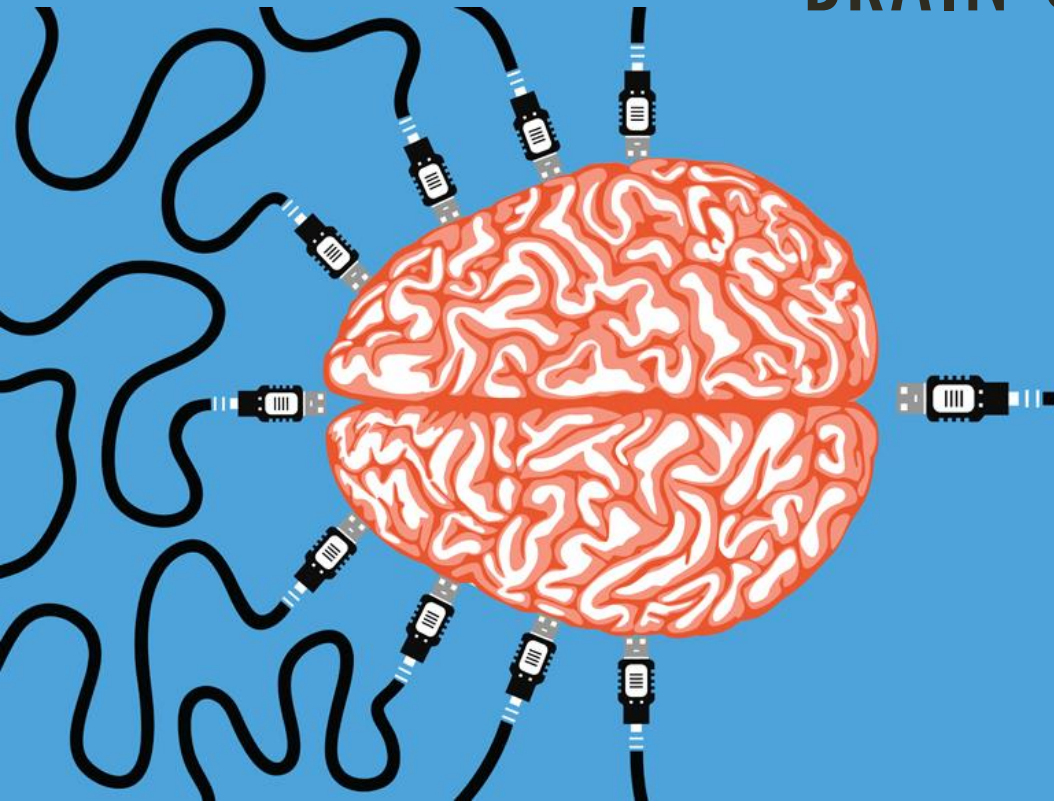
MAKE ME THINK

A BRIEF INTRODUCTION TO THE BRAIN-COMPUTER INTERFACES



Nikita Lukianets

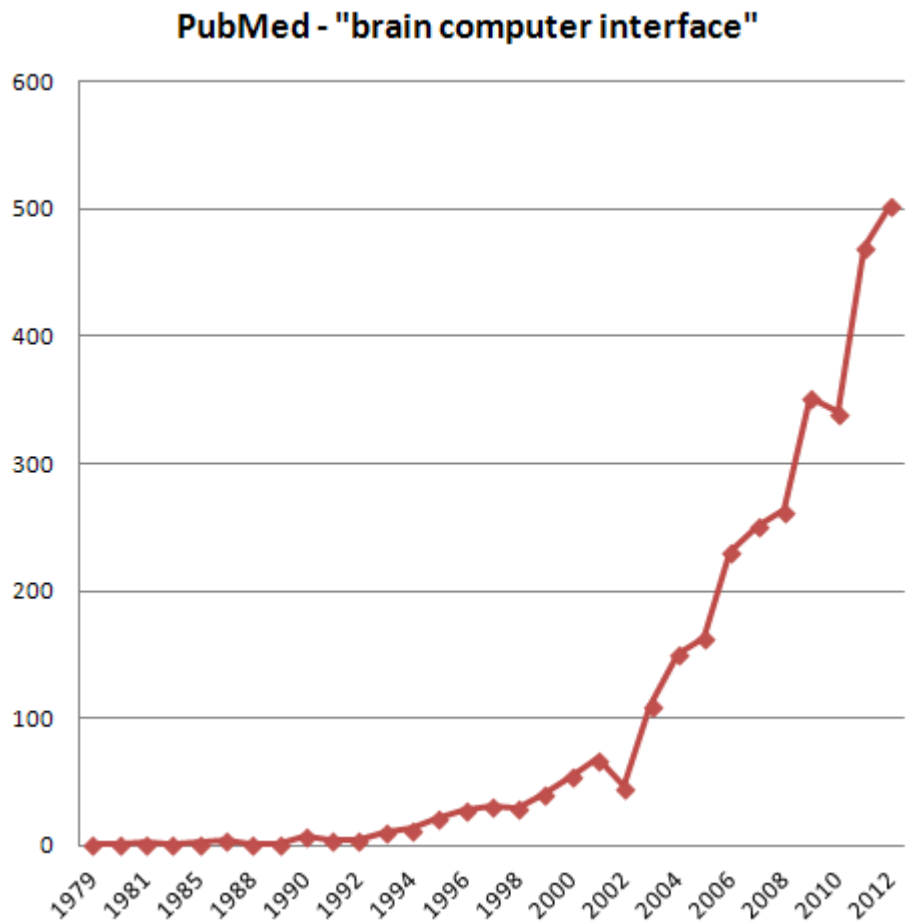
Neuroscience Researcher, SIGNALIFE

@nikiluk #BCI #WUD

WHAT IS THE BRAIN-COMPUTER INTERFACE?

