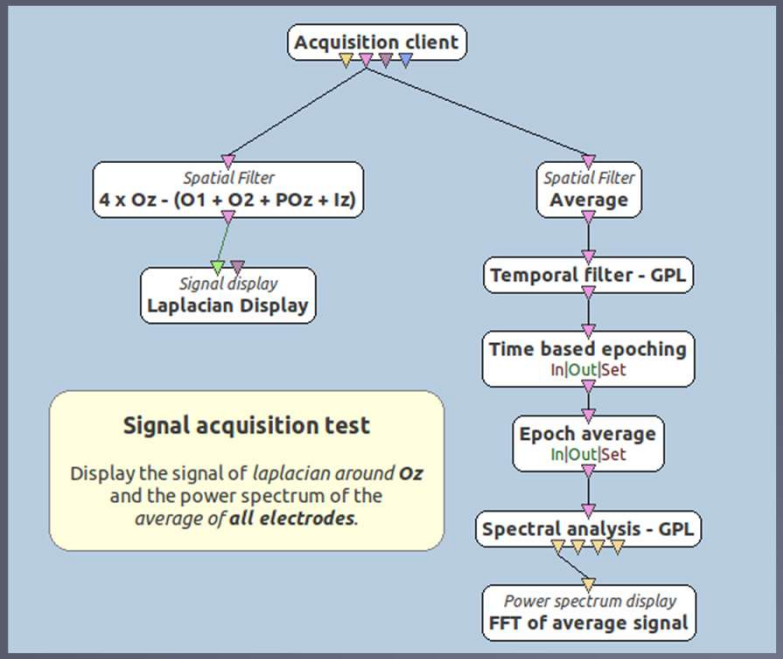
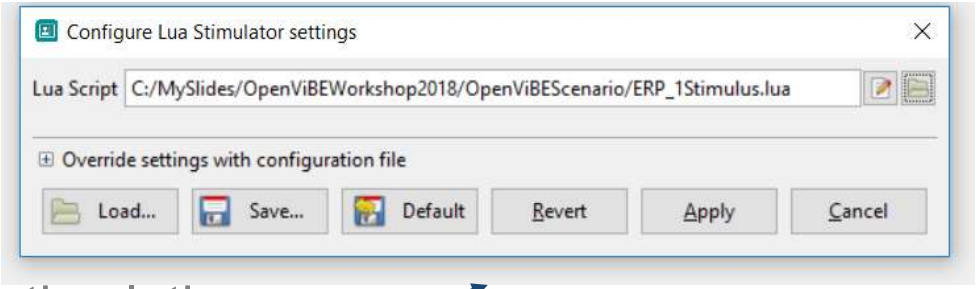


Using OpenViBE in practice: LUA Stimulator

Laurent Bougrain

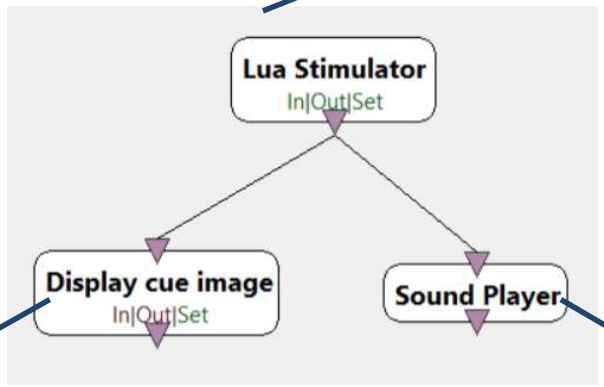
Université de Lorraine/LORIA (France) Team Neurorhythms

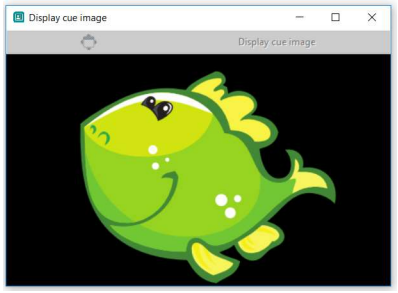
Simple protocol

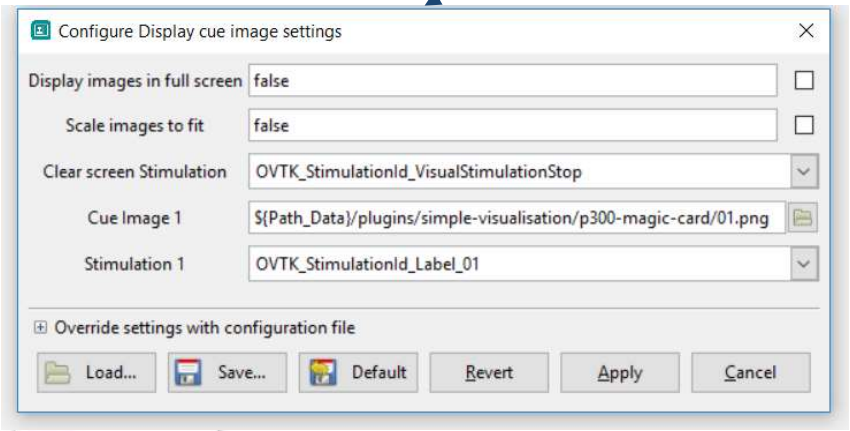


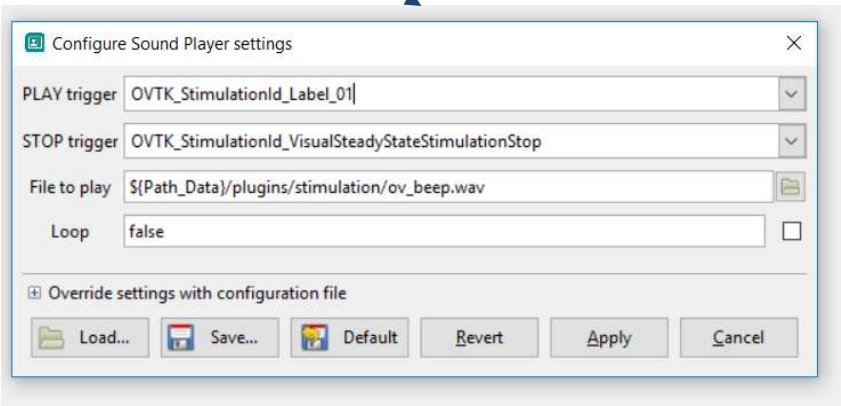
Displays stimulus when receiving the stimulations:

- Display Cue Image box (visual stimulus)
- Sound Player box (audio stimulus)









Designing simple BCI/EEG protocols

- How to generate stimuli at specific times and use them?

Generating events:

1. By using OpenViBE Stimulations
2. By using the Lua stimulator box and writing a lua script (Lua is a simple script language)
3. By specifying variable initial values as box settings

OpenViBE Stimulation codes

http://openvibe.inria.fr/stimulation-codes/

OpenViBE stimulation codes

- Existing stimulations : http://openvibe.inria.fr/stimulation-codes

A short list with GDF codes (recognized by EEGlab,…)

```
OVTK_GDF_SSVEP                          0x131       //  305
OVTK_GDF_Stage_1                        0x411       //  1041
OVTK_GDF_Stage_2                        0x412       //  1042
OVTK_GDF_Stage_3                        0x413       //  1043
OVTK_GDF_Stage_4                        0x414       //  1044
OVTK_GDF_Start                          0x580       //  1408
OVTK_GDF_Start_Of_Inspiration           0x40F       //  1039
OVTK_GDF_Start_Of_New_Segment           0x7FFE      //  32766
OVTK_GDF_Start_Of_Trial                 0x300       //  768
OVTK_GDF_Swallowing                     0x445       //  1093
OVTK_GDF_TMS                            0x12F       //  303
OVTK_GDF_Tongue                         0x304       //  772
OVTK_GDF_Tongue_Movement                0x444       //  1092
OVTK_GDF_Up                             0x30C       //  780
OVTK_GDF_VEP                            0x121       //  289
OVTK_GDF_Vertical_Eye_Movement          0x436       //  1078
OVTK_GDF_Wake                           0x410       //  1040
OVTK_StimulationId_AddedSamplesBegin    0x00008311  //  33553
OVTK_StimulationId_AddedSamplesEnd      0x00008312  //  33554
OVTK_StimulationId_Artifact             0x00008302  //  33538
OVTK_StimulationId_BaselineStart        0x00008007  //  32775
```

- You can add your own stimulation names and codes in specific files but you need to recompile sources

OpenViBE stimulation codes

Name	Decimal value
OVTK_StimulationId_ExperimentStart	32769
OVTK_StimulationId_ExperimentStop	32770
OVTK_StimulationId_TrialStart	32773
OVTK_StimulationId_TrialStop	32774
OVTK_StimulationId_SegmentStart	32771
OVTK_StimulationId_SegmentStop	32772
…	

OpenViBE stimulation codes

Name	Decimal value
OVTK_StimulationId_Target	33285
OVTK_StimulationId_NonTarget	33286
OVTK_StimulationId_Train	33281
OVTK_StimulationId_TrainCompleted	33287
…	
OVTK_StimulationId_VisualStimulationStart	32779
OVTK_StimulationId_VisualStimulationStop	32780
OVTK_GDF_Right_Hand_Movement	1090
OVTK_StimulationId_Label_01	33025
OVTK_StimulationId_Label_02	33026
OVTK_StimulationId_Label_03	33027
…	

Oddball paradigm and ERP

Evoked Potentials

A distinction can be made between:

