December 14th 2022

OpenViBE: an open source BCI software suite

PART 1 - Introduction

Arthur Desbois, Marie-Constance Corsi

ARAMIS team, Paris Brain Institute

Outline

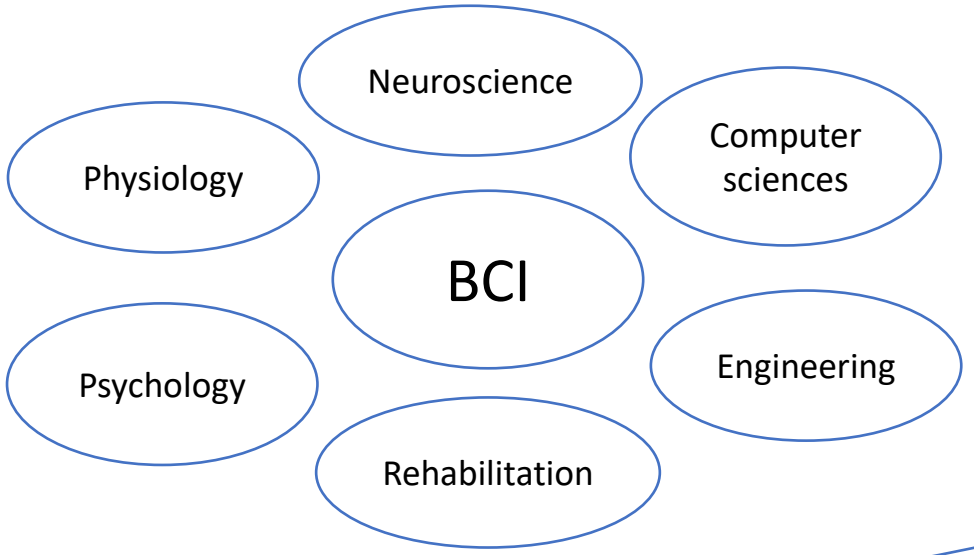
- **PART 1:** Intro to BCI (approx. 30 minutes)
  - What is a BCI system? Examples of clinical applications
  - Designing a BCI system: goals, methods, paradigms
  - OpenViBE: an open source BCI framework
- **PART 2:** Designing BCI protocols using OV (approx. 1.5 hours)
  - Details on Motor Imagery paradigm, and features of interest
  - Scenario 1 – data acquisition
  - Scenario 2 – signal processing
  - Scenario 3 – classification
- **PART 3:** Going further & concluding remarks (approx. 30 minutes)
  - C++ Algo Box development for OpenViBE
  - Python/Matlab scripting
  - HappyFeat : automating & simplifying usage of BCI protocols
  - Current research works and perspectives on BCI - *(optional)*

PART 1 – Introduction to BCI Systems

1.1 - What is a BCI ?

What is a BCI?

Context



Today

1970

1st implanted BCI

~10k publications
3 research groups

2000

> 30k publications
6-8 research groups

2005

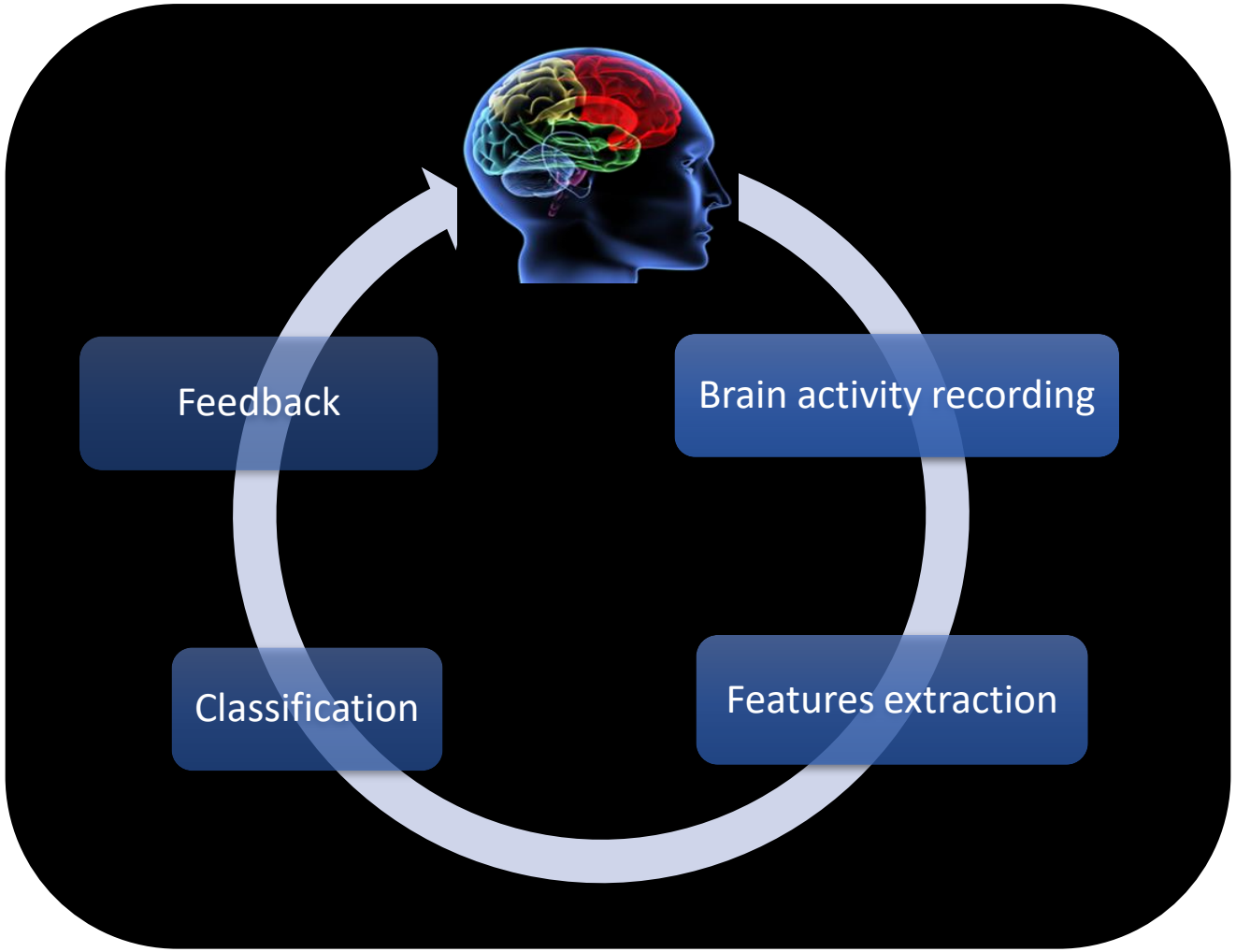
> 50k publications
> 100 research groups

