Proposal for Access to Cam-CAN MEG Resting-State Dataset: Contrastive Representation Learning for Lifespan Brain State Analysis

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Abstract

We request access to the Cambridge Centre for Ageing and Neuroscience (Cam-CAN) Stage 2 MEG resting-state dataset to investigate lifespan-related functional brain patterns using contrastive self-supervised deep learning and explainability techniques. This work aims to learn meaningful, age-sensitive neural representations from high-resolution MEG data without relying on explicit labels, and to interpret the temporal, spectral, and spatial features that drive age-related clustering of brain states.

Background and Motivation

Understanding how brain function changes across the adult lifespan is a central challenge in cognitive neuroscience. The Cam-CAN MEG dataset is uniquely suited for this work: it contains long-duration, high-quality resting-state recordings from a demographically balanced cohort aged 18–87 years. Unlike MRI, MEG offers millisecond temporal resolution, enabling the study of fast neural dynamics and oscillatory patterns that may be

sensitive to ageing. Recent advances in self-supervised contrastive learning (e.g., SimCLR, BYOL) have shown promise for extracting robust representations from complex biomedical time series, yet this approach has not been systematically applied to MEG for lifespan analysis.

Proposed Methods

We will preprocess resting-state MEG recordings using MNE-Python, applying filtering (1–45 Hz), artefact removal, and segmentation into short overlapping windows. Each window will be augmented via noise injection, channel dropout, and time-warping to create positive pairs for contrastive learning. A 1D-CNN-based encoder will be trained with a normalized temperature-scaled cross-entropy loss (NT-Xent) to map MEG segments into a compact embedding space. We will cluster embeddings (e.g., k-means, UMAP visualisation) to detect natural groupings of brain states across the lifespan. Explainability methods—perturbation analysis, gradient saliency, and frequency-band masking—will identify neural features most predictive of age-related separation.

Expected Impact

This project will:

- Provide a novel application of contrastive self-supervised learning to MEG lifespan analysis.
- Deliver interpretable neural markers of functional ageing.
- Contribute methodological tools for explainable deep learning in neuroimaging.

Findings will be shared in open-access venues, with all analysis code made publicly available, in full compliance with Cam-CAN data use agreements.