- Spontaneous EEGs
- **Evoked EEGs**
  - Exogenous (PEs) triggered by sensory stimulation and with small amplitudes and short latencies
    - Auditory potentials
    - Visual potentials
    - Somatosensory potentials
    - Olfactory potentials
  - **Endogenous (ERPs) triggered by cognitive activity and with long latencies**
    - Cognitive potentials

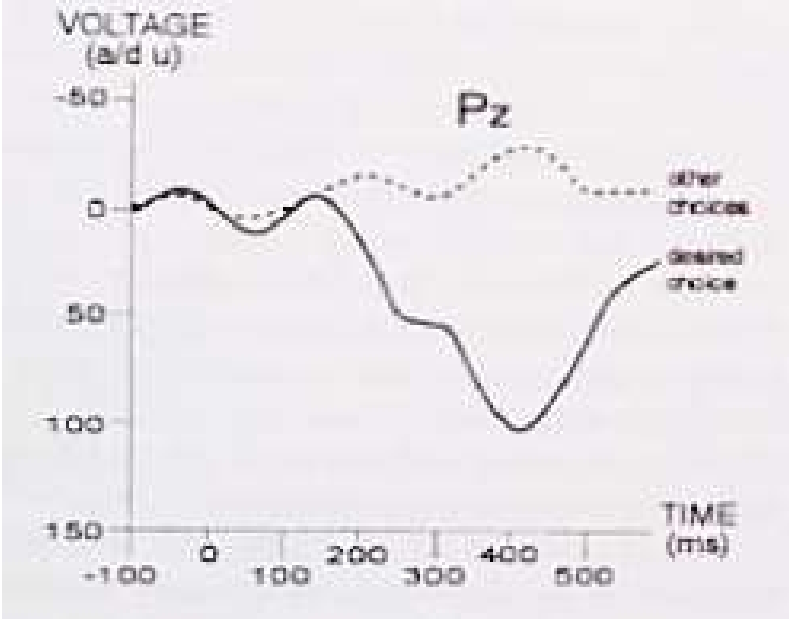
- Polarity: P (positive déflection) or N (negative deflection)
- Latency: in ms

Oddball Paradigm and P300

Present stimuli from two categories

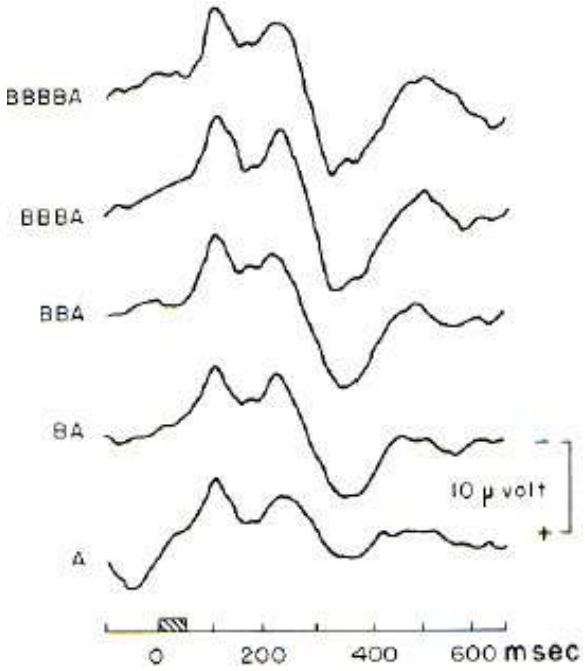
One category is rare compare to the other

When the subject recognizes the rare stimulus, an evoked potential occurs corresponding to a positive deflection around 300ms after the stimulus.

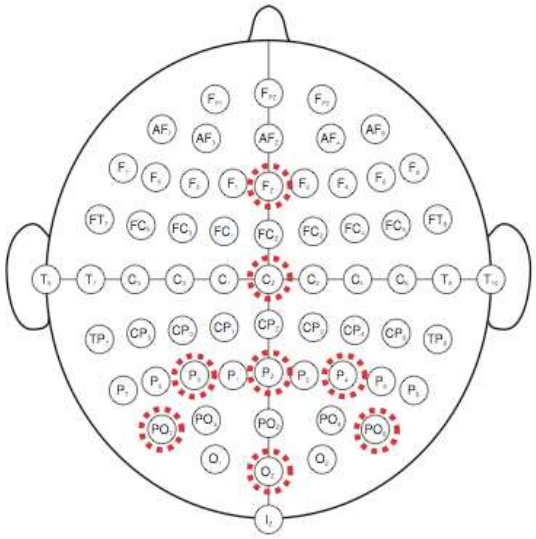


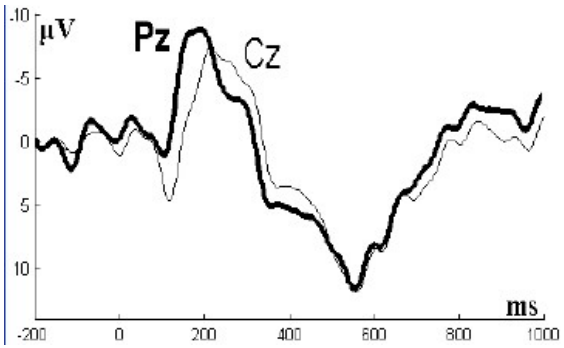
P300

- Amplitude
  - Matching
  - Fatigue
  - Frequency

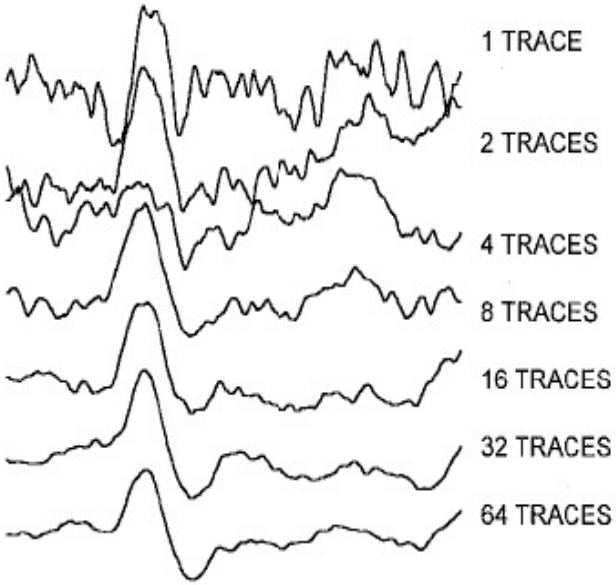


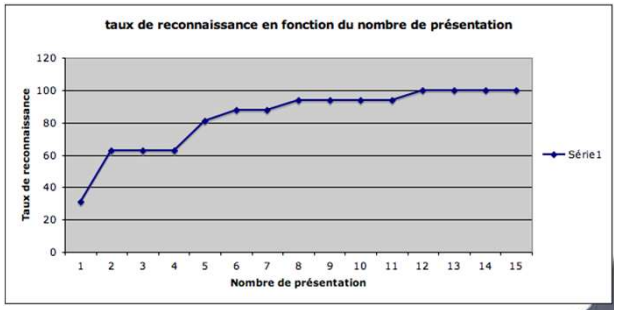
- Location
  - Fz, Cz, Pz





- Averaging
  - Up to 1000 to study pathology

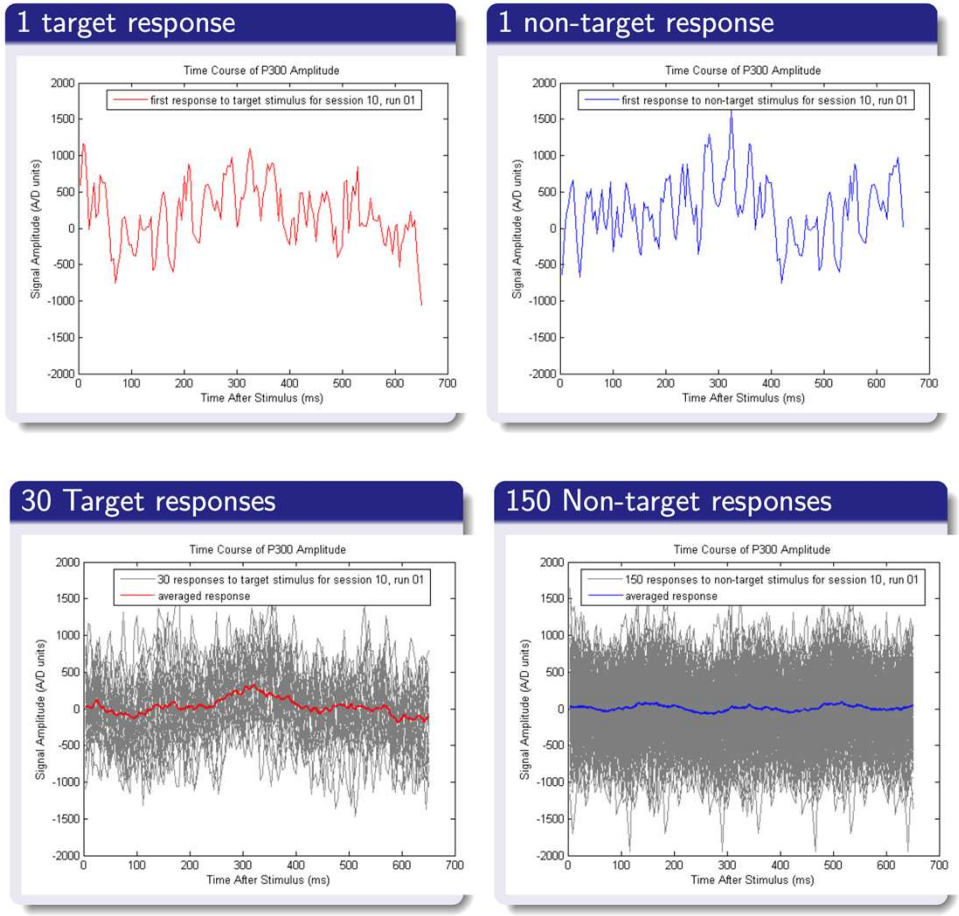




ERP detection

P300 speller paradigm
(Farwell & Donchin, 88)

