



ACCADEMIA NAZIONALE DEI LINCEI

CONVEGNO LINCEO

BRAIN-COMPUTER INTERFACES: OPPORTUNITIES AND CHALLENGES. TOWARD A REASONED USE OF NEUROTECHNOLOGIES

DECEMBER 20, 2024

Organizing Committee: Federica ALEMANNO (Università Vita-Salute San Raffaele), Antonino CATTANEO (Linceo, Scuola Normale Superiore e European Brain Research Institute Rita Levi-Montalcini), Jacopo MELDOLESI (Linceo, Università «Vita-Salute San Raffaele» di Milano), Silvestro MICERA (Scuola Superiore Sant'Anna), Maria Concetta MORRONE (Lincea, Università di Pisa), Pietro MORTINI (Università Vita-Salute San Raffaele), Calogero Maria ODDO (Centro Interdisciplinare Linceo Giovani, Scuola Superiore Sant'Anna, coordinatore), Erica PALMERINI (Scuola Superiore Sant'Anna).

PROGRAMME

Brain-Computer Interfaces (BCI) represent a revolutionary frontier in the field of neurotechnology. They enable direct communication between the brain and computers, opening extraordinary possibilities in various fields, from medicine to everyday life. From a clinical perspective, BCIs promise to improve the quality of life for people with disabilities, offering new ways to interact with the external world. For example, they could play a crucial role in neurological rehabilitation, assisting in the recovery of motor functions after brain injuries or strokes.

On the ethical and philosophical level, BCIs raise significant questions. The possibility of accessing and influencing cognitive processes and brain functions poses issues of privacy, rights, and consent. It is essential to consider who can access this information and how to ensure the security and confidentiality of neural data. Additionally, questions arise regarding identity and personal autonomy, as these technologies could alter how individuals perceive themselves and interact with others.

The philosophical implications also concern the definition of consciousness and the nature of human experience. With the increasing integration of BCIs into daily life, a debate could emerge about the distinction between organic reality and reality mediated by technology.

In conclusion, brain-computer interfaces represent an area of extraordinary innovation that offers significant clinical benefits but also requires careful ethical and philosophical reflection to guide their development and implementation responsibly. For this reason, we find it very interesting to organize a conference with the goal of reaching a common agreement among experts active in biomedical research, clinical practice, and the humanities and social sciences, as well as representatives of institutions and user communities, regarding the development, use, and regulation of brain-computer interfaces.

The meeting will be structured to ensure that all interested parties can express their opinions and contribute to the formation of an overall framework and reach a consensus that addresses both the immense potential and the ethical and social challenges posed by BCIs. The ultimate goal is to draft

a document that facilitates the development of BCI technologies that improve people's lives while respecting the rights and dignity of all individuals involved.

Friday, 20 December

10.00 Welcome from the President of the Accademia Nazionale dei Lincei

10.15 Introduction of the workshop: expected goals

Antonino CATTANEO (Linco, Scuola Normale Superiore and European Brain Research Institute Rita Levi-Montalcini), Pietro MORTINI (Università Vita-Salute San Raffaele):
Introduction

Talks on neuroscience, neurotechnology, ethics, and neuro-rights

10.30 Richard ANDERSEN (Caltech): *Brain-machine Interfaces for Assisting People with Paralysis*

10.45 Leigh R. HOCHBERG (Brown University e Massachusetts General Hospital): *Implantable BCIs for the Restoration of Communication and Mobility*

11.00 Concetta MORRONE (Linco, Università di Pisa): *Visual Restoration with retinal prosthesis*

11.15 Joseph O'DOHERTY (Neuralink): *Brain-computer interfaces for restoring movement, sensation, and independence*

11.30 Stefano PLUCHINO (University of Cambridge): *Leveraging Stem Cell Therapies and Neurotechnologies to Restore Neurological Function in Progressive Multiple Sclerosis*

11.45 Erica PALMERINI (Scuola Superiore Sant'Anna): *Fundamental rights compliant neuro-technologies and market regulations*

12.00 Marcello IENCA (Technical University of Munich): *Neurorights: from Ethics to International Governance*

12.15 Edoardo CHITI (Scuola Superiore Sant'Anna): *How to Regulate Innovation: BCIs, Regulatory Experimentalism and the Rule of Law*