Commercialization of devices oriented to general public

2010

2015

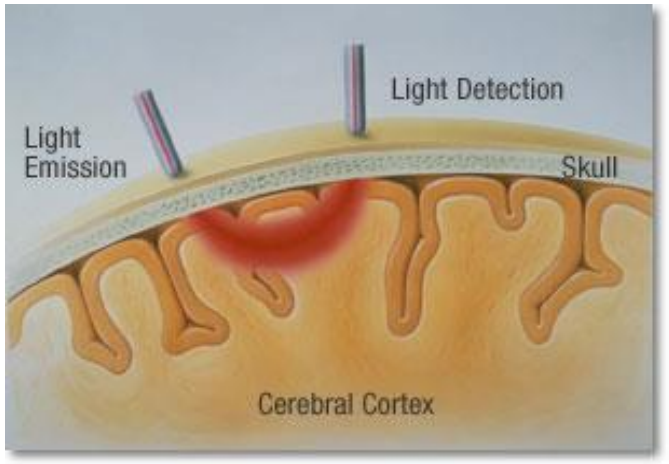
Behind the magic…



Tools to capture brain activity (non invasively)

Electroencephalography (EEG)
(Mak et al, 2012)

Magnetoencephalography (MEG)
(Mellinger et al, 2007)



Near Infrared Spectroscopy (NIRS)
(Fazli et al, 2012)

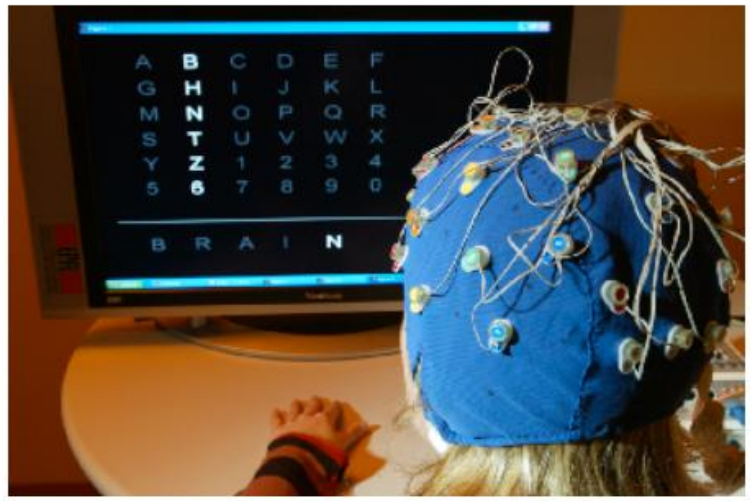
Functional MRI
(Sitaram et al, 2009)

Clinical applications

- **Control**
  - Prosthesis (Fifer et al, 2014)
  - Wheelchair (Carlson & Millan, 2013)
  - Quadcopter (LaFleur et al, 2013)

- **Communication**
  - Verbal & nonverbal communication
    (Jin et al, 2012; Hwang et al, 2012; Kashihara, 2014)
  - Silent talk (Naci et al, 2013)

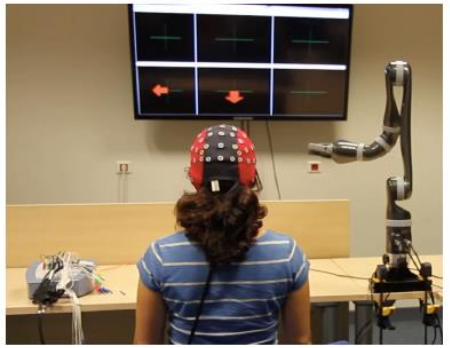
- **Neurological disorders treatment**
  - Stroke (Prasad et al, 2010)
  - Spinal cord injury (King et al, 2013)
  - Consciousness (Chatelle et al, 2012)
  - Psychiatric disorders (Arns et al, 2017)

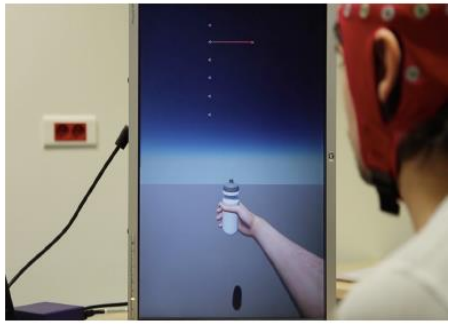


BCI & communication

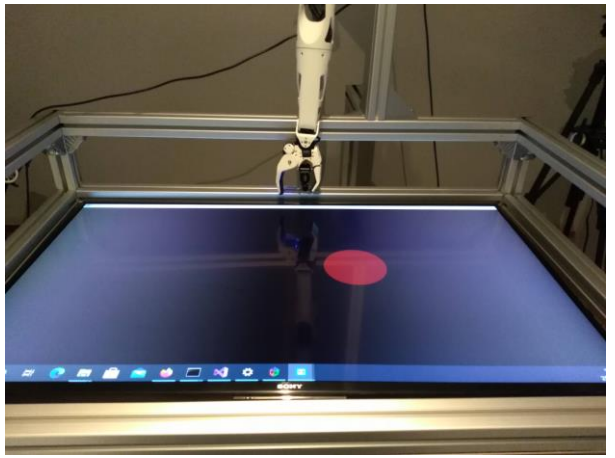
OpenViBE - research and clinical applications

- **OpenViBE applications:**
  - Robotic device control
  - Stroke rehabilitation
  - Better monitoring general anesthesia