Dataset : Wadworth P300 speller
(BCI III competition)

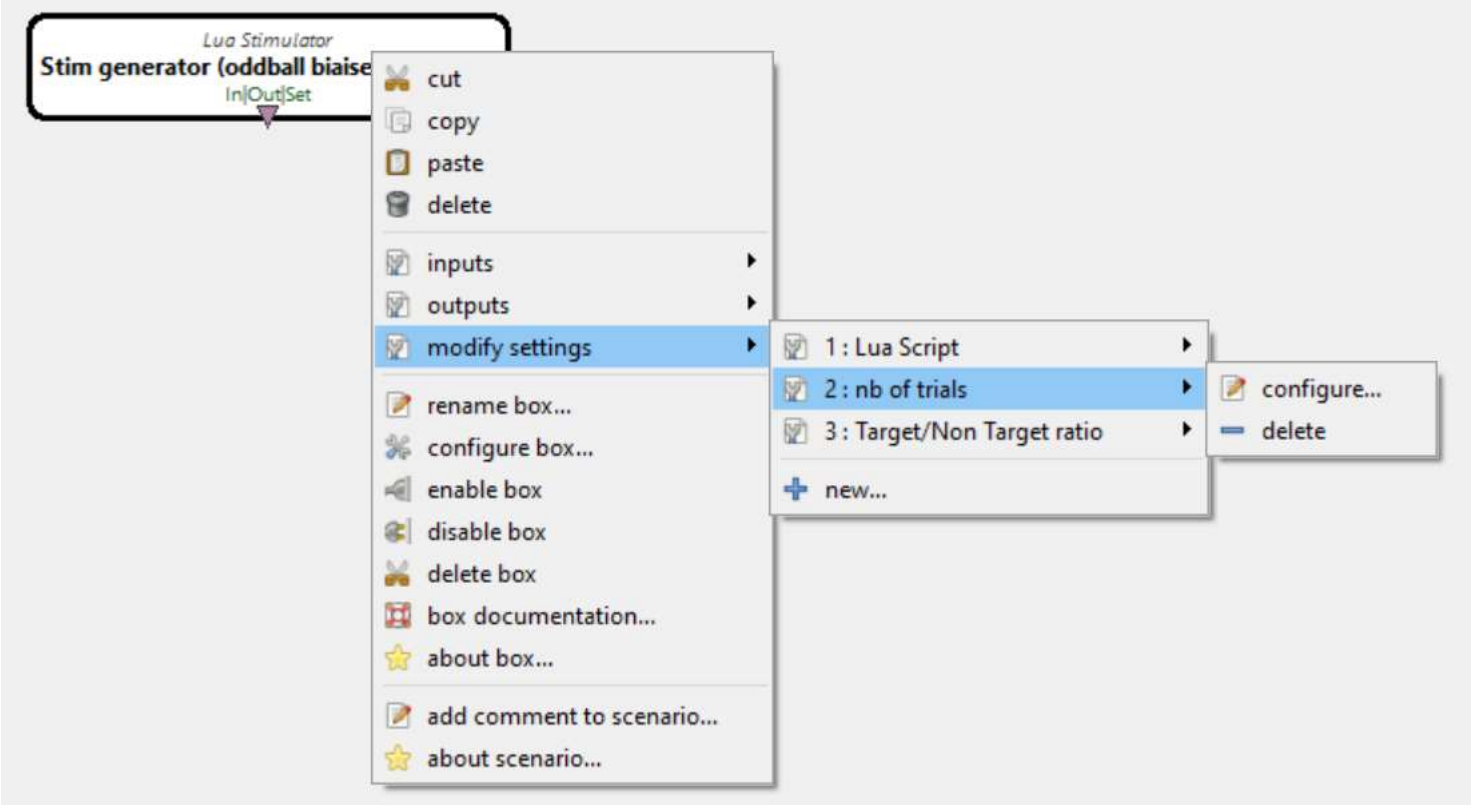


Adding Parameters & Inputs in box

Reminder

LUA Stimulator box (add settings)

- Variable values can be specified as box parameters

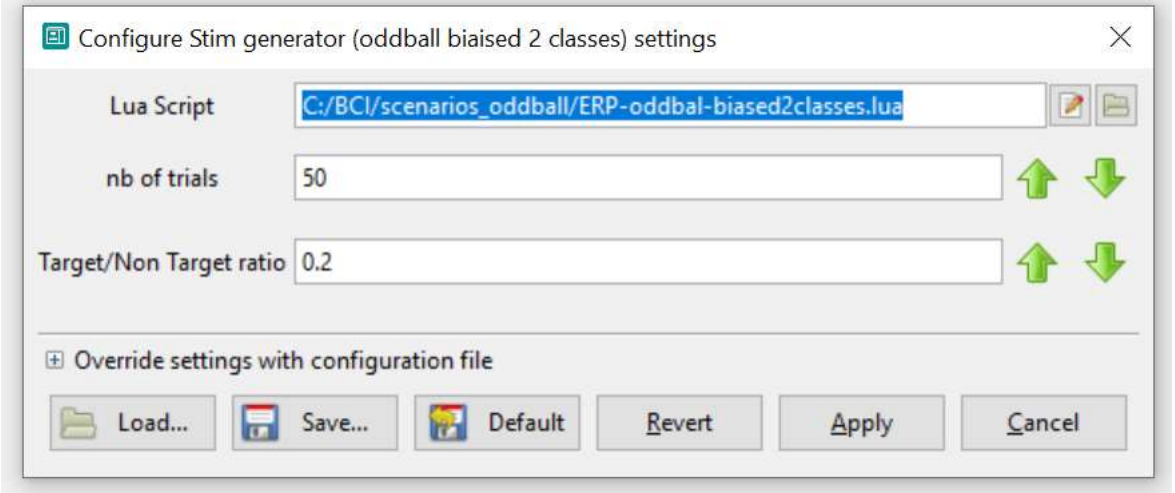


LUA Stimulator box (add settings)

- Variable values can be specified as box parameters

OpenViBE scenario 2

1. Right-click on the LUA stimulation box
2. Click on Modify Settings and then +
3. Add nb of trials
4. Add Target/Non Target ratio



LUA Stimulator box (add settings)

- Variable values can be specified as box parameters

LUA stimulatior script 2

1. get values specified as settings

```
function initialize(box)

   dofile(box:get_config("${Path_Data}") .. "/plugins/stimulation/lua-stimulator-stim-codes.lua")

   -- defining protocol parameters
   nb_trials = box:get_setting(2)
   target_ratio = box:get_setting(3)

end
```

LUA Stimulator box (add entries)

- The LUA script can take into account events (stimulations) as entry when adding stimulation entry to the LUA stimulator box.

OpenViBE scenario

1. Right click on the LUA stimulation box
2. Click on Inputs and then + New…
3. A new stimulator entry is visible on the top of the box

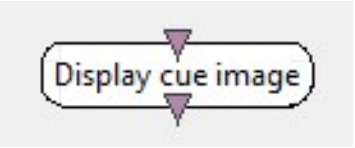
LUA stimulator script

--We get the stimulation value in case we receive it. We use i to indicate which stimulation on the list we are referring to
value, date, time = box:get_stimulation(1,i)

Display cue image box

http://openvibe.inria.fr/documentation/3.3.0/Doc_BoxAlgorithm_DisplayCueImage.html

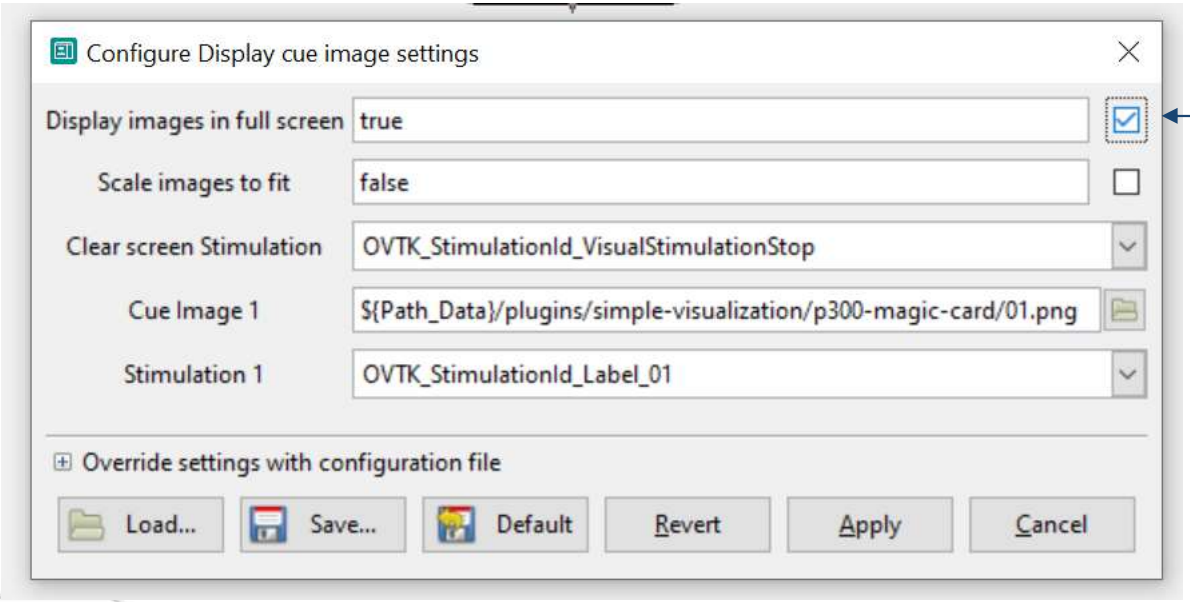
Display cue image box



http://openvibe.inria.fr/documentation/3.3.0/Doc_BoxAlgorithm_DisplayCueImage.html

