Understanding present and future of ELSA in Brain-Computer Interfaces (BCIs) – Partial Results

7ª Escola de Inverno em Avaliação de Tecnologia
Faculdade de Ciências e Tecnologia
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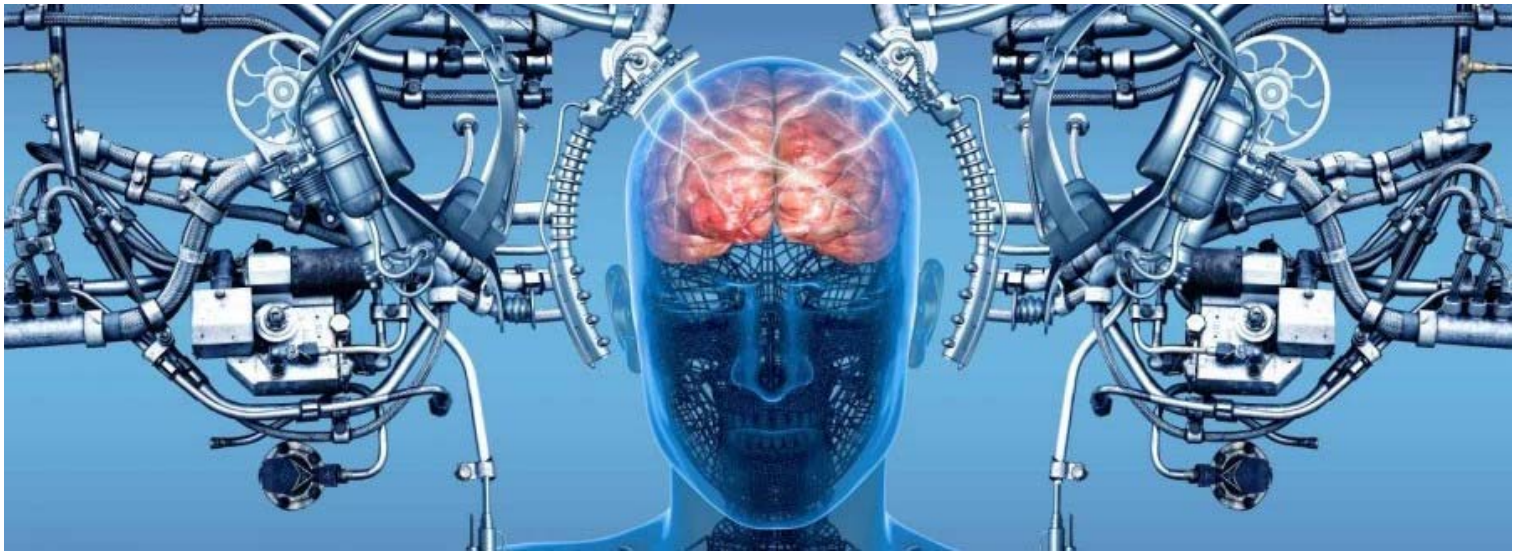
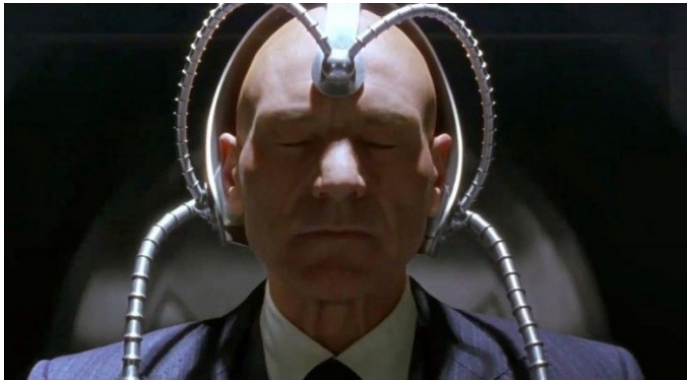


Source: http://blog.espol.edu.ec/taws/2016/07/07/maquina-para-leer-la-mente/

AGENDA

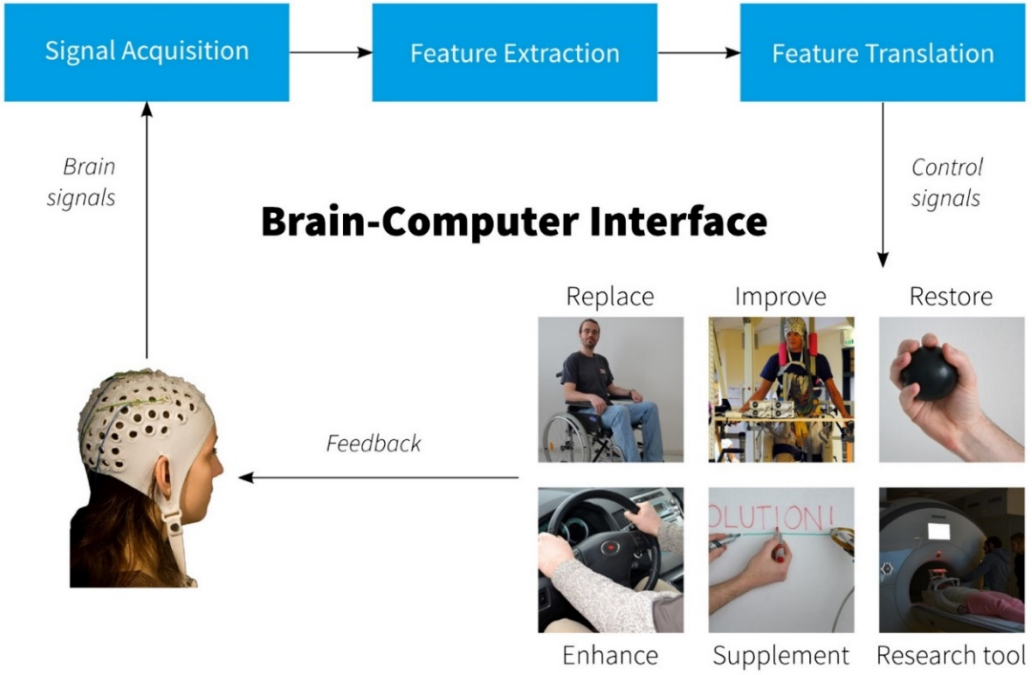
- Brain-computer Interfaces Overview
- Project Overview
- Methodological Framework
- Ethical, Social, Philosophical Aspects
- Interviews
- Survey (ELSA, Enablers and constraints, Future Visions)
- Final considerations



Source: http://www.extremetech.com/extreme/188883-the-first-human-brain-to-brain-interface-has-been-created-in-the-future-will-we-all-be-linked-telepathically/

Brain-computer Interfaces – how does it work?

