# Data analysis and modeling of calcium activity in mice somatostatin interneurons

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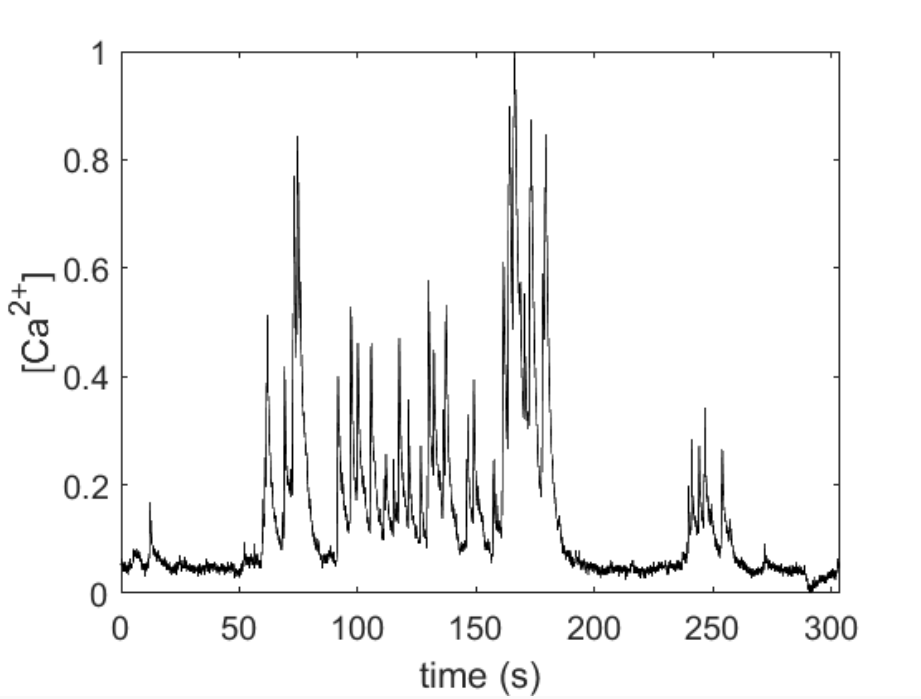
# The GECO group

## Genetics of Cognition (GECO)

- Held by Dr. Francesco Papaleo
- Main objective: uncover the neural mechanisms underlying cognitive and social alterations
- Employed methods: *in vivo* studies on mice, (electrophysiology, calcium imaging, pharmacology)

# Intracellular calcium dynamics

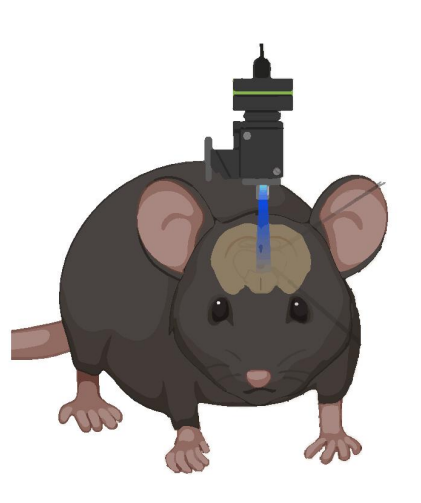
- Neurons show *rapid* and *heavy* changes in the values of their intracellular concentration of $Ca^{2+}$
- The neuron is defined as *active* in correspondence to the peaks in the calcium concentration



# Microendoscopic calcium imaging

Te **Microendoscopic calcium imaging** technique consists in the following steps:

1. Implant of *miniscopes* in the brain region of interest of mice
2. Injection of a virus carrying the **GCaMP** protein
3. Performance of the behavioural task
4. Collection of the video recordings of the fluorescence activity in single neurons
5. Pre-processing and data analysis



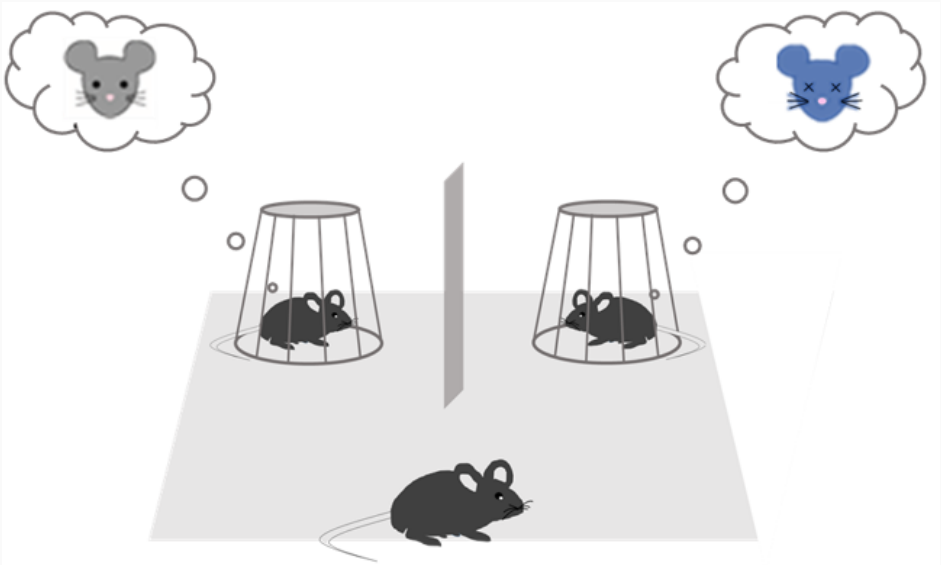
# Main projects

- Mathematical modeling of the calcium patterns occuring in a neuronal pair
- **Data analysis on the altruism task**: recording of $Ca^{2+}$ activity in the *amygdala* during altruistic behaviours
- **Interbrain data analysis**: study of the synchronization between neural activities of two mice

