Brain Computer Interfaces

Introduction by Martin Tall
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Brain Computer Interface

- A brain-computer interface (BCI) is a direct communication pathway between a human or animal brain and an external device.

Brain Computer Interface

One-way BCI

Computers either accept commands from the brain or send signals to it (for example, to restore vision) but not both.

Two-way BCIs

brains and external devices exchanges information in both directions, not yet fully implemented

Detecting neural activity

Invasive

- Intracranial implants used everyday for neuroprosthetics. Exciting developments!

Non-invasive

- EEG - Electroencephalography
- fMRI = Functional Magnetic Resonance Imaging
- EROS - Event Related Optical Signal

Non-invasive EEG

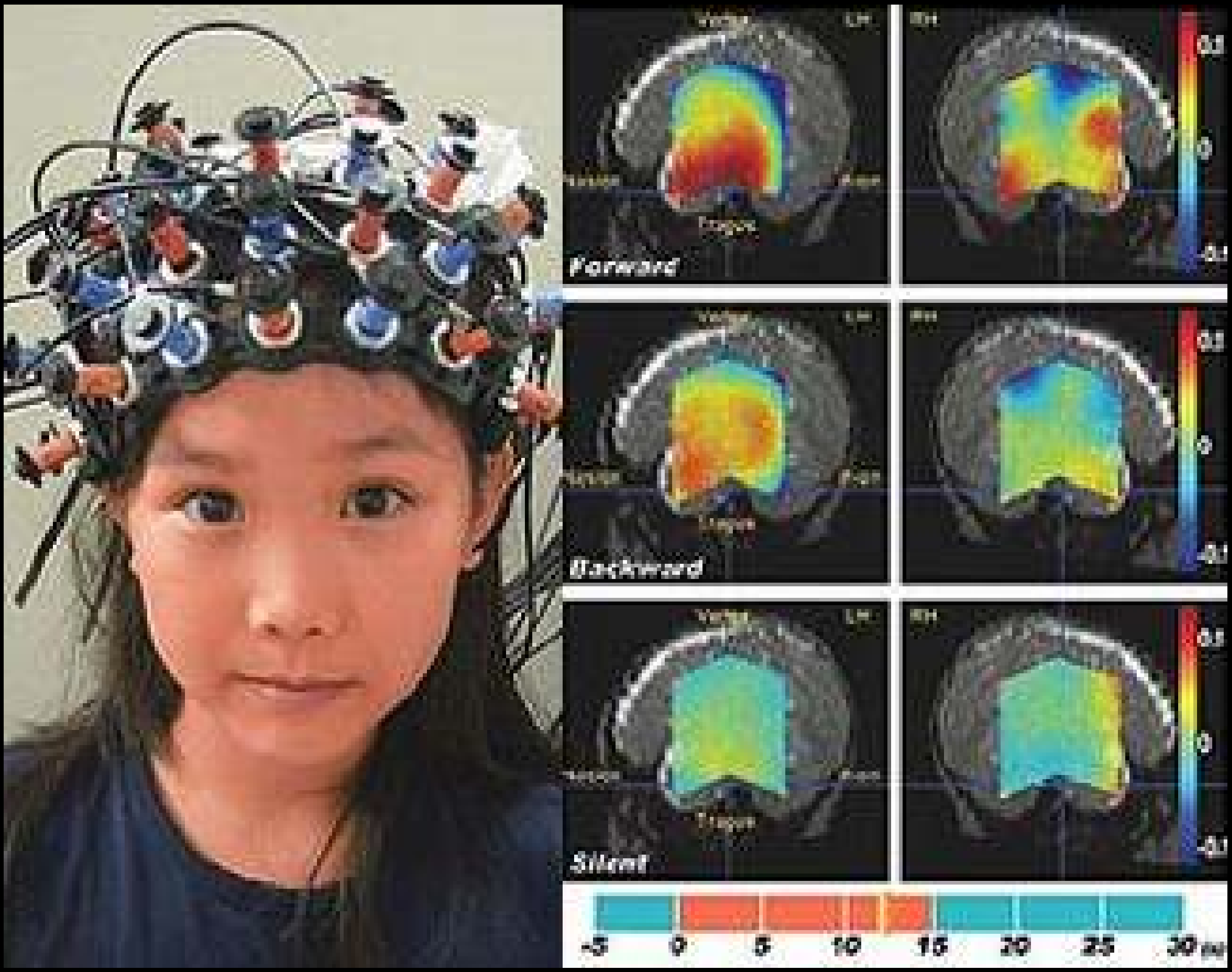
Pros

- + Electroencephalography (EEG) is the most studied potential non-invasive interface, mainly due to its fine temporal resolution, ease of use, portability and low set-up cost.