"A BCI is a system that measures central nervous system (CNS) activity and converts it into artificial output that **replaces**, **restores**, **enhances**, **supplements**, or **improve** natural CNS and thereby changes the ongoing interactions between the CNS and its external or internal environment". *(Wolpaw & Wolpaw, 2012, p3)*



Invasive

Types of BCIs

Non-invasive

In more detail, BCIs can be used in the following six scenarios:

- BCIs can **replace** natural CNS output that has been lost as a result of injury or disease. Examples include communication (through a spelling system and voice synthesis) and motorized wheelchair control.
- BCIs can **restore** lost natural CNS output. Examples include functional electrical stimulation of muscles in a paralyzed person and stimulation of peripheral nerves to restore bladder function.
- BCIs can **enhance** natural CNS output. Examples include monitoring brain activity during prolonged demanding tasks such as driving a car and detecting lapses of attention, which alerts the person and restores attention.
- BCIs can **supplement** natural CNS output. Examples include providing a third (robotic) arm to a person and providing a selection function for people using a joystick.
- BCIs can **improve** natural CNS output. Examples include using a BCI in stroke rehabilitation that detects and enhances signals from a damaged cortical area and stimulate arm muscles or an orthosis to improve arm movements.
- BCIs can be used as a **research tool** to investigate CNS functions in clinical and non-clinical research studies.

Published in: Clemens Brunner; Niels Birbaumer; Benjamin Blankertz; Christoph Guger; Andrea Kübler; Donatella Mattia; José del R. Millán; Felip Miralles; Anton Nijholt; Eloy Opisso; Nick Ramsey; Patric Salomon; Gernot R. Müller-Putz; *Brain-Computer Interfaces* **2015,** 2, 1-10.

PhD Project - “Bridging present and future of Brain-Computer Interfaces: a future oriented constructive technology assessment”

Advisor: Prof. Dr. Antonio Moniz – FCT-UNL / Co-Advisor: Prof. Dr. Armin Grunwald – ITAS-KIT.

- The project focuses on the present and future Ethical, Social, Legal and Philosophical Aspects of BCI Technologies
- A Constructive Technology Assessment (CTA) combined with a Future oriented approach (FTA) was used for this project

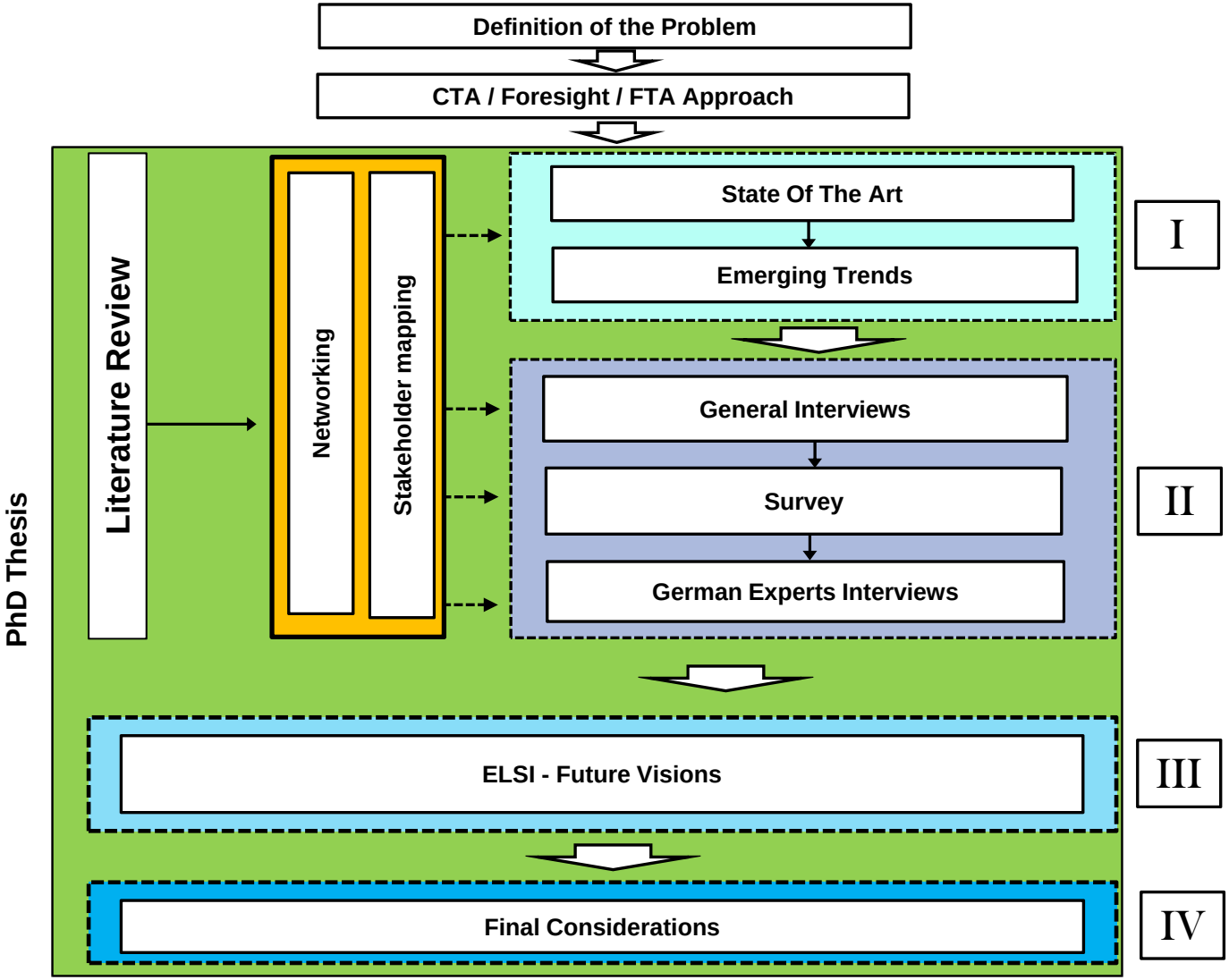
Three comprehensive empirical studies were carried out:

❖A quantitative and qualitative worldwide survey which gathered the perceptions of the BCI Community, other related communities (TA, Foresight, Ethicists), as well as other stakeholders such as Governments, Industry (in the field) and civil society. **T = 176 participants [155 valid respondents]**

❖Two groups of interviews with international and German BCI researchers aiming to at first gather reflections about the Literature Review and then deepen issues raised by the survey.

