



THE
DEVELOPER'S
CONFERENCE

Inteligência Artificial – Lendo mentes com Inteligência Artificial e EEG

Vitor Casadei

Mestre em Ciência da Computação



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CESAR**

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CESAR

C . e . S . A . R

centro de estudos e sistemas
avançados do Recife

gente

negócios

tecnologia

Para nós, inovação sustentável acontece na intersecção das dimensões gente, negócios e tecnologia



C E S A R

Presença NACIONAL

MATRIZ

Recife – PE

ESCRITÓRIO COMERCIAL

São Paulo – SP

REGIONAIS

Curitiba – PR

Sorocaba – SP

Manaus – AM

OUTRAS ATUAÇÕES

Rio de Janeiro - RJ



PILARES DE ATUAÇÃO

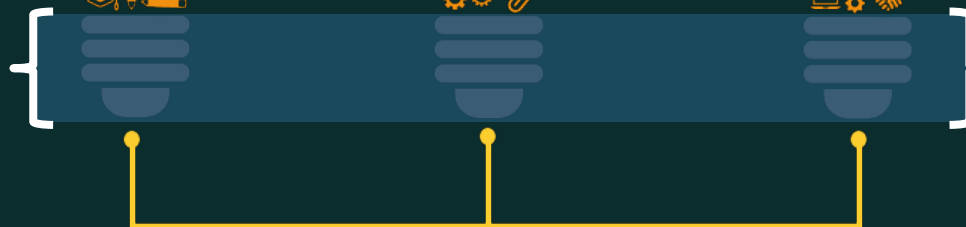
Educação



Design e
Engenharia



Empreendedorismo



Consultorias



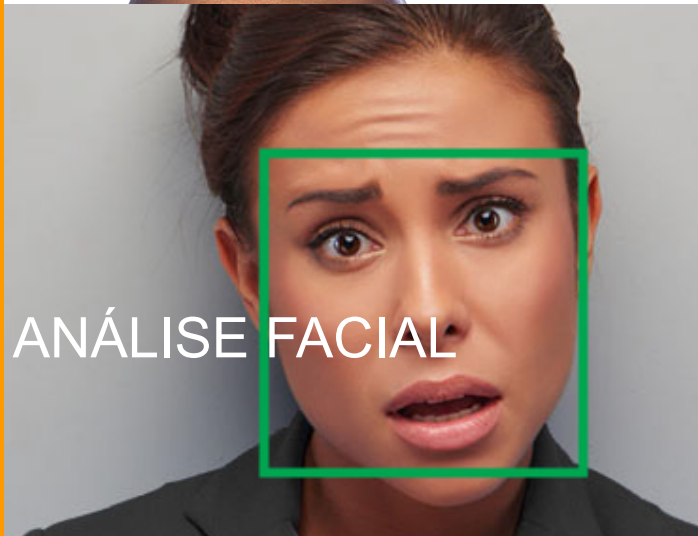
E se pudéssemos
descobrir e
mensurar emoções
e as reações das
pessoas?

UX 2.0

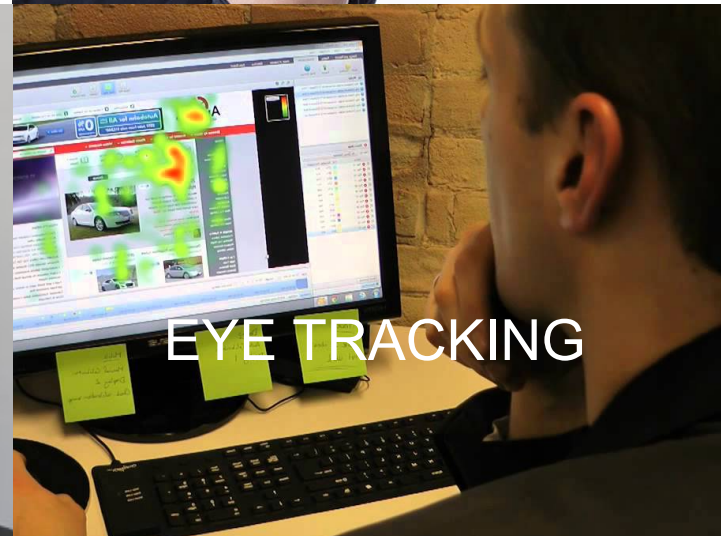
Laboratório de
Emoções



Análise de Emoções



ANÁLISE FACIAL



EYE TRACKING

O que é EEG?



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- Eletroencefalografia (EEG)
- Captura de sinais elétricos de diferenças potenciais na ordem de μV
- Usado comumente para:
 - Padrões de sono
 - Epilepsia
 - Déficit de atenção e hiperatividade (ADHD)
 - Grau de anestesia
- Métricas usadas para estudo do cérebro:
 - Fati ga corporal e mental
 - Emoções
 - Humor
 - BCI - Brain Computer Interface

Desafios de se trabalhar com EEG?



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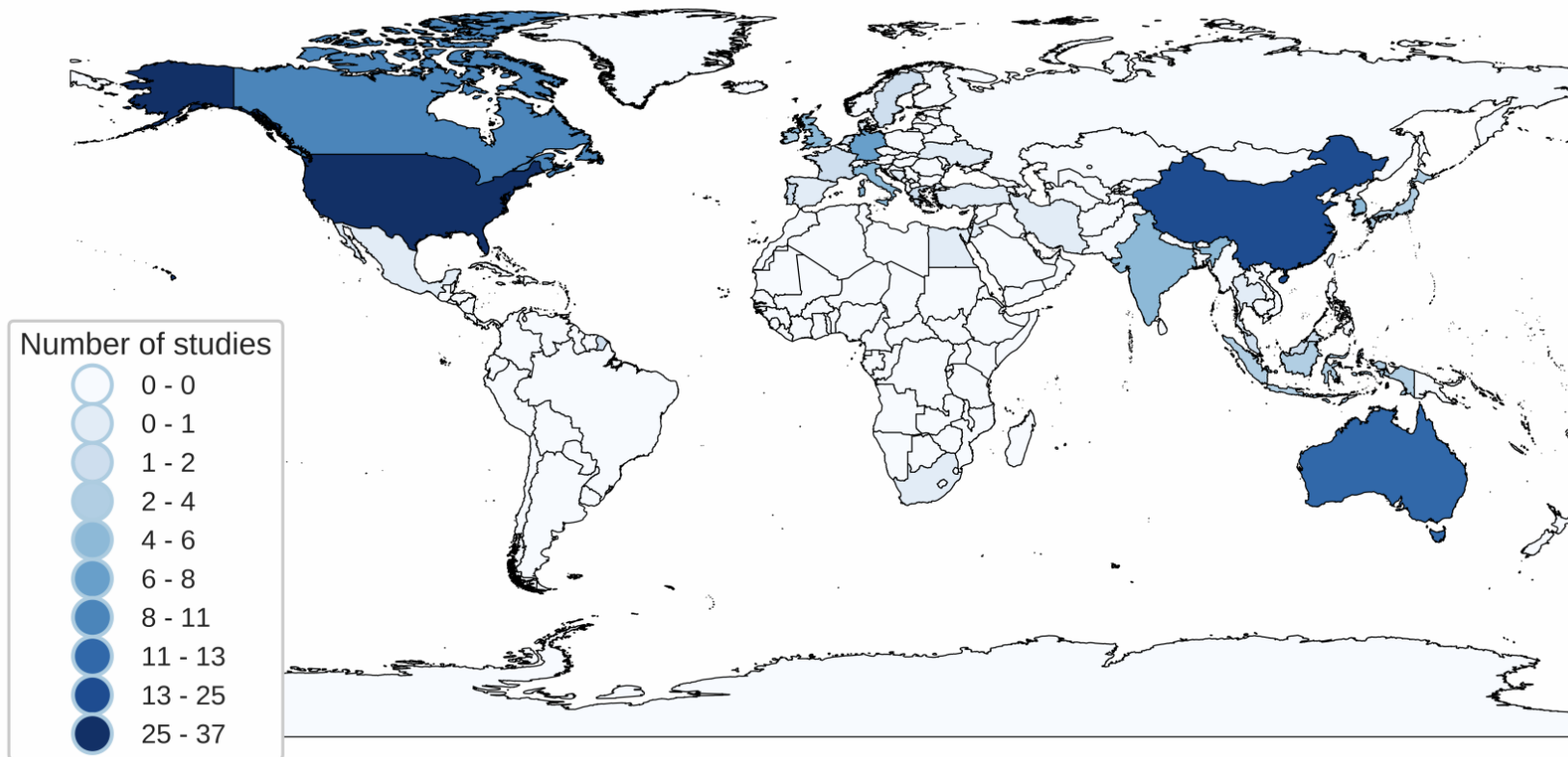
- Muito suscetível a ruídos nos dados
 - Várias técnicas de filtros e redução de ruídos
- Alta diferença de dados entre pessoas
 - A amplitude dos sinais de onda depende muito das experiências de cada grupo de pessoas
 - E também de como o cérebro foi formado
 - Muitas dúvidas ainda nesse assunto
- Sinais de EEG não são estacionários, ou seja, muda constantemente e possui alta chance de interferência de outros pensamentos/atividades/processos

Literatura sobre EEG

<https://arxiv.org/abs/1901.05498v2>



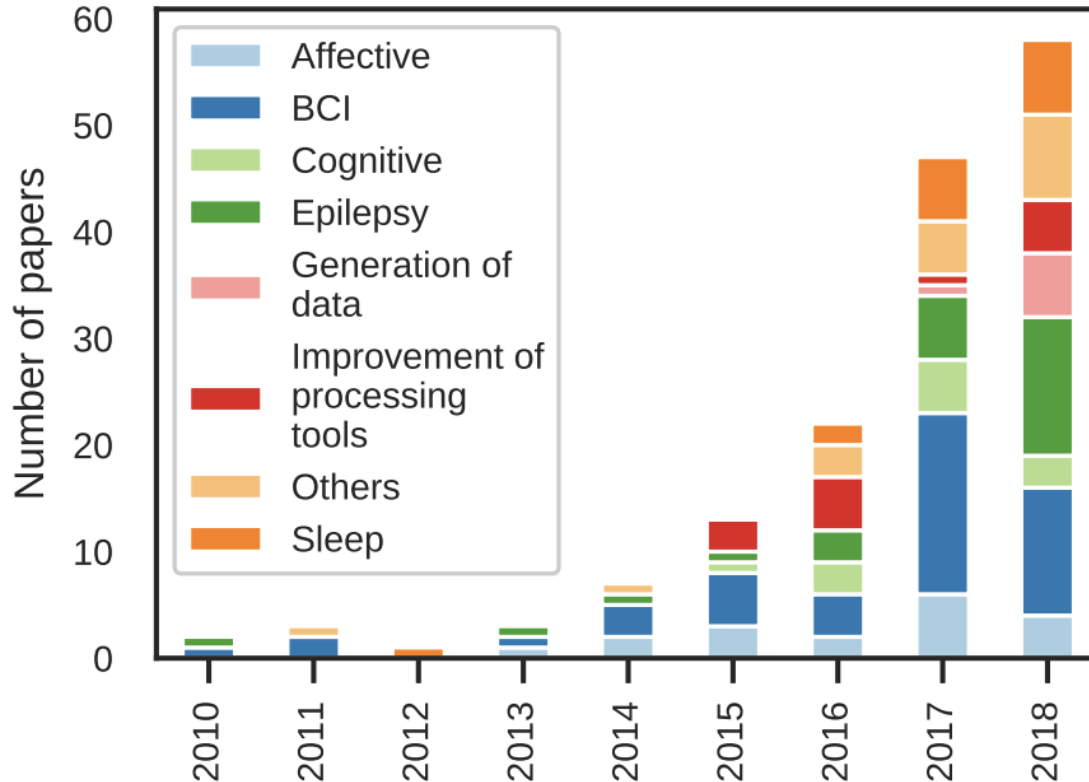
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Literatura sobre EEG