Cons

- - susceptibility to noise
- - extensive training required

EEG Devices

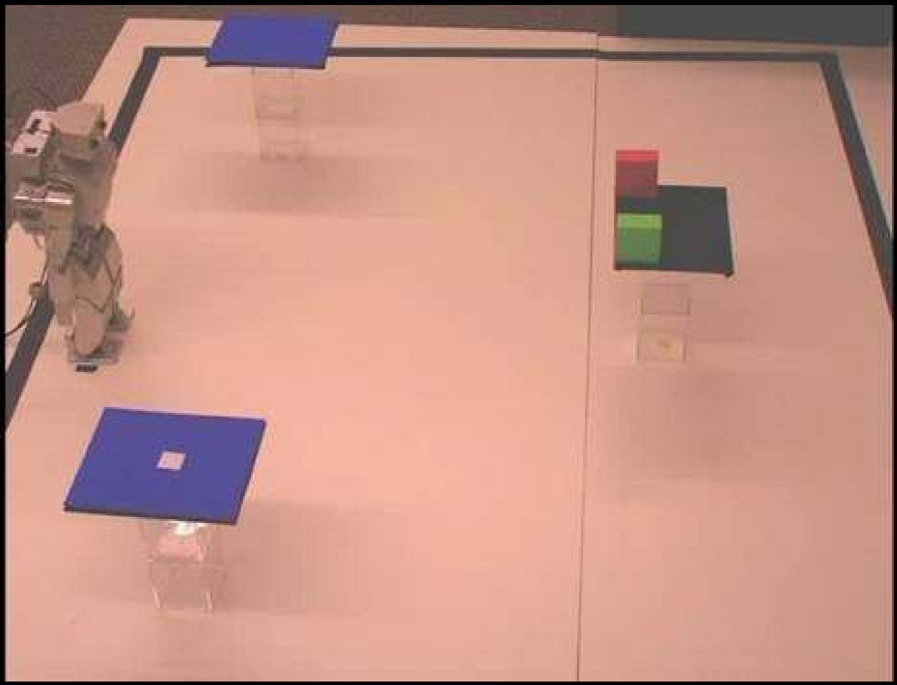


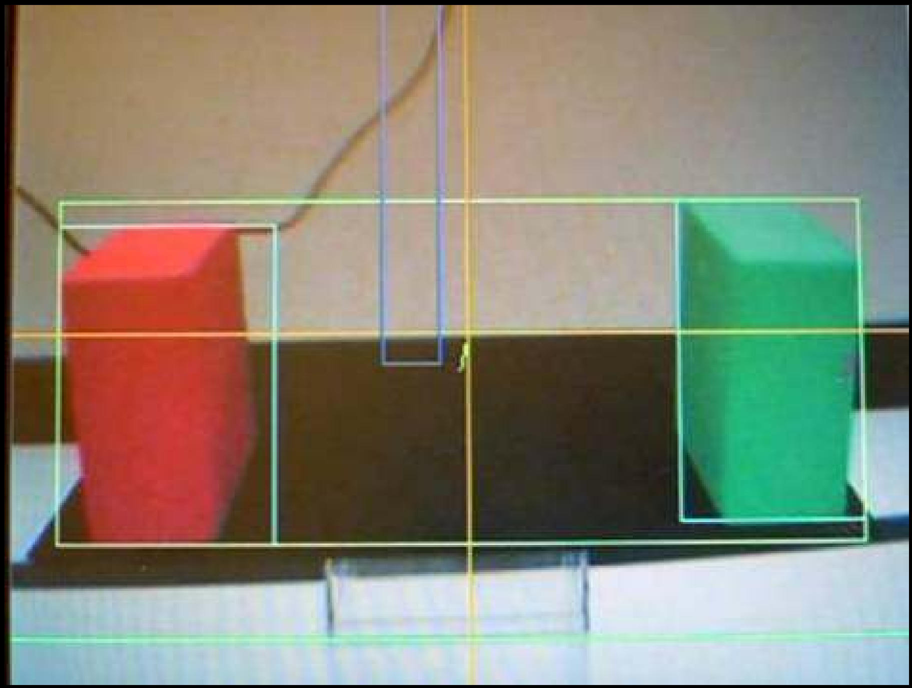
EEG Data

EEG Videogames - Emotive

http://www.emotiv.com/

I, Robot

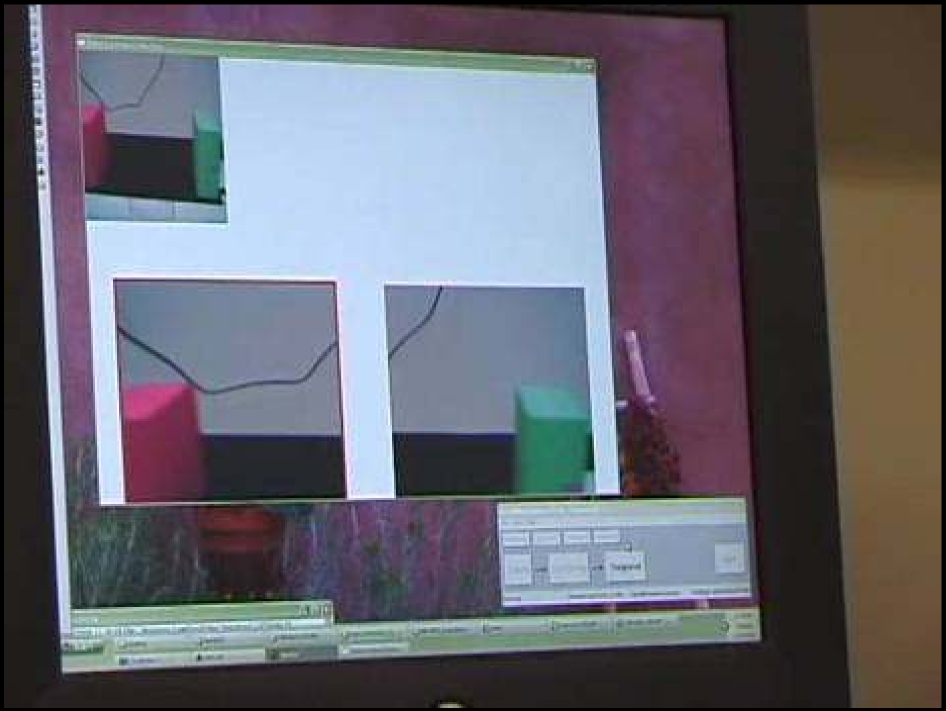




The robot uses computer vision to locate the tables and identify the objects on the tables.

