WS: BRAIN-COMPUTER INTERFACE USING OPENVIBE, AN OPEN-SOURCE SOFTWARE PLATFORM – PART 1

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**: My first BCI experiment using OpenViBE – a hands-on tutorial (approx. 2 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 (interactive choice!) & concluding remarks (approx. 30 minutes)
  - C++ Algo Box development for OpenViBE
  - Python/Matlab scripting
  - Current works and perspectives on BCI

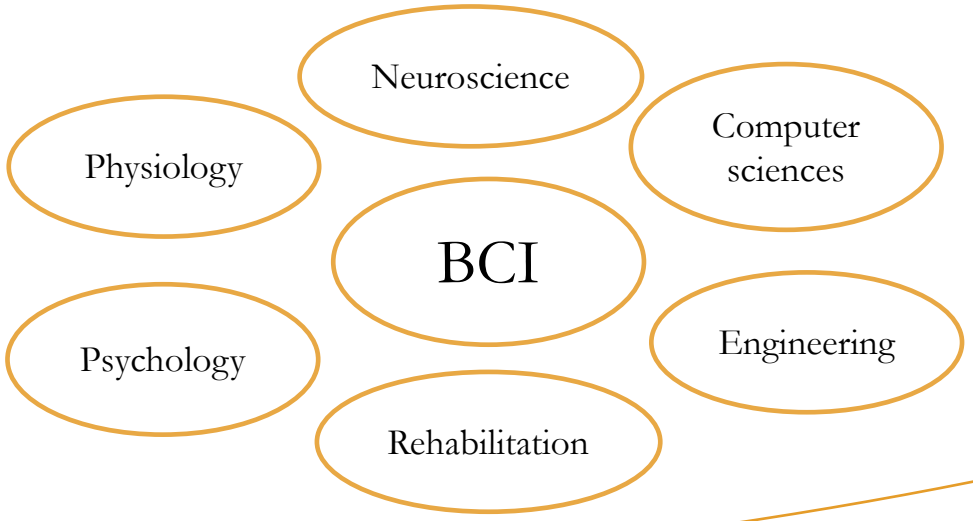
Reminder: you need to have OpenViBE installed!

http://openvibe.inria.fr/downloads/

INTRODUCTION TO BCI SYSTEMS

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

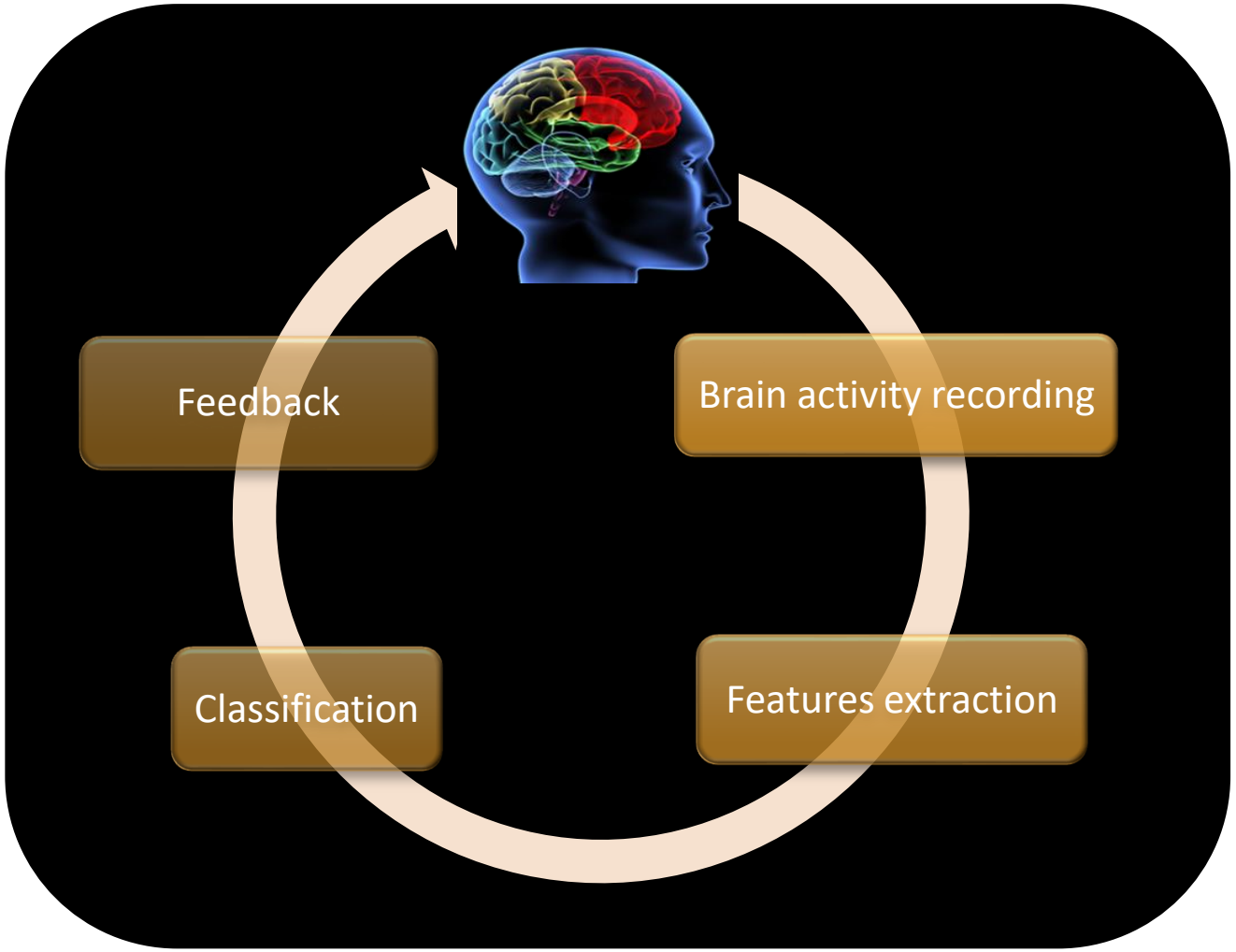
Commercialization of devices oriented to general public