T = 15 experts (10 in International Interviews and 5 in German experts Interviews)

Brain-computer Interfaces Project - a Methodological Framework



Research Questions

This Project aims to answer/understand some questions:

1. Which ethical, legal, social and philosophical issues BCIs have now and which ones might it have in the future?

2. Will these issues be able to delay or even prevent the development of BCIs?

3. Which are the main constraints and enablers in the BCI field?

4. Will the BCI field evolve to the future towards supporting and enhancing a cyborg world?

5. How intimate can BCIs become?

Ethical, Legal, Social Impacts and Philosophical Aspects of BCI Technologies

MAIN ISSUES

Obtaining informed consent from people who have difficulty communicating

Side effects on brain structure and functioning

Human dignity

Autonomy

Privacy

Bodily integrity

Regulations

Blurring the boundaries

Moral responsibility

Free Will

Mental integrity

Social divide

Mind control

Mind-reading

Selective enhancement

The end of the idea of man

Changes in the concept of "Self"

Self perception and body ownership

Side effects in cognitive capacities, personal identity, mood, behavior

The First Group of Interviews: The BCIs Expert's Opinions

Through a group of interviews in the BCI Community it was possible to got more information about the findings in the literature – some implications are confirmed and others not.

1 – What is your opinion on whether all paralyzed individuals should have equal opportunities to access a BCI, even if they cannot give informed consent in a clear way?

"Yes, I do believe that all those people should have an opportunity to have a BCI although they are not able to fully deliver informed consent. Yes. Because we should not prevent people from having an opportunity to communicate and maybe to communicate that in the future they would not communicate. So we should give opportunity to all of them."

2 – In your point of view, do you believe that the growth and wider distribution of BCIs represents a threat to privacy and autonomy? Why?

"It could be a serious threat to privacy if the EEG data is stored or accessible by a third entity. It considers a violation of autonomy the use of BCI with the purpose of modifying the decision making process of individuals by recording a group of people to model the behavior of a bigger group. (i.e. affective-BCI in neuromarketing)."

The First Group of Interviews: The BCIs Expert's Opinions

3 - At the present time, would you say that complete locked-in syndrome (CLIS) patients being unable to communicate using BCIs represent a constraint to the development of the field? Please elaborate.

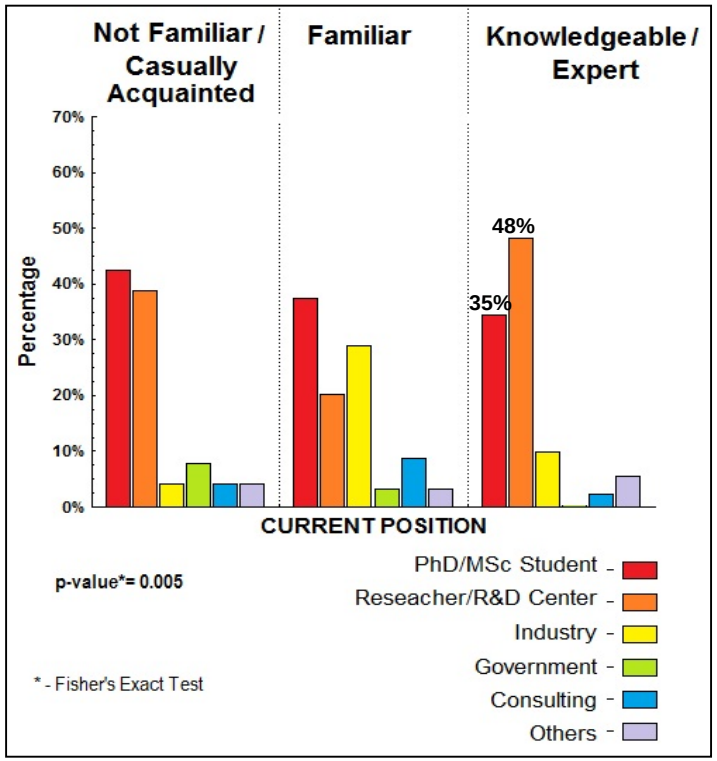
"No, CLIS patients don't constrain the development of the field. They are part of the challenge. BCI has much more applications than interfacing with CLIS patients."

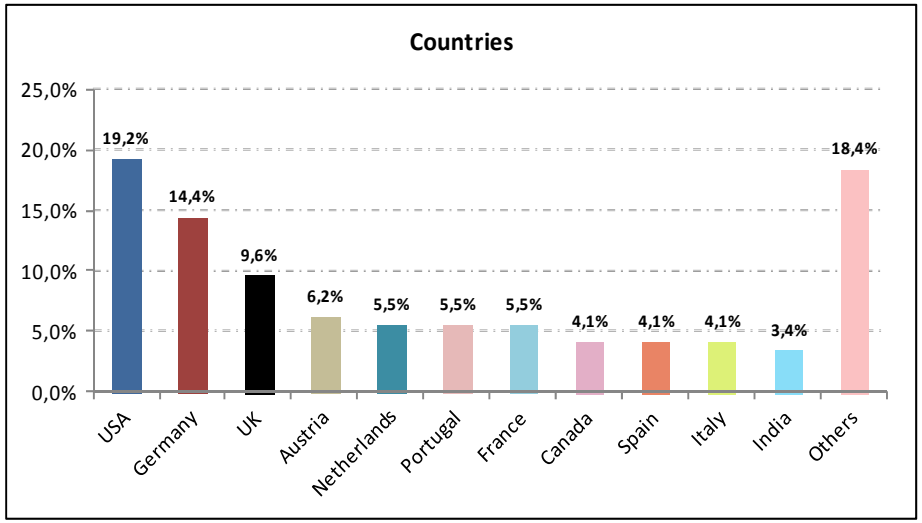
4 - In your opinion will non-invasive EEG BCIs for clinical applications overcome technical and ethical issues and become broadly available to ensure communication and control to those in locked in and complete locked-in states? How?

