

Towards a Cognitive Monitoring BCI application for Assitive Robotics

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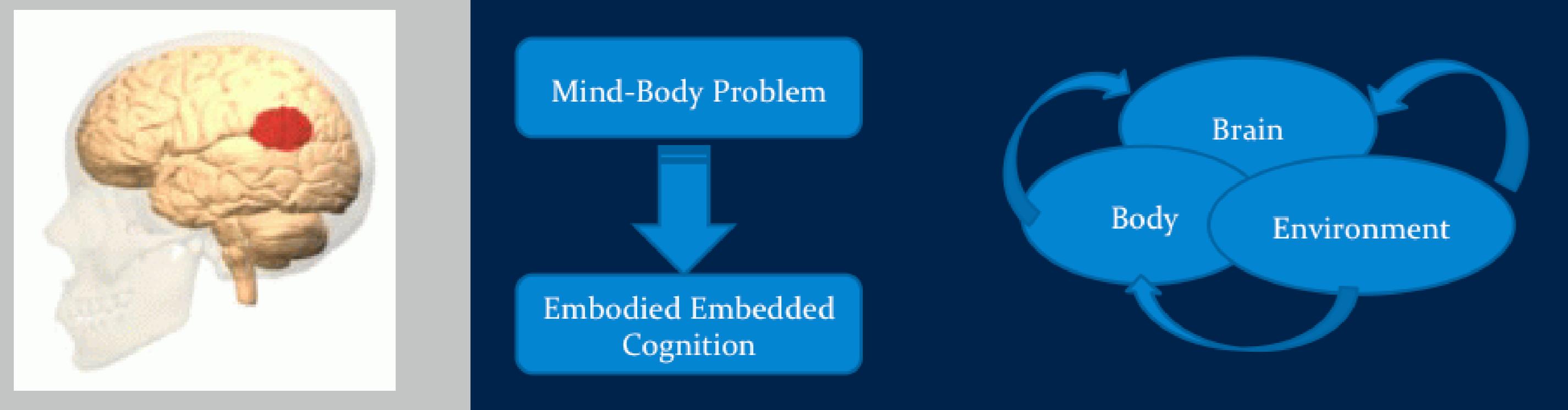
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Introduction

- **Brain Computer Interfaces Research is becoming a mature discipline.**
 - ▷ Through the last fifteen years, many successful projects have proved the feasibility to transfer information from the Central Nervous System to a computer, machine or robot.
- **BCIs are even now being considered an important branch of Human Computer Interaction.**
 - ▷ Games, Neuromarketing, Neuroergonomics, lie detection, biometric security, telepresence.
- Although, this widespread usage, the key aspect of BCI still lies in its support into **Assitive Technologies**.
 - ▷ However, there are many challenges ahead that need to be tackled: "we yet have an impractical and inaccessible exotica for very specific user groups" ([5])
 - ▷ We need **New mental paradigms** and **to get out of the lab into the real world!**