2010

Emotiv, US

2015

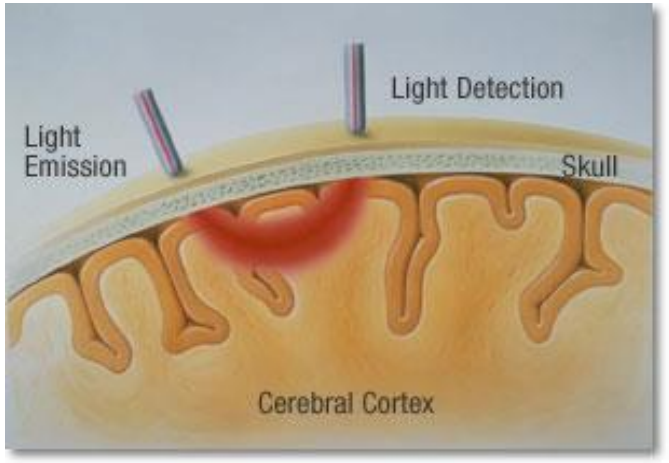
BEHIND THE MAGIC…



TOOLS TO CAPTURE BRAIN ACTIVITY (NON INVASIVELY)

Electroencephalography (EEG)
(Mak et al, 2012)

Magnetoencephalography (MEG)
(Mellinger et al, 2007)



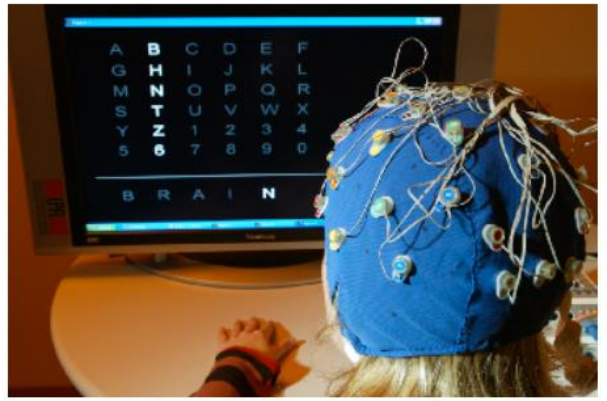
Near Infrared Spectroscopy (NIRS)
(Fazli et al, 2012)

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)



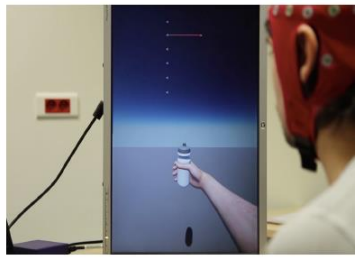
BCI & communication

- 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)

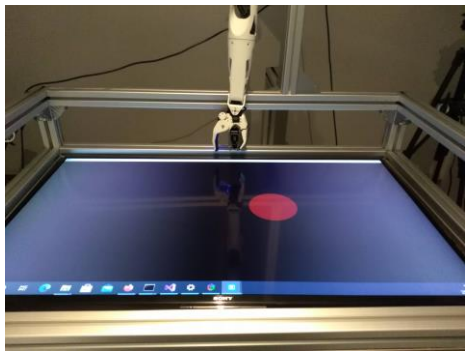
OPENVIBE - EXAMPLES OF RESEARCH AND CLINICAL APPLICATIONS

