BIO-482 Neuroscience: cellular and circuit mechanisms

Mini-project: Neurophysiological data analysis

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In the mini-project, you will use Matlab/Python to analyse a database of *in vivo* recordings of membrane potential during mouse behavior. The data are published:

Kiritani T, Pala A, Gasselin C, Crochet S, Petersen CCH (2023) Membrane potential dynamics of excitatory and inhibitory neurons in mouse barrel cortex during active whisker sensing. PLOS ONE 18: e0287174. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0287174

Kiritani T, Pala A, Gasselin C, Crochet S, Petersen CCH (2023) Data set for “Membrane potential dynamics of excitatory and inhibitory neurons in mouse barrel cortex during active whisker sensing.” [Data set]. Zenodo. https://doi.org/10.5281/zenodo.7833080

Learn about the brain by yourself !

BIO482 Mini-project - General organization

1) Download the **Data** and **Codes**, as well as the **Questions** from the Google drive: https://drive.google.com/drive/folders/0AFT2-uCkxrQ0Uk9PVA

2) Install Matlab or Python and follow the instructions in *Miniproject 2025_Questions* to run the codes.

3) Answer questions 1-3 using (**some** of) the figures produced by the codes

4) Devise your own question, write the code to perform the analysis and answer your question

5) Submit your **individual** report as a single pdf file by email to sylvain.crochet@epfl.ch by **Friday 19th December midnight**.

6) Miniproject report will count towards **1/3 of the final grade**

BIO482 Mini-project - General organization

1) Miniproject can be done in group of 2-5 students => indicate your group members on the report

2) Optional but recommended: Get some help from the TAs and Sylvain Crochet every Wednesday 13:15 – 15:00 in room CM 1105 and every Friday 13:15 – 15:00 in Room CE 1106.

3) Also optional but highly recommended: Submit a 1 page proposal for the **Personal Question 4** directly to Sylvain Crochet: sylvain.crochet@epfl.ch (1 proposal /group)

BIO482 Mini-project – Analyses and report

Part 1 – Properties of cortical neurons during spontaneous activity
Part1-a. Suprathreshold activity (firing of action potentials)
Part1-b. Subthreshold activity

Part 2. Membrane potential dynamics and motor activity

Part 3. Sensory evoked neuronal activity

Part 4. Personal question

BIO482 Mini-project – Questions

Question 1 (2/20 marks).

Based on what you have learned during the course, explain what could be the impact of the AP threshold, the mean Vm and the SD of the Vm on the mean firing rate of a neuron.

Based on the analyses performed in **Part 1**, identify which property(ies) actually influence the mean firing rate of cortical neurons across cell-classes? Justify your answer with some graphs.

Question 2 (4/20 marks).

Based on the analyses performed in **Part 1**, what are the specificities of each class of cortical neurons allowing to best distinguish excitatory vs inhibitory neurons? and between the different subclasses of inhibitory neurons? How well can we distinguish between cell classes?
Justify your answers with some graphs.

BIO482 Mini-project – Questions

Question 3 (4/20 marks)

Based on the analyses performed in **Part 2 and 3**, summarize what happens at whisking onset time and active-contact onset time for the different cell-classes. Justify your answers with some graphs.

Based on what you have learned in the course, what could be a possible mechanism explaining the change in membrane potential of somatostatin (SST) expressing GABAergic neurons at whisking onset?

BIO482 Mini-project – Questions

Question 4 - Your personal project (10/20 marks):

Explain in a few lines what is the question you want to address, what is the rational and what is your hypothesis?

Explain briefly what analyses you have done to answer your question and how you have proceeded.

Present your results with some graphs and explanations.

Interpret your results, answer your question if possible or explain why you cannot, conclude.

BIO482 Mini-project – Questions

Some ideas of personal questions:

- Build a classifier to identify cell-classes
- Spike history: how inter-spike interval impacts firing threshold or the Vm dynamic before spike initiation (slope of the Vm just before AP threshold)
- Layer/cell depth dependency: how neuron properties change with cell-depth/layer (that works well for passive properties and changes at whisking onset time)
- Cortical column dependency: how the response to active contact changes as a function of the cell position relative to the principal barrel column (C2 barrel column) (possible with only EXC cells, maybe PV cells)
- Compare Vm properties for quiet and active states
- Impact of inter-contact interval on sensory evoked responses
- Relationship between the reversal potential of the sensory-evoked response and the change in firing rate for active-contacts (should focus on EXC and PV cells)
- Investigate burst firing (large depolarizing potentials): proportion of neurons displaying burst firing in different cell classes.
- Identify spikelets (a few mV spike events) as possible indicator of gap junction coupling.

BIO482 Mini-project – Questions

Grading of Question 4: <u>10 points max</u>

Rational:	2.0 / +0.5 for clarity
Methodology:	2.5 / +0.5 for clarity
Results:	2.5 / +0.5 for clarity
Interpretation:	1.0 / +0.5 for clarity
Bonus for originality / difficulty:	+1.0

Some important remarks:

- You do not need to use the whole data set (you can focus on a subset of the data or even a few cells)
- It is OK to obtain negative results, or even to fail, as long as you demonstrate the logic and rational of your project