13.00 Lunch

Parallel round table discussions, plenary discussion, conclusions (by invitation only)

14.00 Parallel round table discussions

Chairs: Calogero Maria ODDO (Scuola Superiore Sant'Anna) and Federica ALEMANNI (Università Vita-Salute San Raffaele)

16.00 Coffee break

16.30 Report from the parallel round table discussions and plenary discussion

17.30 Conclusions

Emanuele GRUPPIONI (INAIL), Silvestro MICERA (Scuola Superiore Sant'Anna and École Polytechnique Fédérale de Lausanne)

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Sant'Anna
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MNESYS "A Multiscale integrated approach to the study of the nervous system in health and disease"

Cod. PE_00000006 - Partenariati estesi alle università, ai centri di ricerca, alle aziende per il finanziamento di progetti di ricerca di base

Missione 4 - Componente 2 - Investimento 3.1

CUP J83C22001400002

THE "Tuscany Health Ecosystem"

Cod. ECS_00000017 - Ecosistemi dell'innovazione" costruzione di "leader Territoriali di R&S

Missione 4 - Componente 2 - Investimento 1.5

CUP J13C22000420001

BRIEF "Biorobotics Research and Innovation Engineering Facilities"

Codice identificazione progetto: IR0000036 - Infrastrutture di Ricerca

Missione 4 - Componente 2 - Investimento 3.1

CUP: J13C22000400007

ROMA - PALAZZO CORSINI - VIA DELLA LUNGARA, 10

Segreteria of the meeting: convegni@lincei.it - <https://www.lincei.it/it>

Information on conference attendance (in person or online) is available on the following website:

<https://www.lincei.it/it/manifestazioni/le-interfacce-cervello-computer-convegno>

The certificate of participation in the conference will be issued only following on attendance in presence and must be requested to the staff in charge on the same day of the conference.

Brain-machine Interfaces for Assisting People with Paralysis

Richard ANDERSEN (Caltech)

Tetraplegia, the loss of movement and feeling in all four limbs, can result from spinal cord injuries at the level of the neck. Brain-machine interfaces (BMIs) can help people with tetraplegia by allowing them to control assistive devices with their thoughts. A BMI consists of tiny electrodes that can record the activity of large numbers of cortical neurons, and machine learning algorithms that can interpret the intent of the participant from the neural activity. Electrical stimulation through electrodes implanted in sensory cortex can also restore the sense of touch. Our lab and collaborating colleagues have used a novel approach of implanting electrodes in a variety of specialized cortical areas rather than just the motor cortex. Using this approach, the participants can control robotics and computers, allowing them to drink a beverage, use video games and programs like photoshop, drive an automobile, feel touch to the previously insensate hand, and decode speech, including silent internal speech.

Implantable BCIs for the Restoration of Communication and Mobility

Leigh R. HOCHBERG (Brown University e Massachusetts General Hospital)

Implantable brain-computer interfaces (iBCIs) are poised to revolutionize our ability to restore lost neurologic functions. By recording high resolution neural activity from the brain, the intention to move one's hand can be detected and decoded in real-time, toward providing people with motor neuron disease, stroke, or spinal cord injury with restored ability to control communication devices, assistive technologies, and their own limbs. Over the past 20 years, clinical trials of the investigational BrainGate system have demonstrated that people with tetraplegia can control a computer cursor, a tablet computer, and other devices quickly and intuitively, simply by thinking about the movement of their own hand. More recently, for people with profound dysarthria due to motor neuron disease, recordings from speech-related areas of the motor cortex have enabled clinical trial participants to 'speak' (brain-to-audible-text) at more than 60 words per minute. In addition to their potential restorative value, the neural data recorded by iBCIs are rich in information content, raising myriad important questions that would benefit from practical, concrete answers to guide the ethical use, sharing, and consent for recording these data.

