



Research Center for Enterprise and Innovation Studies

BRAIN-COMPUTER INTERFACES WHAT DOES THE FUTURE HOLD?



Source: <http://www.brainmachine.co.uk/about-2/>

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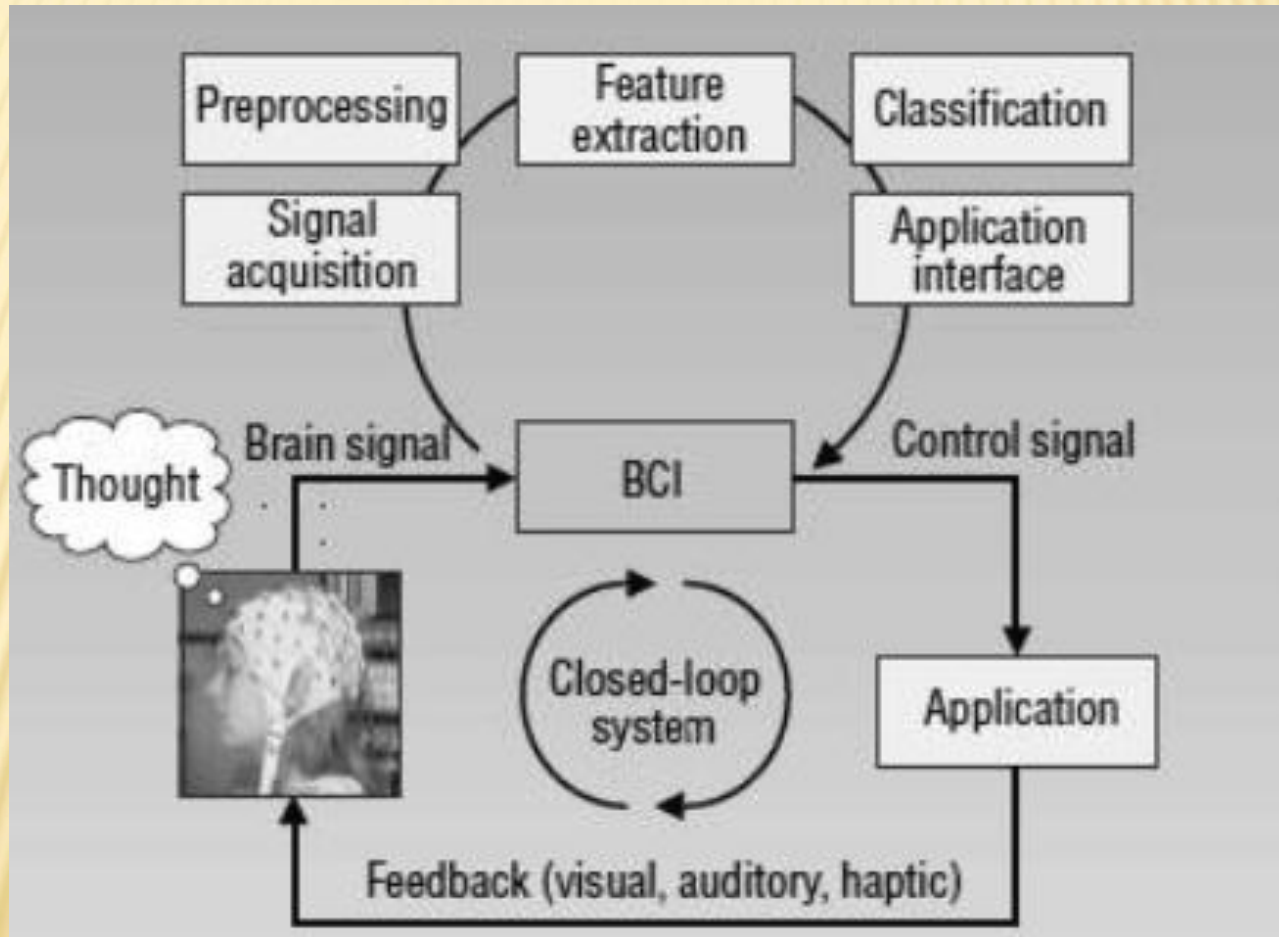
BRAIN-COMPUTER INTERFACES WHAT DOES THE FUTURE HOLD?