LORIA projects
Courtesy of S. Rimbert

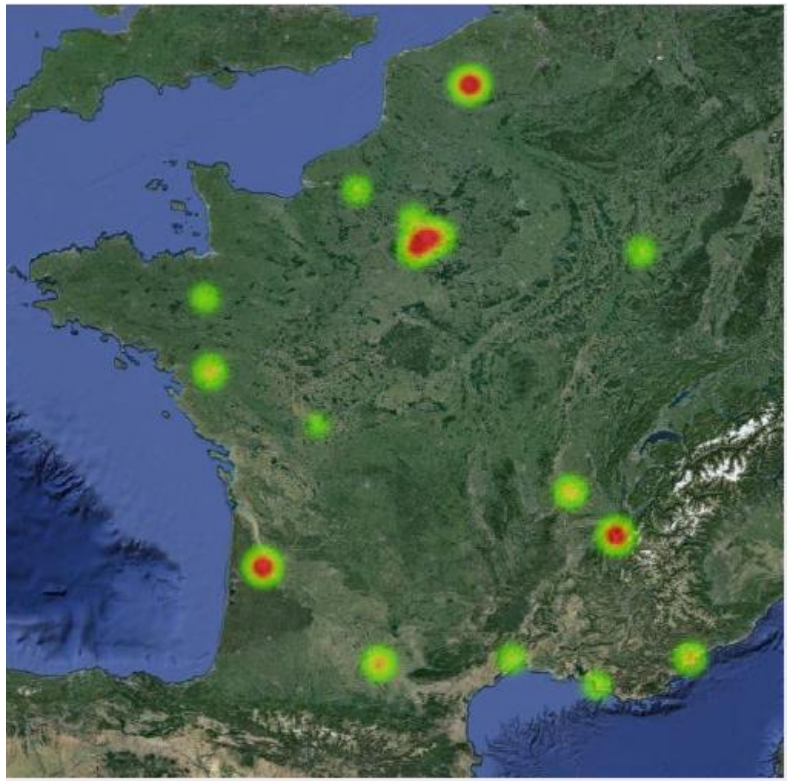


ARAMIS projects
Courtesy of T. Venot

OpenViBE - research and clinical applications

- **Involved laboratories**
  - LORIA team (Nancy, France)
  - Hybrid team (Rennes, France)
  - Potioc team (Bordeaux, France)
  - ARAMIS team (Paris, France)

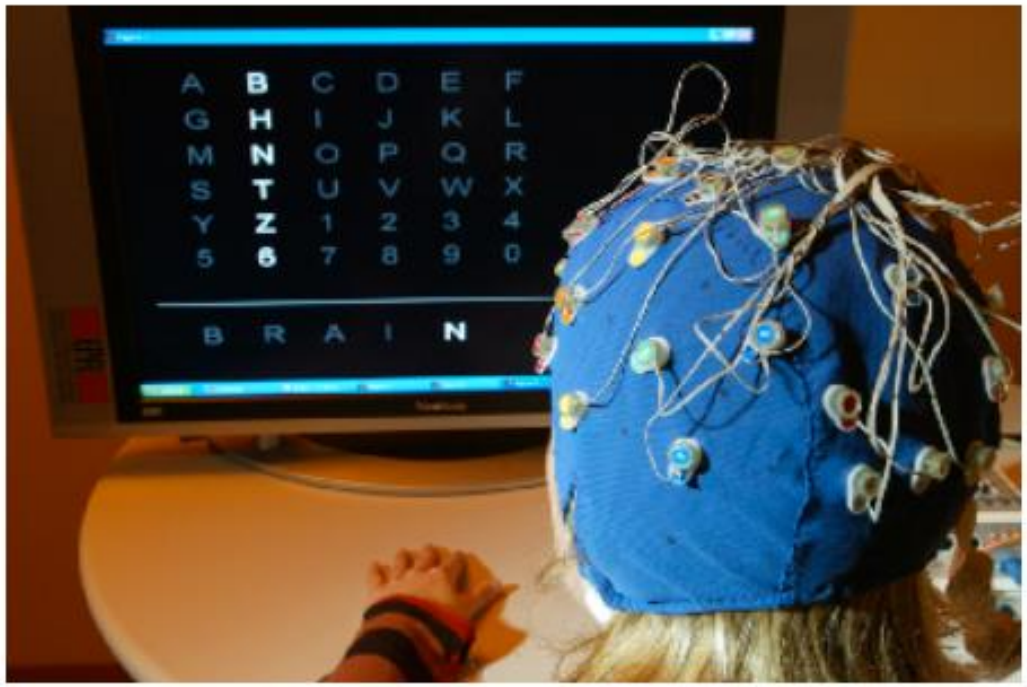
- **Most salient disciplines:**
  - EEG Signal Processing & Machine Learning
  - Clinical Neuroscience
  - Human-Computer Interaction & BCI
  - Computational Neuroscience
  - Invasive BCI research
  - Ethics



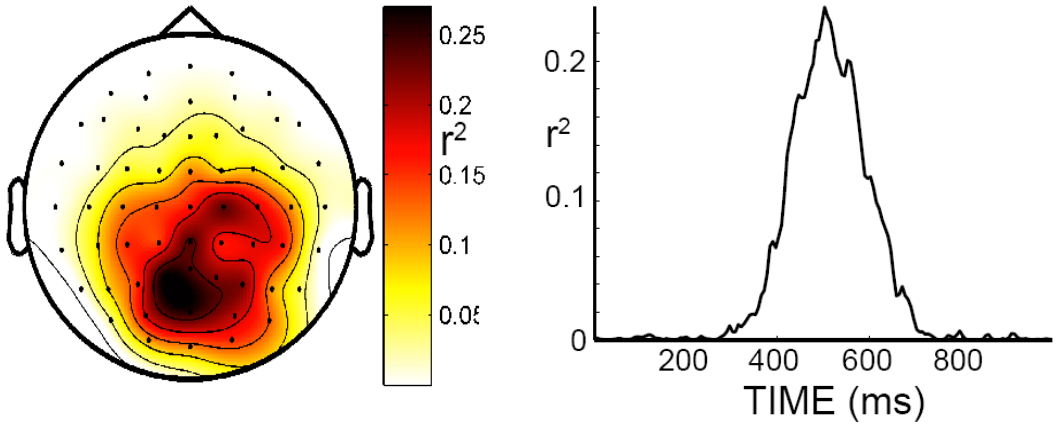
BCI labs localization in France

⇒ Link to an interactive map of laboratories (work in progress, not exhaustive)