"system that permits neuronal activity alone to communicate with an external device

A BIT OF FASHION: CONCEPT IS NOT NEW



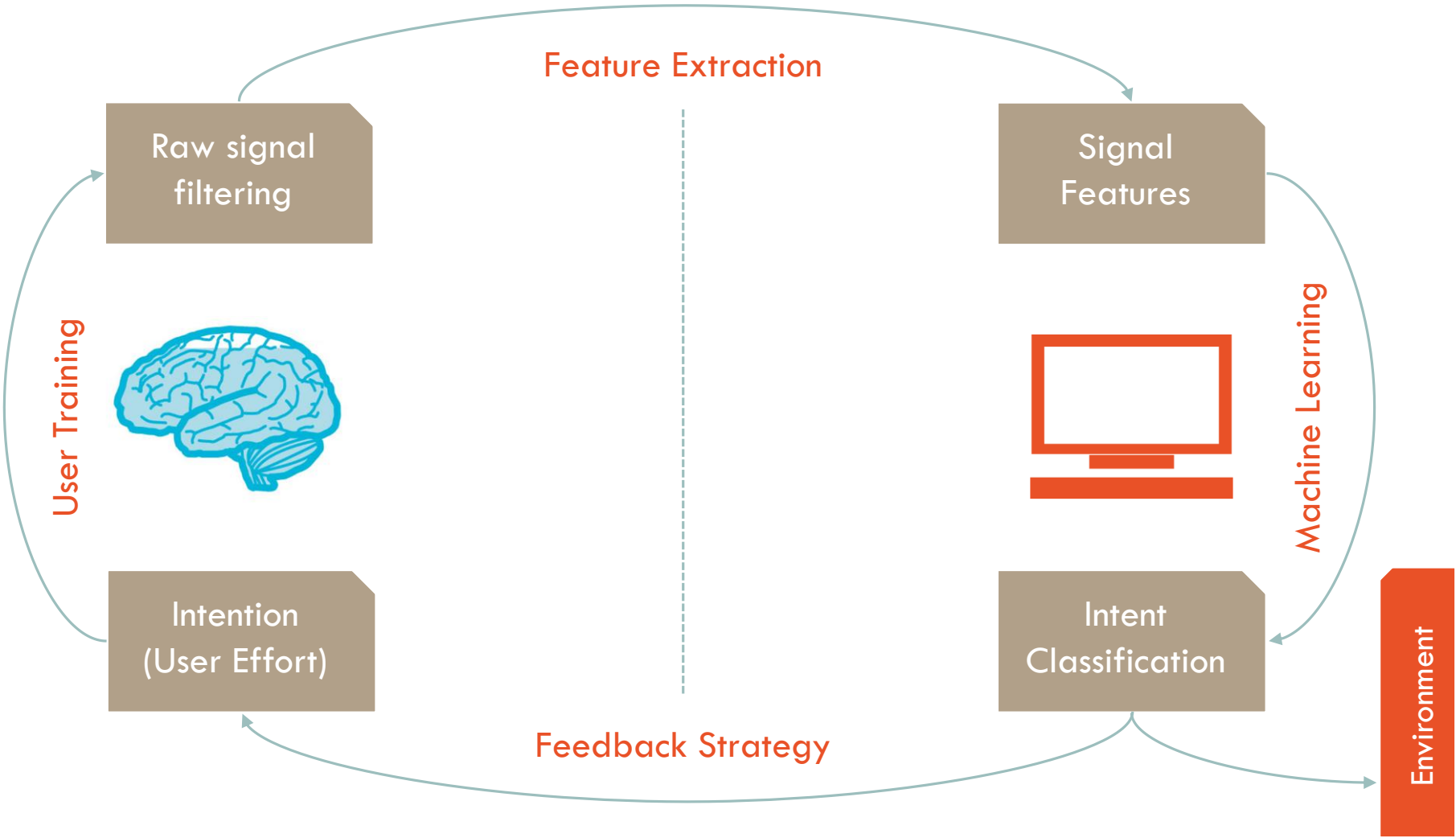
1929: Hans Berger discovers the EEG. Studies of brain diseases

1959: David H. Hubel and Torsten Wiesel. Single neuron recordings to map the visual cortex

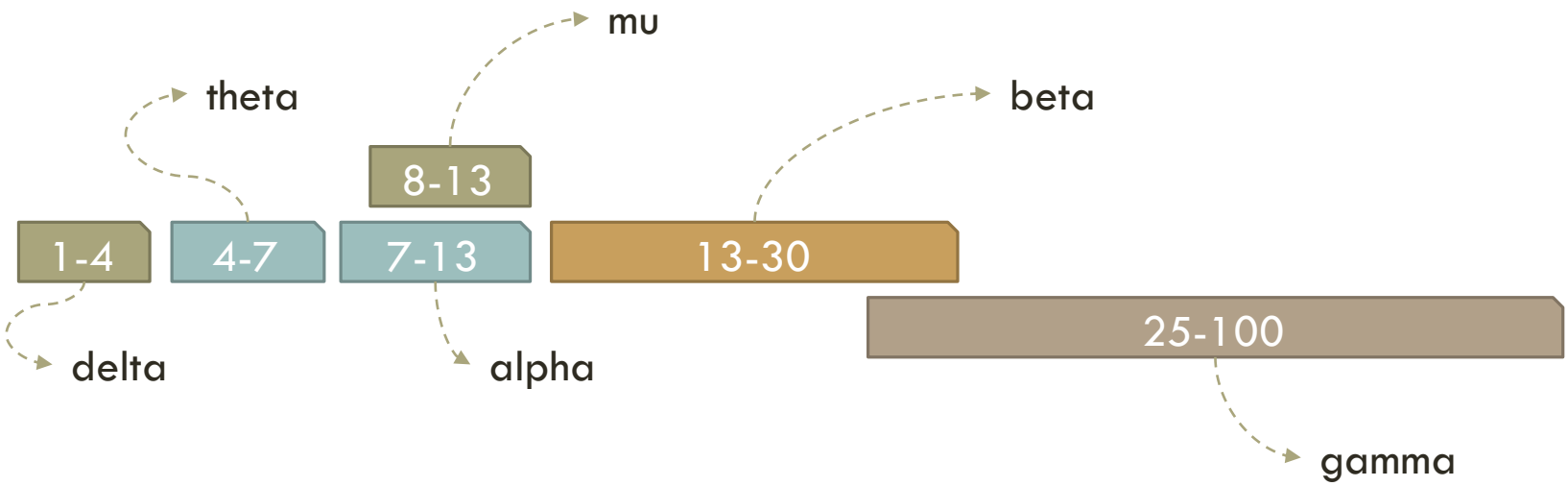
1967: The first record by multi-electrode arrays.

