

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

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PERCONA



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



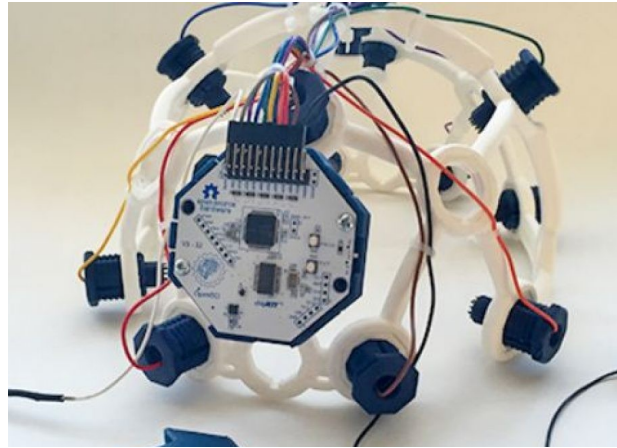
EMOTIV EPOC
14-Channel, 799\$



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



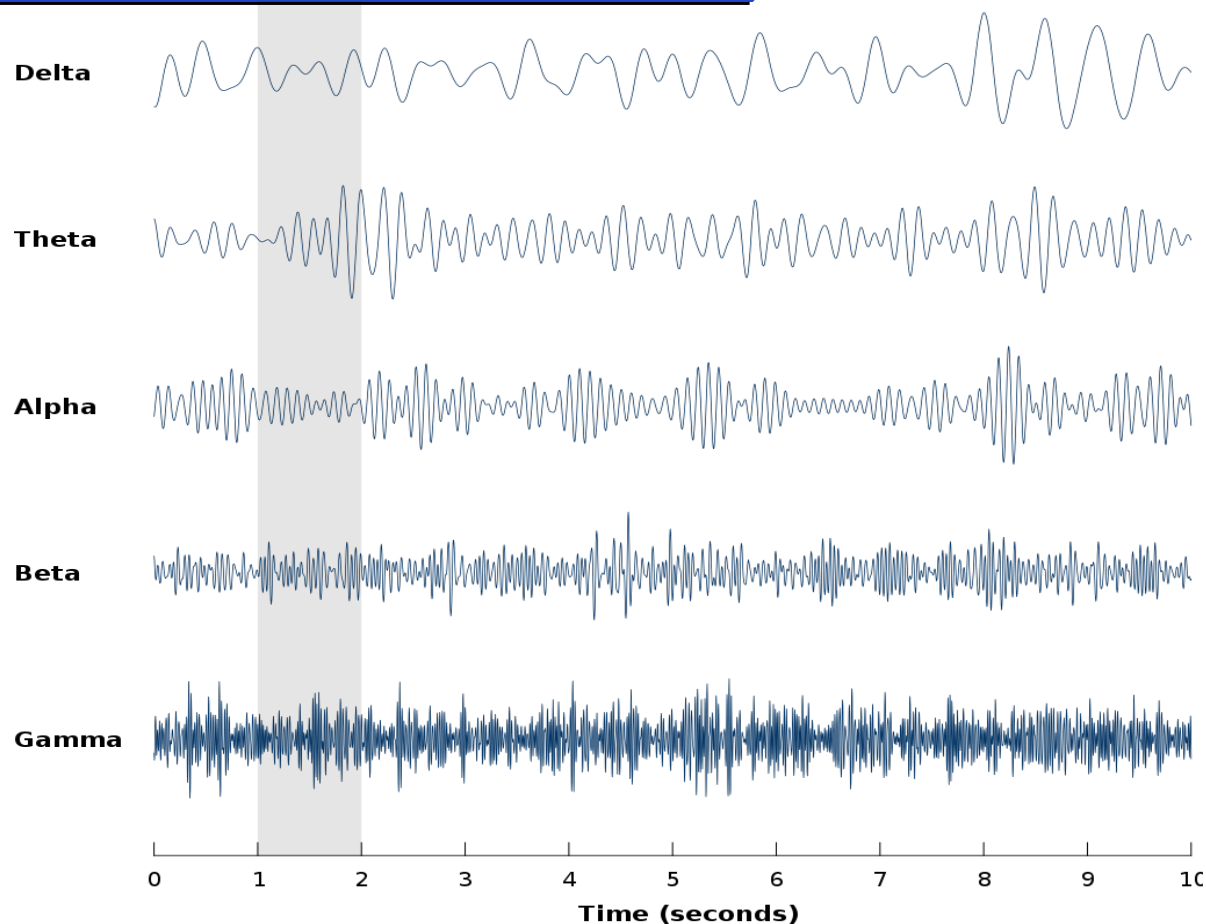
Puzzlebox Orbit



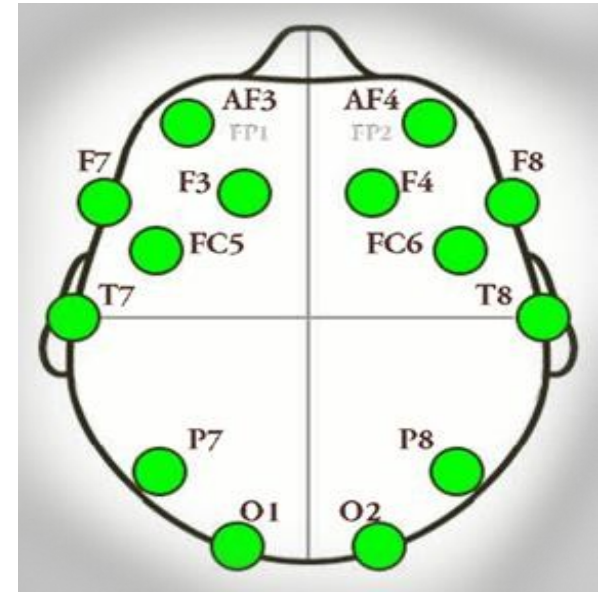
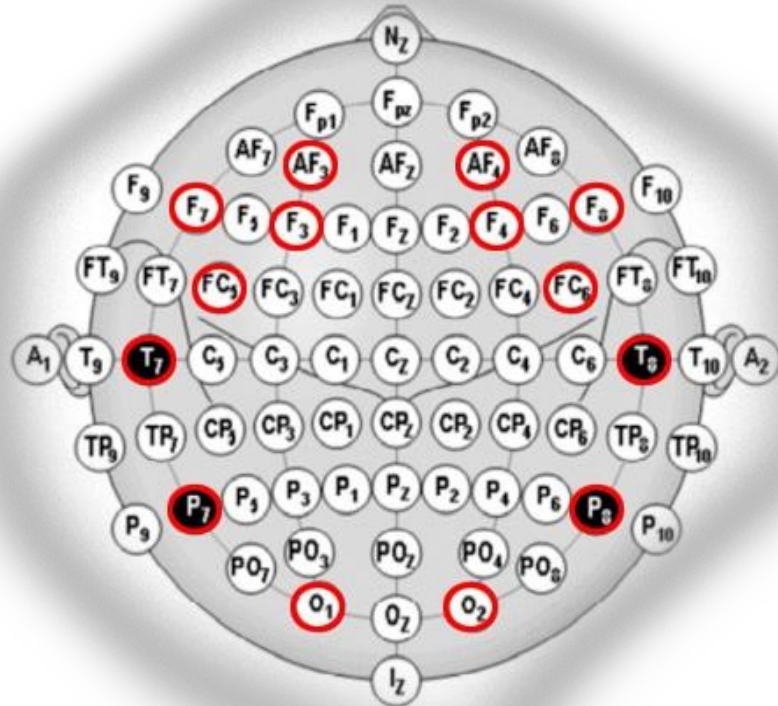
Nekomimi Ears

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



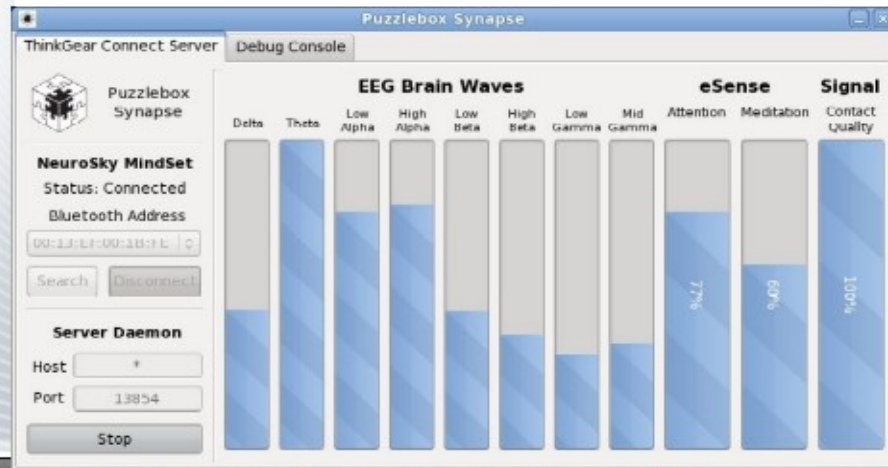
EEG sensors placement (EPOC/EPOC+)



