QUANTIFYING THE HUMAN BRAIN DURING HCI WITH A BCI

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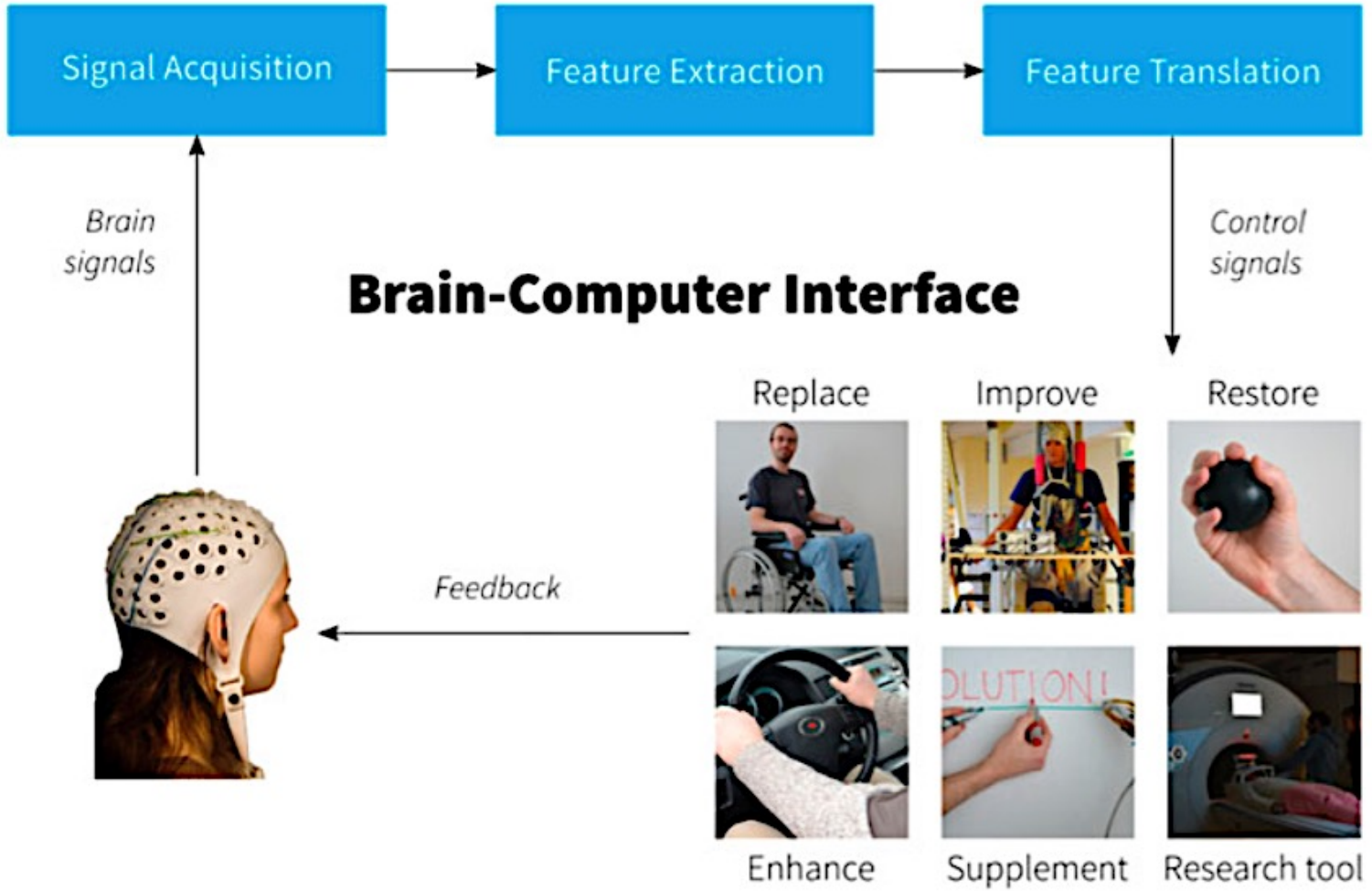
ABOUT ME – MARVIN ANDUJAR

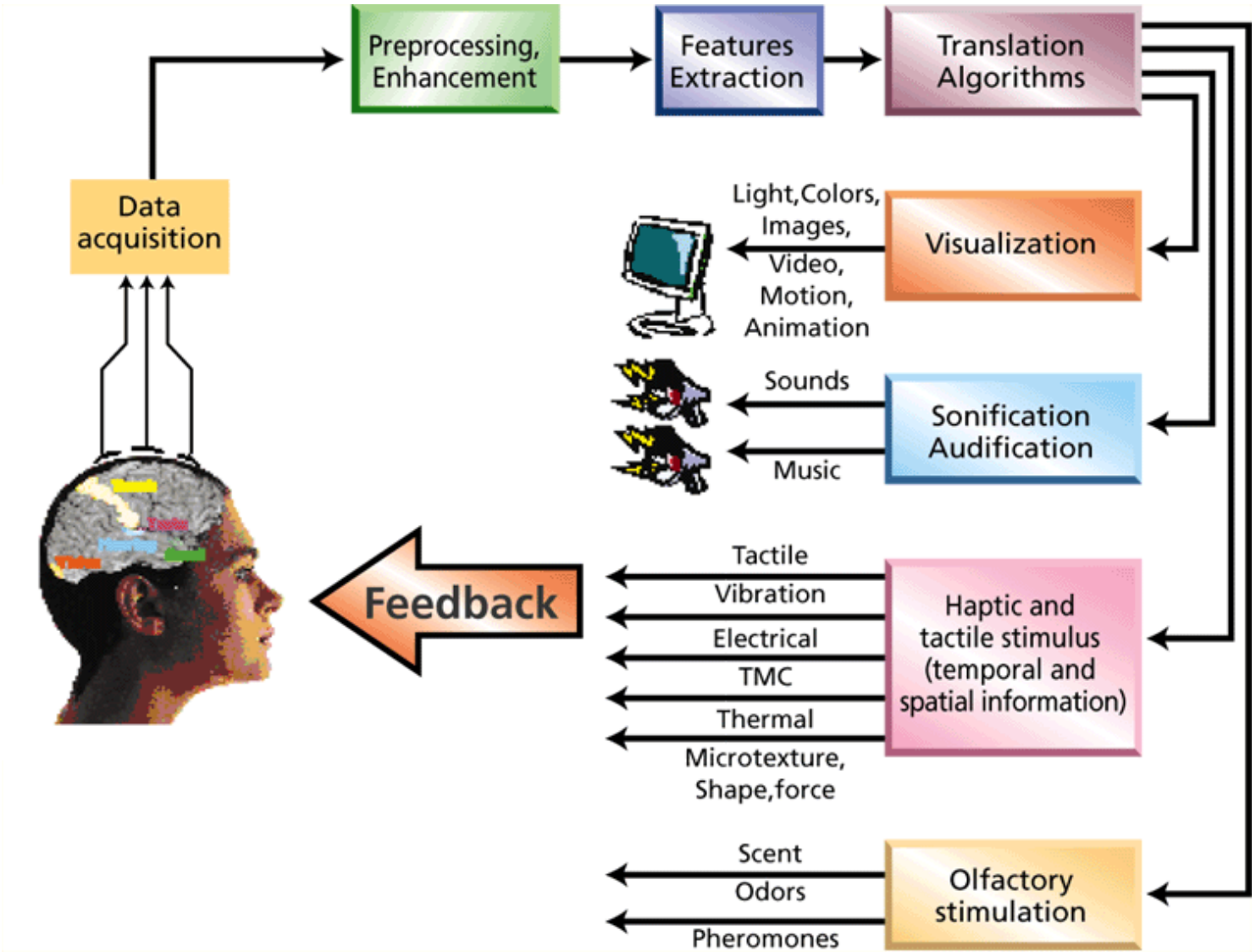
- Assistant Professor in Dept. of CS&E
- PhD in Human-Centered Computing
  - University of Florida
- Research Areas
  - Brain-Computer Interfaces
  - Brain-Robot Interaction
  - Human-Computer Interaction
  - Quantified-Self/Personal Informatics

BRAIN-COMPUTER INTERFACES (BCI)

- The use of a wearable device to enable the brain to control machines
- Measure and decode the affective and cognitive states



FEEDBACK TYPES

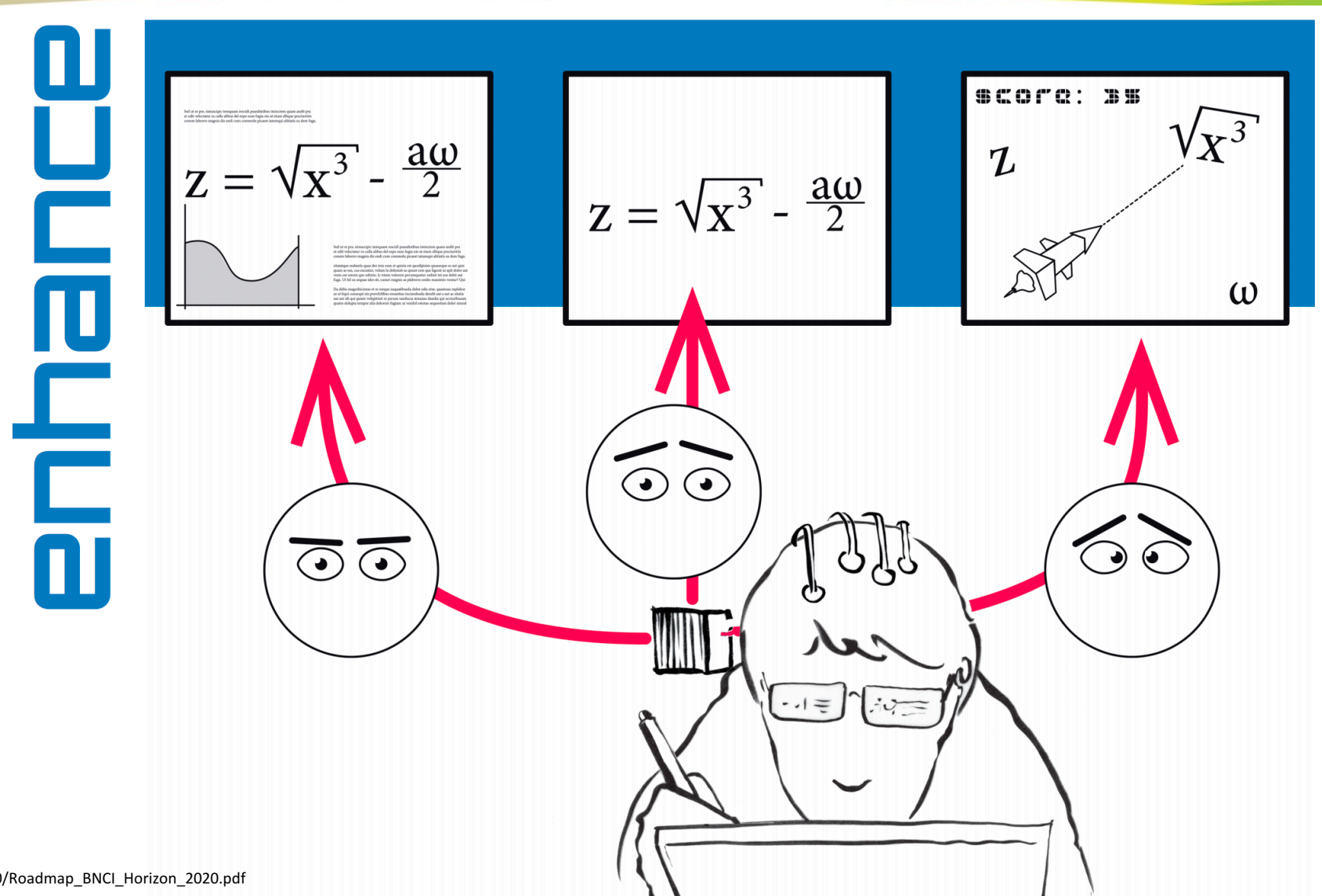


EXAMPLE OF A FAMOUS BCI APPLICATION

ELECTROENCEPHALOGRAPHY (EEG)