1998: Kennedy and Bakay, control of a cursor.

BCI LOGICAL SCHEME



FREQUENCIES

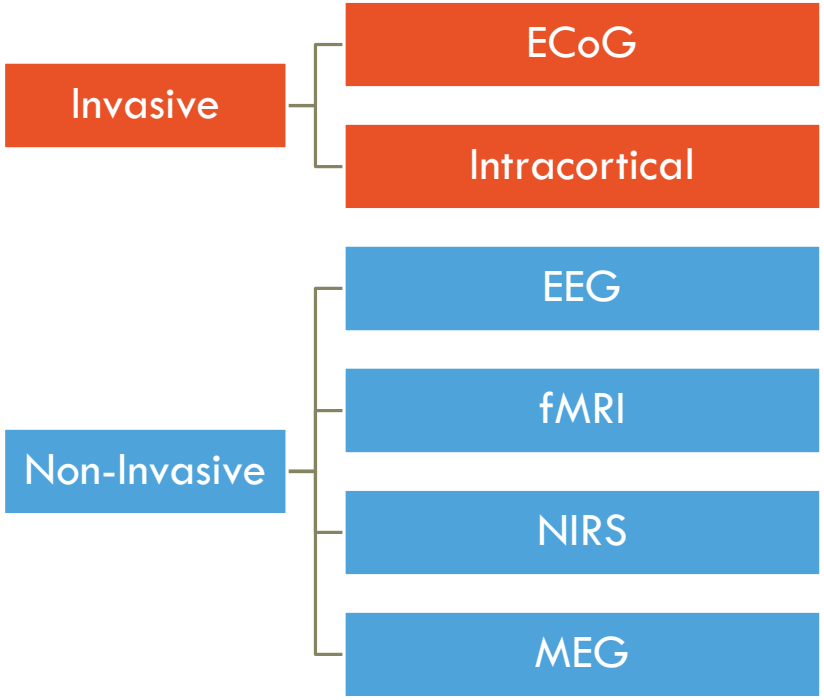


Oscillatory activity is observed throughout the central nervous system at all levels of organization. Three different levels have been widely recognized: the micro-scale (activity of a single neuron), the meso-scale (activity of a local group of neurons) and the macro-scale (activity of different brain regions)

NEUROIMAGING

How can we record from the brain?

