We Present a Method for Determining Visual Stimulus Based on Differences in Brain State

Decoding Visual Stimulus from MEG Signals

Mu Yangjiayi[1,2,3] (22110850009@m.fudan.edu.cn),
Mark Forbush[2,3,4] (mforbush@ucsc.edu),
Qiuhao Yin[2,3,6] (qiuhao.yin.2022@scis.smu.edu.sg),
Chun Yin Mou[2,3,5] (chrismou2015@gmail.com)

Background

Magnetoencephalography (MEG) is a non-invasive neuroimaging technique that records the magnetic fields produced by neuronal activity. Magnetic fields are generated in the brain by electrical currents, primarily from postsynaptic potentials in pyramidal neurons.

MEG also has significant advantages over other neuroimaging techniques; such as better temporal resolution, improved signal quality, high spatial resolution, making it an ideal tool for understanding conscious and subconscious activity in the brain.

Objective

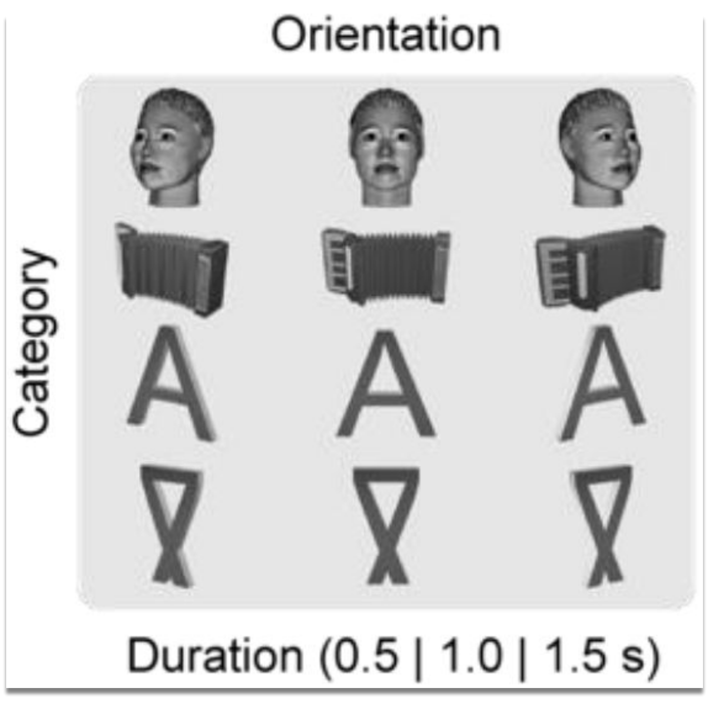
To accurately determine the category of visual stimulus based on state of the MEG sensor array.

Methods

1. MEG sensor array
2. Maxwell filtering (SSS)
3. Independent Component Analysis (ICA)
4. Event Related Field analysis
5. Multi-class SVM classification

Visual Stimulus

Subjects are presented a visual stimulus of a face, object, letter, or false letter for a period between 500ms and 1500ms.

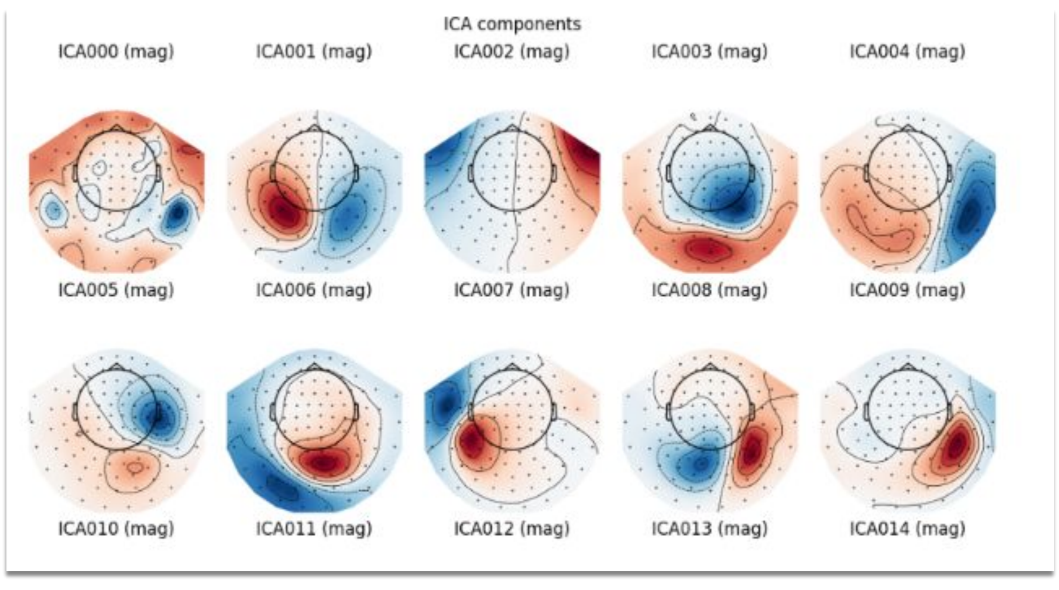


Above, we can see examples of each category of stimulus, a well a variations of the orientation of each stimulus (Melloni, et al 2023).