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

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

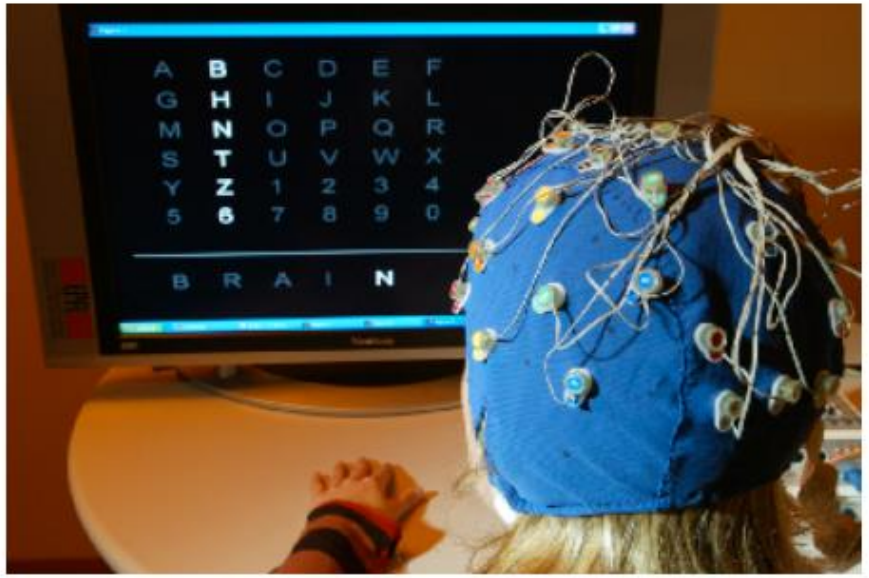


LORIA projects
Courtesy of S. Rimbert

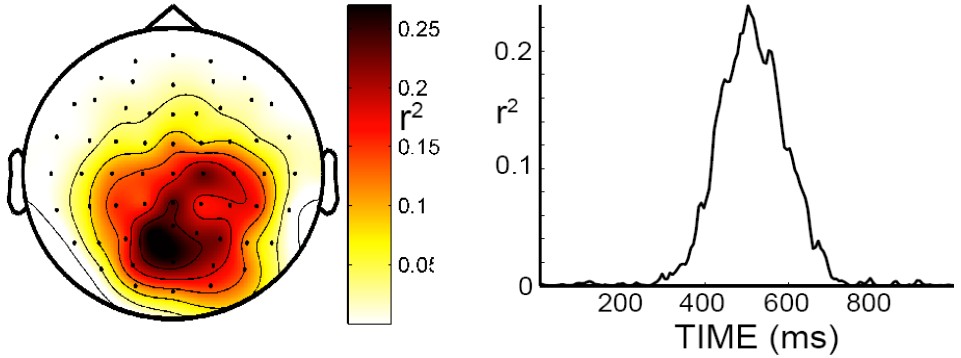


ARAMIS projects
Courtesy of T. Venot

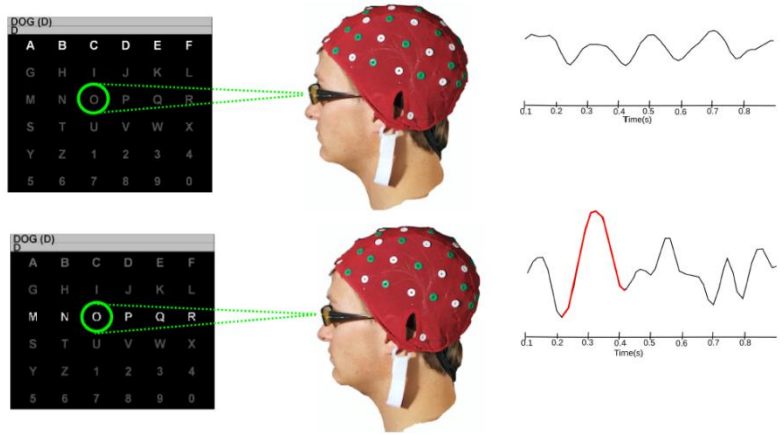
DIFFERENT TYPES OF BCI – P300 SPELLER



P300 Speller

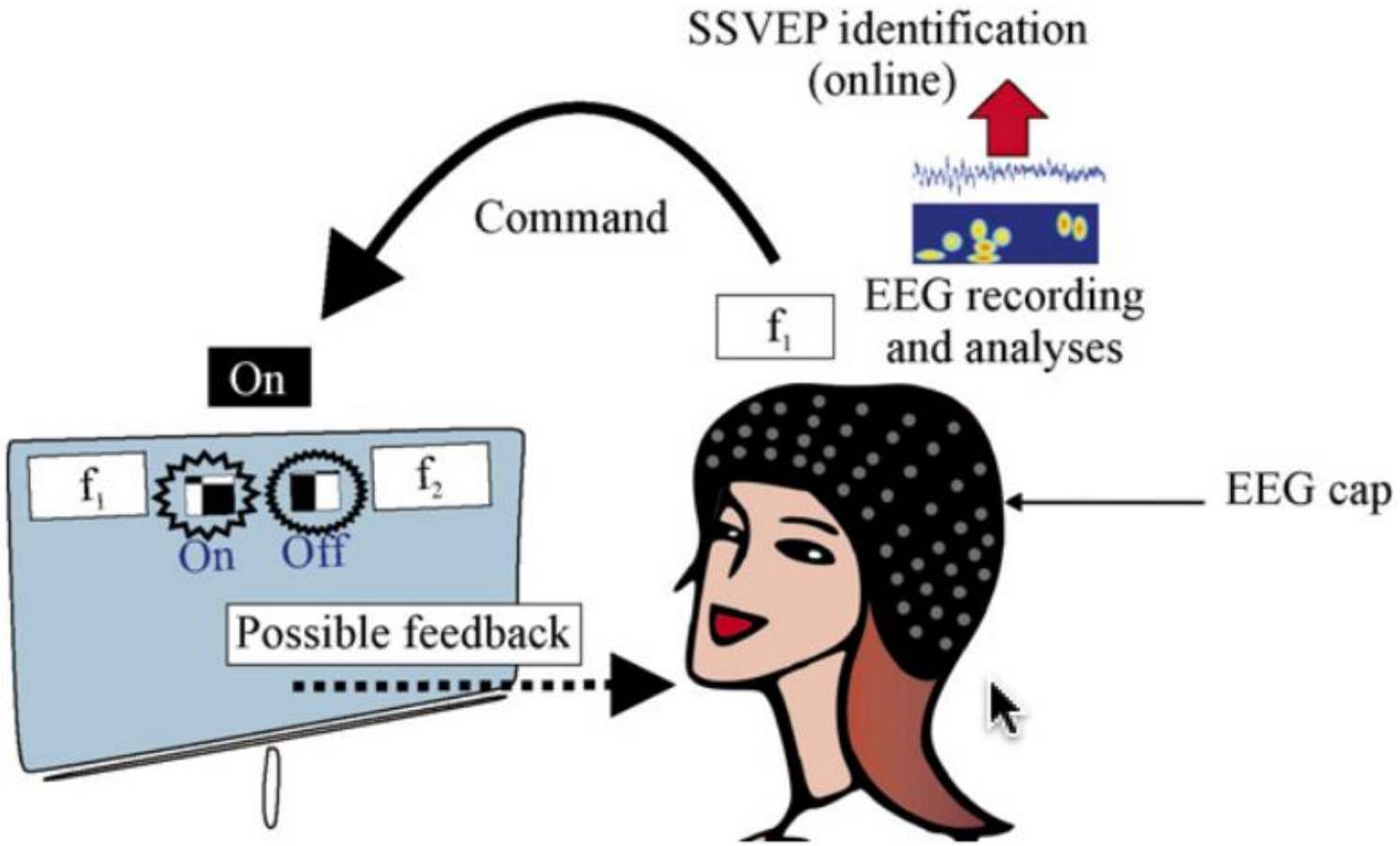