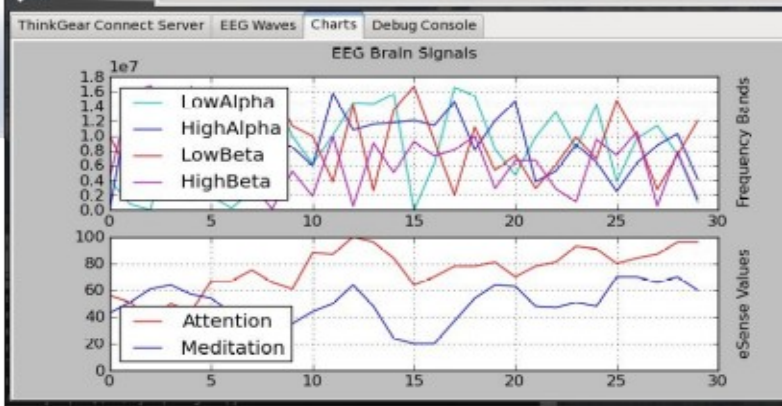
How to get data from device

- 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:**

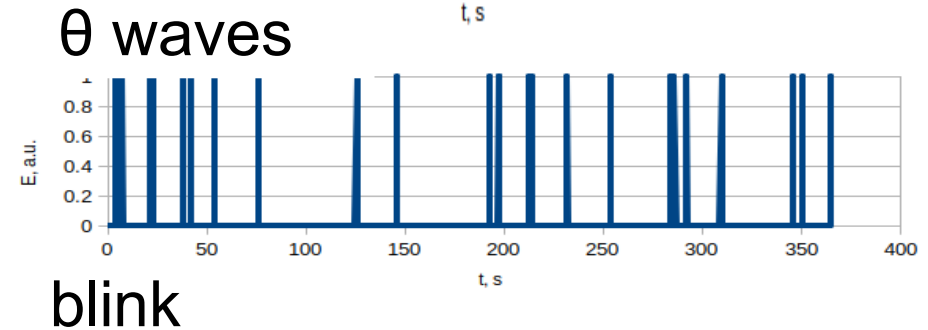
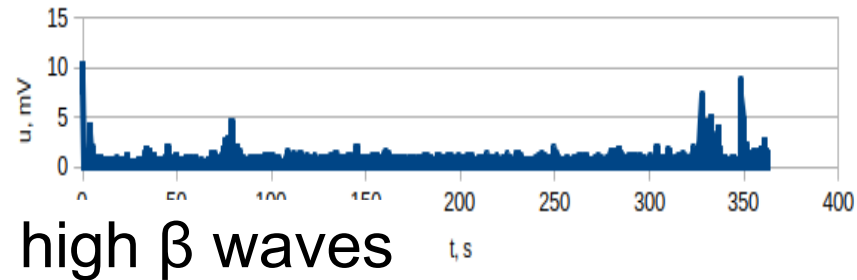
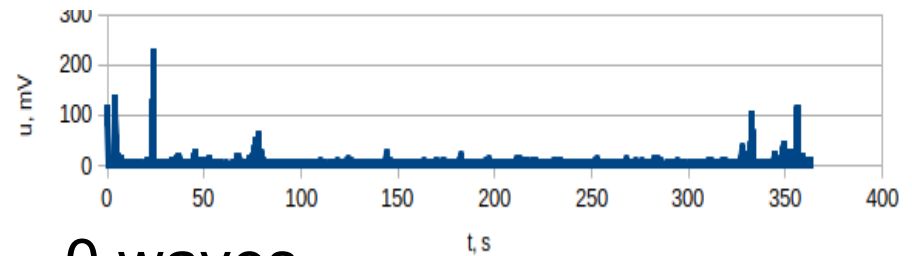
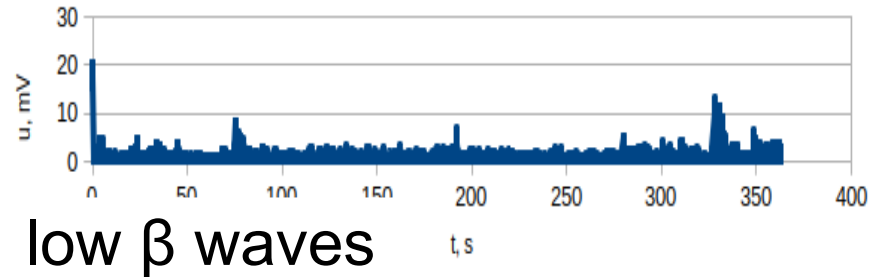
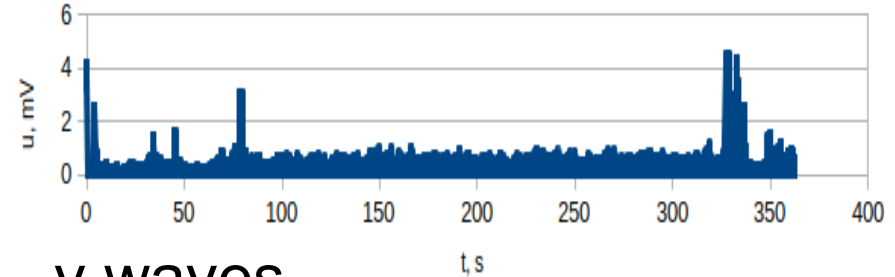
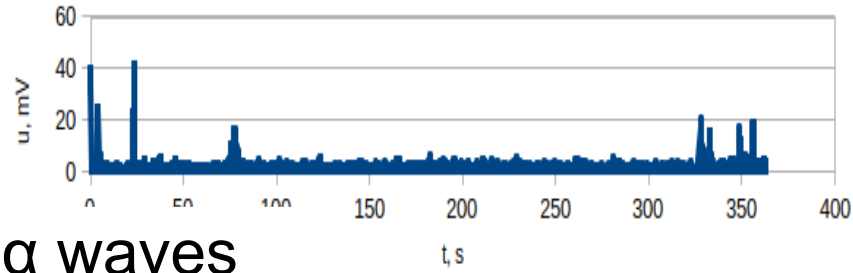
- Emotiv EPOC
- Emotiv EPOC+
- Emotiv Insight