What is a Brain-Computer Interface (BCI)?

A Brain-Computer Interface (BCI) is an **emerging technology** which provides a direct communication & control channel between the brain and a computer for conveying messages and/or commands to the external world.

It is a truly direct connection, with no use of the normal output pathways of peripheral nerves and muscles, allowing for the brain to have control over devices and softwares without intermediates, relying solely on mental activity to perform tasks.

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Source: <http://future-bnci.org>

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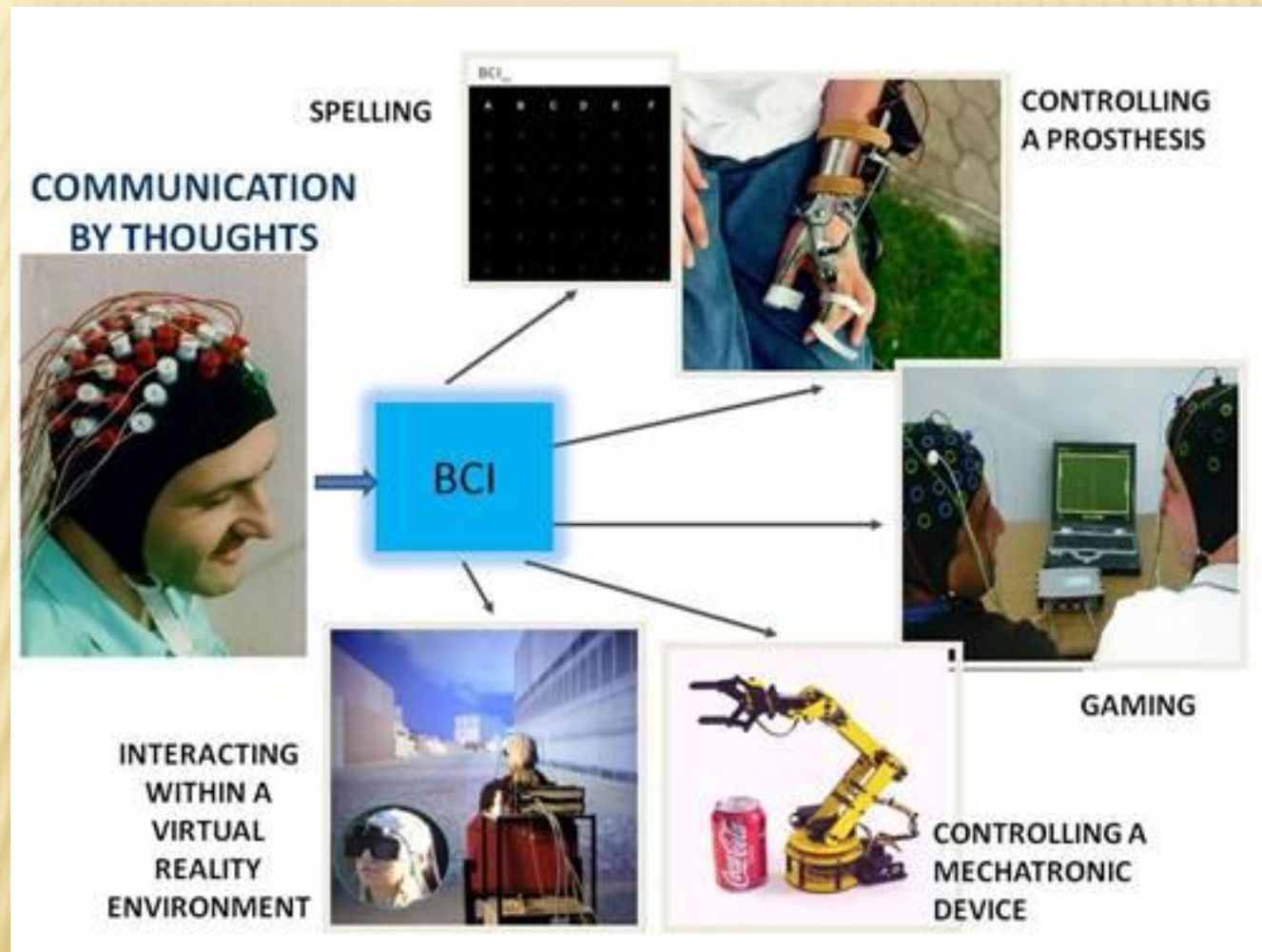
BCI Applications

BCIs can have multiple applications across a variety of fields, medical and non medical. However four big application areas can be highlighted: Communication & Control, Motor substitution, Motor Recovery and Entertainment.