- Display cue images when receiving stimulations
- By default,
  - display: **01.png**

  - start when **OVTK_StimulationId_Label_01** is received
  - stop when **OVTK_StimulationId_VisualStimulationStop** is received



Check the box
to display full screen

LUA Stimulator box

http://openvibe.inria.fr/documentation/3.3.1/Doc_BoxAlgorithm_LuaStimulator.html

LUA Stimulator box

- Send stimulation according to a lua script-defined timing

- by default the box has:
  - 0 entry
  - 1 output (stimulation type)
  - 1 parameter (lua script)

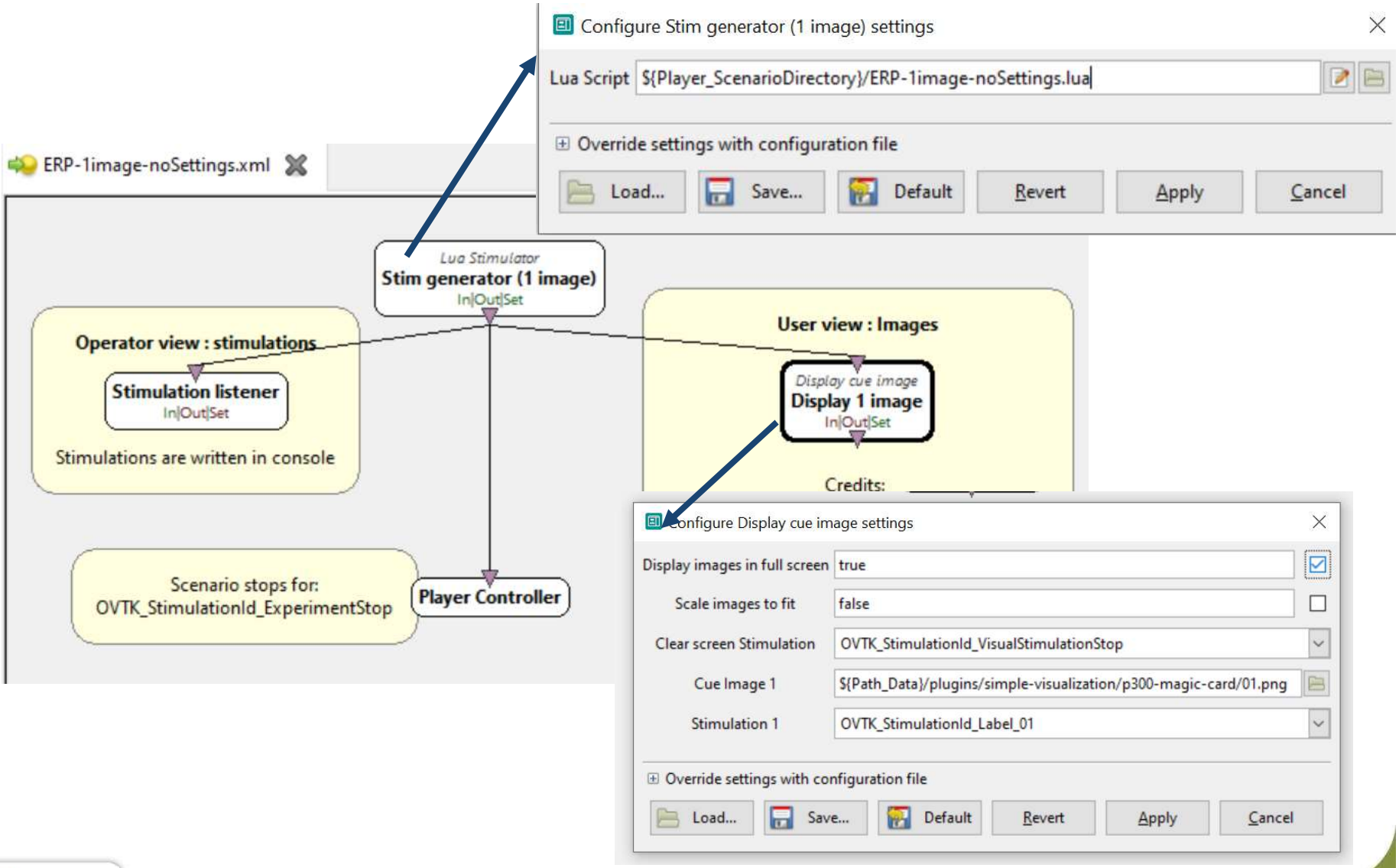
- Additional **inputs and outputs** can be added as for any other box (if possible) by right clicking on the box, clicking on Inputs or outputs and then + New…
- Additional **parameters** can be added as for any other box by right clicking on the box, clicking on Modify Settings and then +

LUA Stimulator script

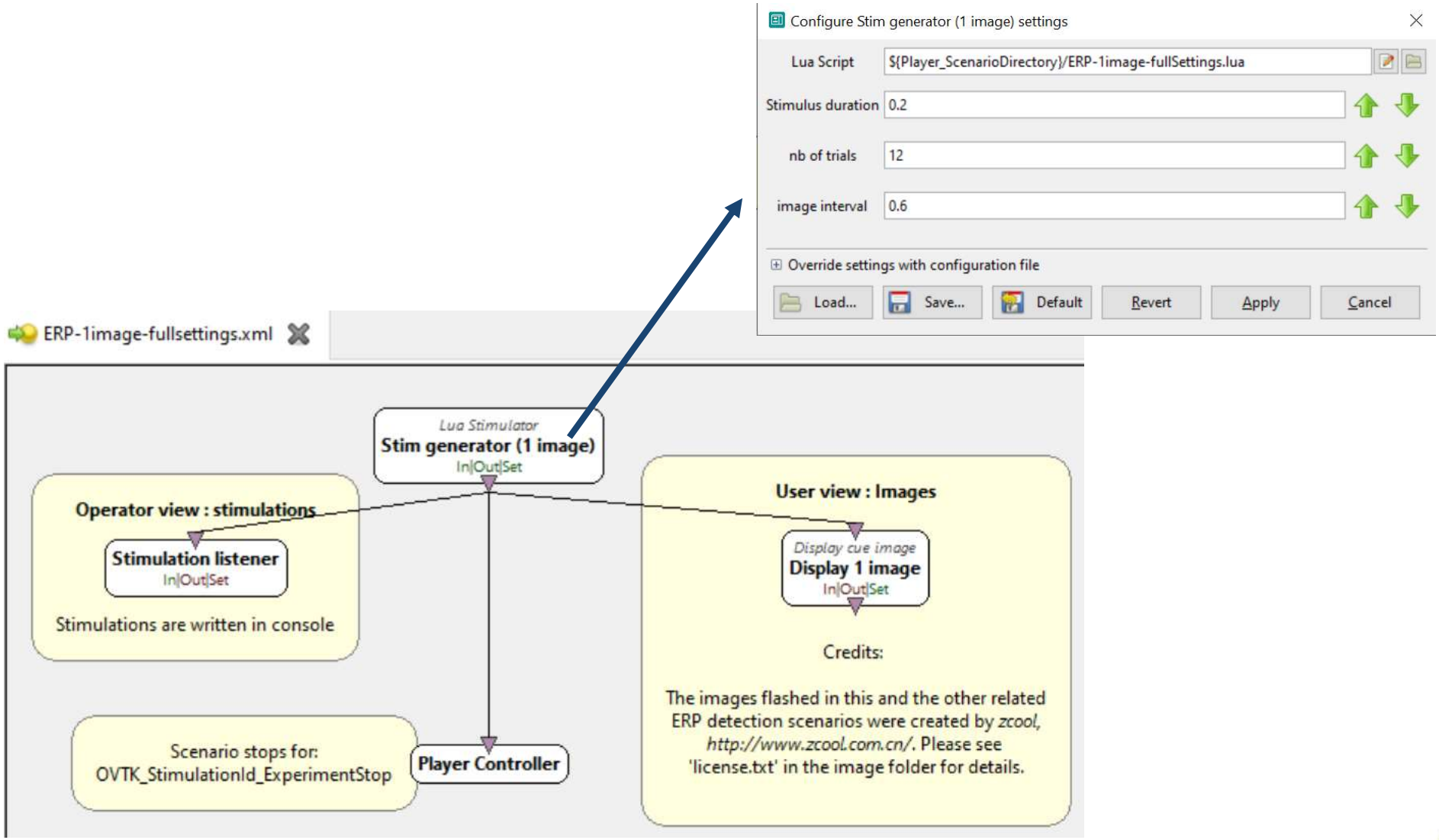
Example: sending 1s-long stimulations every 2s

```lua

function initialize(box)

    dofile(box:get_config("${Path_Data}") .. "/plugins/stimulation/lua-stimulator-stim-codes.lua")

    -- defining protocol timings
    stimulus_duration = 1
    number_of_trials = 10;
    inter_trial_interval = 2

end

function process(box)

    local t = 0

    --for each trial
    for i = 1, number_of_trials do

        -- send a stimulation to display a stimulus
        box:send_stimulation(1, OVTK_StimulationId_Label_01, t, 0)
        t = t + stimulus_duration

        -- afte the required time, send a different stimulation to stop the display of the stimulus
        box:send_stimulation(1, OVTK_StimulationId_VisualStimulationStop, t, 0)
        t = t + inter_trial_interval -- wait for some time before the next trial starts
    end
end
```

