DIY electrophysiography

(The safest thing you can do involving connecting your cranium to an electronic device you built in your garage.)

Flavours

- Electrocardiography (ECG) - heart.
- Electroencephalography (EEG) - brain.
- Electromyography (EMG) - muscle.
- Electrocorticography (ECoG) - cortical surface (don't try this one at home).

Practical applications and other applications

Practical

- Sleep tracking.
- Brain-computer interfaces.
- Biofeedback.
- Cardiac abnormality identification.
- Seizure detection.

Practical applications and other applications

Practical

- Sleep tracking.
- Brain-computer interfaces.
- Biofeedback.
- Cardiac abnormality identification.
- Seizure detection.

Questionably-practical

- Binaural beats.
- Game design.

Practical applications and other applications

Practical

- Sleep tracking.
- Brain-computer interfaces.
- Biofeedback.
- Cardiac abnormality identification.
- Seizure detection.

Questionably-practical

- Binaural beats.
- Game design.

Awesome

- Object recognition with evoked-response potentials.
- Controlling your powered exoskeleton.

Design

- Electrodes (wet/dry, active/passive).
- Instrumentation amplifier.
- Bandpass filter (for EEG, high-pass at ~1Hz, low-pass at ~40Hz).
- Notch filters at 50Hz (for Australian AC).
- Driven right-leg circuit.
- ADC.

Proprietary consumer hardware

- NeuroSky.
- Emotiv (EPOC, Insight).
- BCInet (formerly Neural Impulse Actuator).
- Star Wars Force Trainer.