- **metrics:**

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

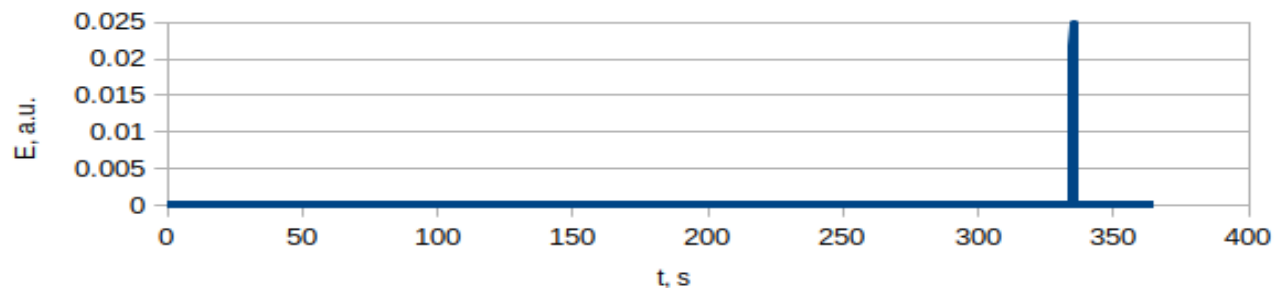


EmotivEEG metrics (1/2)