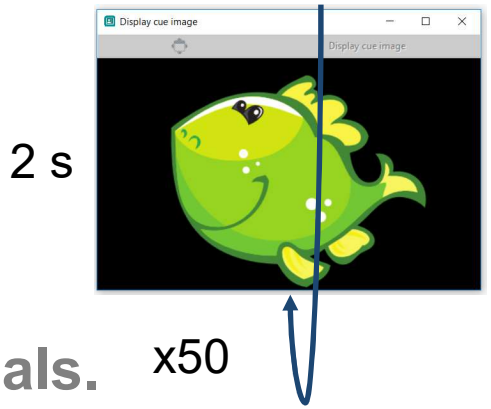
1 image scenario (noSettings)



1 image scenario (fullSettings)



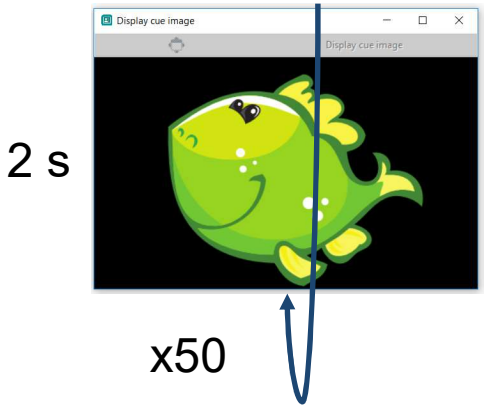
Pseudo-code Stimulator 1



- **Send stimulations corresponding to 50 trials.**
- **OVTK_StimulationId_Label_01 will be used to display image1**

```
nb_trials = 50
OVTK_StimulationId_ExperimentStart
For t = 1 to nb_trials do
        OVTK_StimulationId_TrialStart
        OVTK_StimulationId_VisualStimulationStart
        OVTK_StimulationId_Label_01
        OVTK_StimulationId_Target
        t = t + 0.1 — display duration
        OVTK_StimulationId_VisualStimulationStop
        OVTK_StimulationId_TrialStop
        t = t + 2 — inter-trial duration
OVTK_StimulationId_ExperimentStop
```

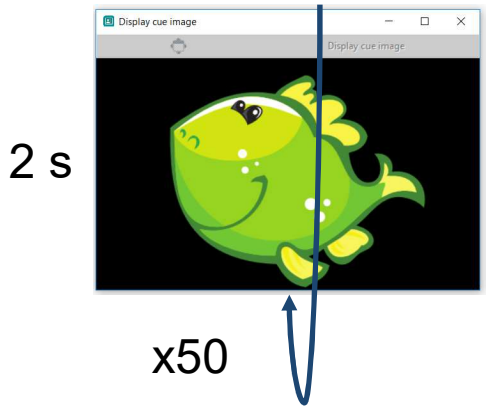
LUA Stimulator script 1



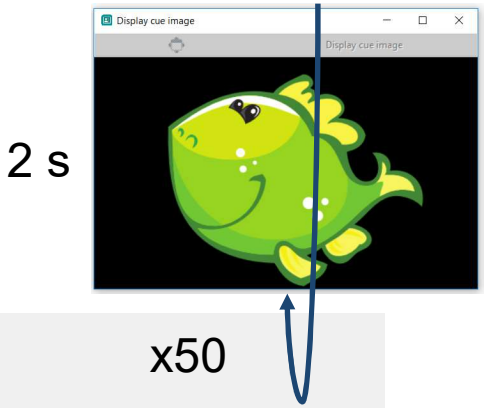
1. Open a new scenario
2. Add a LUA stimulation box (right search
3. Double-click on the LUA stimulation box
4. Edit the LUA script
5. Add a Listener box from the box repository
6. Connect the two boxes
7. Run the scenario (press the play icon)

8. Add a Display Cue Image box from the box repository
9. Connect the two boxes
10. Change the setting (right clic>edit) to select the image to show when stimulation OVTK_StimulationId_Label_01 is received
11. Run the scenario

LUA Stimulator script 1 (solution)



LUA Stimulator scenario



ERP detection

Images Generator Scenario

Signal Acquisition & DataSaving

Data acqusisition

Acquisition client

Lua Stimulator

Stim generator (oddball biaised 2 classes)

In|Out|Set

User view : Images

Display cue image

In|Out|Set

Credits:

The images flashed in this and the other related ERP detection scenarios were created by *zcool, http://www.zcool.com.cn/*. Please see 'license.txt' in the image folder for details.