Illustrations from BCI2000 website



(Lotte et al, 2015)

DIFFERENT TYPES OF BCI – VISUAL EVOKED POTENTIAL (VEPS)



(Vialatte et al, 2010)

OPENVIBE

INTRODUCTION - 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 & 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

- BioSig
  - Matlab / Octave toolbox

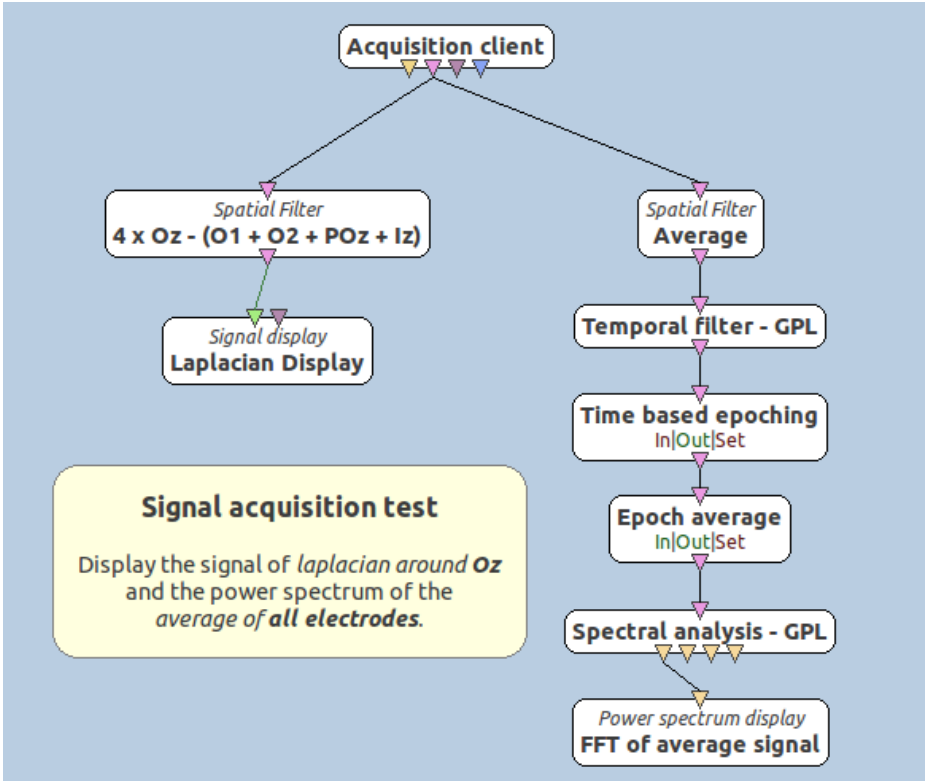
- BCI++
  - C/C++ based framework for designing BCI experiments.
  - Not open-source