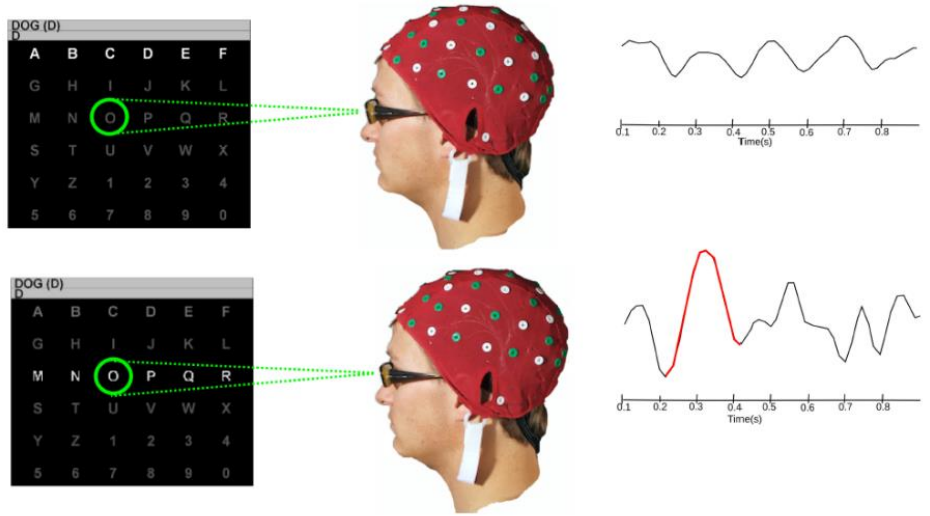
Types of BCI – P300 Speller



P300 Speller

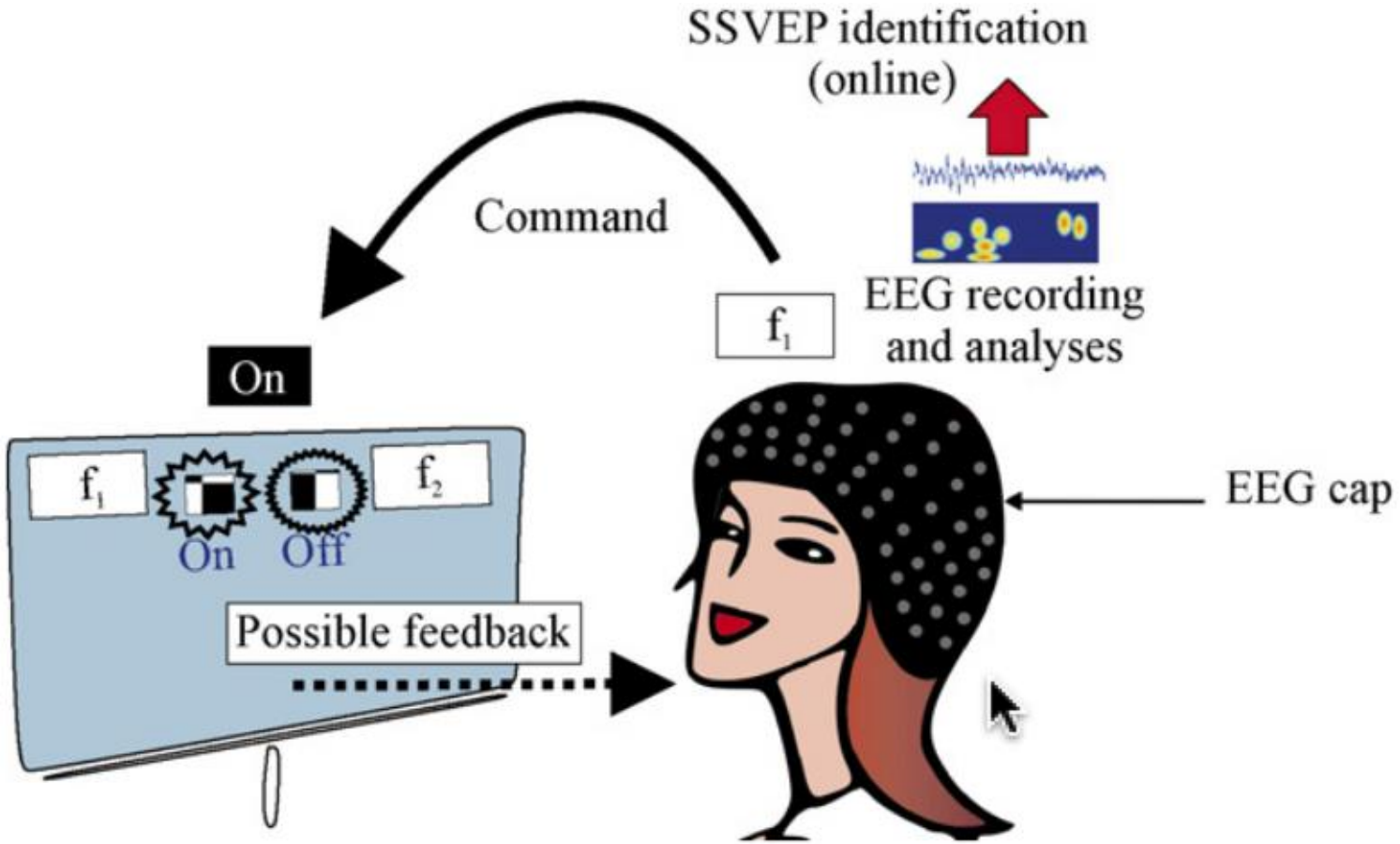


Illustrations from BCI2000 website



(Lotte et al, 2015)

Types of BCI – Visual Evoked Potential (VEPS)



(Vialatte et al, 2010)

PART 1 – Introduction to BCI Systems

1.2 – OpenViBE: An open-source BCI Framework

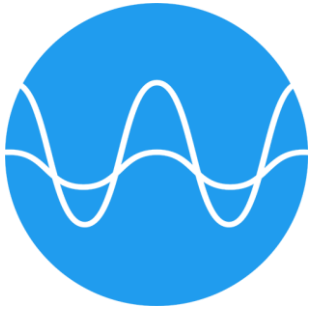
OpenViBE

- **Open-source software platform - http://openvibe.inria.fr/**
  - Design, test & use BCIs
  - Generic system for realtime EEG acquisition, processing and visualization
- **Key features - http://openvibe.inria.fr/features/**
  - Modularity, flexibility
  - Aimed for different types of users
  - Portability, cross-platform
  - Compatibility with EEG hardware, + VR integration
  - Compatibility with Python, MATLAB, LUA
  - BCI paradigms available as demos (P300, MI, Neurofeedback…)

Other BCI Systems and Toolboxes…

- **BCI2000**
  - C++ based system for BCI research
  - Not open source, but sources & executables available for free (non-profit & educ. purposes)
  - Real-time BCI through 4 stages : acquisition, processing, user interface, operator/visualization interface

- **TimeFlux**
  - Open-source, Python-based, flexible… check it out!



