Community-accessible EEG monitoring of the user's mental state in the UX/UI research

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PERCONA

BrSTU

Biometrics in usability

- Biometric measuring tools have recently undergone a new wave of attention in the usability researches
- New powerful user-grade measuring gadgets are the reason
    - Mass-market production for the entertainment and fitness applications made them much cheaper
    - The precision they provide for contemporary games can be a valuable addition for the UX research
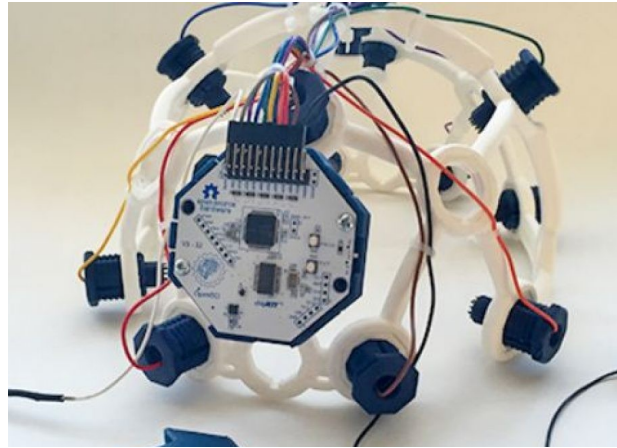
EMOTIV EPOC
14-Channel, 799$

EMOTIV Insight
5-Channel, 299$

NeuroSky MindWave
1-Channel, 159$

Open hardware
solution from
OpenBCI
4-16 Channels
$600 and up

# NeuroSky MindWave primary goals :)

NeuroSky
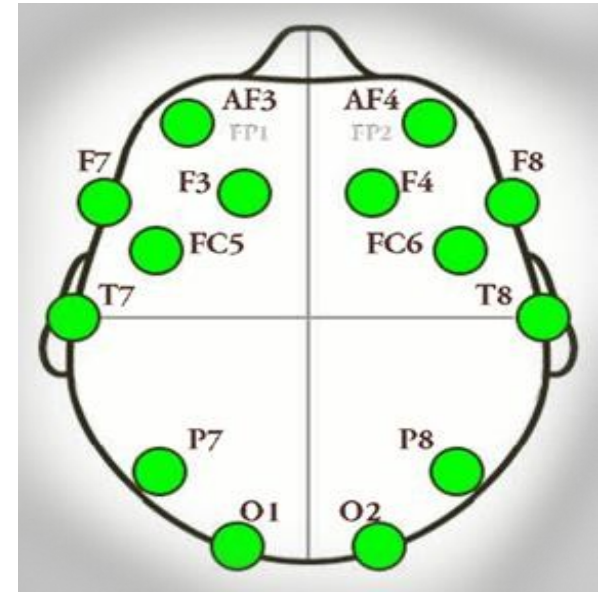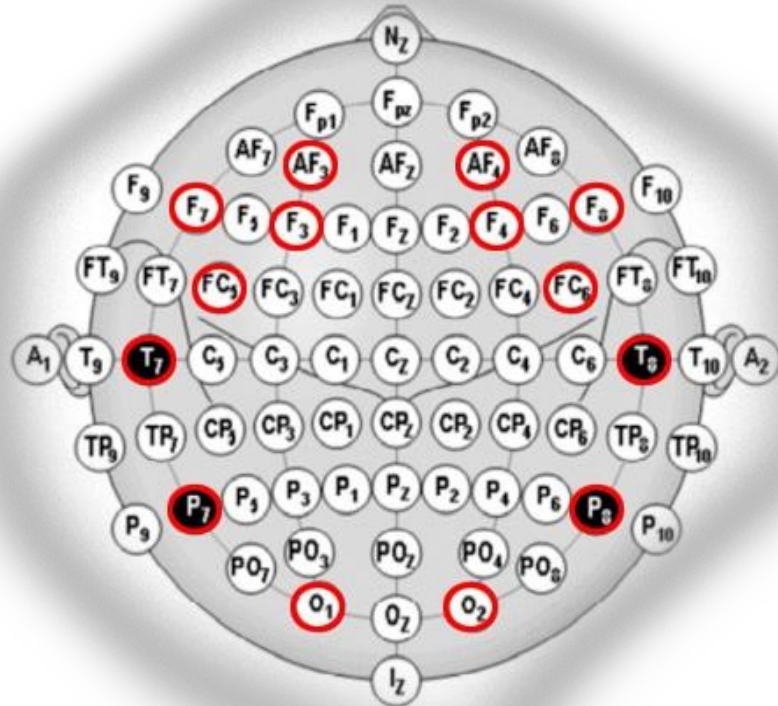MindWave