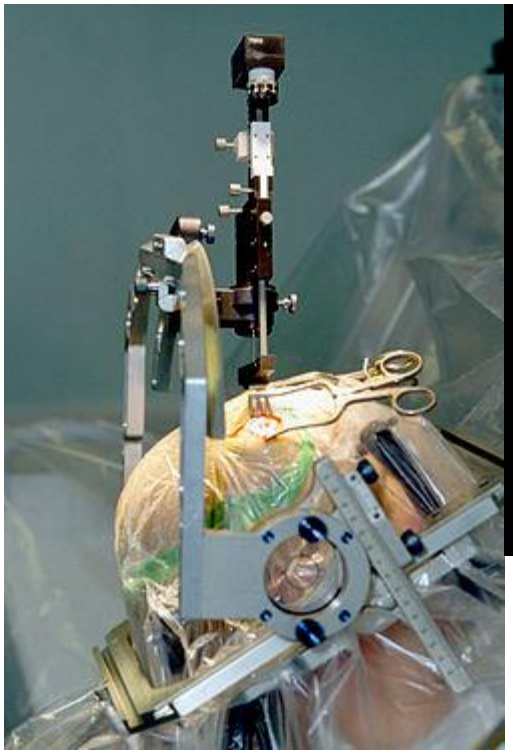
BCI CLASSIFICATION BY NEUROIMAGING

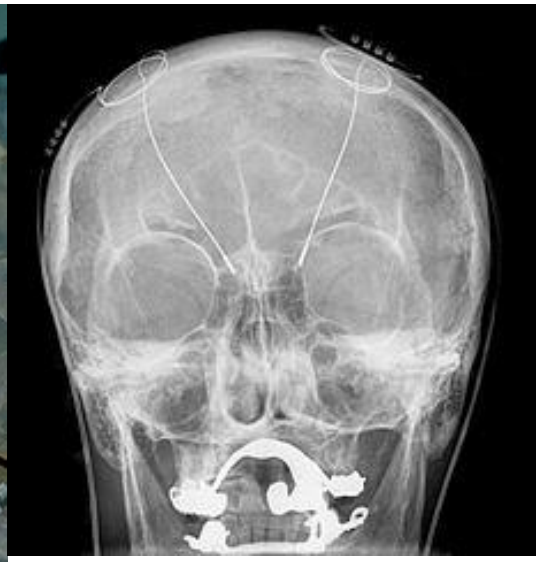


DEEP BRAIN STIMULATION/RECORDING

Stimulation/recording using microelectrodes/Microarrays

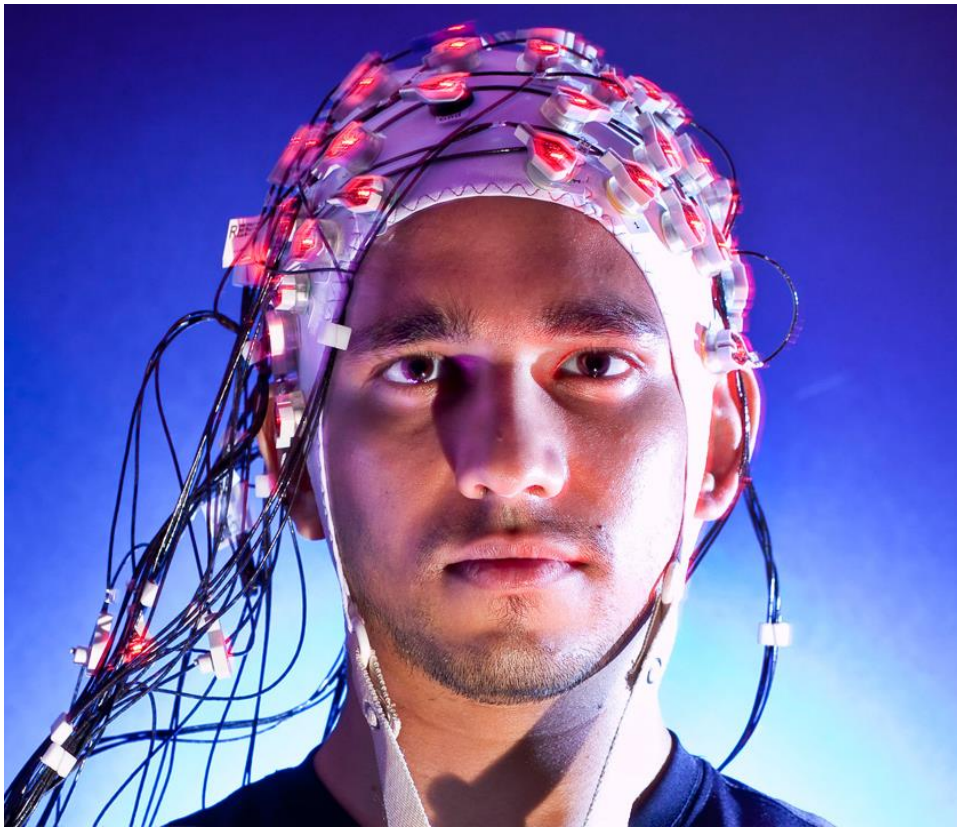
- Parkinson
- Severe depression
- Tourette Syndrome
- Chronic pain





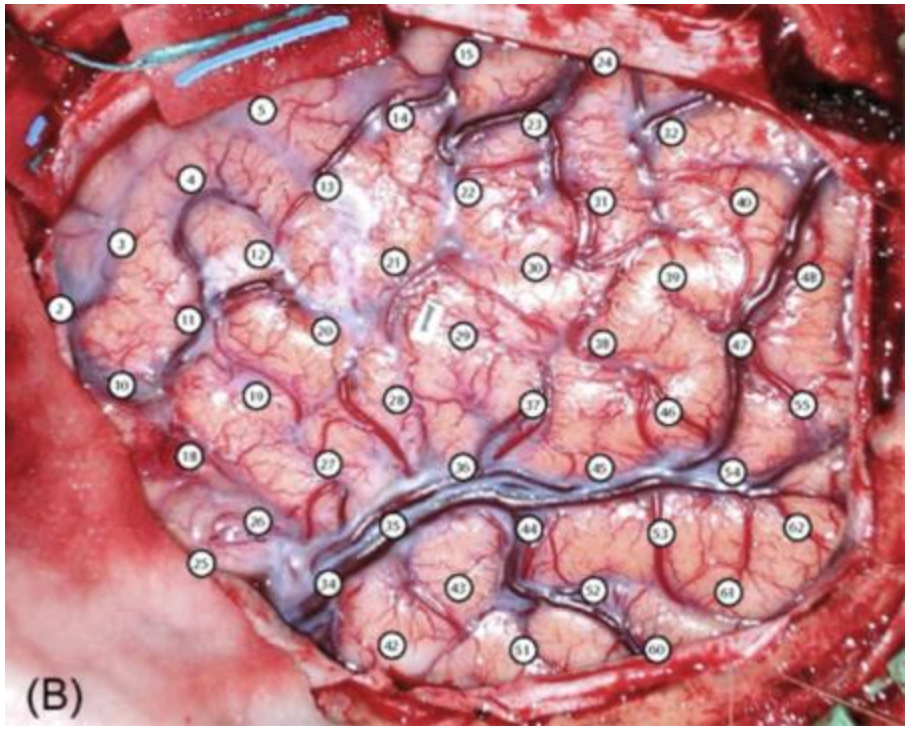
EEG

Recording of electrical activity along the scalp. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain



ECOG

Electrocorticography (ECoG), or intracranial EEG (iEEG), is the practice of using electrodes placed directly on the exposed surface of the brain to record electrical activity from the cerebral cortex. ECoG may be performed either in the operating room during surgery (intraoperative ECoG) or outside of surgery (extraoperative ECoG)



FMRI

Detecting associated changes in blood flow

- Non-Invasive
- High precision
- Robust, expensive
- Non-portable

MEG

The spatial distributions of the magnetic fields are analyzed to localize the sources of the activity within the brain

NIRS

fNIR is a non-invasive imaging method involving the quantification of chromophore. NIR spectrum light takes advantage of the optical window in which skin, tissue, and bone are mostly transparent to NIR light in the spectrum of 700-900 nm, while hemoglobin (Hb) and deoxygenated-hemoglobin (deoxy-Hb) are stronger absorbers of light.