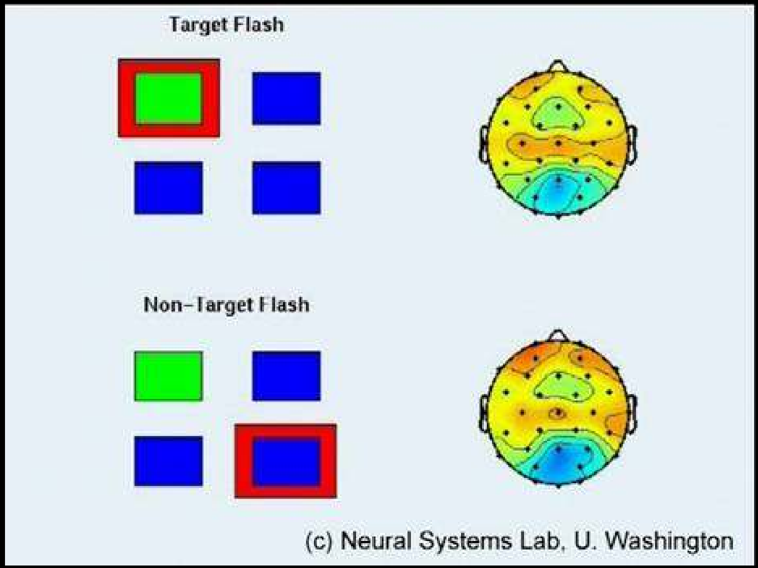
Neural Systems Lab at the University of Washington
http://www.cs.washington.edu/homes/pshenoy/BrainControlledRobot.html

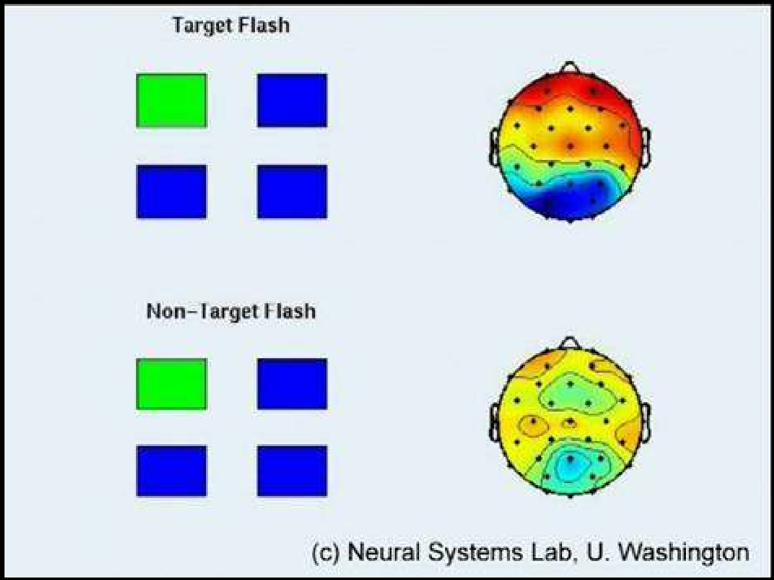
Robot, I



The subject focuses on the object they want the robot to pick up. The interface works by flashing a tiny border around each image in succession. When the border around the attended-to image flashes, the users brain signals register this event.

Detecting corresponding EEG





The user is attending to the green object shown. Border around the green object (target) is flashed. The second picture shows how, around 300 milliseconds later, the subjects brain responds characteristically to the target flash, but not to a non-target flash.