Puzzlebox Orbit

Nekomimi Ears

EEG waves

- **Delta** – deep/dreamless sleep, unconscious state
  - 0.1 – 4 Hz
- **Theta** – light sleep, deep meditation, creative, recall, fantasy
  - 4 Hz – 7.5 Hz
- **Alpha** – relaxed, light meditation, creative, super learning
  - 7.5 Hz – 12 Hz
- **Beta** – concentration, focus, physical senses
  - 12 Hz – 30 Hz
- **Gamma –** motor functions, higher mental
 - 30 Hz – 100 Hz
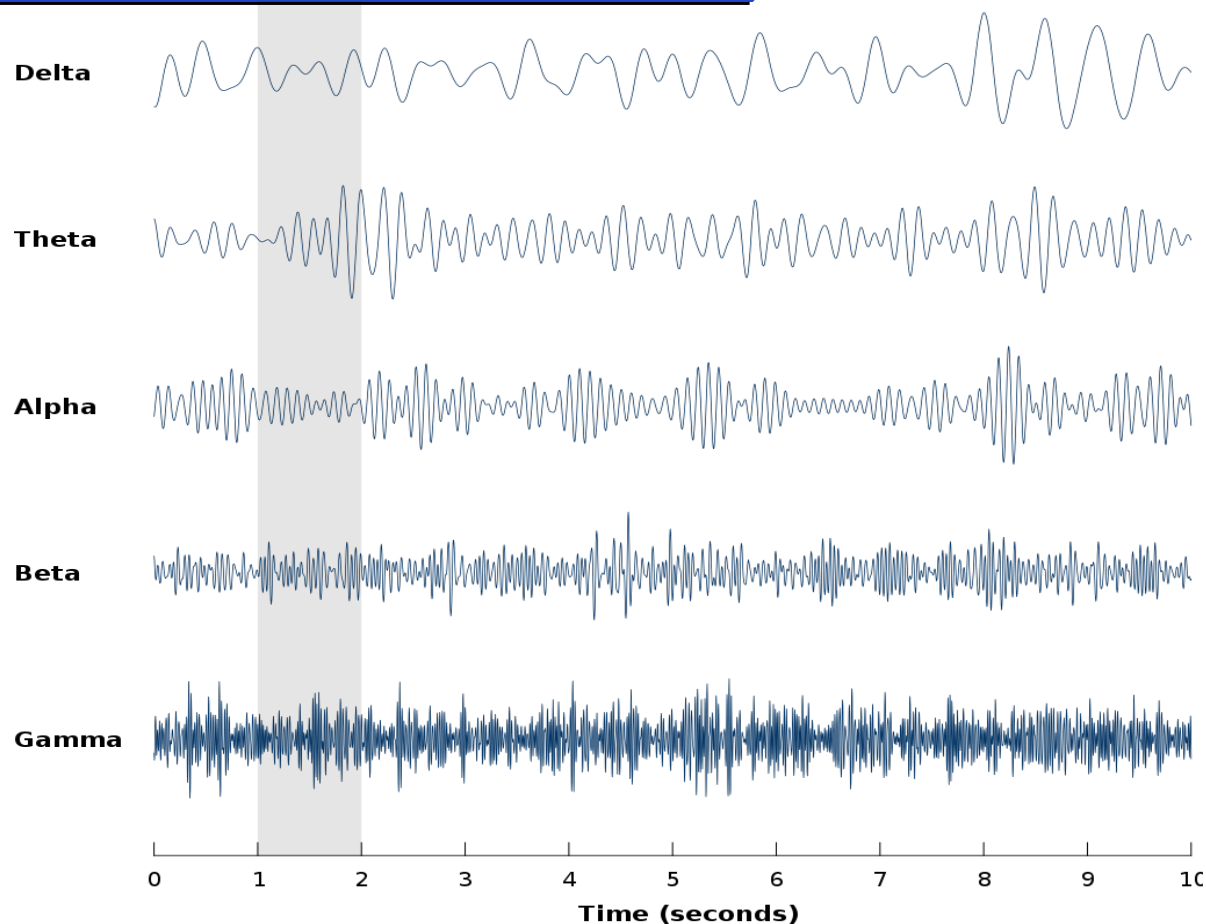
EEG sensors placement (EPOC/EPOC+)