BCI NEUROIMAGING COMPARISON

Neuroimaging method	Activity measured	Direct/ Indirect Measurement	Temporal resolution	Spatial resolution	Risk	Portability
EEG	Electrical	Direct	~0.05 s	~10 mm	Non-invasive	Portable
MEG	Magnetic	Direct	~0.05 s	~5 mm	Non-invasive	Non-portable
ECoG	Electrical	Direct	~0.003 s	~1 mm	Invasive	Portable
Intracortical neuron recording	Electrical	Direct	~0.003 s	~0.5 mm (LFP) ~0.1 mm (MUA) ~0.05 mm (SUA)	Invasive	Portable
fMRI	Metabolic	Indirect	~1 s	~1 mm	Non-invasive	Non-portable
NIRS	Metabolic	Indirect	~1 s	~5 mm	Non-invasive	Portable

//Luis Fernando Nicolas-Alonso, Brain Computer Interfaces, a Review, Sensors 2012

REGISTRATION POSSIBILITIES

Non-invasive 0-60 Hz

Invasive 0-10 000 Hz

CONTROL SIGNALS

What are Control signal types in BCI?

COMPARISON

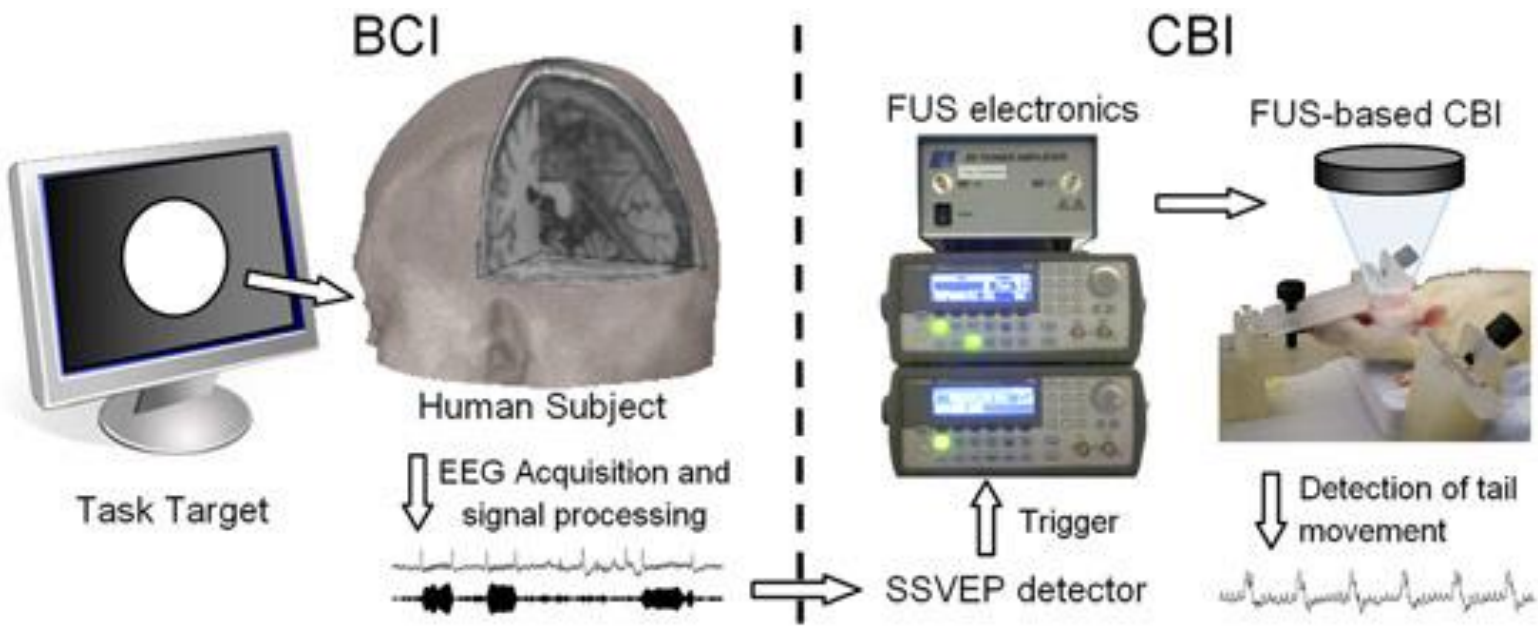
Signal	Physiological phenomena	Number of choices	Training	Information transfer rate
VEP	Brain signal modulations in the visual cortex	High	No	60–100 bits/min
SCP	Slow voltages shift in the brain signals	Low (2 or 4, very difficult)	Yes	5–12 bits/min
P300	Positive peaks due to infrequent stimulus	High	No	20–25 bits/min
Sensorimotor rhythms	Modulations in sensorimotor rhythms synchronized to motor activities	Low (2, 3, 4, 5)	Yes	3–35 bits/min

STEADY STATE VISUALLY EVOKED POTENTIALS

Based on “resonance” effect

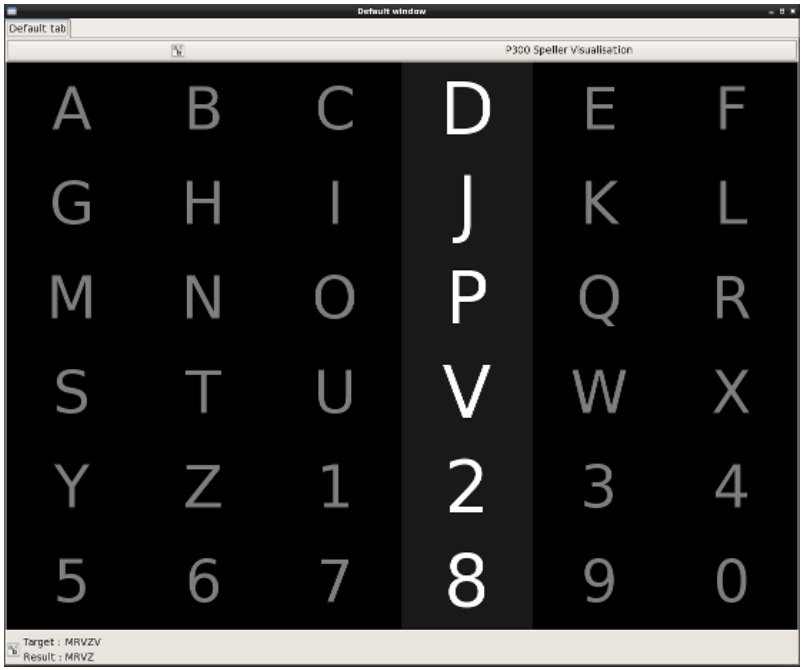
SSVP + Transcranial focused ultrasound (FUS, TMS)

http:// www.youtube.com/watch?v=VaJjHgyHnEc



EVENT-RELATED POTENTIALS (P300/N400)

When recorded by electroencephalography (EEG), it surfaces as a positive deflection in voltage with a latency ~300ms.