Noise Filtering and ICA

Time series data is first denoised using Maxwell filtering (Taulu and Simola 2006), which attempts to remove artefacts based on our physical understanding of the MEG sensors. Then, we apply ICA (Hyvärinen and Oja 2002) and remove components that appear to related to muscle movement; such as eye movement and heartbeat.

Below we see a table of Independent Components. It's likely ICA002 is related to eye movement.

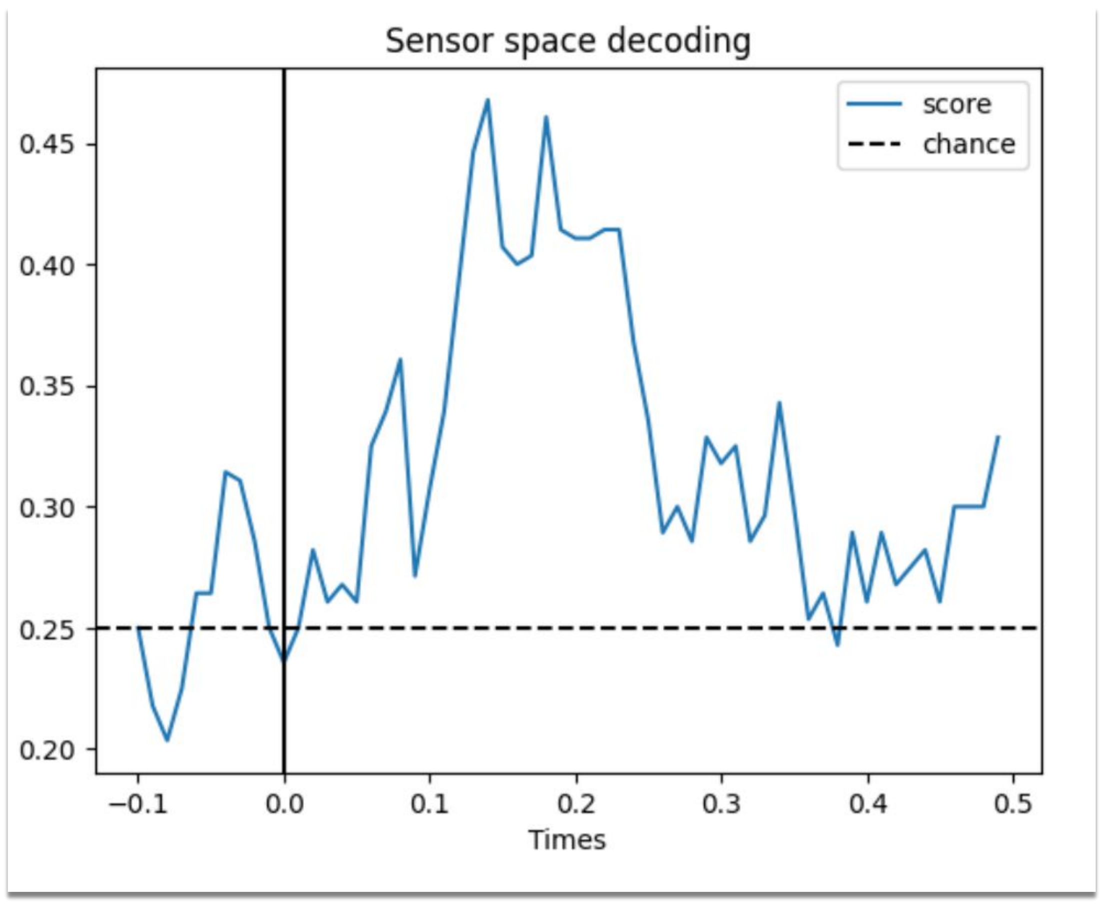


Event Related Fields (ERFs)

Time series data (Woodman 2010) is broken up into windows of 600ms around stimulus (100ms before and 500ms after). We expect the prior 100ms to act as baseline activity for later comparison.

Classification of ERFs using Multi-class SVM Model

Using a multi-class support vector machine, we classify each time point in the sensor space, in order to determine the most likely category of visual stimulus.



From the graph above we see that the classifier performs significantly better than random chance, indicating our model is able to discern distinct neuronal activity for each visual stimulus, with accuracy of classification peaking at around 150ms post stimulus.

Classification of prior 100ms resembles random chance, indicating baseline activity in the subject.

1. Fudan University
2. Institute of Science and Technology for Brain-Inspired Intellegence
3. Global Research Internship Progam at Fudan University
4. University of California Santa Cruz
5. University of Leeds
6. Singapore Management University

Key References:

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