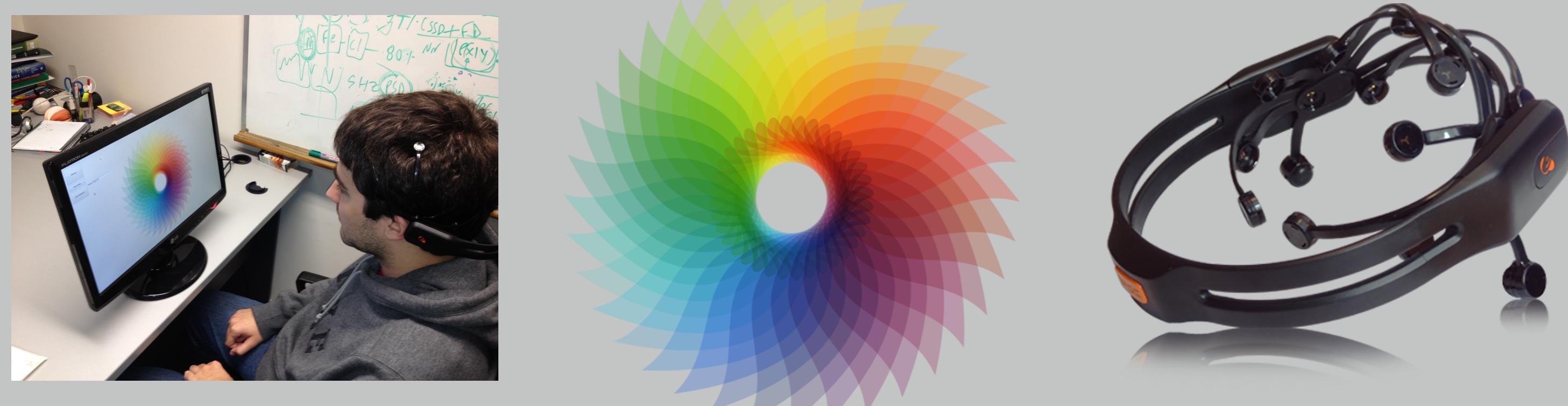
Embodiment and The Extended Mind Thesis

- Cognition is not strictly located within the physiological borders of the brain.
- Intelligent behaviour emerges out of the interplay between brain, body and world. Cognition is predominantly Active and Multisensorial [1,3]
- Spatial Localization: the Temporo Parietal Junction is involved in processes of self-localization, self-identification and is related to the situatedness of agents in their environments.
- We want to verify that if cognition relies strongly on the interaction with the environment and the agent's sensorial loop, then there must be a noteworthy signal feature strong enough to be detected by non invasive EEG.
- We also hypothesize that this signal could be modulated to effectively transmit volition.



Visual Spatial Covert Attention and α waves

- Alpha (8-13 Hz) waves are an inhibitory signal and are stronger on cognitive idle states when there is an absence of interaction with the environment.
- Inside the practical bandwidth of EEG signals (0-40 Hz).
- Affordable in the terms of Cost, with Wearable Commercial Devices (i.e. EPOC Emotiv).



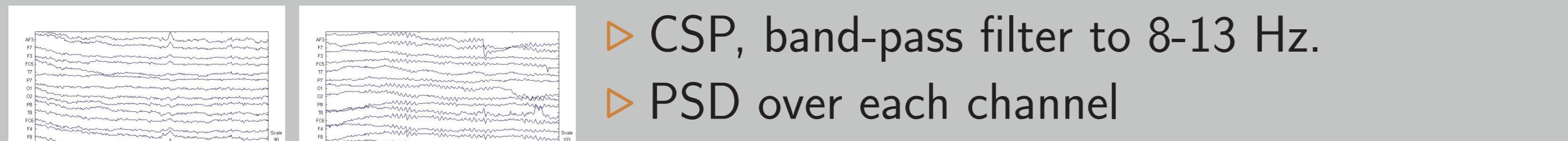
Protocol

Subject is instructed to count the number of flashes on the sides of an image. Gazing not allowed ! [4]

Flickering light on both sides of the screen at random frequency rates (similar to Oddball paradigm). 16 trials, $T = 4\text{s}$ each.
15 healthy voluntary subjects were recruited.

Analyze Method

EEGLAB, BCILAB, Matlab, fieldtrip



- ▷ CSP, band-pass filter to 8-13 Hz.
- ▷ PSD over each channel
- ▷ Estimation of winner channel: Left or Right?

Current Results

- ▷ Estimating flickering side: very low error rate: 58 % !!
- ▷ Is the device accurate ? Next: gaze tracker, EOG detection, CSSD.
- ▷ Work in Progress !!!