# Intebrain analysis for the EDT

## Emotion discrimination task (EDT)

- An *observer* mouse faces a *neutral* and a *stressed* demonstrator
- Three phases of the task: *homecage*, *habituation*, *test*
- Main goal: investigate synchronization between overall and single neuron activities between mice and correlations with emotional state



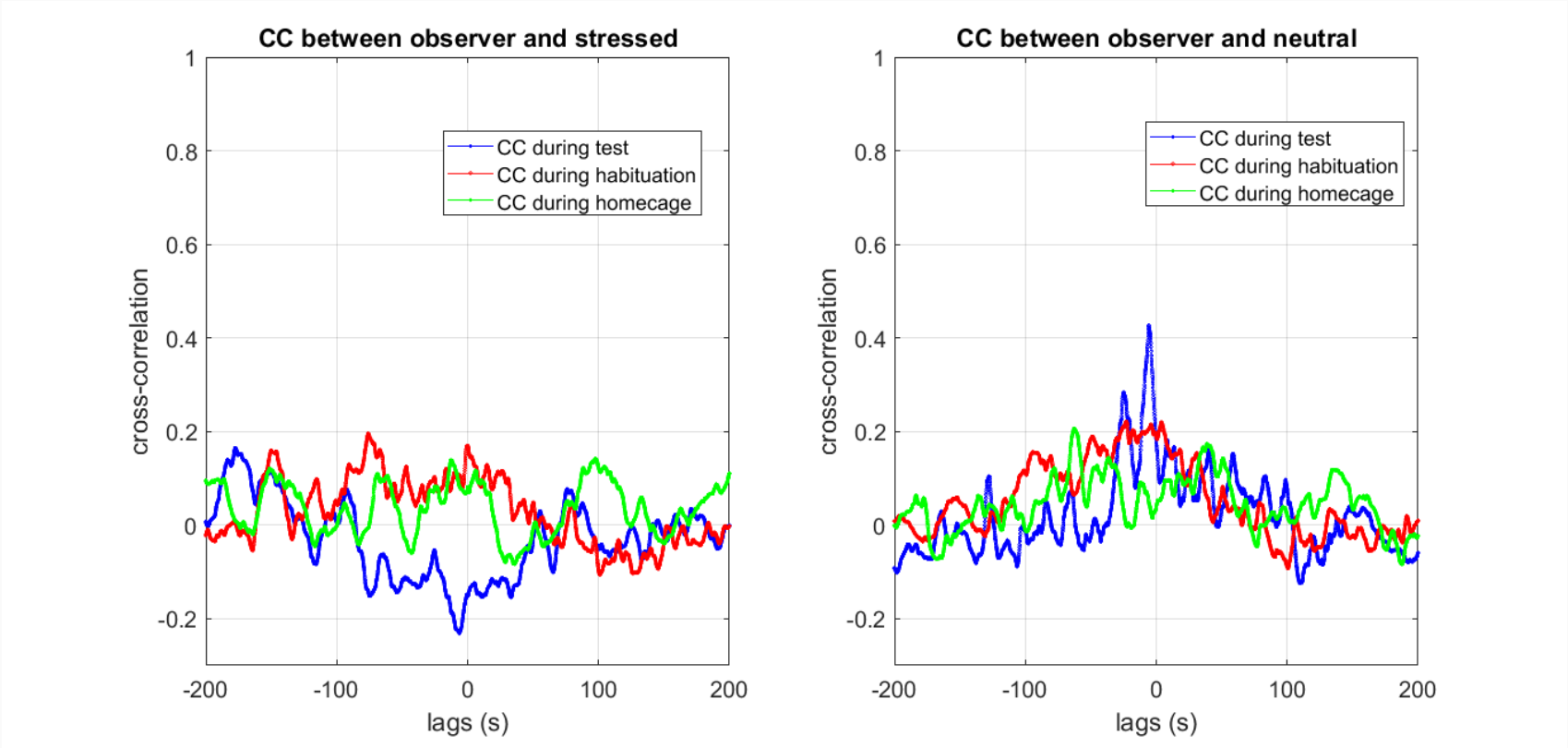
# Cross-Correlation analysis

Considering the *average activity* of the neurons, the synchronziation has been quantified using the **cross-correlation**.
Given two functions $f = f(t)$ and $g = g(t)$, we define the cross-correlation between them as

$$[f(t) \star g(t)](\tau) = \int_{-\infty}^{+\infty} f(\tau) g(t + \tau) dt$$

# Results on the cross-correlation analysis

The cross-correlation peaks around $lag = 0$ only for the interaction observer - neutral. Such result is not present in the control phases of homecage and habituation.