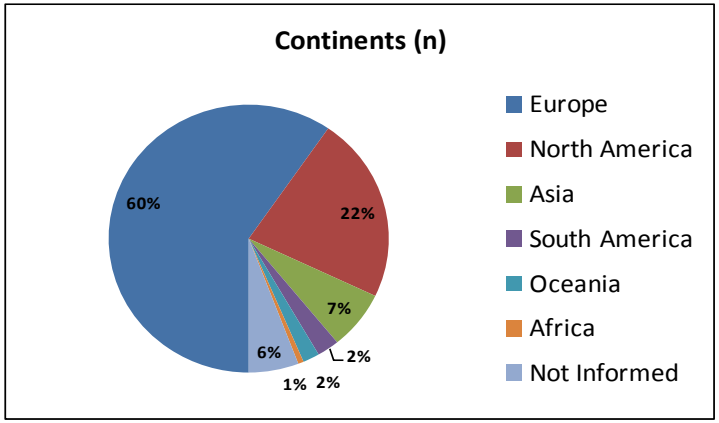
"I am not sure that the technical and ethical issues will be overcome in the case of CLIS patients, given the presently inadequate state of (neuroscientific) knowledge about the preservation of purposeful thinking in the CLIS state. In the case of LIS states, BCI systems must be able to meet the economic competition with other assistive technologies that LIS patients may use."

Survey - Perceptions on Brain-Computer Interfaces

Designed in 3 main Sections, the survey was performed between 09/14 - 04/15 – it had 155 valid respondents (out of 176 total) from 46 different countries.







NOT FAMILIAR: You don't know anything about the topic.
CASUALLY ACQUAINTED: You have read or heard about the topic - have had eventual relations with groups of interest regarding the subject.
FAMILIAR: You have read about it and you have formed opinions about it.
KNOWLEDGEABLE: You are in the process of becoming an expert - or you work in a neighboring field and occasionally draw up upon or contribute to the development of this topic.
EXPERT: You are a part of the community who currently dedicate themselves to the topic.

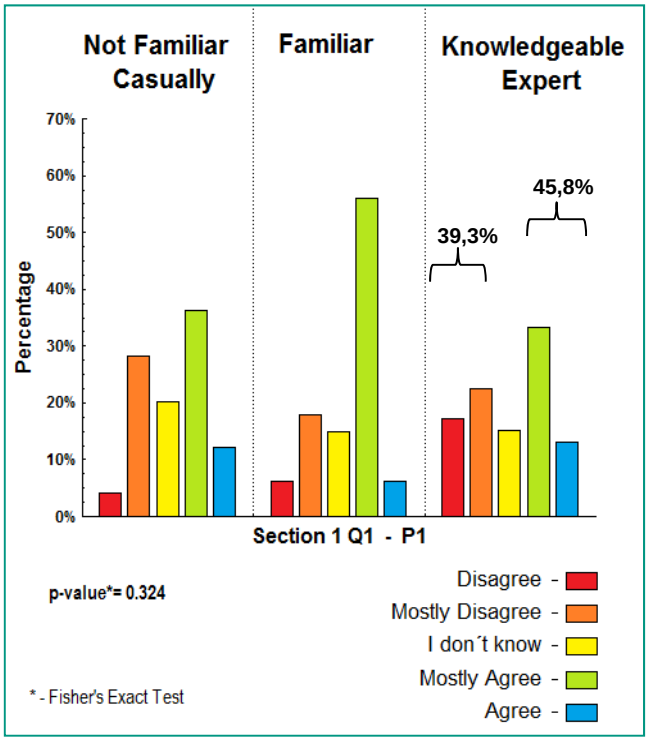
Survey – Section 1 – About ethics, morals and responsibilities

With 23 topics, this Section aimed to identify the **ethical, social, legal issues and philosophical aspects in the field**. At the present, some issues have not yet been adequately understood and some deserve further consideration.

INFORMED CONSENT

P1. To people in locked-in-states, a simple 'yes' or 'no' given by the blink of an eye is sufficient to establish that the patient had the cognitive and emotional capacity to make complex decisions.

153 respondents – 94 knowlegeable & experts



"A simple 'yes' or 'no' given by the blink of an eye is sufficient to establish that the patient had the cognitive and emotional capacity to make complex decisions".

"Not a simple blink, because it can be accidental, this would be highly circumstantial, and can be inducted".

"The locked-in state has different stages of progress, if the subject is in early or middle stage, the decision can be made effectively".

Disagree + Mostly Disagree:
17% + 22,3% = **39,3%**

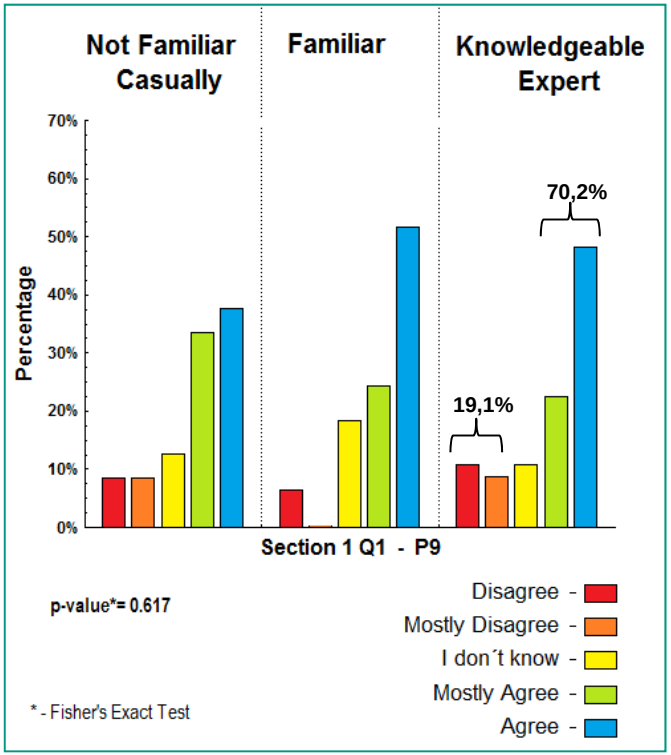
Agree + Mostly Agree = 12,8% + 33% = **45,8%**

Survey – Section 1 – About ethics, morals and responsibilities

PRIVACY

P9. The notion of privacy will change when the brain's extracted information is used for commercial purposes such as smarter advertising or to maximize productivity through employees' surveillance.