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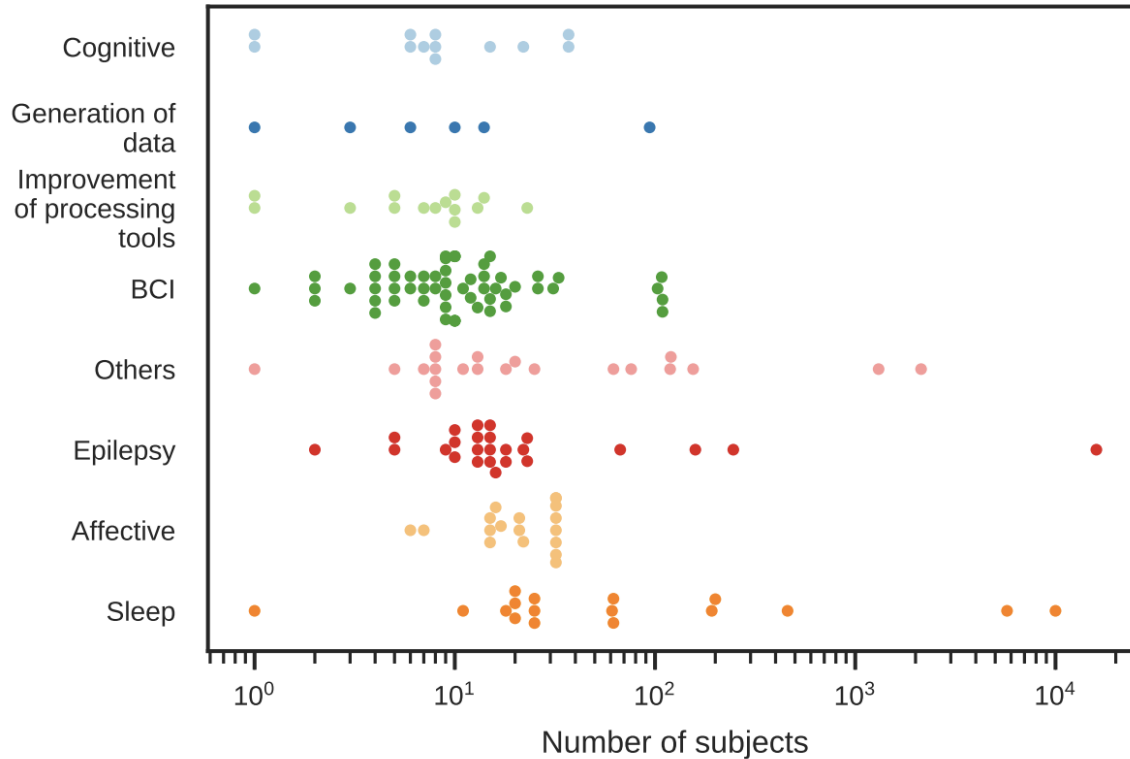


<https://arxiv.org/abs/1901.05498v2>

Literatura sobre EEG



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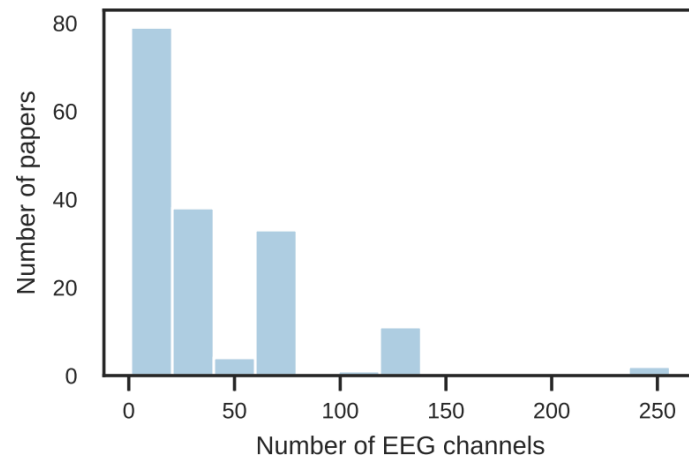
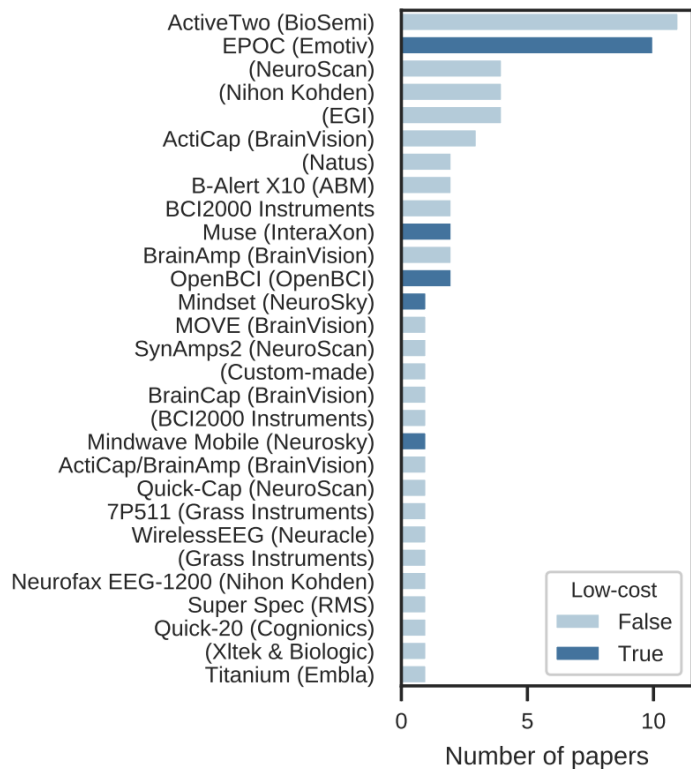


Literatura sobre EEG



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<https://arxiv.org/abs/1901.05498v2>

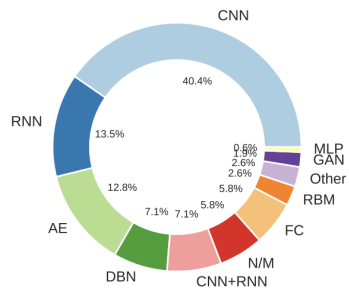


(b) Distribution of the number of EEG channels.

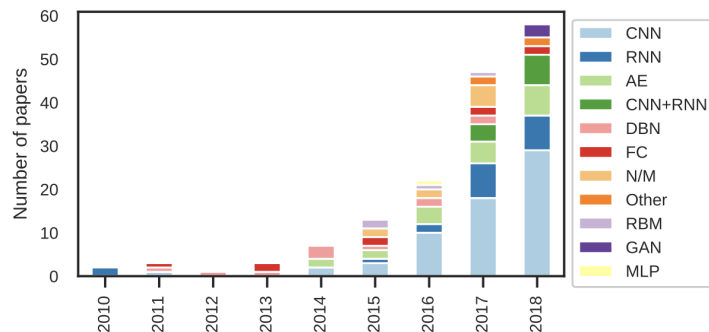
Literatura sobre EEG



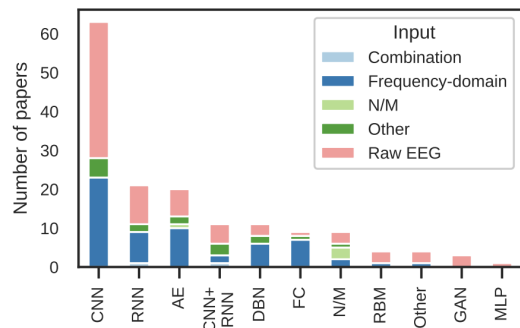
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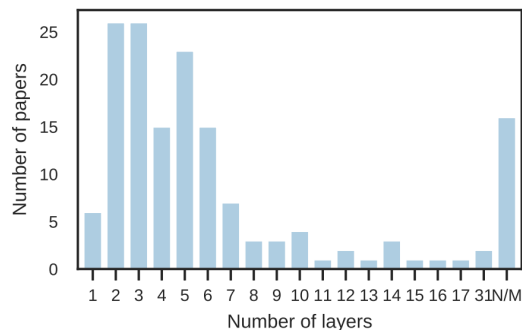
(a) Architectures.



(b) Distribution of architectures across years.



(c) Distribution of input type according to the architecture category.

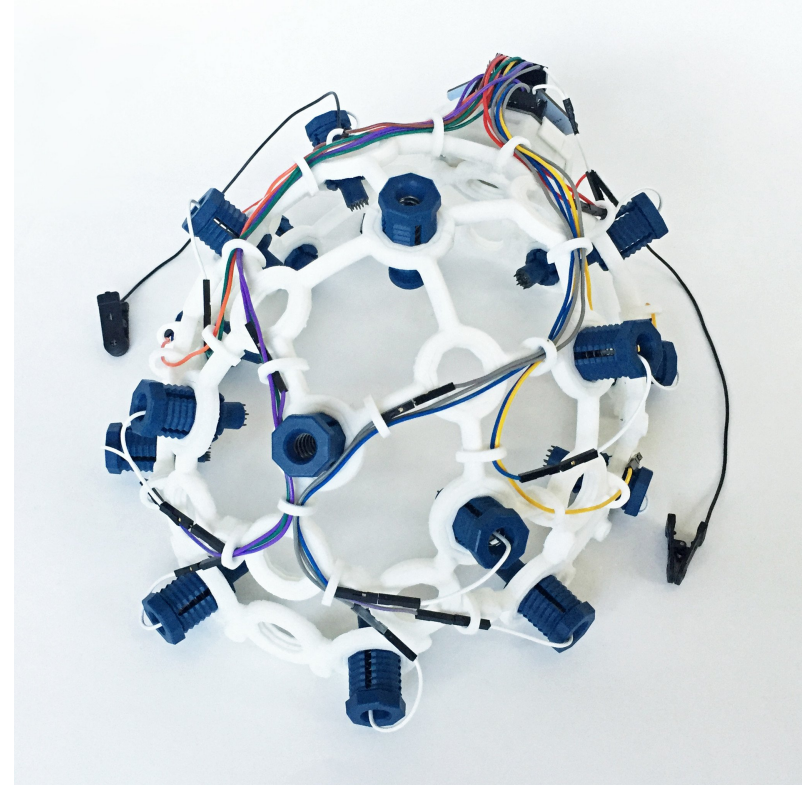


(d) Distribution of number of neural network layers.

