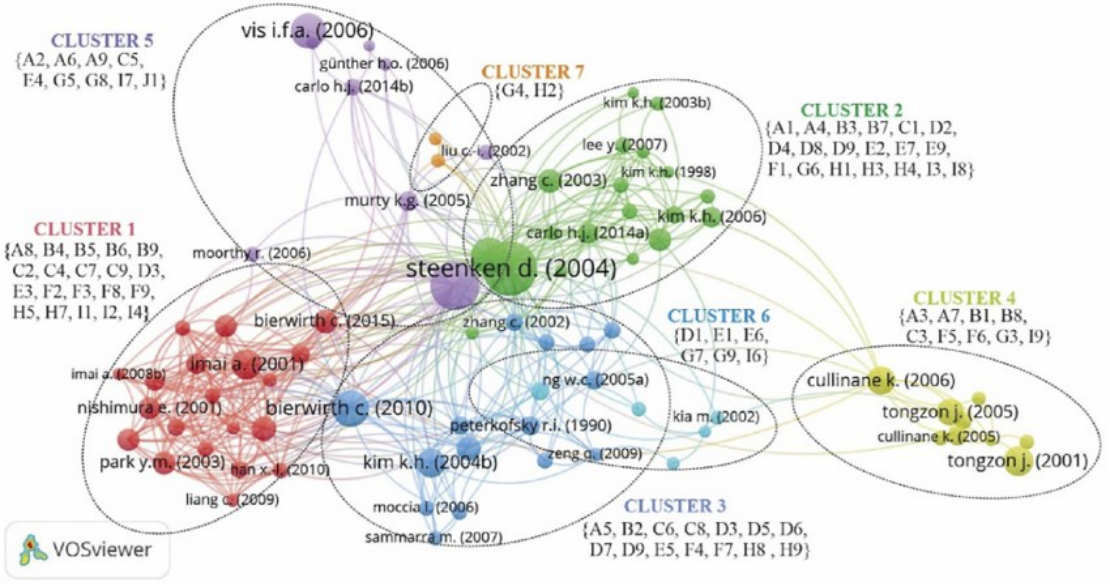


Explore patterns and extract research trends based on most common keywords in neuroscience publications (i.e. textual information based on the PubMed database)

Study how such trends changed over time

P#16: Influential papers in neuroscience

- *Bioinformatics* : literature search based project, query Pubmed

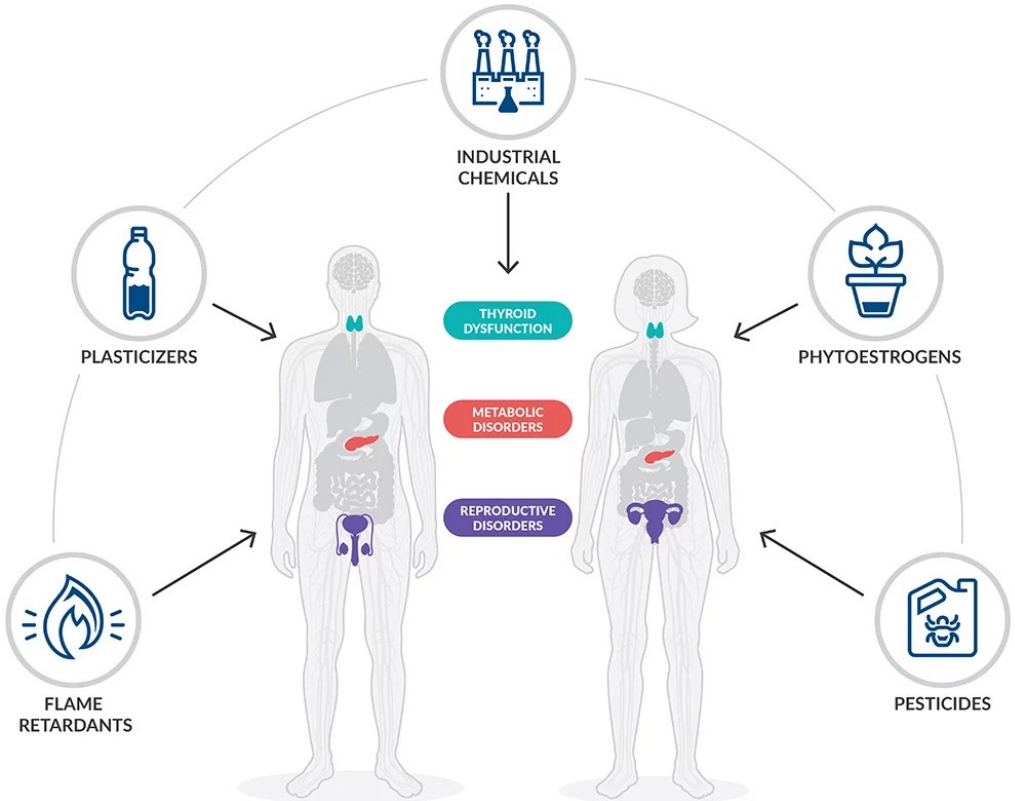


Identify influential papers in Neuroscience based on citation counts, i.e., which articles and topics received most citations

Compare the impact based on citations with the impact factors of the journals in which the articles are published

P#17: Endocrine disrupting chemicals and obesity

- *Bioinformatics* : literature search based project, query Pubmed



Endocrine disruptors are natural or man-made chemicals that may mimic or interfere with the body's hormones, known as the endocrine system.

Study endocrine disruptors and their links to **obesity**.