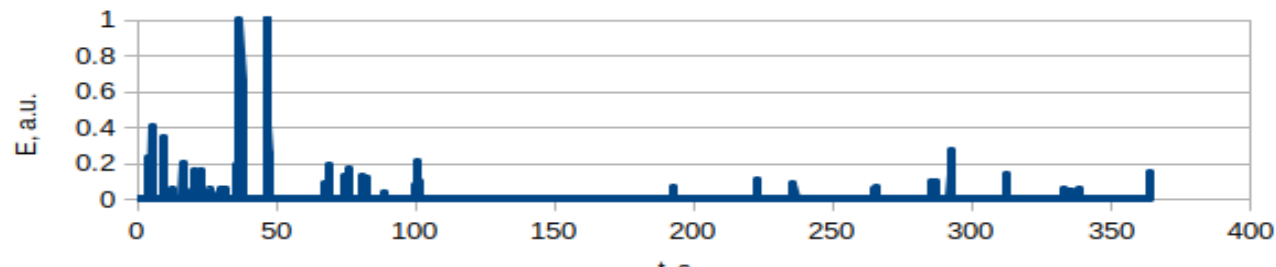


EmotivEEG metrics (2/2)

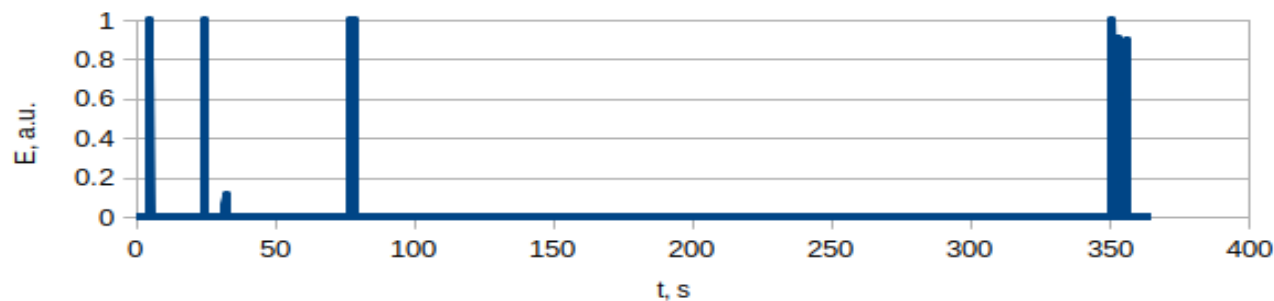
surprise



frown



smile

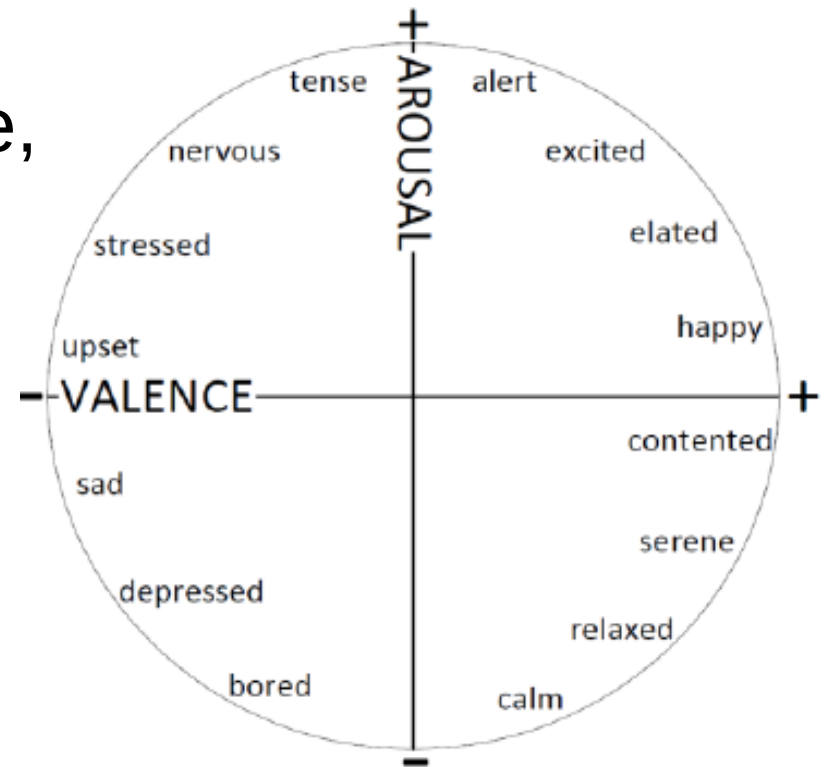


Emotions, the circumplex model

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

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

- Valence:
$$V = \frac{\alpha_{F4}}{\beta_{F4}} - \frac{\alpha_{F3}}{\beta_{F3}}$$