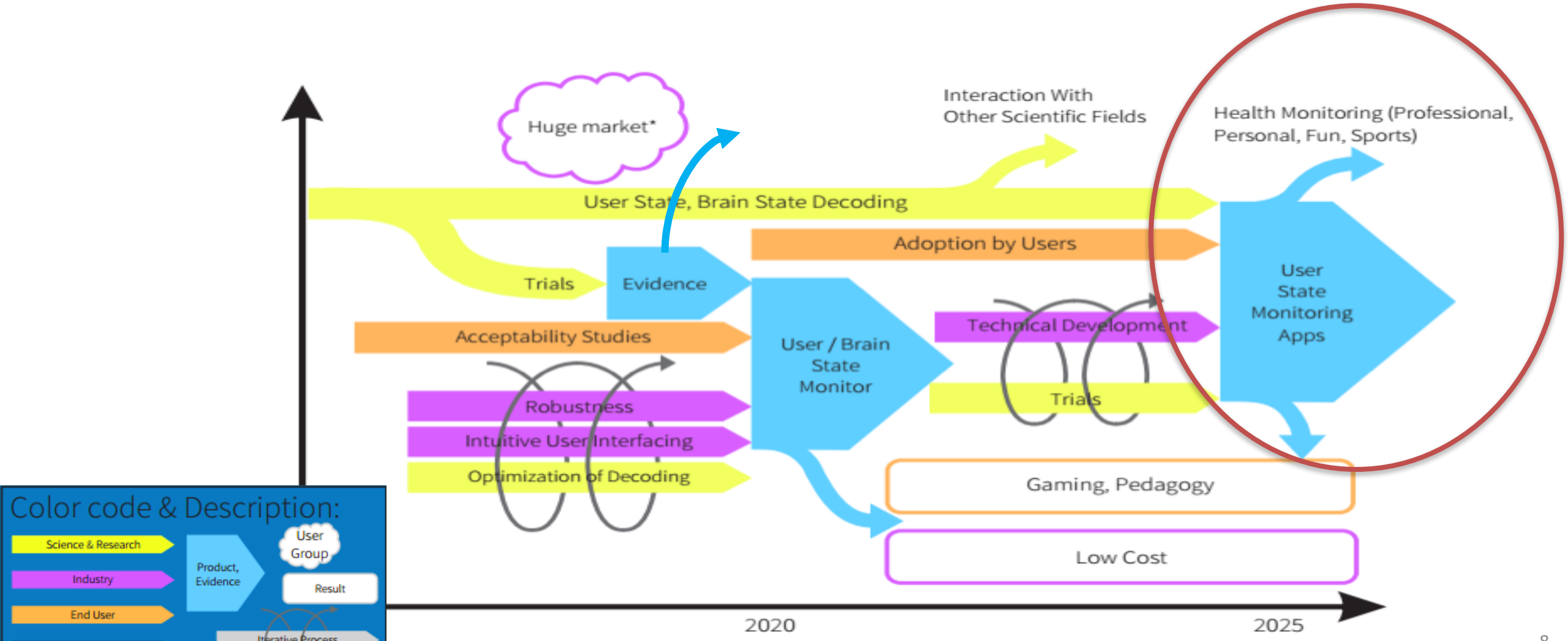
- Reads electrical brain activity from the scalp (surface of the head)
- Non-invasive procedure that can be applied to patients, healthy adults, and children with no risk
- Good **temporal** resolution, but low **spatial** resolution
- Allows mobile testing (outside the lab)
- Flexible stimulus presentation (visual, complex naturalistic scenes, audio)

BCI SOCIETY: ENHANCE APPLICATION



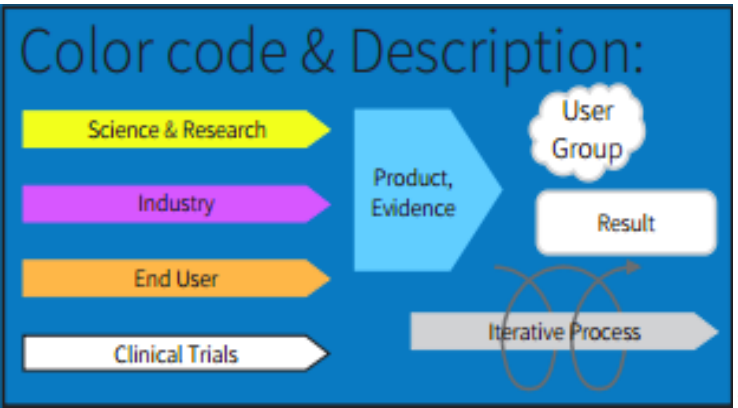
http://bnci-horizon-2020.eu/images/bncih2020/Roadmap_BNCI_Horizon_2020.pdf