Motivations

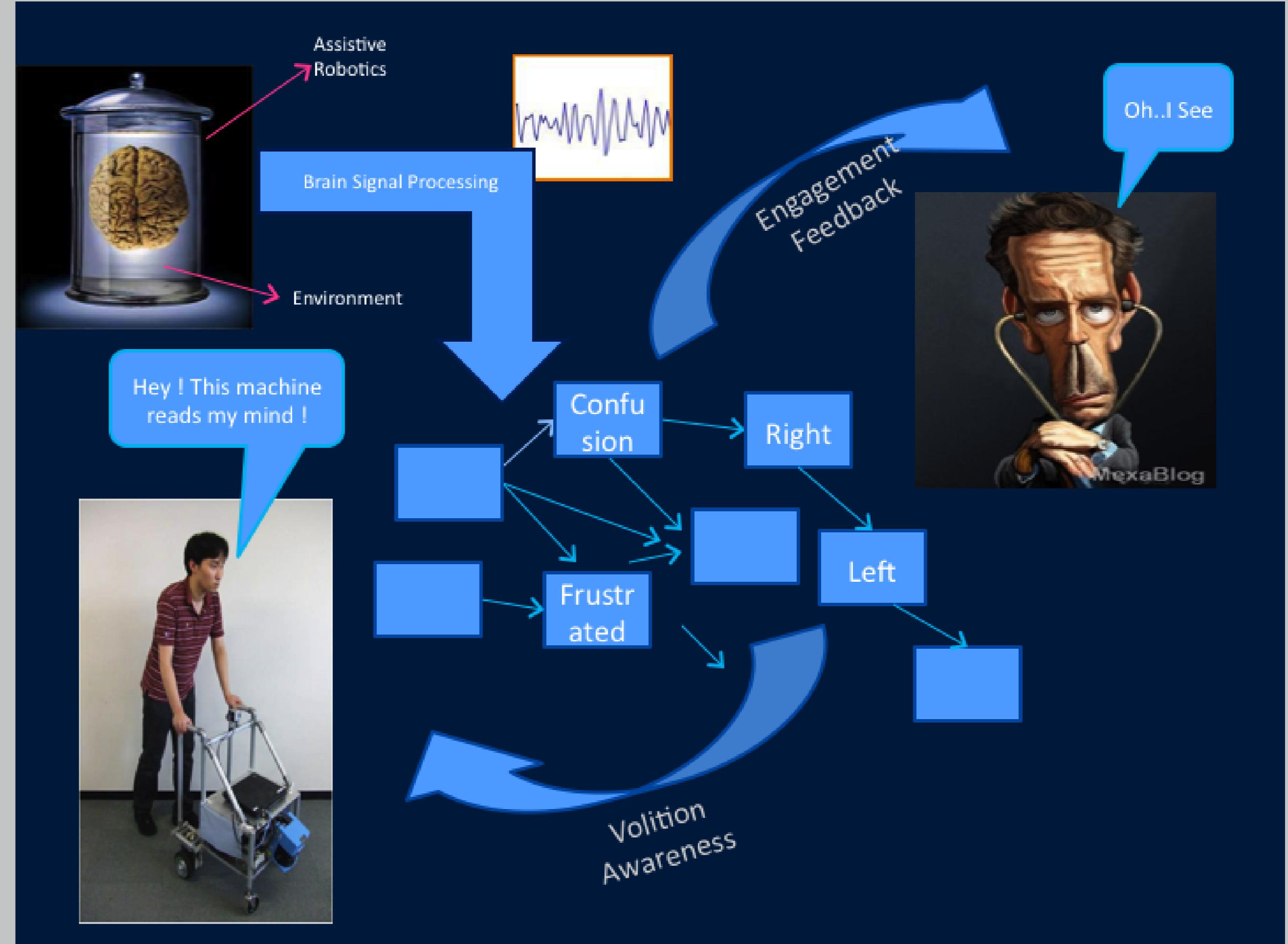
- Aging Societies
 - ▷ Estimated for 2025, 800 millions people will be over 65 old.
 - ▷ 2/3 of them on "developing" countries.
 - ▷ Increased tendency to develop diseases that affect motor pathways.
- Through technology, provide a better quality of life for more people.
 - ▷ Specially for those affected by diseases or disabilities.
- Active lifestyle: enhance mobility.
 - ▷ Ability to walk independently is a key indicator of psychological and physical health.
- Digital World demands more methods of interactions.
 - ▷ We need more mechanisms to interpret our surrounding world and to translate our intentions through our digital gadgets.



Cognitive Monitoring BCI application for Assitive Robotics

Objectives

- Develop a Cognitive Monitoring Non-invasive BCI mobile device.
- Real Time, Online, Single Trial, Active, Wearable,
- It will assist both, subjects with limited but remanent walking abilities, and their therapists, by providing valuable feedback in rehabilitation procedures.



Research Questions: Work in progress

- Does an Active BCI-powered assistive device allows better controllability and maneuverability?
- Is it possible to use Passive BCI (e.g. without user awareness) to enhance the safety of an assistive walking device ?
- Rehabilitation procedures are improved by using a Cognitive Monitoring BCI device ?
- Is it possible to achieve an improved BCI device in terms of Cost, Throughput, Utility, Integration and Appearance ? [6]

References and Previous Works

- 1 Clark, Andy. *Supersizing the Mind: Embodiment, Action, and Cognitive Extension: Embodiment, Action, and Cognitive Extension*. Oxford University Press, 2008.
- 2 A. Cherubini, G. Oriolo, F. Macri, F. Aloise, F. Babiloni, F. Cincotti, and D. Mattia. Development of a multimode navigation system for an assistive robotics project. *Proceedings 2007 IEEE International Conference on Robotics and Automation*, pages 2336–2342, April 2007.
- 3 Ionta, Silvio, Roger Gassert, and Olaf Blanke. Multi-sensory and sensorimotor foundation of bodily self-consciousness—an interdisciplinary approach. *Frontiers in psychology* 2 (2011).
- 4 Bahramisharif, Ali, et al. "Lateralized responses during covert attention are modulated by target eccentricity." *Neuroscience letters* 491.1 (2011): 35-39.
- 5 Tan Desney S. (Editor), Nijholt Anton (Editor) et al, *Brain-Computer Interfaces: Applying our minds to Human-Computer Interaction*, 2010, Springer
- 6 Allison, Brendan Z. "Toward ubiquitous bcis." *Brain-Computer Interfaces*. Springer Berlin Heidelberg, 2010. 357-387.