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

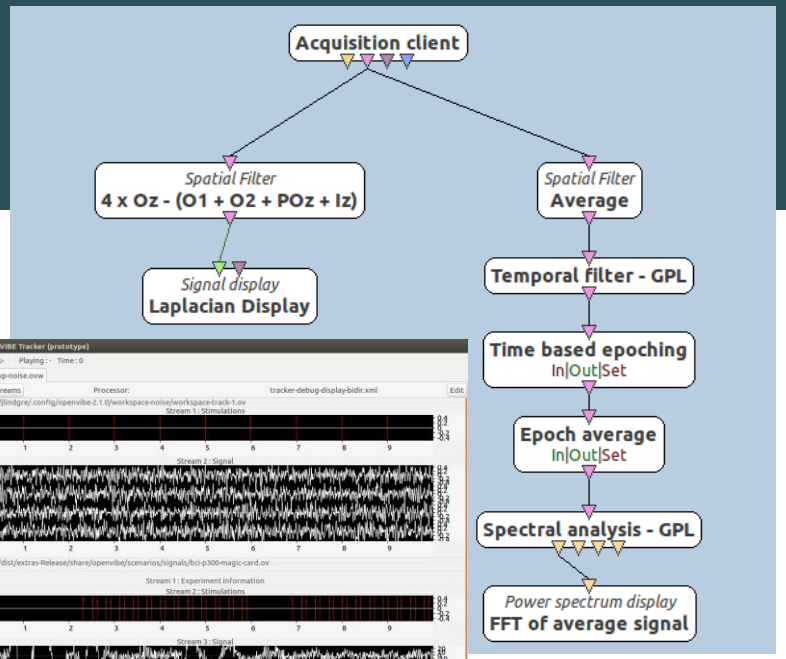
OPENVIBE

TECHNICAL CONCEPTS

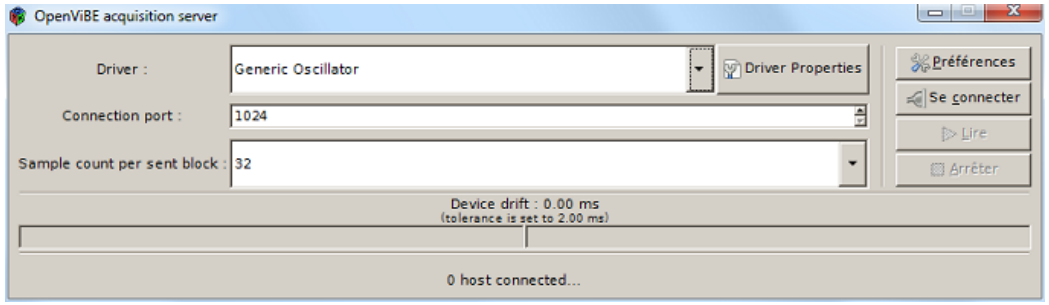
OPENVIBE – IN DEPTH

- 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

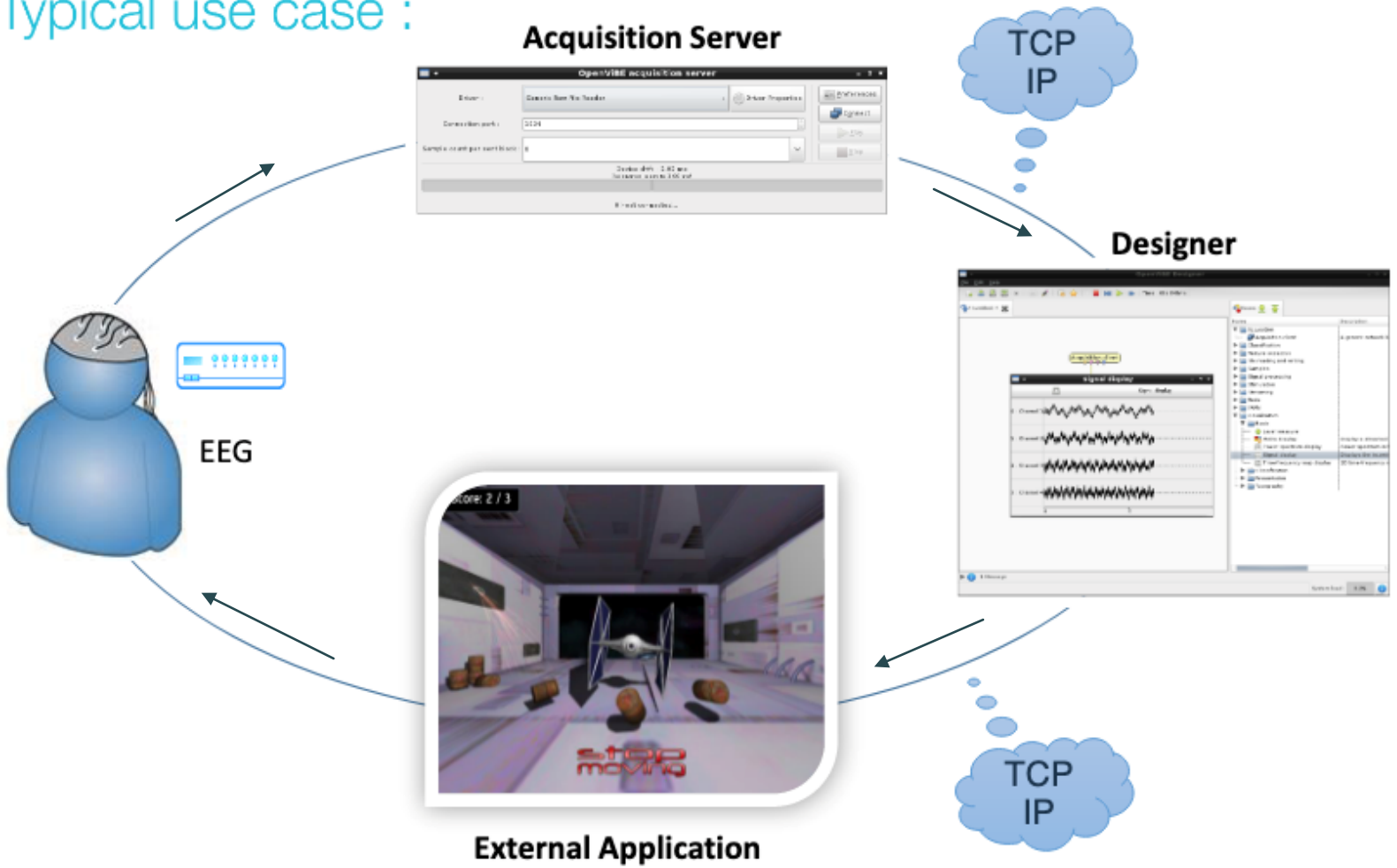


- **OpenViBE Acquisition Server**
  - Acquires EEG & bio signals from the hardware
  - Translates signals to a common format
  - Transmits data to connected apps, such as the Designer, over a local network (or on the same computer)