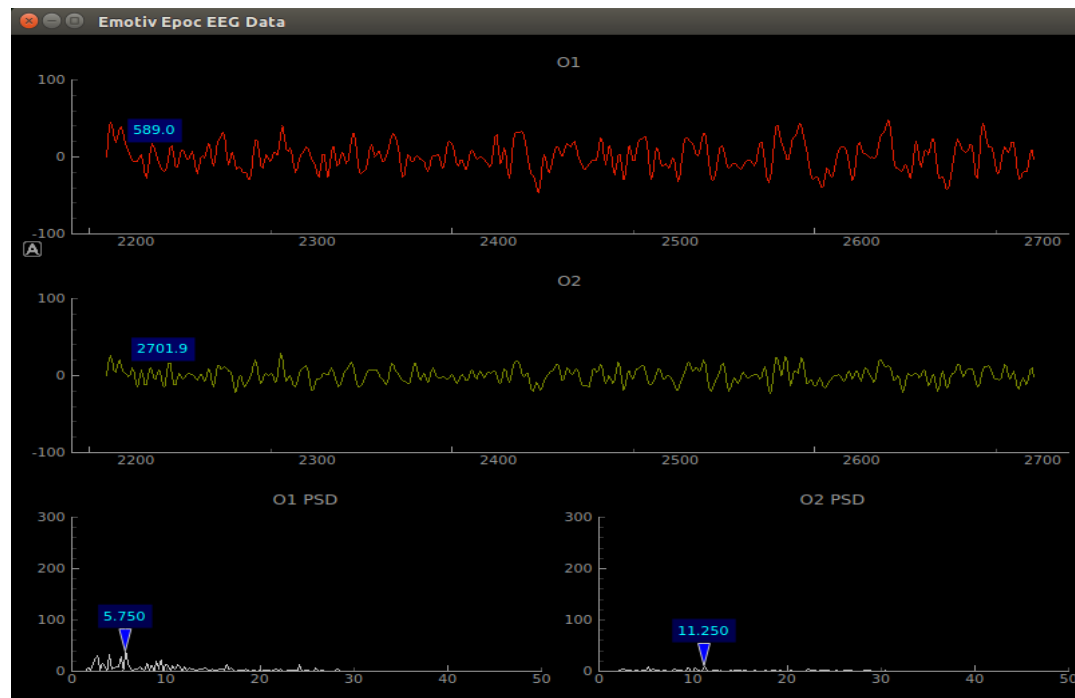


EPOC devices – Emokit

<https://github.com/openyou/emokit>

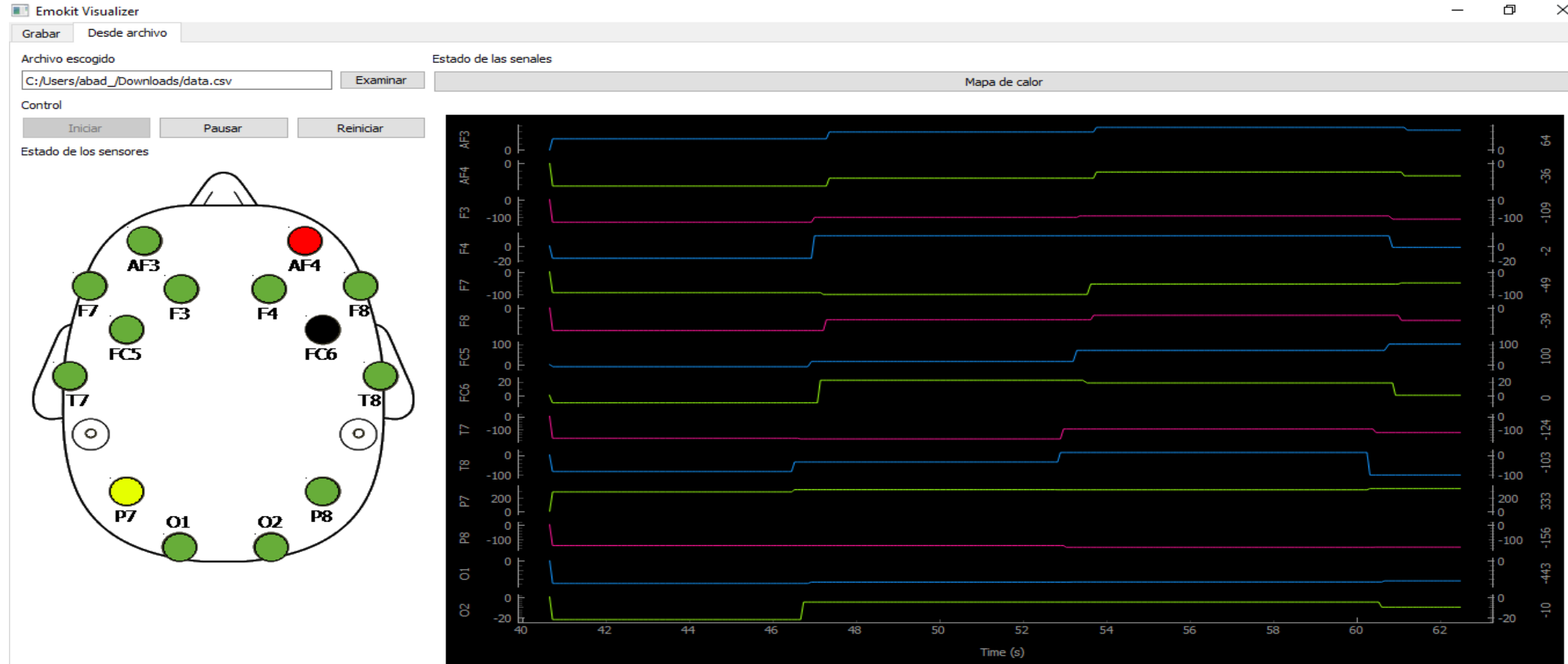
https://github.com/xribene/Emokit_Epoc_GUI

```
user@user-VirtualBox: ~/emokit/python
Emokit - v0.0.8 SN: SN201401223848GM Old Model: False
=====+
| Sensor | Value | Quality | Quality L1 | Quality L2 |
|-----+-----+-----+-----+-----+
| F3      | 4645.1212116567 | 12.3636363624 | Nothing | Nothing |
| FC5     | 4275.7575753300 | 12.3636363624 | Nothing | Nothing |
| AF3     | 4221.1515147294 | 0.0 | Nothing | Nothing |
| F7      | 4758.9696964938 | 8.2424242416 | Nothing | Nothing |
| T7      | 4717.7575752858 | 8.2424242416 | Nothing | Nothing |
| P7      | 4883.6363631480 | 8.2424242416 | Nothing | Nothing |
| O1      | 4381.3636359255 | 4.1212121208 | Nothing | Nothing |