Equipamentos - OpenBCI



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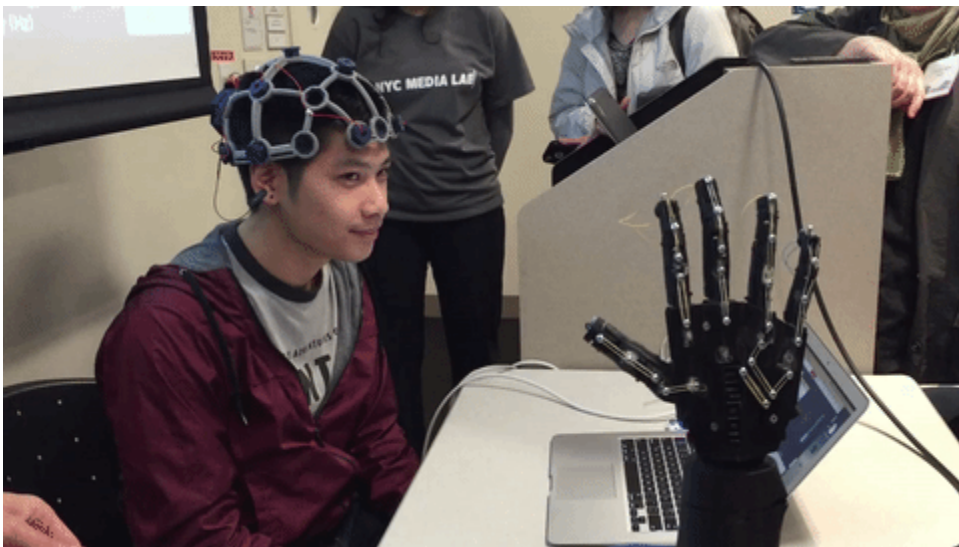


Ultracortex "Mark IV" EEG Headset -
<https://bit.ly/2lZZfZ2> (\$599,99 - \$999,99)

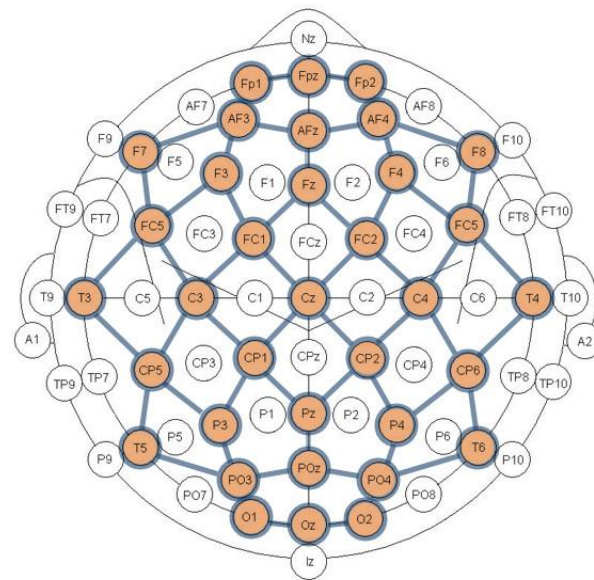
Equipamentos - OpenBCI



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Ultracortex Mark IV Node Locations (35 total)



Based on the internationally accepted **10-20 System**
for electrode placement in the context of EEG research

Equipamentos - Emotiv



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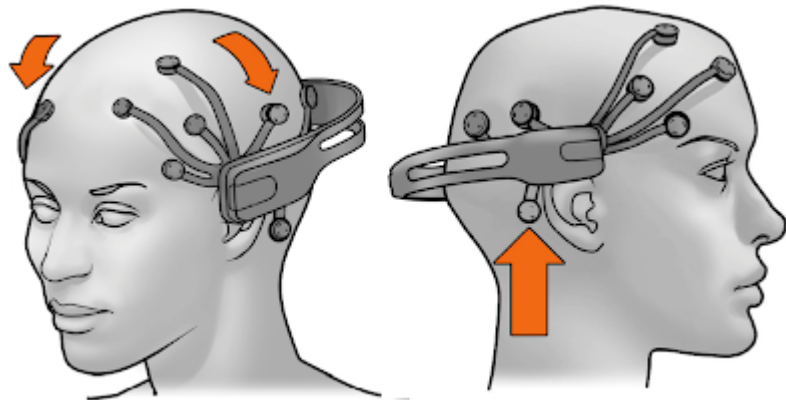


Emotiv EPOC+ - <https://bit.ly/2ln8rYg>
\$799,99

Equipamentos - Emotiv



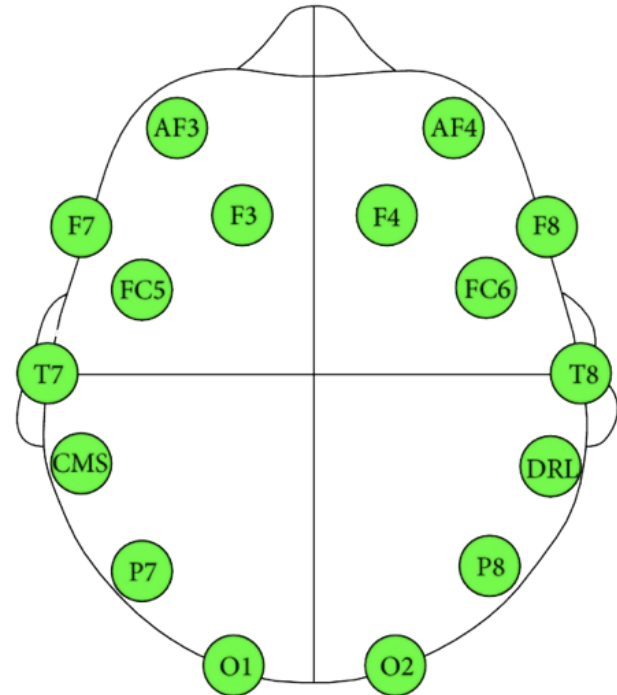
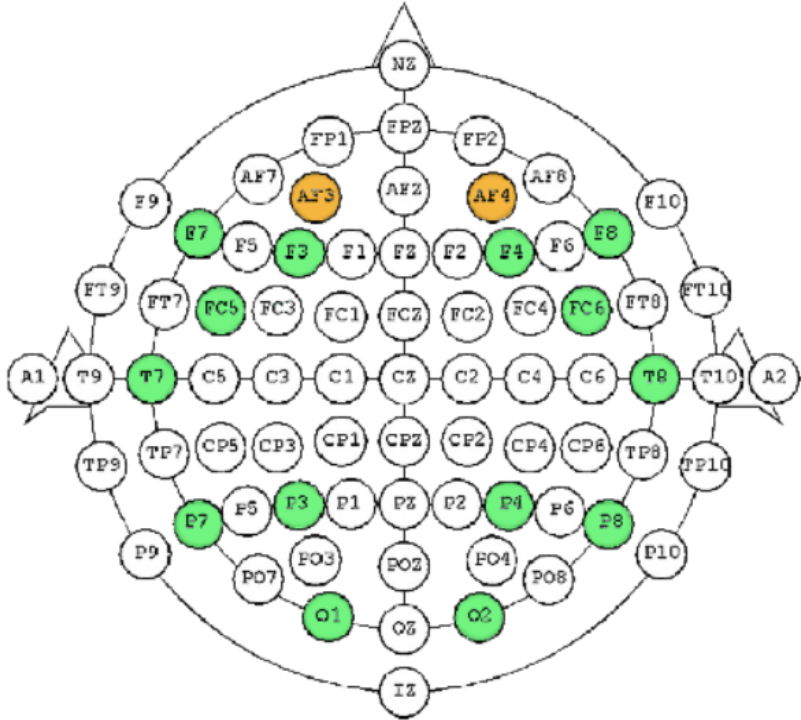
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Equipamentos - Emotiv



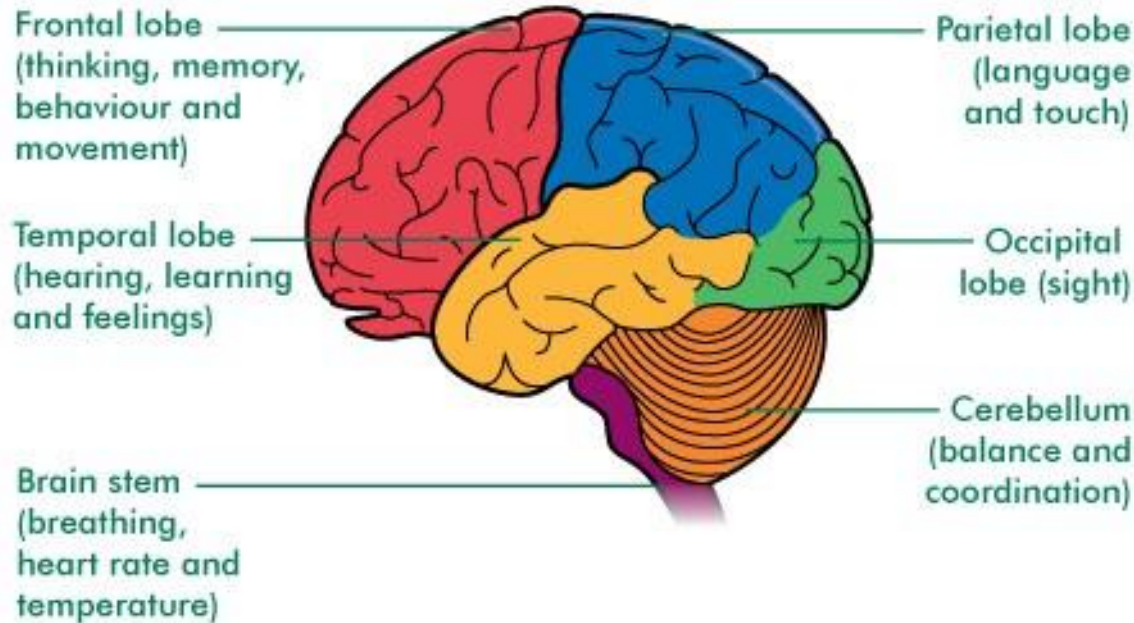
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Entendendo EEG



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Entendendo EEG



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The electrodes of an EEG device capture **electrical activity** expressed in various EEG frequencies. Using an algorithm called a **Fast Fourier Transform (FFT)**, these raw EEG signals can be identified as **distinct waves with different frequencies**. Frequency, which refers to the speed of the electrical oscillations, is measured in cycles per second—one Hertz (Hz) is equal to one cycle per second. Brainwaves are categorized by frequency into four main types: **Beta, Alpha, Theta and Delta**.

Entendendo EEG



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Beta Waves (frequency range from 14 Hz to about 30 Hz)

Beta waves are most closely associated with **being conscious** or in an **awake, attentive and alert state**. **Low-amplitude** beta waves are associated with **active concentration**, or with a **busy or anxious** state of mind. Beta waves are also associated with **motor decisions** (suppression of movement and sensory feedback of motion). When measured by an EEG device, the signals are often referred to as EEG beta waves.

Entendendo EEG



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Alpha Waves (frequency range from 7 Hz to 13 Hz)

Alpha waves are often associated with a **relaxed, calm and lucid** state of mind. Alpha waves can be found in the **occipital** and **posterior** regions of the brain. Alpha waves can be induced by closing one's eyes and relaxing, and they are **rarely present during** intense cognitive processes like **thinking, mental calculus and problem solving**. In most adults, alpha waves range in frequency from 9 to 11 Hz. When measured by an EEG device, these are often referred to as EEG alpha waves.

Entendendo EEG



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Theta Waves (frequency range from 4 Hz to 7 Hz)

Brain activity within a frequency range comprised between 4 and 7 Hz is referred to as Theta activity. Theta rhythm detected in EEG tests is often found in young adults, particularly over the temporal regions and during hyperventilation. In older individuals, theta activity with amplitude greater than about 30 millivolts (mV) is seen less commonly, except during drowsiness. When measured by an EEG device, these are often referred to as EEG theta waves.

