Uncovering the neural dynamics of inner speech from EEG signals

M2 research internship (2025-2026)

Laboratoire Parole et Langage (CNRS UMR 7309) (Aix-en-Provence)

Scientific context

The ability to mentally produce speech or "inner speech" is a cornerstone of human cognition. It is involved in a plethora of activities such as reading, planning, or remembering [for reviews, see 1, 2]. Despite the ubiquity of this inner voice, the cognitive and neural mechanisms leading to this subjective experience remain poorly known. One prominent perspective is that the sensory content of inner speech would correspond to the predicted sensory consequences of inhibited motor commands (issued by pairs of internal forward and inverse models, respectively) [e.g., 3, 4, 5, 6]. However, the precise neural implementation and timecourse of each sub-process remains to be described.

Objectives, methods, and expected outcomes

The main objective of this internship is a fundamental one and consists in better understanding the cognitive and neural processes involved in inner speech. To this end, we will reanalyse an existing electroencephalography (EEG) dataset by employing the decoding approach of [7], which consists in testing at which moment in time a specific mental content becomes decodable from brain activity (here, EEG signals) (Figure 1).

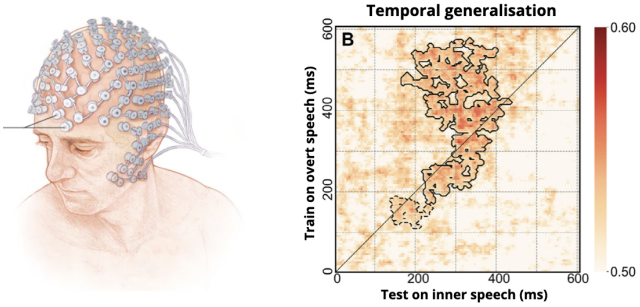

Figure 1. Illustration of an high-density EEG set-up (left) and a temporal generalisation matrix resulting from the decoding approach of [7] (right).

More precisely, we will assess when phonological features become decodable during either overt and covert (inner) speech production, which features do generalise from overt speech planification and production to inner speech, and the spatial patterns underlying successful classification over time. By doing so, we will **characterise the precise timecourse of information-processing stages during overt and covert speech production**.

Profile and missions

We are seeking a motivated Master's student with a background in computer science and/or cognitive neuroscience to join our research project. The internship will involve the following tasks: i) understanding the research question through a review of the literature on inner speech and multivariate pattern analysis, ii) implementing and extending existing code to perform both individual- and group-level analyses using MNE-Python, and iii) interpreting the results and writing a final report (Master's thesis). The ideal candidate is fluent in English or French, has a solid foundation in machine learning, and demonstrates **excellent programming skills in Python**. Applications should include a short motivation letter, a CV, M1 transcripts, and the names of two referees.

Lab and supervision

The internship will take place at the Laboratoire Parole et Langage (CNRS UMR 7309) located in Aix-en-Provence (remote work is possible), under the supervision of:

Dr. Ladislas Nalborczyk (CNRS, LPL)
Web: https://lnalborczyk.github.io
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References

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[4] R. Grandchamp, L. Rapin, M. Perrone-Bertolotti, C. Pichat, C. Haldin, E. Cousin, J.-P. Lachaux, M. Dohen, P. Perrier, M. Garnier, M. Baciu, and H. Lœvenbruck, "The ConDialInt Model: Condensation, Dialogality, and Intentionality Dimensions of Inner Speech Within a Hierarchical Predictive Control Framework," *Frontiers in Psychology*, vol. 10, 2019.

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