How to get data from device

- Using the device API and/or protocols
  - Bluetooth, USB, etc.
  - Open-source tool/library to get data
    - Mindwave – **PuzzleBox Synapse** project
    - EMOTIV – Old deprecated **community SDK** from EMOTIV
    - Third-party open source tools for EMOTIV headsets
- Cloud API from the device vendor
  - Device sends data to vendor's server, and user's tool downloads them back
  - New SDK from EMOTIV

More on NeuroSky MindWave
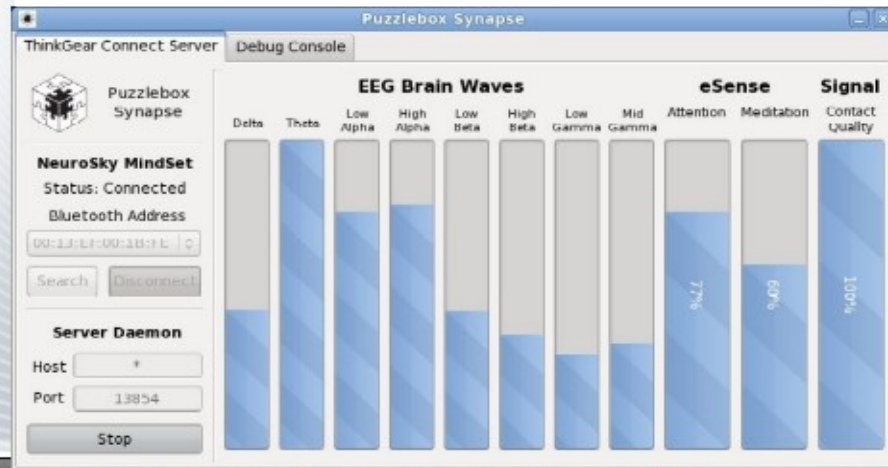
- eSense Attention