| O2      | 4582.7878783296 | 0.0 | Nothing | Nothing |
| P8      | 4713.6363631650 | 4.1212121208 | Nothing | Nothing |
| T8      | 4802.2424237622 | 8.2424242416 | Nothing | Nothing |
| F8      | 4776.9999995223 | 12.3636363624 | Nothing | Nothing |
| AF4     | 4499.8484843985 | 4.1212121208 | Nothing | Nothing |
| FC6     | 4605.4545449940 | 12.3636363624 | Nothing | Nothing |
| F4      | 4388.0606056218 | 0.0 | Nothing | Nothing |
| X       | 42.0 | N/A | N/A | N/A |
| Y       | 42.0 | N/A | N/A | N/A |
| Z       | ? | N/A | N/A | N/A |
| Batt    | 32 | N/A | N/A | N/A |
|-----+-----+-----+-----+
| Packets Received: 3526 | Packets Processed: 3525 |
| Sampling Rate: 134 | Crypto Rate: 138 |
|-----+-----+-----+-----+
=====+
```



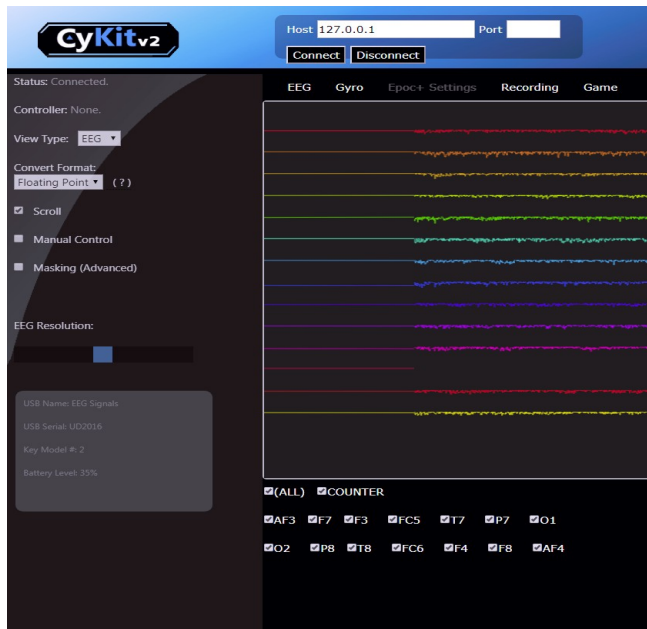
Emokit frontend (dead)