Apart from these three aforementioned medical applications which in some cases might even be used for healthy users (eg. Elderly care), entertainment is not the limit here. BCI's can provide remote control in situational disability circumstances such as astronauts and surgeons, improve cognitive functions, such as improving attention, working memory and executive functions, etc.

Moreover there are many non medical applications which might have different levels of impact on society, such as Gaming, Virtual Reality environments, biometric identification for security or even commercial purposes, control of smart homes, robot control, for entertainment, health or security... And this not mentioning the potential for Hybrid BCI's, Passive BCI's and Emotive BCI's.

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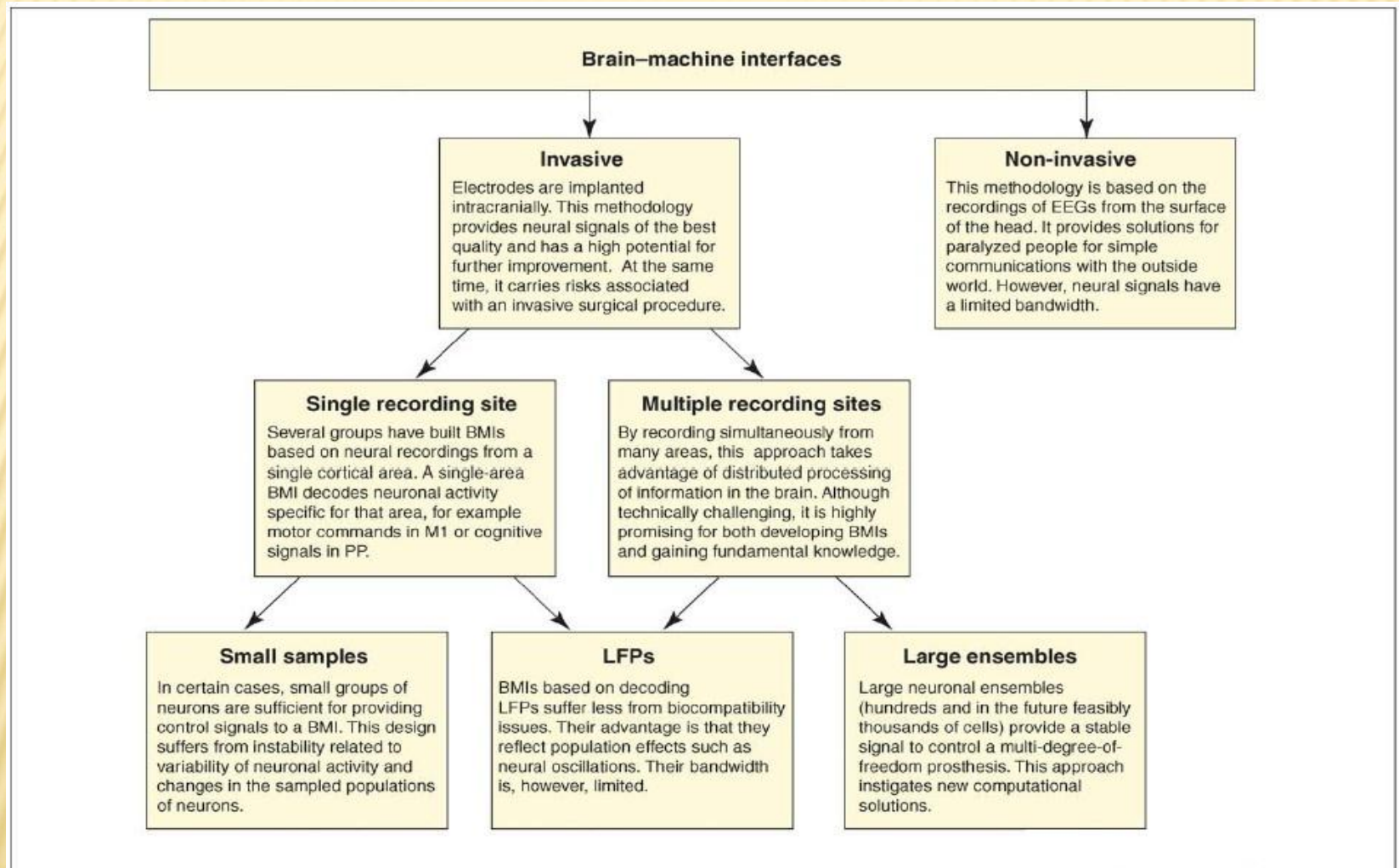