- eSense Meditation
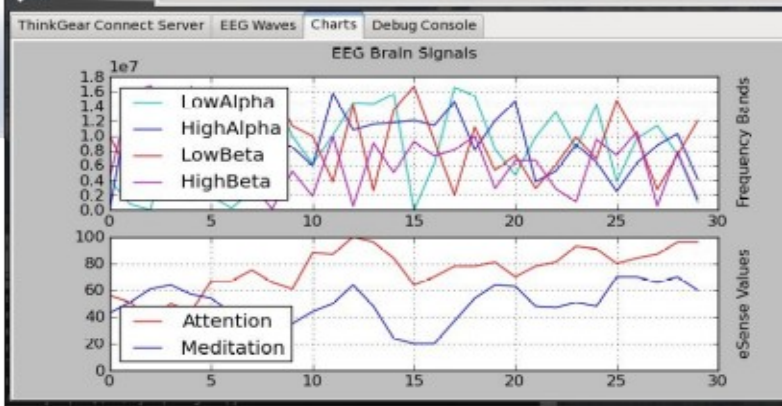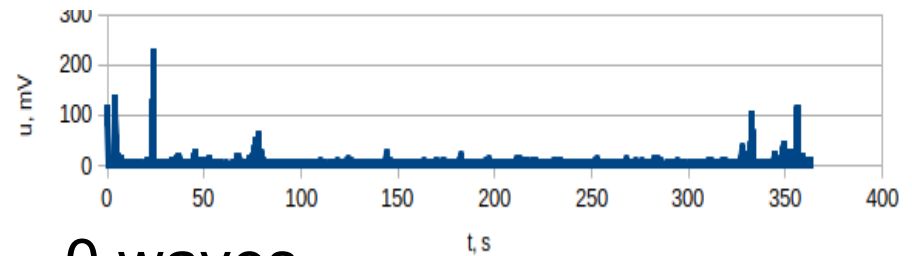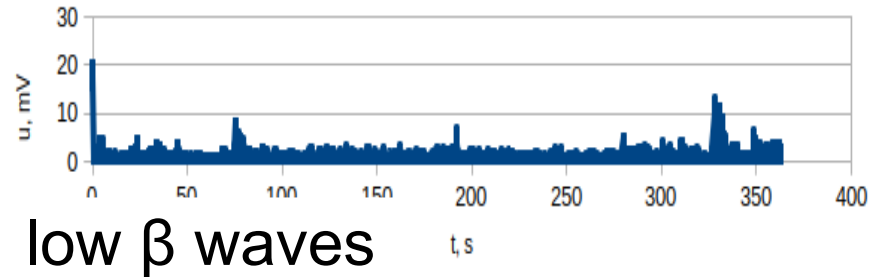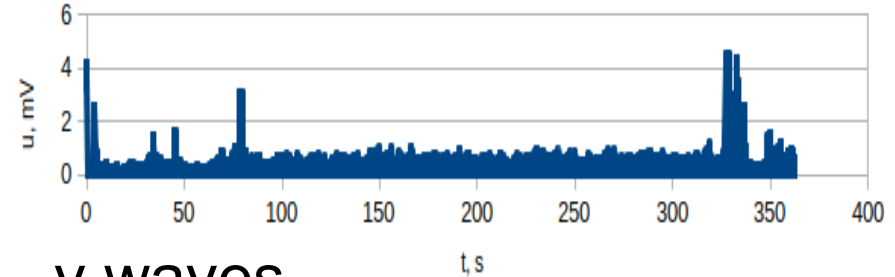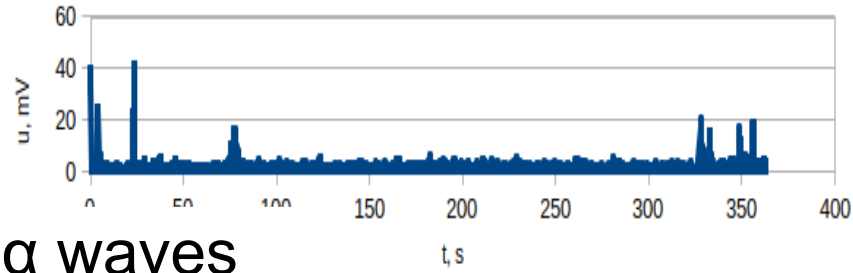
More on Emotiv headsets

- **devices:**
  - Emotiv EPOC
  - Emotiv EPOC+
  - Emotiv Insight