NEUROFEEDBACK

What Modalities could be used for Feedback?

NEUROFEEDBACK

- Appropriate feedback strategy should depend on the control signal
- Incapable users may particularly benefit from positively-biased feedback
- Intracortical stimulation/Optogenetics/FUS/TMS/Visual and Auditory

fMRI
20 mins

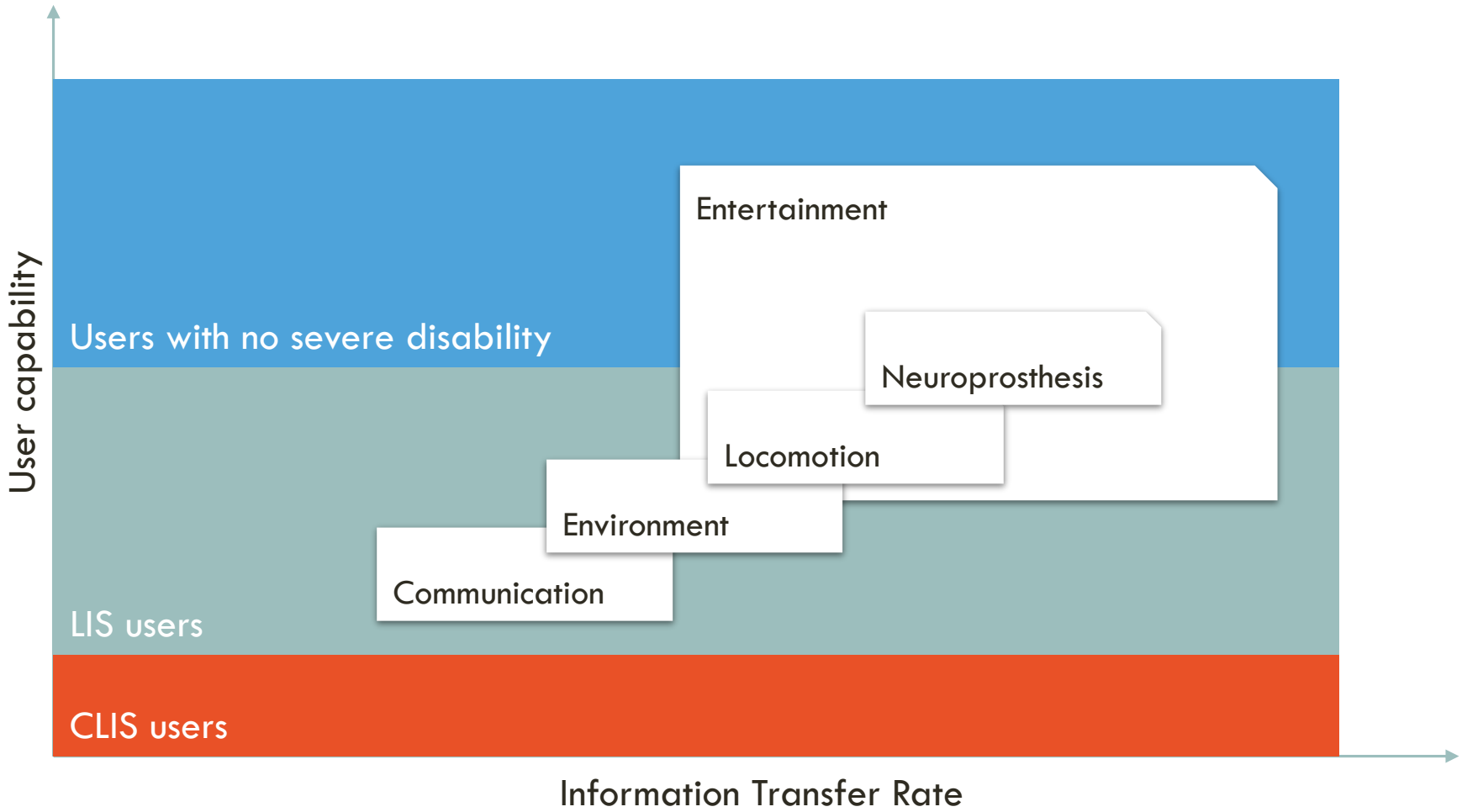
>

EEG
30 hours

APPLICATIONS

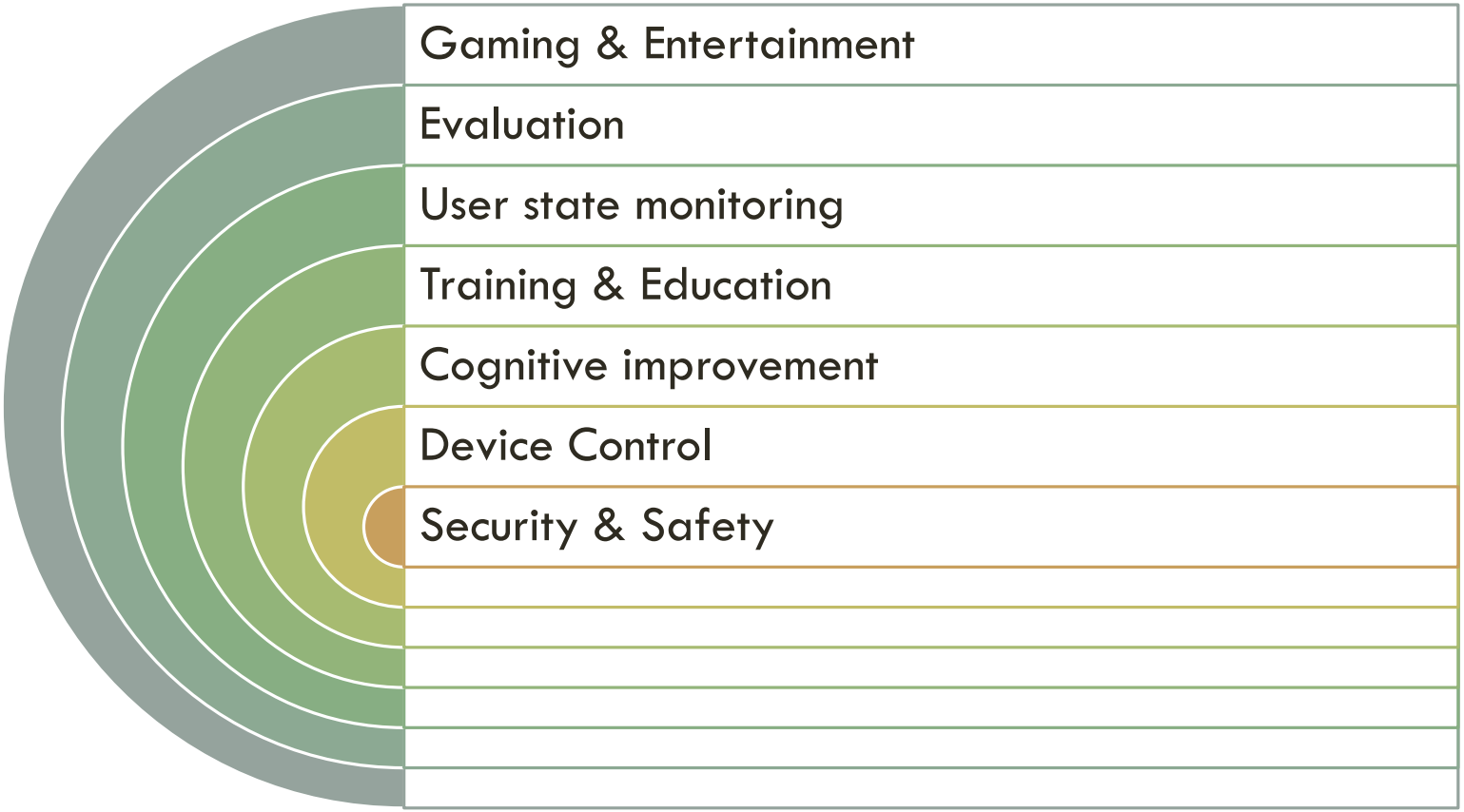
What are the applications of BCI?

APPLICATIONS



//Luis Fernando Nicolas-Alonso, Brain Computer Interfaces, a Review, Sensors 2012

BEYOND MEDICAL APPLICATIONS



CONSUMER APPS

What is available on the market today?

NECOMIMI

Electrodos: 1

1 mental state

July 2012

Neuroware

MINDWAVE MOBILE

Electrodos: 1

2 mental states (based on 4 brainwaves), eyeblinks

21 March 2011

Neurosky

.NET,Android,iPhone,Arduino

MINDSET

Electrodos: 1

2 mental states (based on 4 brainwaves), eyeblinks

1 December 2011

Neurosky

MINDBALL

Electrodos: 1

1 mental state

21 December 2009

Mattel (Neurosky partner)

STAR WARS FORCE TRAINER

Electrodos: 1

1 mental state

21 June 2009

Uncle Milton (Neurosky partner)

XWAVE SPORT

Electrodos:1

8 EEG bands

5 January 2011

XWave

MYNDPLAY

Electrodos:1

8 EEG bands

1 December 2011

MyndPlay

NEURAL IMPULSE ACTUATOR

Electrodos:3

2 brainwaves (Alpha & Beta), facial muscle and eye movements

May 2008

OCZ Technology

Python

EMOTIV EPOC

Electrodos:14

4 mental states (based on brainwaves), 13 conscious thoughts, facial expressions, head movements (sensed by 2 gyros)