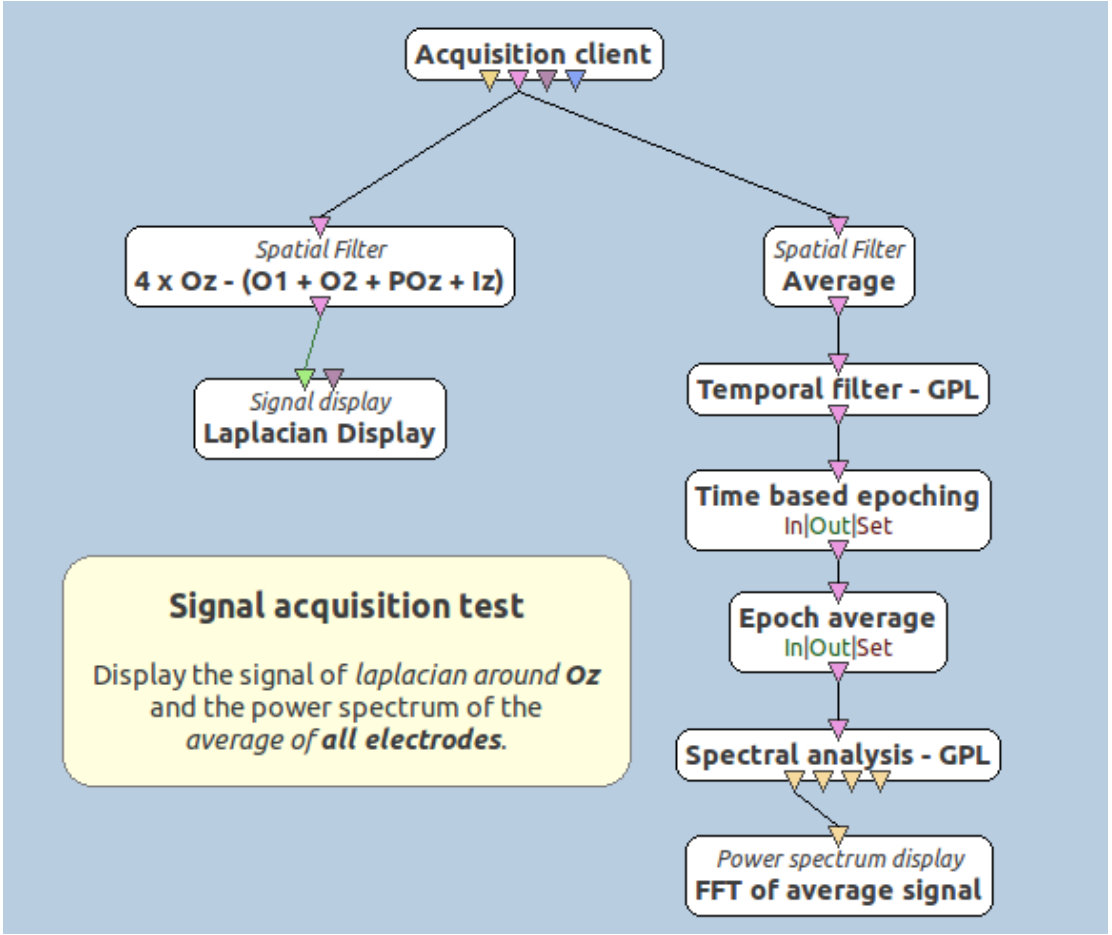
OPENVIBE – TYPICAL USECASE

- Typical use case :



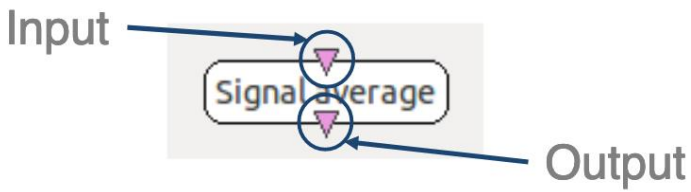
OPENVIBE – PLUGINS & « BOXES »

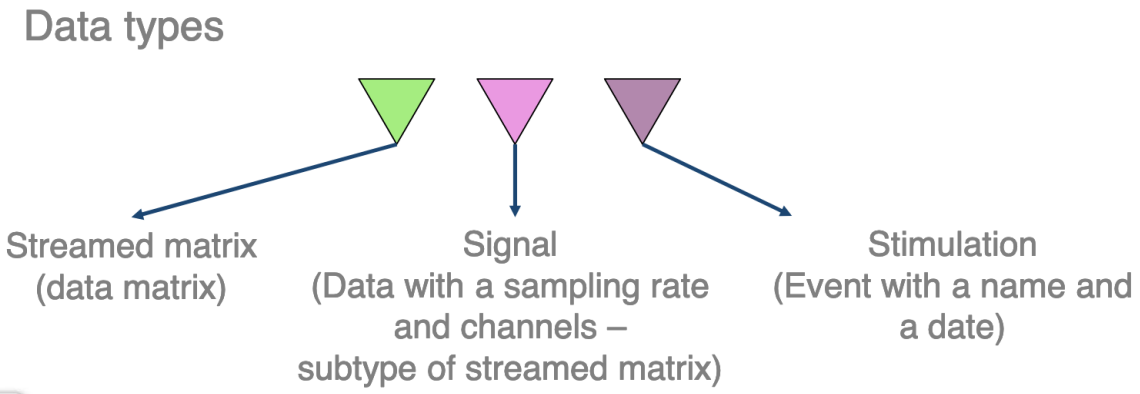
- **Processing boxes**
  - I/O (file and stream reading/writing)
  - Signal Processing (filtering, spectral analysis…)
  - Classification
  - Visualization (topography, time signals, spectra…)
  - Scripting (LUA, Matlab, Python…)
  - Scenario/experiment management
- **Different links btw. boxes**
  -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