- **metrics:**

  - α, β, γ, θ waves
  - Facial expressions:
    - smile, surprise, frown, blink, wink, clench teeth
  - Emotional States:
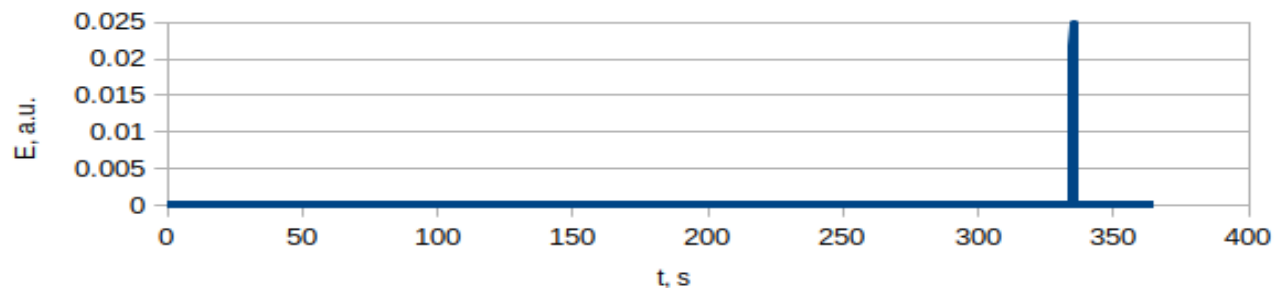   - Excitement, stress, engagement, relaxation, focus, interest
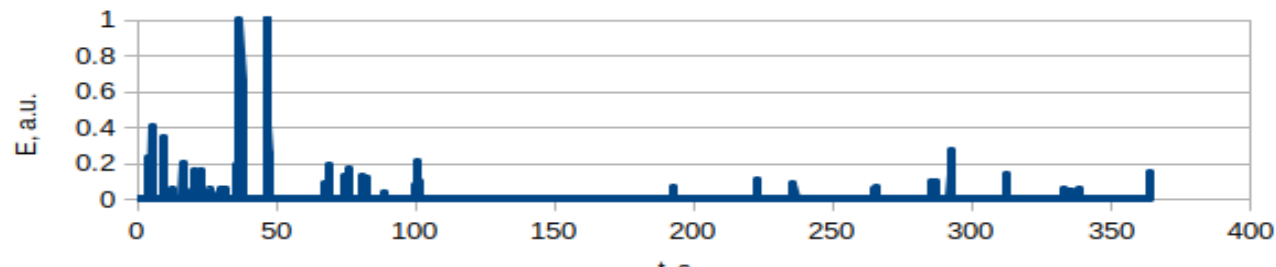 - movements