Entendendo EEG



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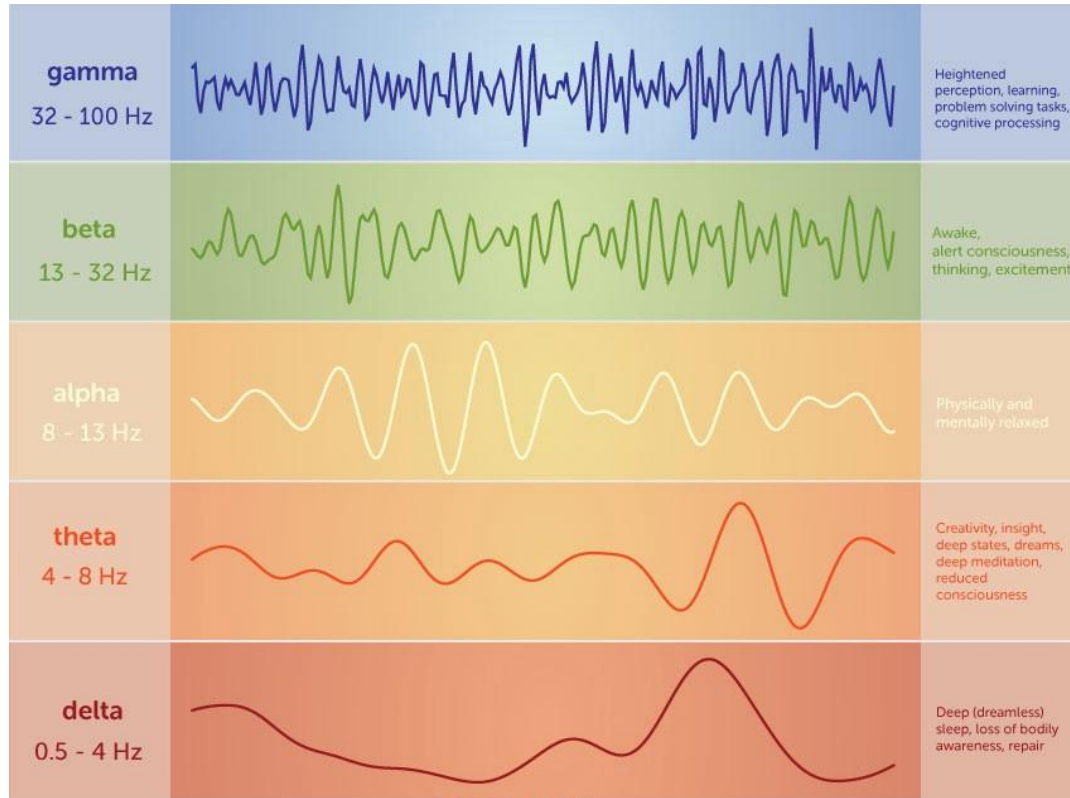
Delta Waves (frequency range up to 4 Hz)

Delta activity is **predominantly found in infants**. Delta waves are associated with **deep stages of sleep in older subjects**. Delta waves have been documented interictally (between seizures) in patients with absence seizures, which involve brief, sudden lapses in attention. Delta waves are characterized by **low-frequency (about 3 Hz), high amplitude waves**. Delta rhythms can be present during wakefulness—they are responsive to eye-opening and may be enhanced by hyperventilation as well. When measure by an EEG device, these are often referred to as EEG delta waves.

Entendendo EEG



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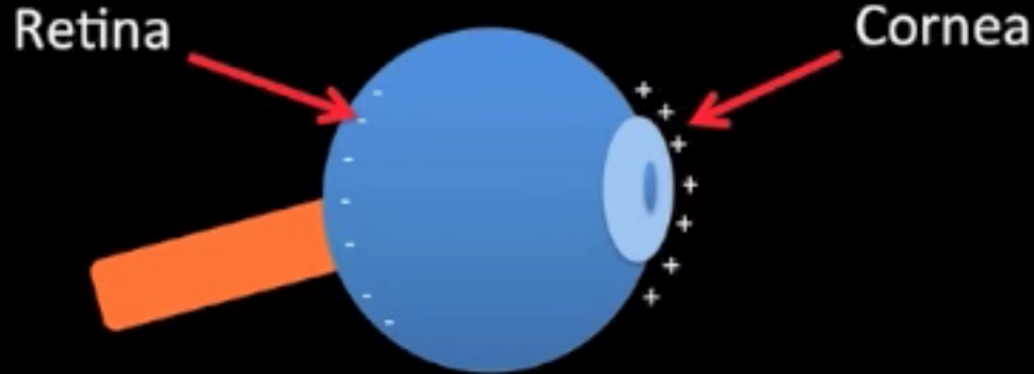
Movimento dos olhos

<https://youtu.be/s1GknlqKGYo>



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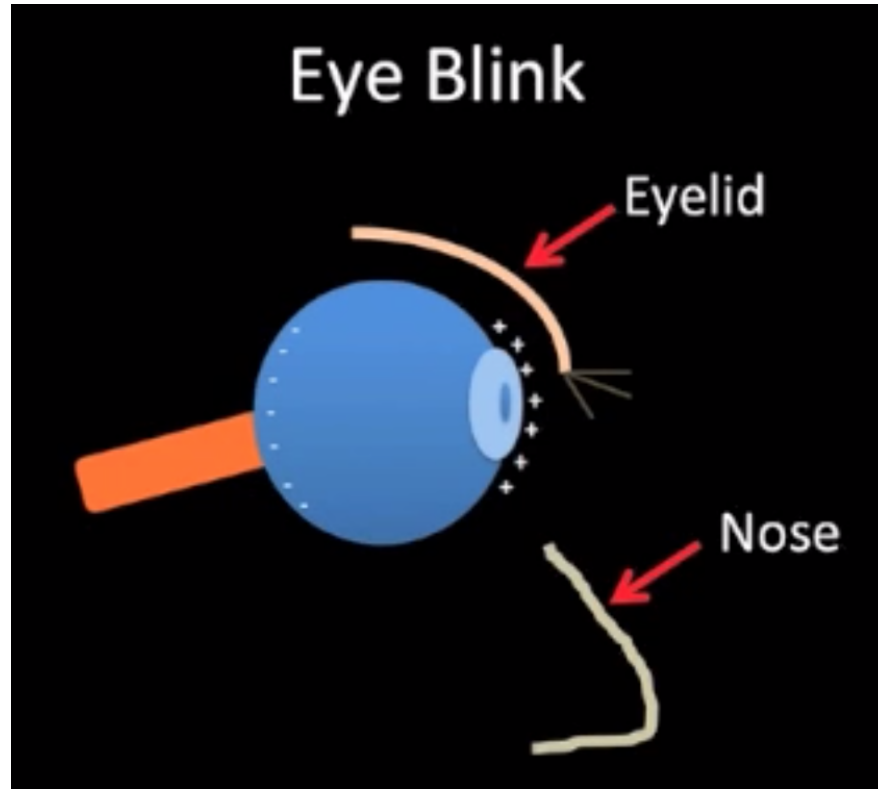
Polarity of the Eye



Movimento dos olhos em EEG



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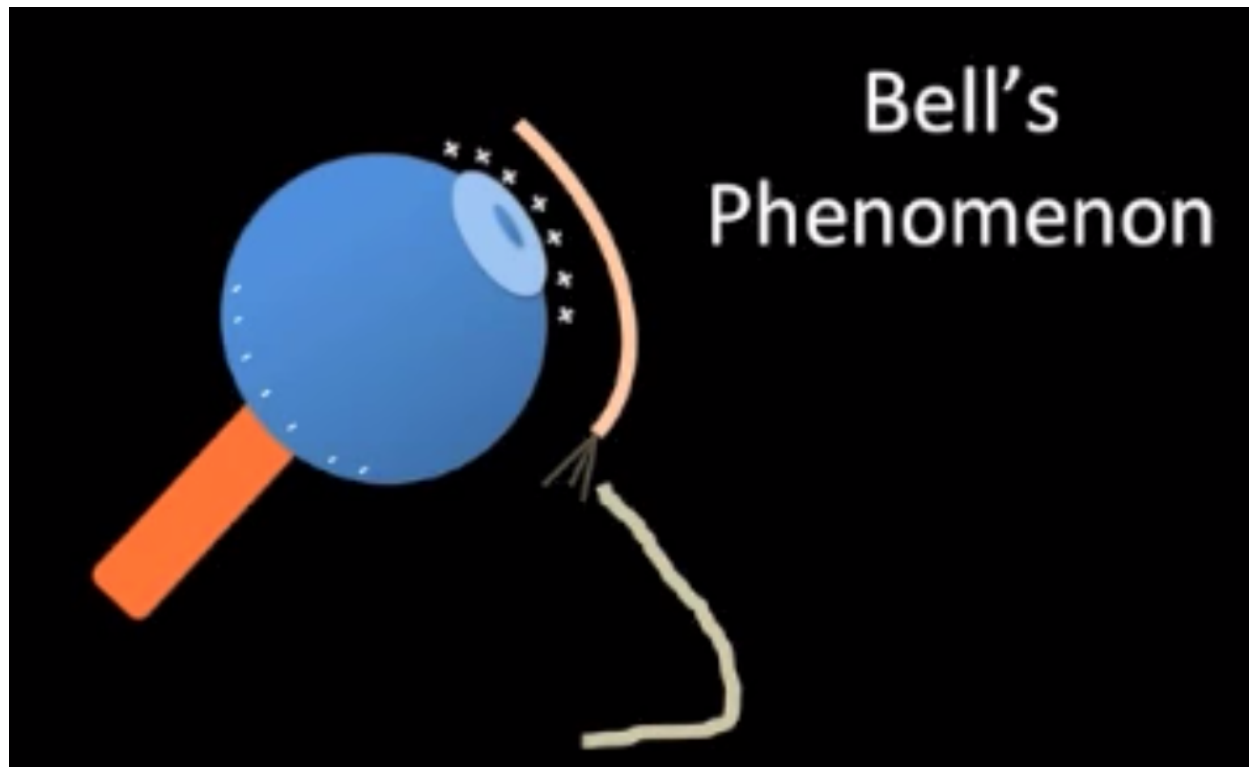
<https://youtu.be/s1GknlqKGYo>

Movimento dos olhos

<https://youtu.be/s1GknlqKGYo>



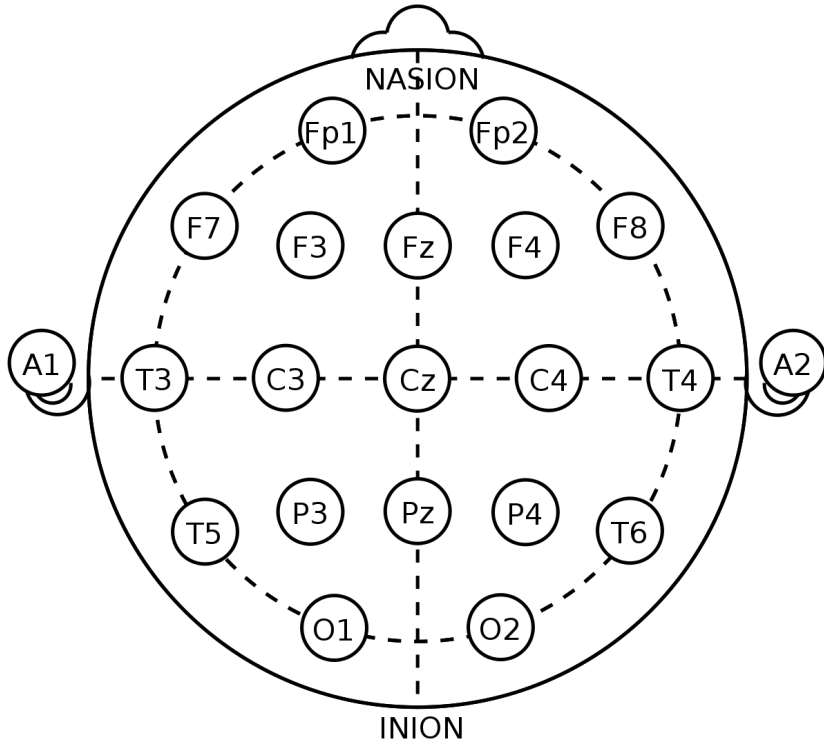
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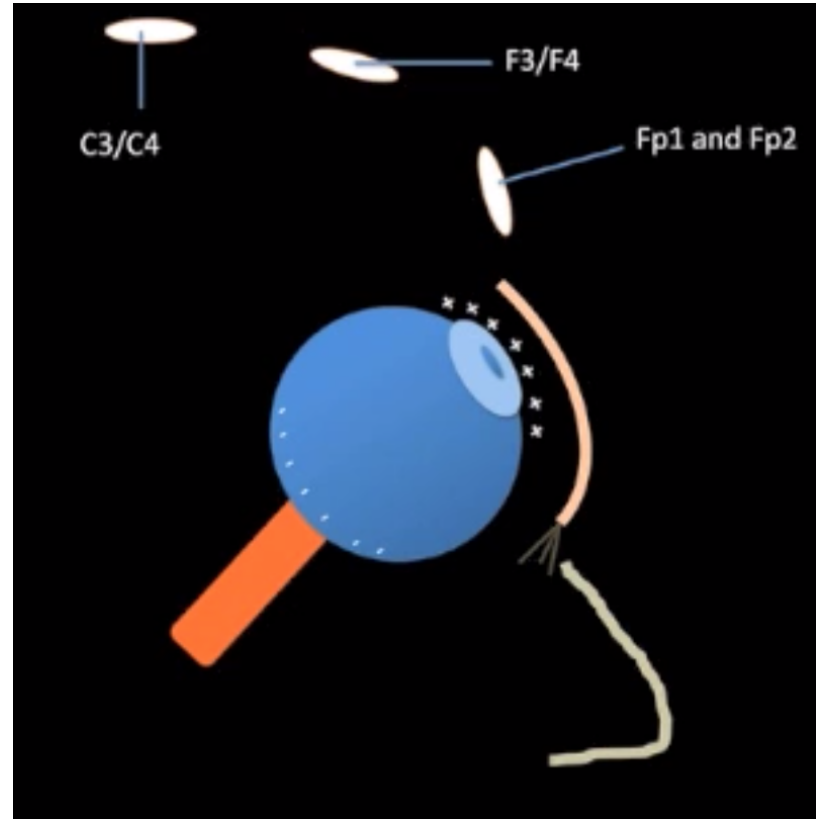
Movimento dos olhos