Visual Restoration with retinal prosthesis

Concetta MORRONE (Lincea, Università di Pisa)

Contrary to common belief, plastic changes in primary visual cortex extend throughout adult life, and also after many years of visual deprivation, as in late blind people. Understanding the residual plastic potential of the adult visual cortex, and how to enhance it, is potentially important as the progress in retinal prosthesis technology opens new possibilities for vision restoration in blind people with retinal pathologies. I will demonstrate that plastic change in visual cortex of patients with ARGUS-II retinal prosthesis is possible, reinforcing the feasibility of visual restoration in adults. However, the plastic change emerges only after years of

continuous training, calling for target rehabilitative techniques to potentiate the plastic potentials in adults.

Leveraging Stem Cell Therapies and Neurotechnologies to Restore Neurological Function in Progressive Multiple Sclerosis

Stefano PLUCHINO (University of Cambridge)

Recent advancements in neurotechnologies and stem cell biology offer promising avenues for addressing central nervous system disorders, including progressive Multiple Sclerosis (MS). While stem cell therapies traditionally focused on cell replacement, emerging research has highlighted the significant role of intercellular communication between grafts and host tissues, producing beneficial immune modulation and neuroprotective effects. Neural stem/precursor cells (NSCs) have shown potential in experimental models by enhancing immune signalling and fostering healing in the CNS.

By integrating neurotechnologies such as brain-computer interfaces (BCIs) with biohybrid regenerative bioelectronics, we are uncovering new possibilities for both restoring neurological functions and monitoring their progress with high precision. These biohybrid devices, which combine the reparative capabilities of NSCs with advanced electronic monitoring and control, represent a new frontier in treatment, addressing the needs of replacing and enhancing damaged neural pathways.

This presentation will explore the translational potential of combining NSC therapies with these burgeoning neurotechnological innovations to advance treatment outcomes in progressive MS. Discussing mechanisms of cellular licensing and intercellular signaling, I will illustrate how these approaches may lead to significant strides in neuroprotection and functional recovery. Moreover, ongoing research into bio-compatible BCIs and biohybrid devices aims to refine these therapeutic interactions, offering exciting prospects for future clinical applications.

Overcoming current technological barriers, such as seamless integration of biological and electronic components, is crucial for unlocking the full potential of biohybrid regenerative devices. By merging the domains of cell therapy and neurotechnology, we aspire to develop comprehensive strategies that not only address CNS degeneration but also harness technology to maximize therapeutic efficacy and bridge the gap between bench and bedside.

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Disclosure

SP is founder, CSO and shareholder (>5%) of CITC Ltd.

Fundamental rights compliant neuro-technologies and market regulations

Erica PALMERINI (Scuola Superiore Sant'Anna)

Several regulatory bodies governing the market for neurotechnological devices can be the normative ground for the protection and enforcement of fundamental rights. Addressing neurotechnologies from the angles of safety, security and data protection, these legislative orders contribute to both fostering the rights touched upon by advanced research and innovation in this field, and shielding them from potential risks. In my speech, I will focus on the right to health, to autonomy and identity, and on the values of equality and justice to show how the conceptual pair “rights and market” should not be understood in oppositional, but rather complementary terms.

Neurorights: from Ethics to International Governance

Marcello IENCA (Technical University of Munich)

Il presente intervento offrirà una panoramica aggiornata sui cosiddetti "neurodiritti", ovvero il sottoinsieme dei diritti umani relativi alla dimensione cerebrale e mentale della persona. Dopo un'introduzione storico-concettuale, la presentazione discuterà come tale strumento etico-normativo ci può affrontare ad affrontare le emergenti sfide etico-giuridiche delle neurotecnologie, specialmente in relazione alla crescente integrazione dell'intelligenza artificiale nelle neurotecnologie tramite il canale cervello-macchina. Inoltre, verrà discusso come negli ultimi anni i neurodiritti si sono trasformati da costrutto teorico a strumento normativo fondante di documenti giuridici internazionali (come le Raccomandazione dell'OCSE e dell'UNESCO o le linee guida del Consiglio d'Europa) e nazionali (come ad esempio la riforma costituzionale in Cile). Infine si proporrà una roadmap per il progresso responsabile nelle neurotecnologie e un simultaneo avanzamento bilanciato del quadro normativo, al fine di massimizzare i benefici di queste tecnologie minimizzandone i rischi.