151 respondents – 94 knowlegeable & experts



"It is not possible to extract information from a person's brain unless they give consent. If someone consents to have their brain activity used for commercial purposes, then it is not a privacy issue. Employers typically use surveillance techniques to observe employees' behavior in many contexts. The internet performs constant surveillance on our actions and the information is used for advertising".

"Privacy is privacy. It should not change based on who is accessing or using the data. But just looking at what has happened with social media, makes me think that this statement, unfortunately, end up being true".

Disagree + Mostly Disagree:
10,6 % + 8,5% = **19,1%**

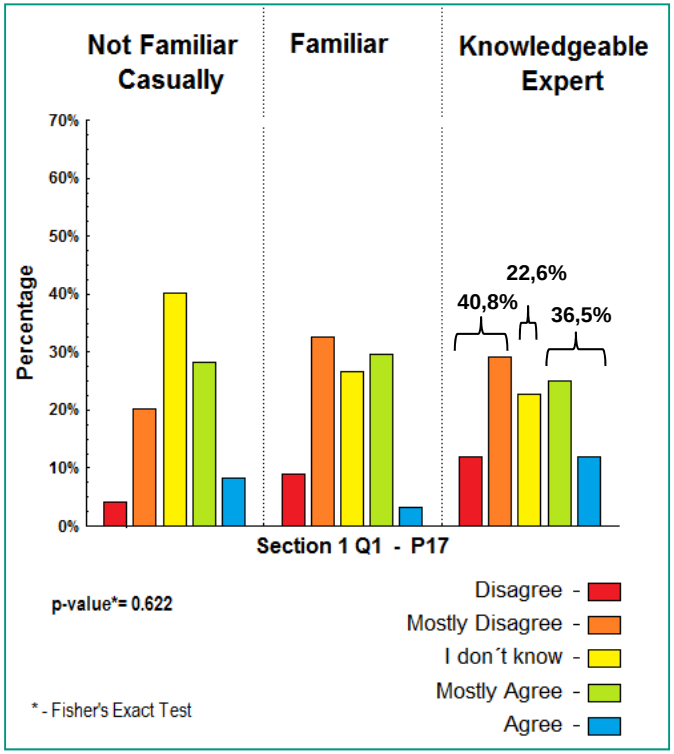
Agree + Mostly Agree = 47,9%
+ 22,3% = **70,2%**

Survey – Section 1 – About ethics, morals and responsibilities

AUTONOMY

P17. BCI can induce changes in cognitive capacities, psychological continuity or personal identities, which challenge the capacity to autonomous decision making.

151 respondents – 93 knowlegeable & experts



"Right now we have no ideal how BCI might change any of these things by direct action on the brain, but I think it'll be a drop in the ocean compared to the effects of coping with disability, having surgery, etc, on the same things".

"I would say they challenge our current conception of autonomous decision making".

"Neurofeedback has been shown to alter cognition. I don't know about altering the capacity to make decisions".

Disagree + Mostly Disagree: 11,8% + 29% = **40,8%**

Agree + Mostly Agree = 11,8% + 24,7% = **36,5%**

I don't know = 22,6

Survey – Section 1 – About ethics, morals and responsibilities

SIDE EFFECTS

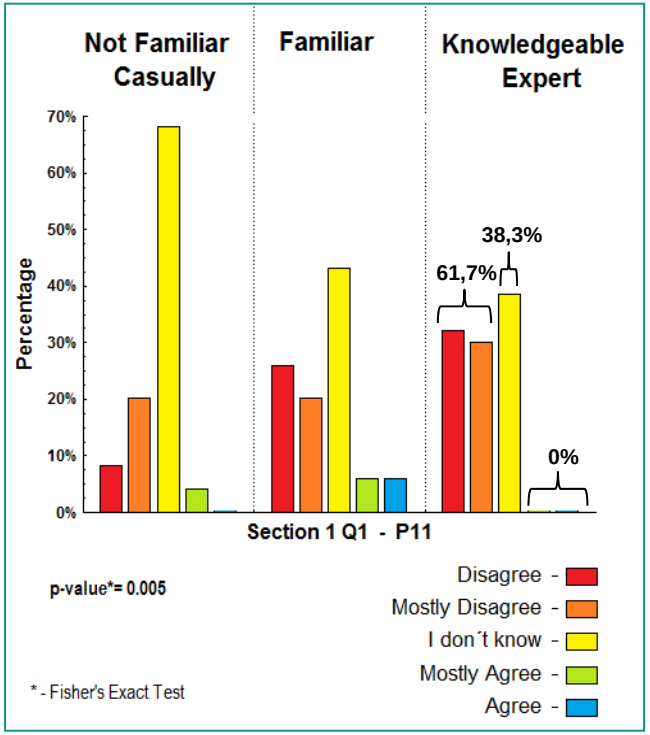
P11. The long term use of non-invasive BCI leads to negative consequences on brain structure and functioning.

154 respondents – 93 knowledgeable & experts

"Change is inevitable, especially when the potential of feedback is utilized. Positive or negative is a matter of interpretation".

"Non-invasive procedures will not negatively change the brain any more than verbal and environmental communication will. The brain functions as an organ that responds to its environment and changes is structured accordingly. People's brains are merely an expression of who they are".

"There is a less experience on the long-term consequences, but the consequences could be similar to use a mobile phone".



Disagree + Mostly Disagree:
31,9% + 29,8% = **61,7%**

Agree + Mostly Agree = 0% + 0% = **0%**

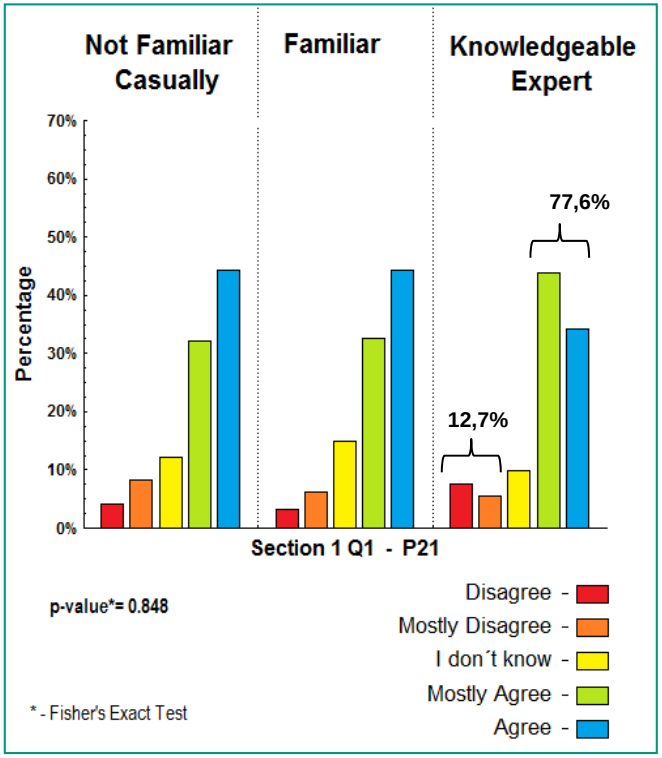
I don't know = 38,3

Survey – Section 1 – About ethics, morals and responsibilities

PHILOSOPHICAL ASPECTS

P21. There are moral and philosophical questions when considering the blurring distinction between man and machine and the idea of the cyborg.