Monkey think, Robot do

Non invasive fMRI

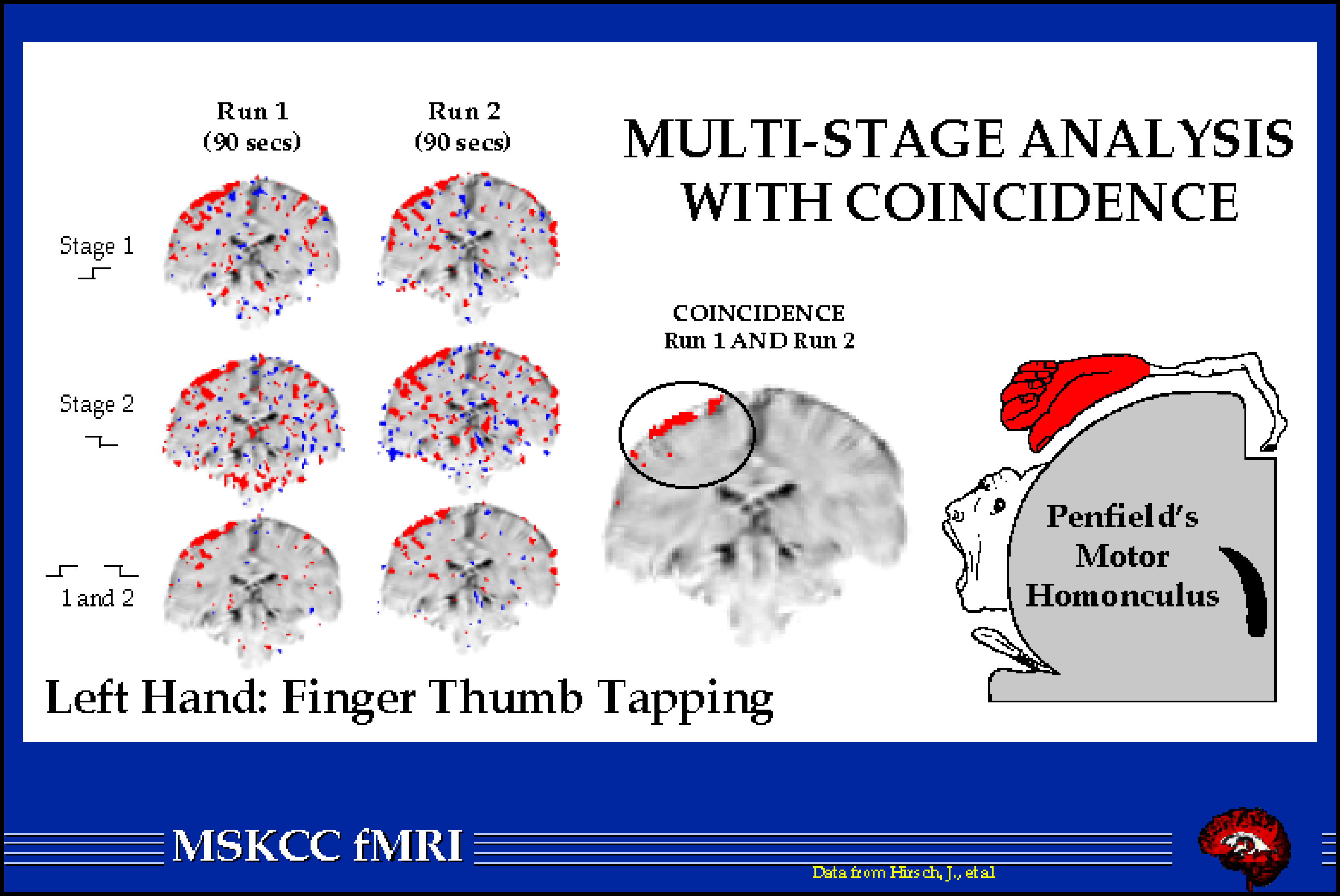
Pros

- No surgery required
- No specific training required
- Wide range of usage

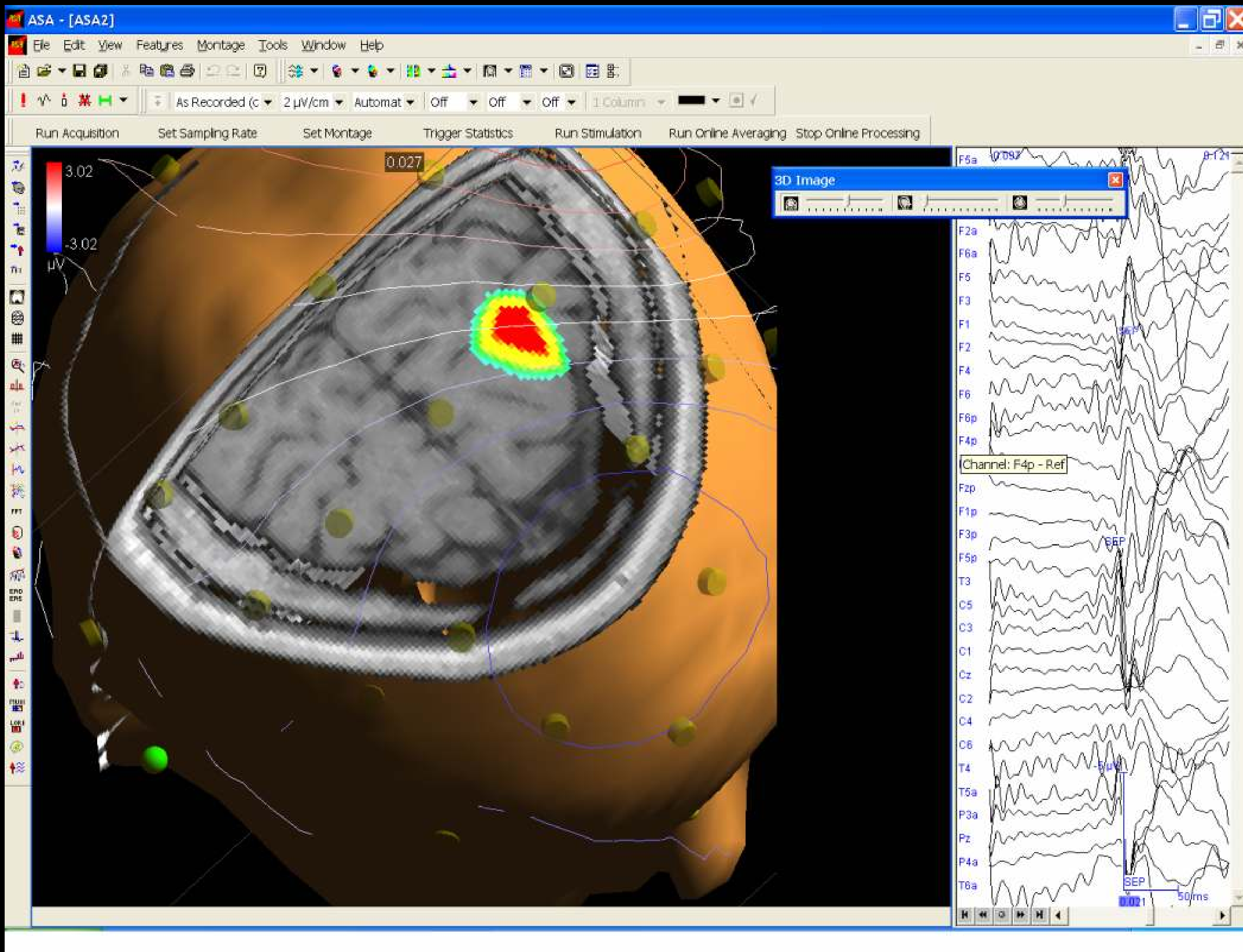
Cons

- Massive scanners
- Expensive professional equipment
- Slow, several seconds delay (low temporal resolution)

Non invasive fMRI



fMRI Software

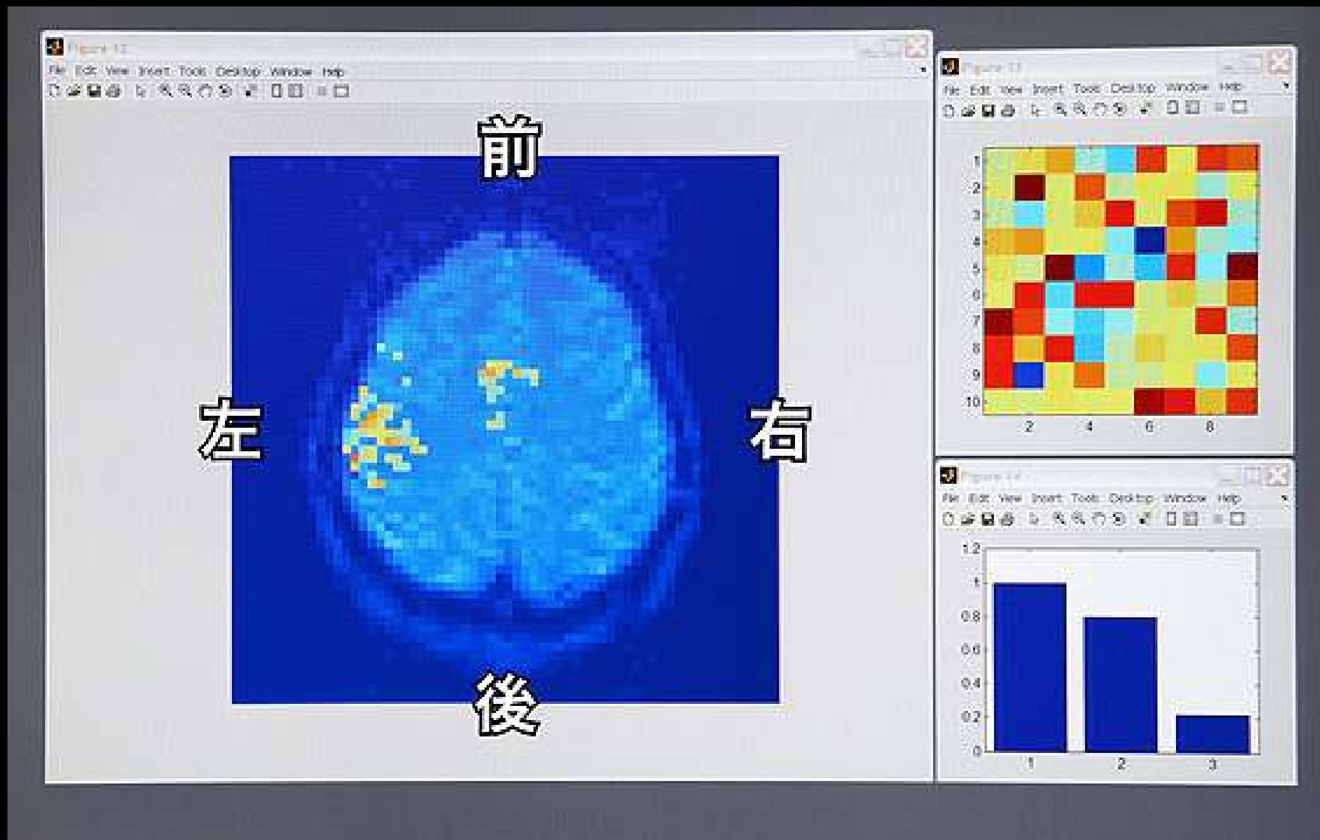


fMRI - BCI

ATR and Honda, interface for manipulating robots

The subject in an MRI scanner makes a finger gesture, paper, rock or scissors

Non invasive fMRI



Changes in his/her hemodynamic responses associated with brain activity are monitored every second. Specific signals generating paper-rock-scissors movements are extracted and decoded by a computer program