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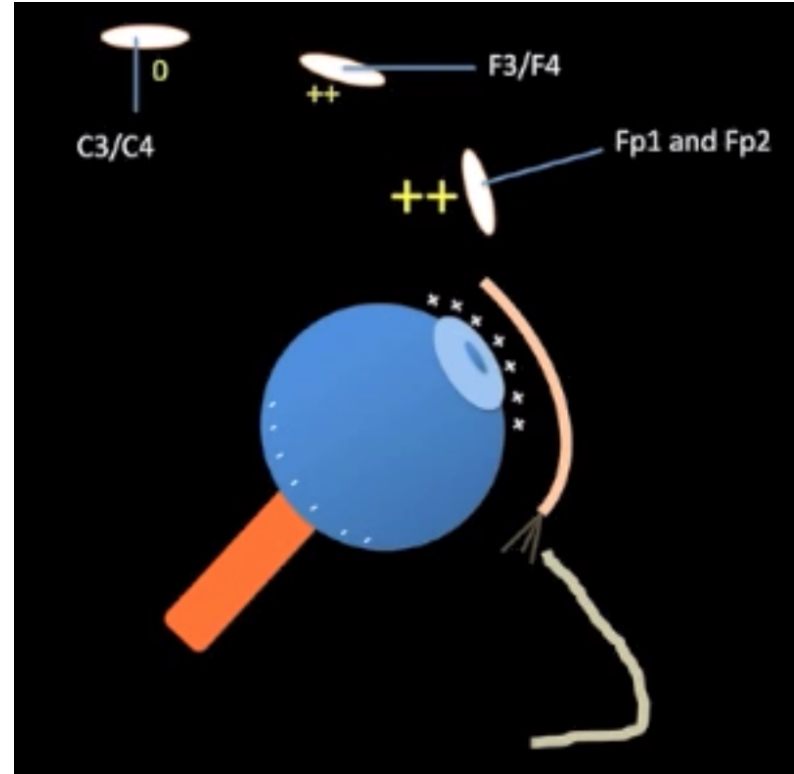
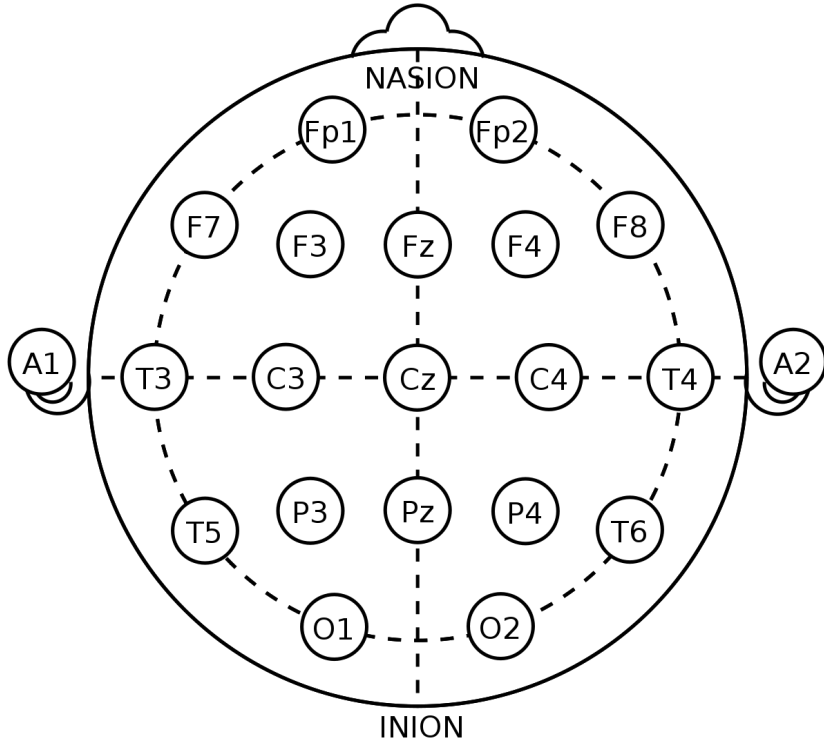
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Movimento dos olhos



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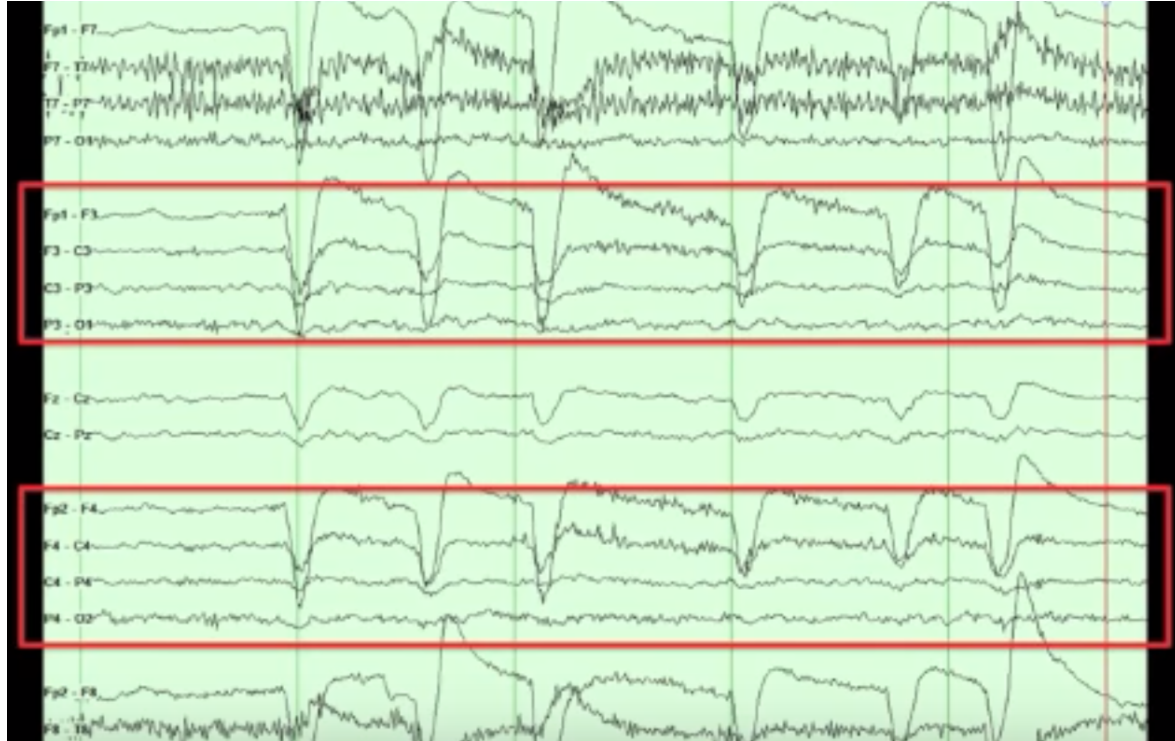


<https://youtu.be/s1GknlqKGYo>

Movimento dos olhos em EEG



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<https://youtu.be/s1GknlqKGYo>

Predict Open/Closed Eyes



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- **EEG Eye State Data Set**

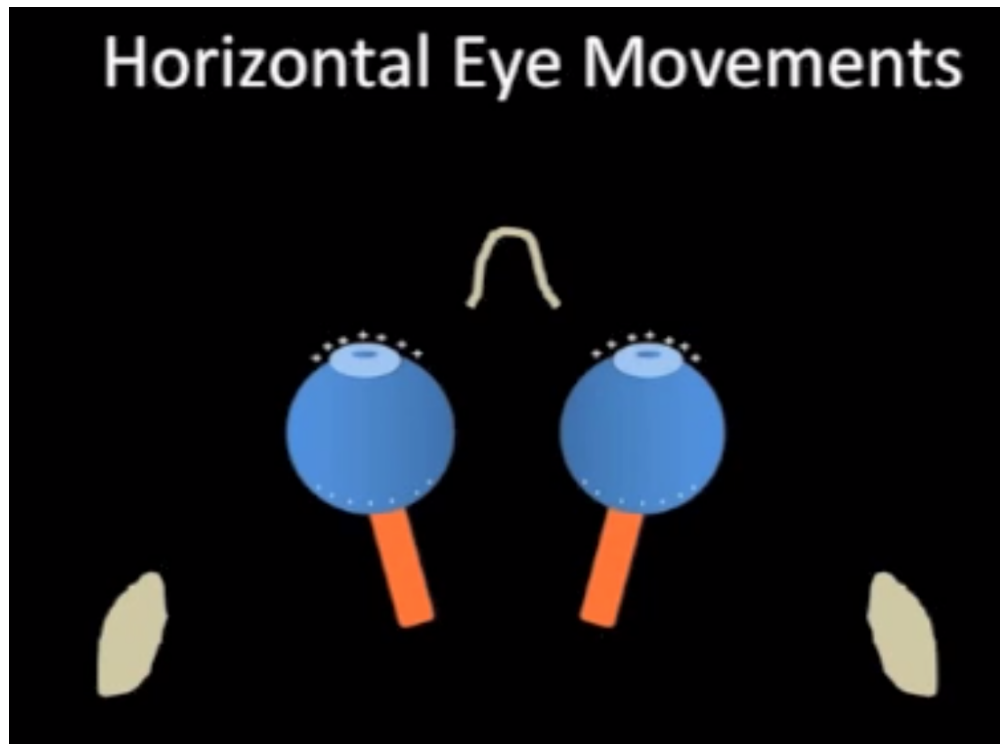
- 14,980 observations (rows) were made over the 117 seconds
- 128 observations per second
- Emotiv Epoc
- 14,977 instances with 15 attributes each (14 attributes representing the values of the electrodes and the eye state)
- 55.12% - Olho aberto
- 44.88% - Olho fechado

**4452.82,4032.31,4295.38,4130.26,4330.26,4592.31,4078.46,4620,4227.18,4268
.72,4312.31,4353.33,4808.21,4549.23,0**
**4445.13,4017.95,4292.82,4121.54,4325.13,4591.79,4077.44,4628.72,4229.23,4
273.33,4316.92,4350.77,4810.26,4552.82,1**