153 respondents – 94 knowlegeable & experts



"There are ethical and moral questions. Moral relates to group beliefs, but ethical beliefs are personal".

"In my opinion among the most important questions resides on the definition of voluntary actions when these actions are jointly performed by man and machine (in particular, when the later has increasing autonomy). Another is the fact the potential enhancement of human capabilities (through melding with machines) may further increase social inequality depending on who has access to such technologies".

Disagree + Mostly Disagree:
7,4% + 5,3% = **12,7**

Agree + Mostly Agree = 34% + 43,6% = **77,6%**

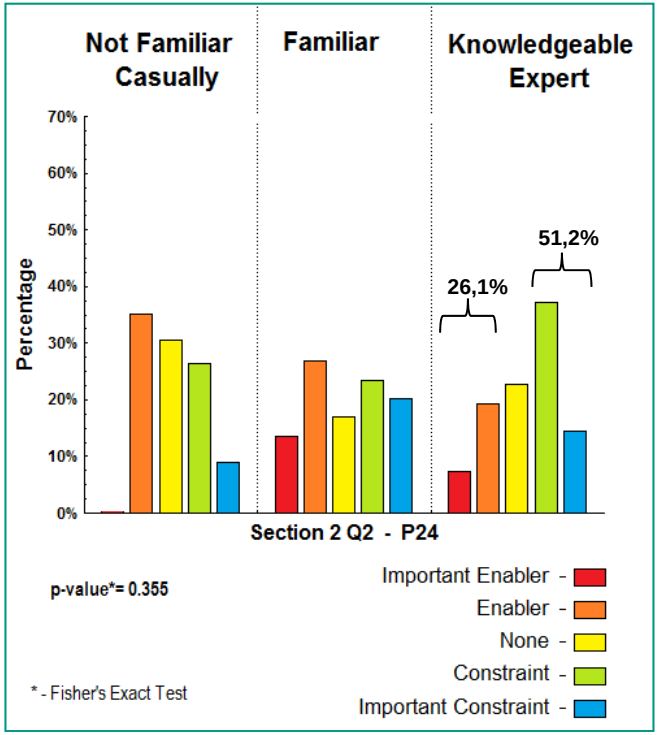
Survey – Section 2 – Perspectives and Challenges

With 13 topics, this section aimed to identify important irreversibilities resulting from actions and interactions among reseachers, institutes, companies and policymakers in the form of **enablers and constraints** for the future of the field.

ENABLERS AND CONSTRAINTS

P24. The fact that complete locked-in syndrome (CLIS) patients are unable to communicate using BCIs, at the present time.

137 respondents – 84 knowlegeable & experts



"This is a hard one to put first when I'm struggling with the terms enabler and constraint. It is a challenge to the field that people with CLIS can't use BCI, but it is an opportunity for further research. But, I have trouble saying that it is helpful to the field, except that it is likely to make us understand what BCIs really do better".

Important Enabler + Enabler: 7,1 % + 19% = **26,1%**

Constraint + Important Constraint = 36,9% + 14,3% = **51,2%**

None = 22,6 %

Survey – Section 2 – Perspectives and Challenges

ENABLERS AND CONSTRAINTS

P35. The lack of systematization of ethical issues that are placed in the present and will emerge in the future.

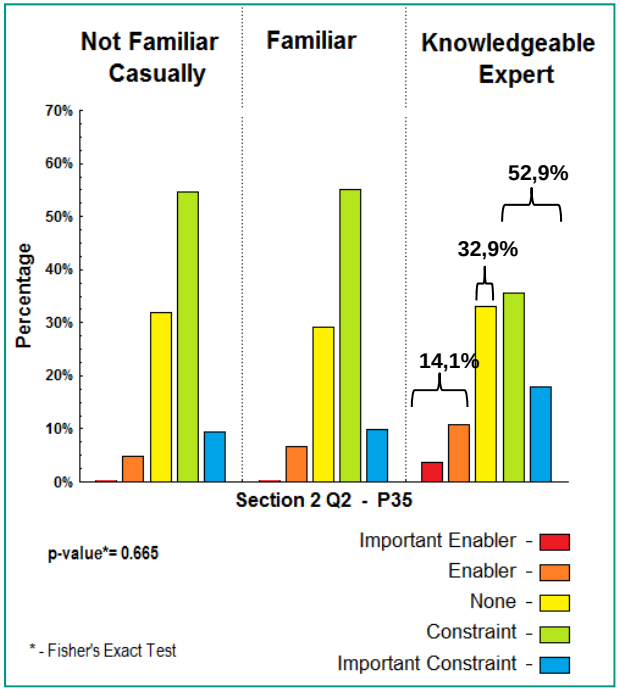
138 respondents – 85 knowlegeable & experts

"Many of the ethical issues faced by BCI are common to other technologies – such as robotics and neuro. We don't need to reinvent the wheel".

"This additional parallel process needs time, but it is only a constraint for BCI as an assistive technology or other purposes than for clinical applications".

"Because it may scare people and thus degrade the public image of the field, thus potentially reducing research supports in the future".

"As long as no questions are asked, most developers will try not to think about the rights and wrongs".