Figure 1. Classification of brain-machine interfaces. Abbreviations: BMI, brain machine interface; EEG, electroencephalogram; LFP, local field potential; M1, primary motor cortex; PP, posterior parietal cortex.

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WHY ASSESS BRAIN-COMPUTER INTERFACES?

BCIs have potential to revolutionize the life of many people with motor disabilities, mobility issues, the way people communicate with the world, interact with information technology and the world itself.

BCI's could ultimately change the way we perceive ourselves as human beings.

The emergence and spread of this way of thinking about human beings, their minds and brains, and the new techniques of intervention that are being developed is an important matter for study and discussion.

“Research on neurotechnology is moving so fast that it threatens to leave the stakeholders behind. Policymakers say they are aware that addressing ethical concern is of utmost importance for the design, development and acceptance of neurotechnologies. “ fBNCI Project, 2012

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WHY ASSESS BRAIN-COMPUTER INTERFACES?

The WTEC - World Technology Evaluation Center (Berger et al, 2007 - WTEC Panel Report on International Assessment of research and development in BCI interfaces - final report) states that the motivations for an International Evaluation of BCIs are:

- Advances in neuroscience, computational technology, component miniaturization, biocompatibility of materials, and sensor technology have led to a much improved feasibility of useful brain-computer interfaces.
- There is now a substantially growing interest on the part of industry to commercialize and market BCI systems for medical and non-medical applications.
- Widespread and lasting societal interest in the compelling logic and need for BCIs
- There has been increasing interest among agencies of the U.S. Federal government in funding the improvement of BCI systems.

Moreover, in Europe the same is occurring, with both the 6th and 7th framework programmes of the European Commission harboring several programmes involved with BCI, be it only with BCI or having BCI as part of larger research areas.

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WHY ASSESS BRAIN-COMPUTER INTERFACES?

According to the fBNCI project (A Roadmap for future directions in brain/neuronal computer interaction research, 2012), in contemporary society and considering an aging society, with a rapid increase in the number of people with neurological disorders which will require solutions from neuroengineering, we will have to better address society's concerns. We are already behind schedule. Neurotechnologies like brain-computer interfaces raise public concern since they confront us with issues of existential nature:

Who are we?

Are we only our brains and bodies?

How much technology do we wish to have in our bodies and brains?

Do we want our brains to be 'read' by technology?

We are living in an era of change where we really need to think ahead in order to protect human dignity.

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WHY ASSESS BRAIN-COMPUTER INTERFACES?

The nascent neuroethical debate around BCIs has identified several topics of importance

- ✓ How to obtain informed consent from people who have difficulty communicating?
- ✓ What are the consequences of BNCI technology for the quality of life of patients and their families?
- ✓ Personal responsibility and its possible constraints (e.g. who is responsible for erroneous actions with a neuroprosthesis?)
- ✓ Issues concerning personality and personhood and its possible alteration
- ✓ Therapeutic applications, including risks of excessive use

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WHY ASSESS BRAIN-COMPUTER INTERFACES?

The nascent neuroethical debate around BCIs has identified several topics of importance

- ✓ Questions of research ethics that arise when progressing from animal experimentation to application in human subjects
- ✓ Mind-reading and privacy, and mind-control
- ✓ Selective enhancement and social stratification
- ✓ Regulating safety, and communication to the media
- ✓ The process for certifying BCI devices and the qualification of BCI scientists?

