Somatosensory Gating for an SSSEP-based BCI

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I What are SSSEP?

A sustained vibrotactile stimulus of the skin produces resonance-like evoked potentials named Steady-State Somatosensory-Evoked Potentials or SSSEP. They appear as an increase of activity at the frequency of stimulation.

II What is Sensory Gating?[1]

Sensory gating, or gating, is the capacity of the brain to filter out stimuli perceived as irrelevant during a goal-oriented activity.

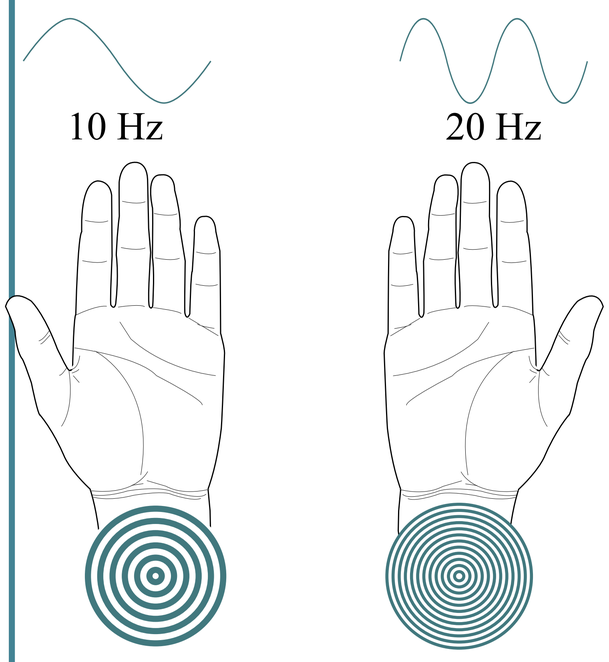
III Idea of an SSSEP-based BCI exploiting Somatosensory Gating

- Performing Motor Imagery (MI) with one or two arms.
- Sustained vibrotactile stimuli on both wrists produces two SSSEP.
- The Gating resulting from the MI should decrease the amplitude of the respective SSSEP.
- The amplitude of the two SSSEP are used as classification features.

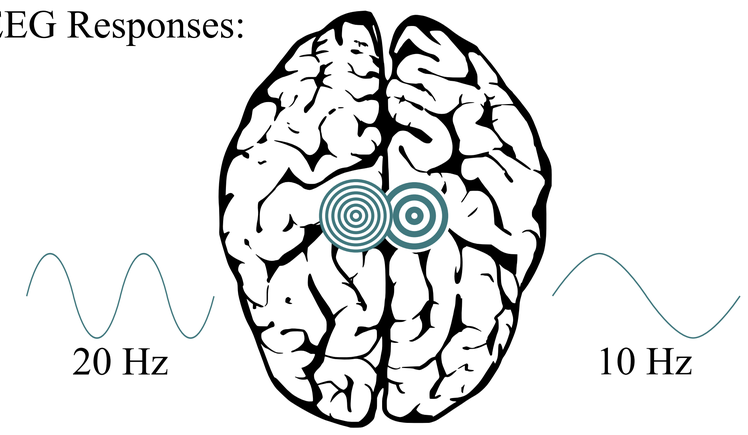
Illustration of a command selection in this context