fMRI Robot control

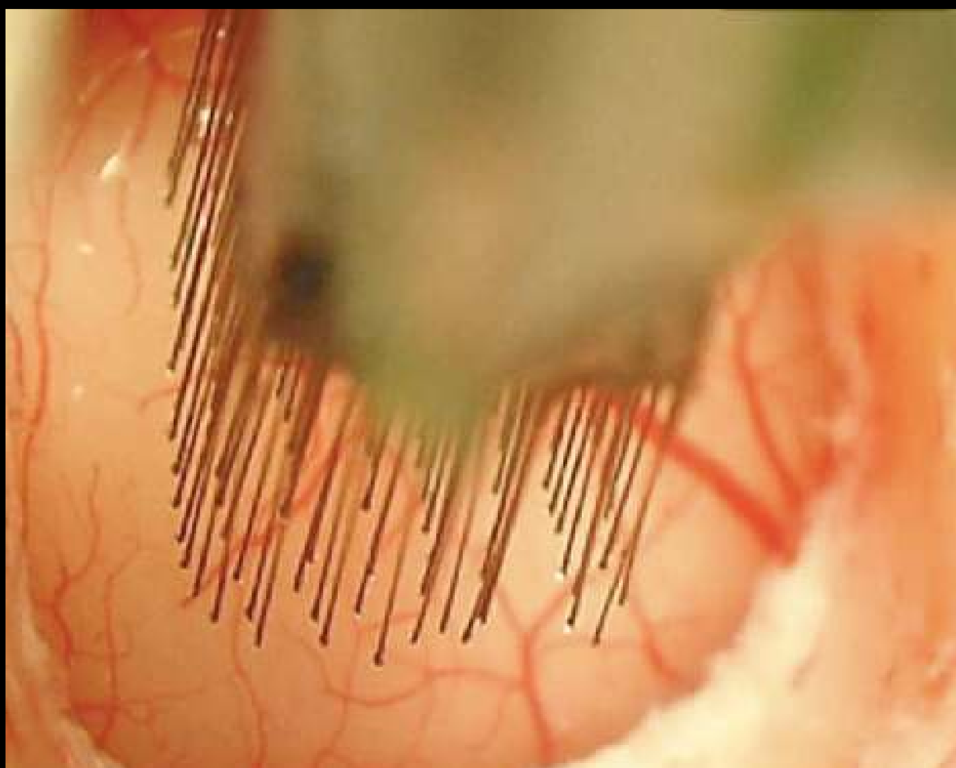
The decoded information is transferred to a hand-shaped robot to simulate the original movement performed by the subject.

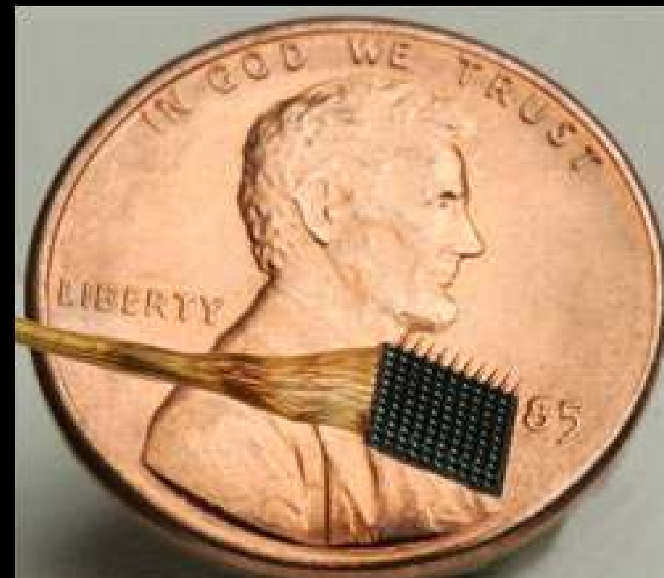
Invasive

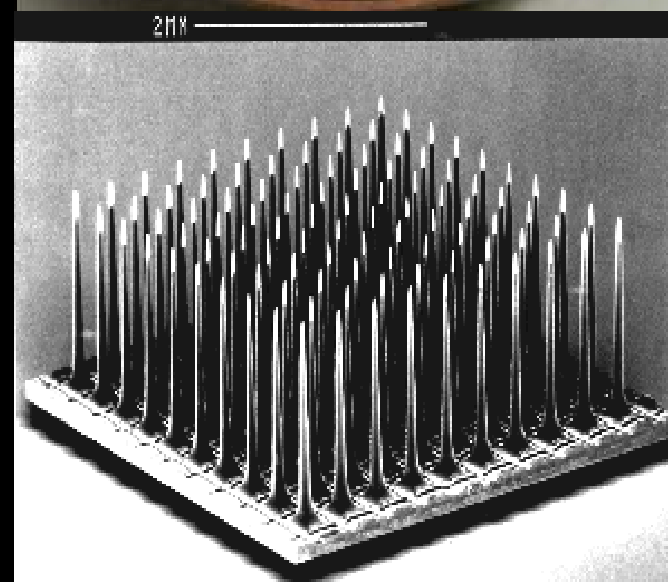
- They produce the highest quality signals but are prone to scar-tissue build-up, causing the signal to become weaker or even lost as the body reacts to a foreign object in the brain.
- The most widely used are neuroprosthetic device is the cochlear implant, which was implanted in approximately 100,000 people worldwide as of 2006

Invasive neural implants

- Neuro-engineering
- Neuroprosthetics







Decoding LGN

- In 1999, researchers led by Garrett Stanley at Harvard University decoded neuronal firings to reproduce images seen by cats.