<https://github.com/EmokitAlife/EmokitVisualize>



Emokit frontend (alive)

<https://github.com/tahesse/CyKITv2>



```
\Python>CyKITv2.py

<Version: CyKITv2:2017.12.15> -- Python 2.7.6 on Win32

Usage: Python.exe CyKITv2.py <IP> <Port> <Model#<1-6>> [config]

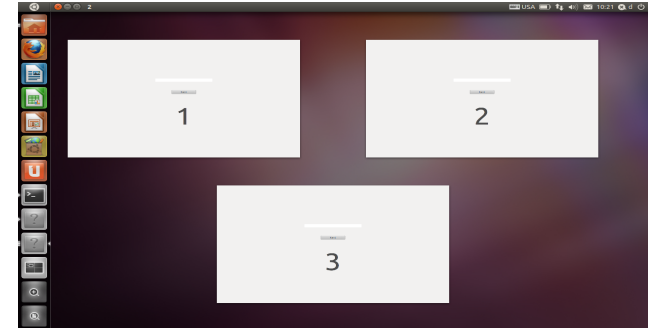
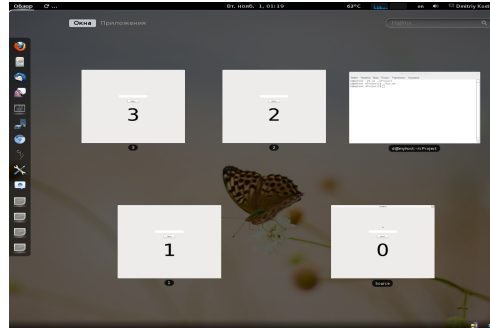
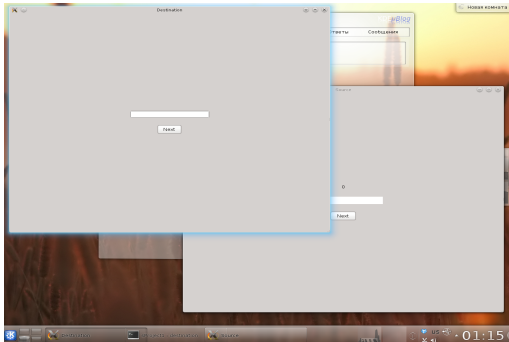
<IP> <PORT> for CyKIT to listen on.

<Model#> Choose the decryption type.

1 - Epoc <Research>
2 - Epoc <Standard>
3 - Insight <Research>
4 - Insight <Standard>
5 - Epoc+ <Research>
6 - Epoc+ <Standard>
```

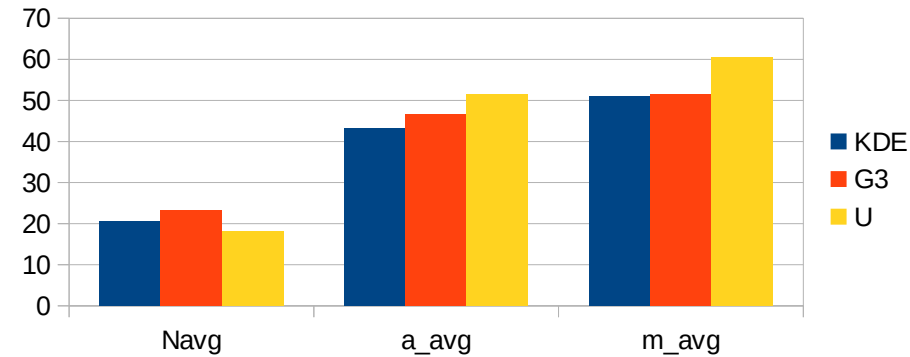

Sample GUI testing (window switching)

- 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