Initial State: IDLE

Mechanical stimulation frequencies

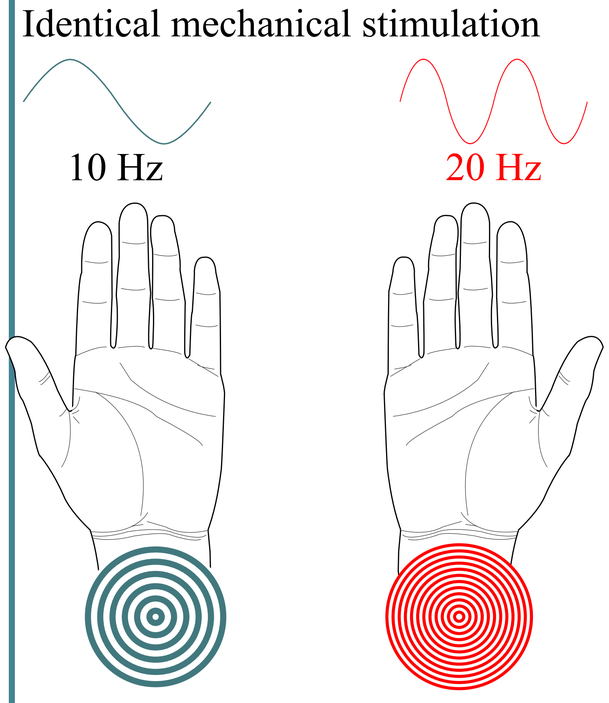


EEG Responses:

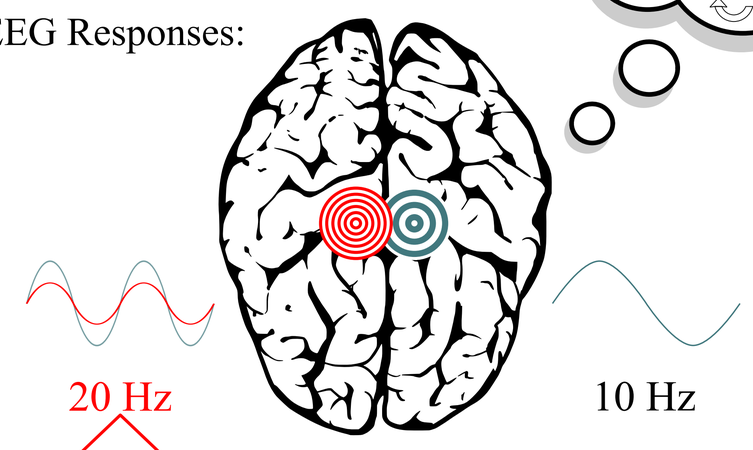


Motor Imagery with the right arm:

Identical mechanical stimulation



EEG Responses:

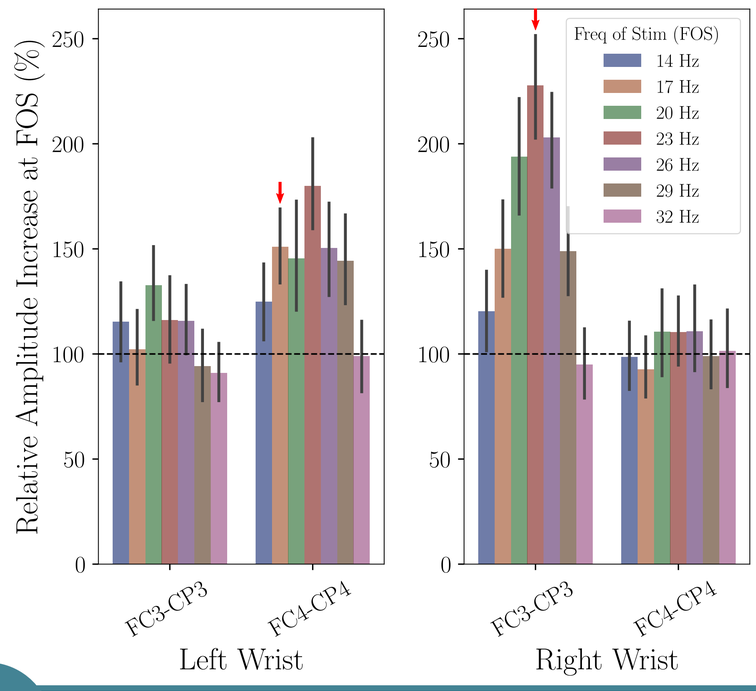


SSSEP's amplitude decrease, caused by Sensory Gating

IV Mandatory step: Screening procedure[2,3]

- Objective: Identify the stimulation frequency with the highest SSSEP.
- How: Train of stimulations of 2 s, at different frequencies: from 14 to 32 Hz.
- Amplitude estimation: fast Fourier Transform.