Stimulation listener

In|Out|Set

Generic stream writer

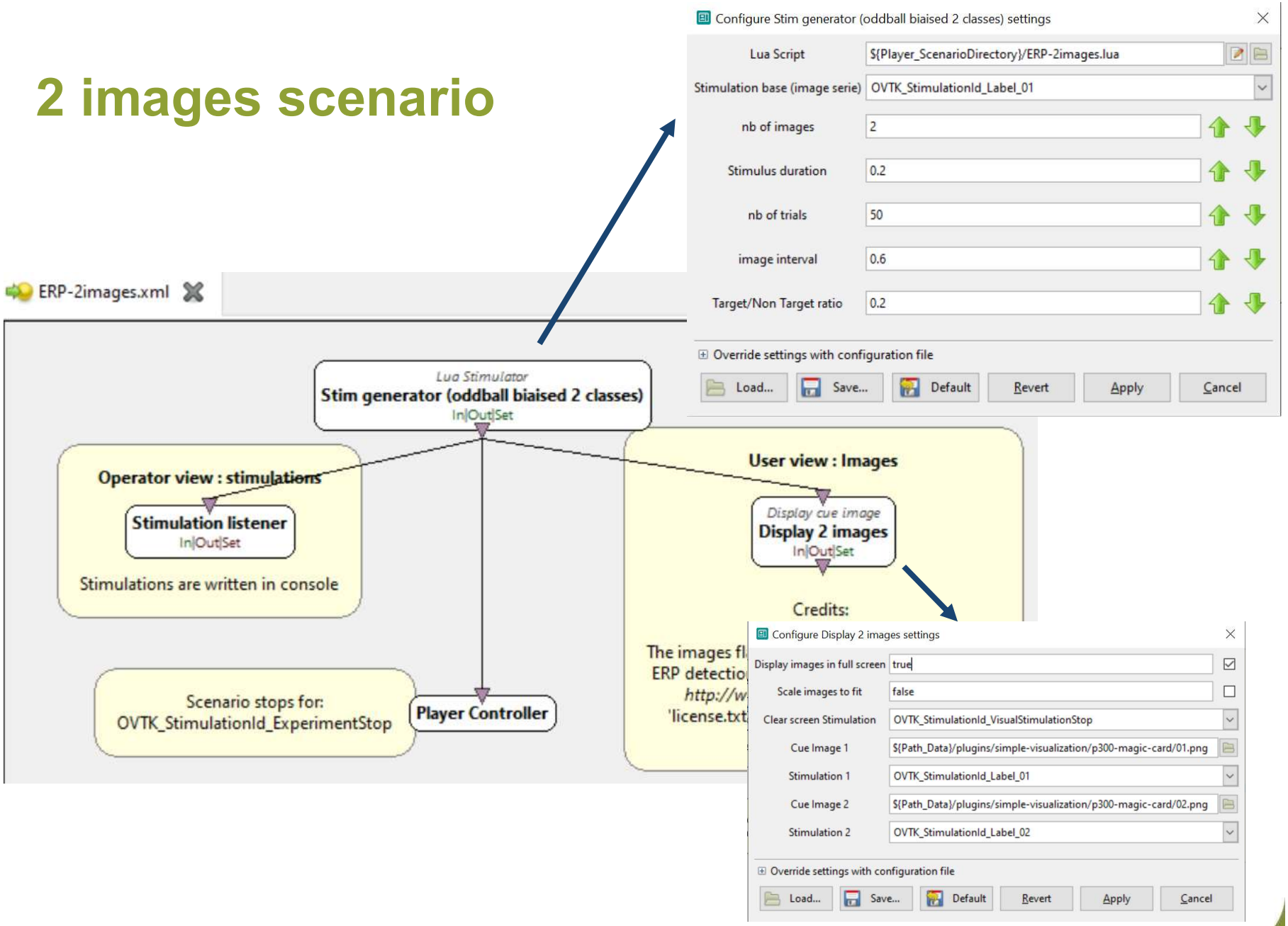
In|Out|Set

GDF file writer

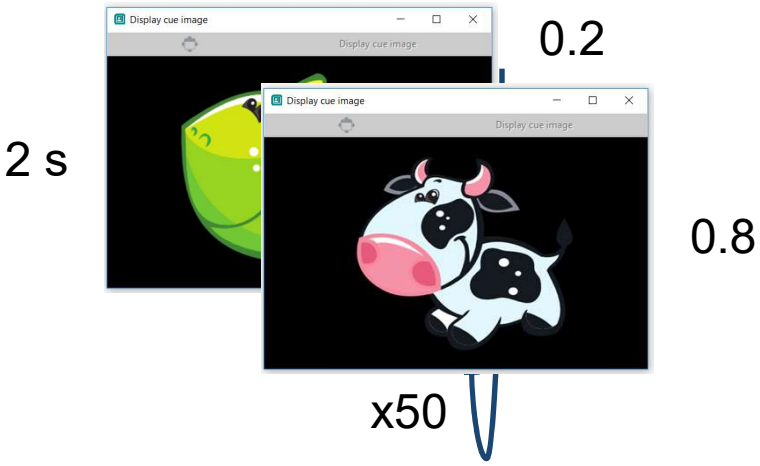
Player Controller

Scenario stops for:
OVTK_StimulationId_ExperimentStop

2 images scenario



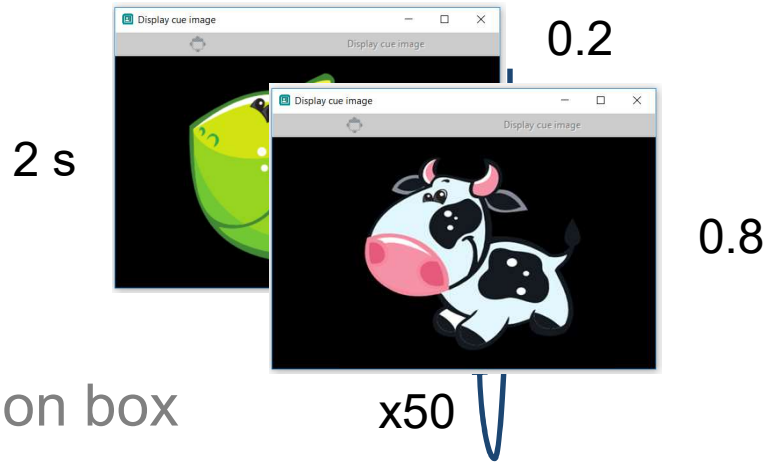
Pseudo-code Stimulator 2




```
nb_trials = 50
RatioTargetNonTarget = 0.2
math.randomseed(os.time)
OVTK_StimulationId_ExperimentStart
For t = 1 to nb_trials do
        OVTK_StimulationId_TrialStart
        OVTK_StimulationId_VisualStimulationStart
        if (math.random(100) < RatioTargetNonTarget*100 then
                OVTK_StimulationId_Label_01
                OVTK_StimulationId_Target
        else
                OVTK_StimulationId_Label_02
                OVTK_StimulationId_NonTarget
        t = t + 0.1
        OVTK_StimulationId_VisualStimulationStop
        OVTK_StimulationId_TrialStop
        t = t + 2
OVTK_StimulationId_Train
OVTK_StimulationId_ExperimentStop
```

LUA Stimulator script 2

1. Open a new scenario
2. Copy-paste the first scenario
3. Double-click on the LUA stimulation box
4. Edit the LUA script
5. Edit the Display Cue Image box
6. Run the scenario

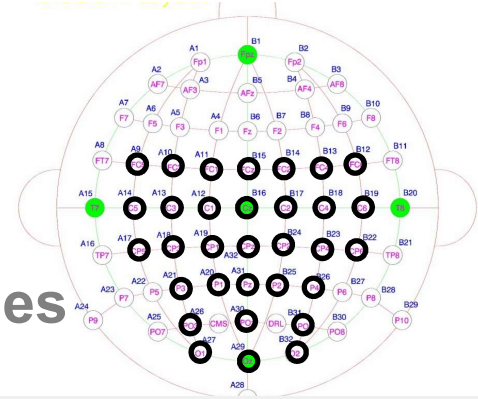


LUA Stimulator script 2 (solution)

ERP OpenViBE scenarios

1. Data acquisition
2. Training classifier
3. Testing

Acquisition



by a biosemi amplifier with 32 active electrodes at 2048 Hz

ERP-2images-1-acquisition.xml

ERP detection

Images Generator Scenario

Signal Acquisition & DataSaving

Operator view : signal screening

Channel Selector
Cz;CPz;Pz;O1;O2
In|Out|Set

Temporal Filter
1- 20 HZ
In|Out|Set

Signal Decimation
2048 -> 256 Hz

Signal display
In|Out|Set

Data acqusisition

Acquisition client

Lua Stimulator
Stim generator (oddball biaised 2 classes)
In|Out|Set

Stimulation listener
In|Out|Set

Data saving

Generic stream writer
In|Out|Set

GDF file writer

Directory : ${Player_ScenarioDirectory}/
File OV : Calibration_XX_[$core{date}-$core{time}].ov
File GDF : Calibration_XX_[$core{date}-$core{time}].ov

Player Controller

User view : Images

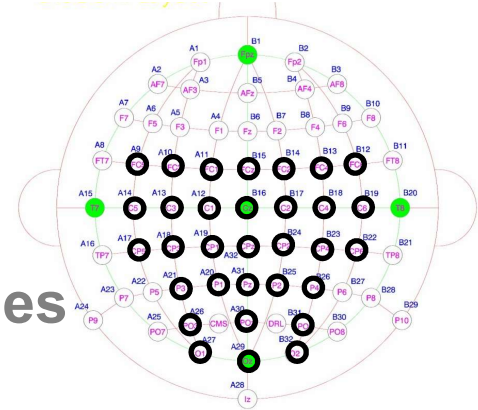
Display cue image
Display 2 images
In|Out|Set

Credits:

The images flashed in this and the other related ERP detection scenarios were created by *zcool, http://www.zcool.com.cn/*. Please see 'license.txt' in the image folder for details.

Scenario stops for:
OVTK_StimulationId_ExperimentStop

Data reading



by a biosemi amplifier with 32 active electrodes at 2048 Hz

ERP-2images-1-offline.xml

Remember to change the filename in the Generic Stream Reader box

ERP detection

DataReading

Operator view : signal screening

Channel Selector
Cz;CPz;Pz;O1;O2
In|Out|Set

Temporal Filter
1- 20 HZ
In|Out|Set

Signal Decimation
2048 -> 256 Hz

Signal display
In|Out|Set

Data acqusisition

Generic stream reader
In|Out|Set

Stimulation listener
In|Out|Set

Player Controller

User view : Images

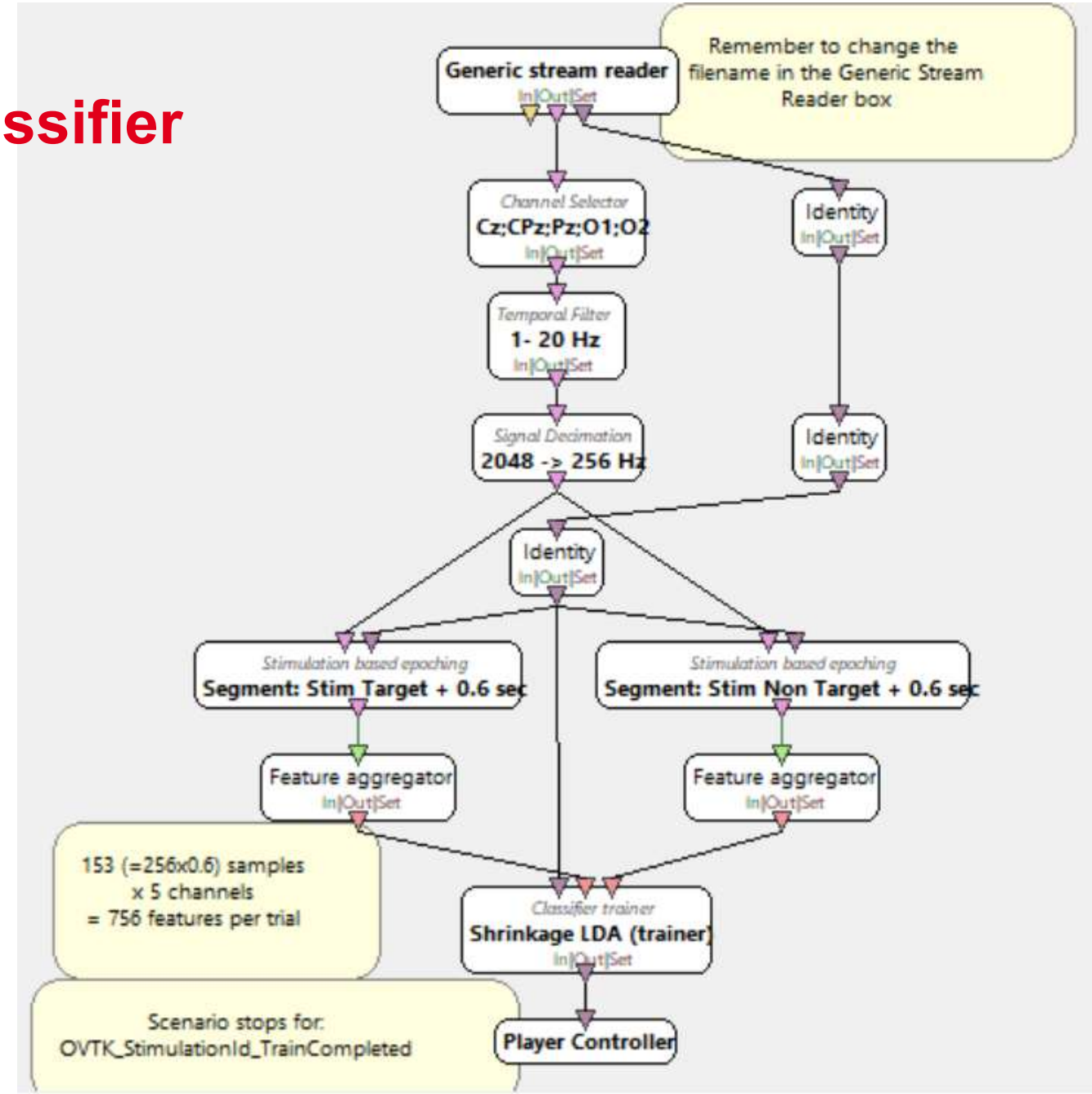
Display cue image
Display 2 images
In|Out|Set