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WHAT SHOULD BE ASSESSED?

Why assess only non-invasive BCIs in Europe?

Non invasive BCI is the most practical modality to bring BCI technology to a large population. It is in a more advanced state than invasive BCI, being already available on the market, and it is stronger and more intense in Europe than anywhere else. Some projects in course within the 7th Framework Programme of the European Commission are dealing exclusively with non-invasive BCI, such as TOBI and Mindwalker. (fBNCI, 2011, WTEC Report , 2007)

Why should we consider more applications other than just medical ones?

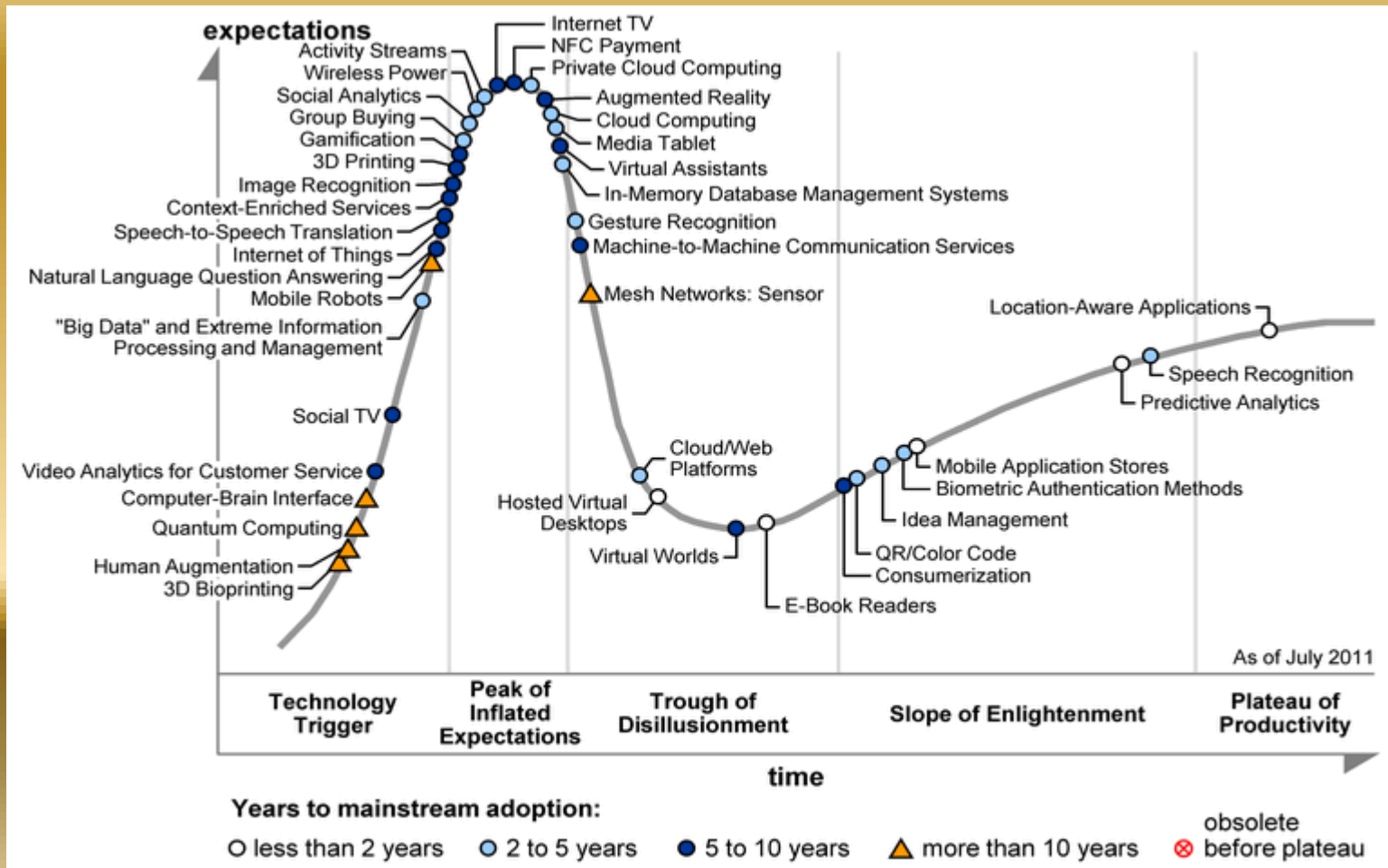
Apart from the economical aspect, as entertainment alone involves a lot of money, a whole new category of BCI applications is being developed. Emerging applications for BCI adumbrate dramatic changes in user groups. Instead of being devices that only help severely disabled users and the occasional curious technophile, BCIs could benefit a wide variety of disabled and even healthy users.

