Alpha oscillations as bursting and traveling waves in the human brain

Project supervisors:

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Main aim: The proposed M2 internship (6 months) will focus on analyzing oscillatory burst activity and traveling waves of human brain activity acquired with magnetoencephalographic data.

Scientific Background:

Whether rhythmic brain activity plays a canonical role in timing has raised major debates in cognitive neurosciences (Treisman et al., 1994; Pöppel, 1997; Buzsáki, 2006; van Wassenhove, 2016; van Wassenhove et al., 2019; Tsao et al., 2022) with the strong working hypothesis that neural oscillations embody temporal metrics for neural timing, cognition, and ultimately, an individual's experience of time (Pöppel, 1971, 1997; Treisman, 1984; Buzsáki, 2006; van Wassenhove, 2016). An enduring notion in the field is that time perception relies on an internal clock. The clock hypothesis posits that in the absence of external sensory inputs, the rate of endogenous oscillatory activity (i.e. the "pacemaker" of the posited internal biological clock) will predict an individual's estimate of elapsing time (duration) (Hoagland, 1935; Treisman, 1963). The clock hypothesis assumes that neural oscillations are stationary, i.e. that rhythmic brain activity is continuously and steadily present over time (Miall, 1989; Gibbon and Church, 1990; Buhusi and Meck, 2005; Gu et al., 2015; Kononowicz and van Wassenhove, 2016). *Rather, s*pontaneous rhythmic activity is *display* non-stationarities of bursting and traveling patterns that fluctuate over time (Steriade et al., 1990; Cole and Voytek, 2017; Muller et al., 2018; Raut et al., 2021). Thus, non-stationarities of rhythmic brain activity violate the posited regularities of clock-like mechanisms.

In this master project, the intern will help assess whether spontaneous bursts of oscillatory activity can be attributed to traveling waves activity. For this, s/he will use previously acquired MEG and EEG data to characterize the dynamics of alpha (8-12 Hz) burst and traveling wave activity as they relate to measures of episodic time collected in healthy human participants. For this, we will build on important methodological work *(Alexander et al., 2013, 2016, 2019; Muller et al., 2018; Davis et al., 2020)* that has been initiated by another master student in the team. The models to characterize traveling waves have been coded using MNE-python tools (Gramfort et al., 2013) and preliminary results confirm the existence of traveling waves in this dataset. Thus, the main goal is to pursue and refine this preliminary characterization and make a quantitative and reasoned comparison between alpha bursts and traveling waves activity.

What is expected of the intern:

- Minimally getting acquainted with the literature and a short-targeted review of it
- MEG and EEG data analyses
- Clean and documented coding
- Reporting of the analytical outcomes in English (article-format)

Keywords: neural oscillations, traveling waves, traveling waves

Methods: magnetoencephalography, electroencephalography, MNE-python

Requirements:

- Background knowledge in cognitive neuroscience, 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
- (Plus) Knowledge in computational modeling or machine learning
- (Plus) Experience with EEG or MEG studies

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