EmotivEEG metrics (1/2)

α waves

γ waves

low β waves

θ waves
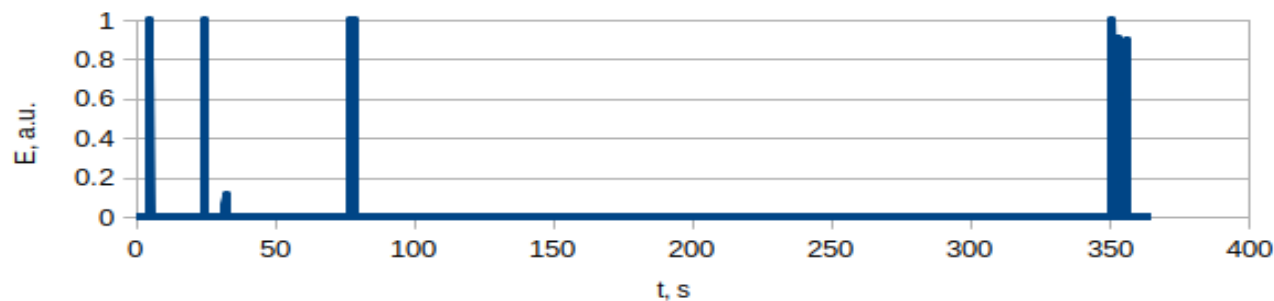
high β waves

blink
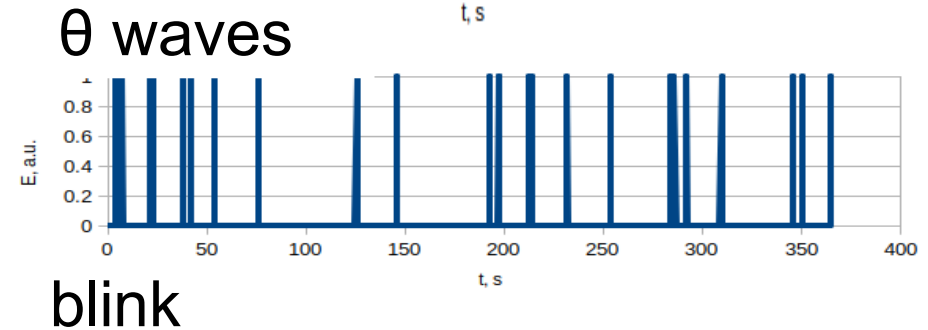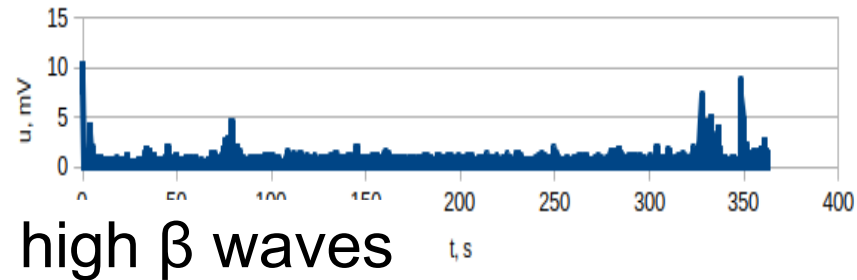
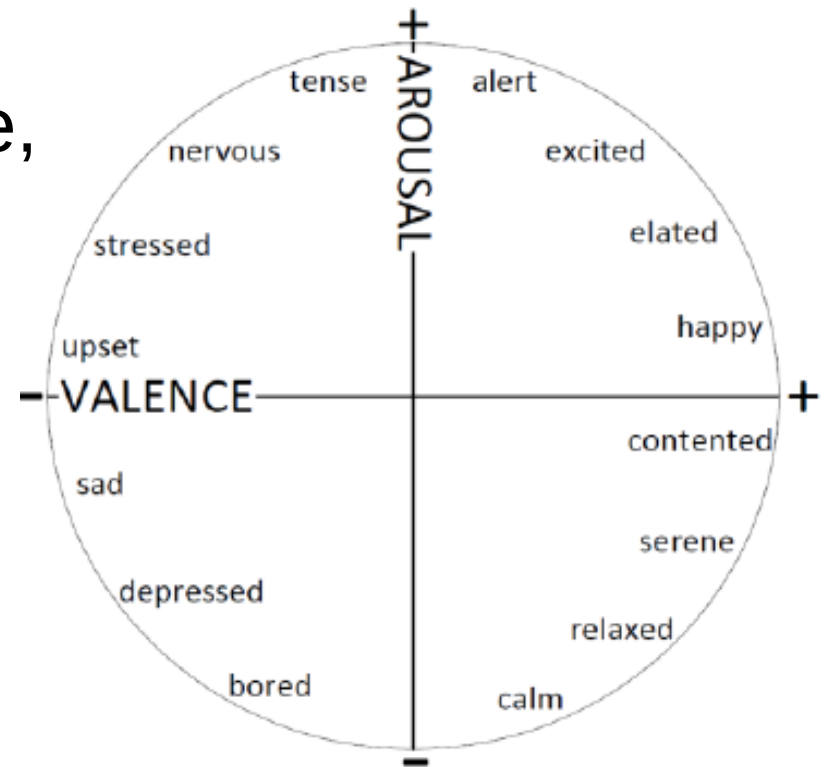# EmotivEEG metrics (2/2)

surprise

frown

smile

Emotions, the circumplex model

- developed by James Russell
- two-dimensional circular space, containing valence (approach/withdrawal motivation) and arousal dimensions

