simao@ufpr.br - 2023

***BCI** - **B**rain **C**omputer **I**nterfaces*

***BMI** - **B**rain **M**achine **I**nterfaces*

Brain Controlled …

... Robot
… Machine
… Home
... Automation
...

Prof. Simão

simao@ufpr.br - 2023

Think & make it happen
with none any physical effort

Gerando respostas para você...

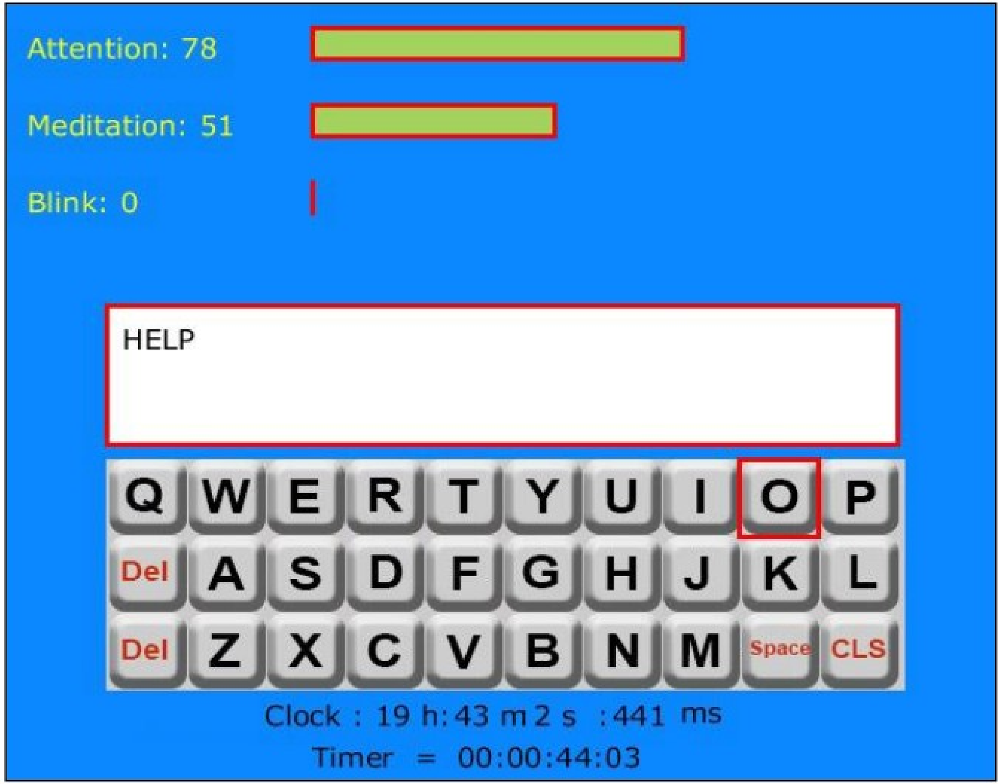
A comunicação cérebro-computador é a comunicação direta entre o cérebro humano e um dispositivo externo, que pode ser usado para auxiliar ou melhorar funções motoras ou cognitivas [1]. O princípio básico é captar os sinais elétricos gerados pelos neurônios e convertê-los em dados digitais que podem ser processados por um computador [2]. Assim, é possível enviar ou receber informações do cérebro, como sons, imagens, movimentos, etc. Existem diferentes tipos de interfaces cérebro-computador, que podem ser invasivas ou não invasivas, dependendo de como os sinais são captados [3].

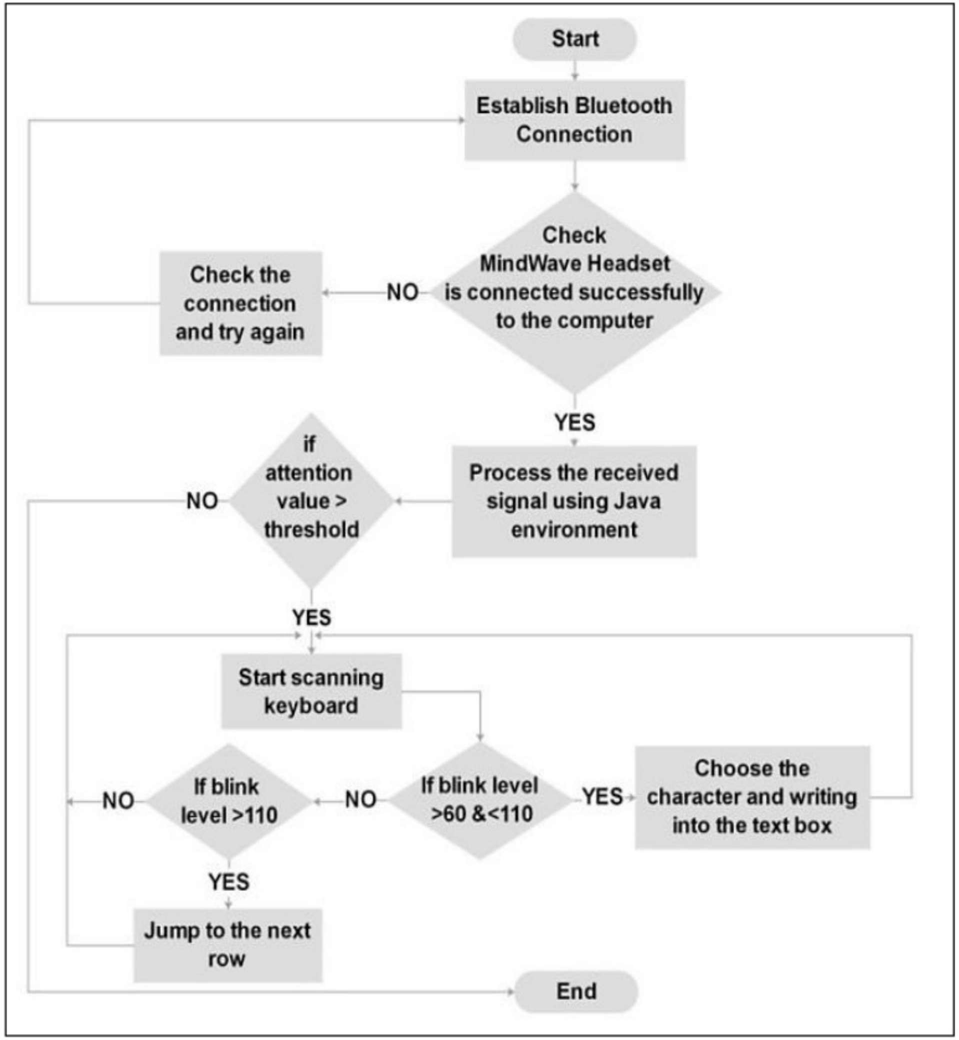
Saiba mais: 1. pt.wikipedia.org 2. techtudo.com.br 3. super.abril.com.br +2 mais **1 de 5**

Fonte: Bing Chat

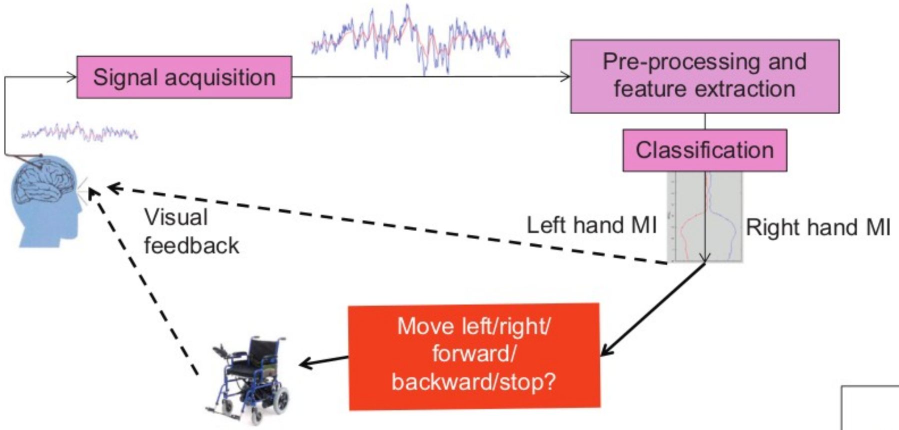
Hawking used a computer program to help him speak for several years, which was fairly high-tech for the late 1980s and early 90s. In 2005 he began using a program which allowed him to communicate via computer using only the movement of his cheek muscles, and in 2012 he began experimenting with brainwave-powered communication devices.

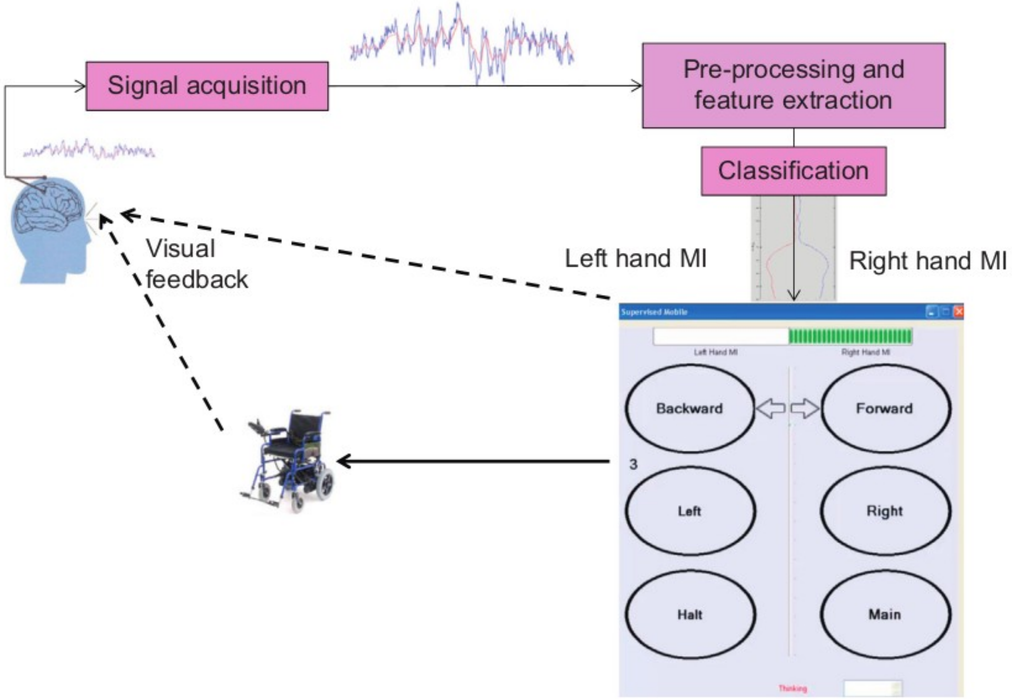
https://neurosky.com/biosensors/eeg-sensor/ultimate-guide-to-eeg/





SALIH, Thair A.; ABDAL, Yasir M.. ***Brain computer interface based smart keyboard using neurosky mindwave headset***. TELKOMNIKA Telecommunication, Computing, Electronics and Control Vol. 18, No. 2, April 2020, pp. 919~927





GANDHI, Vaibhav. ***Brain computer interfacing for assistive robotics***. *Electroencephalograms, Recurrent Quantum Neural Networks and User-Centric Graphical Interfaces*. London : Elsevier, 2015.

Data

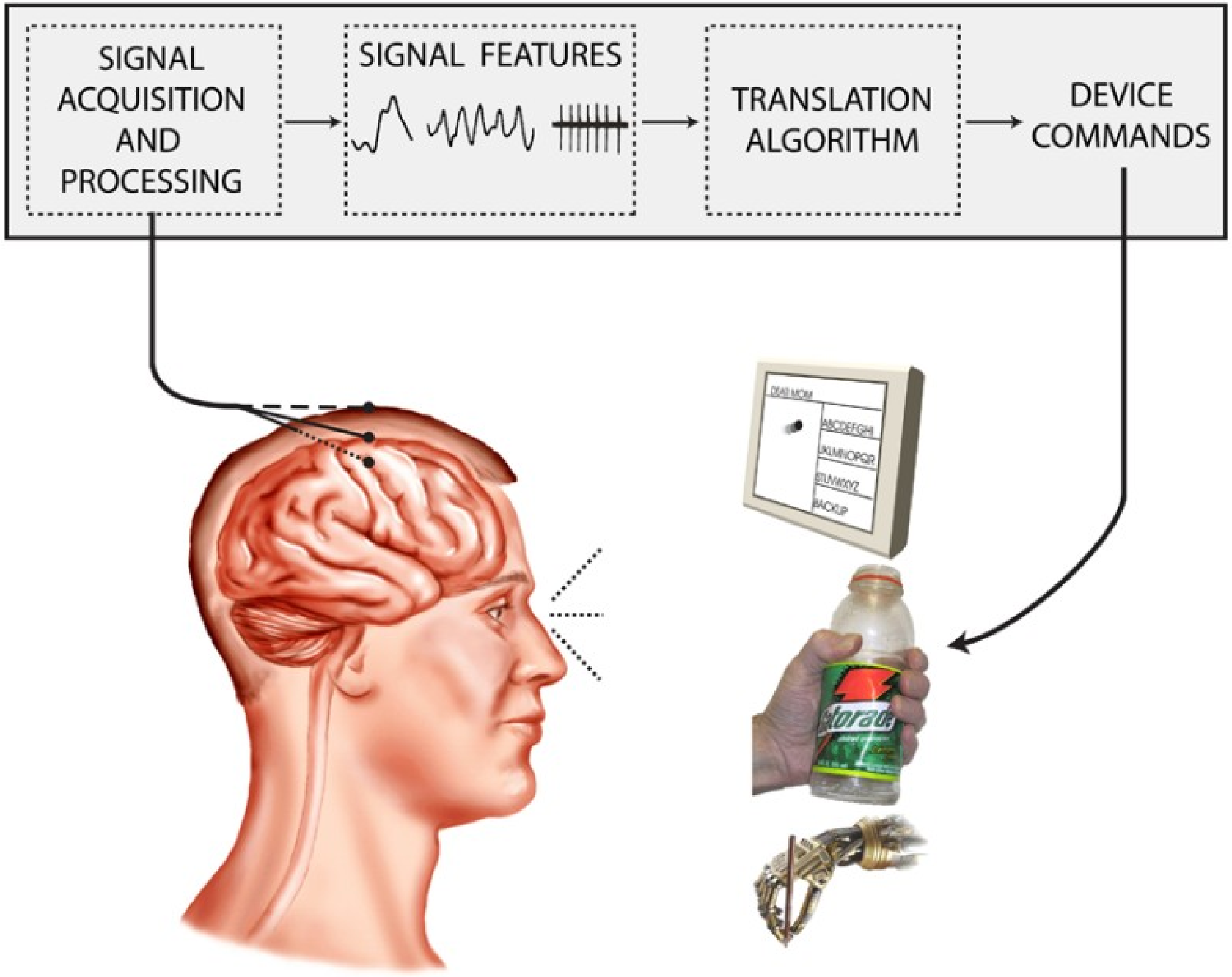
> *'Most brain-computer interfaces work, but don't work well.'*
>
> Dr Fabien Lotte, Inria, France

Technology on the other hand also remains a challenge. Dr Aaron Schurger, assistant professor at Chapman University in the US, argues that the approach to data-analysis BCIs use can be improved. Traditionally, BCIs only use the data from when users want to take an action. They, for example, collect large amounts of brain data from when a user wants to make a mouse pointer go left and use that to better realise when they need to take that action.

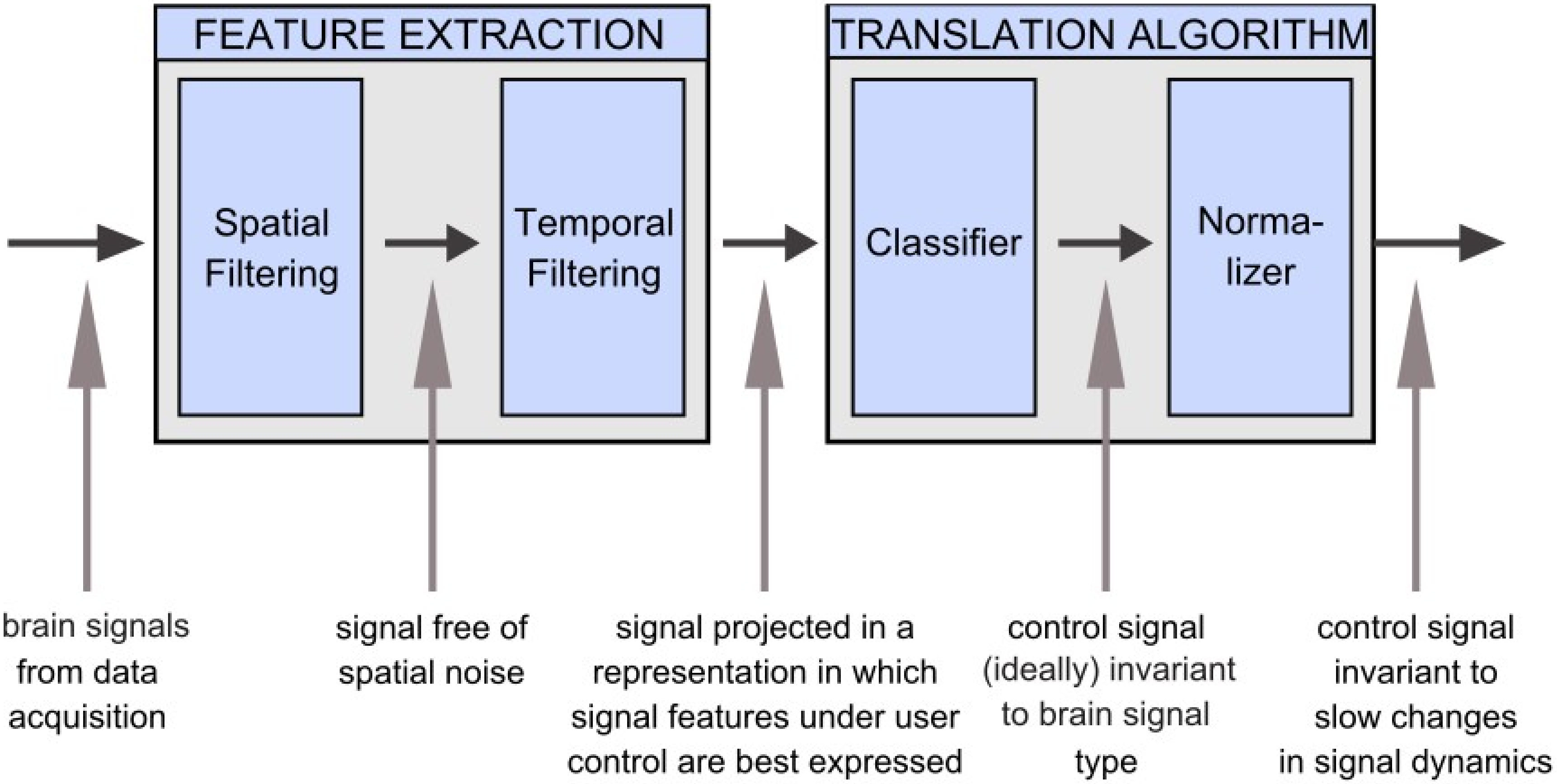
But Dr Schurger argues we need to look beyond that narrow set of information, and also include data from when the brain is, say, at rest. This is a concept he previously explored in the research project ACTINIT. 'We're now looking at all the data,' said Dr Schurger. 'Not only the data right before a movement.'

Dr Schurger compares this to weather forecasting, where meteorologists use large amounts of weather data to make predictions about what will happen. 'If you want to predict when it's going to rain, you won't do a very good job if you only look at rainy days. You will miss half the picture that way.'

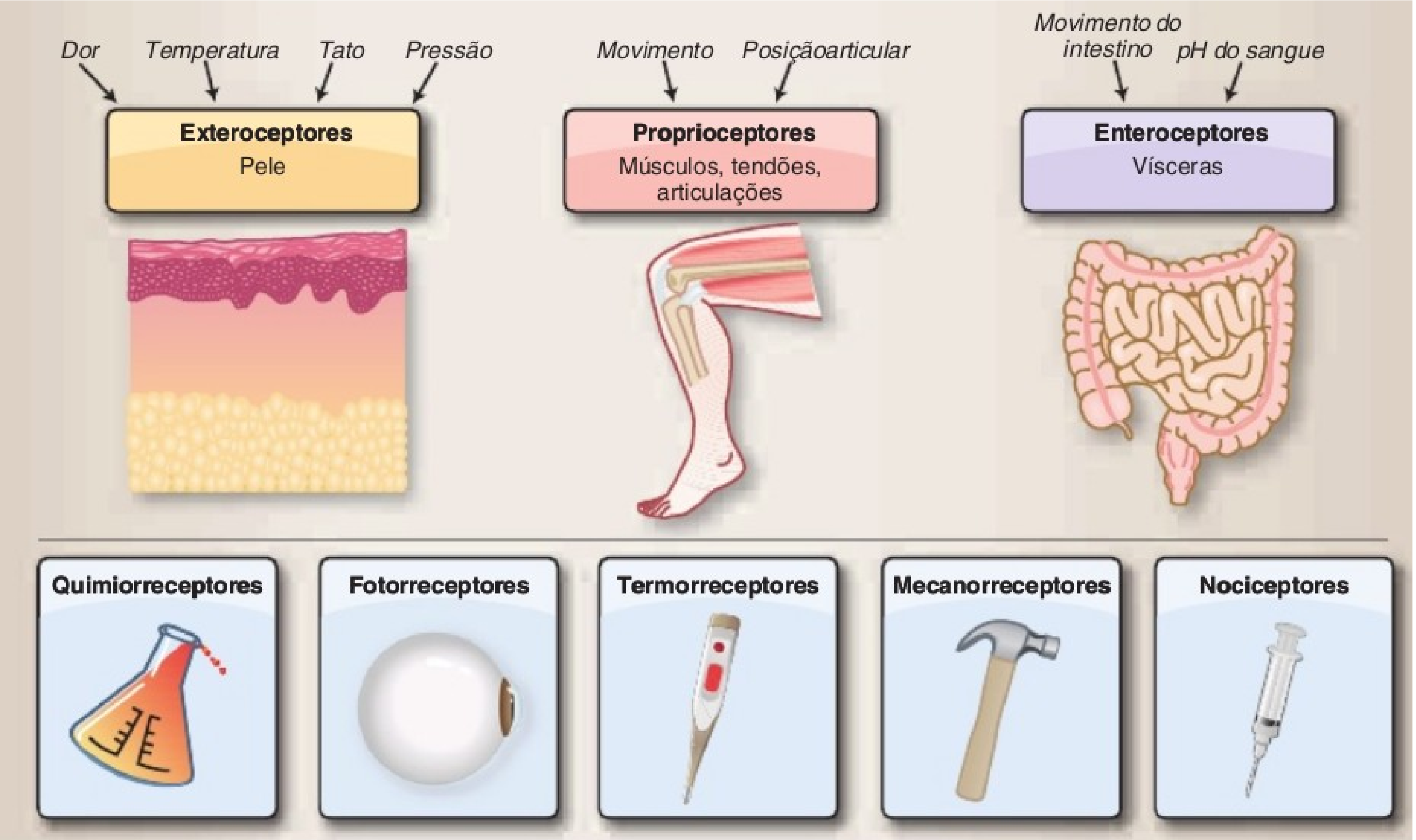
Yet if BCIs want to really fix the issues that are plaguing them right now, more radical action might be needed than user training or better data analysis. It will require researchers to go beyond non-invasive technologies. One key non-invasive method is called EEG or electroencephalography. Here electrodes are attached to the scalp, which measure the electrical current sent by the neurons inside the brain. 'EEG measures microcurrents that reflect brain activity,' said Dr Lotte.