Movimento dos olhos



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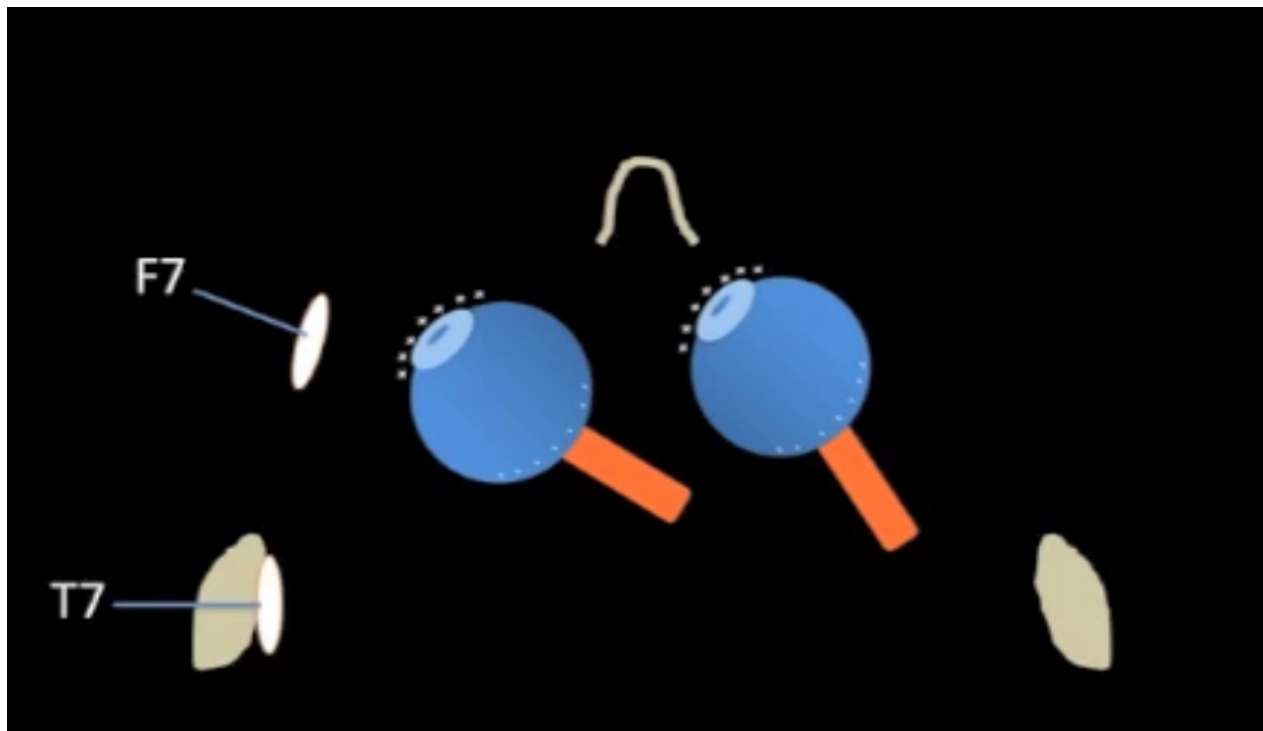


<https://youtu.be/s1GknlqKGYo>

Movimento dos olhos



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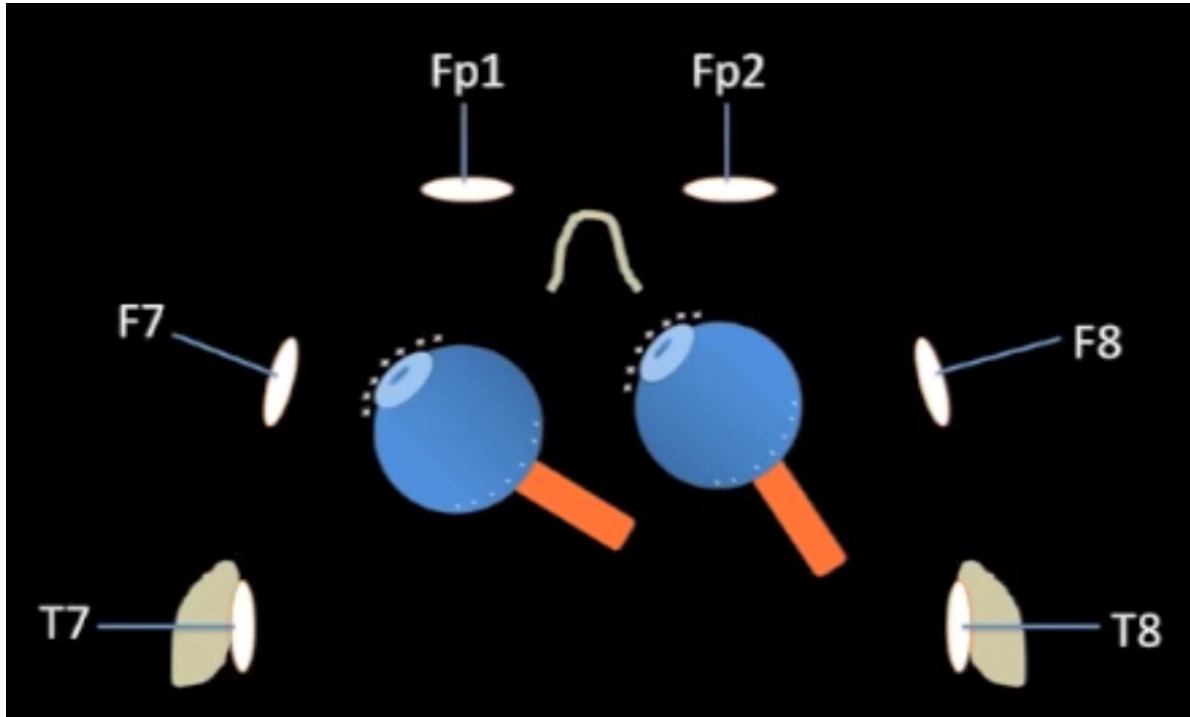


<https://youtu.be/s1GknlqKGYo>

Movimento dos olhos



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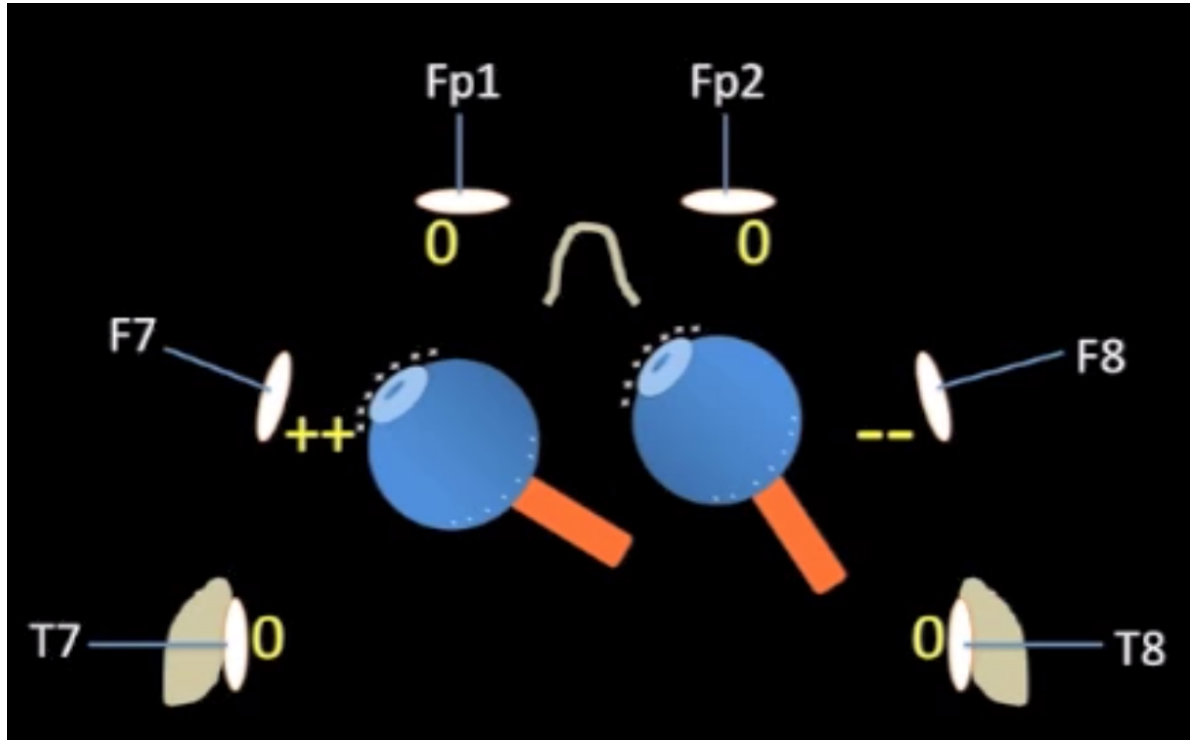


<https://youtu.be/s1GknlqKGYo>

Movimento dos olhos

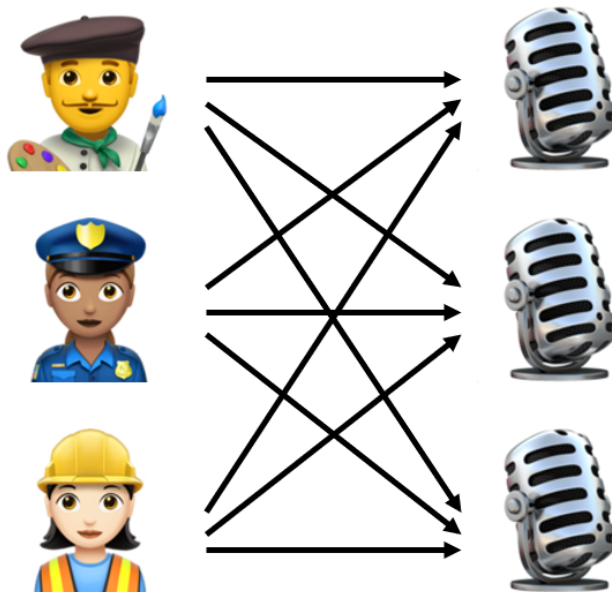


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<https://youtu.be/s1GknlqKGYo>

Redução de ruídos

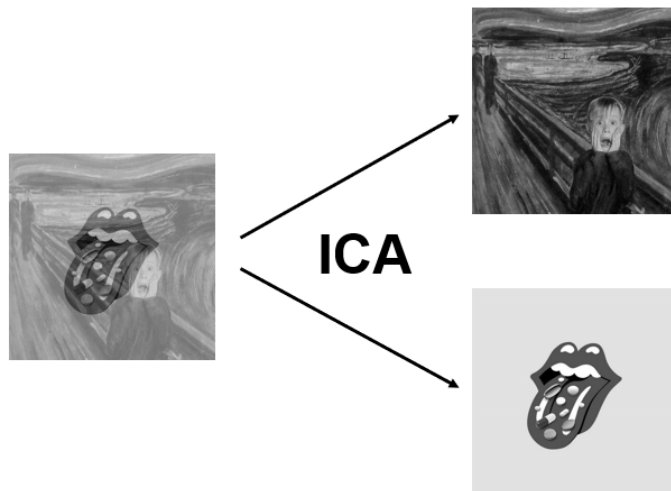


The cocktail party problem

Redução de ruídos - ICA



- Independent Component Analysis
- Técnica de aprendizado supervisionado em Machine Learning