- **BCI++**
  - C/C++ based framework for designing BCI experiments.
  - Not open-source

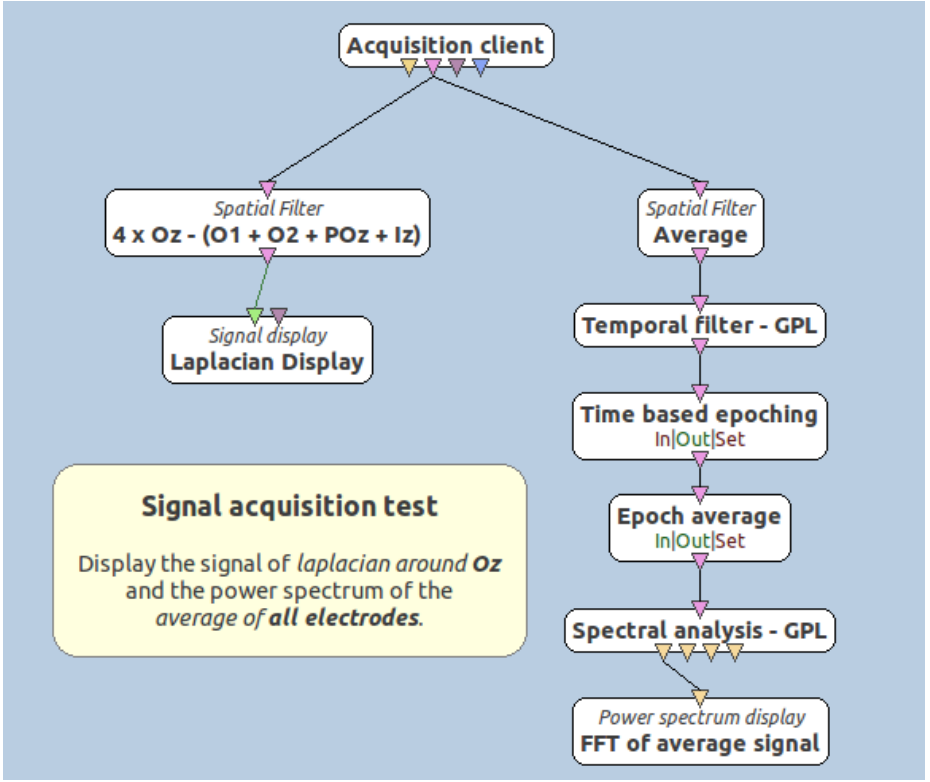
OpenViBE – EEG Hardware compatibility

- **Any EEG device can be supported, through the development of a C++ driver**
- **Already supported :**
  - Brain Products devices (Brainamp series, VAmp…)
  - Brainmaster (Atlatis, Discovery)
  - EGI (Netamps 300)
  - Micromed devices (via SystemPlus Evolution software)
  - OpenEEG
  - Neurosky … … …
- **Full list on http://openvibe.inria.fr/supported-hardware/**

OpenViBE - Modularity

No need to be a programmer to design a BCI system!

- Processing boxes
- Links for different types of data flow & info
- Easy prototyping, flexibility for experimenting



OpenViBE: Open-source, community

- **Contributions are possible… and more than welcome!**
  - Many processing boxes have been integrated following user submissions

- **Community -** http://openvibe.inria.fr/forum/
  - Discussions about usage, ongoing developments, issues…

- **License -** http://openvibe.inria.fr/license/
  - Fully AGPL-3 (http://www.gnu.org/licenses/agpl-3.0.html)

OpenViBE: Open-source, community

- **Existing tutorials**
  - Level 1 - beginners
    - My first OpenViBE setup
    - Choosing my BCI paradigm
    - Using a (new) hardware with OpenViBE

  - Level 2 – more advanced
    - Troubleshooting OpenViBE scenarios
    - How to do repeatable experiments with OpenViBE
    - Using Python with OpenViBE
    - Using Matlab with OpenViBE
  - Level 3 – OpenViBE black belt
    - How to make a box plugin library

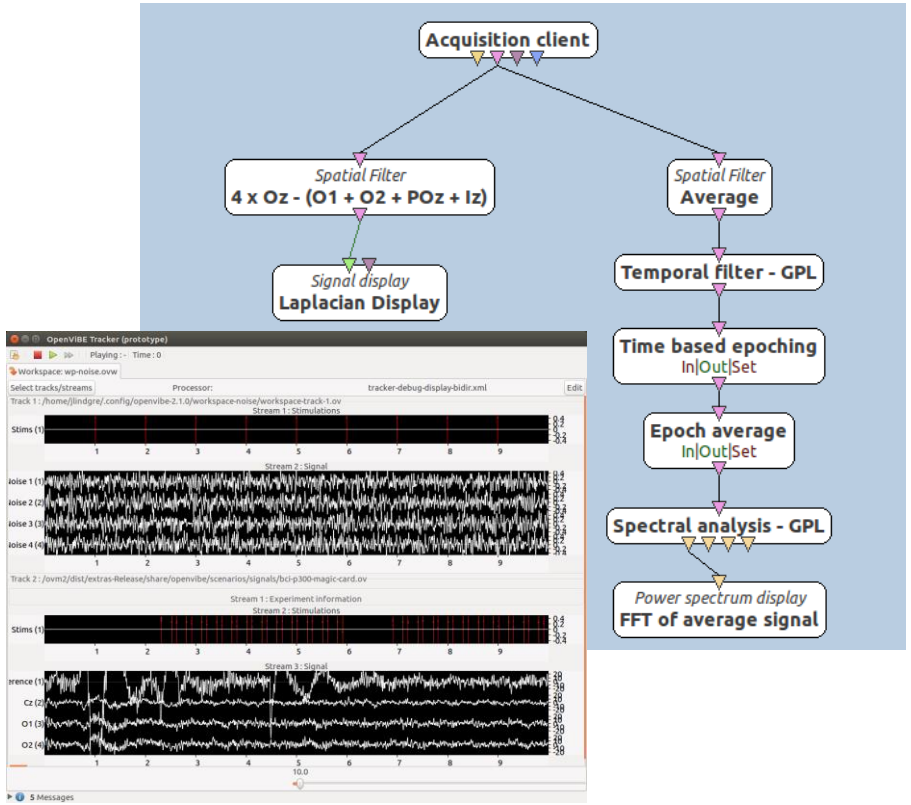
PART 1 – Introduction to BCI Systems

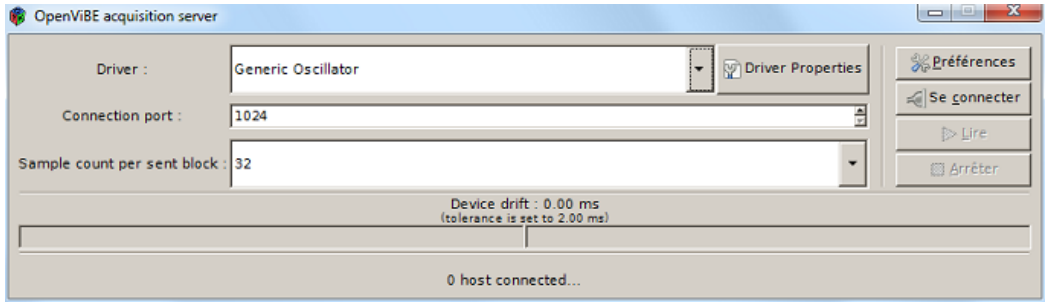
1.3 – OpenViBE: Technical Concepts

OpenViBE - let's dive in!