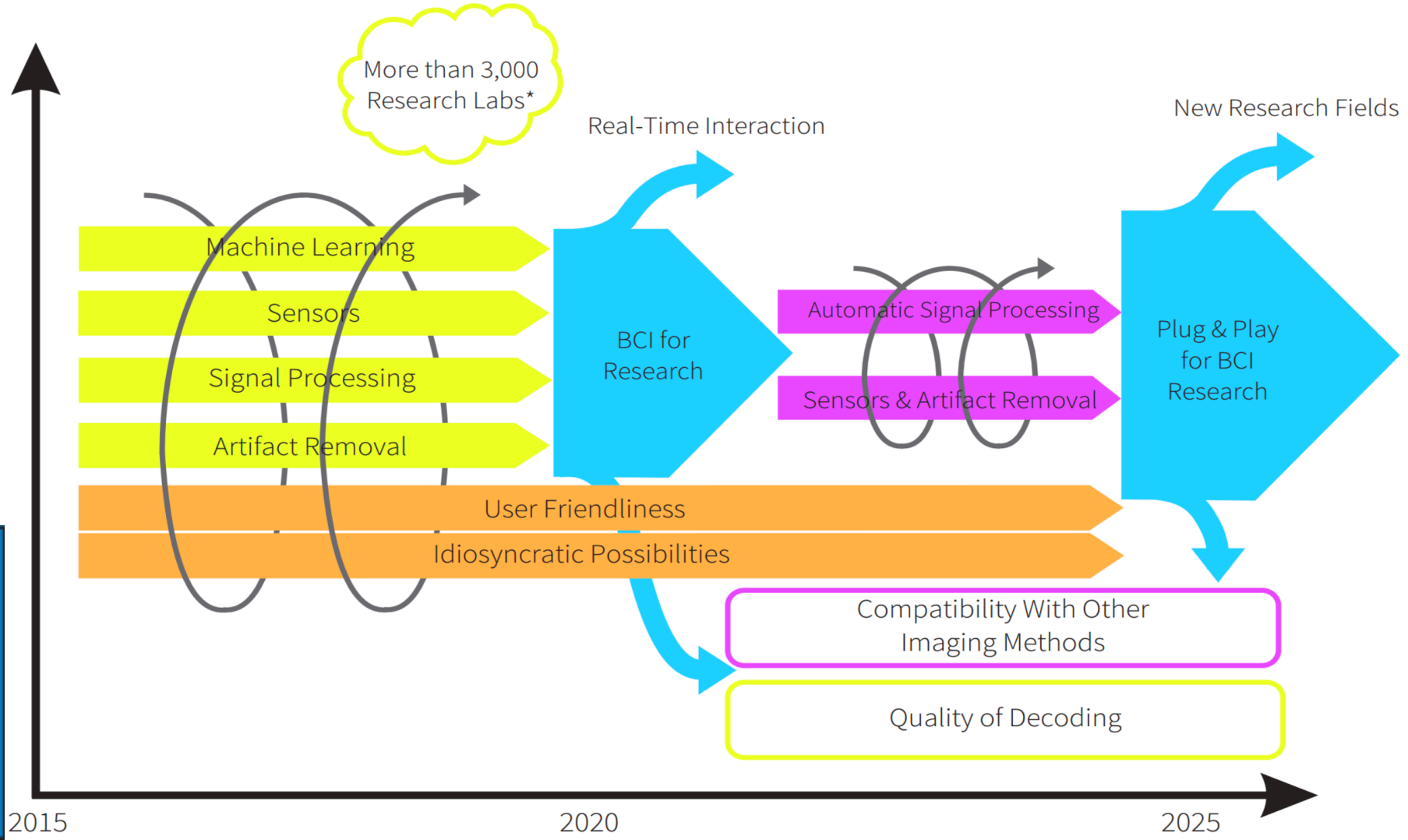
BCI SOCIETY: ENHANCE ROADMAP

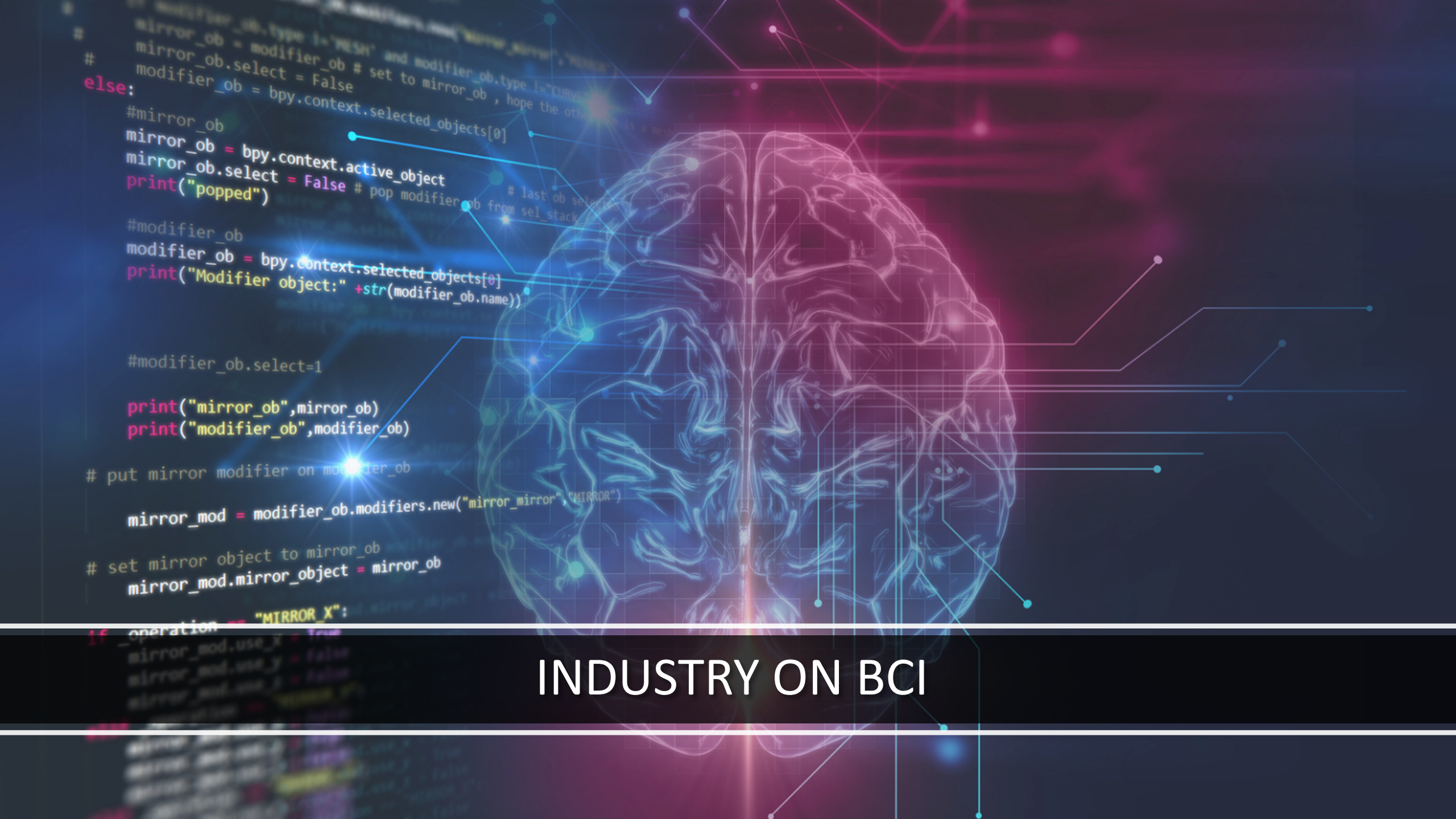


http://bnci-horizon-2020.eu/images/bncih2020/Roadmap_BNCI_Horizon_2020.pdf

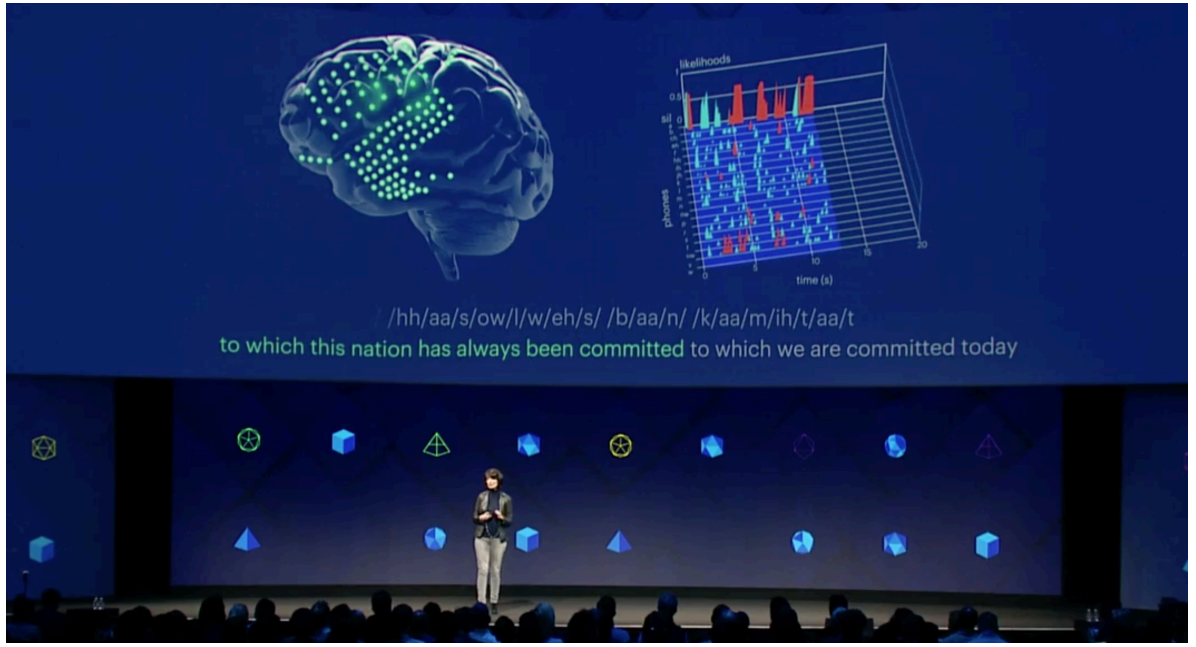
BCI SOCIETY: RESEARCH TOOL ROADMAP





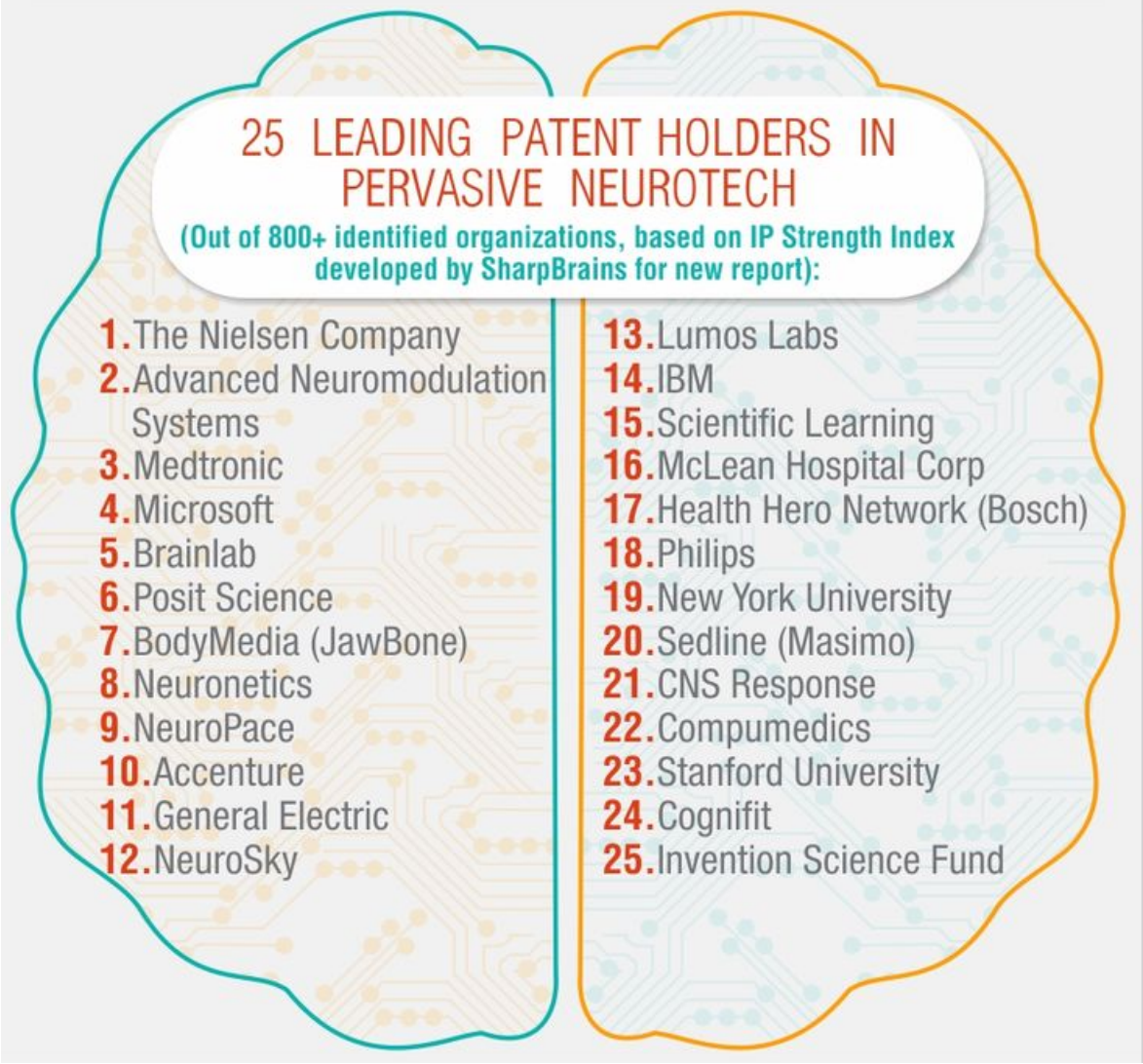


INDUSTRY ON BCI



ELON MUSK AND FACEBOOK

INDUSTRIES ON BCI

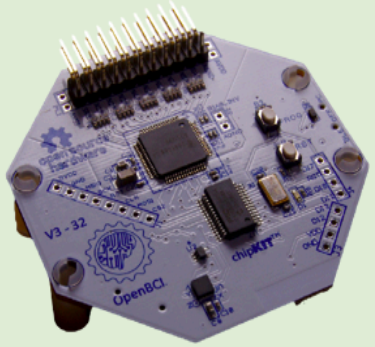


Neurosky Mindwave

Muse

Emotiv Epoc+

Emotiv Insight



OpenBCI

B-Alert Headset

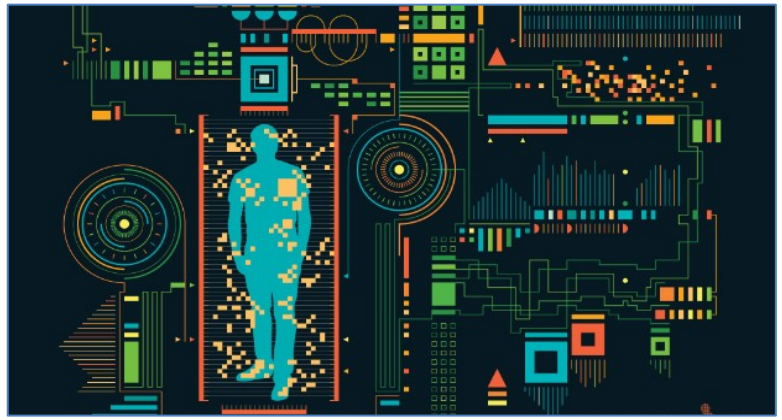
Wireless G.tec

Enobio

SOME CHALLENGES

- Big amount of data to interpret over time
  - Data acquisition is in milliseconds
  - In mobile computing, phones cannot handle the constant receiving of data
- What machine learning is the most appropriate for signal classification for a specific task?
- How can we motivate users to adapt BCIs in their daily life
  - Like Fitbit

NEURO-SYMBIOTIC MACHINE INTERACTION LAB



Quantified-Self

Learning

Human-Robot Interaction

Automotive

User Experience

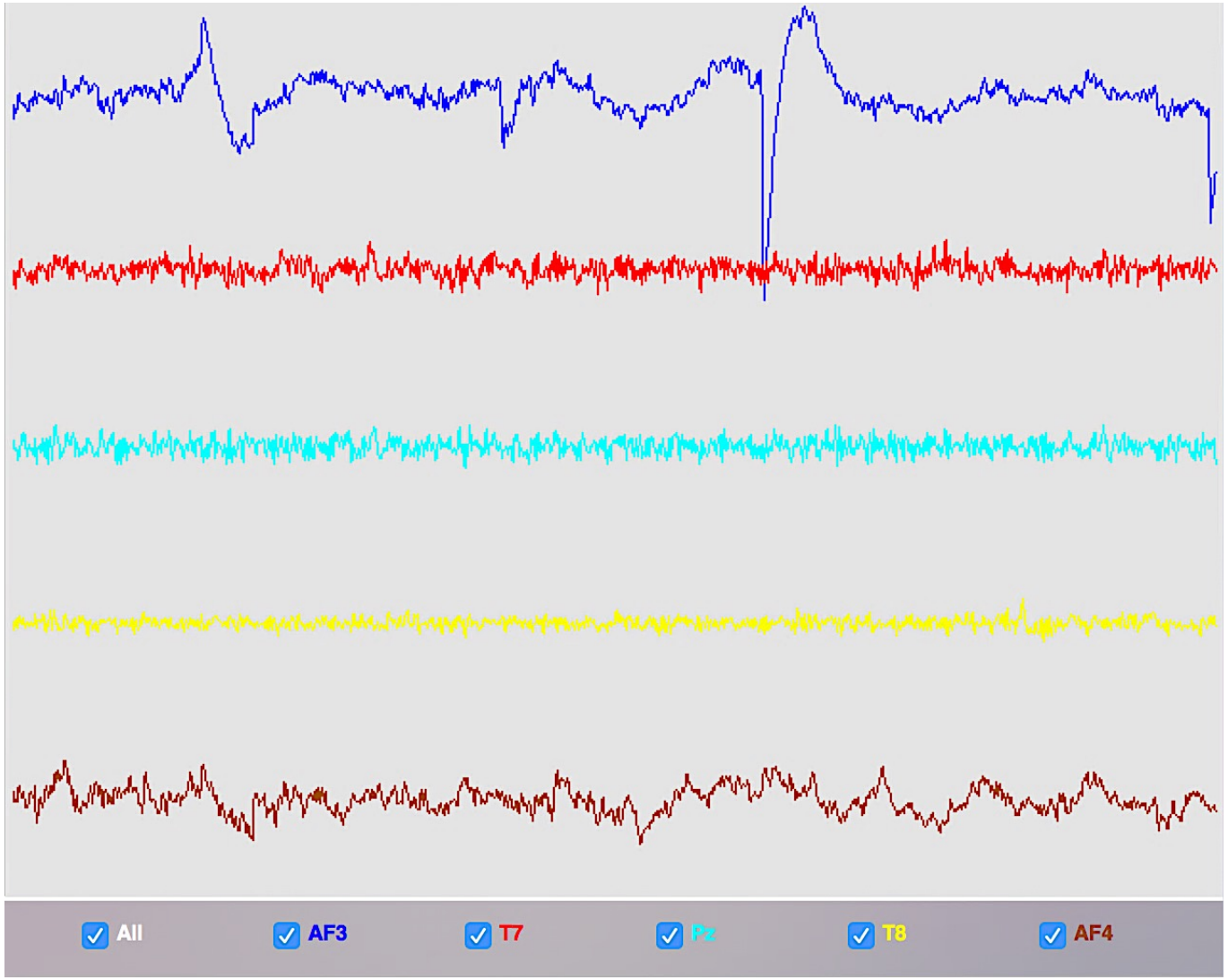
Brain-Controlled Drones

I don't own most of these images.