21 December 2009

Emotiv Systems

C#, C++, Java, Matlab, Python

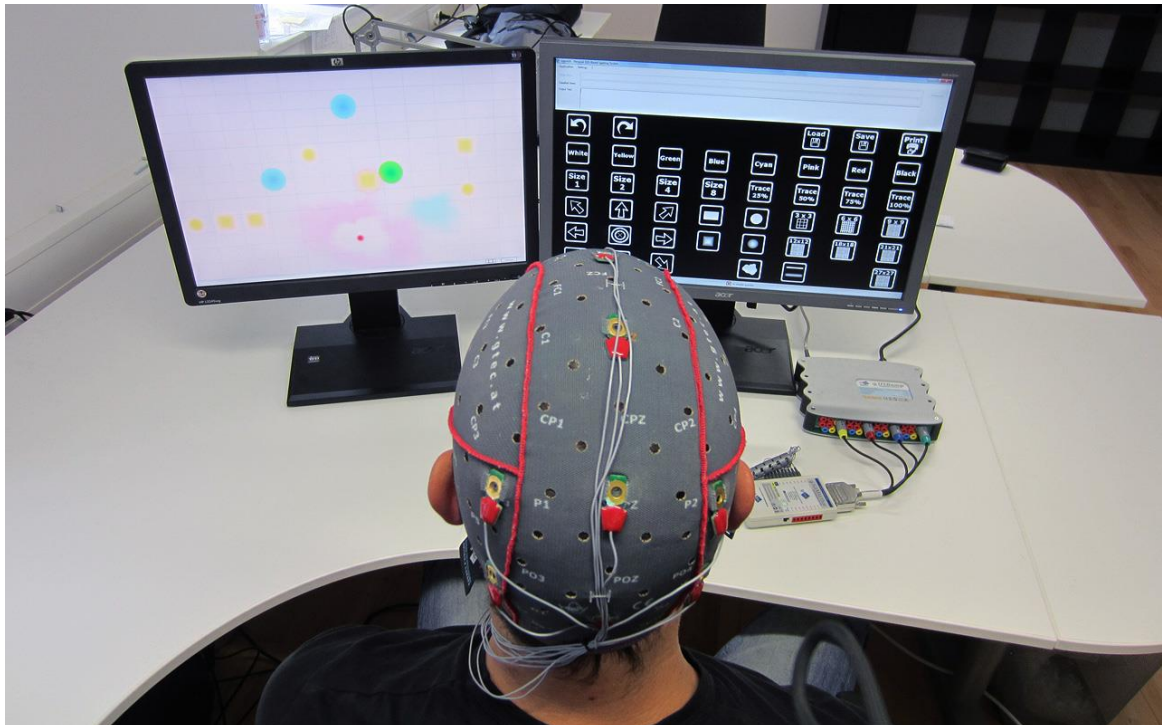
INTENDIX

Electrodos: 64

It can detect different brain signals with an accuracy of 99%

March 2012

G.TEC



OPENEEG

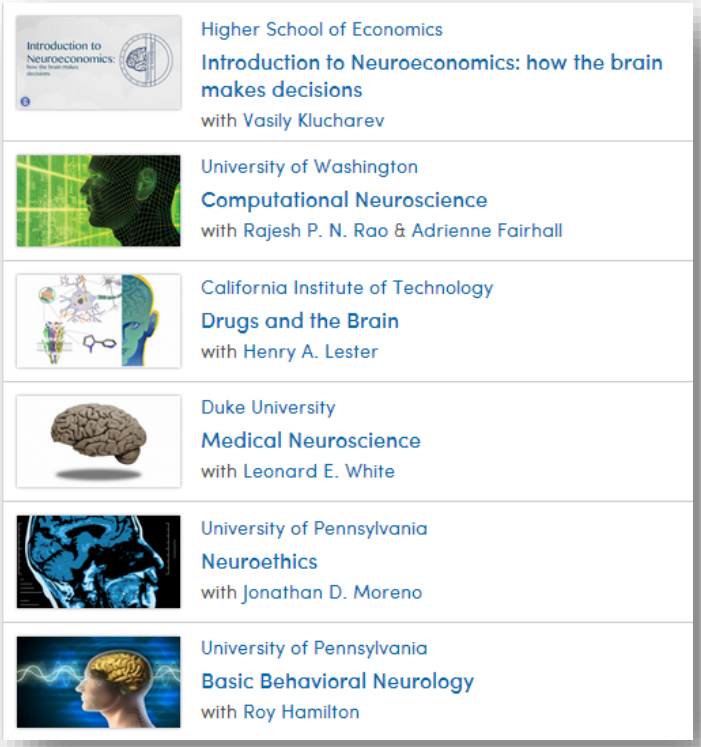
OpenEEG project is about making plans and software for do-it-yourself EEG devices available for free (as in GPL)

OPENVIBE

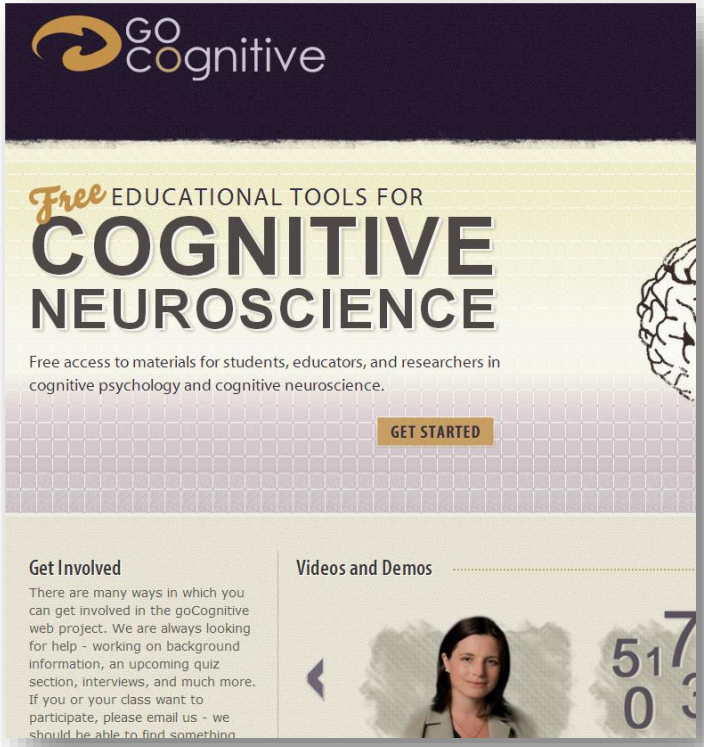
OpenViBE is a Open Source oftware platform dedicated to designing, testing and using brain-computer interfaces

TO LEARN MORE

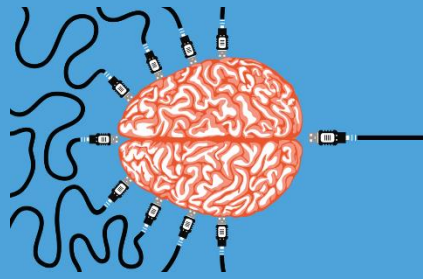
1) http://www.coursera.org



2) http://www.gocognitive.net/



THANK YOU!



Nikita Lukianets

http://linkedin.com/in/nikiluk