Important Enabler + Enabler:
3,5 % + 10,6% = **14,1%**

Constraint + Important Constraint = 35,3% + 17,6% = **52,9%**

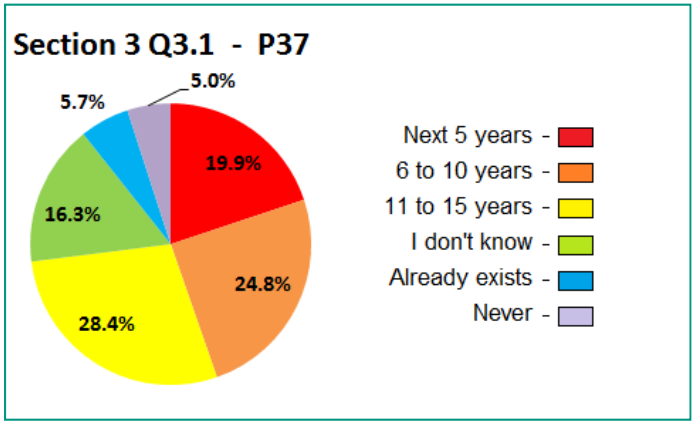
None = 32,9%

Survey – Section 3 – 3.1 - Future Visions

This Section aimed to get perceptions about the future of the field. It is divided in 2 Subsections. The Future Visions Subsection presented 5 topics.

P37. Non-invasive EEG BCIs for clinical applications will overcome technical issues and will be fine-resolution, friendly, wireless, cheaper, faster, reliable, high performance and will become broadly available to ensure communication and motor control to those in locked in and complete locked-in states.

141 respondents – 86 knowlegeable & experts



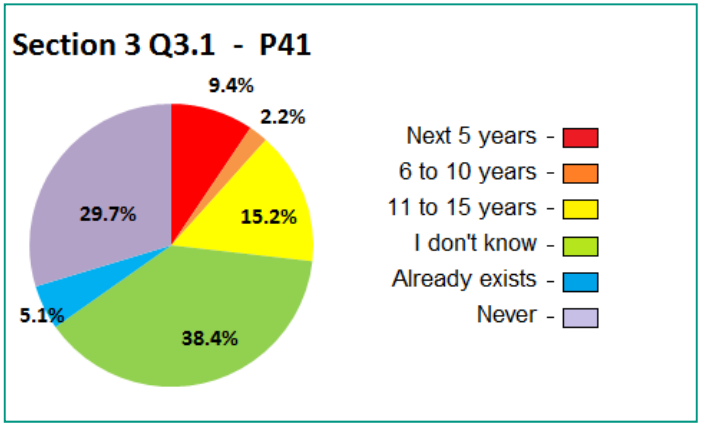
"In theory, yes. But in practice, governments and insurance companies ration access to such benefits and those most able to benefit (handicapped) are often the very last to be given them".

"We will get better and better with BCIs and it will be a 'never ending' project. Neurotechnology will reshape the world forever".

Survey – Section 3 – 3.1 - Future Visions

P41. The BCI technologies will evolve allowing for direct communication between two individual's brains with great possibilities for enhancement purposes, even creating home-made brain interfacing devices, but this will be accompanied by massive violations of privacy and coercive control from man over another man.

138 respondents – 85 knowlegeable & experts



"If this enables a paralysed and/or handicapped blind, autistic, immobile person to enjoy a relatively normal level of movement and communication, this could be justified".

"I don't want to say 'never' in the same way that I'm not going to say aliens will 'never' contact us or the earth will 'never' be hit by an asteroid".

Survey – Section 3 – 3.2 – Vision Statements

This Section aimed to get perceptions about the future of the field. It is divided in 2 Subsections. The Vision Statements Subsection presented 6 topics.

Are BCI innovations, which will extend life and health as well as increase performance, part of a new era of human enhancement?

138 respondents – 84 knowlegeable & experts

Variável		Not Familiar / Casually	Familiar	Knowlegeable / Expert
Yes	(n)	83,3% (20)	83,3% (25)	79,8% (67)
No	(n)	16,7% (4)	16,7% (5)	20,2% (17)
total	(n)	100% (24)	100% (30)	100% (84)

"That is the base of knowledge over the brain functionality and the neccessary starting point for a part of human enhancement".

"The beginning (and end) of eras can only be properly identified in once they've passed (despite what bloggers, PR representatives and tabloids say). Having said that, I think the development of BCIs is framed within a series of innovations (medical, technological, societal) that are changing the way we perceive ourselves interact with others".

"As long as psychology is not understood (because it is equated with neurology) and humans are still seen as moral and rational beings, there will be no enhancement, but only a more controlled and suppressed species".

"In their current form, BCIs won't extend life and health directly, but will do so by enabling a better understanding of the brain functioning. This will definitely bring a new era of human enhancement".

Survey – Section 3 – 3.2 – Vision Statements

Are BCIs as assistive technologies controversial?
138 respondents – 84 knowlegeable & experts

Variável		Not Familiar / Casually	Familiar	Knowlegeable / Expert
Yes	(n)	66,7% (16)	60% (18)	40,5% (34)
No	(n)	33,3% (8)	40% (12)	59,5% (50)
total	(n)	100% (24)	100% (30)	100% (84)

"If they provide enhanced independence to those who otherwise lack independence they are not controversial".

"Although they raise some concerns, they're a positive game changer".

"People fear what is new, especially when there are little or no ethical protocols in place".

"Yes because they are unlikely to go to those most in need to enable them to enjoy as 'normal' a life as possible owing to economic constraints; yes because they raise ethical issues especially where the potential for abuse by malevolent people is concerned; No if they help those in obvious need".

"Mainly misunderstood. People don't understand the field of BCI at all. We need to inform people what we are doing right now, what's coming soon, what's the potential and what are the limitations of the moment".

"They're supposed to be assisting, but is it more "controlling" than assisting".

The Second Group of Interviews: German Experts Opinions

1 - Which are the main risks and benefits you identify within the Brain-Computer Interface area?

2 - At the current moment, what are the main social and ethical concerns and challenges raised by Brain-Computer Interface Technologies according to your knowledge?

3 - In your opinion, is there a need for a robust and effective regulation for Brain-computer Interfaces? Please, justify your response.

4 - Recent studies have pointed out that non-invasive EEG-based BCIs might not fulfill its ultimate goal of providing people with an efficient means of communication and motor control. ------ Based upon this statement, do you believe that BCI research will find the solutions to these challenges? And will it be possible to find solutions only within non-invasive EEG based BCI research?

5 - If the invasive methods become the chosen path for BCI R&D, which would be in your opinion the main ethical, moral and philosophical issues that could dominate future social debates in the field?