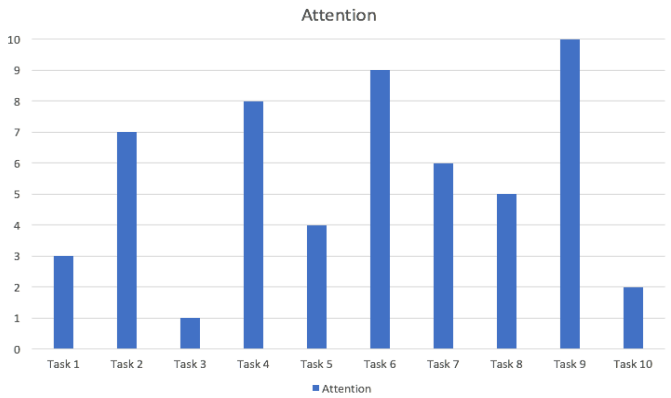
QUANTIFIED-SELF

ENGAGEMENT WITH A BCI

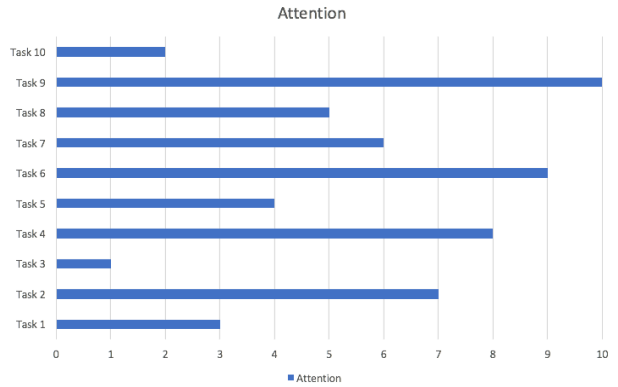
EEG NOT USER FRIENDLY



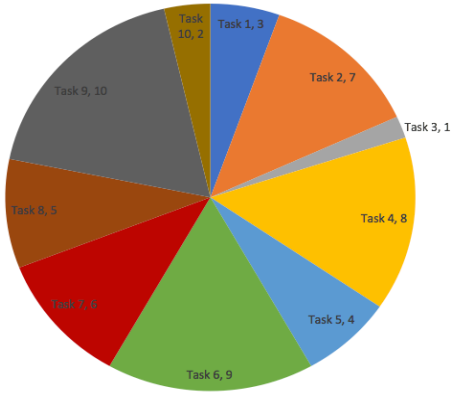
STATIC VISUALIZATION



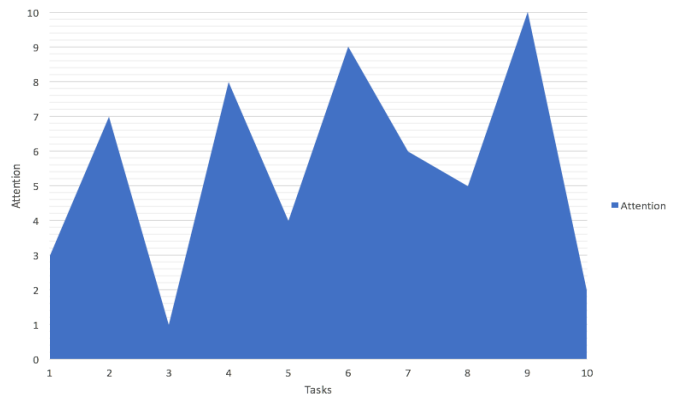
Bar Graph



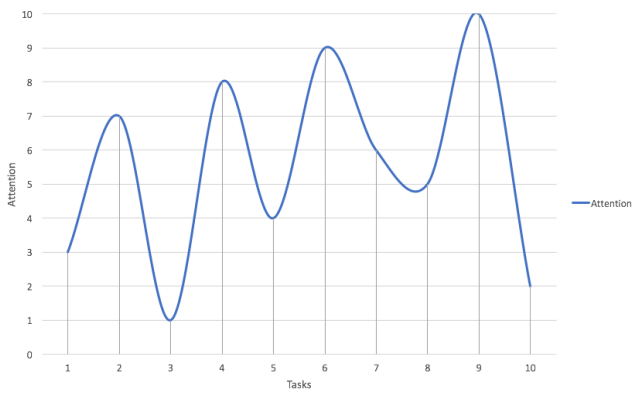
Clustered Graph



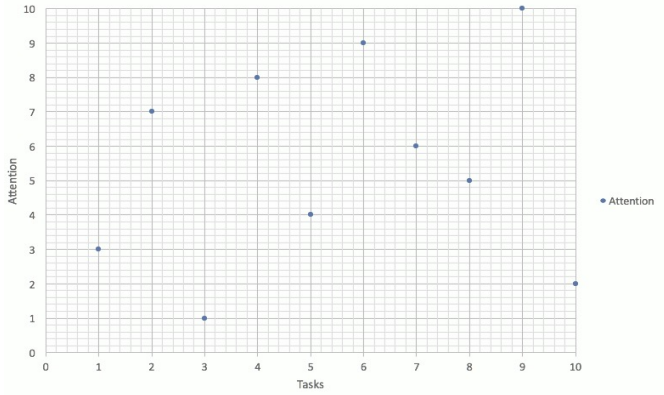
Pie Chart



Area Graph

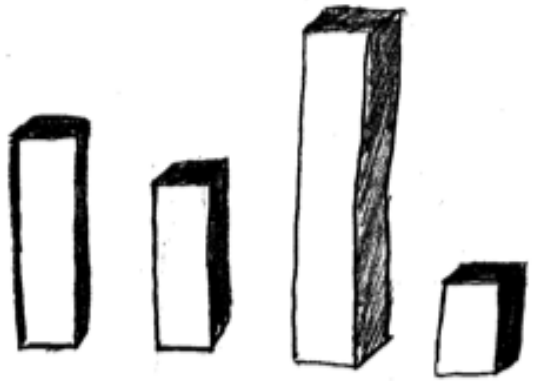


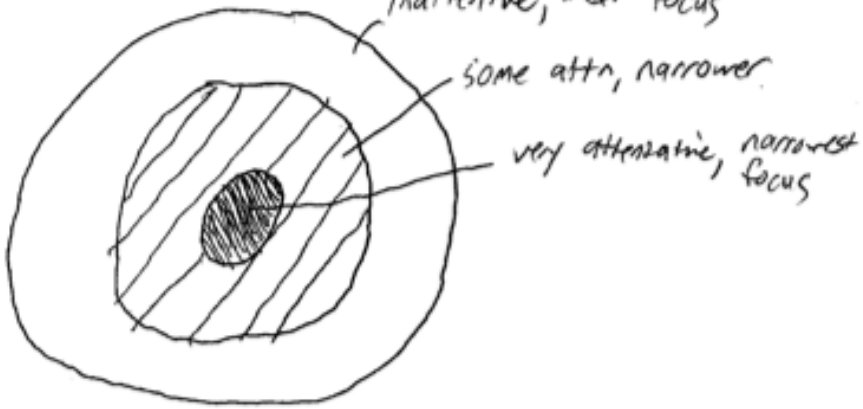
Line Graph

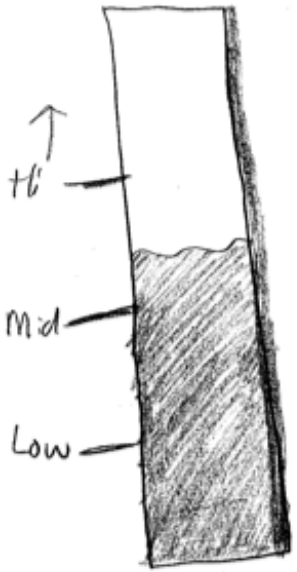


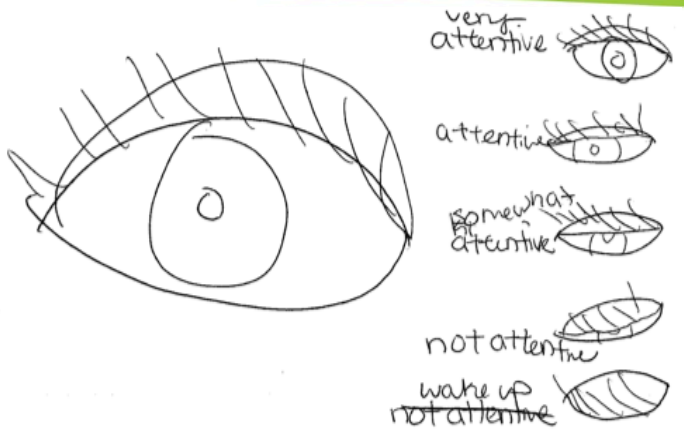
Dots Graph

TOP VISUALIZATIONS



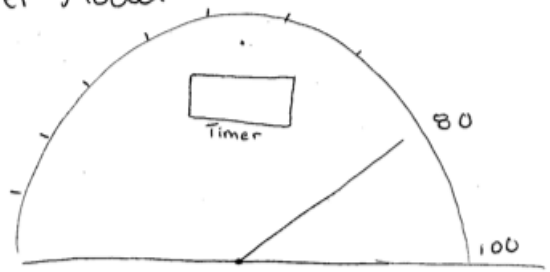


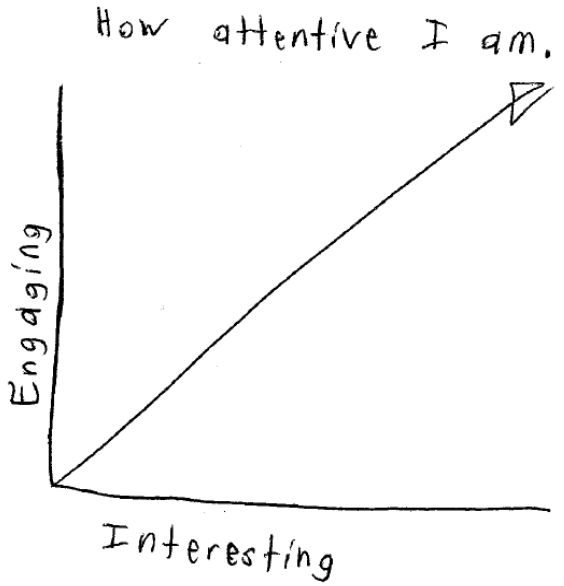




a lightbulb that increases in light intensity as attention increa

Speedometer Model





SPECTRAL BANDS BREAKDOWN

- Beta (β) - (13-30 Hz)
  - Mental Activity, Alerted

- Alpha (α) - (8-13Hz)
  - Relaxation

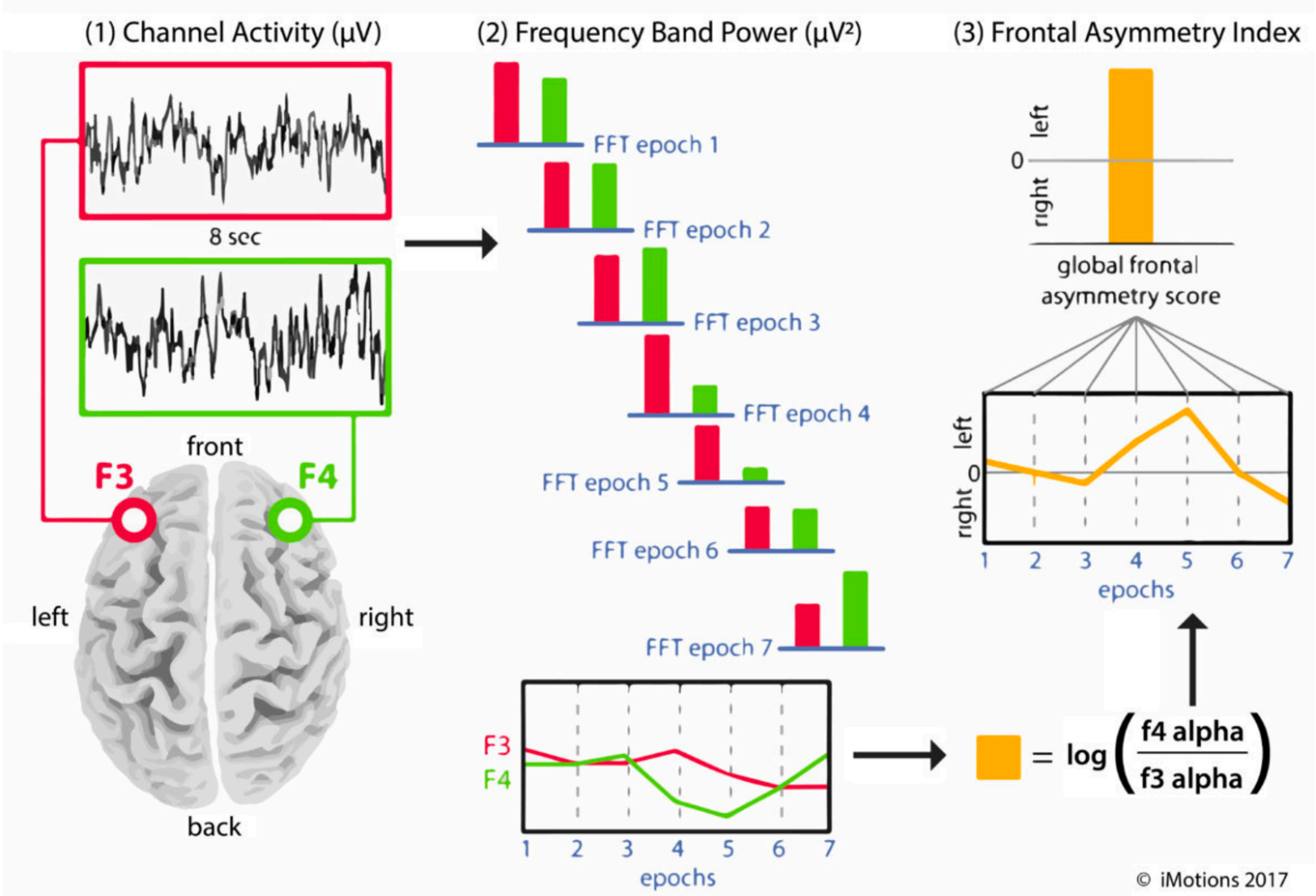
- Theta (θ) - (4-8 Hz)
  - Drowsiness

ENGAGEMENT INDICES

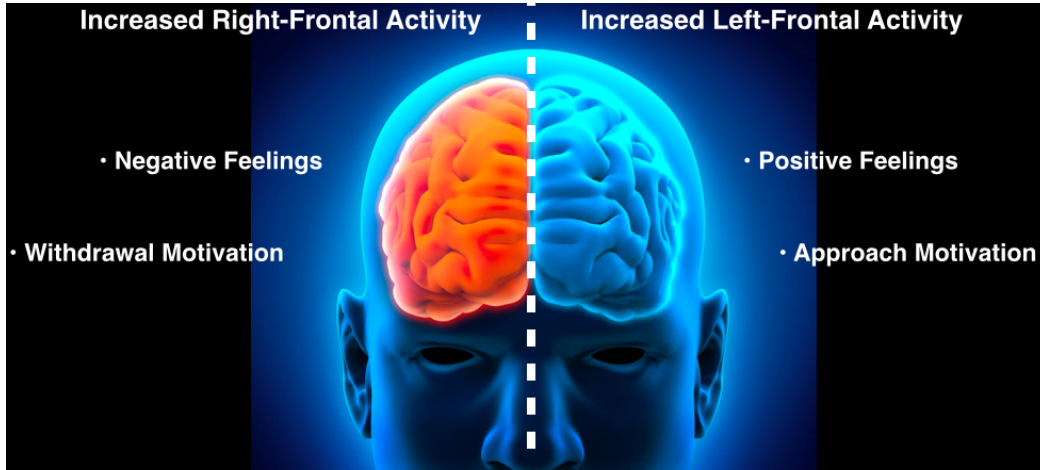
$$\mathbf{E} = \frac{\boldsymbol{\beta}}{(\boldsymbol{\alpha} + \boldsymbol{\theta})} \qquad \mathbf{E} = \frac{\boldsymbol{\beta}}{\boldsymbol{\alpha}} \qquad \mathbf{E} = \boldsymbol{\beta}$$

$$\mathbf{FAS} = \log\left(\frac{\alpha\ power\ right\ F4}{\alpha\ power\ left\ F3}\right)$$