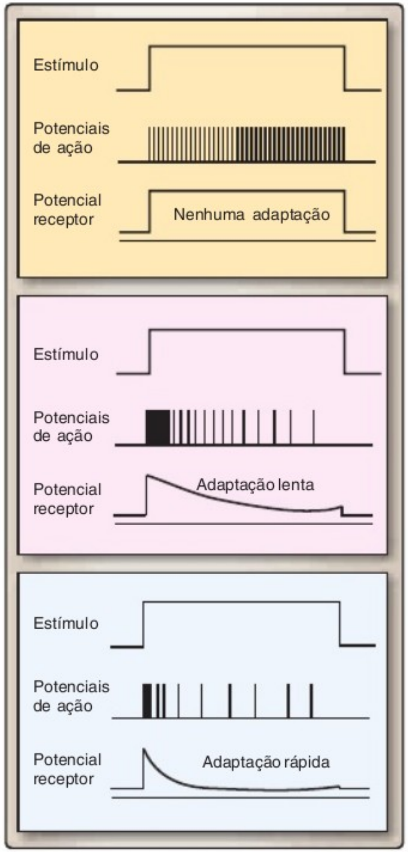


SCHALK, Gerwin; MELLINGER, Jürgen. ***A Practical Guide to Brain–Computer Interfacing with BCI2000***. *General-Purpose Software for Brain–Computer Interface Research, Data Acquisition, Stimulus Presentation, and Brain Monitoring*. London : Springer-Verlag, 2010.

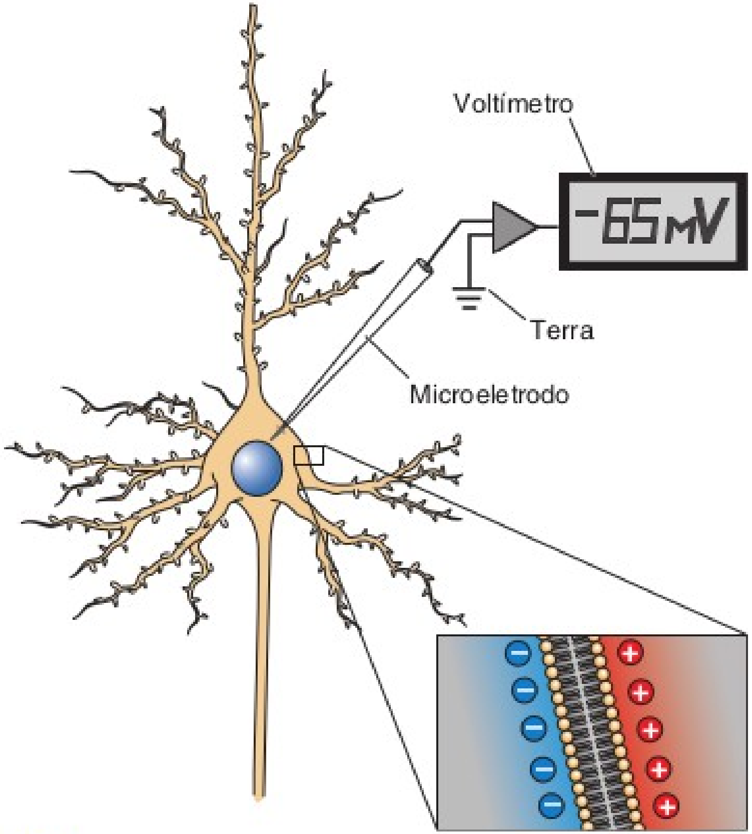


SCHALK, Gerwin; MELLINGER, Jürgen. ***A Practical Guide to Brain–Computer Interfacing with BCI2000***. *General-Purpose Software for Brain–Computer Interface Research, Data Acquisition, Stimulus Presentation, and Brain Monitoring*. London : Springer-Verlag, 2010.





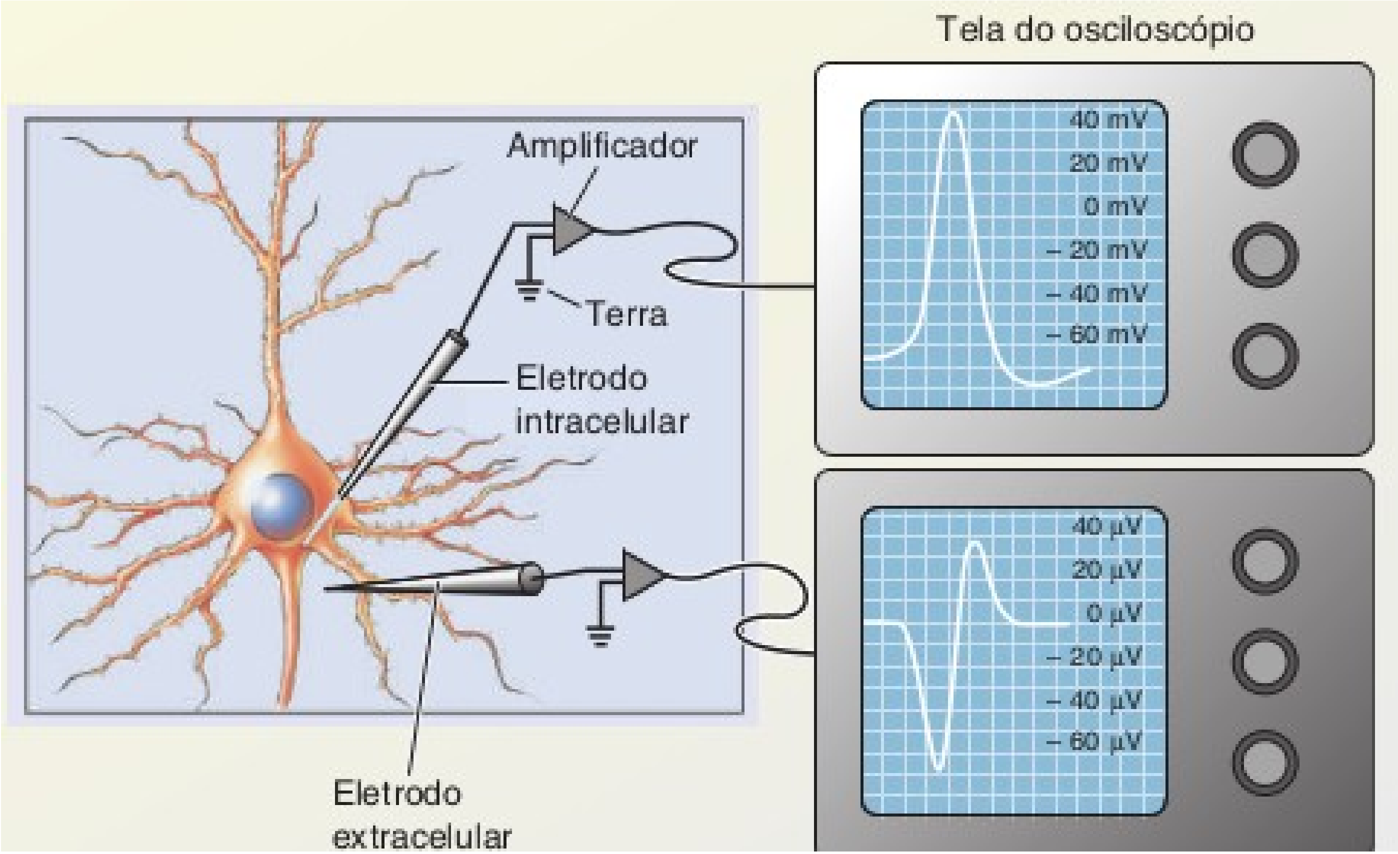
KREBS, Claudia; WEINBERG, Joanne; AKESSON, Elizabeth. **Neurociências ilustrada**. Porto Alegre : Artmed, 2013.



▲ FIGURA 3.11

Medição do potencial de repouso da membrana. Um voltímetro mede a diferença no potencial elétrico entre a ponta de um microeletrodo inserido na célula e um cabo colocado no líquido extracelular, convencionalmente denominado "terra", pois é eletricamente conectado à Terra. Em geral, o interior do neurônio está ao redor de – 65 mV em relação ao exterior. Esse potencial é causado pela distribuição desigual de carga elétrica através da membrana

BEAR, Mark F.; CONNORS, Barry W.; PARADISO, MIchael A. **Neurociências**: desvendando o sistema nervoso. Porto Alegre : Artmed, 2017.



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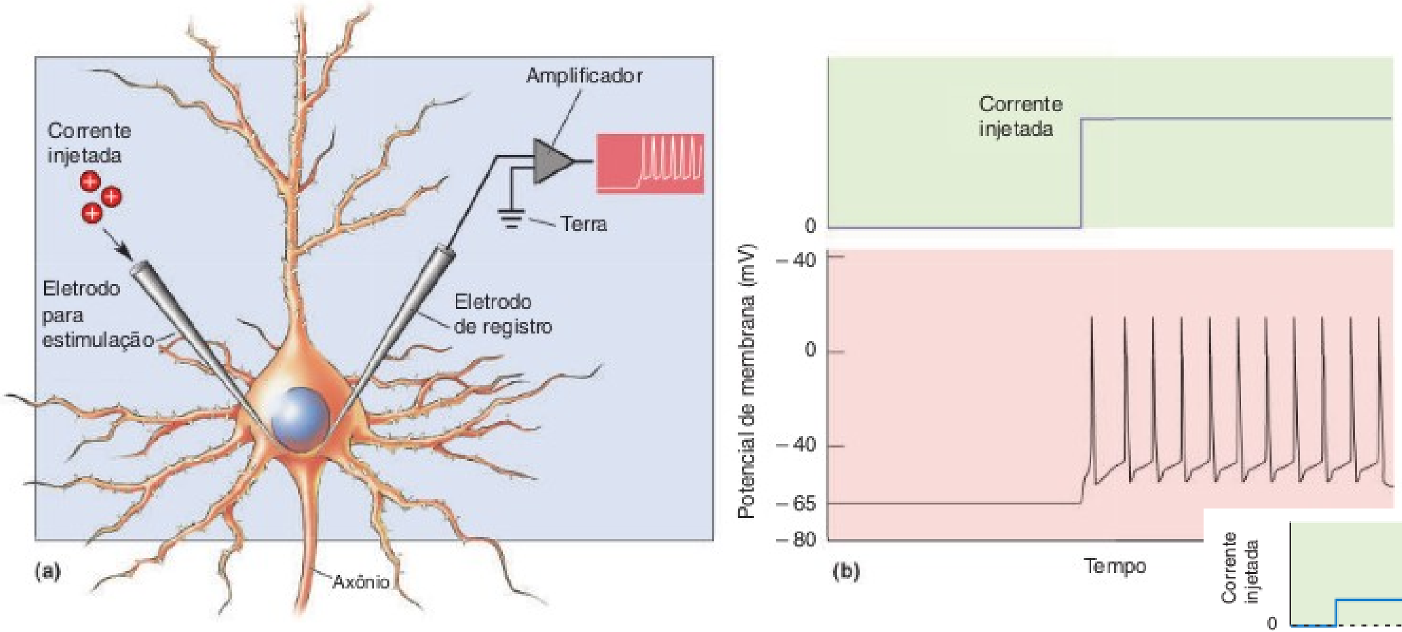
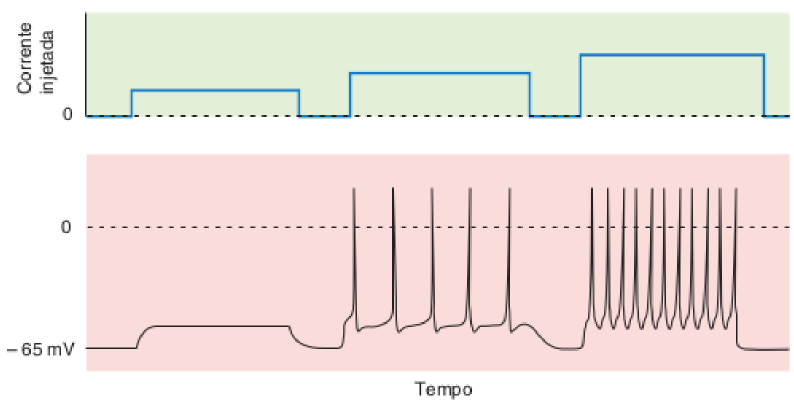


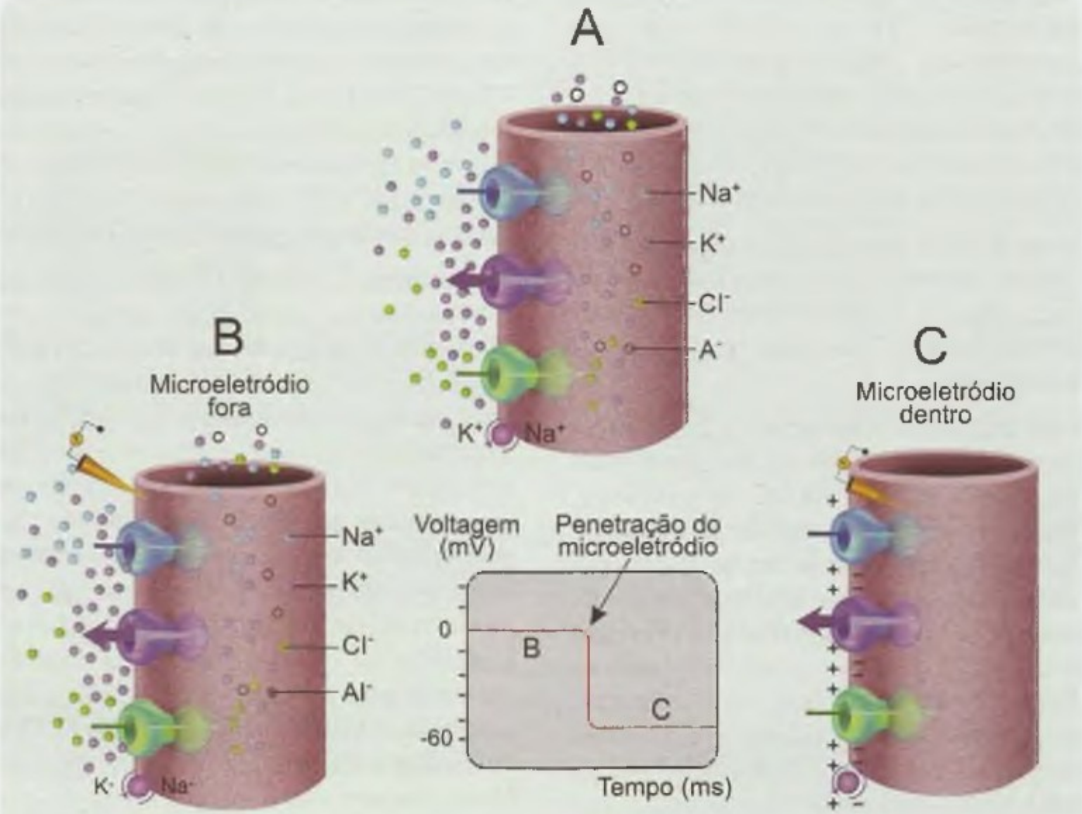


Se a corrente injetada não despolarizar a membrana até o limiar, não haverá geração do potencial de ação.

Se a corrente injetada despolarizar a membrana além do limiar, potenciais de ação serão gerados.

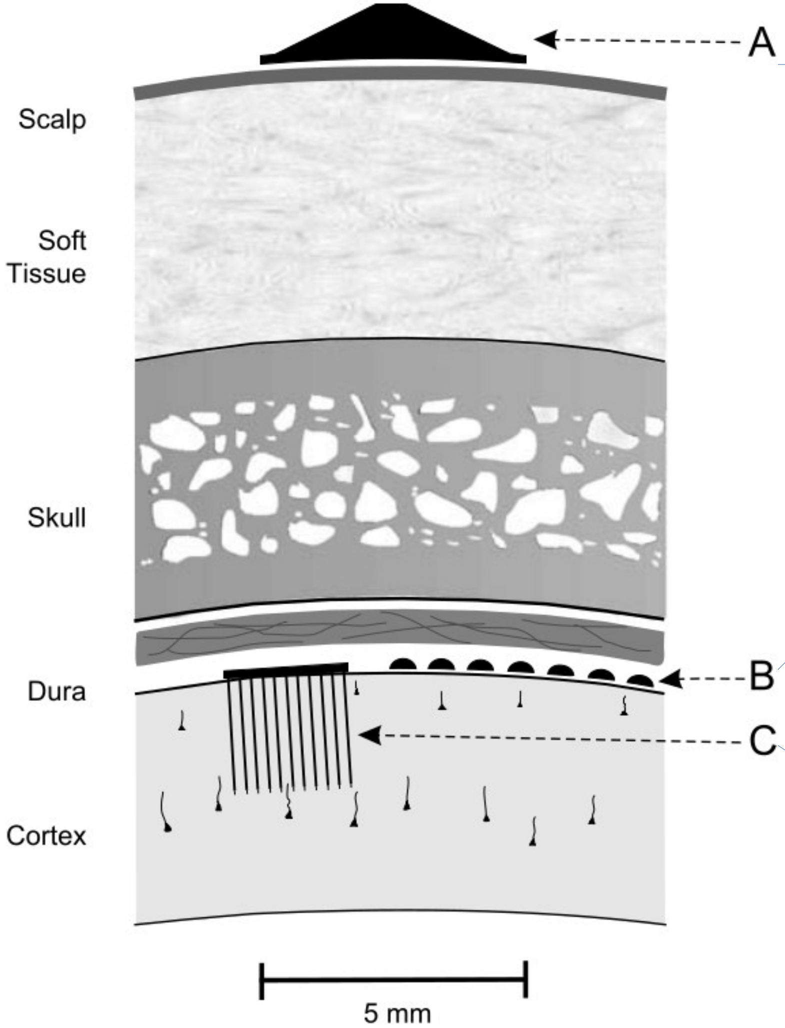
A frequência de disparo do potencial de ação aumenta à medida que a corrente despolarizante aumenta.

BEAR, Mark F.; CONNORS, Barry W.; PARADISO, MIchael A. **Neurociências**: desvendando o sistema nervoso. Porto Alegre : Artmed, 2017.



▸ **Figura 3.13.** ***A***. *O potencial de repouso existe porque o fluxo de K^+ para fora do neurônio é grande, o de Na^+ e Cl^- para dentro é pequeno, e os ânions orgânicos (A^-) permanecem "estacionários". A esfera maior violeta-clara representa a bomba de Na^+/K^+.* ***B***. *Quando um microeletródio está fora do neurônio, ele registra a diferença de potencial entre dois pontos isoelétricos, isto é, zero.* ***C***. *Quando o eletródio é inserido através da membrana, capta a negatividade da face interna em relação à face externa, registrando uma diferença de potencial negativa. O gráfico mostra o registro de potencial zero antes do eletródio atravessar a membrana (**B**), o momento do transpasse (seta), e o registro de potencial negativo depois, quando o eletródio já está no interior do neurônio (**C**).*

LENT, Roberto. **Cem bilhões de neurônios**. Conceitos fundamentais de neurociência. 2. ed. São Paulo : Atheneu, 2010.



A - Os eletrodos são colocados de forma não invasiva, no couro cabeludo (eletroencefalografia, EEG)

B - Os eletrodos são colocado na superfície do cérebro (eletrocorticografia, ECoG)

C - Os eletrodos são colocados de forma invasiva dentro do cérebro (um único neurônio, gravações)

SCHALK, Gerwin; MELLINGER, Jürgen. ***A Practical Guide to Brain–Computer Interfacing with BCI2000***. *General-Purpose Software for Brain–Computer Interface Research, Data Acquisition, Stimulus Presentation, and Brain Monitoring*. London : Springer-Verlag, 2010.

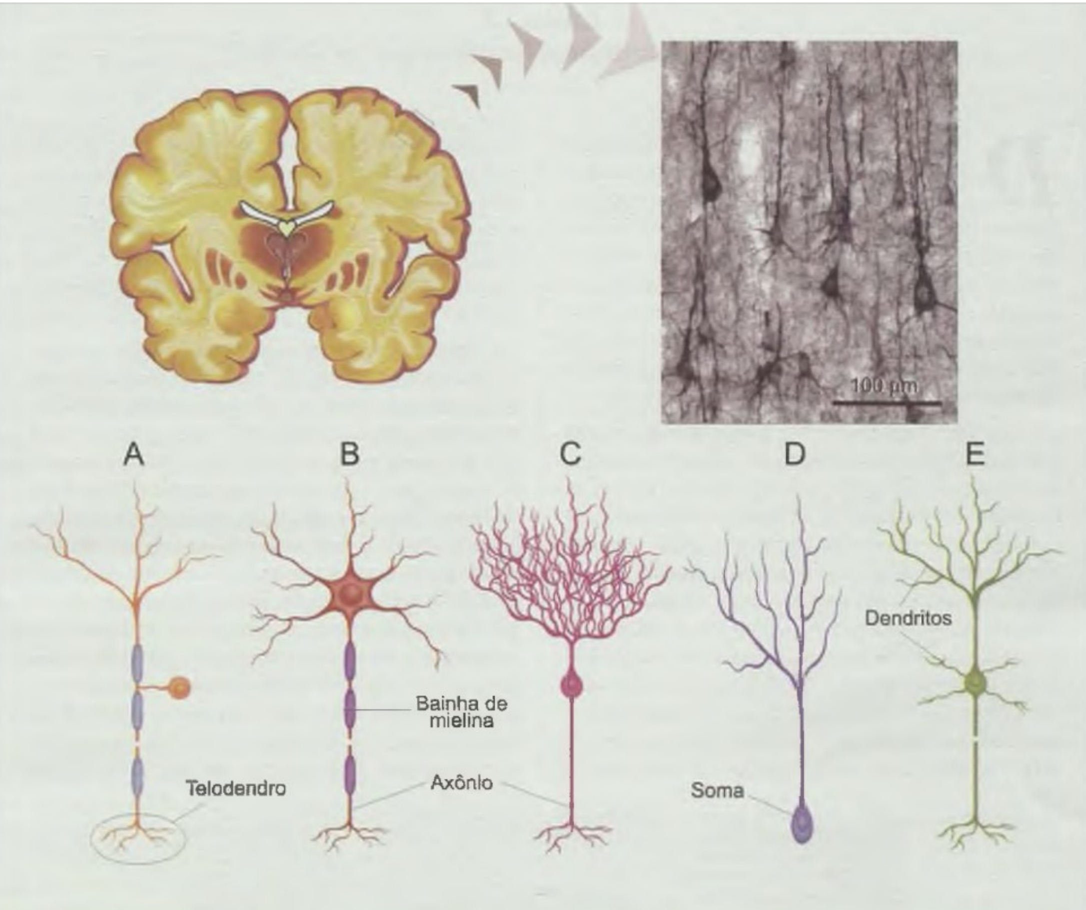
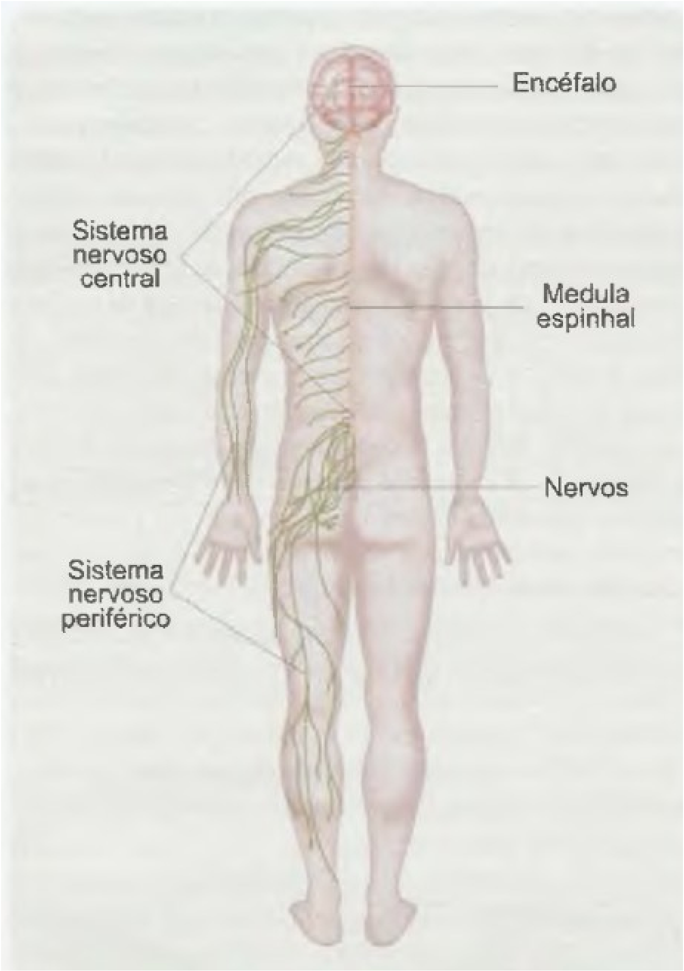
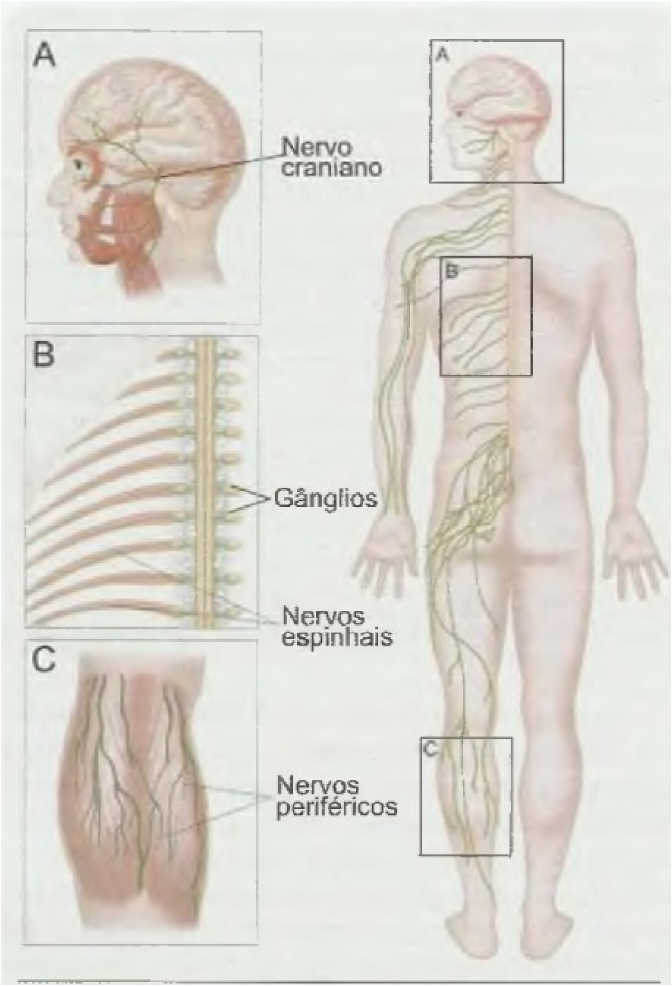


Figura 1.9. *Os neurônios só podem ser vistos ao microscópio, geralmente depois que se retira um pequeno pedaço do encéfalo (acima, à esquerda), levando-o ao micrótomo para obter cortes bem finos. Estes podem ser corados com substâncias fluorescentes ou corantes visíveis à iluminação comum, para mostrar os neurônios com suas formas variadas na disposição dos dendritos e do axônio (acima, à direita). Os desenhos representam neurônios de diversos tipos morfológicos, localizados em diferentes regiões do sistema nervoso: pseudounipolar (**A**), estrelado (**B**), de Purkinje (**C**), unipolar (**D**) e piramidal (**E**). A foto, ilustrando neurônios do córtex cerebral de um macaco, foi cedida por Juliana Soares, do Instituto de Biofísica Carlos Chagas Filho, UFRJ.*

LENT, Roberto. **Cem bilhões de neurônios**. Conceitos fundamentais de neurociência. 2. ed. São Paulo : Atheneu, 2010.