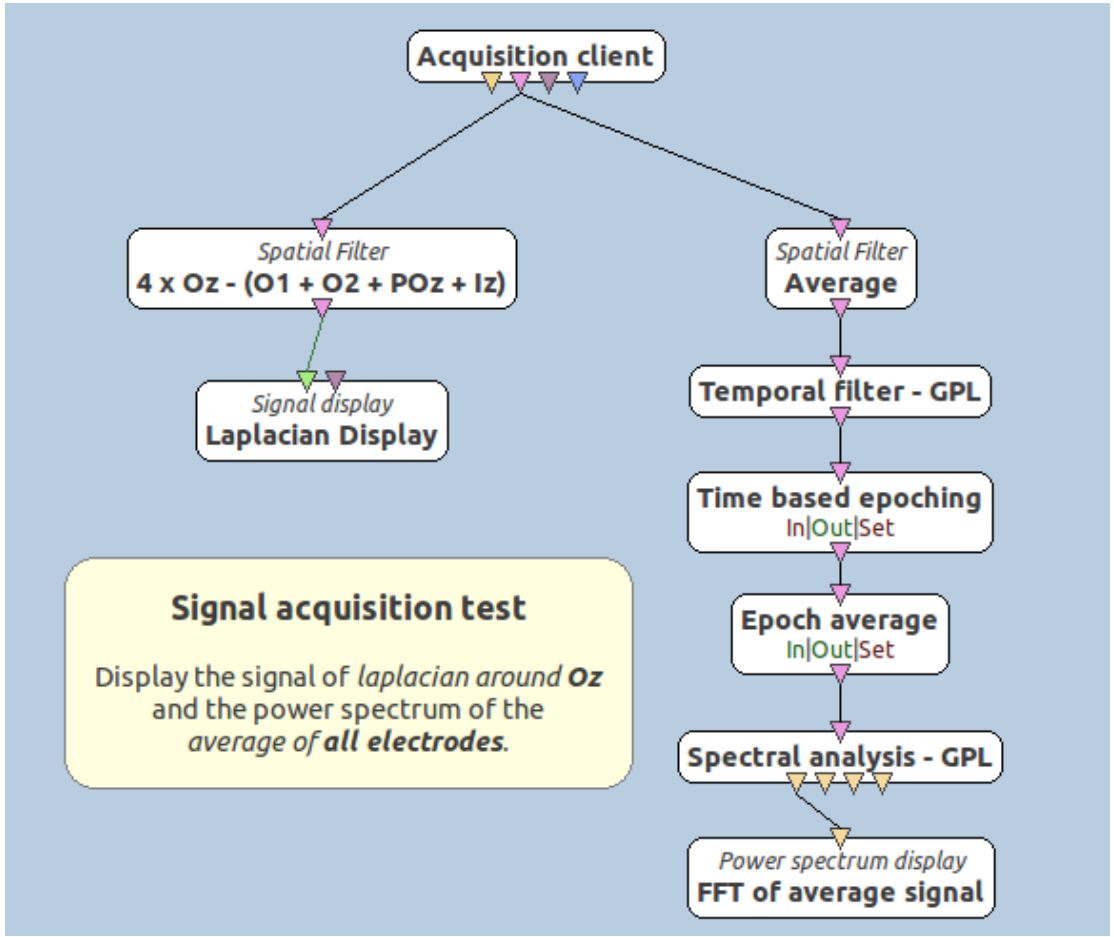


OPENVIBE – PLUGINS & « BOXES »