FRONTAL ALPHA ASYMMETRY

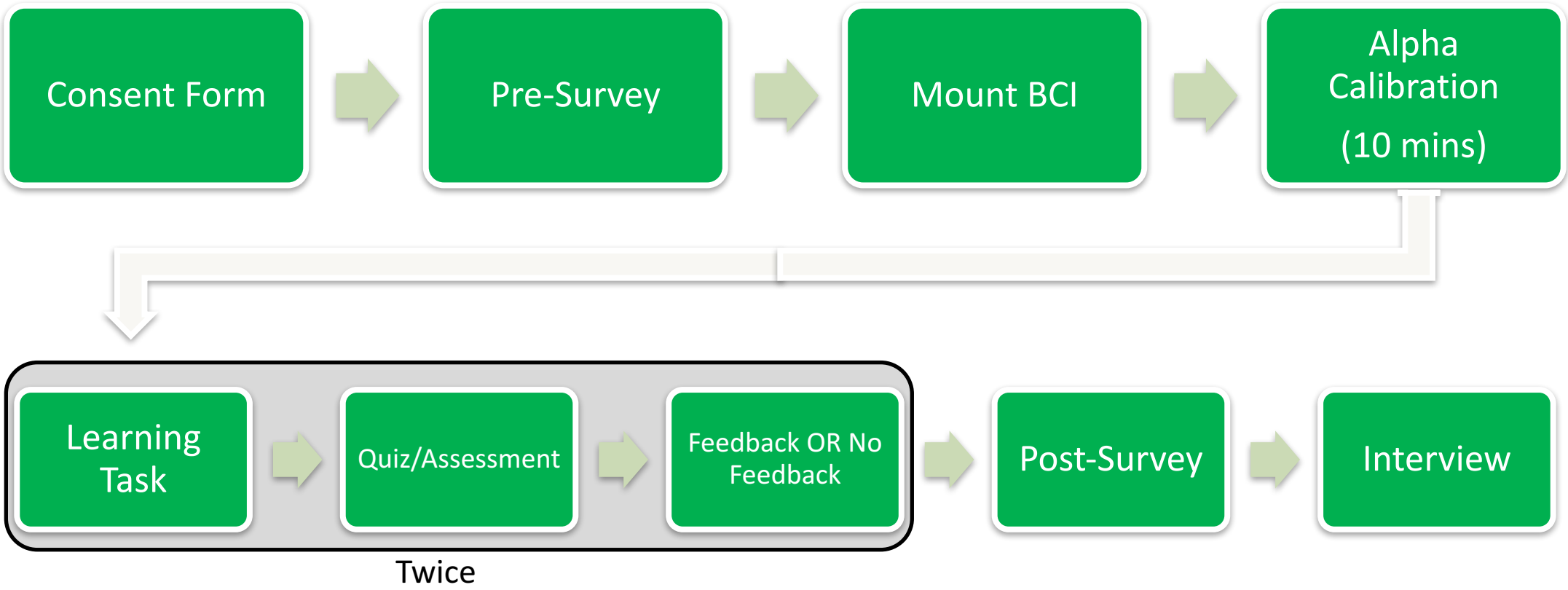


$$\textbf{FAS} = \log\left(\frac{\alpha\ power\ right\ F4}{\alpha\ power\ left\ F3}\right)$$



https://imotions.com/blog/frontal-asymmetry-101-get-insights-motivation-emotions-eeg/

STUDY

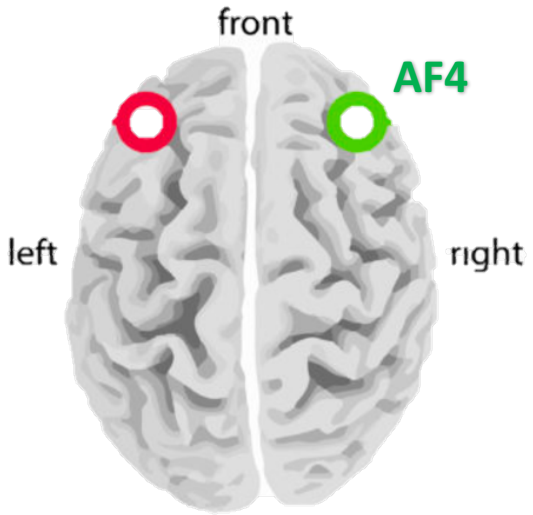

Consent Form
Pre-Survey
Mount BCI
Alpha Calibration (10 mins)
Learning Task
Quiz/Assessment
Feedback OR No Feedback
Twice
Post-Survey
Interview

EFFECTS OF QUANTIFIED-SELF ATTENTION FEEDBACK

- Analysis of Covariance (One-Way ANCOVA) to determine increment of attention from first to second task

High beta engagement index β/α	**AF4**	**P = .033**

$$E = \frac{High\ \beta}{\alpha}$$

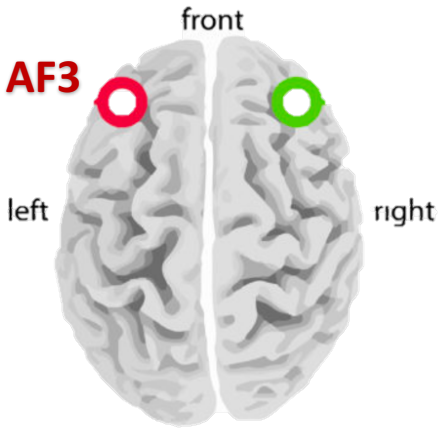


QUIZ SCORE & ATTENTION LEVELS CORRELATION

- Pearson's product-moment correlation test
  - There is a negative correlation between quiz 2 and low beta AF3 2 (r = -.288, P = 0.016)

Low β	**AF3**	**P = .016**

$$\mathbf{E} = \boldsymbol{Low\ \beta}$$



QUALITATIVE **HIGHLIGHTS**

- Students with ADHD found the tool helpful to monitor their attention
  - Unexpected
- Students without ADHD, but with “poor attention” think this tool would be beneficial for improvement
- Students in general would like to use this tool to improve as a person and learn more about how they go about learning
- Because students knew they were being monitored (reinforcer), they tried to put extra effort on the task
  - Unexpected

AUTOMOTIVE

DISTRACTED DRIVING

- 3 Main Distractions
  - Manual (Hands off the wheel)
  - Visual (Eyes of the road)
  - Cognitive (Mind off driving)