- Arousal: $A = \dfrac{\beta_{AF3+AF4+F3+F4}}{\alpha_{AF3+AF4+F3+F4}}$

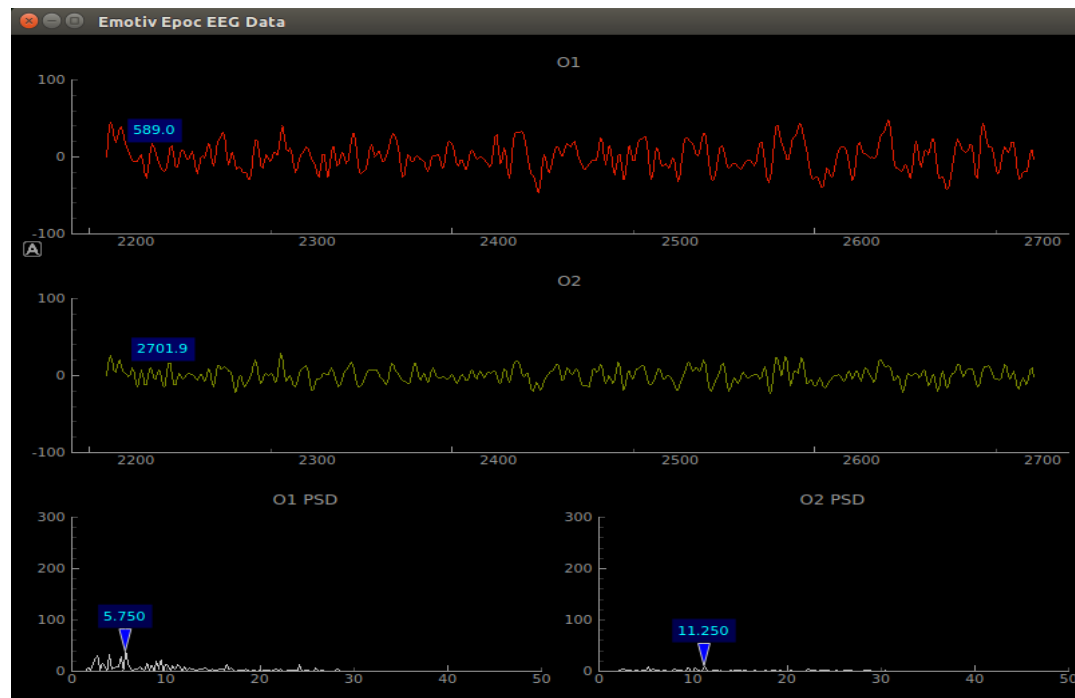- Valence: $V = \dfrac{\alpha_{F4}}{\beta_{F4}} - \dfrac{\alpha_{F3}}{\beta_{F3}}$
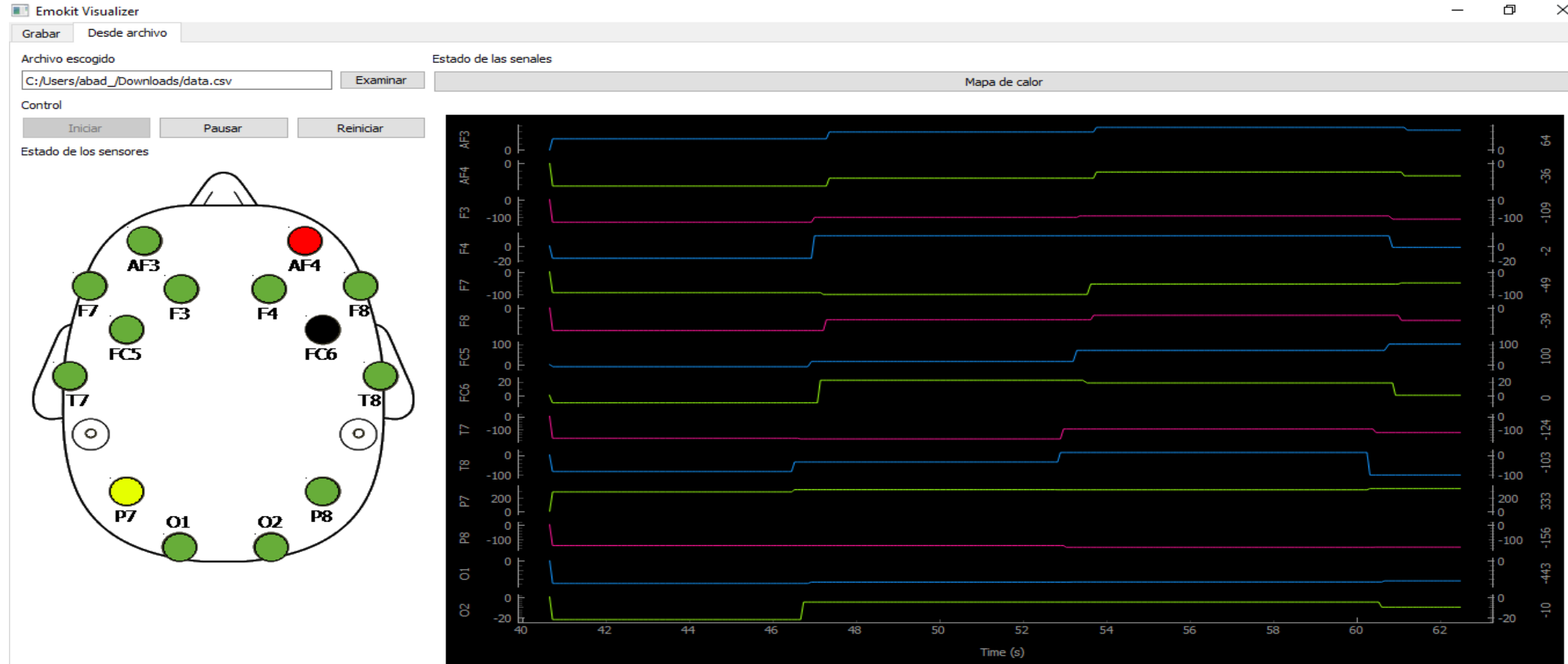
EPOC devices – Emokit

https://github.com/openyou/emokit

https://github.com/xribene/Emokit_Epoc_GUI

Emokit frontend (dead)

https://github.com/EmokitAlife/EmokitVisualize

Emokit frontend (alive)

https://github.com/tahesse/CyKITv2

Sample GUI testing (window switching)