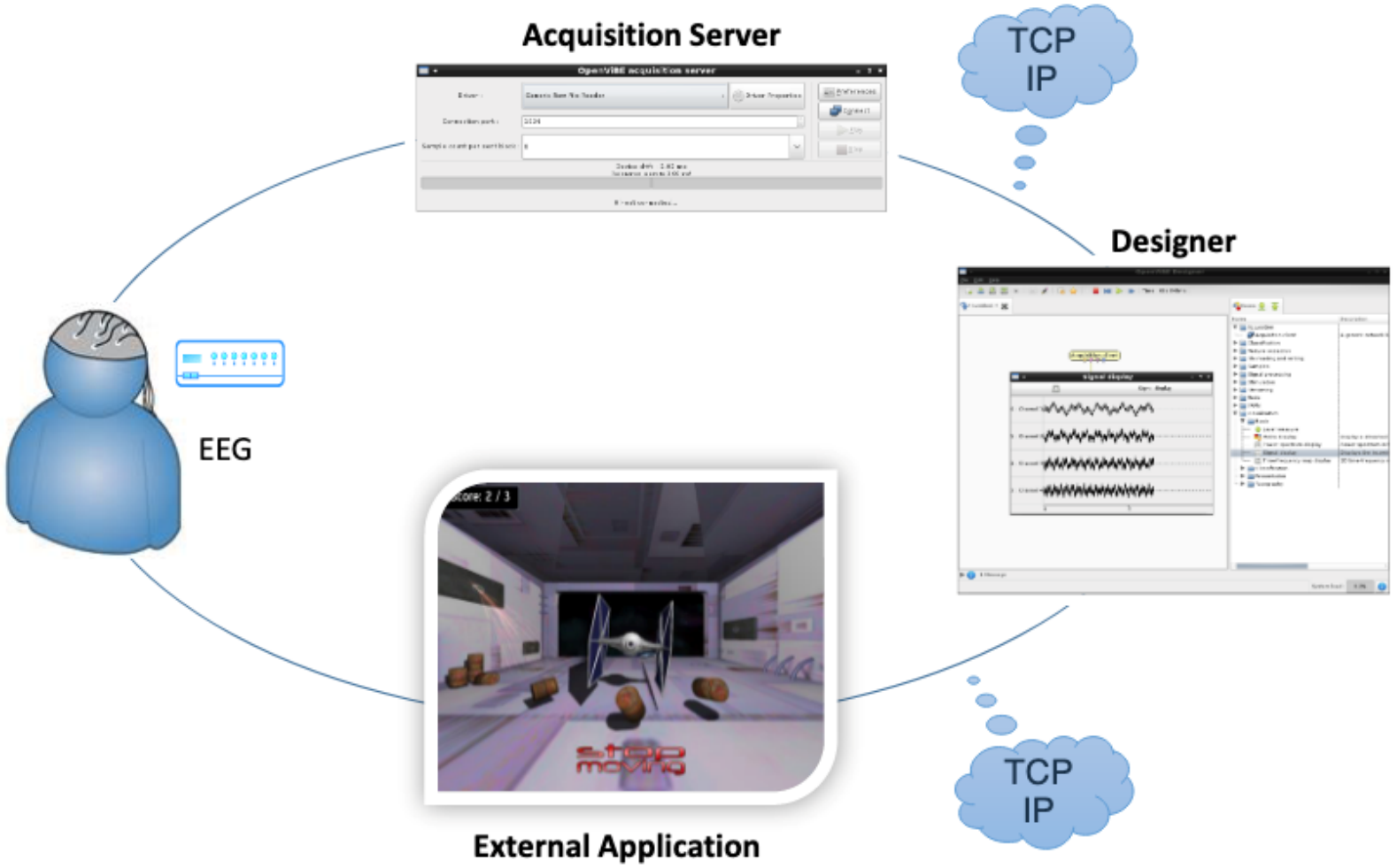
OpenViBE is made of two principal applications :

- **OpenViBE Designer**
  - For creating, modifying and using BCI scenarios
  - Fully graphical interface, data visualization
  - Processing boxes to link and parametrize
- **OpenViBE Acquisition Server**
  - Acquires EEG & bio signals from the hardware
  - Translates signals to a common format
  - Transmits data to connected apps, such as the Designer, over a local network (or on the same computer)