Why must we consider 10 years ahead?

BCI is an emerging technology on its early stages of development. On Gartner's yearly Hype Cycle for Emerging Technologies BCI has been put as reaching mainstream adoption in more than 10 years. And BCI has been on this position for the last 3 years in a row.

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HYPE CYCLE OF EMERGING TECHNOLOGIES 2011



Source: Gartner Inc, 2011

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AND HOW TO ASSESS BCI?

FTA – Future Oriented Technology Analysis

“Human action is geared towards the future” (Lente, 2011)

- Future-Oriented Technology Analysis (FTA) provides a common umbrella for the foresight, forecasting and technology assessment communities. These closely related communities play an important role in guiding policy and decision making to anticipate and shape future developments.
- In this context, **FTA can generate 'informing', 'structuring' and 'capacity-building'** benefits while enabling a shift in innovation foci towards grand challenges. (Cagnin et al, 2012)

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AND HOW TO ASSESS BCI?

CTA – Constructive Technology Assessment

- CTA is a participatory methodology and takes into account that technology is a social product;
- CTA emphasizes the early involvement of a broad array of actors to facilitate social learning about the technology and its potential impacts;
- CTA basically seeks to create an infrastructure in which multiple actors can meet and exchange. It takes place in a stepwise manner with a focus on enhancing learning processes;
- CTA focuses on activities at an early stage of design and development when technological change is still possible and before “lock-in” has occurred. CTA has been pointed out as one of the best options for TA of emerging technologies;
- The emphasis on constructivism and the shaping of technology in an early stage of development made CTA a separate stream within the field of TA;

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Thesis Structure

Definition of main objectives: public policies, public and private strategic directives

Strategic goals: public and private plans and programs, priority issues, critical questions