- Plasma Desktop (KDE)

- Gnome Shell

- Ubuntu Unity
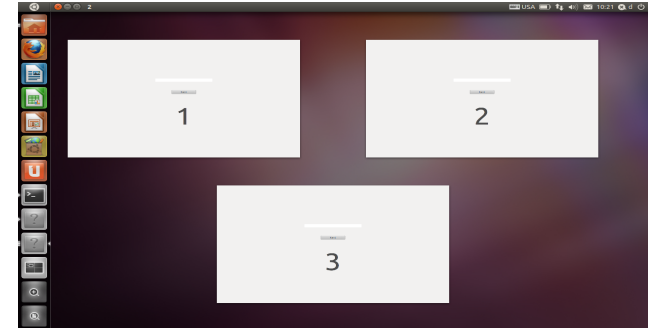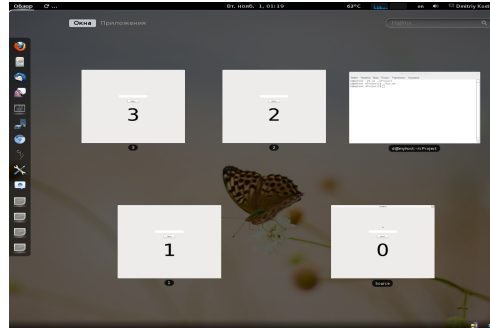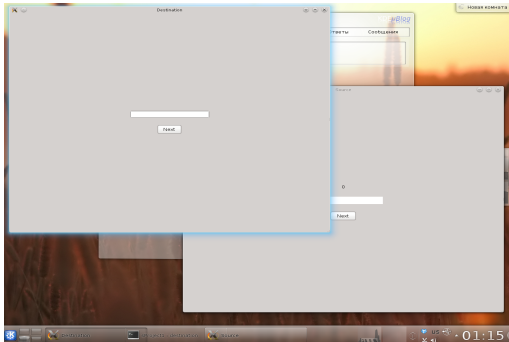
Tempo and mind concentration

- Tempo:

  - Highest in Gnome

  - Lowest in Unity (inconvenient window switching model)

- Mind concentration:

  - Highest in Unity

  - Lowest in KDE (and lowest mind concentration variability)

Conclusions

- Consumer-grade EEG is enough mature to be used in the UI/UX comparison
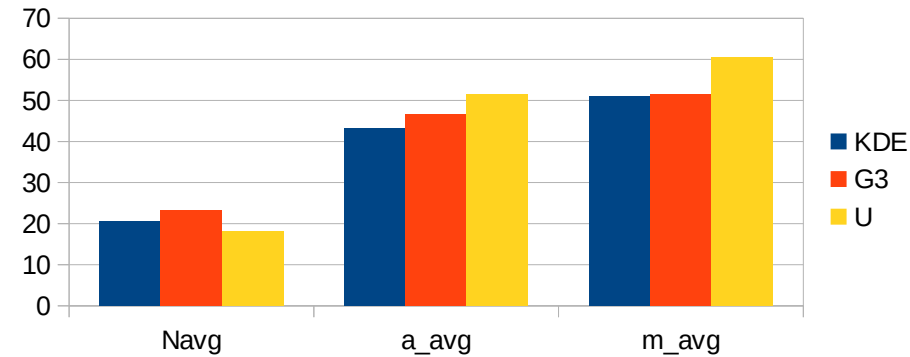 - The mass market devices are more or less open source friendly
  - The more comprehensive device you plan to use, the more difficulties you will meet
    - MindWave is the best choice if you just need mind concentration
    - OpenBCI is expensive to buy and hard to build because of legacy components out of production
    - EPOC+ and Insight try to protect your EEG data from yourself and try to convince you to expensive licensing for researches
- EEG metrics can be really useful in practical evaluation of the humans mental load and emotional state
  - Based on the test results, the average values for the listed parameters and the maximum deviation of the parameter from the average component can be easily calculated