Credits:

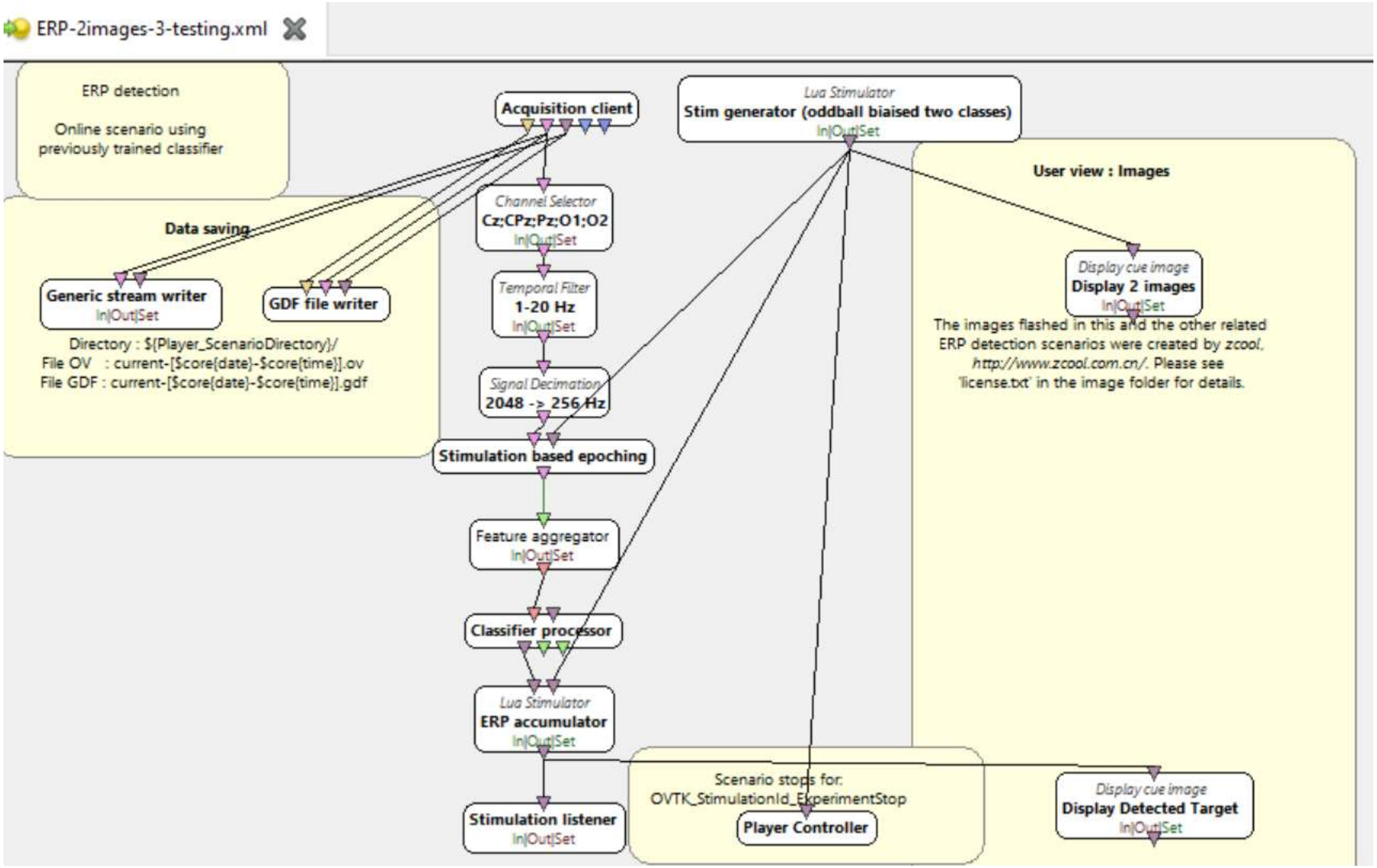
The images flashed in this and the other related ERP detection scenarios were created by *zcool*, *http://www.zcool.com.cn/*. Please see 'license.txt' in the image folder for details.

Scenario stops for:
OVTK_StimulationId_ExperimentStop

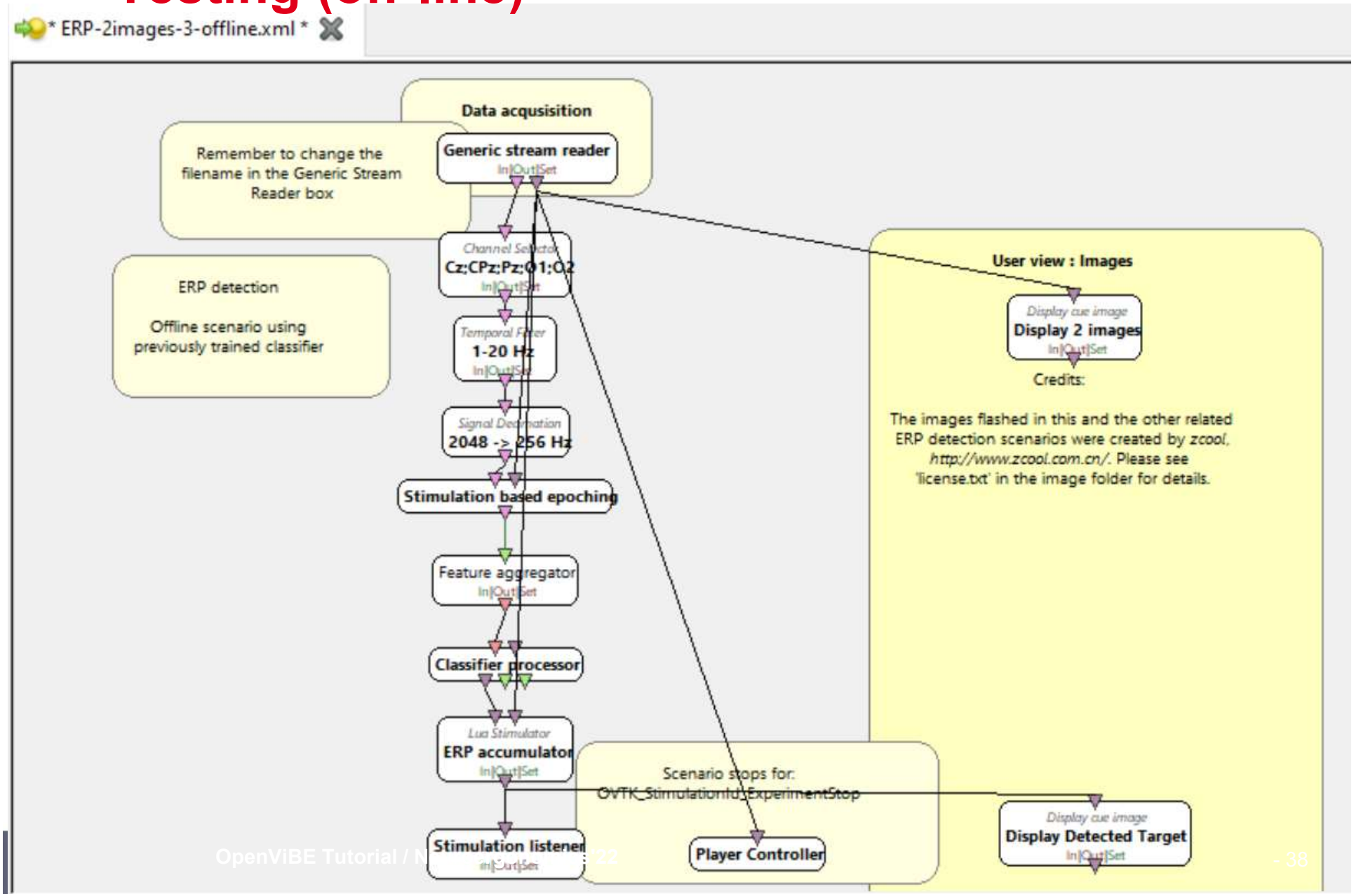
Training classifier



Testing


ERP-2images-3-testing.xml
ERP detection
Online scenario using previously trained classifier
Data saving
Generic stream writer
In|Out|Set
GDF file writer
Directory : ${Player_ScenarioDirectory}/
File OV : current-[$core{date}-$core{time}].ov
File GDF : current-[$core{date}-$core{time}].gdf
Acquisition client
Channel Selector
Cz;CPz;Pz;O1;O2
In|Out|Set
Temporal Filter
1-20 Hz
In|Out|Set
Signal Decimation
2048 -> 256 Hz
Stimulation based epoching
Feature aggregator
In|Out|Set
Classifier processor
Lua Stimulator
ERP accumulator
In|Out|Set
Stimulation listener
In|Out|Set
Lua Stimulator
Stim generator (oddball biaised two classes)
In|Out|Set
User view : Images
Display cue image
Display 2 images
In|Out|Set
The images flashed in this and the other related ERP detection scenarios were created by zcool, http://www.zcool.com.cn/. Please see 'license.txt' in the image folder for details.
Scenario stops for:
OVTK_StimulationId_ExperimentStop
Player Controller
Display cue image
Display Detected Target
In|Out|Set