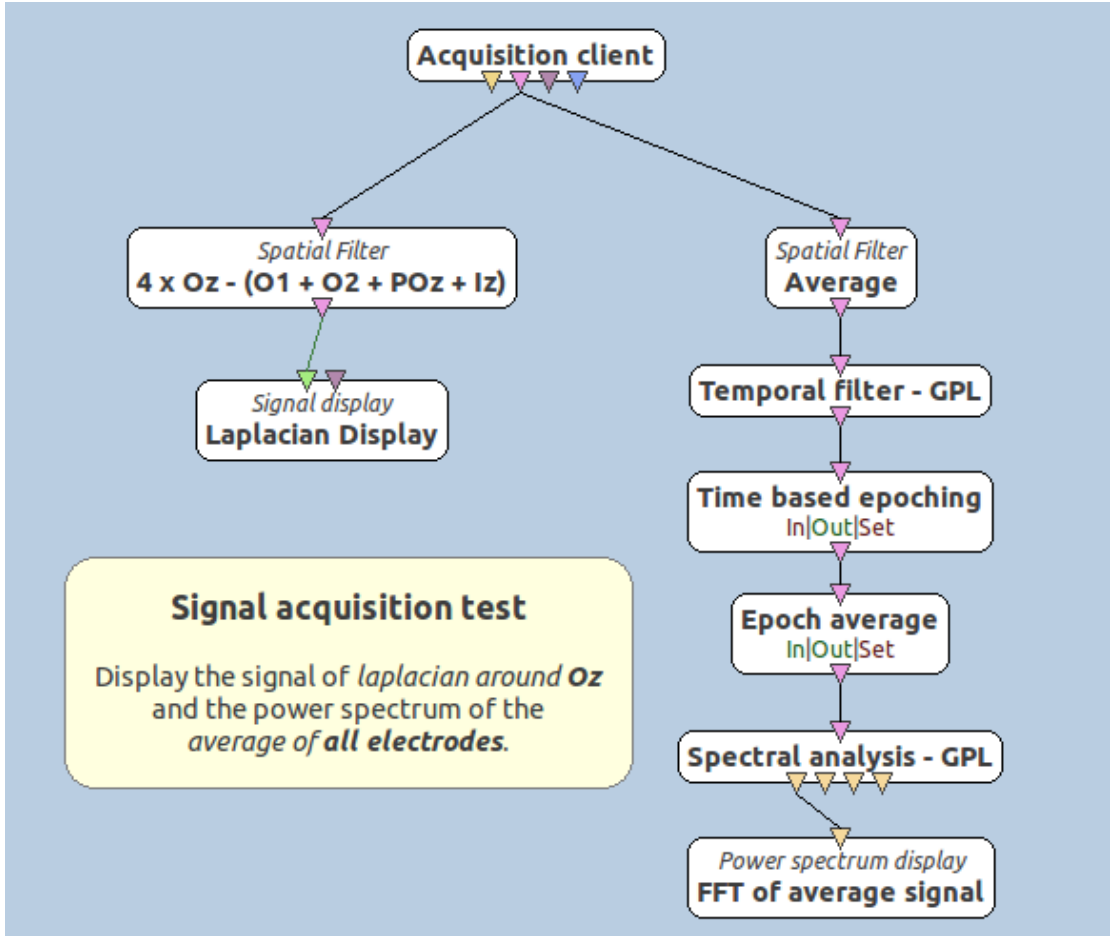


OpenViBE - Typical Usecase



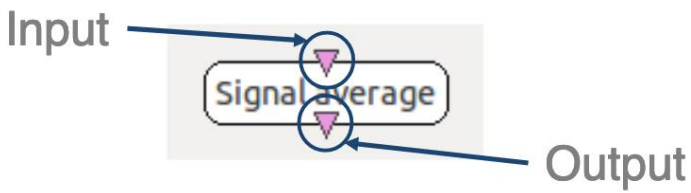
Plugins & Boxes

- **Processing boxes**
  - I/O (file and stream reading/writing)
  - Signal Processing (filtering, spectral analysis…)
  - Classification
  - Visualization (topography, time signals, spectra…)
  - Scripting (LUA, Matlab, Python…)
  - Scenario/experiment management
- **Different links btw. boxes**
  - Signal streams (multi-channel signal, matrix,…)
  - Experiment stimulations

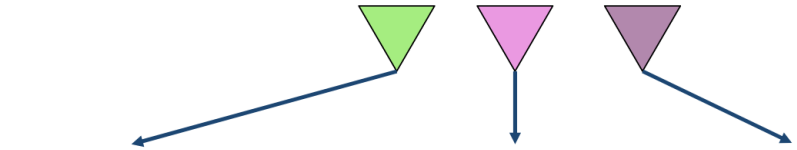


Plugins & Boxes

- **Data streams**



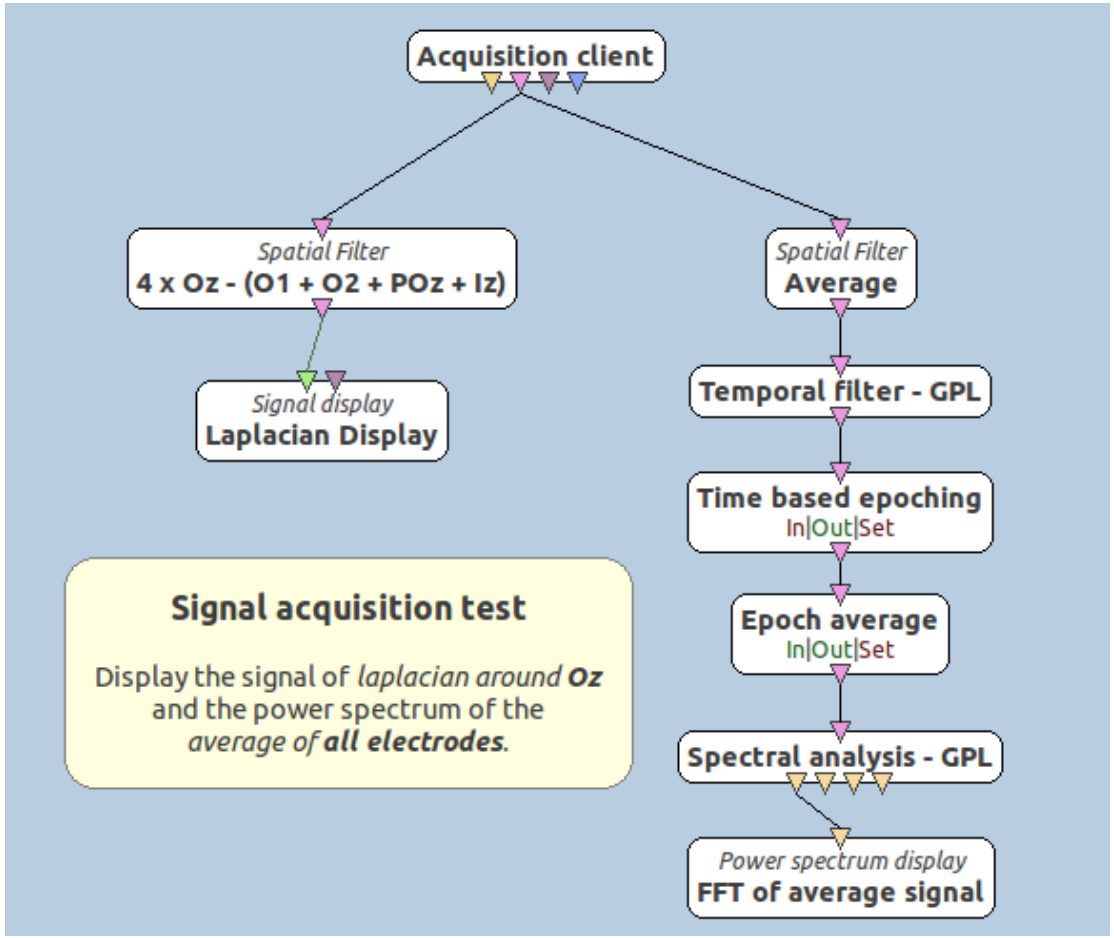
Data types



Streamed matrix
(data matrix)