Open hardware designs

OpenBCI EEG board

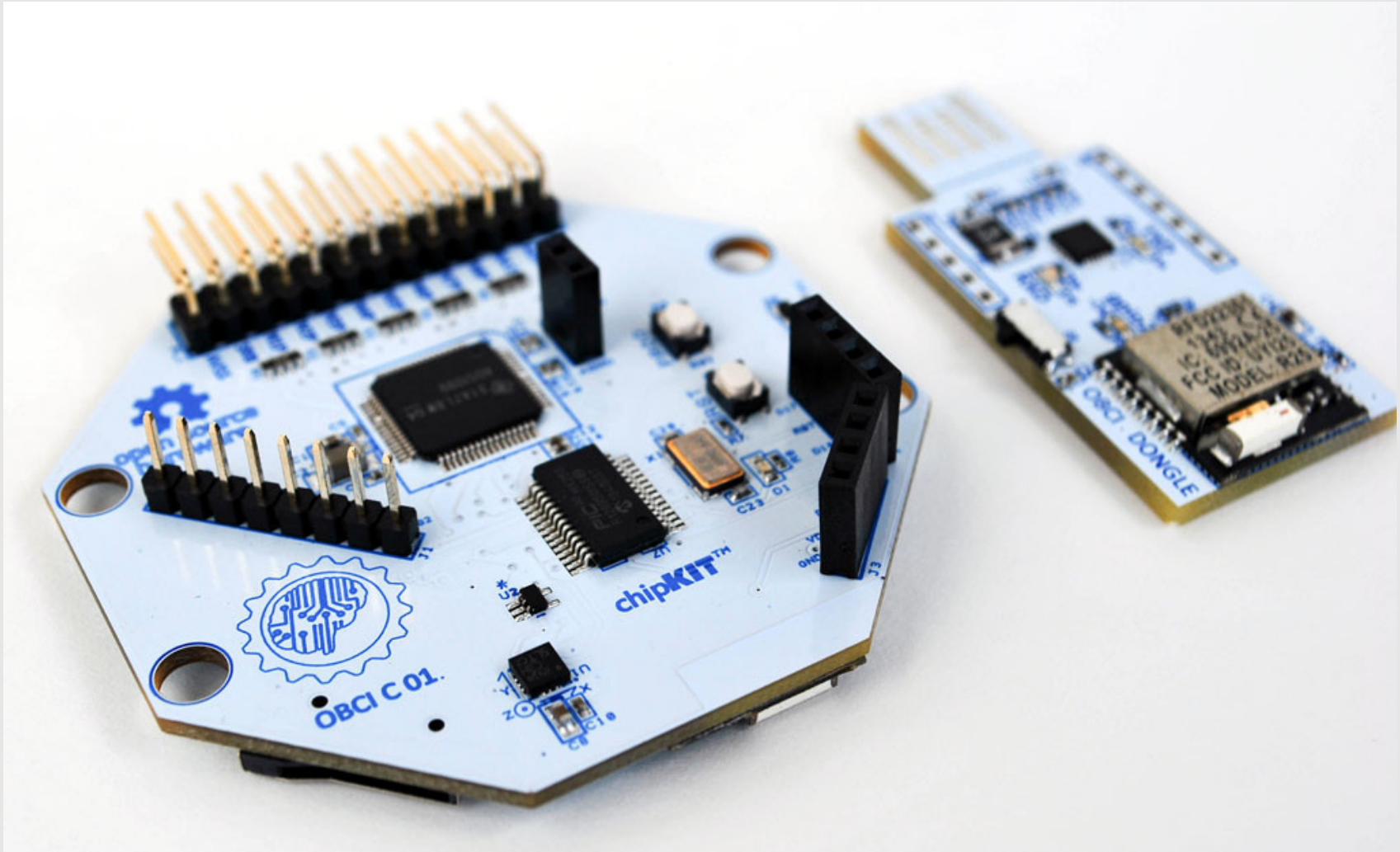

Figure 1: http://openbci.com

Open hardware designs

Olimex ECG Arduino shield

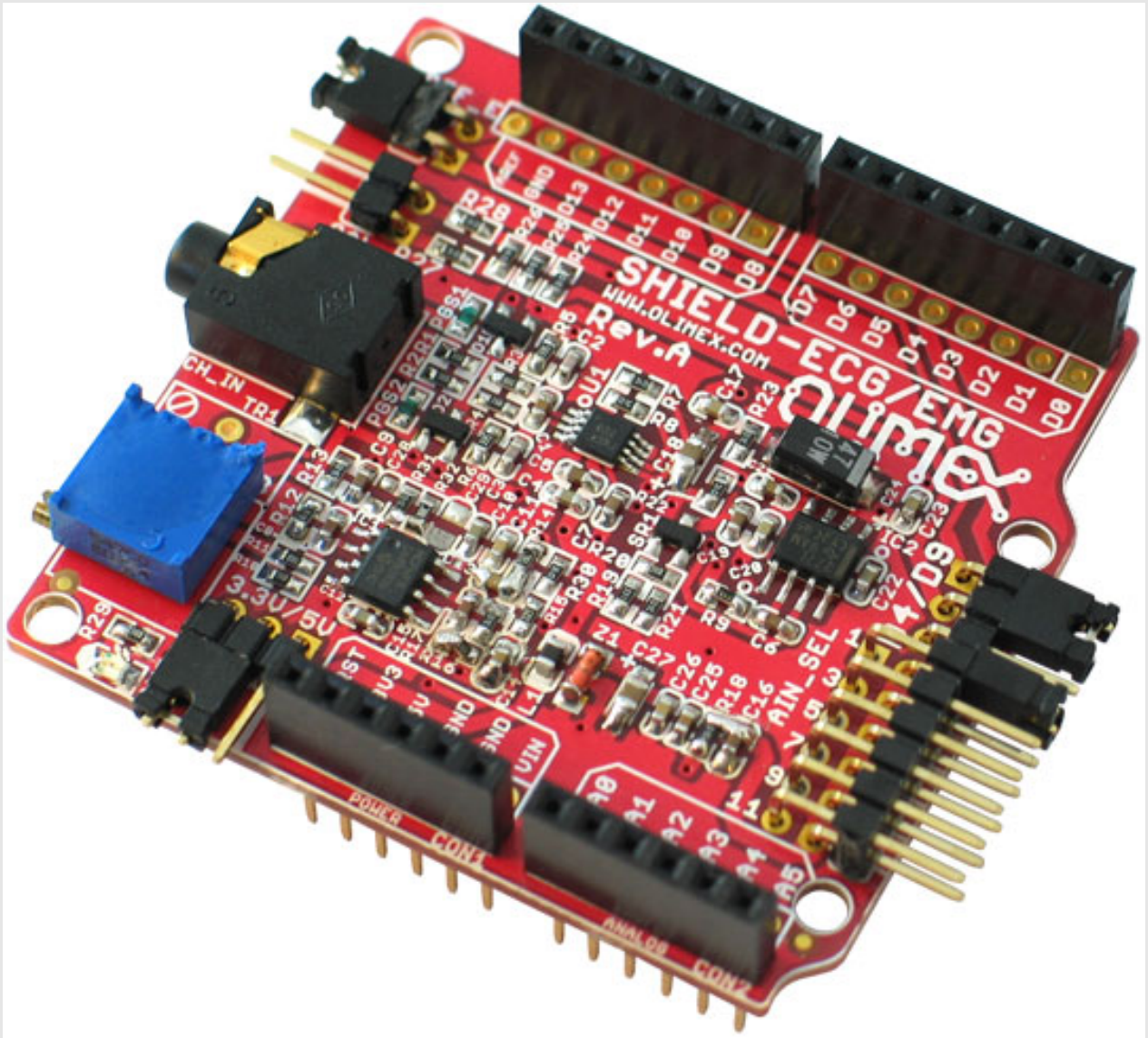

Figure 2: https://www.olimex.com/

Analysis: know your squiggly lines

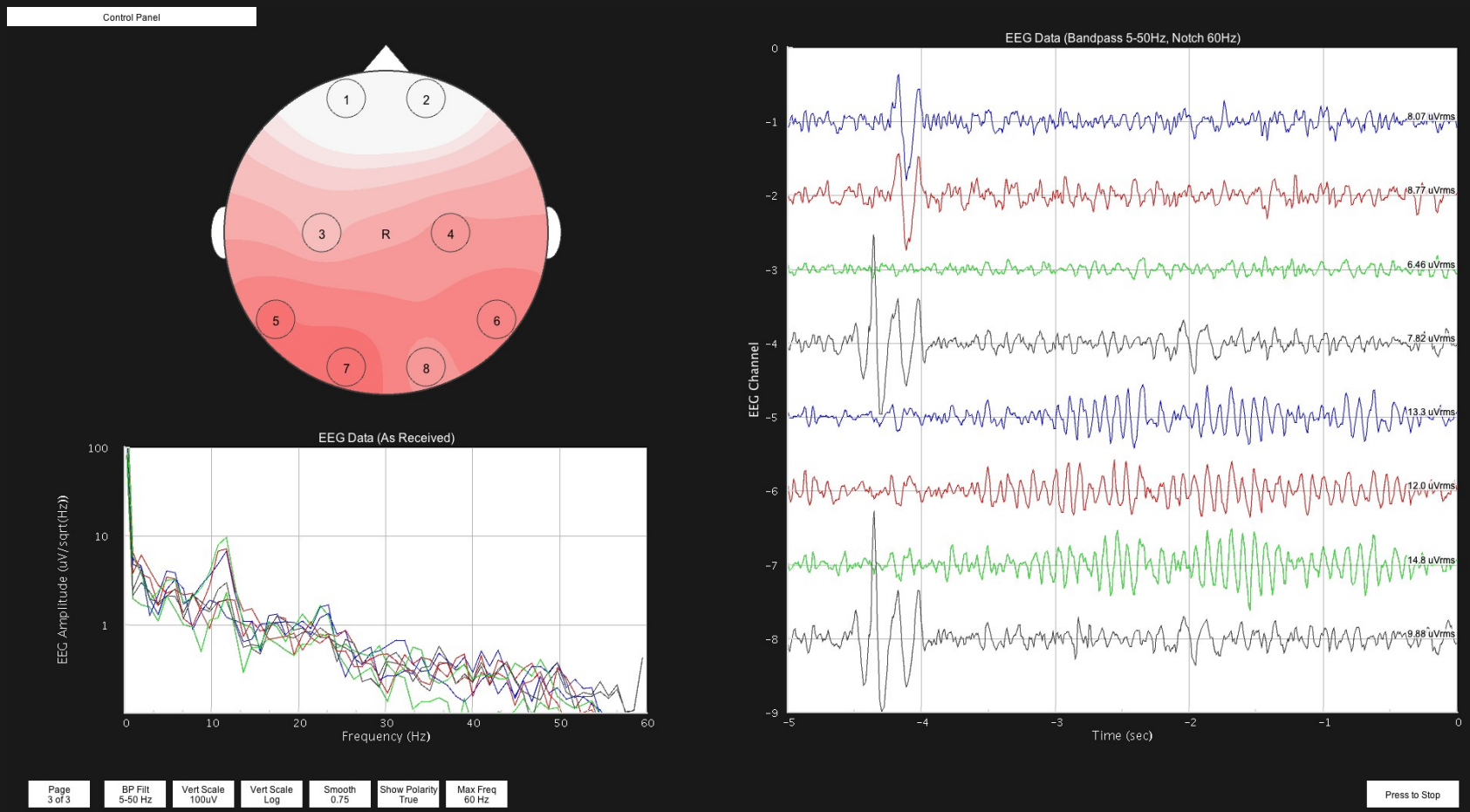

Figure 3:OpenBCI Processing GUI (image by Conor Russomanno)

Analysis: Fourier transform

- Breaks a signal into its components (sinusoids).
- Allows identification of EEG bands ("brainwaves").

EEG bands

Frequency (Hz)	Band	Significance
0-4	delta	slow-wave sleep (stage-3 NREM)
7.5-12.5	alpha	thalamic pacemaker, associated with relaxed states
12.5-30	beta	reduced in sleep and coma, signifies normal wakefulness
25-100	gamma	hippies talking about consciousness

Analysis: wavelet decomposition

- Breaks a signal into individual ‘spikes’ over time.
- Allows identification of common features, and provides a basis for isolating uncommon features.