- The researchers attached electrodes to 177 cells in the thalamus region of the cat's brain and monitored their activity.

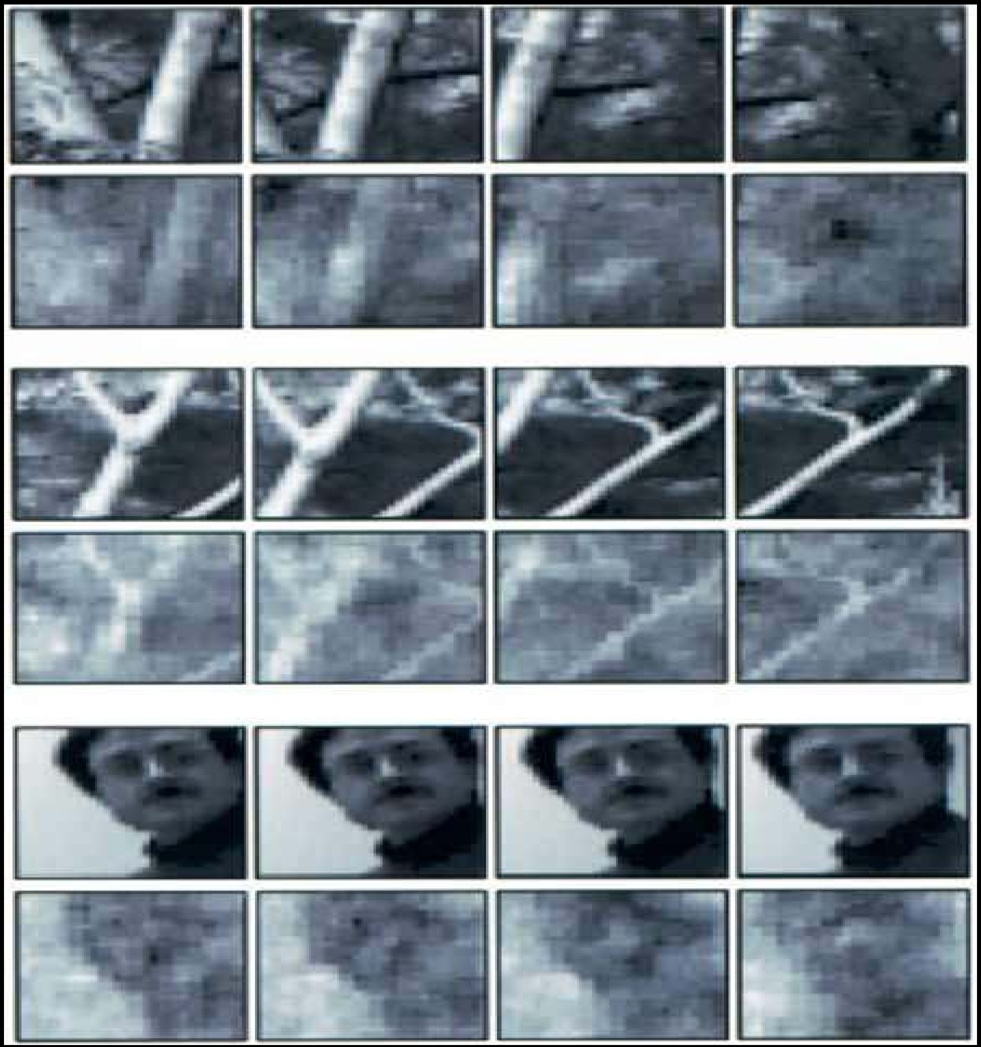
Decoding LGN

“The LGN in the thalamus is connected directly to the cat's eyes via the optic nerve.

Each of its cells is programmed to respond to certain features in the cat's field of view. Some cells "fire" when they record an edge in the cat's vision, others when they see lines at certain angles, etc. This way the cat's brain acquires the information it needs to reconstruct an image.