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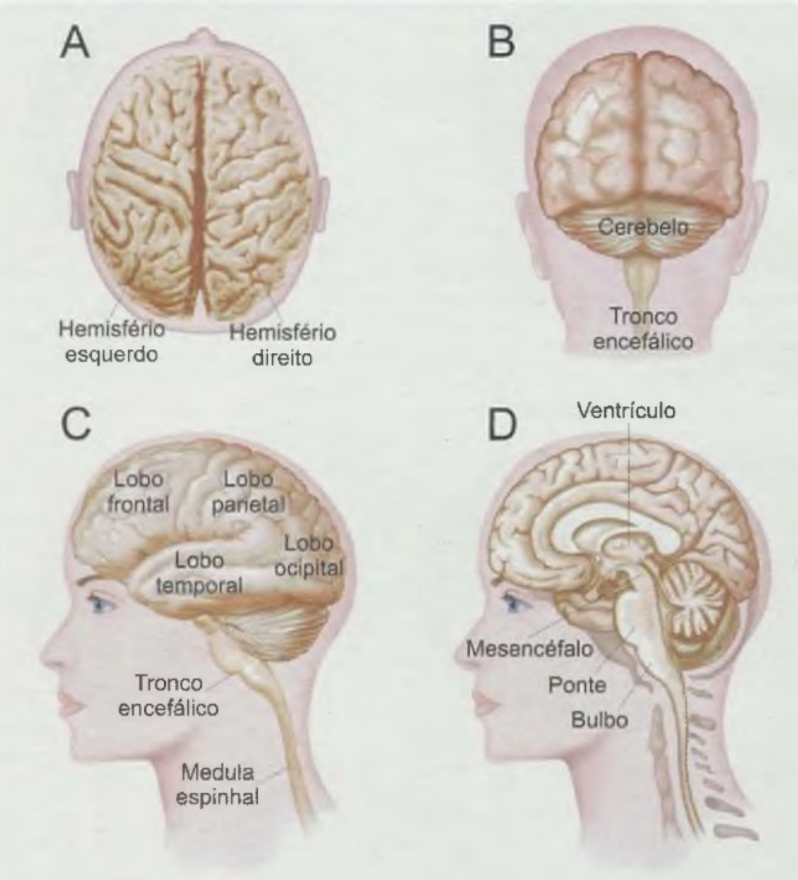


▶ **Figura 1.4.** *Os dois hemisférios cerebrais podem ser vistos de cima (**A**) ou de trás (**B**). O cerebelo e o tronco encefálico são visualizados por trás (**B**) ou de lado (**C**). E quando o encéfalo é dividido ao meio no plano sagital (**D**), veem-se algumas das estruturas internas como os ventrículos e a face medial dos hemisférios cerebrais, e estruturas parcialmente encobertas pelos hemisférios e o cerebelo, como o mesencéfalo, a ponte e o bulbo.*

LENT, Roberto. **Cem bilhões de neurônios**. Conceitos fundamentais de neurociência. 2. ed. São Paulo : Atheneu, 2010.

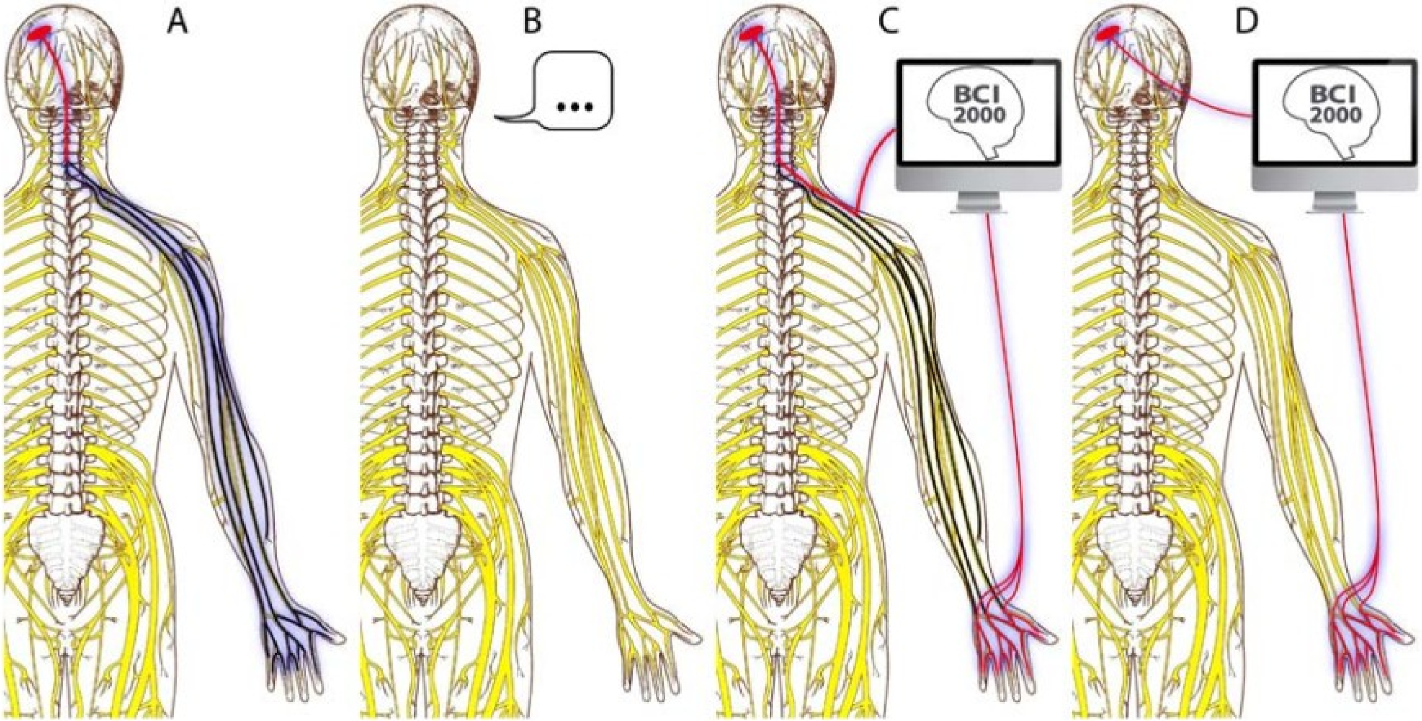
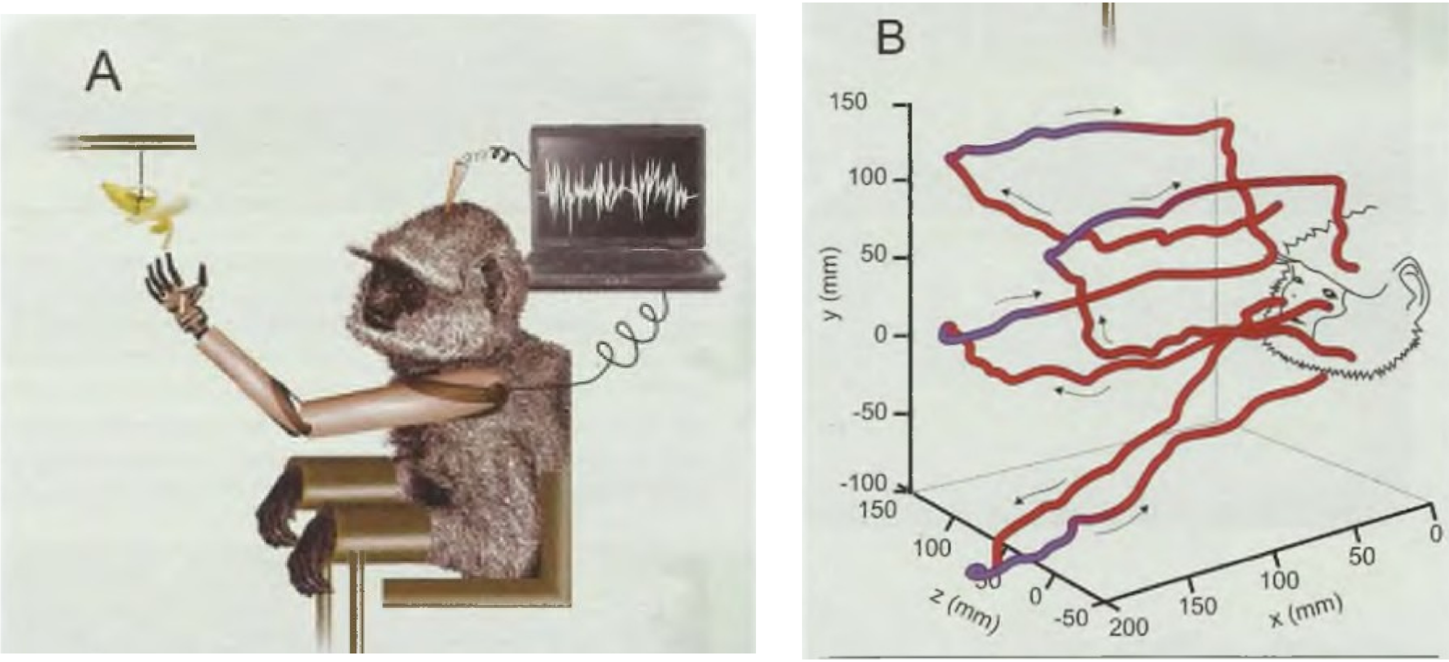


Fig. 1.1 Communication options for the paralyzed. **A**: Normal output communication channels from the brain to the periphery (e.g., the right hand) are disrupted. **B**: Option 1: Communication by substitution with other options (such as speech). **C**: Option 2: Communication by circumventing the impaired pathway. **D**: Option 3: Adding a new communication channel directly from the brain to an output device or an existing limb – a Brain–Computer Interface (BCI)

SCHALK, Gerwin; MELLINGER, Jürgen. ***A Practical Guide to Brain–Computer Interfacing with BCI2000***. *General-Purpose Software for Brain–Computer Interface Research, Data Acquisition, Stimulus Presentation, and Brain Monitoring*. London : Springer-Verlag, 2010.

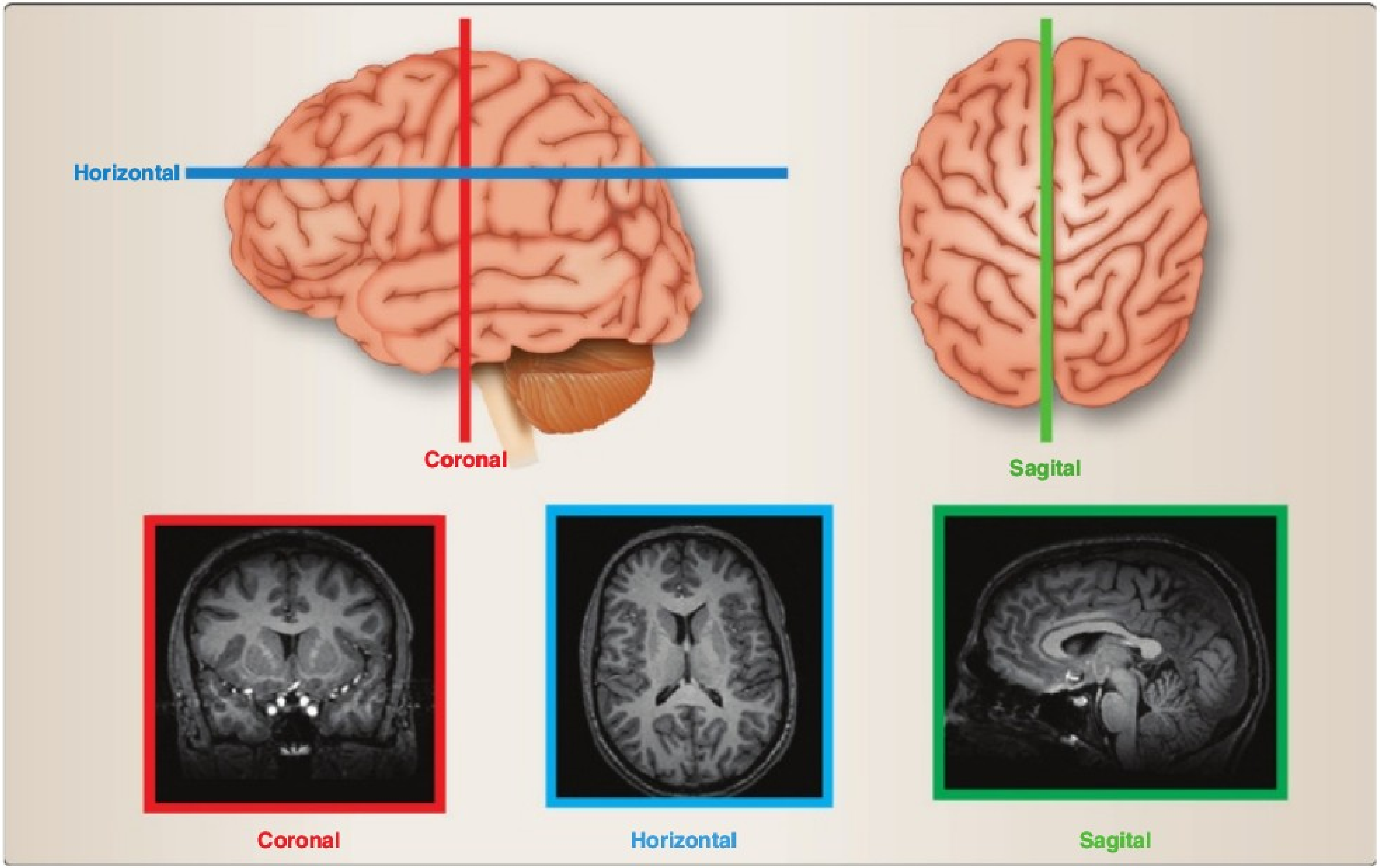


Neuroengenharia

Pesquisadores captaram, por meio de microeletródios inseridos no cérebro de um macaco a atividade elétrica simultânea de grande número de neurônios, encarregados da programação motora do braço (fig. A)

Depois, os padrões de movimento para coletar uma fruta foram analisados e um braço robótico pode ser acionado a partir dos movimentos detectados (Fig. B)

SCHALK, Gerwin; MELLINGER, Jürgen. ***A Practical Guide to Brain–Computer Interfacing with BCI2000***. *General-Purpose Software for Brain–Computer Interface Research, Data Acquisition, Stimulus Presentation, and Brain Monitoring*. London : Springer-Verlag, 2010.



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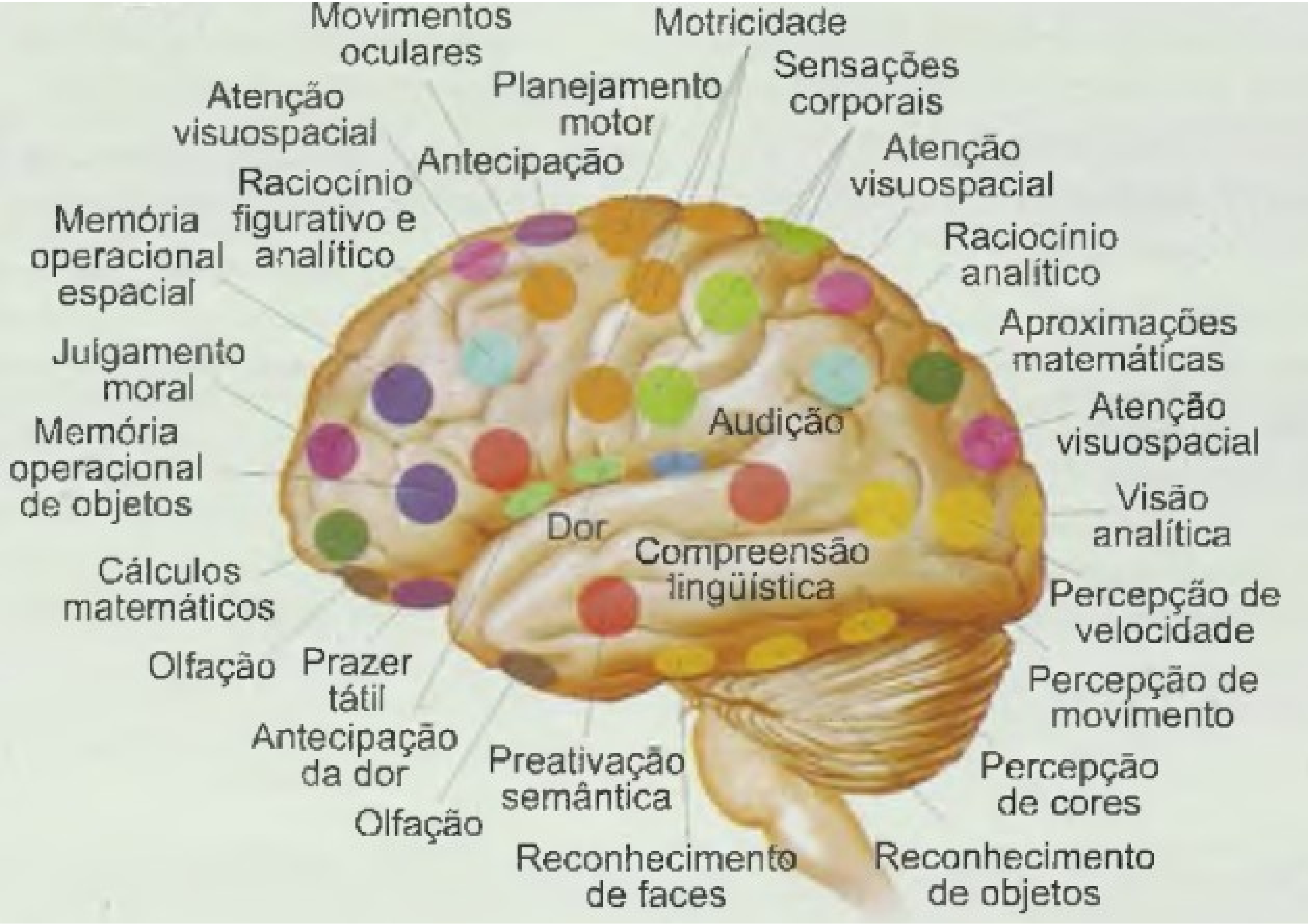

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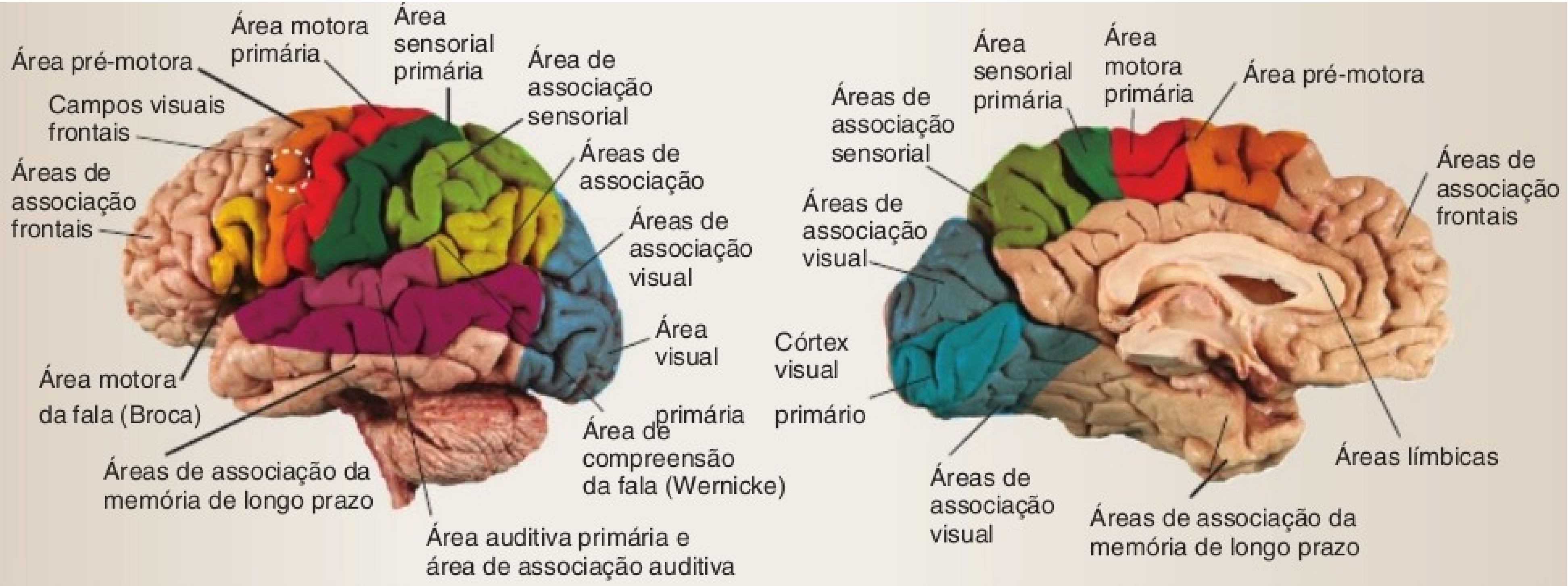

