Are durations encoded as neural trajectories? Testing temporal representations in a multidimensional space.

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Main aim: The proposed M2 internship (6 months) will investigate whether trajectories of beta activity encode relative or absolute durations. The project is funded by an ERC SyG 101167367 CHRONOLOGY.

Background:
The coding of temporal durations is associated with different patterns in brain activity. For instance, we have previously demonstrated that the fluctuations of beta activity (rhythmic bursting activity in the 15-30 Hz range) can predict the length of a reproduced duration so that higher beta power is associated with longer reproductions (e.g., Kononowicz et al., 2015; Kononowicz et al., 2019). Beyond simple amplitude effects in the frequency domain, the dynamics of this oscillatory activity can be described as a neural trajectory in a latent space (Kononowicz et al., 2019). Such trajectories are typically extracted from brain electrophysiological data (M/EEG) using dimensionality reduction techniques, allowing researchers to characterize how population-level neural activity unfolds over time (e.g. Kobak et al., 2016).

In parallel, recent work suggests that temporal information can be encoded in multiple formats. Both relative (context-dependent) and absolute (metric) representations of duration have been identified in the brain, in mice (Akdogan et al., 2023) and humans (Centanino et al., 2026), raising the question of how these representations are implemented at the level of neural dynamics.

This internship will address this question by investigating whether beta-band neural trajectories encode durations in a relative or absolute manner. To do so, we will analyze an existing MEG dataset collected during a duration reproduction task, where an experimental manipulation allows to dissociate absolute from relative encoding of time.

To address this question, we will combine dimensionality reduction techniques using deep learning architectures with time–frequency analyses. This strategy will allow us to reduce the high-dimensional information contained in the MEG time-series into beta-band neural trajectories, thus studying their relationship to duration encoding.

What is expected of the intern:

- Minimally getting acquainted with the literature and a short-targeted review of it
- MEG data analyses
- Deep learning network application
- Clean and documented coding
- Reporting of the analytical outcomes in English (article-format)
- Positive and dynamic attitude

- Good team player capable of autonomous thinking and learning

Keywords: duration perception, neural oscillations, autoencoders, neural trajectories
Methods: magnetoencephalography, MNE-python, deep learning

Requirements:

- Background knowledge in cognitive neuroscience, computational neuroscience.
- Background knowledge in neuroimaging and time-series data analysis.
- Programming experience or data analysis skills with Python.
- Sufficient English ability for scientific reading, writing and oral communication.
- Knowledge in computational modeling or machine learning.
- (Plus) Experience with EEG or MEG studies.
- (Plus) Knowledge with deep learning libraries like PyTorch.

References:

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