- **Data Streams**

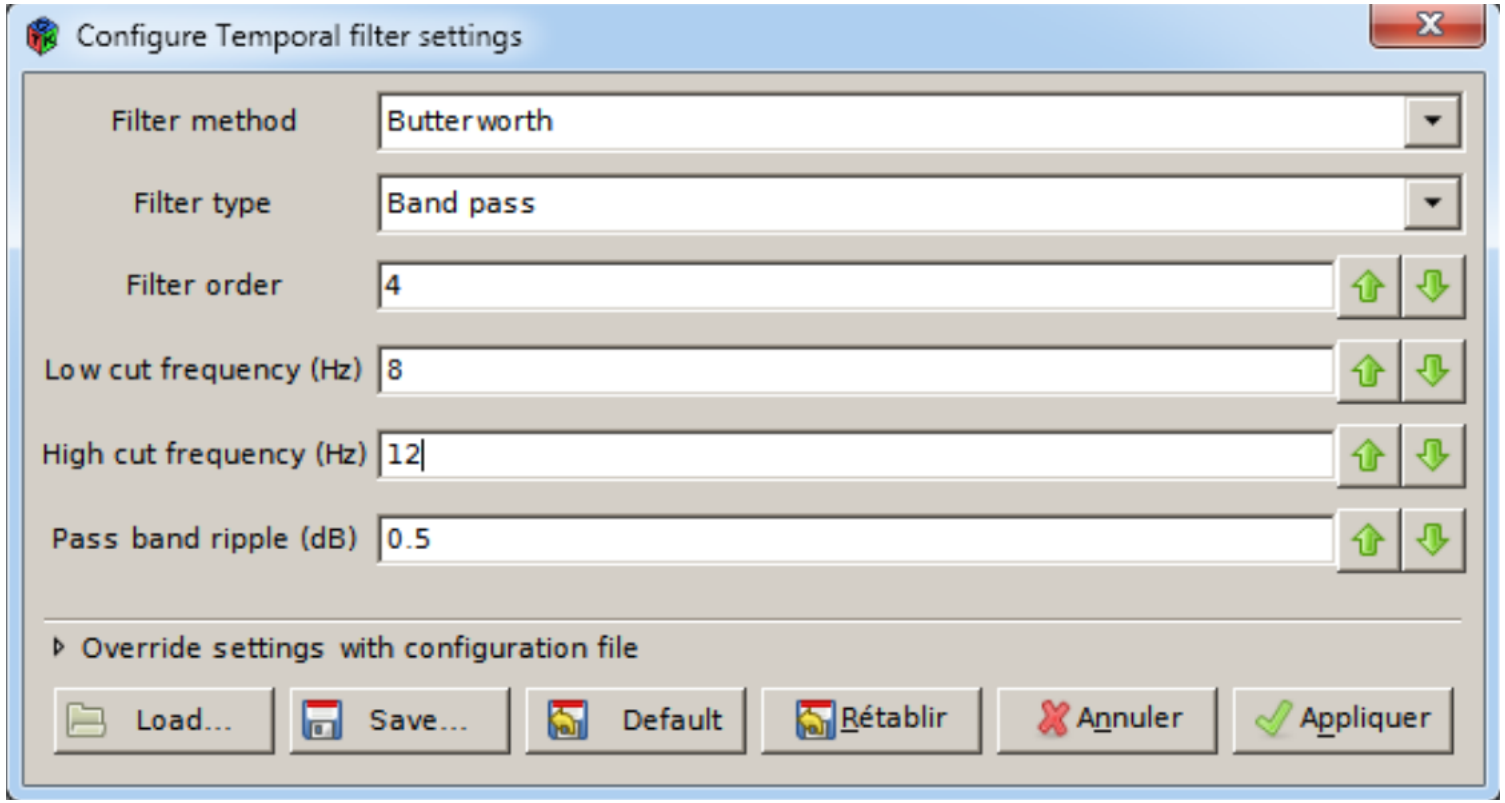






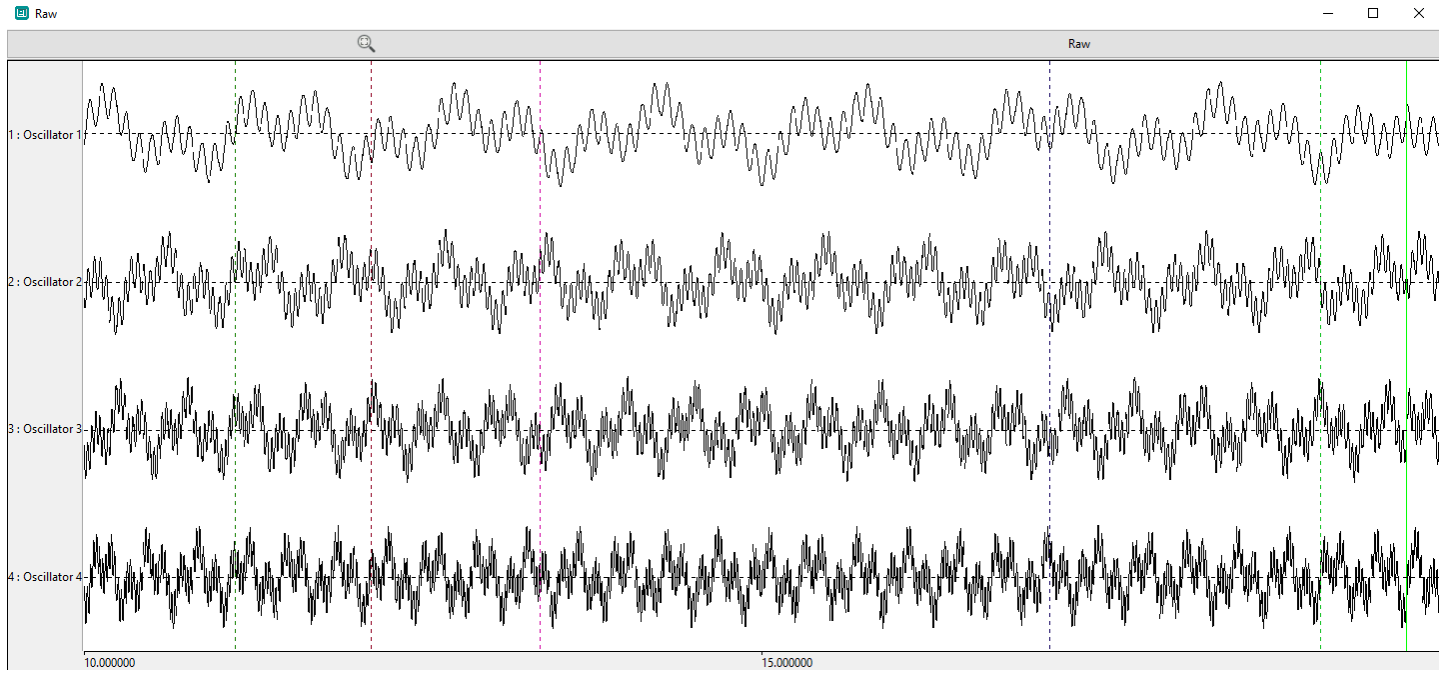
OPENVIBE – PLUGINS & « BOXES »

- **Box parameters**



OPENVIBE – STIMULATION CONCEPT (+ GRAPH)

- **“Stimulations” = events**
  - Management of particular sections or useful events in a BCI experiment
  - *Experiment Start/Stop*
  - *Button pressed*
  - *New trial…*
- **Synchronized with the acquired signal**
- **More info in Part 2!**



CHAPTER 1 – Q&A

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

OPENVIBE – PLUGINS & « BOXES »