Strategic focus: non invasive BCIs

Time horizon: 10 years

Context: research state in Europe - mentioning Japan and USA as well

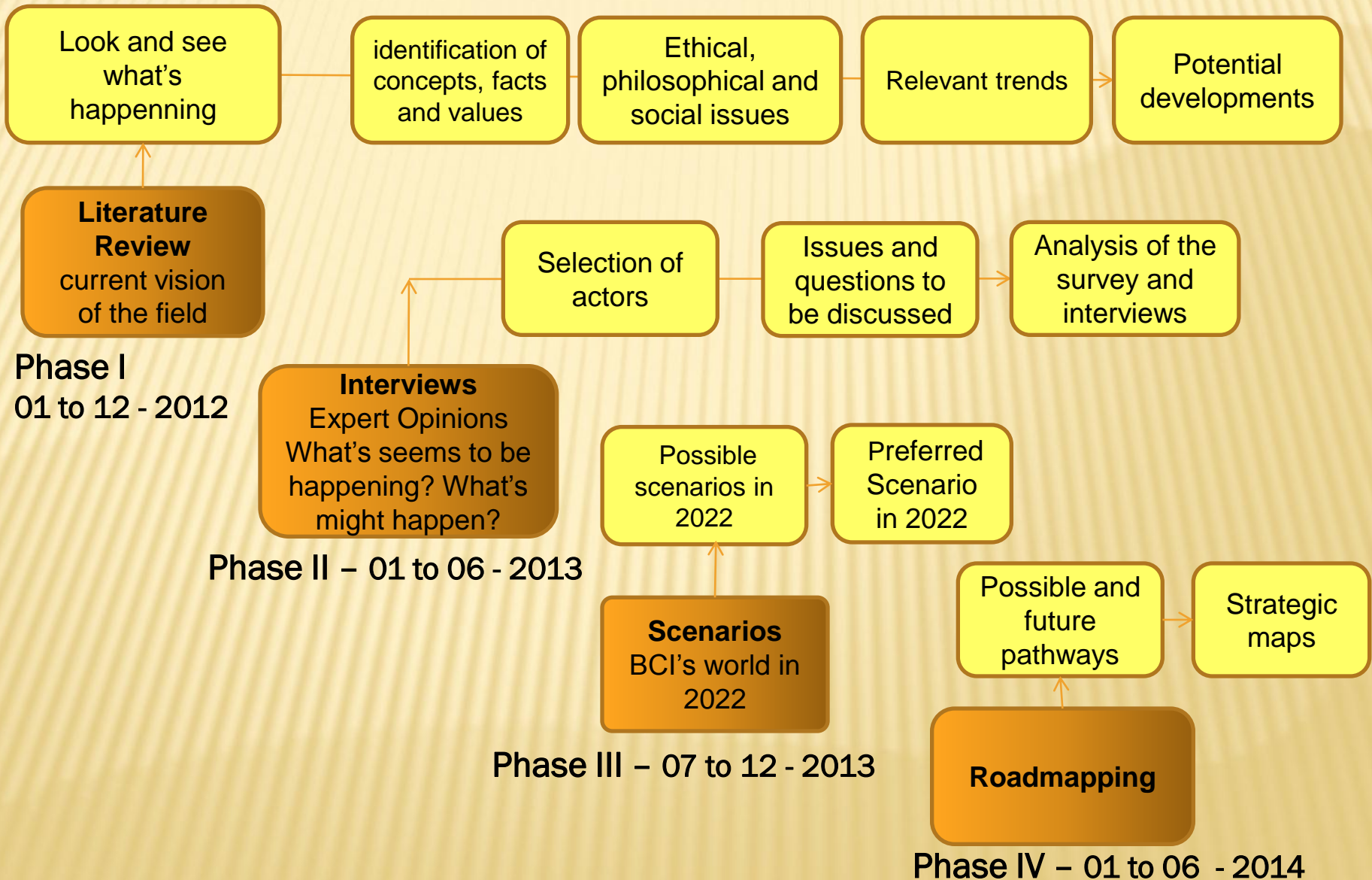
Institutional and expert mobilization: public and private; scientists, decision makers; policy makers; civil society; relationship with ongoing initiatives, etc

Duration: 3 years

Methodology: methods and techniques (expert opinions, scenario planning, roadmapping)

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METHODOLOGY



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OBJECTIVES

To perform an evaluation of the BCIs aiming at fostering its development.

- Present its actual state and future perspectives;
- Identify and analyse possible and future pathways for the technology;
- Identify and analyse the main social, technological, economical, environmental and emerging political and ethical questions associated to BCIs;
- Offer opinions and suggestions to researchers and other stakeholders in order to promote the development of the technology.

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EXPECTED FINDINGS

BCIs can change the way human beings are perceived and accepted, as well as change how the world is seen.

- Its implications in social, ethical, technological and even anthropological and religious aspects can be severe.
- Contribute to the development of BCIs through a comprehensive analysis of the present challenges and obstacles to the advancement of the technology;
- Offer a broader view of the relevance of BCIs, as well as of the difficulties and impacts associated with its development;
- Offer future perspectives of the development and the evolution of BCIs looking to prevent and/or minimize negative impacts perceived;
- The results of this project should be able to provide insights to pave the way for the future.

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SOME ETHICAL, LEGAL AND SOCIAL NETWORKS

- MAKING PERFECT LIFE

This project constitutes a search for social meaning of the so-called NBIC convergence, the powerful combination of nanotechnology, biotechnology, information technology, and cognitive science. Coordination: Rathenau Institute, The Hague. Ongoing project.