<https://bit.ly/2ZLoyRx>

Redução de ruídos - ICA



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Redução de ruídos - ICA



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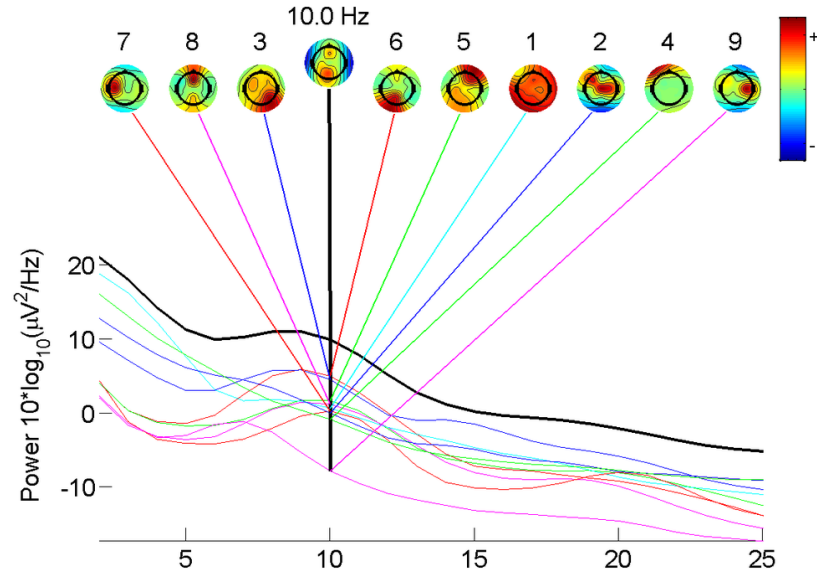
- Condições:
 - As fontes dos dados conjuntas devem ser não gaussianas ou distribuídas normalmente
 - Cada fonte deve ser independente da outra, e não podem repetir o mesmo dado
- O ICA tem como princípio que as vozes são diferentes entre si, e portanto, procura a **independência estatística máxima das fontes**
 - Entretanto, o algoritmo não consegue identificar sozinho quantas vozes (fontes) existem numa amostra, nós devemos especificar isso.

Redução de ruídos - ICA



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- Tipos de ruído:
 - Piscar o olho, movimento com os olhos, movimentos com a cabeça ou musculares, frequência elétrica de equipamentos



<https://bit.ly/2J6zJy8>

Detecção de Emoções



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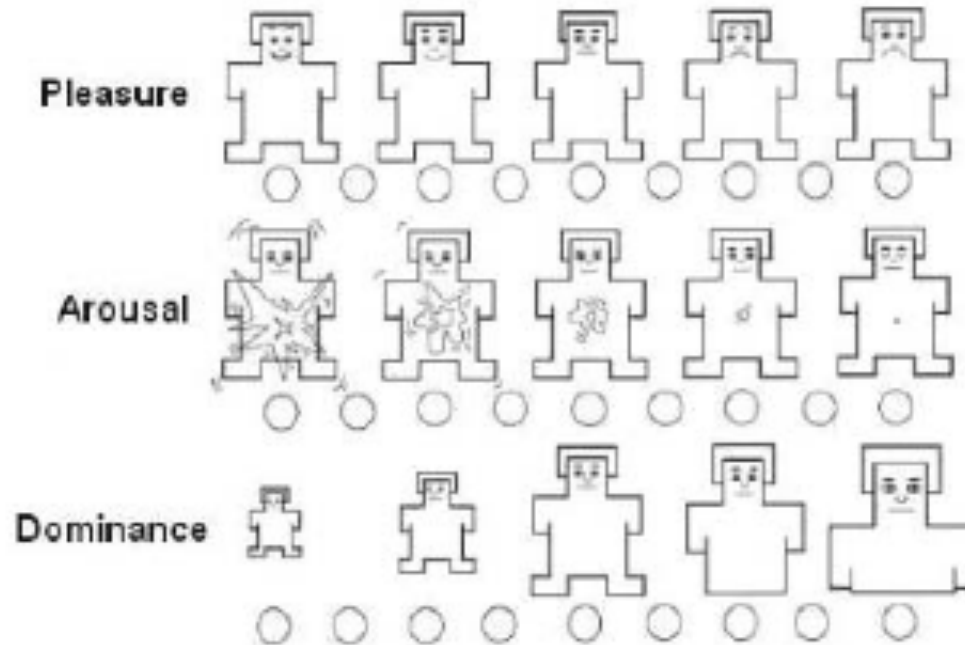
- É utilizada em diversos contextos e aplicações
 - Em UX por exemplo, existe uma área totalmente dedicada ao estudo das emoções e como elas afetam a interação com interfaces
 - Nesse contexto, uma das técnicas mais aceitas e usadas na literatura é o formulário SAM (Self Assessment Manikin)
 - O SAM mede **Satisfação, Excitação e Controle**

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: the self-assessment manikin and the semantic differential. *Journal of behavior therapy and experimental psychiatry*, 25(1), 49-59.

Detecção de Emoções



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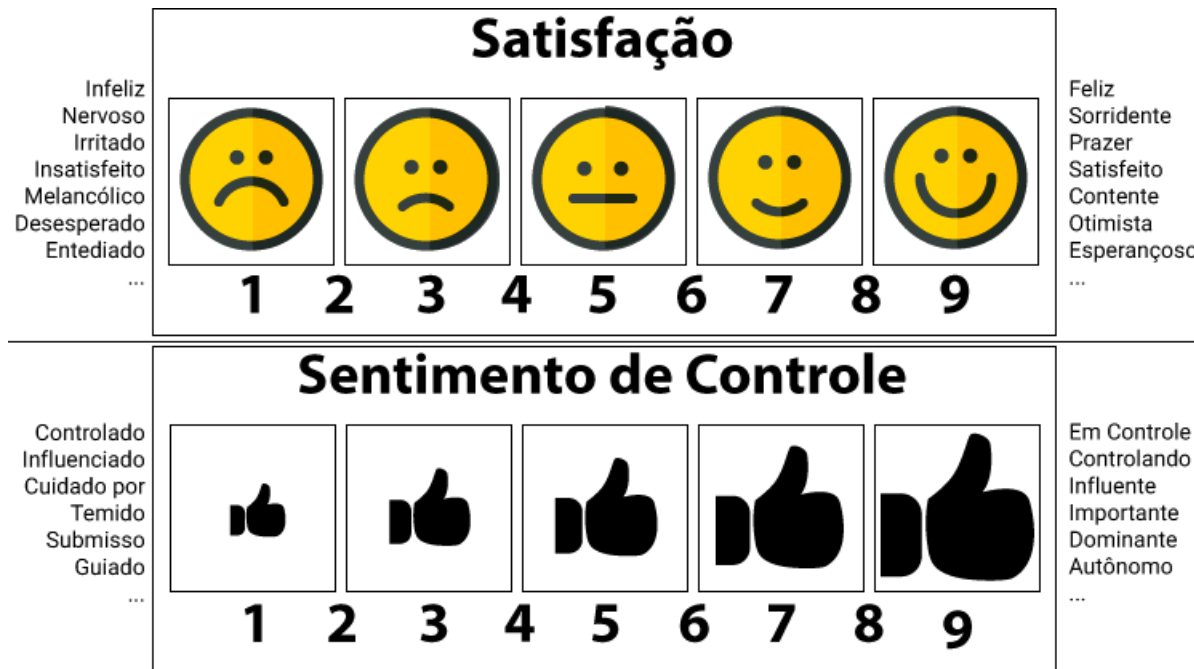


Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: the self-assessment manikin and the semantic differential. *Journal of behavior therapy and experimental psychiatry*, 25(1), 49-59.

Detecção de Emoções



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CASADEI, V. et al. Accessibility evaluation of design patterns on moodle mobile. In: Brazilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação-SBIE). [S.l.: s.n.], 2016. v. 27, n. 1.

Detecção de Emoções



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- Com o avanço da tecnologia, outra abordagem muito utilizada para detecção de emoções é visão computacional
 - Um grande exemplo é o **Noldus FaceReader** (<https://bit.ly/2XQoSfU>)
 - Capaz de reconhecer 7 expressões faciais



happiness
100%



sadness
96%



anger
96%



surprise
96%



fear
89%



disgust
96%



neutral
100%

Detecção de Emoções



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- Entretanto, reconhecimento de expressões por visão computacional depende de uma série de condições
 - Iluminação, capacidade expressiva muscular, acessórios no rosto,...
- Para obter resultados mais certos, várias estratégias são utilizadas em conjunto:
 - Batimento cardíaco
 - Condutividade da pele
 - Dilatação pupilar
 - EEG (mais recentemente)

Detecção de Emoções



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- A detecção de emoções com EEG é baseado num método da psicologia, onde os sentimentos subjetivos podem ser projetados num plano 3D, contendo
 - Arousal
 - positive emotion
 - negative emotion
 - Valence
 - strong emotion
 - weak emotion
 - Tension
 - tensed emotion
 - relieved emotion

Detecção de Emoções



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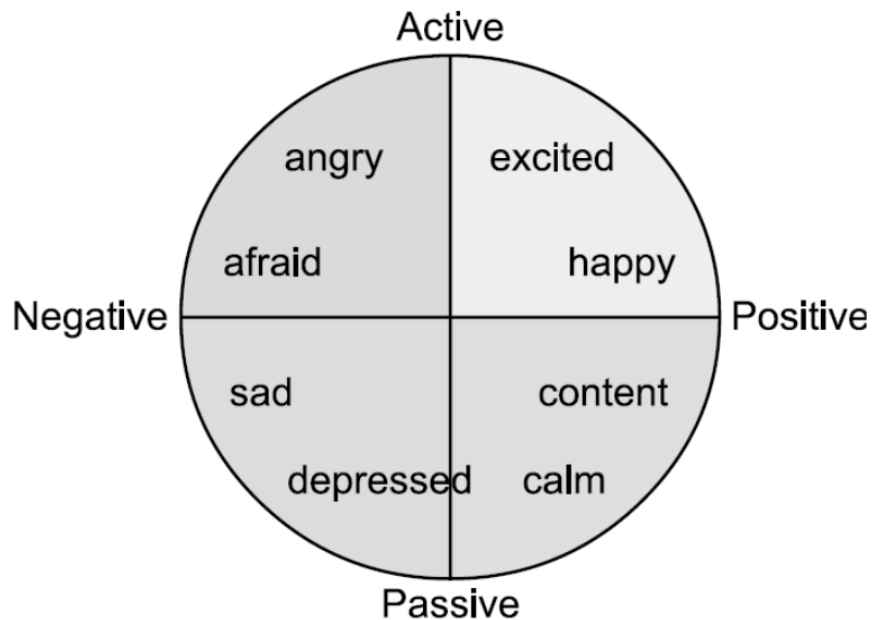


Figure 1. Valence-Arousal model [2].

