Theme: Cognitive Neuroscience

Decoding Spatial Representations of Tactile Stimuli in the Primary Somatosensory Cortex Using MVPA

Carolina Travassos[1,2]*, Alexandre Sayal[1,2,4], Paulo Fonte[1,5,6], Bruno Direito[1,3,4], Teresa Sousa[1,4,7], Miguel Castelo-Branco[1,4,7]

1 Coimbra Institute for Biomedical Imaging and Translational Research (CIBIT), Institute for Nuclear Sciences Applied to Health (ICNAS), University of Coimbra (UC), Pólo das Ciências da Saúde Azinhaga de R. Santa Comba, 3000-548, Coimbra, Portugal

2 Siemens Healthineers, Rua Irmãos Siemens, 1 - 1A, 2720-093, Lisbon, Portugal

3 Centre for Informatics and Systems of the University of Coimbra (CISUC), Rua Miguel Bombarda, 3030-790 Coimbra, Portugal

4 Intelligent Systems Associate Laboratory (LASI), Escola de Engenharia - Universidade do Minho, Campus Azurém, 4800-058 Guimarães, Portugal

5 Laboratory of Instrumentation and Experimental Particle Physics (LIP), Departamento de Física da Universidade de Coimbra, Rua Larga, 3004-516 Coimbra, Portugal

6 Polytechnic Institute of Coimbra, Coimbra Institute of Engineering, Rua Pedro Nunes - Quinta da Nora, 3030-199 Coimbra, Portugal

7 Medicine Faculty, University of Coimbra (UC), Coimbra, Portugal

*presenting author

Abstract:

The primary somatosensory cortex (S1) exhibits a well-established topographic organization, particularly for the fingers and hand. This study investigated the ability of multivariate pattern analysis (MVPA) to decode somatosensory representations of four segments of the right upper limb (middle finger, hand, forearm, and arm) using functional magnetic resonance imaging (fMRI) data, contributing to mapping less known topographic organizations. Tactile stimuli were delivered using a custom-built electrical stimulation device, with 4-second monophasic waveforms (bursts of 0.2ms at 100Hz) applied at personalized current levels. Randomized inter-stimulus intervals were used between stimulation sites, and each site was stimulated twice per run across four runs. Eleven healthy, right-handed volunteers (6 females) underwent fMRI acquisition while receiving the stimulation. The dataset was pre-processed using a standard fMRIPrep pipeline (including motion, slice-timing and susceptibility distortion corrections, spatial normalization to MNI space, and co-registration) and analyzed with NiLearn (Python). A general linear model (GLM) was applied to the data of each subject, modeling each trial separately to create predictors for all stimulation positions. The resulting beta maps (one per stimulation event) were then used as input for the MVPA. Decoding was focused on a left hemisphere mask of S1. An ANOVA-based feature selection approach was used to retain the most discriminative features before training a linear Support Vector Classifier with Leave-One-Run-Out cross-validation. Preliminary results demonstrated the model's capacity to discriminate between the four segments with mean balanced accuracies above chance for all participants. These findings highlight the potential of combining GLM techniques and MVPA for detailed mapping of somatosensory representations and provide insights into the spatial encoding of tactile stimuli within S1.

Keywords: Functional magnetic resonance imaging (fMRI); Somatosensory cortex; Somatotopy; Brain decoding; Multivariate pattern analysis (MVPA).