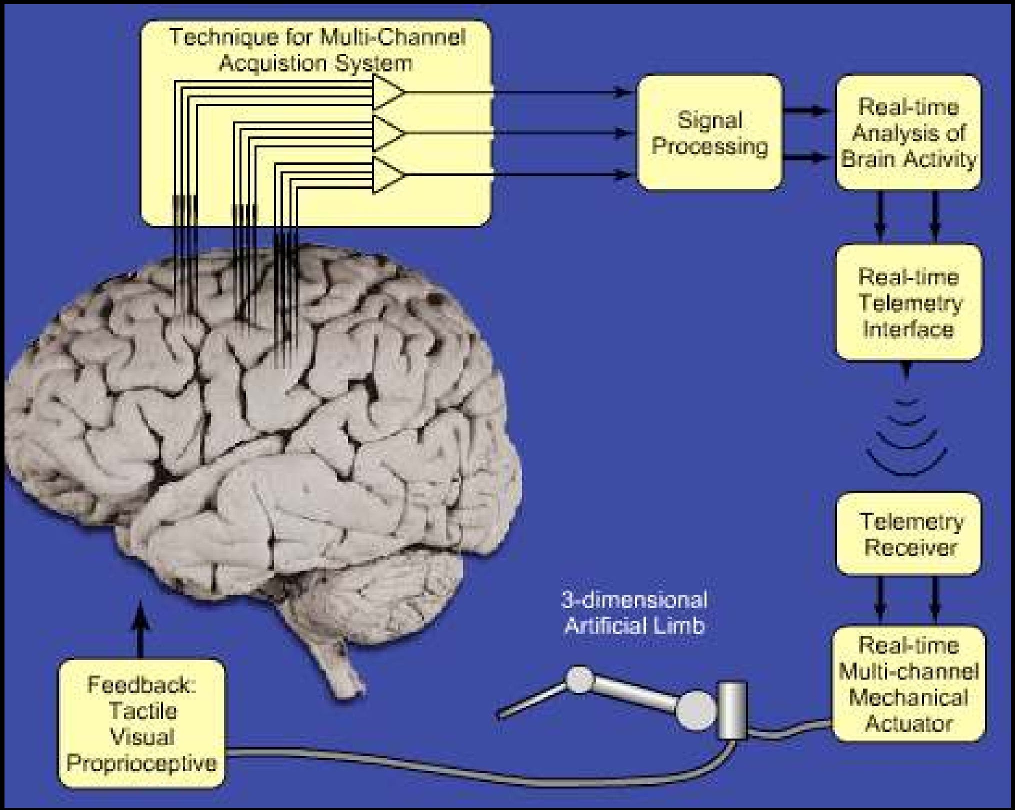
The scientists recorded the patterns of firing from the cells in a computer. They then used a technique they describe as a "linear decoding technique" to reconstruct an image.”

Decoding LGN



Owl monkey BCI

Miguel Nicolelis, Professor of Neurobiology, Biomedical Engineering and Psychological and Brain Sciences at Center for Neuro-engineering, Duke University Medical Center

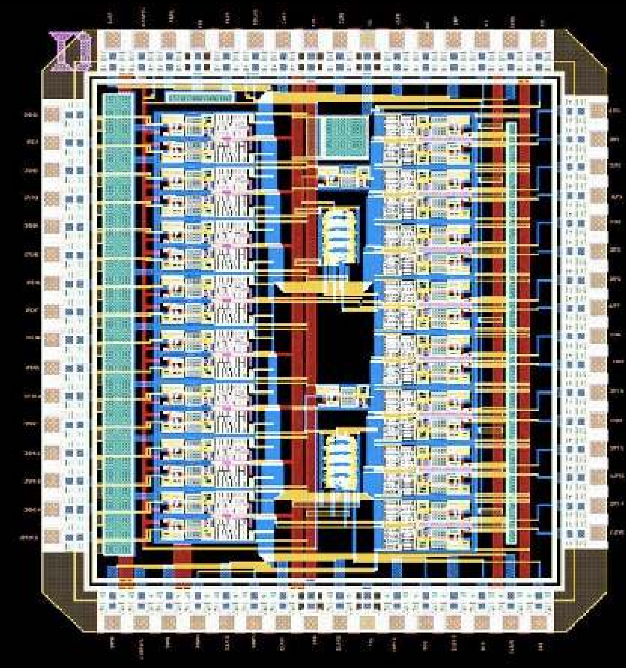


Decoded brain activity in owl monkeys and used the devices to reproduce monkey movements in robotic arms.

http://www.nicolelislab.net/NLnet_Load.html

Getting the data

- From implant chip to raw neural data



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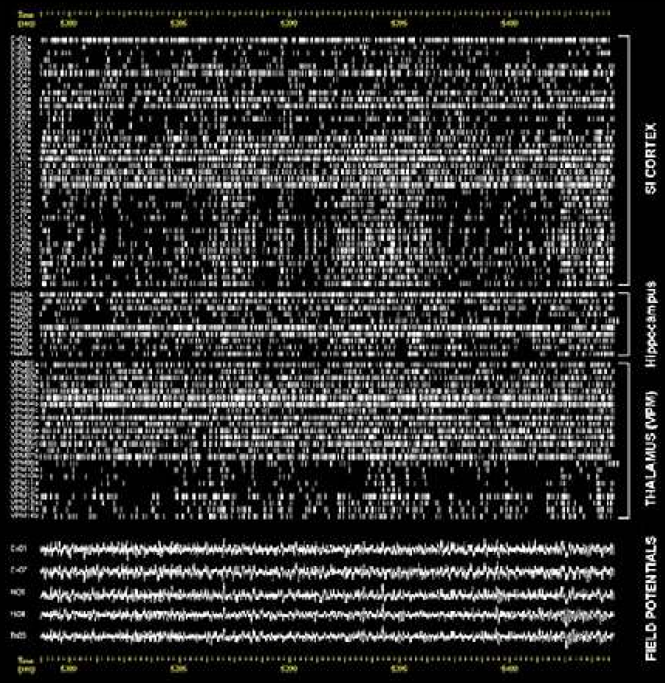

Owl monkey BCI

http://www.youtube.com/watch?v=7-cpcoIJbOU

http://www.nicolelislab.net/NLnet_Load.html