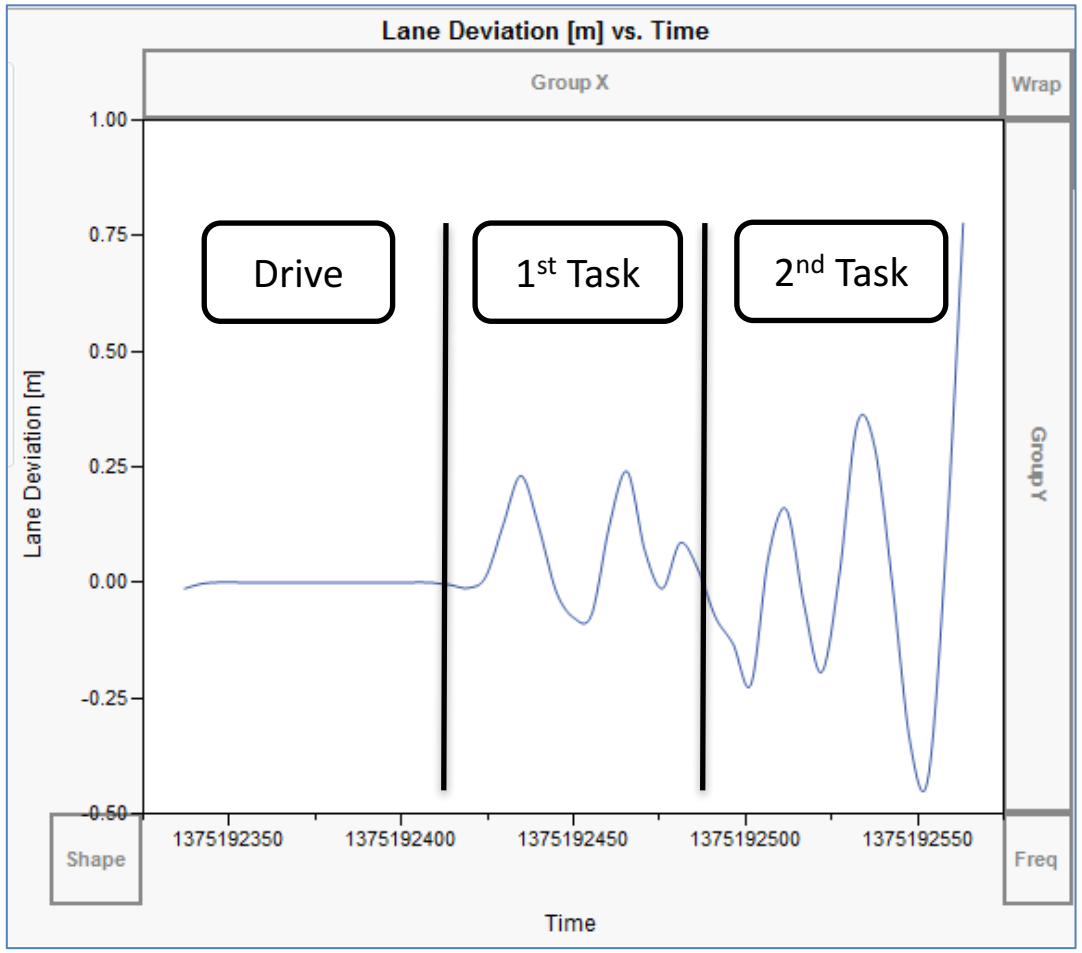
Manual

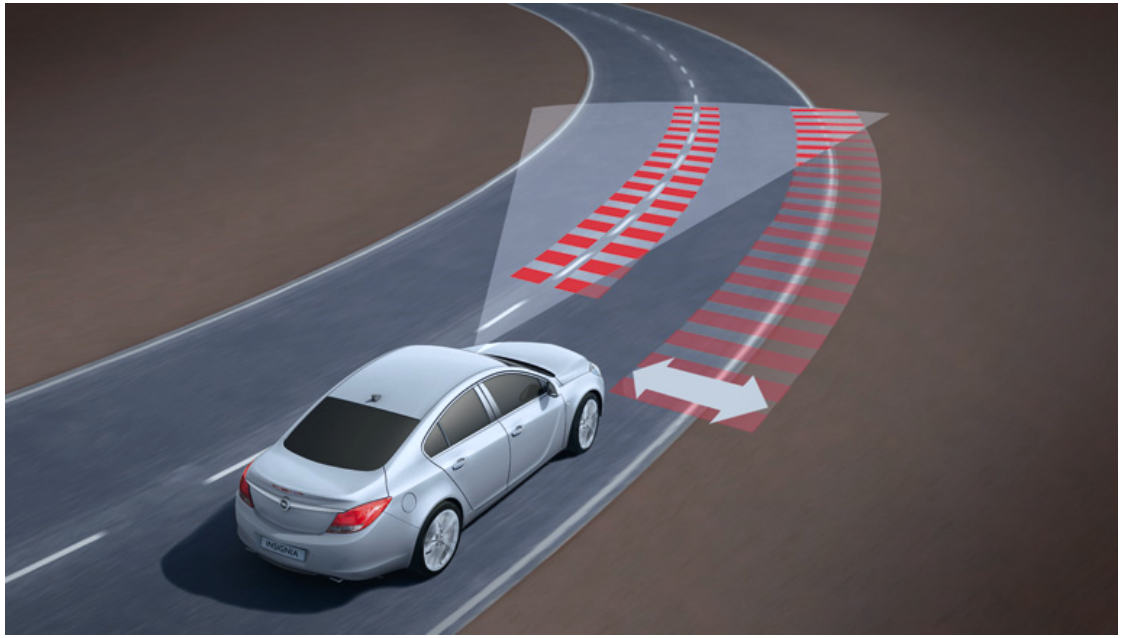
Visual

Cognitive

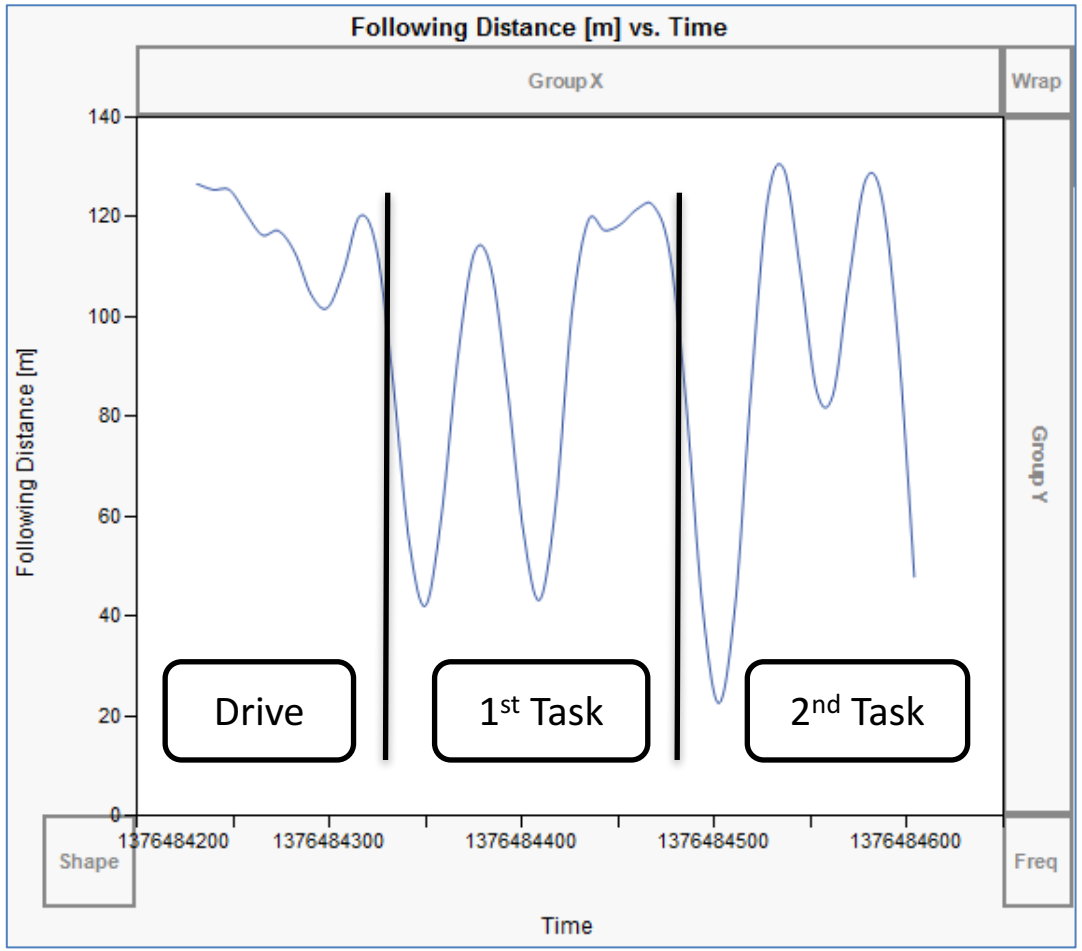
AUTOMOTIVE SETUP

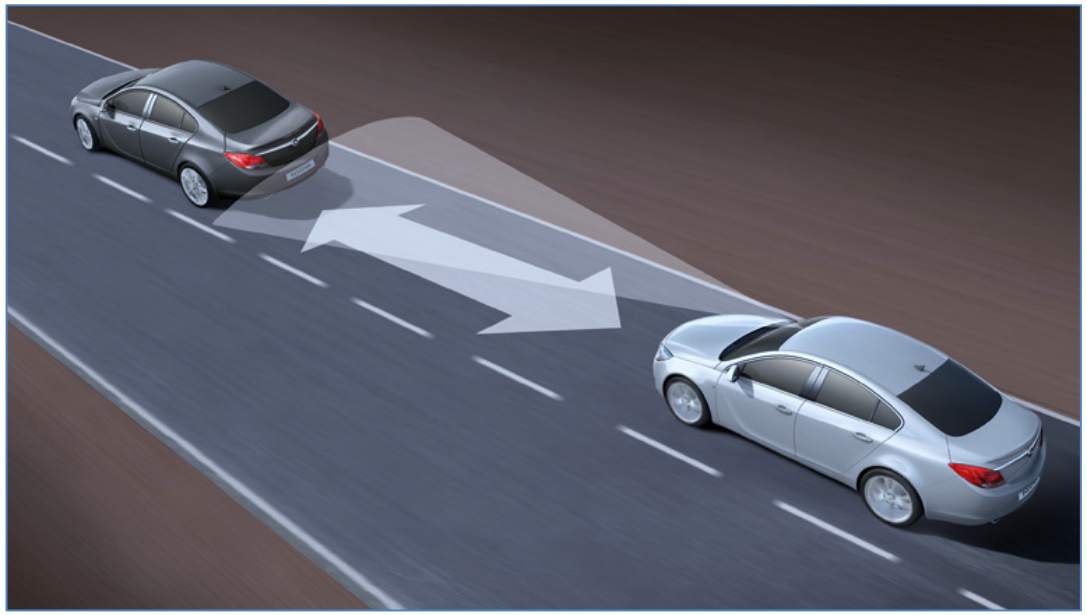
Lane Deviation





Following Distance





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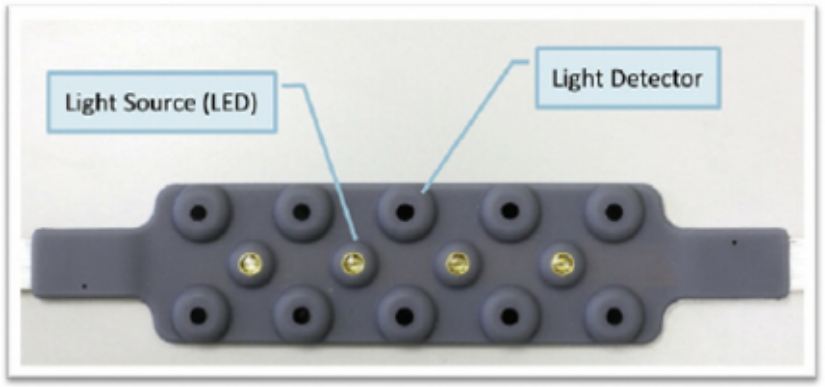
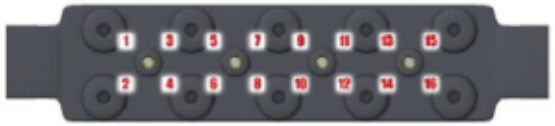
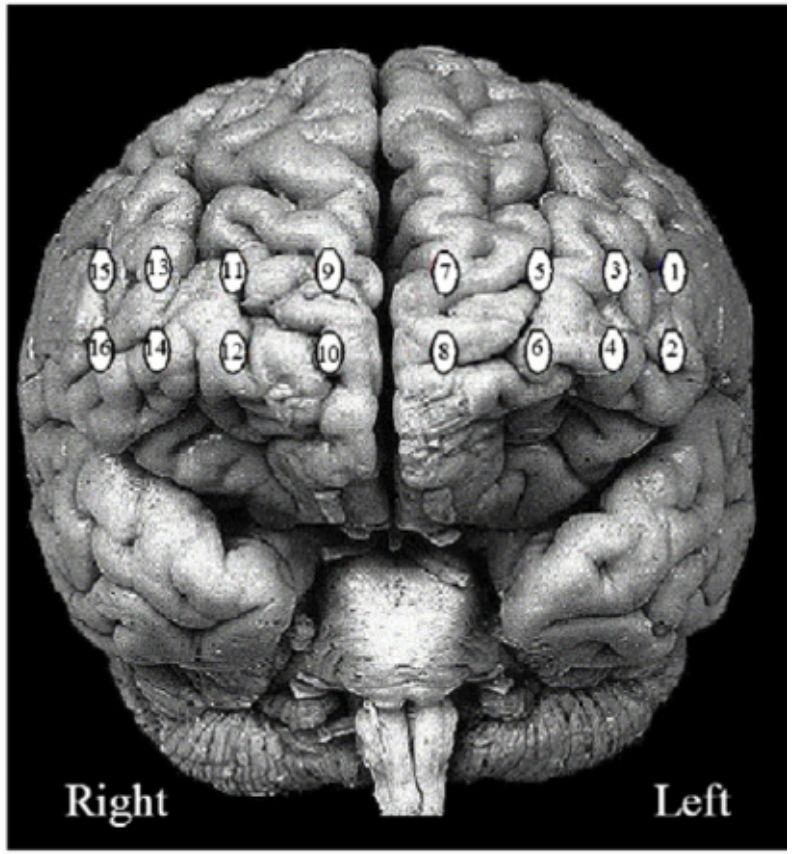
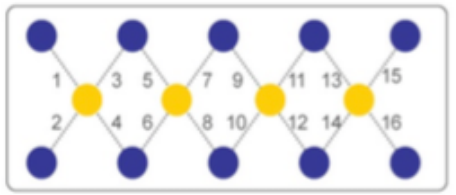
FNIRS DEVICE

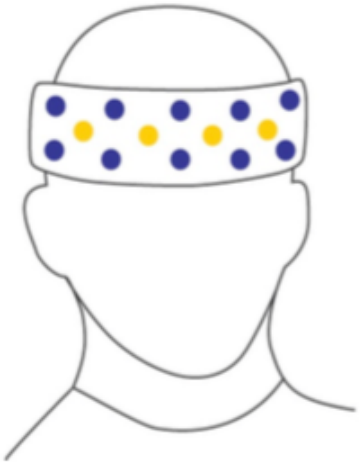
- Sensors: consist of light-source/detector pairs positioned on the head