Screening results (subject #10)



V An experiment to test the Somatosensory Gating for an SSSEP-based BCI

Setup:

- Subject is sitting in front of a computer.
- Frequency of Stimulation (FOS) identified during a screening session.
- C-2 Tactors tapped to both wrists[4].
- EEG amplifier & Laptop: powered by batteries.

Experimental Conditions:

- Stay IDLE.
- Performing Motor Imagery (MI) with one arm.

Signal Processing:

Preprocessing:

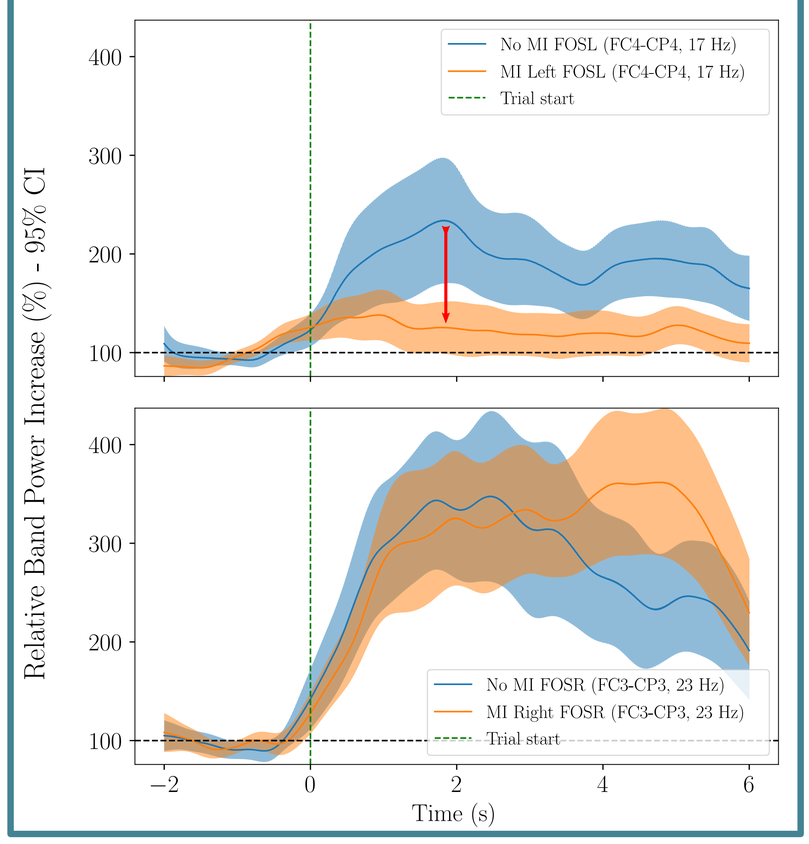
- Non-causal highpass filter at 5 Hz.
- Peak-to-peak signal amplitude for eye blinks detection. Trial removed, if significant.

Subject #10: ≈ 15% of data rejection.

Amplitude estimation:

- Narrow non-causal bandpass filter.
- Signal squared.
- Smoothen by a moving average (window length = 30 x FOS periods).

VI Observed effect (subject #10)



[1] J. I. A. Voisin, C. Mercier, P. L. Jackson, C. L. Richards, and F. Malouin. Is somatosensory excitability more affected by the perspective or modality content of motor imagery? *Neuroscience Letters* (2011)
[2] C. Breitwieser, V. Kaiser, C. Neuper, and G. R. Müller-Putz. Stability and distribution of steady-state somatosensory evoked potentials elicited by vibro-tactile stimulation. *Medical & Biological Engineering & Computing* (2012)
[3] J. Petit, J. Rouillard, and F. Cabestaing. EEG-based Brain-Computer Interfaces exploiting Steady-State Somatosensory-Evoked Potentials: A Literature Review. *Journal of Neural Engineering* (2021)
[4] C. Pokorny, C. Breitwieser, and G. R. Müller-Putz. A Tactile Stimulation Device for EEG Measurements in Clinical Use. *IEEE Transactions on Biomedical Circuits and Systems* (2014)

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