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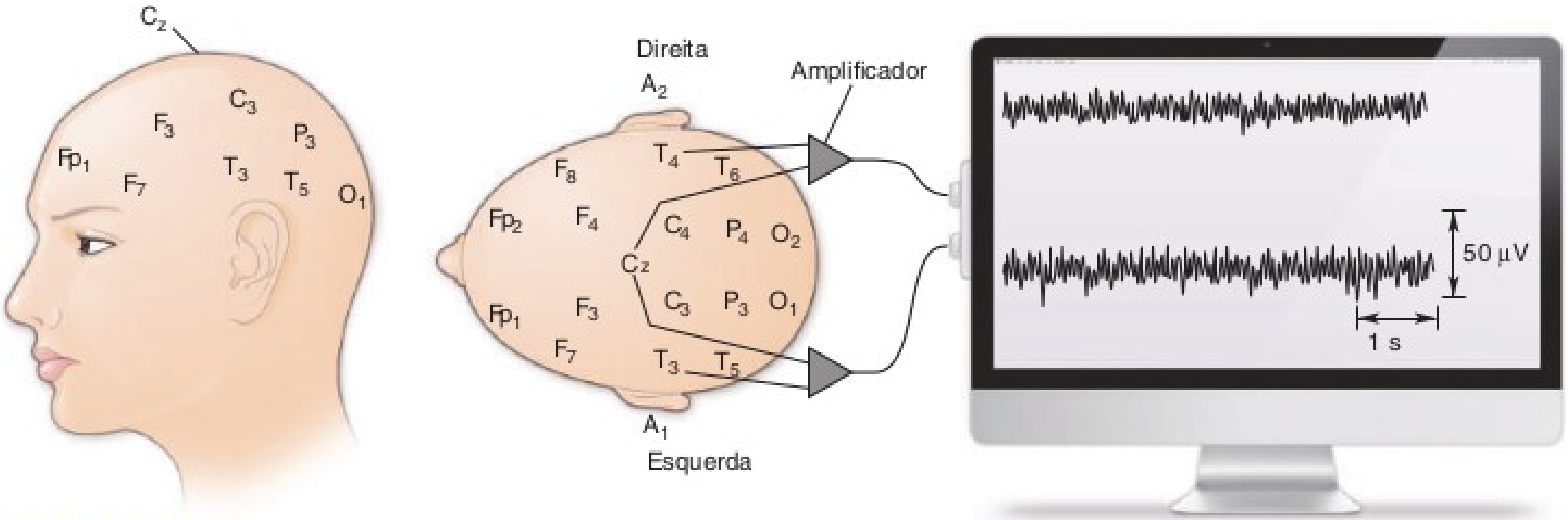
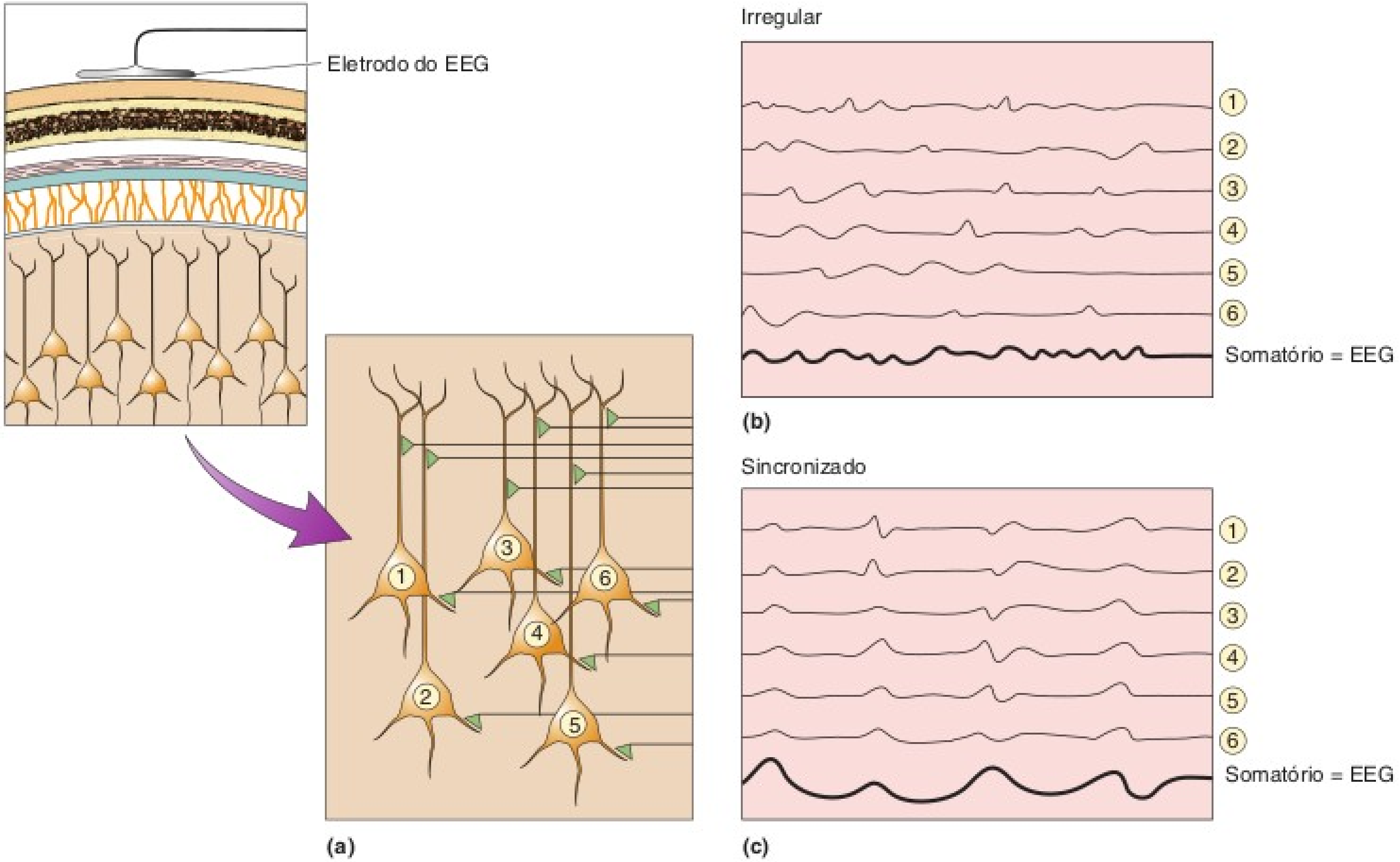


FIGURA 19.3

Posições-padrão para a colocação dos eletrodos para o EEG. A, aurícula (ou orelha); C, central; Cz, vértex; F, frontal; Fp, fronto-polar; O, occipital; P, parietal; T, temporal. Os cabos dos pares de eletrodos estão conectados aos amplificadores, cada um deles registrando medidas de diferenças de voltagem entre dois pontos no couro cabeludo. Os sinais de saída de cada amplificador são armazenados em um computador para análise e para visualização.

BEAR, Mark F.; CONNORS, Barry W.; PARADISO, MIchael A. **Neurociências**: desvendando o sistema nervoso. Porto Alegre : Artmed, 2017.

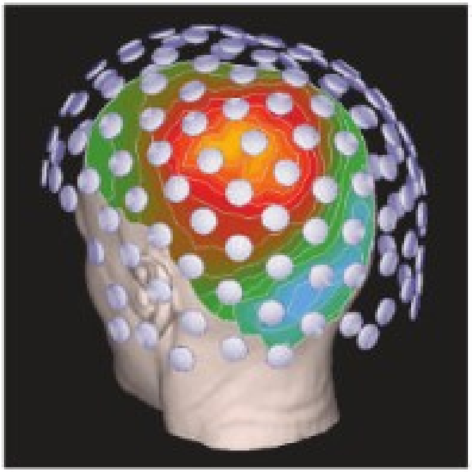


BEAR, Mark F.; CONNORS, Barry W.; PARADISO, MIchael A. **Neurociências**: desvendando o sistema nervoso. Porto Alegre : Artmed, 2017.

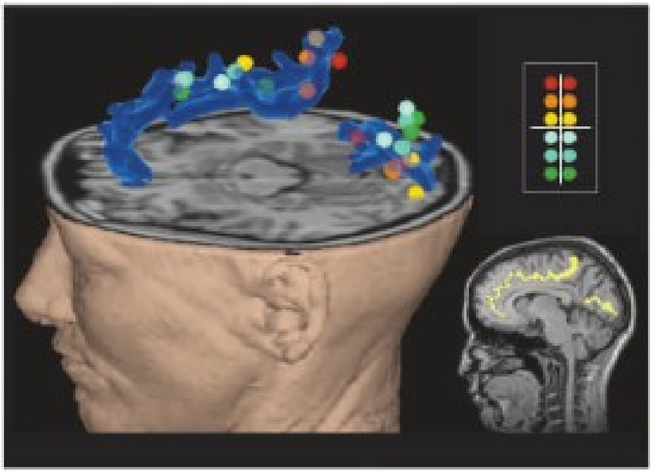
(a)

FIGURA 19.6

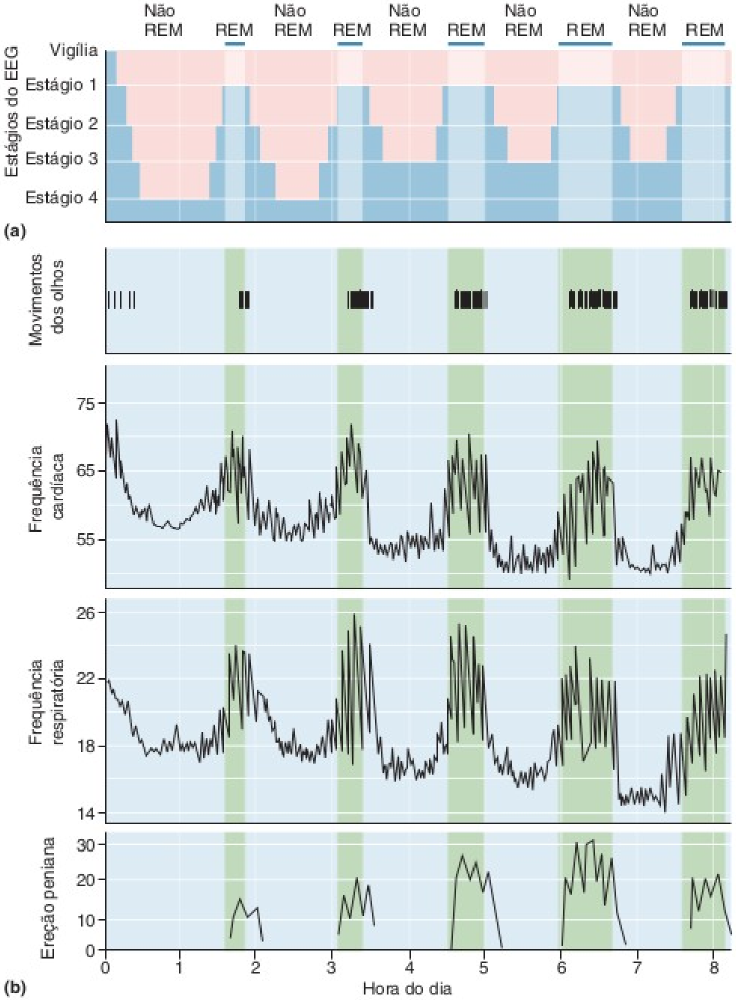
Magnetencefalografia (MEG). **(a)** Uma pessoa submetida a um esquadrinhamento encefálico por meio de MEG. **(b)** Os minúsculos sinais magnéticos gerados pelos neurônios no encéfalo são detectados por um conjunto de 150 detectores magnéticos bastante sensíveis. **(c)** Os pesquisadores utilizam os sinais para calcular as localizações das fontes de atividade neural (codificados por meio de cores, nesta imagem). (Fontes: parte a, http://infocenter.nimh.nih.gov/il/public_il/image_details.cfm?id=80; partes b e c, Los Alamos National Laboratory.)

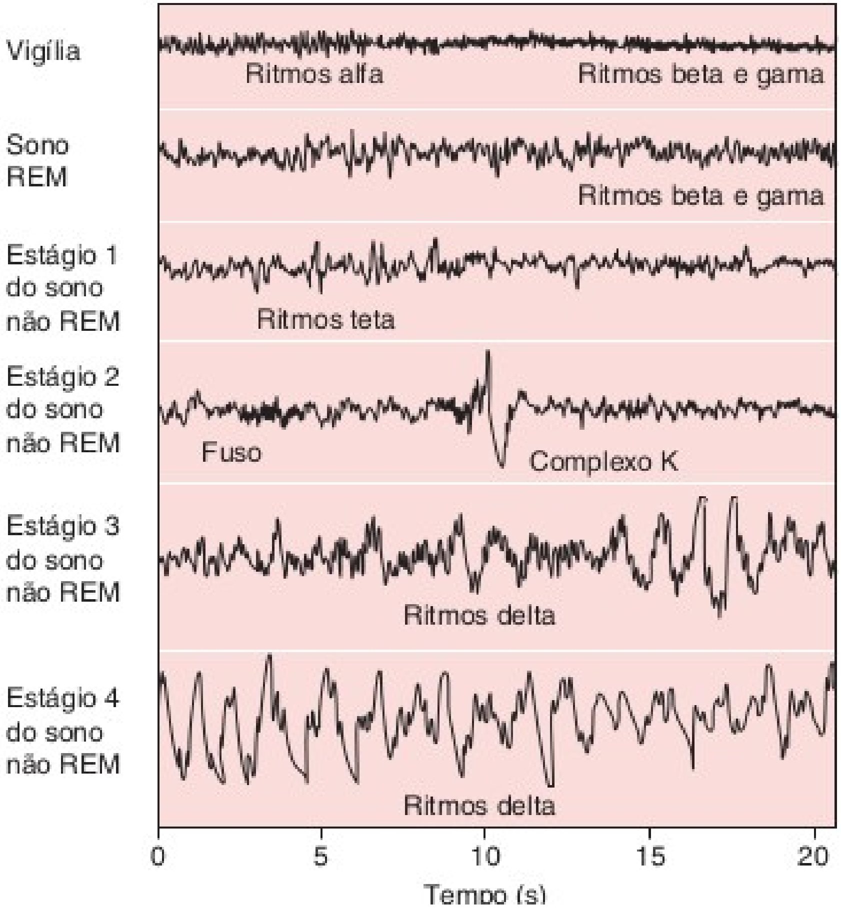


(b)



(c)





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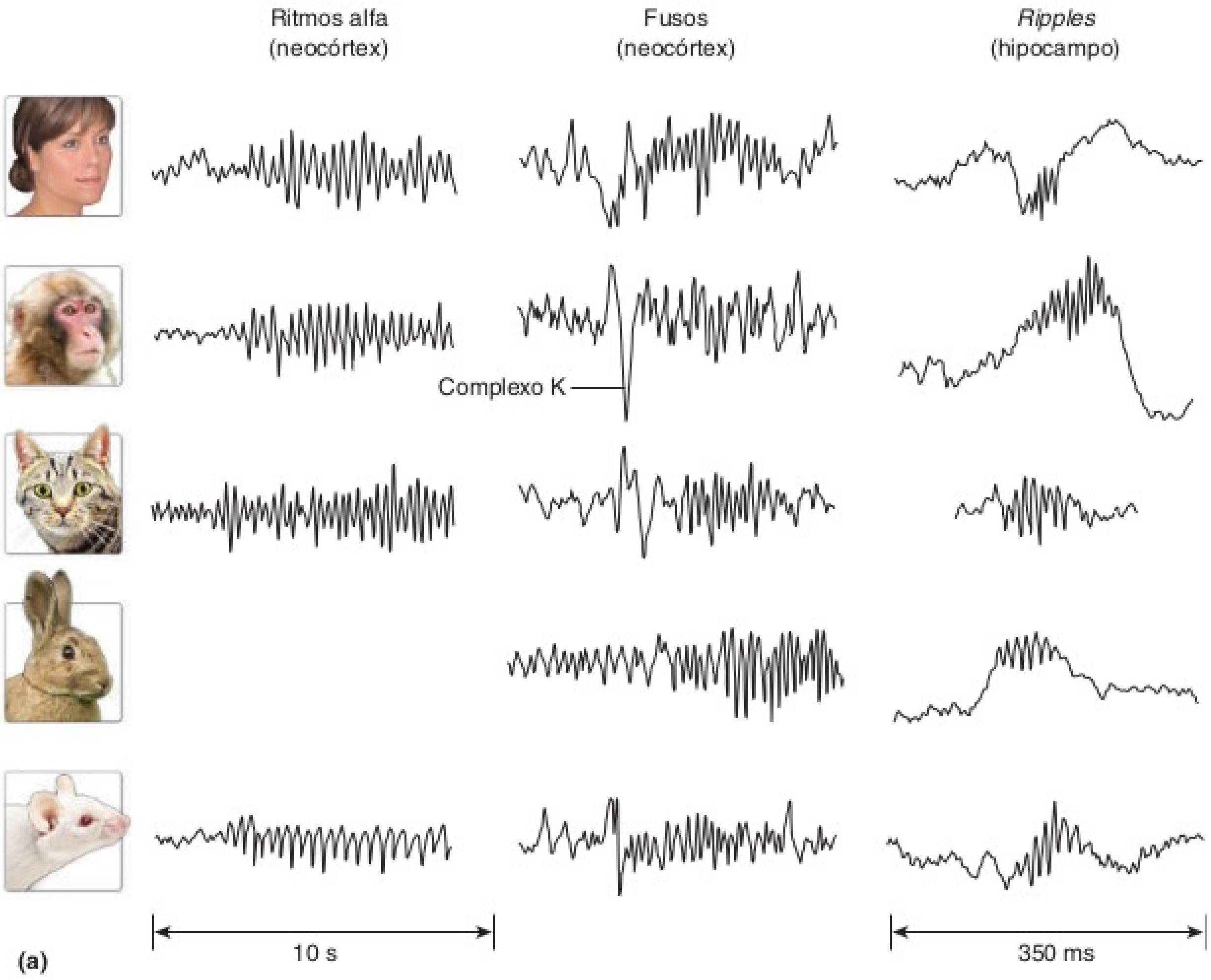


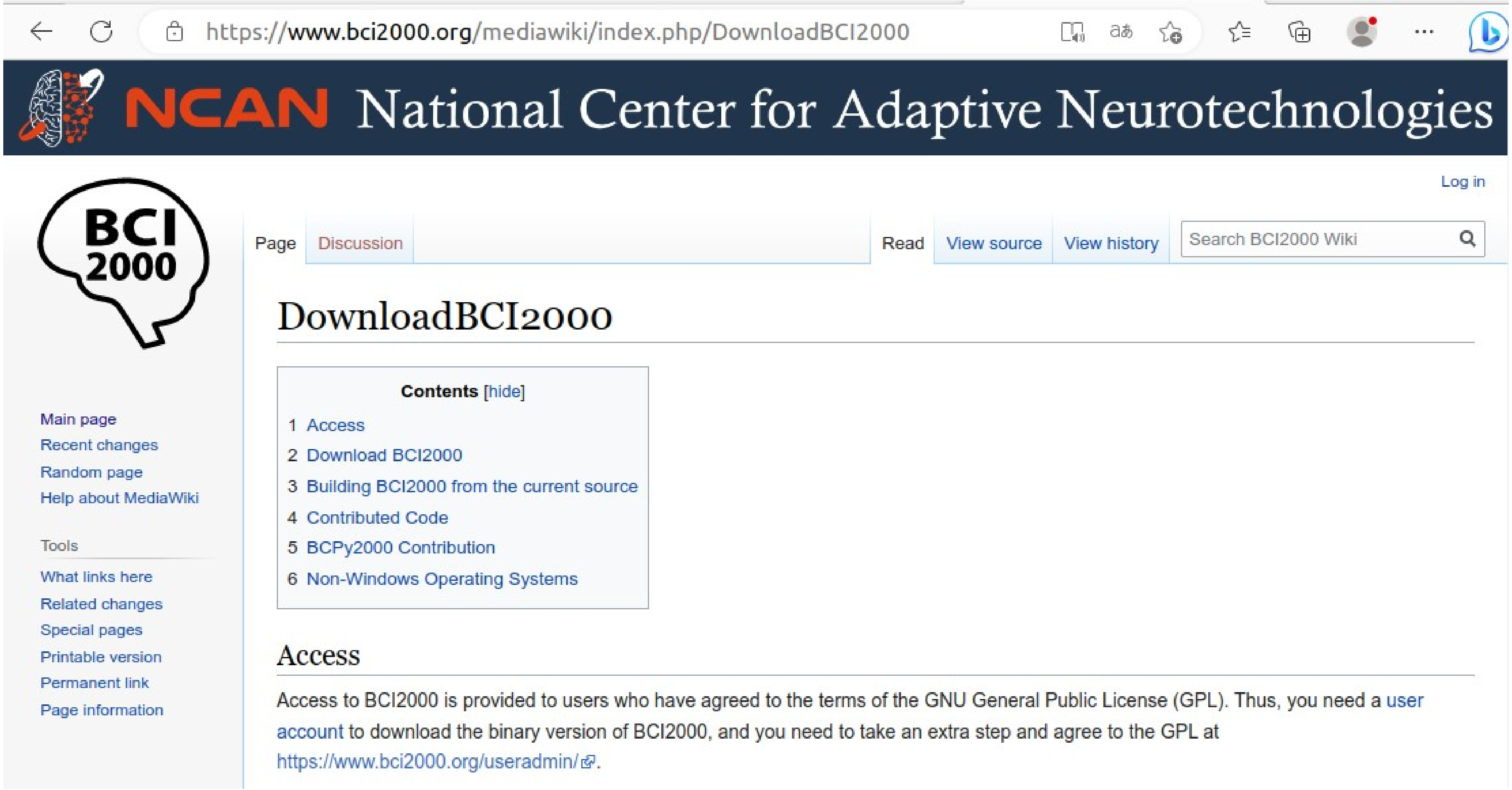
BEAR, Mark F.; CONNORS, Barry W.; PARADISO, MIchael A. **Neurociências**: desvendando o sistema nervoso. Porto Alegre : Artmed, 2017.

O que estudar? Exemplos...

- Artérias – se falta sangue em uma área um comportamento ou movimento pode ser prejudicado
- Drogas – como a química funciona e afeta o funcionamento do cérebro
- Comportamento – estruturas cognitivas e seus problemas

O que estudar? Exemplos...