6 - As BCI technology develops, patterns emerging from actions and interactions among researchers, institutes, companies, policy makers and end users may eventually constrain or enable future activities. Please explain, in your point of view, which are the main enablers and constraints to overcome the present technical issues to run a BCI in an optimal way in order to fulfill its ultimate goal of replacing, restoring, enhancing, supplementing and/or improving natural CNS?

7 - A possible future scenario for the next 10-20 years could be that of neuroprosthetic developments having a “a fully implantable recording system that wirelessly transmits multiple streams of electrical signals, derived from thousands of neurons, to a BMI capable of decoding spatial and temporal characteristics of movements and intermittent periods of immobility, in addition to cognitive characteristics of the intended actions” (Lebedev & Nicolelis, 2006). Which would be your vision for the future of BCI research and development?

Some Findings / Final Remarks

- ✓ These points under questioning are considered challenges and is possible that they could be drivers of change of some concepts and values at the present.
- ✓ Although half of the experts agreed (45,8%) that a simple 'blink of the eye' is sufficient to get an **informed consent**, part of them disagree (39,3%) indicating that there is not yet a clear consensus on this topic.
- ✓ The 2 faces of **PRIVACY** and **AUTONOMY**
  - ✓ At the present:
    - ✓ if clinical applications of BCIs are successful in restoring communication and control for people in locked-in-states, it will give them more autonomy and privacy.
  - ✓ In the future:
    - ✓ if BCIs are be able to extract information from the brain, then this information could be used to manipulate others, with a plethora of possible uses, including for comercial purposes.
    - ✓ If BCIs are able to compel behavior or plant thoughts and/or feelings, this would constitute an unprecedented invasion of autonomy related to coercive control, free will and moral responsibility.

Some Findings / Final Remarks

- ✓ There is no consensus about the side effects of invasive BCIs, mostly because there are few research and experiments about them.
- ✓ On the other hand, experts don't believe in side effects related to non-invasive BCIs, but according one to of the german experts during the interview, there are unexpected side effects related to non-invasive BCIs.
- ✓ 79,8% (67) of the experts believe that BCI innovations will be part of a new era of human enhancement. At the same time, 59,5% (50) of the experts don't believe that BCI technologies are controversial.

Comments from the Section 2 (perspectives and challenges) of the Survey:

"Incorporation of other professionals is one of the most important factor in the field right now. BCI is heavily multidisciplinary. Contribution from all fields is very important".

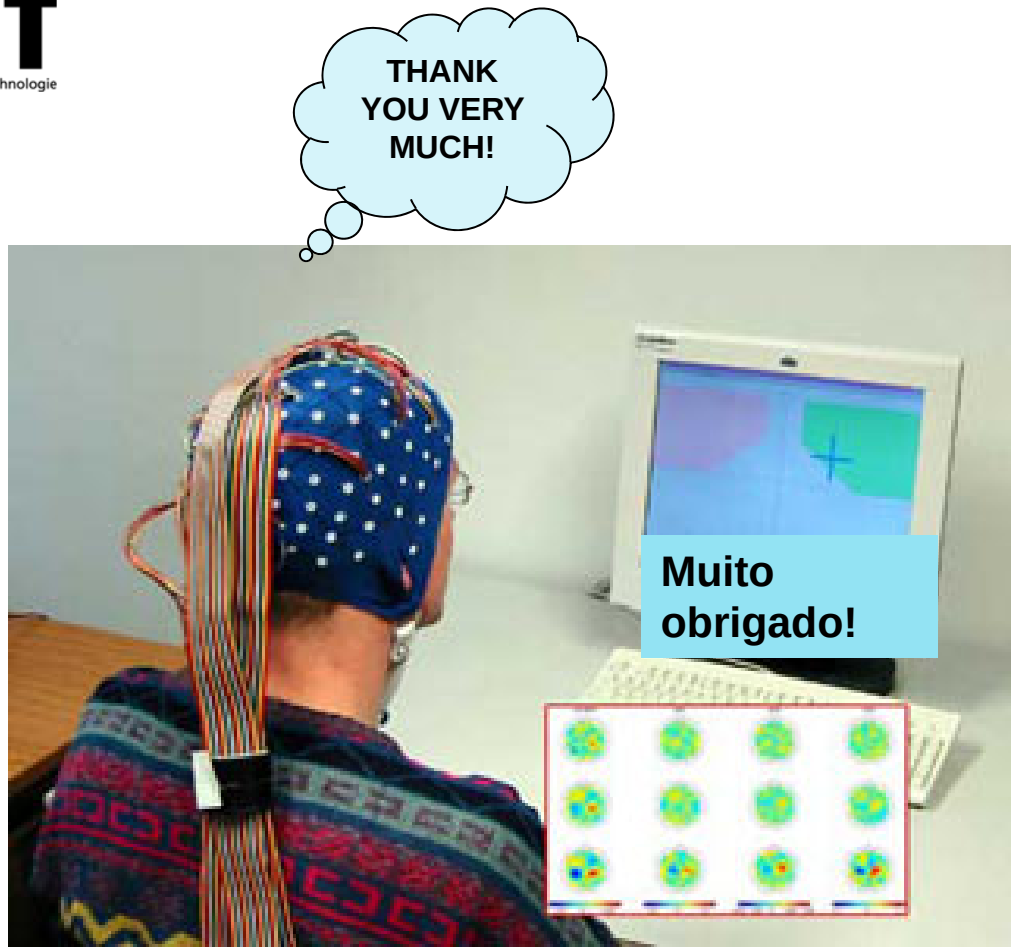
"Understanding Central Nervous System - CNS - function should help the field, so it is an enabler, but the limited state of our understanding is a constraint".

Some Findings / Final Remarks

- ✓ BCI technology is still in its experimental stage and due to its technological complexity, neither risks nor benefits are very well known and understood at this moment.
  - ✓ Researchers have not yet fully developed well-informed opinions about ethical, legal and social issues.
  - ✓ Ethicists don't have enough knowledge about neurotechnologies (Neuroscience) and have difficulties to understand the subject.
  - ✓ The targeted disabled community also shows a lack of knowledge regarding BCIs.

*Comment from the Section 1 (*About ethics, morals and responsibilities) *of the Survey:*

"If you include actual psychology representatives and not just neuroscientists (who don't do psychology) and if the ethical representatives were there in equal numbers to the hard-science representatives, ***some humanity may be preserved****".*



Ref: https://www.newscientist.com/article/dn8826-mental-typewriter-controlled-by-thought-alone/

QUESTIONS ?
DOUBTS?

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