- EUROPEAN CITIZENS' DELIBERATION ON BRAIN SCIENCE

European Citizens' Deliberation on Brain Science was a two-year pilot project led by a European panel of 126 citizens. A partner consortium of technology assessment bodies, science museums, academic institutions and public foundations from nine European countries launched this initiative in 2004 with the support of the European Commission. From 2004 to 2006.

- BRAINS IN DIALOGUE

Brains in Dialogue (BID) was a three year project funded by the European Commission under the Seventh Framework Programme and coordinated by the Interdisciplinary Laboratory of Advances Studies at SISSA, Trieste, Italy. The main goal of the project was to build an effective dialogue among key-stakeholders in a crucial area of health advancement: Brain Science, and in particular Predictive Medicine, Brain Imaging and Brain Machine Interfaces.

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SOME ETHICAL, LEGAL AND SOCIAL NETWORKS

- EUROPEAN GROUP ON ETHICS IN SCIENCE AND NEW TECHNOLOGIES

The EGE is an independent, pluralist and multidisciplinary body advising the European Commission on ethics in science and new technologies in connection with Community legislation or policies. http://ec.europa.eu/bepa/european-group-ethics/index_en.htm

- BRAIN, SELF AND SOCIETY IN THE 21ST CENTURY

BSS is a three-year project located within the BIOS Centre at LSE and funded by the Economic and Social Research Council (ESRC). Its goal is to map the social and political impacts the 'new brain sciences' are having on our understanding of selfhood, personhood, and identity and with what consequences and implications. From September 2007 to November 2010. Coordination: Professor Nikolas Rose, Martin White Professor of Sociology at LSE and director of LSE's BIOS research centre.

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SOME ONGOING PROJECTS

- **DECODER – BCI and Detection of Consciousness** - <http://www.decoderproject.eu/>
DECODER is a European collaborative project that will deploy Brain-Computer-Interfaces (BCI) for the detection of consciousness in non-responsive patients.

Budget: € 2,799,921.00 millions **Duration:** February 2010 - February 2013

Coordination: University of Würzburg, Germany

Partners: Fondazione Santa Lucia, Italy; Technische Universität Graz, Austria; Medical Research Council, UK; Universiteit Maastricht, The Netherlands; Université de Liège, Belgium; Eberhard Karls Universität Tübingen, Germany; Association du Locked-In Syndrom (ALIS), France; Guger Technologies OG, Austria.

- **TOBI – Tools for Brain-Computer Interaction** - <http://www.tobi-project.org/>
TOBI is a large European integrated project which will develop practical technology for brain-computer interaction (BCI) that will improve the quality of life of disabled people and the effectiveness of rehabilitation.

Budget: €12 millions - **Duration:** November 2008 - January 2013

Coordination: Ecole Polytechnique Fédérale de Lausanne

Partners: Technische Universität Berlin, Technische Universität Graz, Fondazione Santa Lucia, Eberhard-Karls Universität Tübingen, University of Glasgow, Qualilife S.A, Stiftung Orthopaedische Universitätsklinik Heidelberg, Schweizerische Unfallversicherungsanstalt, Kreuznacher Diakonie, Associazione Italiana per l'Assistenza agli Spastici della Provincia di Bologna, University of Würzburg, Medel GmbH.

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- MIND WALKER– <https://mindwalker-project.eu/>

Mind controlled orthosis and VR training environment for walk empowering.

Budget: €. 2.750 millions **Duration:** March 2010 – December 2012

Coordination: Space Applications Services, Belgium

Partners: Laboratory of Neurophysiology and Movement Biomechanics (ULB/LNMB), Fondazione Santa Lucia, Universiteit Twente, Technische Universiteit Delft, eemagine – Medical Imaging Solutions GmbH, OSSUR

- BrainAble - <http://www.brainable.org/en/Pages/Home.aspx>

Autonomy and social inclusion through mixed reality Brain-Computer Interfaces: Connecting the disabled to their physical and social world.

Budget: €. 2.976.940,00 millions **Duration:** January 2010 – December 2012

Coordination: Barcelona Digital Technology Centre

Partners: Graz University of Technology; Universitat Pompeu Fabra; Meticube; Guger Technologies; AbilityNet; Institut Guttmann

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Thank you!
Good bye!

Thank you !
Good bye!