- Sinais
  - Como descobrir, ou ‘tentar descobrir’ o que está acontecendo no cérebro em função dos sinais captados a partir de seu funcionamento
    - As interações entre os neurônios são eletroquímicas, geram sinais (e campos) elétricos



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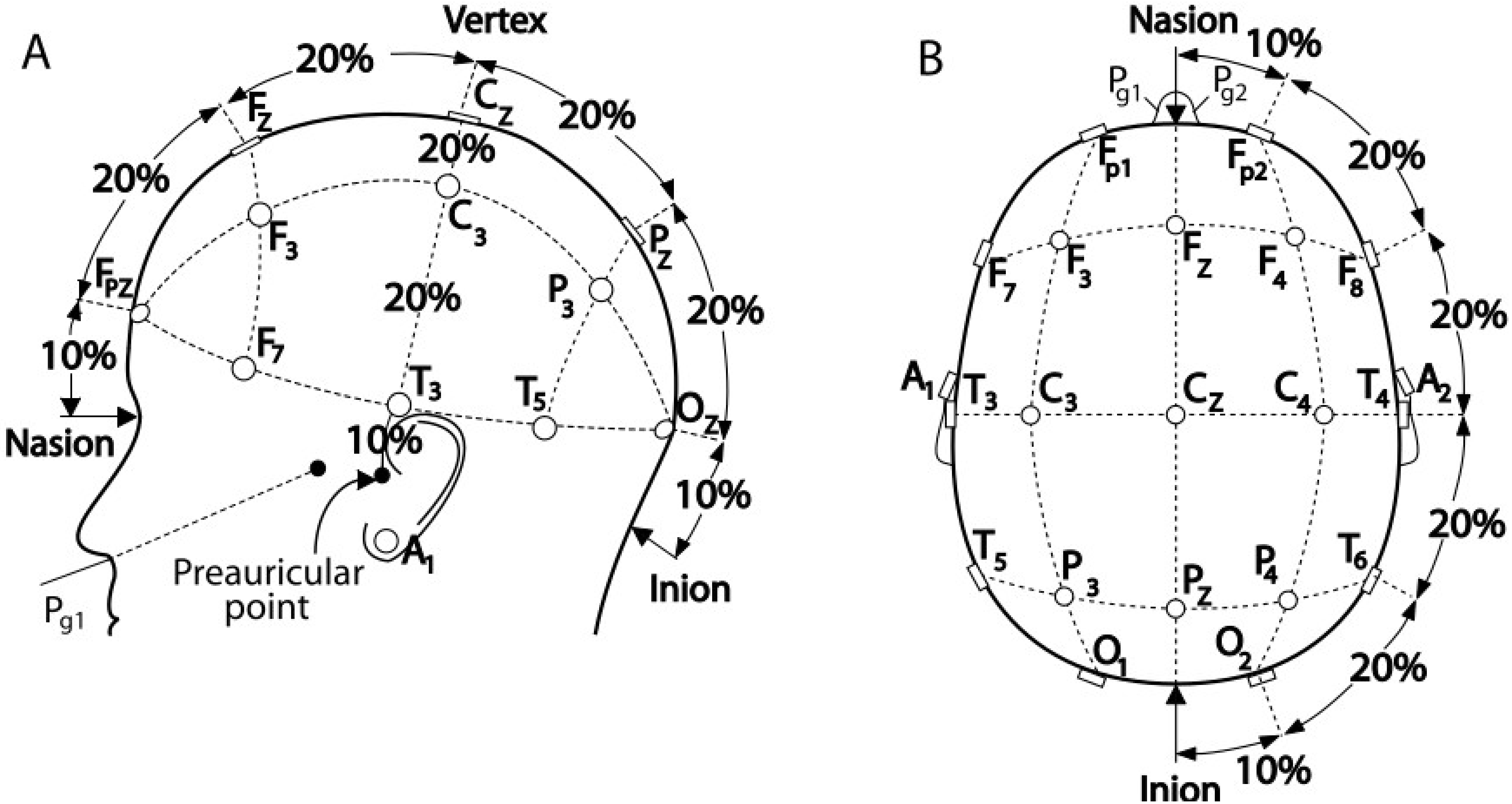

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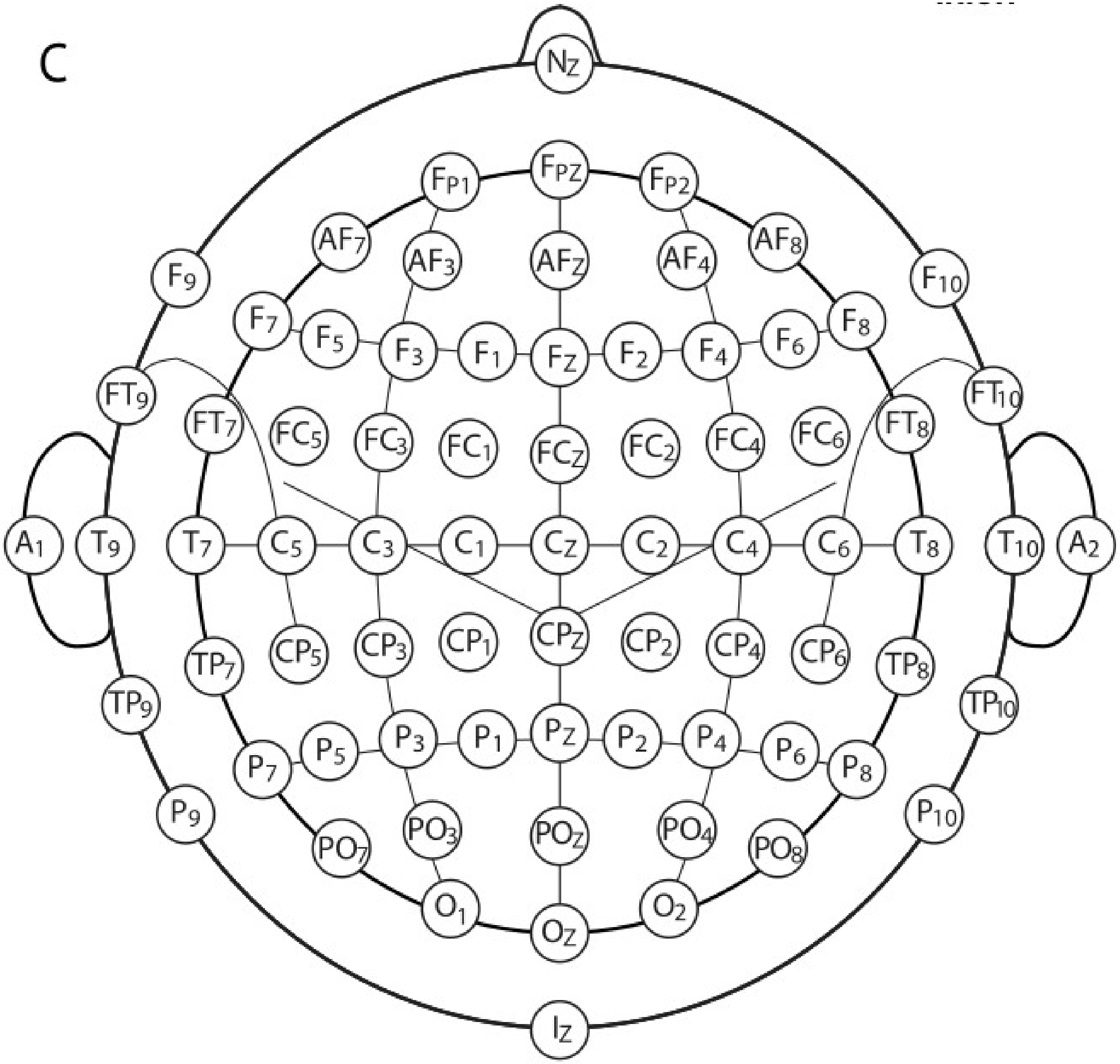


SCHALK, Gerwin; MELLINGER, Jürgen. ***A Practical Guide to Brain–Computer Interfacing with BCI2000***. *General-Purpose Software for Brain–Computer Interface Research, Data Acquisition, Stimulus Presentation, and Brain Monitoring*. London : Springer-Verlag, 2010.

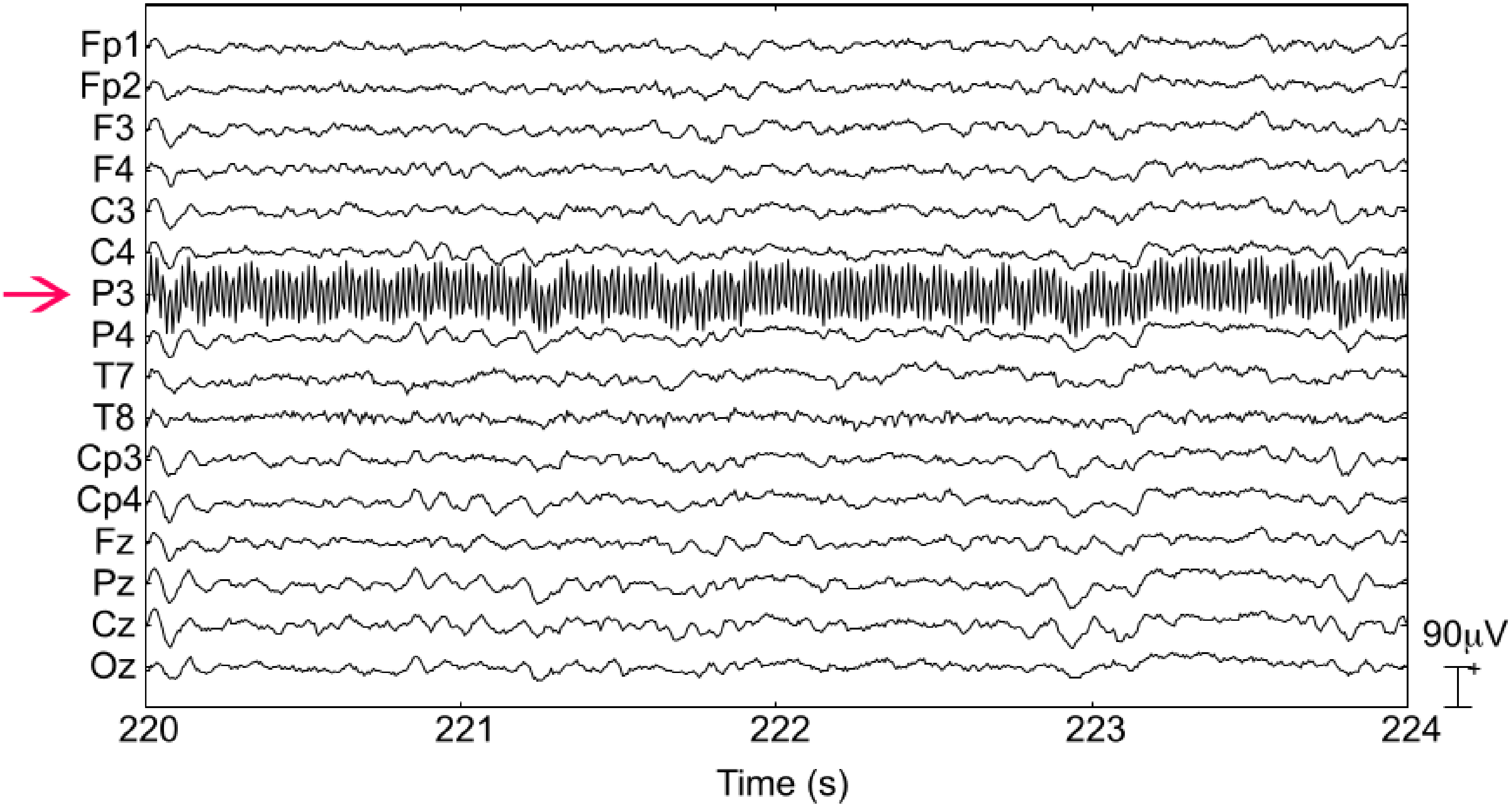
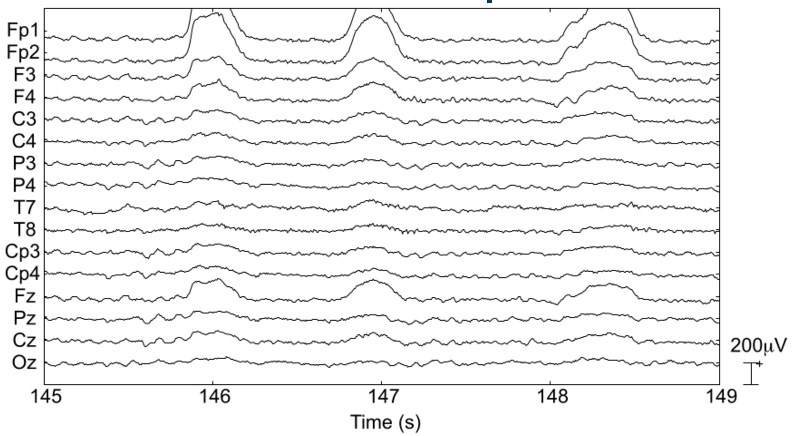


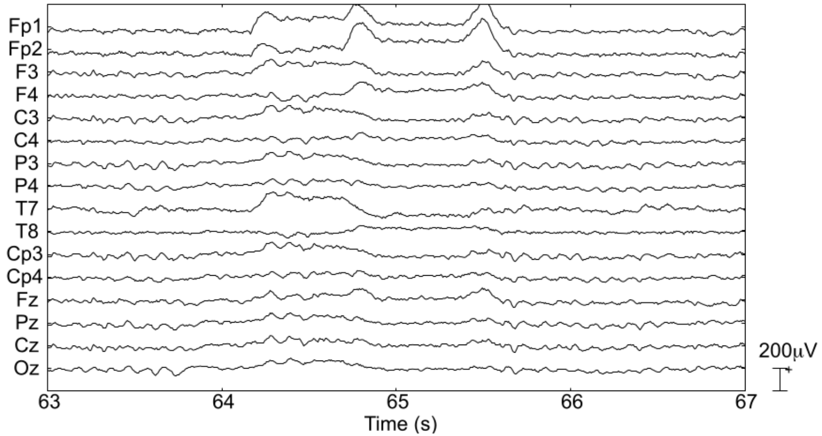
Fig. 2.7 Artifacts due to power line interference. This figure shows an example for one signal channel (marked by the *arrow*) that is contaminated by regular high frequency (i.e., 60 Hz) noise

SCHALK, Gerwin; MELLINGER, Jürgen. ***A Practical Guide to Brain–Computer Interfacing with BCI2000***. *General-Purpose Software for Brain–Computer Interface Research, Data Acquisition, Stimulus Presentation, and Brain Monitoring*. London : Springer-Verlag, 2010.

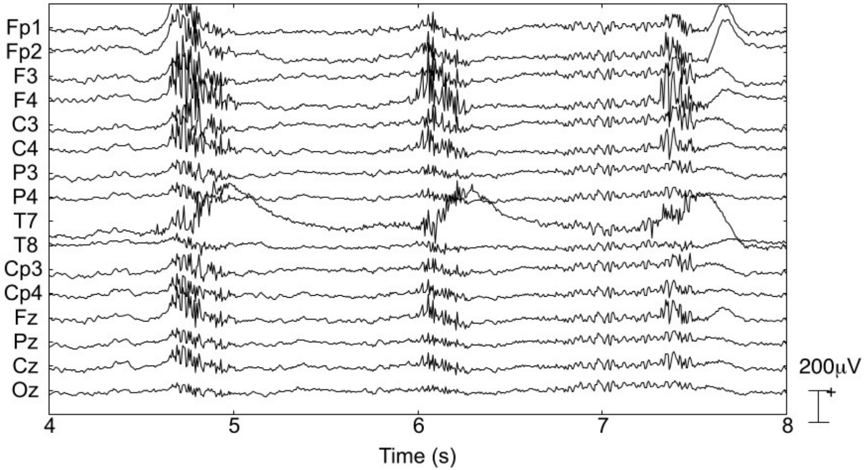
Olho piscando



Olho movimentando



Músculo atuando



SCHALK, Gerwin; MELLINGER, Jürgen. ***A Practical Guide to Brain–Computer Interfacing with BCI2000***. *General-Purpose Software for Brain–Computer Interface Research, Data Acquisition, Stimulus Presentation, and Brain Monitoring*. London : Springer-Verlag, 2010.

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Common average reference (CAR)

$$v'_i = v_i - \frac{\sum_{j=1}^{n} v_j}{n}$$

v_i é a diferença de potencial entre o eletrodo i_{th} e a referência, e n é o número total de eletrodos.

Quando $i = j$, o CAR pode sofrer um sobre ajuste (*over-fit*), pois o potencial do i-ésimo eletrodo é reduzido devido ao processo de média utilizado, podendo ser reduzido não incluindo-se o i-ésimo eletrodo na soma.

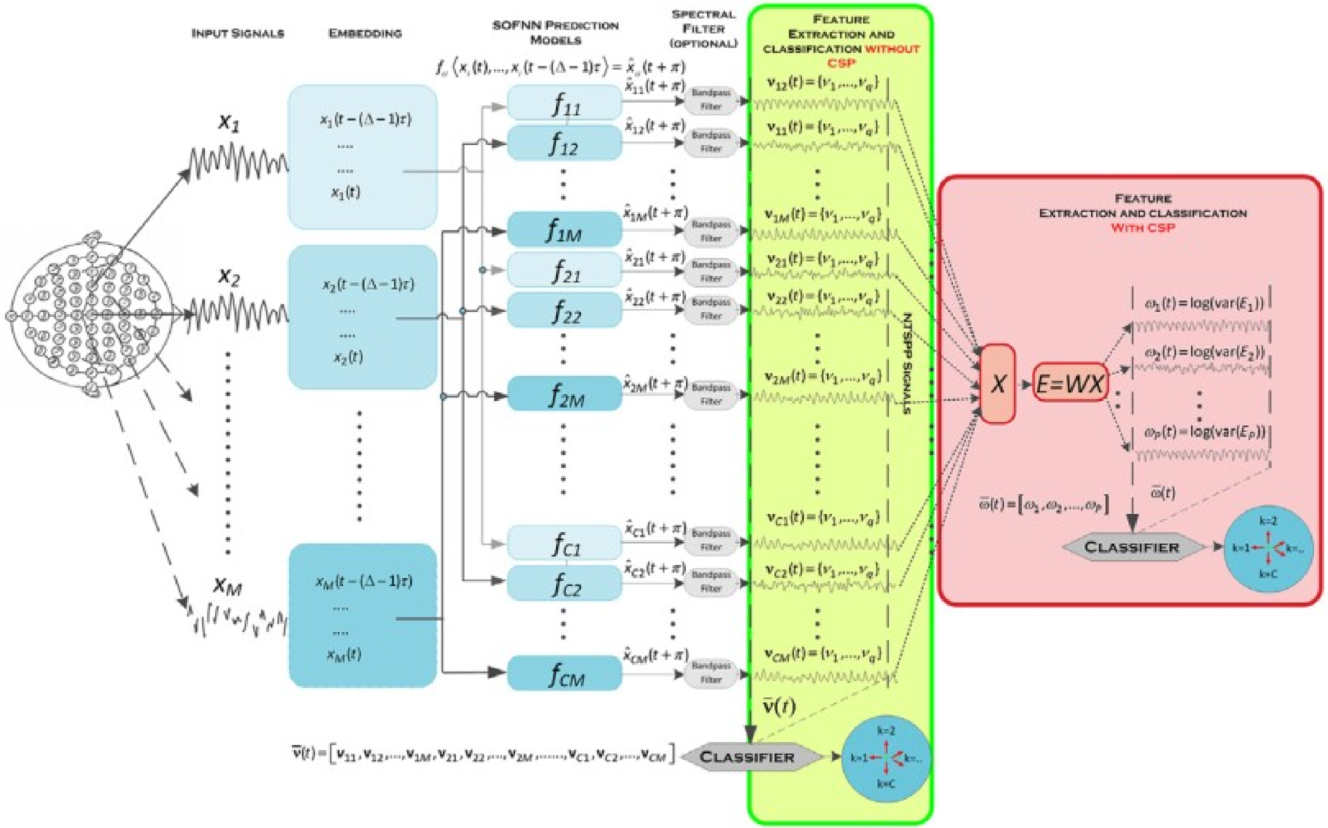
GANDHI, Vaibhav. ***Brain computer interfacing for assistive robotics***. *Electroencephalograms, Recurrent Quantum Neural Networks and User-Centric Graphical Interfaces*. London : Elsevier, 2015.

Preprocessamento

- *Refering Method*
- *Principal Component Analysis*, PCA
- *Independent Component Analysis*, ICA
- *Common Spatial Patterns*, CSP
- *Neural Time Series Prediction Preprocessing*, NTSPP

GANDHI, Vaibhav. ***Brain computer interfacing for assistive robotics***. *Electroencephalograms, Recurrent Quantum Neural Networks and User-Centric Graphical Interfaces*. London : Elsevier, 2015.

Neural Time Series Prediction Preprocessing, NTSPP



GANDHI, Vaibhav. ***Brain computer interfacing for assistive robotics***. *Electroencephalograms, Recurrent Quantum Neural Networks and User-Centric Graphical Interfaces*. London : Elsevier, 2015.

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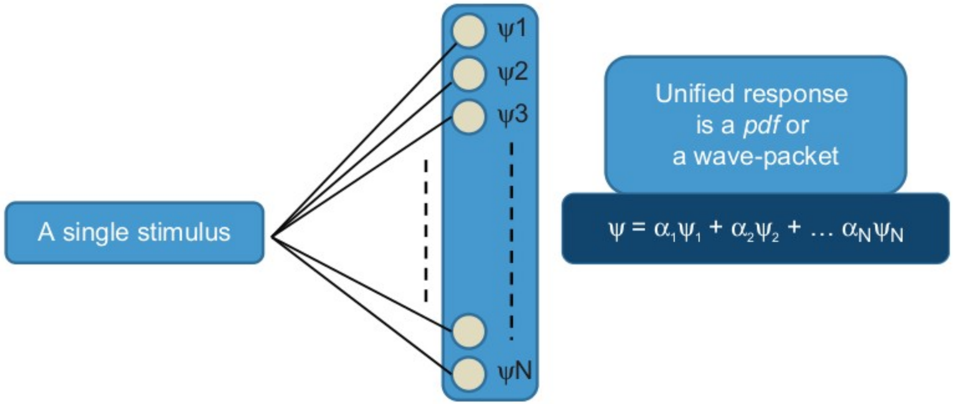
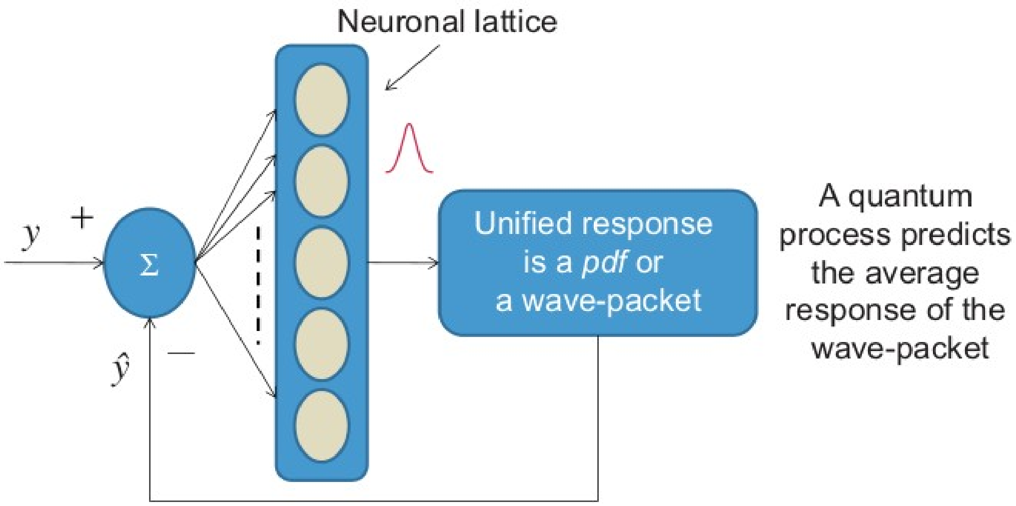
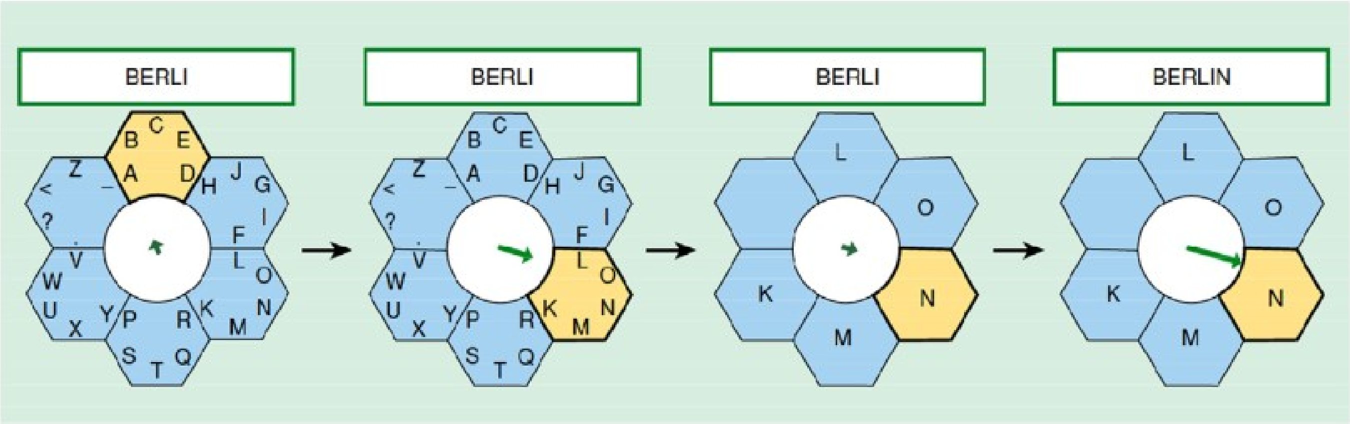


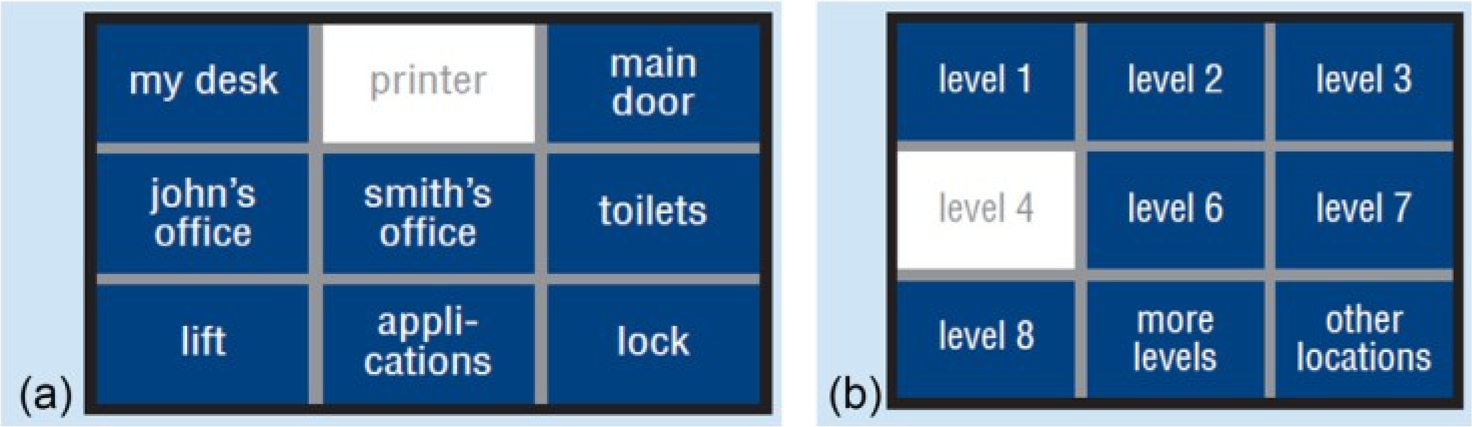
PDF = *probability density function*



GANDHI, Vaibhav. ***Brain computer interfacing for assistive robotics***. *Electroencephalograms, Recurrent Quantum Neural Networks and User-Centric Graphical Interfaces*. London : Elsevier, 2015.