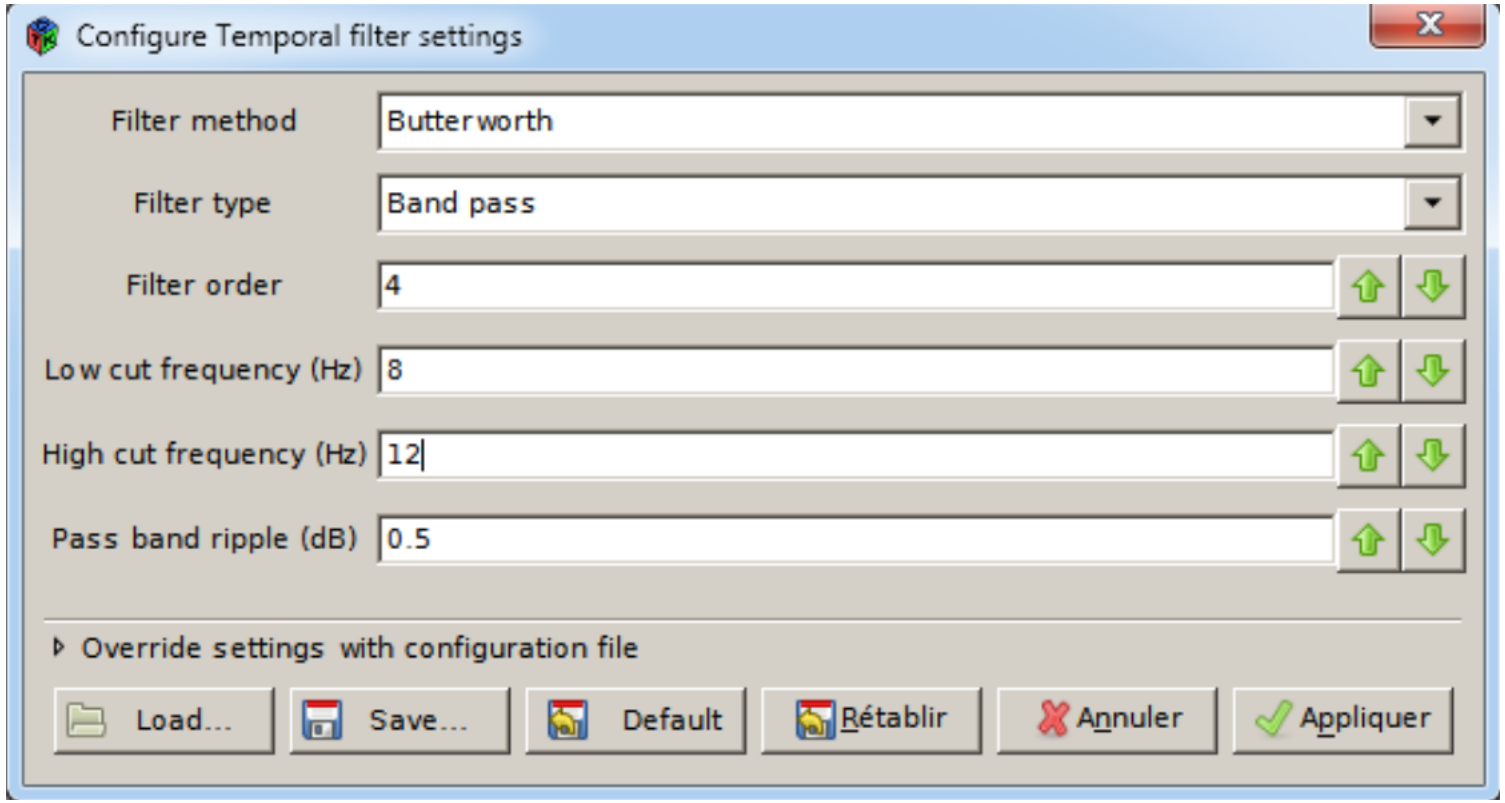
Signal
(Data with a sampling rate and channels – subtype of streamed matrix)

Stimulation
(Event with a name and a date)



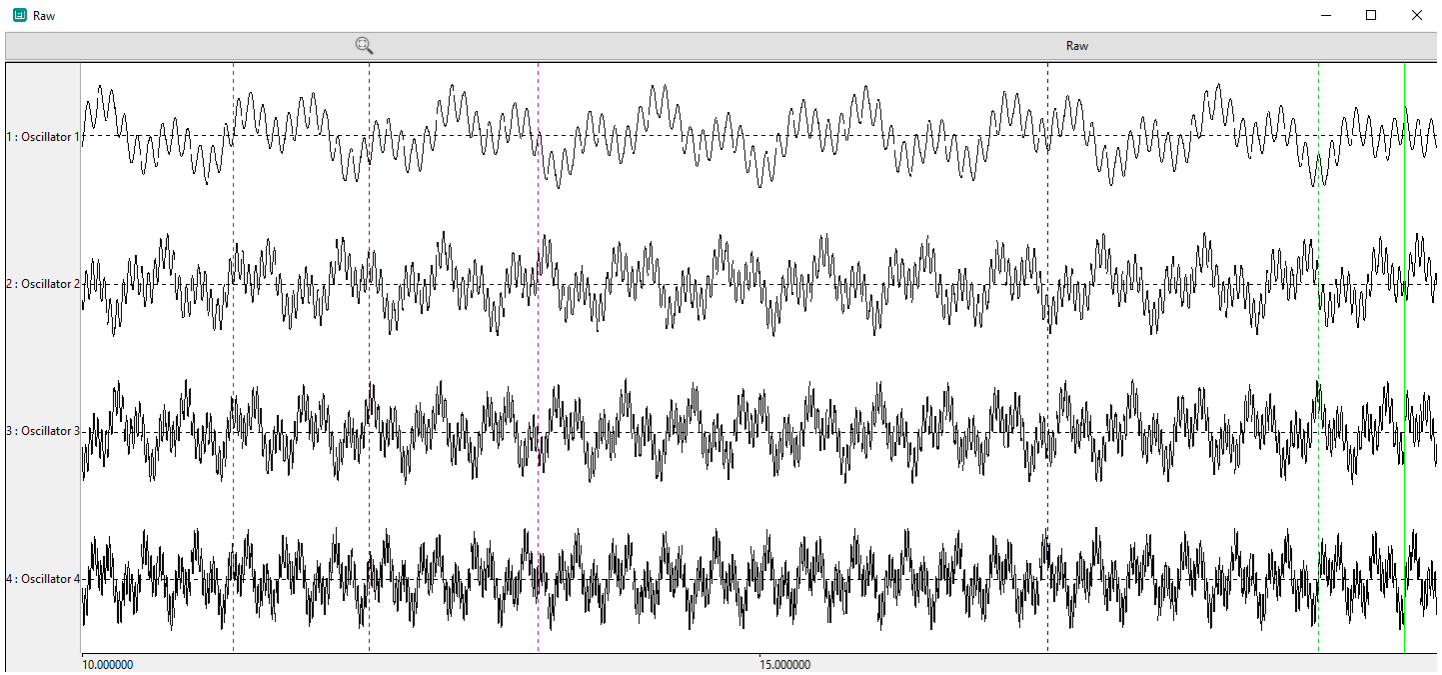
Plugins & Boxes

- **Box Parameters**



Concept of “Stimulations”

- **“Stimulations” = events Synchronized with the acquired signal**
  - Management of particular sections or useful events in a BCI experiment
  - *Experiment Start/Stop*
  - *Button pressed*
  - *New trial…*



Part1 - Q&A

BCI Motor Imagery with OpenViBE in X-Men: First Class

Thanks for your attention! Any questions?