Testing (off-line)

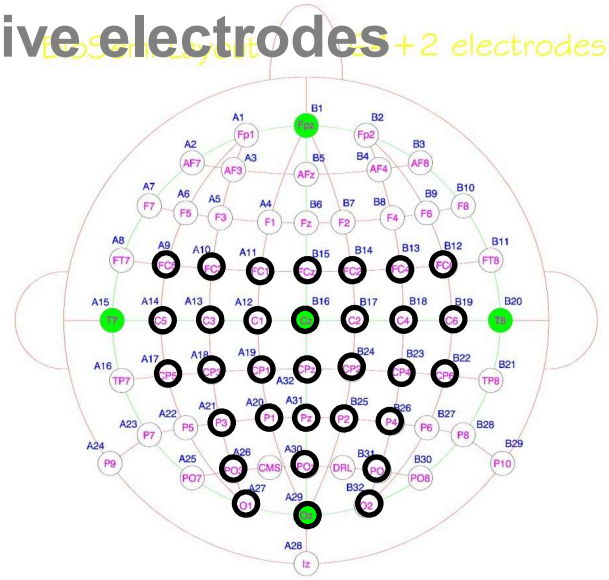


Acquisition

1. INSERT THE SCENARIO
2. PROPOSE TO DOWNLOAD THE SCENARIO

Off-line adaptation

- **The acquisition server box is replaced by the Generic Stream Reader box**
- **The dataset contains 50 trials with a 0.2 ratio**
- **from a biosemi amplifier with 32 active electrodes**



Training classifier

1. INSERT THE SCENARIO
2. PROPOSE TO DOWNLOAD THE SCENARIO

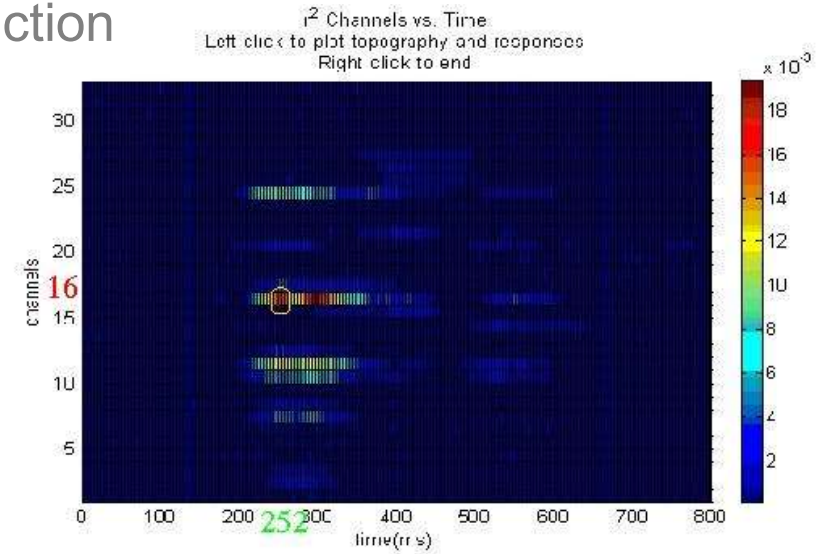
Shrinkage Linear Discriminant Analysis

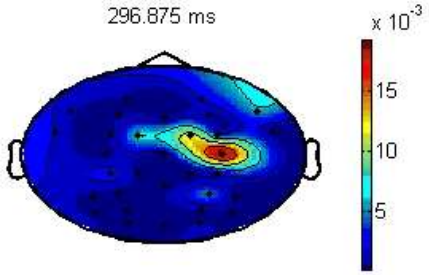
- **METTRE DES FLECHES POUR EXPLIQUER LES ETAPES**

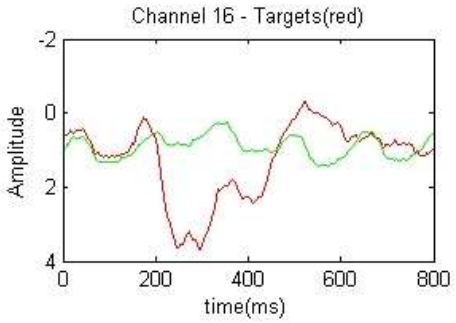
Training classifier

- Feature extraction
  - Squared difference
  - Variable selection

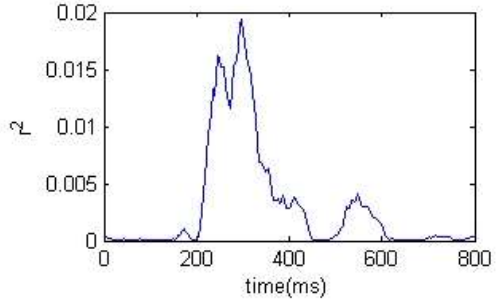
#channel	#sample	Coeff
16	64	1
16	65	1
16	0.252*256	1







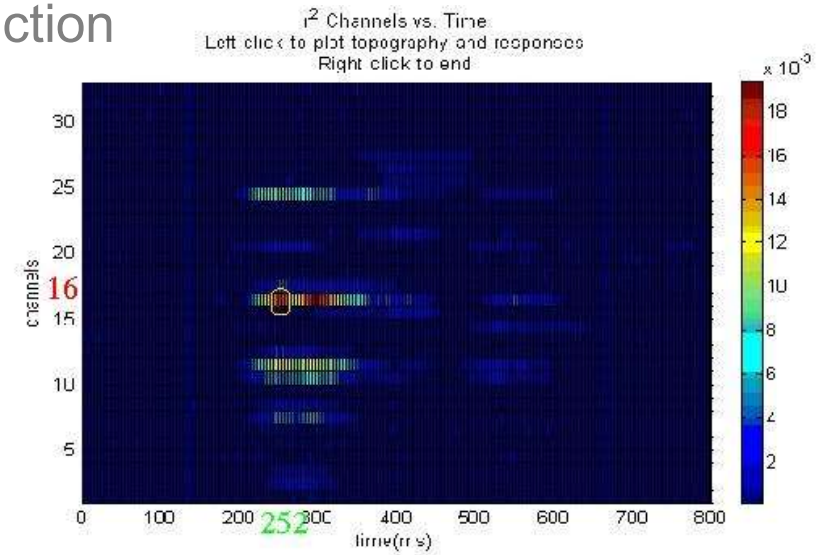
- Classification
  - Unbalanced data
  - Robust classifier

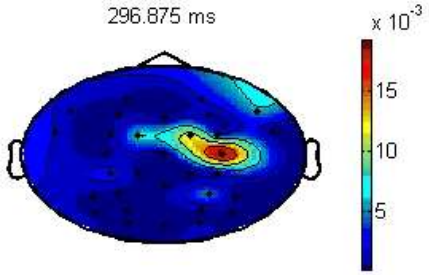


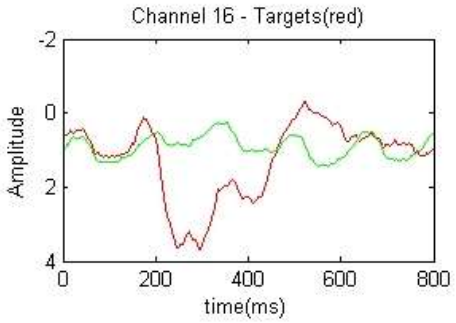
Training classifier

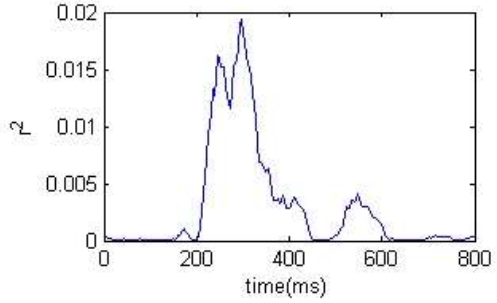
- Feature extraction
  - Squared difference
  - Variable selection

#channel	#sample	Coeff
16	64	1
16	65	1
16	0.252*256	1









- Classification
  - Unbalanced data
  - Robust classifier

Testing

1. INSERT THE SCENARIO
2. PROPOSE TO DOWNLOAD THE SCENARIO

Off-line adaptation

- **The acquisition server box is replaced by the Generic Stream Reader box**
- **The dataset contains 50 trials with a 0.2 ratio**
- **from a biosemi amplifier with 32 active electrodes**

To go futher…

1. Change the features
    1. change the selected electrodes (add/remove/replace)
    2. change the decimation value (increase/decrease)
    3. change the segment to analyze

2. Change the classifier
    1. remove the shrinkage
    2. use another classifier

3. Change the Stimuli
    1. change the number of trials
    2. change the ratio Target/Non Target
    3. replace the images

More info and examples: http://openvibe.inria.fr/recording-erps/