GANDHI, Vaibhav. ***Brain computer interfacing for assistive robotics***. *Electroencephalograms, Recurrent Quantum Neural Networks and User-Centric Graphical Interfaces*. London : Elsevier, 2015.





GANDHI, Vaibhav. ***Brain computer interfacing for assistive robotics***. *Electroencephalograms, Recurrent Quantum Neural Networks and User-Centric Graphical Interfaces*. London : Elsevier, 2015.

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Superfície Laplaciana

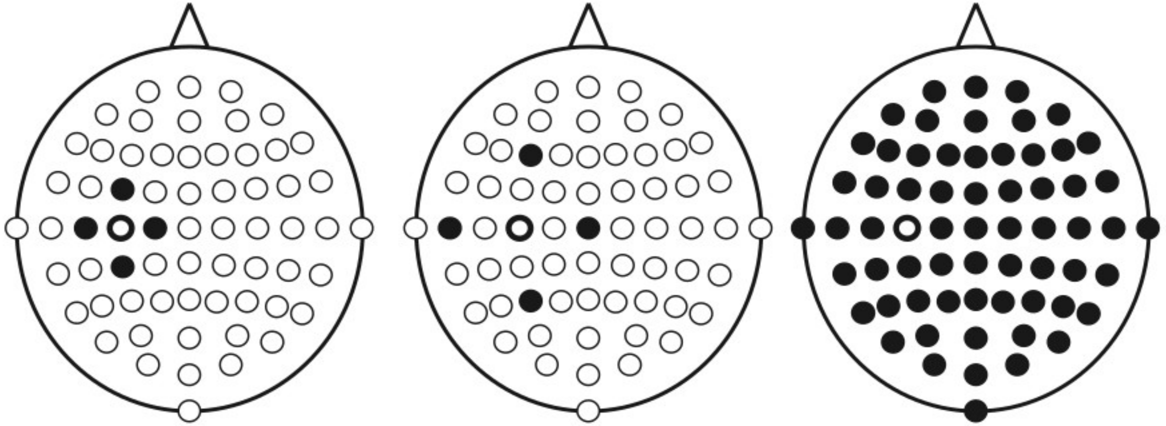
$$s'_h(t) = s_h(t) - \sum_{i \in S_i} w_{h,i} s_i(t)$$

```
#include <iostream>
#include "SockStream.h"

using namespace std;

int main( int argc, char** argv )
{
  const char* address = "localhost:5000";
  if( argc > 1 )
    address = argv[ 1 ];

  receiving_udpsocket socket( address );
  sockstream connection( socket );
  string line;
  // Print each line of BCI2000 input to stdout.
  while( getline( connection, line ) )
    cout << line << endl;

  return 0;
}
```

```
void LPFilter::Process( const GenericSignal& input,
                        GenericSignal& output )
{
  for( int ch = 0; ch < input.Channels(); ++ch )
  {
    for( int s = 0; s < input.Elements(); ++s )
    {
      mPreviousOutput[ ch ] *= mDecayFactor;
      mPreviousOutput[ ch ] +=
           input( ch, s ) * ( 1.0 - mDecayFactor );
      output( ch, s ) = mPreviousOutput[ ch ];
    }
  }
}
```

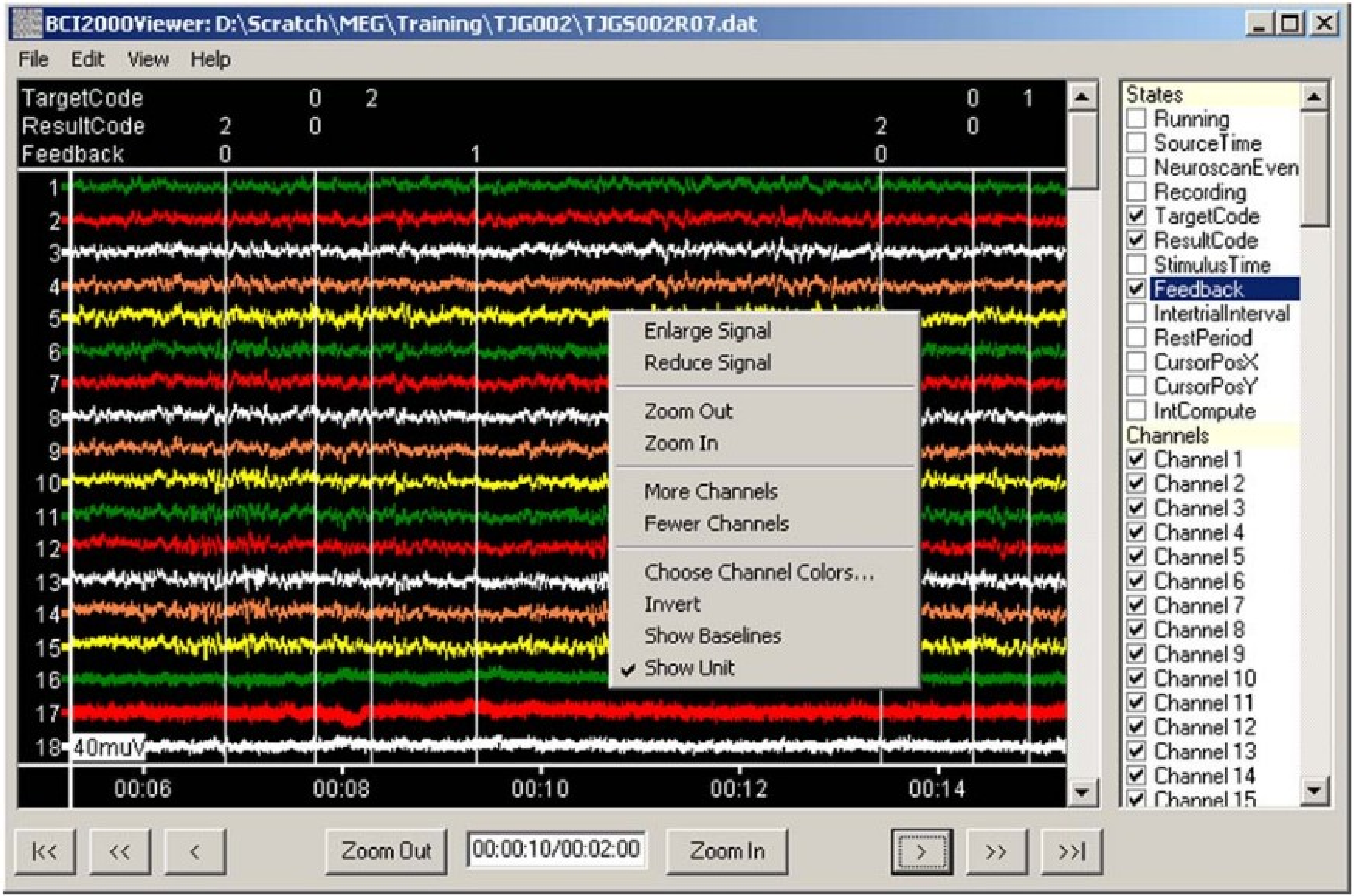
$$w_{h,i} = \frac{\frac{1}{d_{h,i}}}{\sum_{i \in S_i} \frac{1}{d_{h,i}}}$$

O peso $w_{h,i}$ é uma função da distância $d_{h,i}$ entre o eletrodo de interesse *h* e seu vizinho *i*

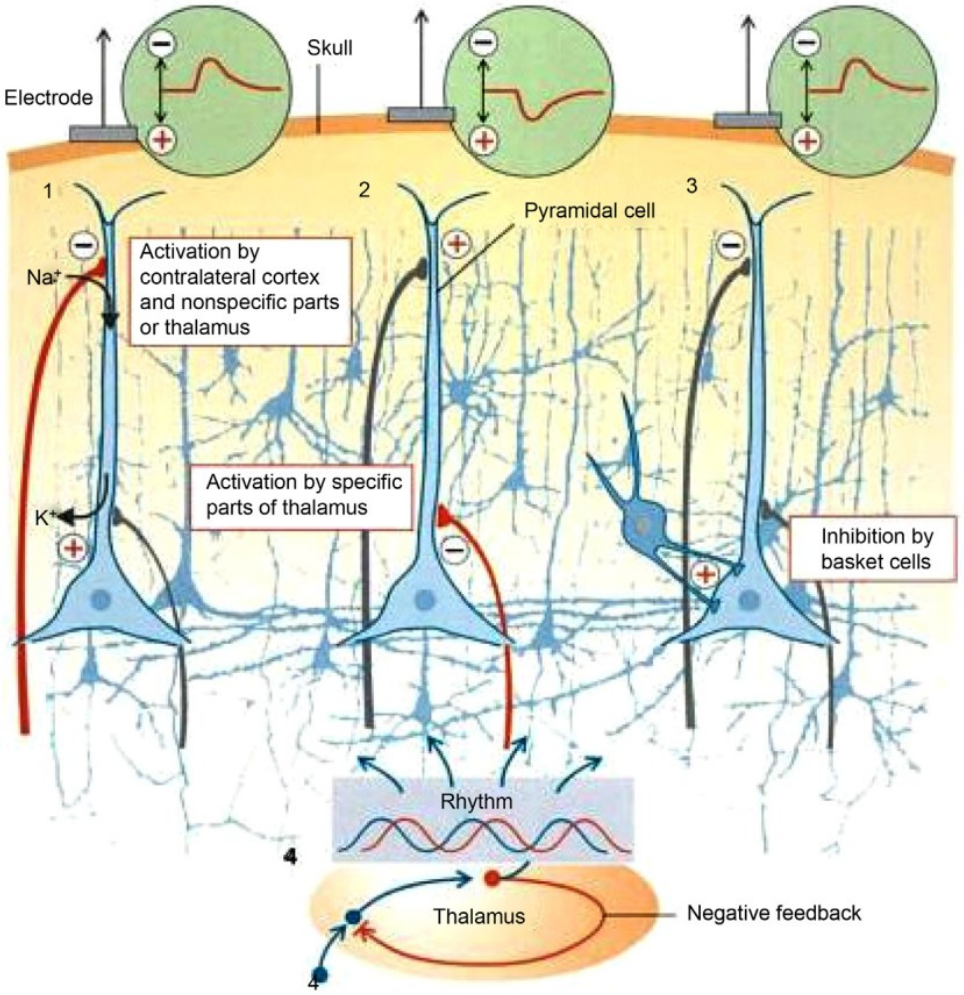


(a) Small Laplacian (b) Large Laplacian (c) Common average reference (CAR)

SCHALK, Gerwin; MELLINGER, Jürgen. ***A Practical Guide to Brain–Computer Interfacing with BCI2000***. *General-Purpose Software for Brain–Computer Interface Research, Data Acquisition, Stimulus Presentation, and Brain Monitoring*. London : Springer-Verlag, 2010.



SCHALK, Gerwin; MELLINGER, Jürgen. ***A Practical Guide to Brain–Computer Interfacing with BCI2000***. *General-Purpose Software for Brain–Computer Interface Research, Data Acquisition, Stimulus Presentation, and Brain Monitoring*. London : Springer-Verlag, 2010.

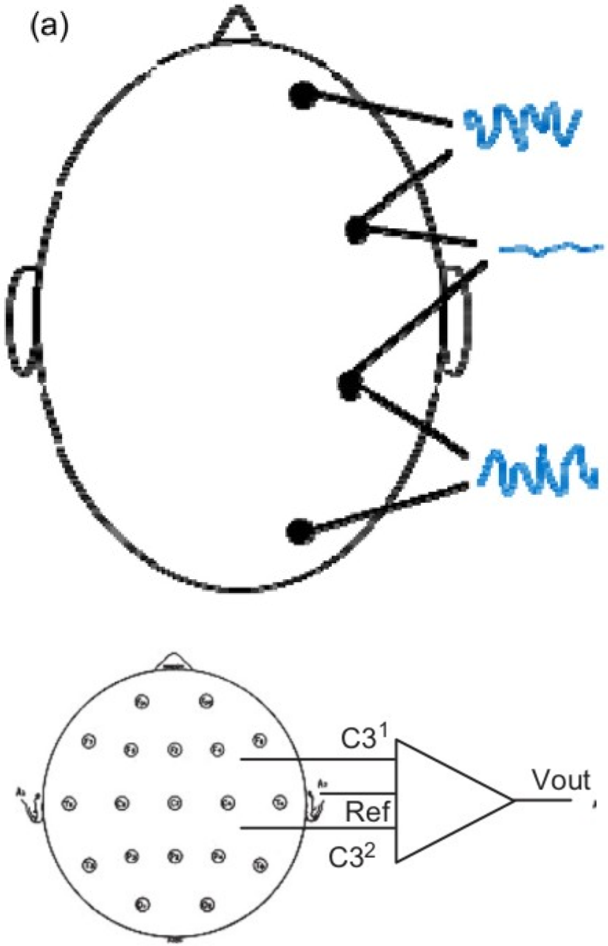


GANDHI, Vaibhav. ***Brain computer interfacing for assistive robotics***. *Electroencephalograms, Recurrent Quantum Neural Networks and User-Centric Graphical Interfaces*. London : Elsevier, 2015.

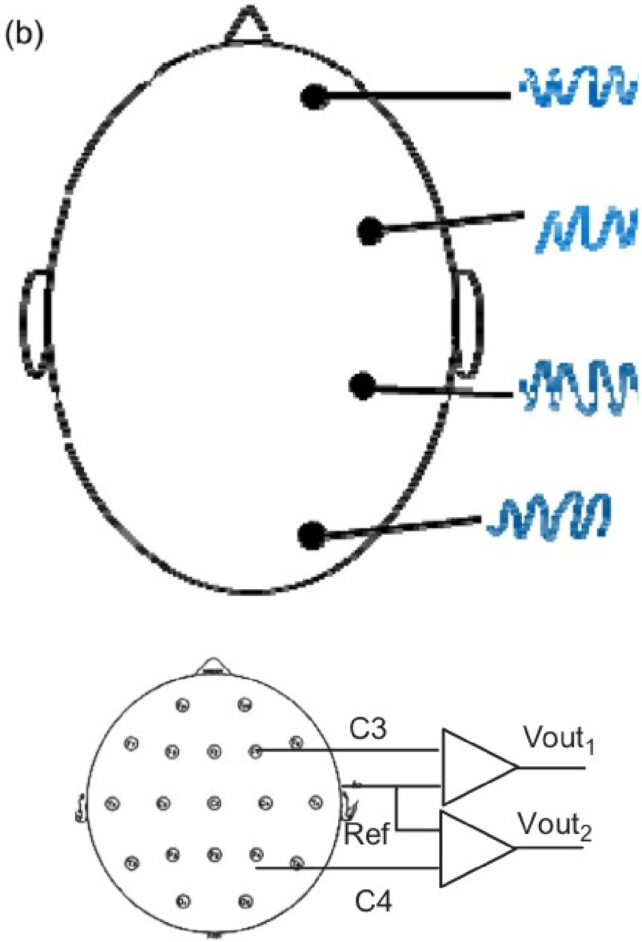
TABLE 2.1 Brain Rhythms and Relevant Frequency Band Details

Brain rhythm	Typical frequency range (Hz)	Normal amplitude (μV)	Comments
Delta	0.5–4	<100	Dominant in infants and during deep stages of adult sleep. Found in the central cerebrum and parietal lobes
Theta	4–7	<100	In children and drowsy normal adults Found in the frontal, parietal and temporal regions
Alpha	8–13	20–60	This is the most prominent rhythm in the normal alert adult brain. Most prominent in the occipital and parietal regions
Mu	9–11	<50	This frequency band is associated with hand movements. Found over the motor and somatosensory cortex
Beta	14–30	<20	This frequency band is also associated with hand movements
Gamma	>30	<2	Found when the subject is paying attention or is having some sensory stimulation

GANDHI, Vaibhav. ***Brain computer interfacing for assistive robotics***. *Electroencephalograms, Recurrent Quantum Neural Networks and User-Centric Graphical Interfaces*. London : Elsevier, 2015.



(a) Bipolar measurement



(b) Unipolar measurement

GANDHI, Vaibhav. ***Brain computer interfacing for assistive robotics***. *Electroencephalograms, Recurrent Quantum Neural Networks and User-Centric Graphical Interfaces*. London : Elsevier, 2015.

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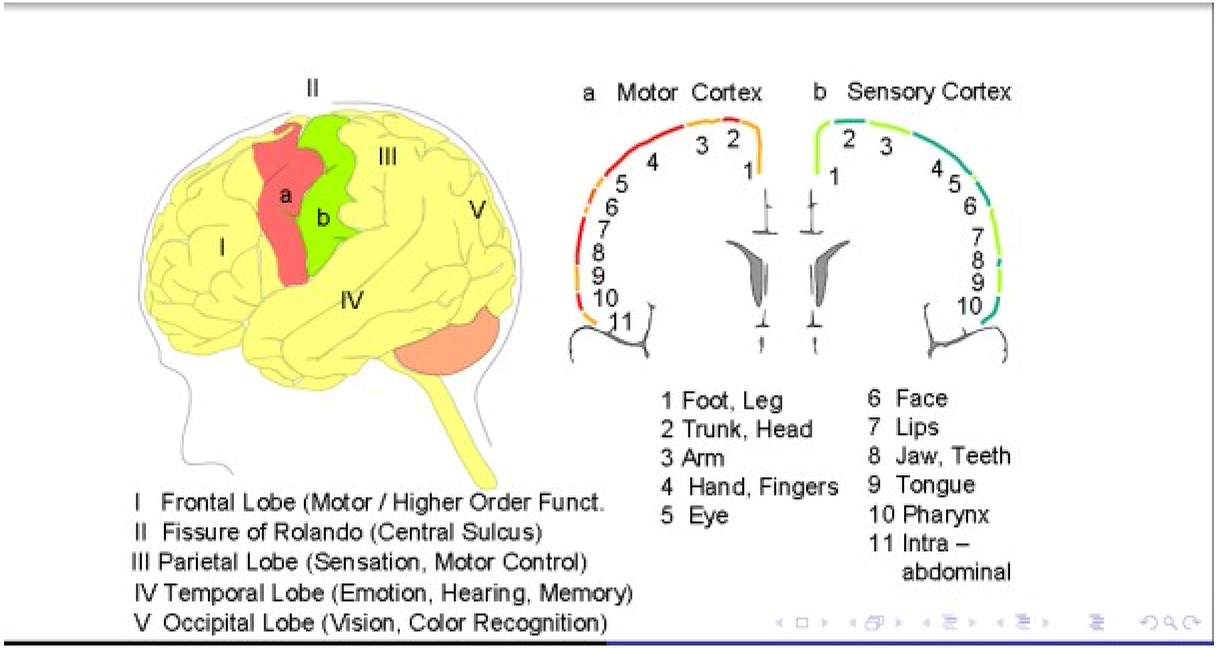
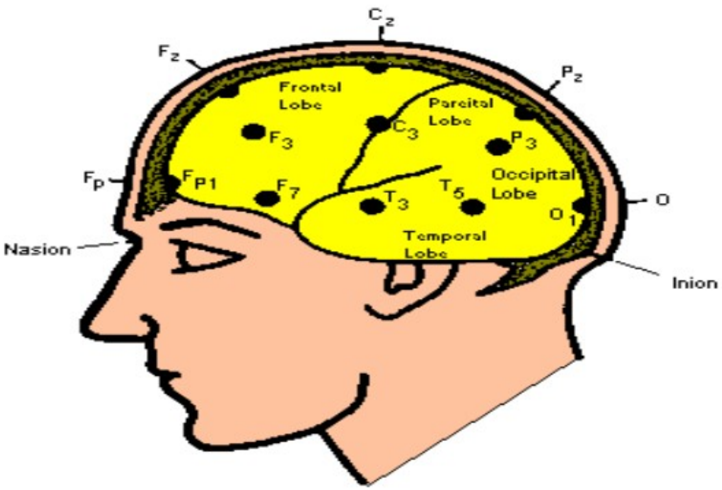
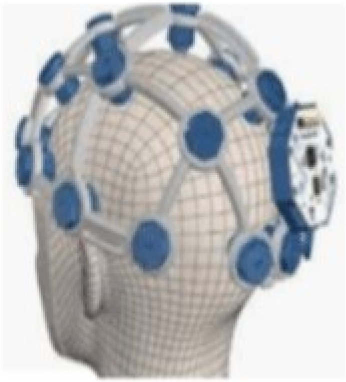
Electrode Placement:

- Standard “10-20 System”
- Spaced apart 10-20%
- Letter for region
  - F - Frontal Lobe
  - T - Temporal Lobe
  - C - Center
  - O - Occipital Lobe
- Number for exact position
  - Odd numbers - left
  - Even numbers - right







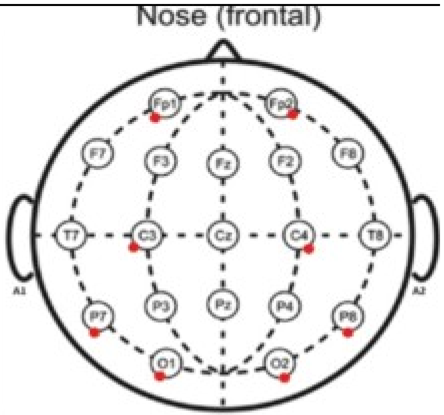


FIGURE 1.34. Rhythmic temporal theta bursts of drowsiness. Note the sharply contoured morphology.

TATUM, Willian O.; HUSAIN, Aatif M.; BENBADIS, Selim R. ***Handbook of EEG interpretation***. Florida : Demos Medical Publishing, 2008.