# Peak correlation analysis

To quantify the amount of *simultaneous peaks* occurred between the neurons of two different mice, we employ the **peak correlation index**

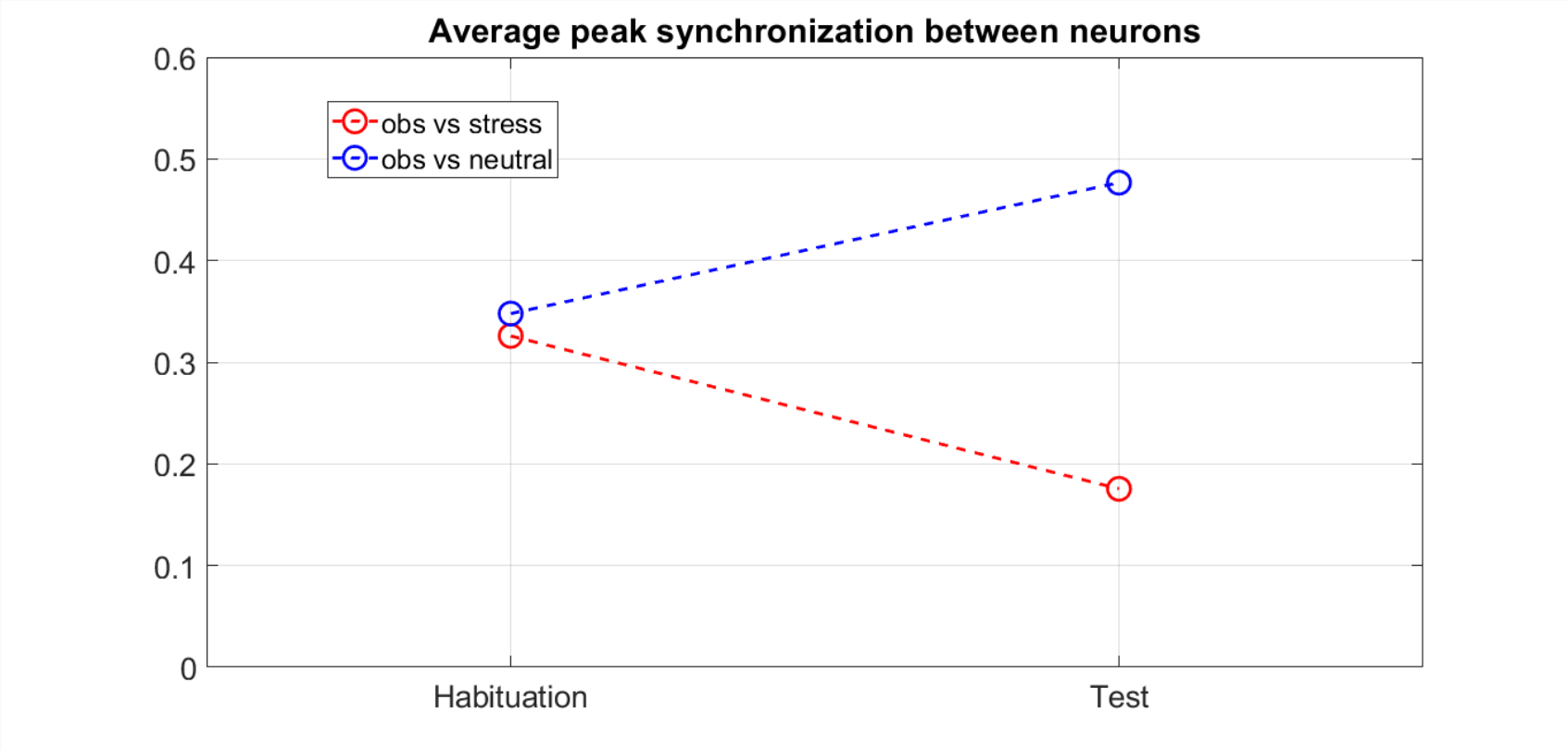
$$i_{AB} = \frac{N_{AB} T}{2 N_A N_B dT}$$

Where:

- $T$ is the overall signals time window
- $dT$ is the synchronization time window
- $N_A$ and $N_B$ are the number of peaks in signal A and B
- $N_{AB} = \sum_{i=1}^{N_A} \sum_{j=1}^{N_B} I_{[-dT, dT]}(|a_i - b_j|)$ is the sum of simulteneous peaks occurred between neurons A and B during the window $dT$

# Results on the peak correlation analysis

In accordance with the cross-correlation result, the pair observer - neutral shows an increase in the average peak correlation index, computed across all neuronal pairs.



# The self-experience task

In the **self-experience** task, the observer is stressed before the beginning of the test. This provokes an *inhibition* of the synchronization (cross- correlation and peak synchronization)