Analysis: wavelet decomposition

- Breaks a signal into individual ‘spikes’ over time.
- Allows identification of common features, and provides a basis for isolating uncommon features.

Uncommon features: seizure onset

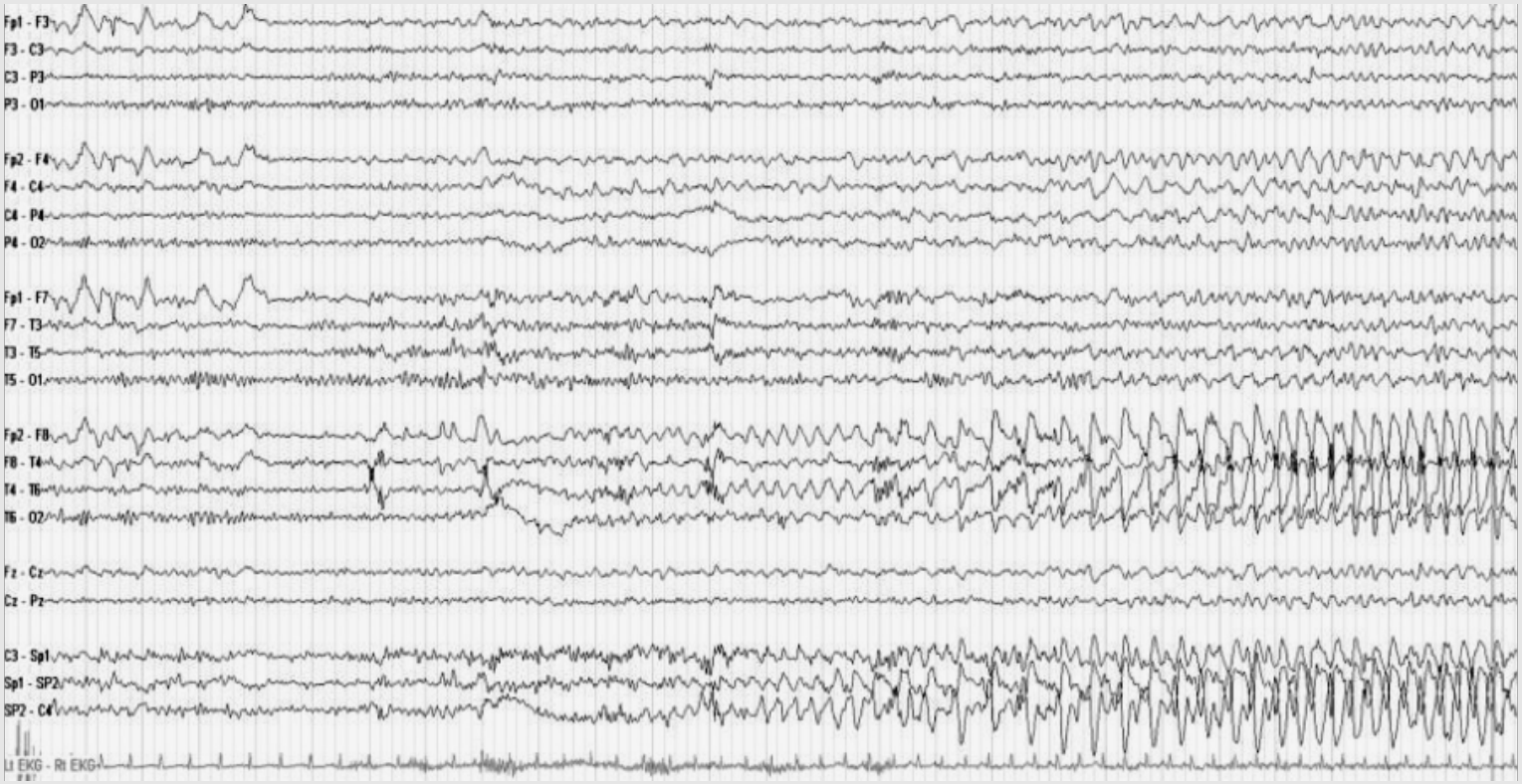

Figure 4: Partial temporal-lobe seizure (image: Teddy Poh)

Analysis - software

Toolkits

- EEGLAB - `http://sccn.ucsd.edu/eeglab/`.
- OpenVIBE - `http://openvibe.inria.fr`.
- SciPy - `http://www.scipy.org/`.

Training datasets

- PhysioBank - `http://physionet.org/physiobank/`.

Fin.

- OpenBCI: `https://github.com/openbci`
- OpenVIBE: `http://openvibe.inria.fr`
- Arduino ECG: `https://github.com/fractalcat/arduecg`

Slides

`https://tesser.org/doc/slides/`

Contact

Sharif Olorin (`sio@tesser.org`) - contrary to rumor, neither citizen nor scientist.