Brainwave Type	Frequency range	Mental states and conditions
Delta	0.1Hz to 3Hz	Deep, dreamless sleep, non-REM sleep, unconscious
Theta	4Hz to 7Hz	Intuitive, creative, recall, fantasy, imaginary, dream
Alpha	8Hz to 12Hz	Relaxed, but not drowsy, tranquil, conscious
Low Beta	12Hz to 15Hz	Formerly SMR, relaxed yet focused, integrated
Midrange Beta	16Hz to 20Hz	Thinking, aware of self & surroundings
High Beta	21Hz to 30Hz	Alertness, agitation

NeuroSky
MindWave

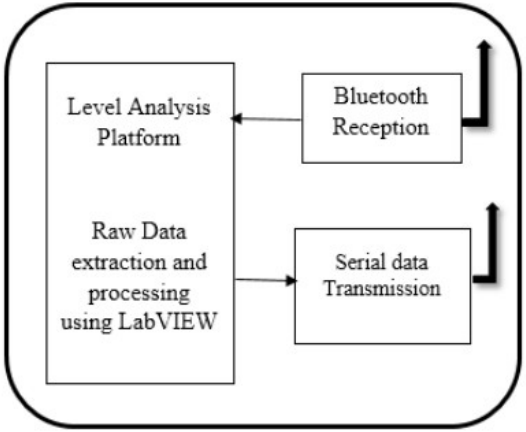


Fig 2: DATA Processing Unit

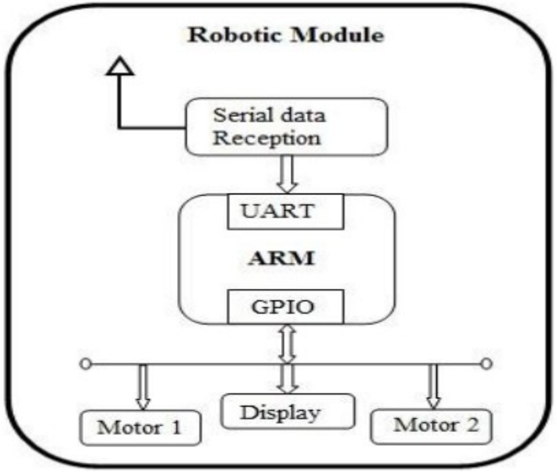
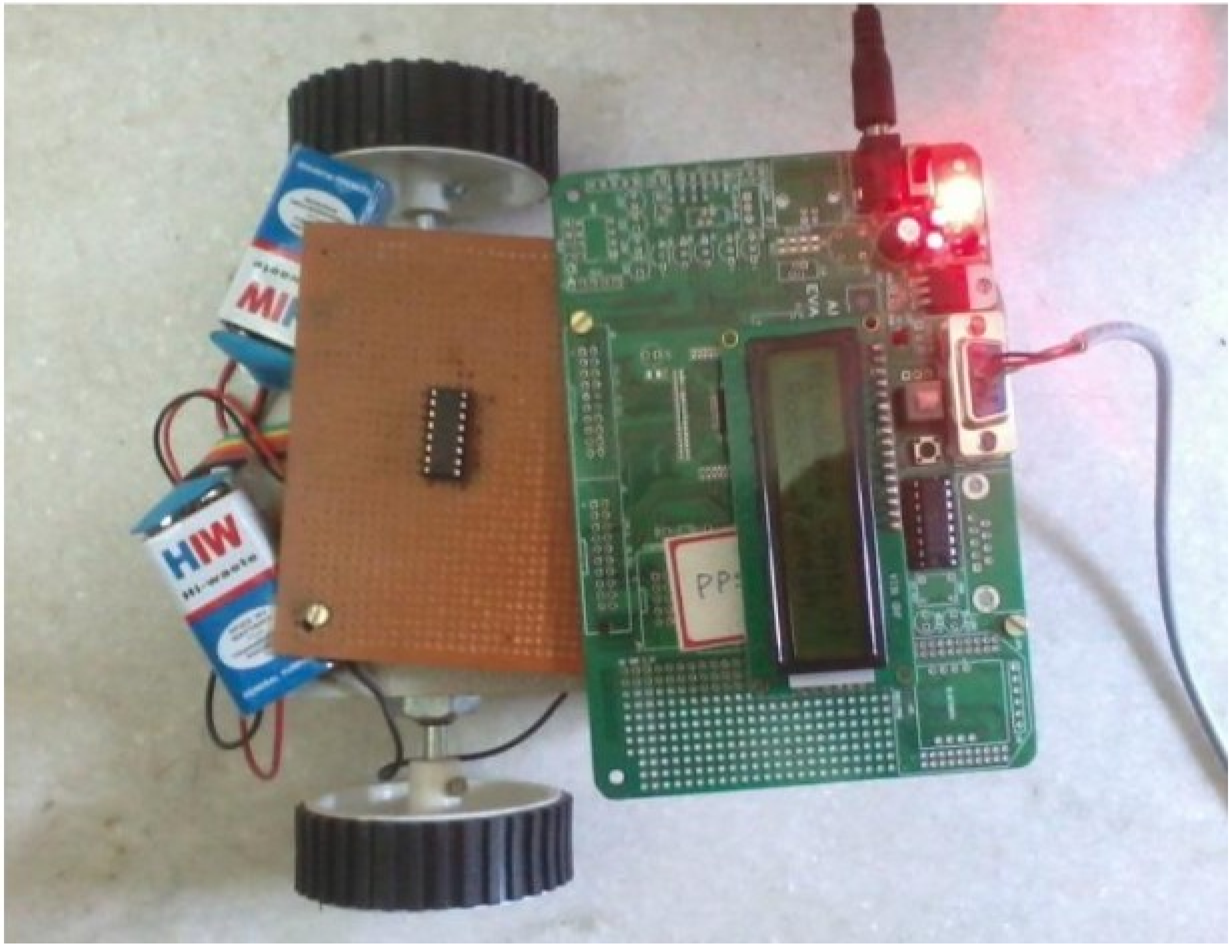
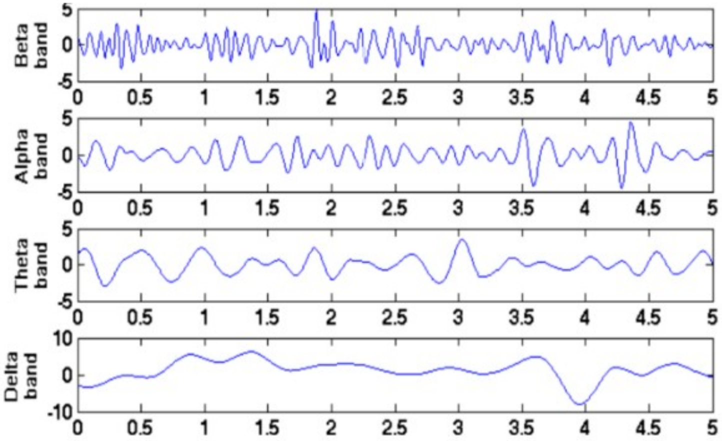


Fig 3: Robotic Module



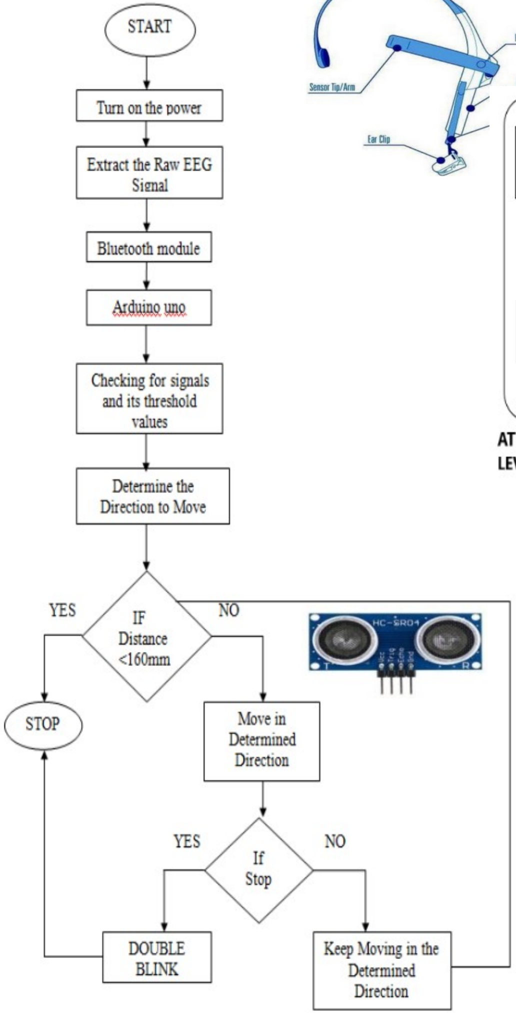
RAMESH, Siliveru; KRISHNA, M.Gopi; NAKIREKANTI, Madhu. ***Brain Computer Interface System for Mind Controlled Robot using Bluetooth***. International Journal of Computer Applications (0975 – 8887), Volume 104 – No 15, October 2014.

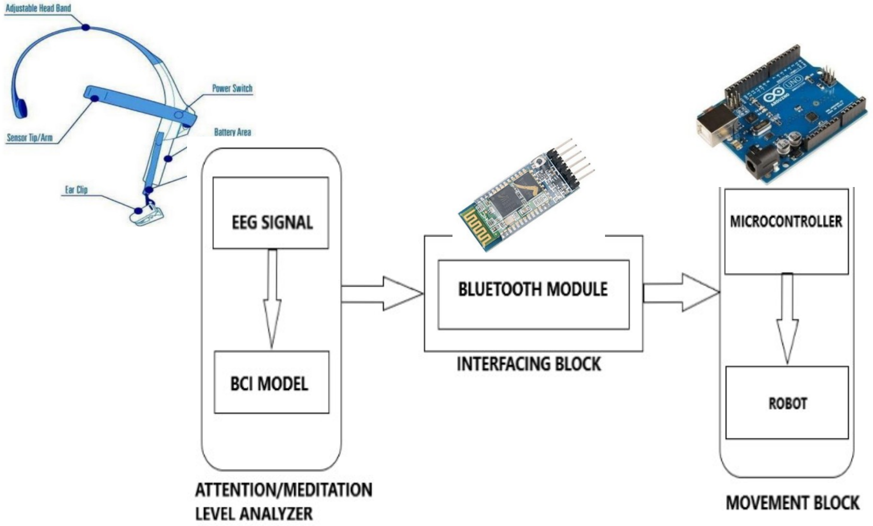


$$\check{s}(n) = -\sum_{i=1}^{p} a(i)s(n-i) \quad (1)$$

Where,
Š(n) = Predicted value
S(n) = Actual value
P = Order of Auto Regressive (AR) Model
a(i) = i^{th} coefficient of the AR Model
The forward prediction error e(n) is given by

$$e(n) = s(n) - \check{s}(n)$$





Delta (0.5 - 4Hz)
Theta (4 – 7Hz)
Alpha (8 – 12Hz)
Beta (13 – 30Hz)

GOUTHAM, P; SHIVARAJ, Hosad; VINAY, K.; PRAJWAL, S,; SHETTY, Shreshta Subodh K. ***Mind Controlled Robot***. IJESC, Volume 11 Issue No.07, July 2021.

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O sensor frontal mede o grau de ‘meditação’, enquanto o sensor no lóbulo da orelha mede frequência cardíaca/ resistência da pele/ serve de referência

Imagens: do autor

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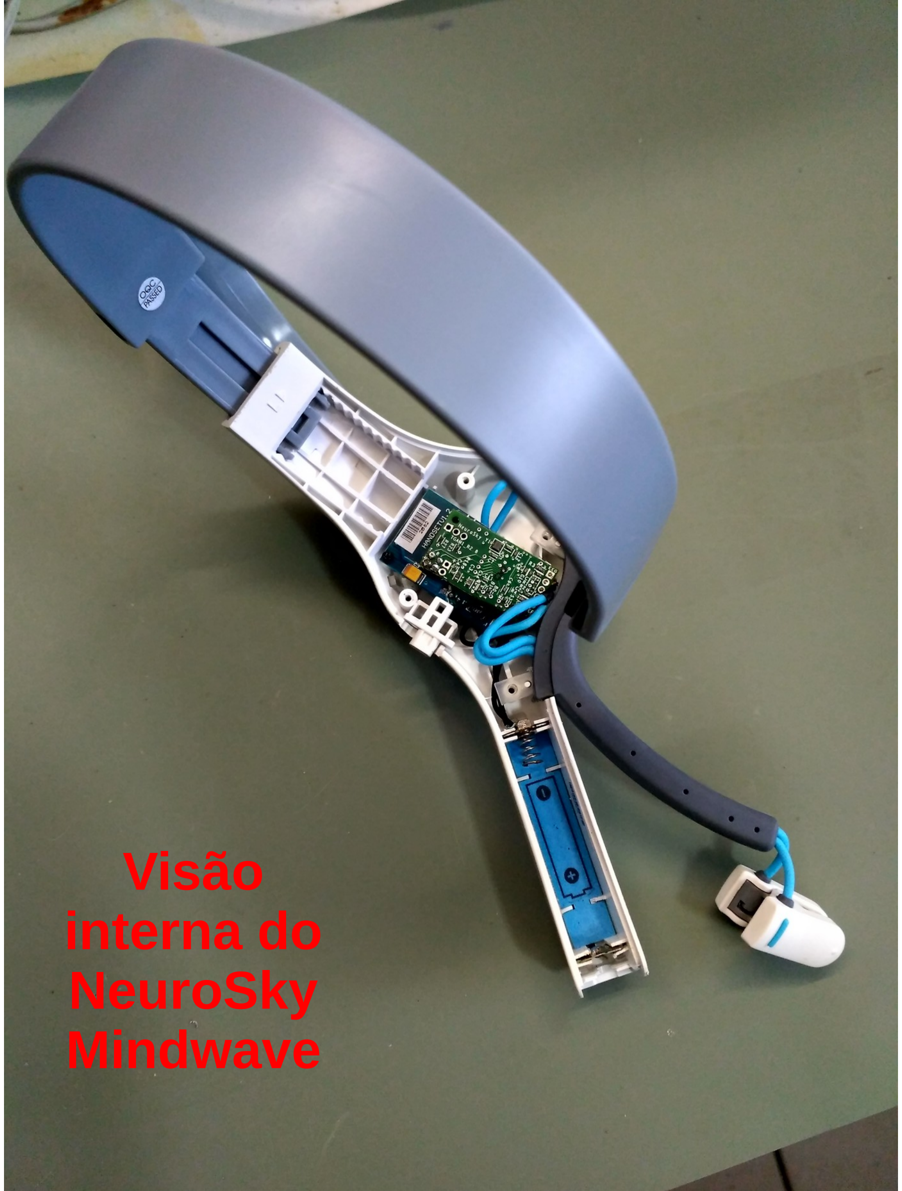
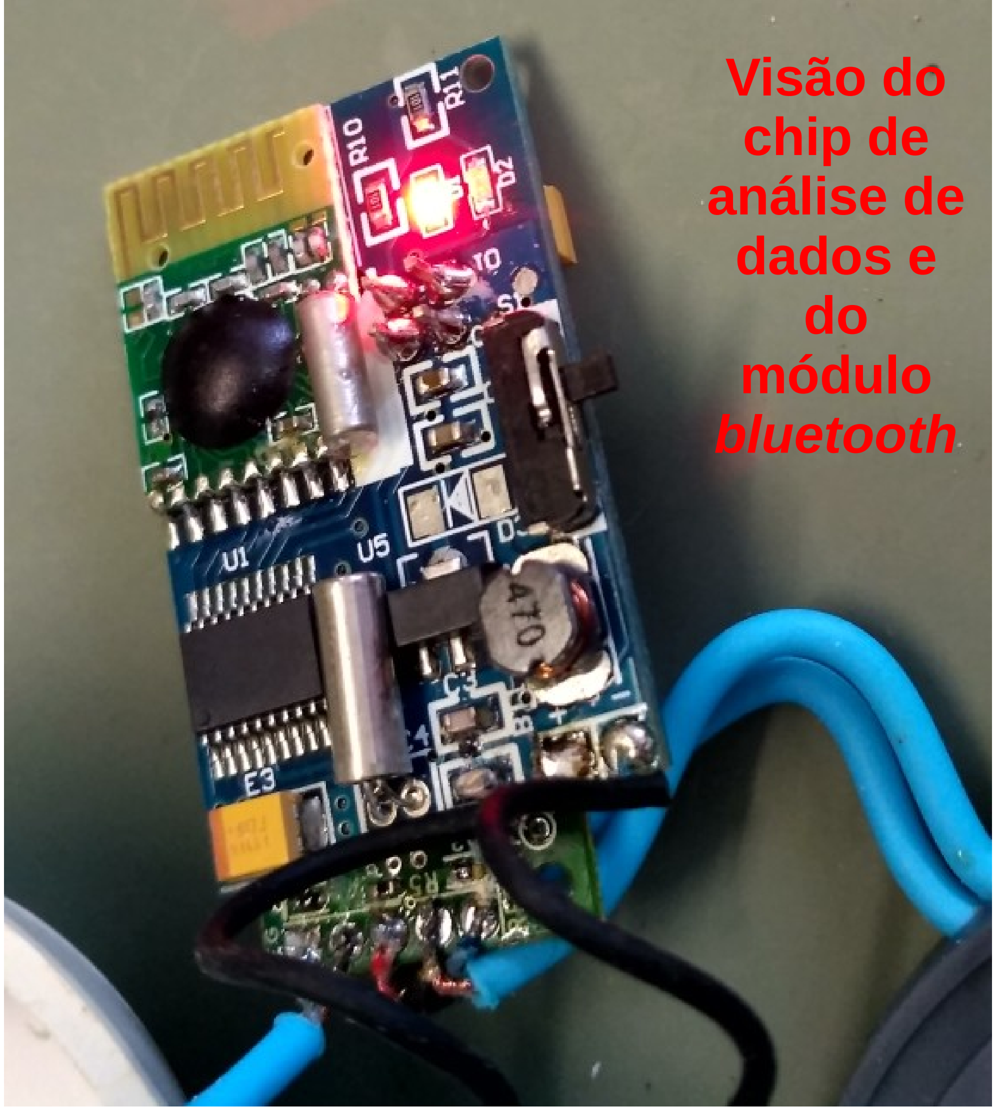


Visão interna do NeuroSky Mindwave



Visão do chip de análise de dados e do módulo *bluetooth*

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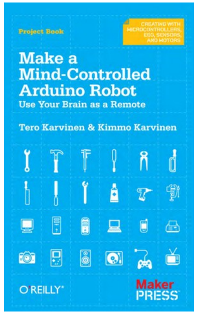

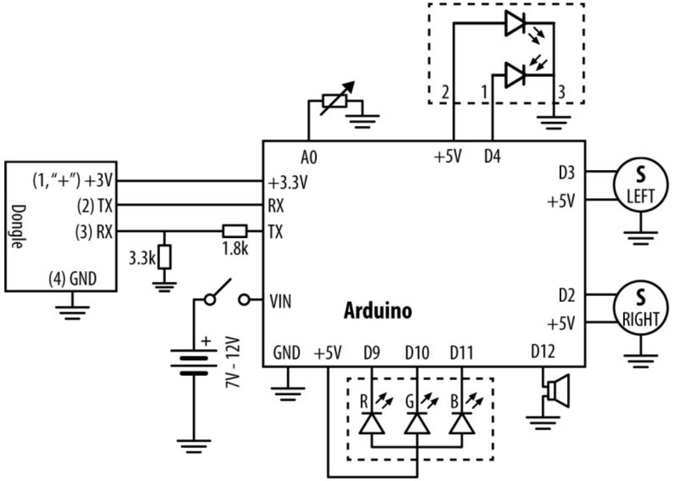

Figure 2-33. *Circuit diagram for complete robot, mindcontrol.pde*

```
void loop()
{
        while (lineDetected()) turn();
        updateAttention();          // ❶
        tr = getThreshold();        // ❷
        if (attention > 0)
                setBlueToRed(attention);
        if (attention > tr) {
                speed = attention;          // ❸
        } else {
                speed = speed * 0.98;       // ❹
        }
        forward(speed);         // ❺
        toggleTinyLed();
}
```

KARVINEN, Tero; KARVINEN, Kimmo. ***Make a mind-controlled Arduino robot***: *use your brain as a remote*. O'Reilly : Sebastopol, CA, USA, 2011.

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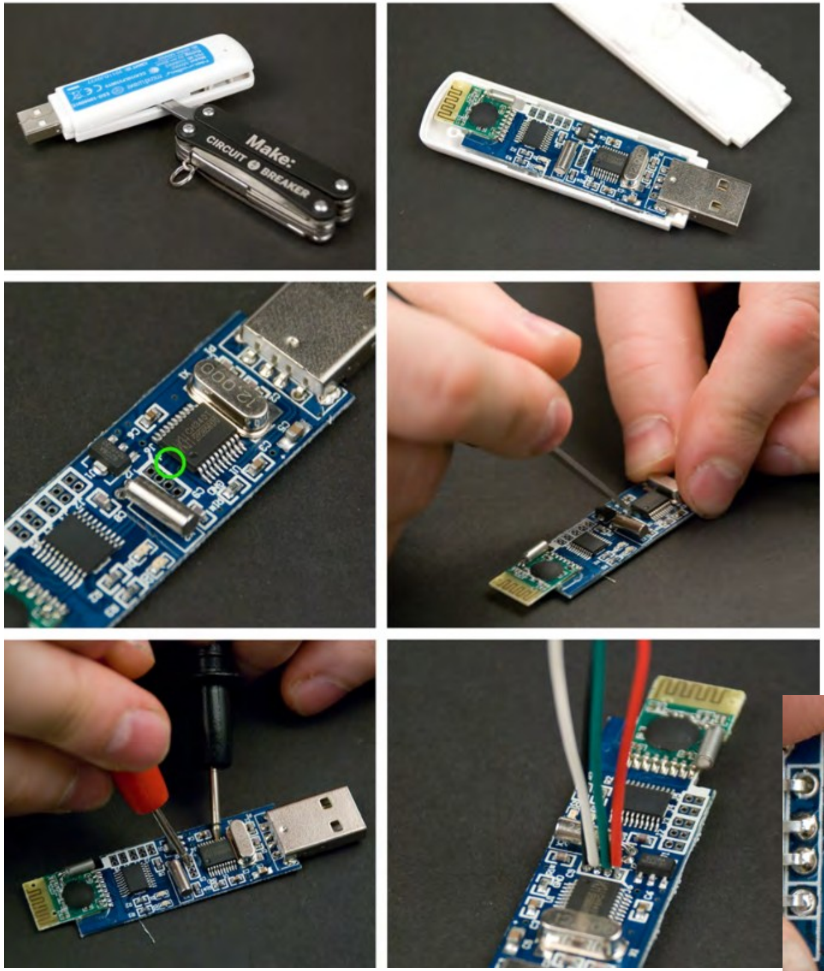
Comunicação com o módulo, sem bibliotecas



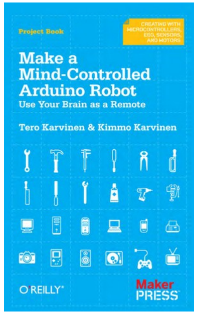
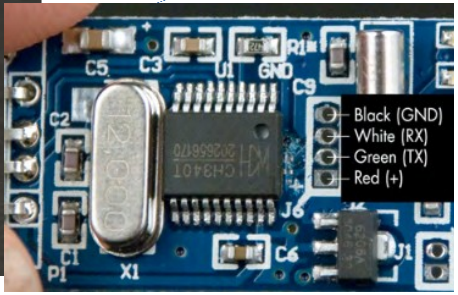


Table 2-2. *Hex numbers used in helloattention.pde*

Hex	Dec	Used in
-0x46	-70	Fail
0x80	128	Skip 2 byte RAW Wave value
0x83	131	Skip 24 byte ASIC_EEG_POWER value
0xAA	170	Sync
0xC2	194	Initiate connection
0xD0	208	Headset connected
0xD1	209	Headset not found
0xD2	210	Headset disconnected
0xD3	211	Request denied

Usa o protocolo de comunicação do mindwave



EEG *Raw*
Attention `int 0-100`
Mediation `int 0-100`
Blink Strength `int 0-255`

KARVINEN, Tero; KARVINEN, Kimmo. ***Make a mind-controlled Arduino robot***: *use your brain as a remote*. O'Reilly : Sebastopol, CA, USA, 2011.