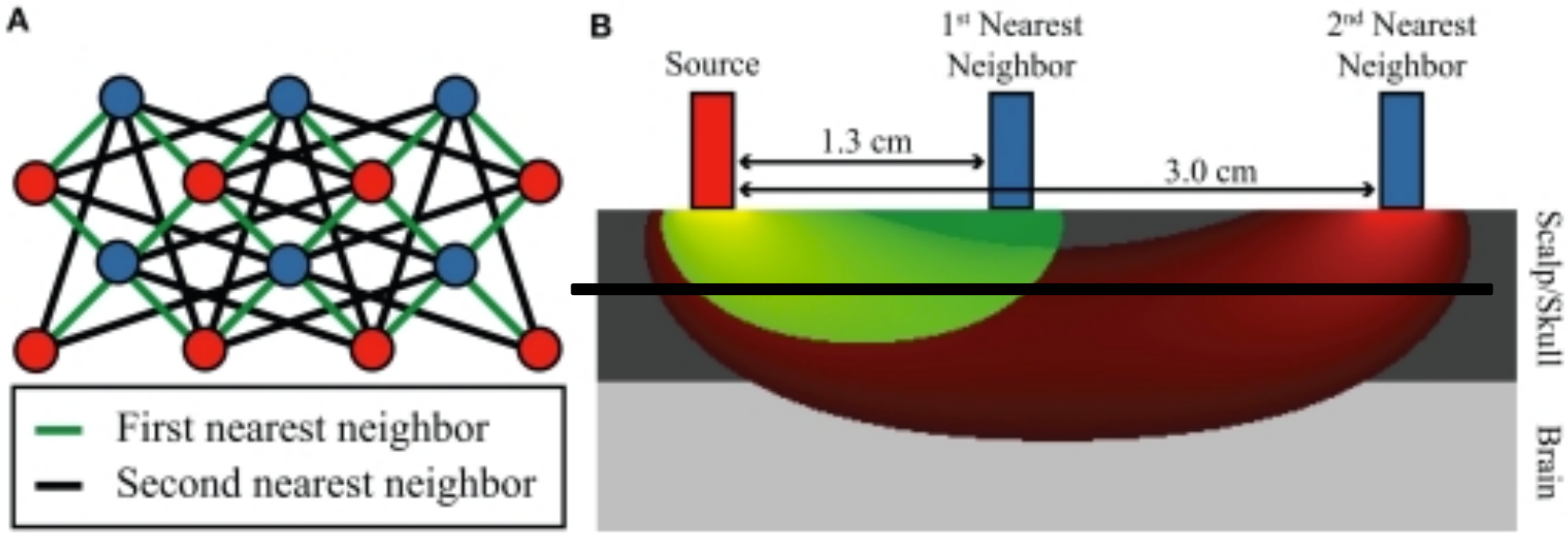




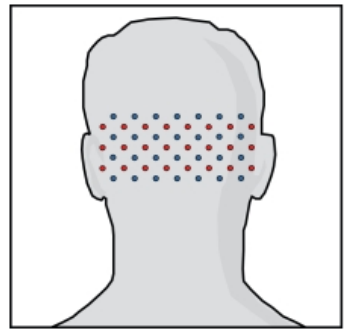




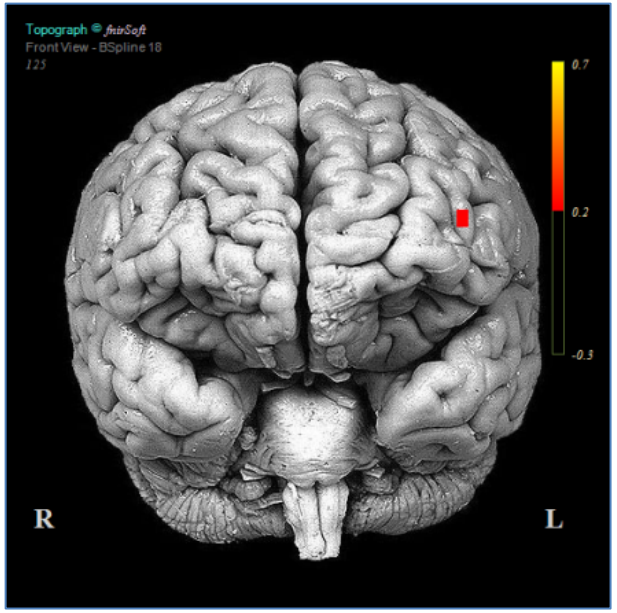
HIGH-DENSITY DIFFUSE OPTICAL IMAGING



- Red dots indicate source positions | Blue dots detector positions
- Interconnecting lines define first and second nearest neighbor source