<https://bit.ly/2Y0kSJX>

Detecção de Emoções



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$$\text{Arousal} = \beta (\text{AF3} + \text{AF4} + \text{F3} + \text{F4}) / \alpha (\text{AF3} + \text{AF4} + \text{F3} + \text{F4})$$

α = força das ondas alfa

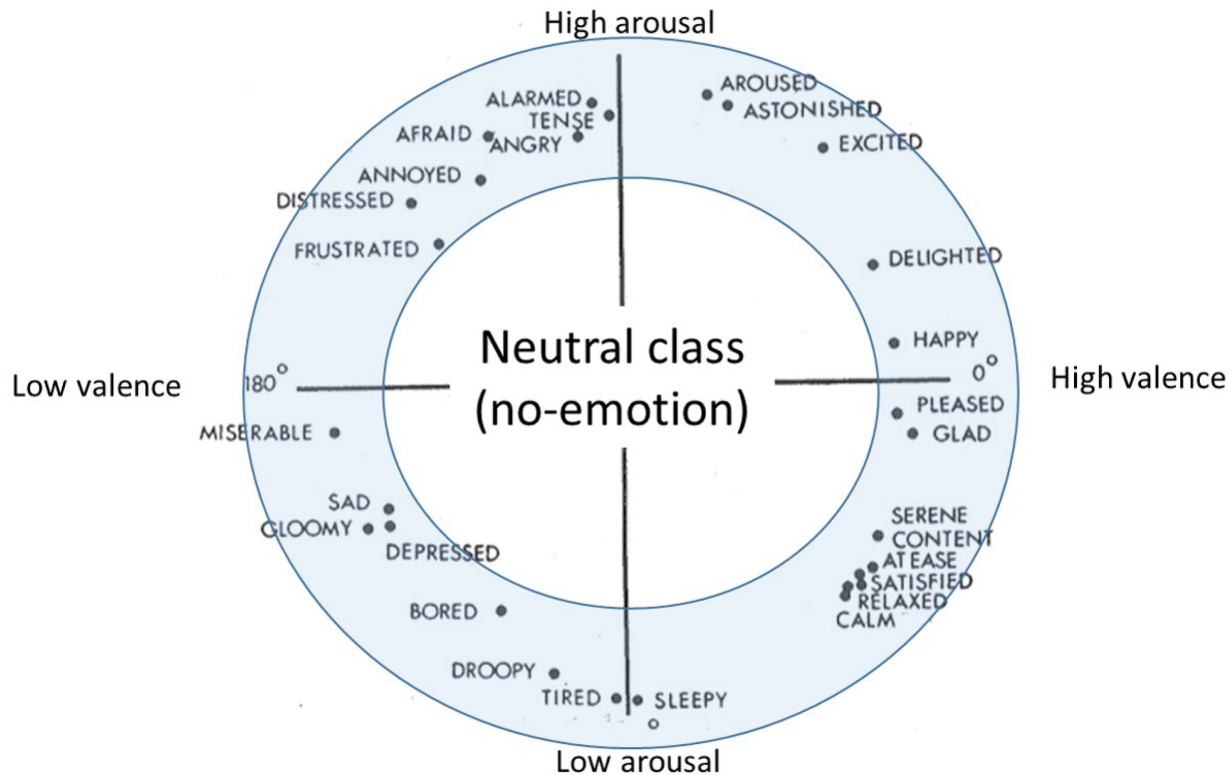
β = força das ondas beta

$$\text{Valence} = \alpha (\text{F4}) / \beta (\text{F4}) - \alpha (\text{F3}) / \beta (\text{F3})$$

Detecção de Emoções



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Trabalhando com EEG



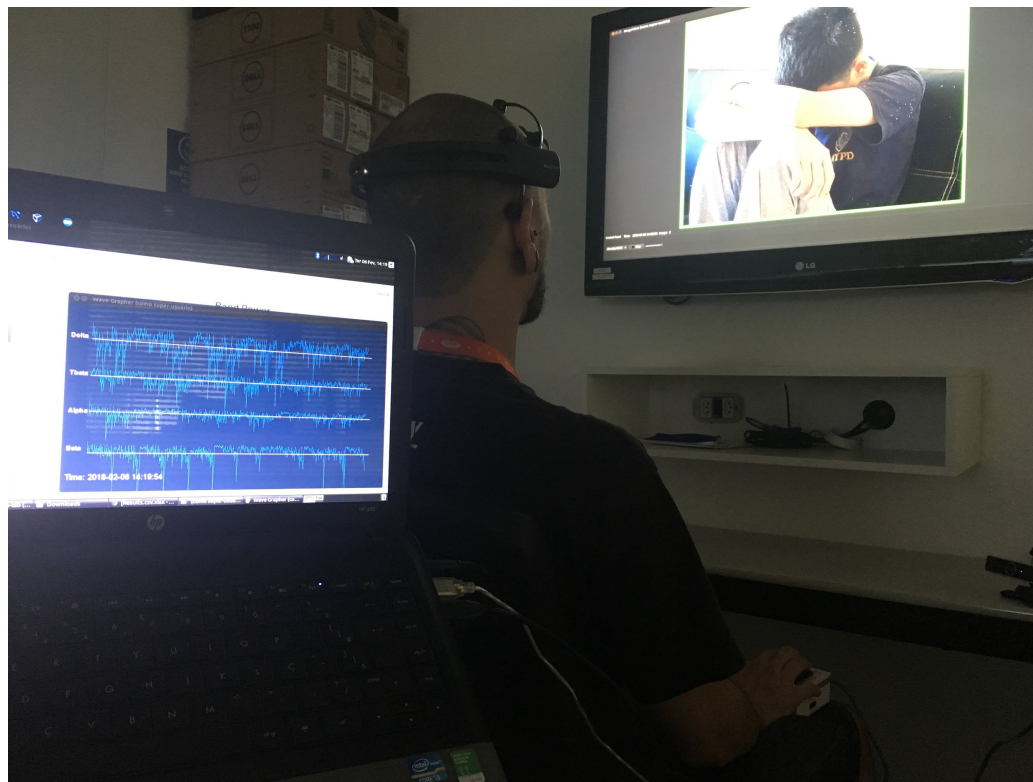
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Trabalhando com EEG



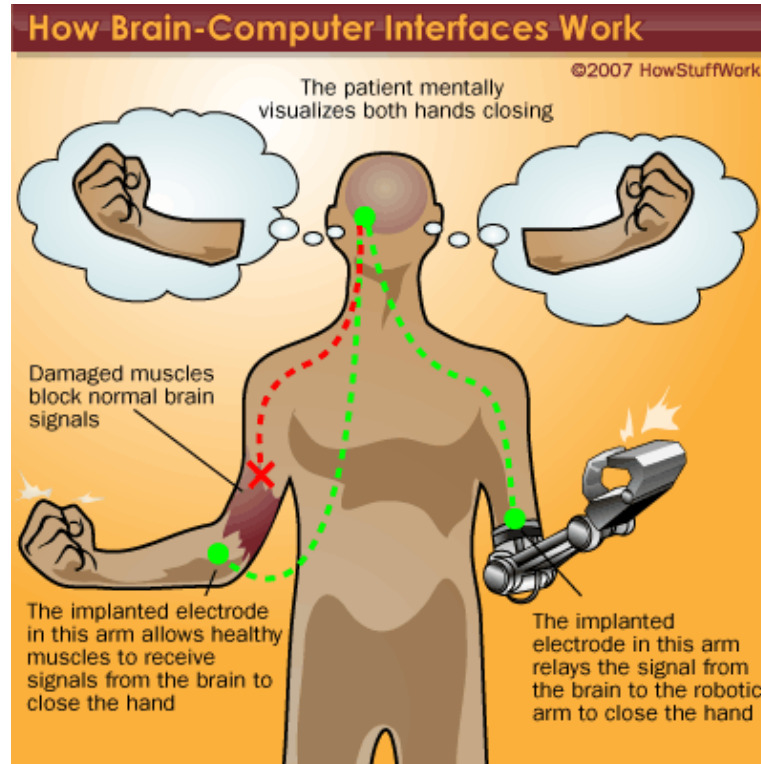
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BCI - Brain Computer Interface



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BCI - Brain Computer Interface



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BCI - Brain Computer Interface



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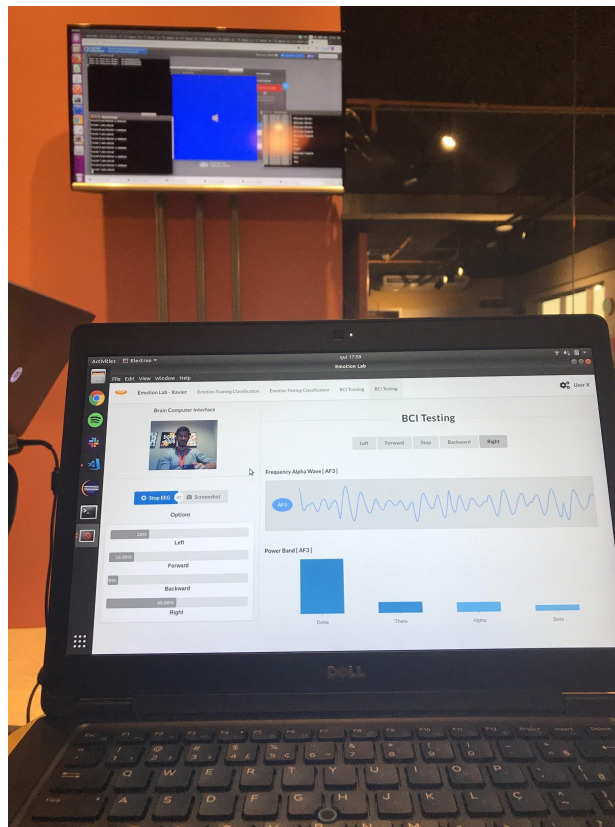
“The car, it doesn’t have pedals, it doesn’t have a steering wheel, it doesn’t have anything”

The CEO of a Brazilian non-profit has become the first person to drive a Formula 1 racing car using only the power of one's mind. Rodrigo Hübner Mendes, Founder and the CEO of the Rodrigo Mendes Institute, used the brain interface technology, which was developed by fellow Young Global Leader Tan Le, Founder of EMOTIV Inc, to pilot the vehicle by thought alone.

Trabalhando com EEG



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Trabalhando com EEG



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Trabalhando com EEG



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The screenshot shows a desktop environment with several windows open. At the top, a Chrome browser window displays the 'Awesome Screenshot: Screen Video Recorder' extension page. Below it, a terminal window shows the output of a Python script named 'spewmer.py', which prints two lines of JSON data: `{\"Tempo que levou para chegar\": 85,4286330615793}` and `{\"Tempo que levou para chegar\": 20,891266117099947}`. To the right of the terminal is a TurtleSim window, which is mostly obscured by a large blue rectangle. Below the terminal, another terminal window shows the output of a Python script named 'keyCatch.py', which repeatedly prints instructions in Portuguese: 'Precione R para Resetar a simulacao', 'Precione I para iniciar', and 'Precione R para Resetar a simulacao'. On the far right, a third terminal window shows the output of a Python script named 'listener.py', which prints a series of log messages with timestamps and coordinates, such as `[INFO] [1595620994,413149]: 0` and `[INFO] [1595620994,615659]: 1 - Frente`. The desktop background features a 'digo' logo and the text 'By the Digo Team Simplify Your Learning'. The taskbar at the bottom shows several open windows with icons for 'mn_2_1.png', 'mn_1_1.png', 'cnn_2_2.png', and 'cnn_2.png'. The system tray in the bottom right corner shows the time as 17:56.

Frameworks



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- [Epoc.js](#) — JavaScript framework to interact with the Emotiv Epoc.
- [Brain bits](#) — A P300 online spelling mechanism for Emotiv headsets.
- [Wits](#) — A Node.js library that reads your mind with Emotiv EPOC EEG headset.
- [Brain monitor](#) — A terminal app written in Node.js to monitor brain signals in real-time.
- [Ganglion BLE](#) — Web Bluetooth client for the Ganglion brain-computer interface by OpenBCI.
- [BCI.js](#) — EEG signal processing and machine learning in JavaScript.

Datasets



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- **MindBigData - The "MNIST" of Brain Digits**
 - 1,207,293 brain signals of 2 seconds each, captured with the stimulus of seeing a digit (from 0 to 9)
- **MindBigData - "IMAGENET" of The Brain**
 - 70,060 brain signals of 3 seconds each, captured with the stimulus of seeing a random image (14,012 so far) from the Imagenet ILSVRC2013 train dataset
- **UCI - EEG Database Data Set**
 - <https://archive.ics.uci.edu/ml/datasets/eeg%2Bdatabase>
- **UCI - EEG Eye State Data Set**
 - <https://archive.ics.uci.edu/ml/datasets/EEG+Eye+State>



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VITOR CASADEI

**ENGENHEIRO DE SOFTWARE @
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