Review: Hands-free flight with EEGSmart's mind-controlled UDrone

By Loz Blain
March 08, 2019

The UDrone uses hands-free "mind controls" via a sensor-heavy headset Tyson Clugg/New Atlas

https://newatlas.com/udrone-mind-controlled-drone-umind-review/58791/

Brainwaves Fly a Drone

By Tony--K in Circuits > Arduino 13.516 196 26 Featured

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https://www.instructables.com/Brainwaves-Fly-a-Drone/

https://www.futurelearn.com/info/courses/robotic-future/0/steps/26359

Brain controlled robots

Mahnaz explains the principles behind mind control of robots (brain patterns, mental activities)

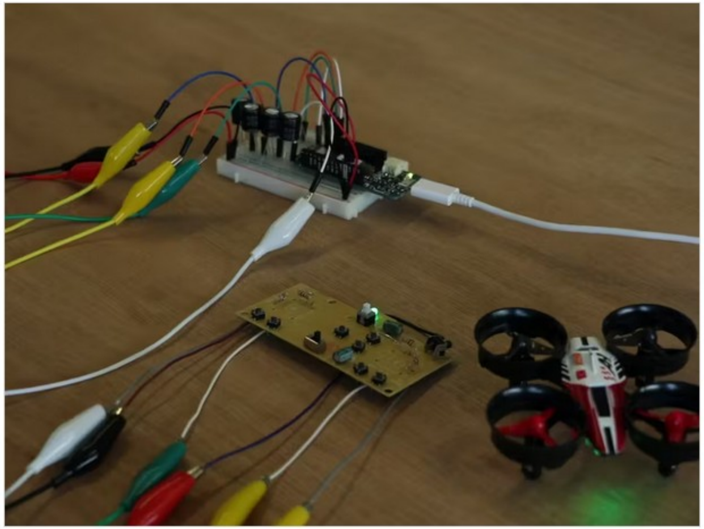
© The University of Sheffield

https://www.hackster.io/WesleyCMD/mind-control-drone-c8b28a

Mind Control Drone

Learn how to lift-off a drone with your mind and a hacked controller using a MindWave sensor, Arduino MKR1000 and Processing.

Intermediate · Full instructions provided · 118,044



https://uavcoach.com/mind-control-drone/

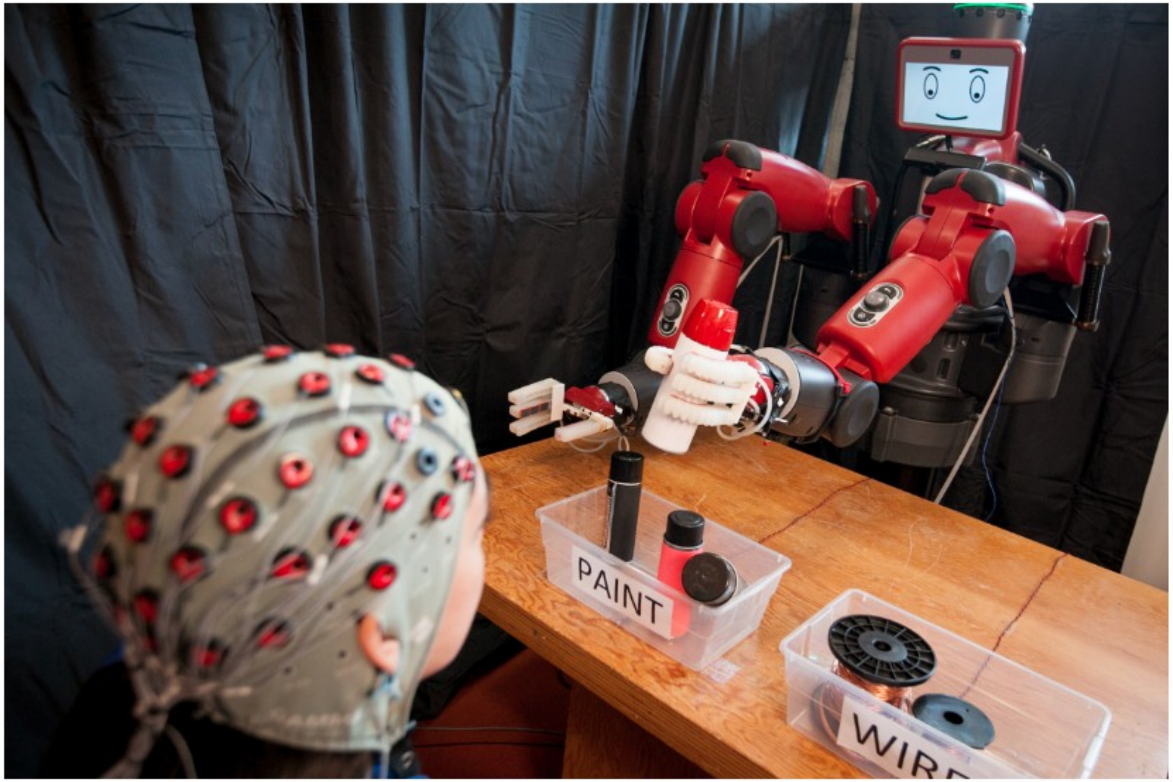
Can You Fly a Drone Using Only Your Mind?

BY ZACC DUKOWITZ

17 November 2021

PROJECT

Brain-Controlled Robots



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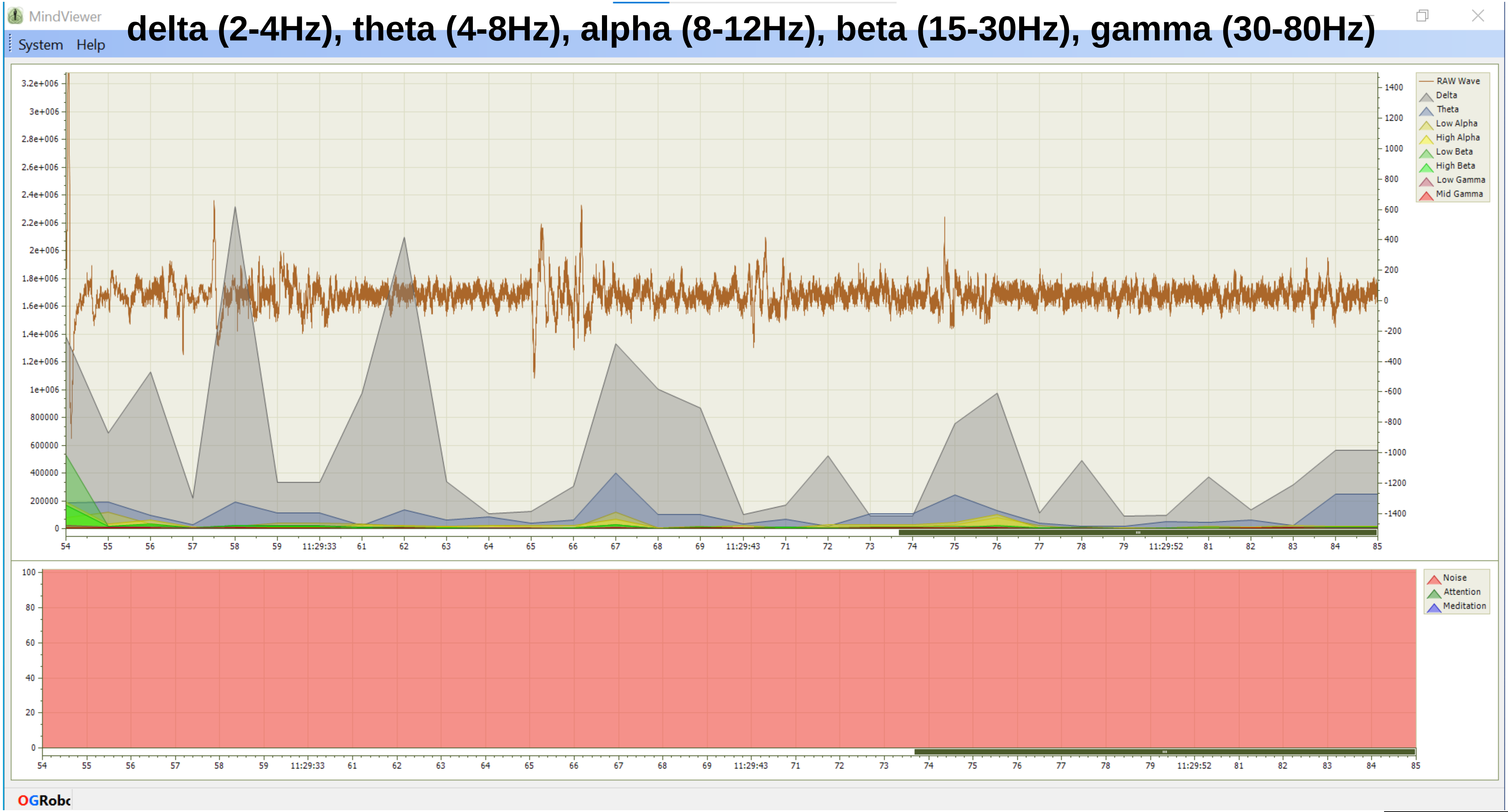
'Kit' TGAM

Placa com chip de análise de dados, módulo *bluetooth*, eletrodo sensor de ondas frontal e dois plugues para os lóbulos

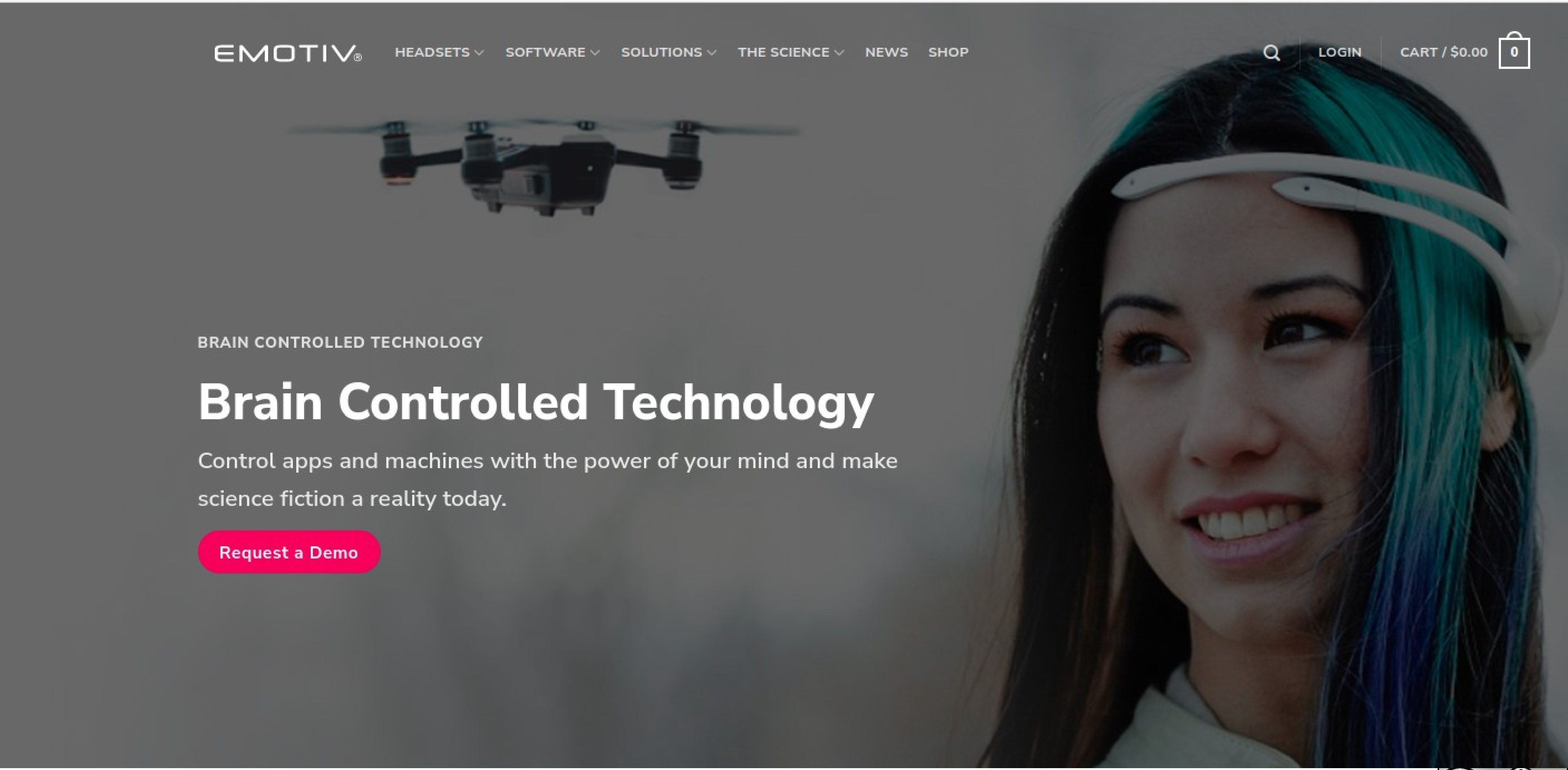
Imagens: do autor / Aliexpress

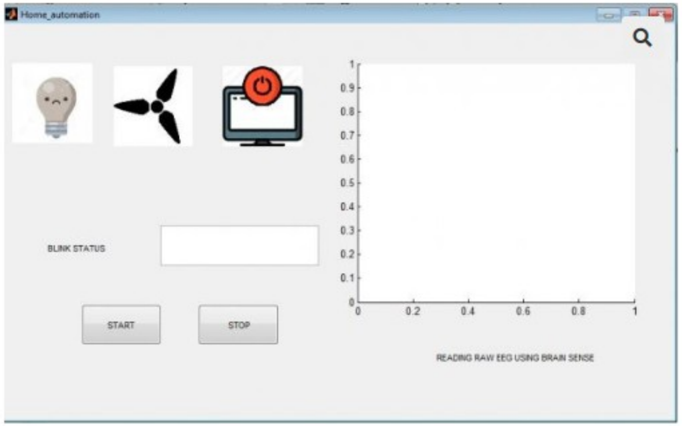
delta (2-4Hz), theta (4-8Hz), alpha (8-12Hz), beta (15-30Hz), gamma (30-80Hz)



Cópia de tela da execução do *software* MindViewer, capturando ondas cerebrais do autor por meio do módulo TGAM

Cópia de tela da execução do *software* MindViewer, capturando ondas cerebrais do autor por meio do módulo TGAM emotiv.com/brain-controlled-technology/





Brain controlled Home Automation

₹20,000.00 Exc Tax

Brain Computer Interface BCI helps to develop Brain actuated applications like Home automation using EEG Brain waves using EEG device such as Brainsense / Mindwave Mobile

Features:

Brain wave visualizing | Brain controlled Home appliance

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Package Includes:

- Complete Hardware Kit
- !!! Online Support !!!
- Demo Video-Embedded Below
- 40 Page report
- Abstract
- Reference Paper
- PPT (20 Slides)

2 in stock

- 1 + ADD TO CART

“Mind”Craft

June 4, 2015

Hacks

https://developer.neurosky.com/features/mindcraft/

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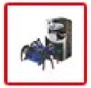

Mindlink controle da mente brainwave aranha robô inteligente brinquedo staem treinamento de atenção

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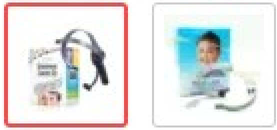

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R$ 3.907,39

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type 1 | type 2 | type 3 | type 4 | type 5 | type 6

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washingtonpost.com/video-games/2020/12/16/brain-computer-gaming/

The Washington Post
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Brain-controlled gaming exists, though ethical questions loom over the tech

By Lewis Gordon

December 16, 2020 at 1:02 p.m. EST

Ienca and Andorno *Life Sciences, Society and Policy* (2017) 13:5
DOI 10.1186/s40504-017-0050-1
Life Sciences, Society and Policy

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Towards new human rights in the age of neuroscience and neurotechnology

Marcello Ienca[1*] and Roberto Andorno[2]

DE GRUYTER Neuroforum 2019; 25(4): 241–250

Review Article

Philipp Kellmeyer*

Artificial Intelligence in Basic and Clinical Neuroscience: Opportunities and Ethical Challenges

The Biopolitics of Neuroethics 17

Fabrice Jotterand and Marcello Ienca

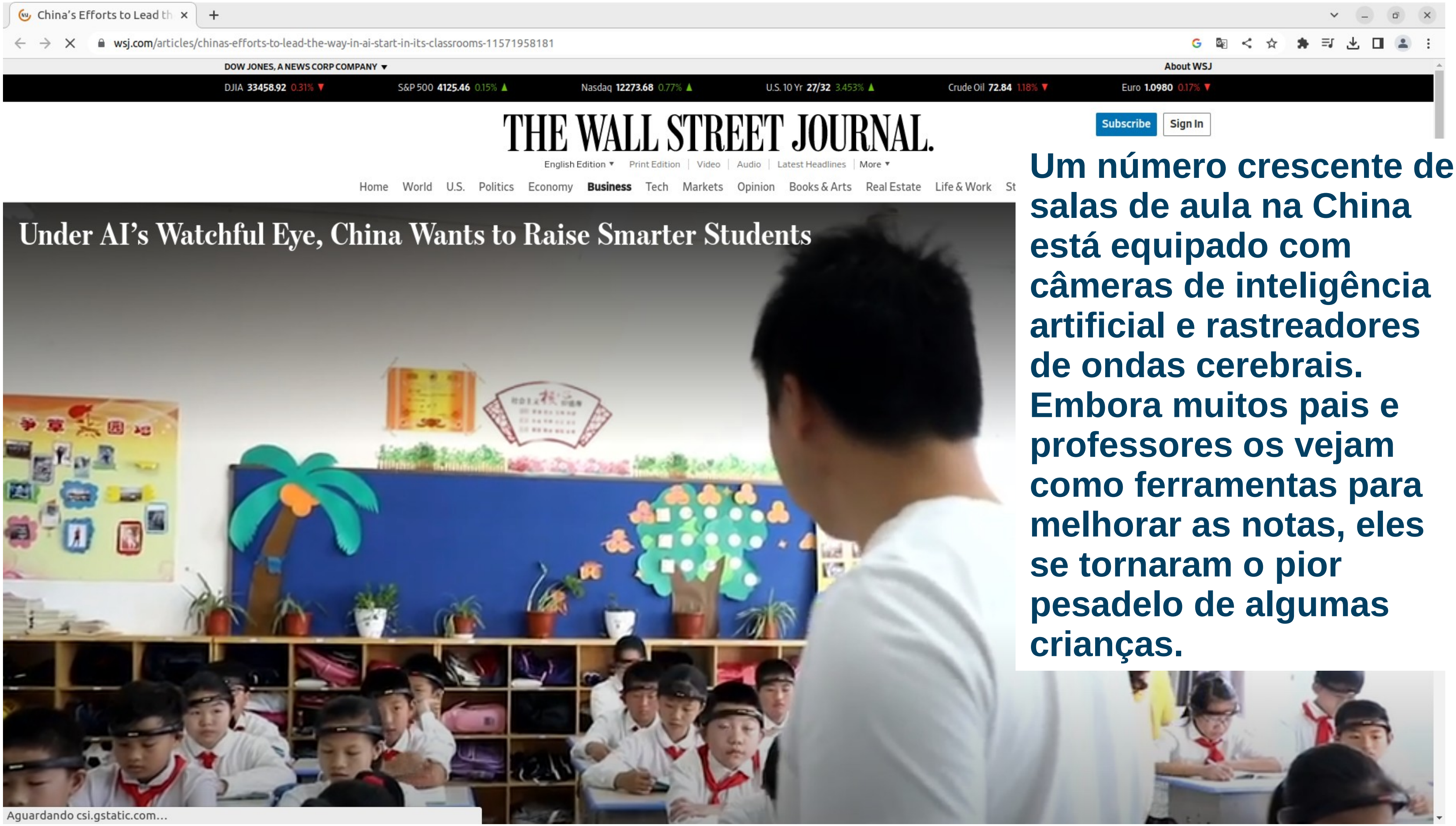
Kögel *et al. BMC Medical Ethics* (2020) 21:2
https://doi.org/10.1186/s12910-019-0442-2
BMC Medical Ethics

RESEARCH ARTICLE Open Access

What is it like to use a BCI? – insights from an interview study with brain-computer interface users

Johannes Kögel[1*], Ralf J. Jox[2] and Orsolya Friedrich[3]

Textos utilizados como base de discussão na disciplina de Tópicos Emergentes / BCI e Neuroética, UFPR-PPGGI. Ver referências a seguir.

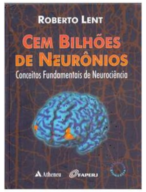


Um número crescente de salas de aula na China está equipado com câmeras de inteligência artificial e rastreadores de ondas cerebrais. Embora muitos pais e professores os vejam como ferramentas para melhorar as notas, eles se tornaram o pior pesadelo de algumas crianças.

https://www.wsj.com/articles/chinas-efforts-to-lead-the-way-in-ai-start-in-its-classrooms-11571958181

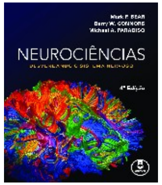
Algumas referências

SCHALK, Gerwin; MELLINGER, Jürgen. ***A Practical Guide to Brain–Computer Interfacing with BCI2000***. *General-Purpose Software for Brain–Computer Interface Research, Data Acquisition, Stimulus Presentation, and Brain Monitoring*. London : Springer-Verlag, 2010.



LENT, Roberto. **Cem bilhões de neurônios**. Conceitos fundamentais de neurociência. 2. ed. São Paulo : Atheneu, 2010.

KREBS, Claudia; WEINBERG, Joanne; AKESSON, Elizabeth. **Neurociências ilustrada**. Porto Alegre : Artmed, 2013.



BEAR, Mark F.; CONNORS, Barry W.; PARADISO, MIchael A. **Neurociências**: desvendando o sistema nervoso. Porto Alegre : Artmed, 2017.

Ienca and Andorno Life Sciences, Society and Policy (2017) 13:5
DOI 10.1186/s40504-017-0050-1

Life Sciences, Society and Policy

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The Biopolitics of Neuroethics 17

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Jotterand, Fabrice & Ienca, Marcello. (2017). ***The Biopolitics of Neuroethics***. 10.1007/978-3-319-54651-3_17. https://www.researchgate.net/profile/Marcello-Ienca/publication/318160086_The_Biopolitics_of_Neuroethics/links/5b043d62aca2720ba099c6b7/The-Biopolitics-of-Neuroethics.pdf

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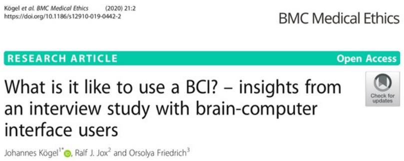

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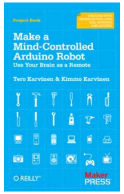

KARVINEN, Tero; KARVINEN, Kimmo. ***Make a mind-controlled Arduino robot***: *use your brain as a remote*. O'Reilly : Sebastopol, CA, USA, 2011.

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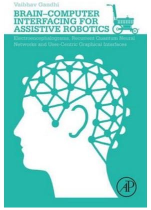
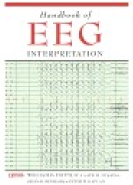
RAMESH, Siliveru; KRISHNA, M.Gopi; NAKIREKANTI, Madhu. ***Brain Computer Interface System for Mind Controlled Robot using Bluetooth***. International Journal of Computer Applications (0975 – 8887), Volume 104 – No 15, October 2014.



GANDHI, Vaibhav. ***Brain computer interfacing for assistive robotics***. *Electroencephalograms, Recurrent Quantum Neural Networks and User-Centric Graphical Interfaces*. London : Elsevier, 2015.

GOUTHAM, P; SHIVARAJ, Hosad; VINAY, K.; PRAJWAL, S,; SHETTY, Shreshta Subodh K. ***Mind Controlled Robot***. IJESC, Volume 11 Issue No.07, July 2021.



TATUM, Willian O.; HUSAIN, Aatif M.; BENBADIS, Selim R. ***Handbook of EEG interpretation***. Florida : Demos Medical Publishing, 2008.

SALIH, Thair A.; ABDAL, Yasir M.. ***Brain computer interface based smart keyboard using neurosky mindwave headset***. TELKOMNIKA Telecommunication, Computing, Electronics and Control Vol. 18, No. 2, April 2020, pp. 919~927

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