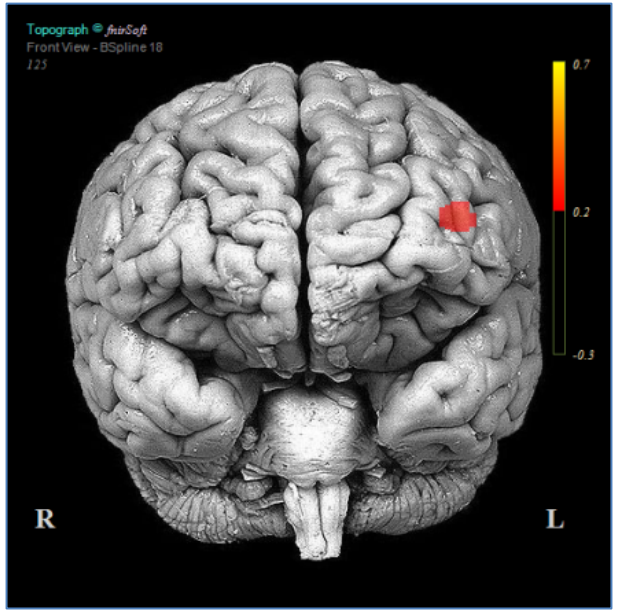


Cognitive Workload



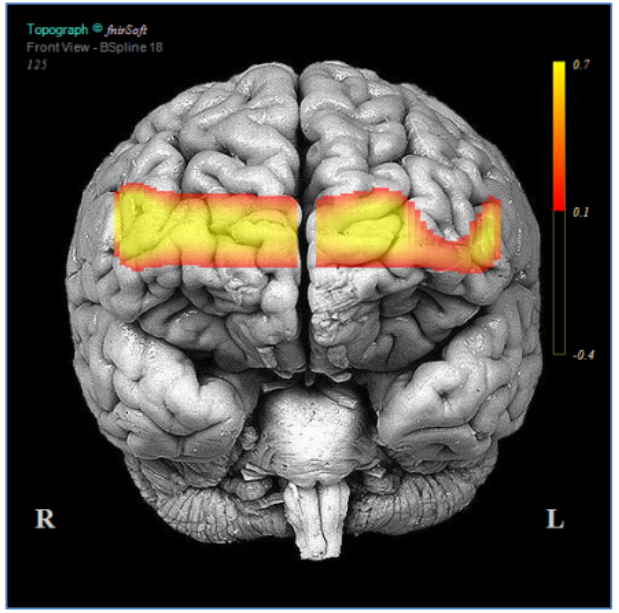
Low-Difficulty Task

Drive



Middle-Difficulty Task

1st Task

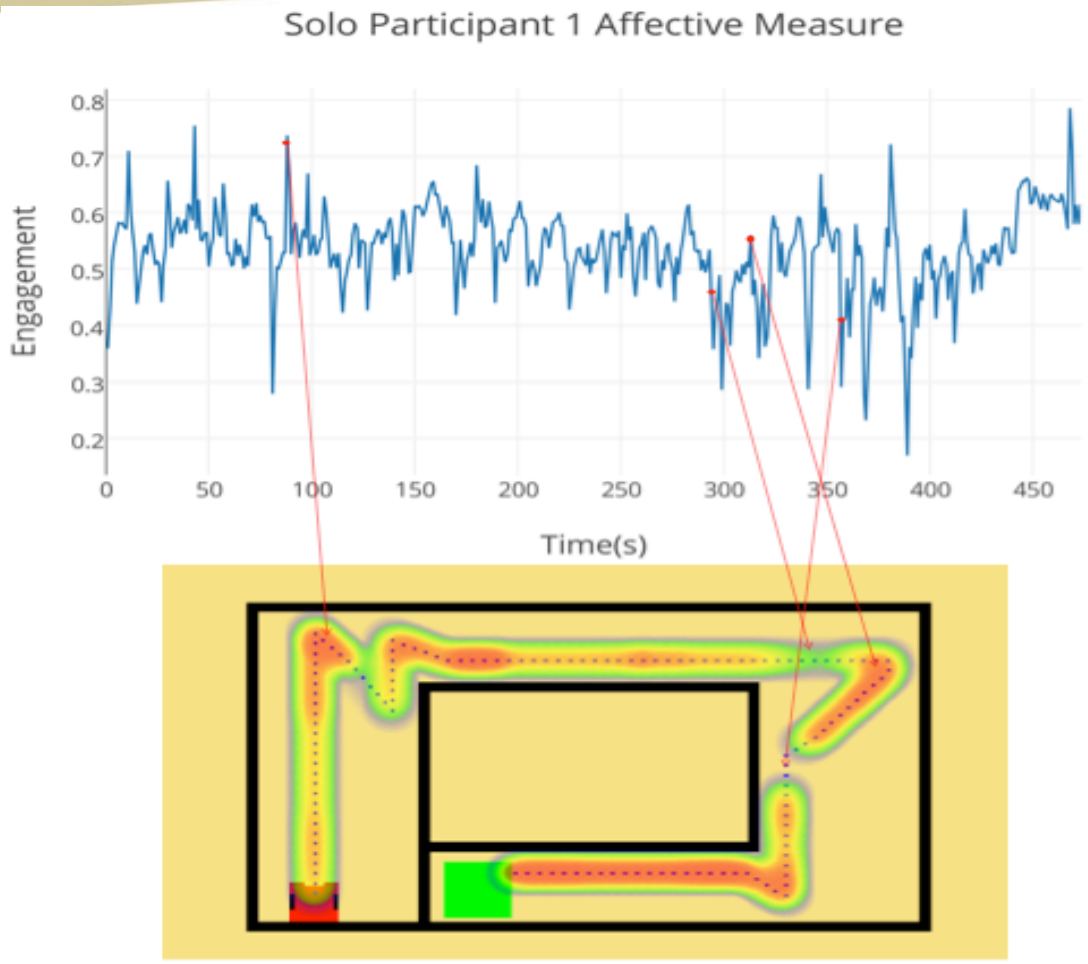


High-Difficulty Task

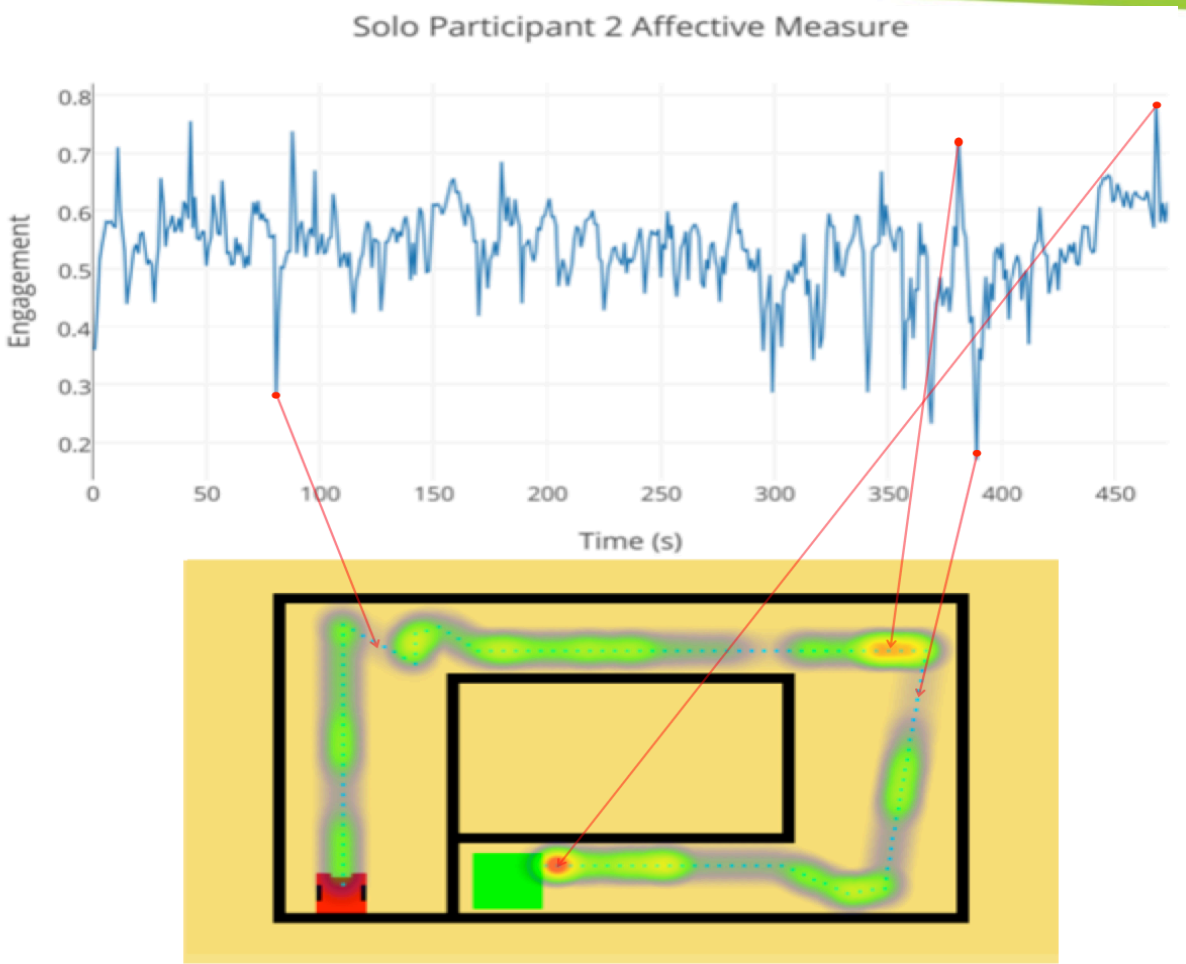
2nd Task

2 BRAIN VS 1 BRAIN: VISUALIZATION

SPATIAL VISUALIZATION: 1 BRAIN

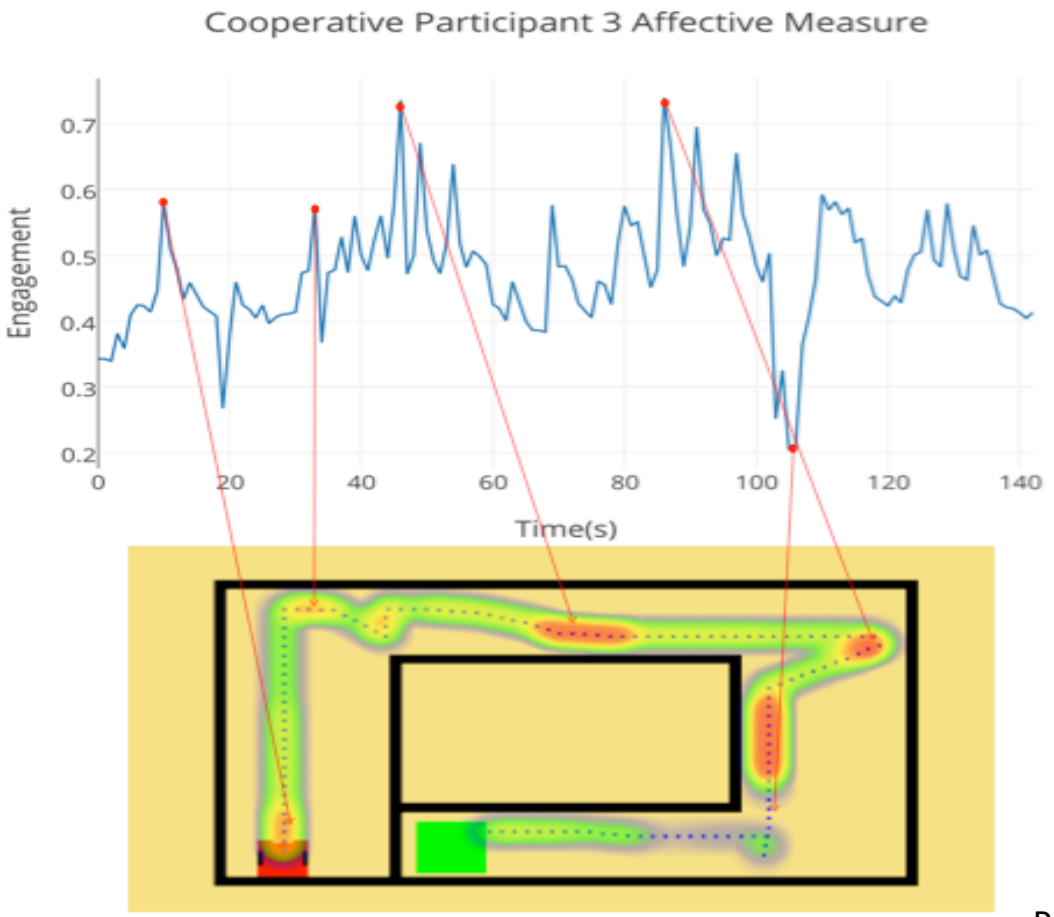


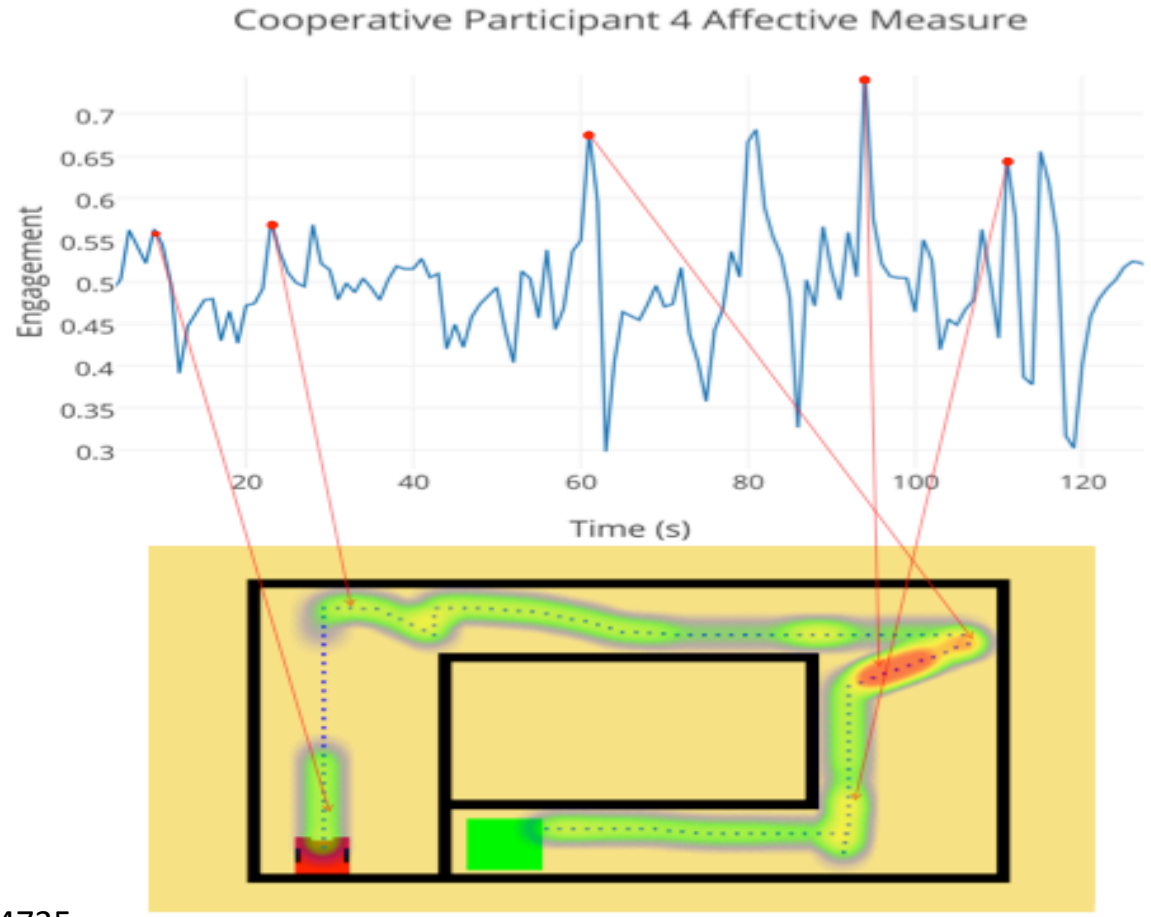
Avg. Eng: 0.5347
Task Completed: 464.90
Errors: 76



Avg. Eng: 0.2065
Task Completed: 474.00
Errors: 192

SPATIAL VISUALIZATION: 2 BRAIN





P3 Avg. Eng: 0.4735
P4 Avg. Eng: 0.4960
Task Completed: 127.00
Errors: 275

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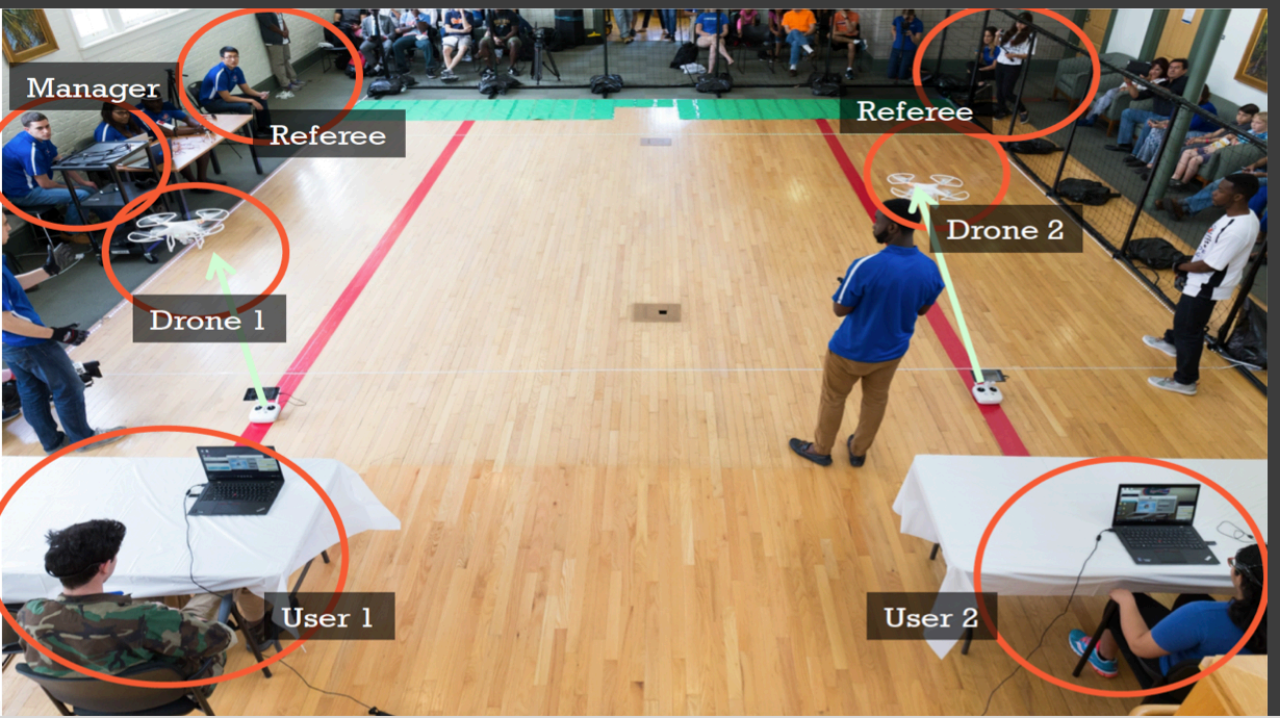
VIDEOS SHOWN

- Brain-Drone Race:
- https://www.youtube.com/watch?v=C0s3w-wqcI8

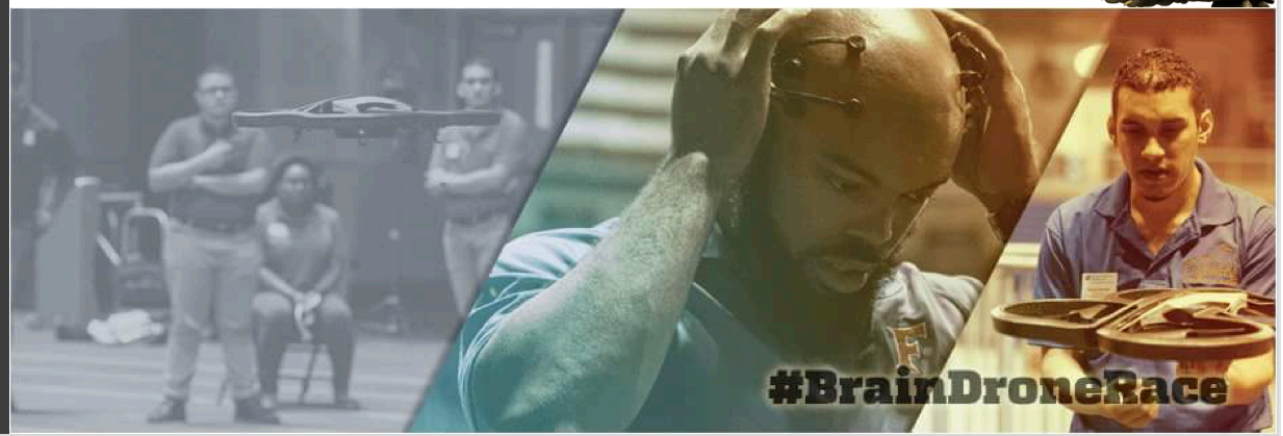


Do you want to control drones with your brain like Yoda?

Do you love writing code?

Join the new USF Brain-Drone Race team by e-mailing your resume to

Dr. Marvin Andujar at andujar1@usf.edu



PhD Student Position in BCI and HCI

Help Disrupt the Future

A research assistant position as a PhD student in **Brain-Computer Interfaces (BCIs)** and **Human-Computer Interaction (HCI)** is available to start Spring 2018 or Fall 2018 in the Department of Computer Science and Engineering at the **University of South Florida, Tampa, FL**. We are looking for students interested in working in cutting edge projects, curious about the human brain, and enthusiastic on learning how to send messages to machines for aid with the brain. For more information please check www.marvinandujar.com.

Potential Projects:

- Competitive Methods of Brain-Controlled Drones
- Attention decoding for ADHD from the brain
- New methods of Human-Computer Interaction with neuro apparatus
- Artistic Brain-Computer Interfaces - Brain Painting

Perks:

- Contribute to cutting edge and unique projects
- Opportunity for your project to be patented and published in the news like **NY times, Discovery Channel, Associated Press, Engadget**, etc.
- Work 30 minutes away from the best beaches in the country: https://www.visittampabay.com/things-to-do/tampa-beaches/#sthash.H4HA0dHq.dpbs
- Travel to great conferences worldwide (i.e. France, Hawaii, Italy, New Zealand, etc.)

DR. MARVIN ANDUJAR
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Qualifications:

- A B.S. or MS degree in Computer Science, Computer Engineering, Electrical Engineering, Informatics or a related field.
- Strong programming skills.
- No Neuro knowledge necessary.
- Knowledge on Matlab, ROS, and/or OpenCV.
- Experience with user study design (good to have, not necessary).
- Applicants must be strongly motivated to pursue a PhD.
- Can work independently, take initiative, self-motivated.
- Strong collaboration, leadership and communication skills.
- It helps to have knowledge in Machine Learning

If you are interested or would like to learn further information, contact Dr. Marvin Andujar at andujar1@usf.edu. **Make sure to include a copy of your resume/curriculum vitae (CV) and unofficial transcript.**

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QUESTIONS

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