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IDIBAPS Institut D'Investigacions Biomèdiques August Pi i Sunyer

A DIALOGUE WITH THE CEREBRAL CORTEX:
CORTICAL FUNCTION AND INTERFACING

April, 29th and 30th, 2015

CAIXAFORUM. AVDA FRANCESC FERRER I GUÀRDIA, 6-8. BARCELONA

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A DIALOGUE WITH THE CEREBRAL CORTEX:
CORTICAL FUNCTION AND INTERFACING

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A DIALOGUE WITH THE CEREBRAL CORTEX:
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WELCOME

Dear Guests and Participants,

It is our pleasure to welcome you to the meeting "A Dialogue with the Cerebral Cortex: Cortical Function and Interfaces", co-organized by **B·DEBATE** (an initiative of Biocat and "la Caixa" Foundation) and the **IDIBAPS**, with the collaboration of the European project CORTICONIC, GTEC (Guger Technologies), NEUROGRAPHENE and AGAUR (NEUROVIRTUAL group).

The need to develop new and efficient tools to restore brain function damaged by disease requires a thorough understanding of brain physiology and its capability of plasticity. Recent developments in computation, imaging, molecular and optical tools, new materials and brain interfacing, have opened new possibilities for brain studies and interventions that were unthinkable just two decades ago. Our aim has been to bring together experts on the function of cortical circuits, computational neuroscientists, neurotechnologists and clinicians, to discuss how the brain functions when is healthy, and how its activity can be modulated to restore function in the context of neurological disease. We will discuss the future of brain-machine interfaces and how their development may improve the lifes of paralyzed patients, and further, how these new technologies it may influence the daily life of the general population and what risks should be taken into account.

We expect an active debate and encourage the active participation of all with loads of questions that may be answered during the workshop or may remain open for future investigations.

Yours sincerely,

Mavi Sánchez Vives (ICREA-IDIBAPS), Scientific leader of the event, and B·DEBATE

PROGRAM

Wednesday, April, 29th, 2015

9:00	**Presentation and Welcome** **Ignasi López**, Director of the Department of Science, "la Caixa" Foundation **Laia Arnal**, Head of Research and Scientific Debate, Biocat **Mavi Sanchez-Vives**, ICREA-IDIBAPS Barcelona
9:30	**SESSION 1: CORTICAL FUNCTION AND COMPUTATIONS** Chair: **Mara Dierssen**, Centre de Regulació Genòmica, Barcelona, Spain
9:30	**Linking Scales of Brain Activity from Single Neurons to Field Potentials and Voltage-Sensitive Dye Imaging** **Alain Destexhe**, CNRS, Paris, France
10:15	**Computational Insights from the Multiscale Organization of Spontaneous Cortical Activity** **Maurizio Mattia**, ISS, Rome, Italy
10:45	**Pitch Presentations of Posters**
11:00	**Coffee Break**
11:30	**Integration and Segregation of Information in the Brain** **Gustavo Deco**, ICREA-Universitat Pompeu Fabra, Barcelona, Spain
12:15	**Optogenetics and Imaging Techniques in Cortical Circuits** **Arthur Konnerth**, Technical University of Munich, Germany
13:15	**Lunch**
14:30	**SESSION 2: STIMULATION TO EXPLORE AND CONTROL BRAIN ACTIVITY** Chair: **Jordi Rumià**, Neurosurgery, Hospital Clinic Barcelona, Spain
14:30	**Brain Stimulation and the Estimation of Consciousness** **Marcello Massimini**, University of Milan, Milan, Italy
15:15	**Controlling Spontaneous Cortical Emergent Activity** **Mavi Sanchez-Vives**, ICREA-IDIBAPS, Barcelona, Spain
16:00	**Coffee Break, Posters and Demos**
16:30	**Modulating Brain Processing and Learning with Targeted Non-Invasive Electrical Stimulation** **Marom Bikson**, CUNY, New York, USA
17:15	**Optogenic Cortical Stimulation to Increase Sleep Slow Oscillation and to Improve Memory Consolidation in Mice** **Igor Timofeev**, Laval Universite, Quebec, Canada
18:00	**Debate on Augmentation of Brain Functions: Facts, Controversy and Future** Chairs: **Mikhail Lebedev,** Duke University and **Marcello Massimini** (University of Milan)
18:45	**Poster session and demos**

PROGRAM

Thursday, April, 30th, 2015

9:00	**SESSION 3: INTERFACING WITH THE CEREBRAL CORTEX: NEW TECHNOLOGIES** Chair: **Arthur Konnerth**, University of Munich
9:00	**Conventional and Future Enabling Technologies to Probe Neuronal Dynamical Response Properties** **Michele Giugliano**, University of Antwerp, Belgium
9:45	**Ultra-Flexible Microelectrode Arrays with Integrated Control Electronics for Electrophysiology Applications** **Guglielmo Fortunato**, IMM-CNR, Rome, Italy
10:15	**Graphene as Brain Interface** **Gemma Gabriel-Buguña** and **Rosa Villa**, Centro Nacional de Microelectrónica-CSIC, Barcelona, Spain
10:45	**Non-invasive Neurotechnologies: Closing the Loop** **Stephen Dunne**, Neuroelectrics, Barcelona, Spain
11:15	**Coffee Break**
11:45	**Optopharmacology to Control Neural Activity with Light** **Pau Gorostiza**, ICREA-IBEC, Barcelona, Spain
12:30	**Magnetrodes for Brain Interfacing** **Myriam Pannetier-Lecoeur**, CEA-CNRS, Paris, France
13:15	**Lunch**
14:30	**SESSION 4: DECODING BRAIN ACTIVITY AND THE FUTURE OF BRAIN COMPUTER INTERFACES** Chair: **Alain Destexhe**, CNRS
14:30	**Cortical Activity Pattern Decoding for Human Intracranial BCI'** **Nick Ramsey**, Brain Center, University Medical Center Utrecht, The Netherlands
15:15	**Translating Brain-Computer Interfaces to End-Users** **José del R. Millán**, EPFL, Lausanne, Switzerland
16:00	**Coffee break**
16:15	**Brain-Machine Interfaces for Movements, Sensations and More** **Mikhail Lebedev**, Duke University, USA
17:00	**Current and Future Applications of BCIs** **Christoph Guger**, GTEC, Austria
17:45	**Debate on the Future of Brain Interfacing** Chairs: **Mavi Sanchez-Vives**, ICREA-IDIBAPS, Barcelona, and **Michele Giugliano**, University of Antwerp, Belgium
18:30	**Closing remarks**

SCIENTIFIC COMMITTEE

Mavi Sanchez-Vives, Team Leader, Systems Neuroscience, IDIBAPS (**Institute of Biomedical Research August Pi i Sunyer**), Barcelona, Spain

Scientific Leader of the Meeting

Mavi Sanchez-Vives, medical doctor and doctor in neurosciences, has been ICREA Research Professor at the IDIBAPS (Institut d'Investigacions Biomediques August Pi i Sunyer) in Barcelona since 2008. She is currently co-director of the Event Lab (Experimental Virtual Environments in Neuroscience and Technology) and Professor Adjunct to the Department of Basic Psychology at the University of Barcelona. Postdoctoral researcher at Rockefeller University and Yale University, she next established her own laboratory at the Instituto de Neurociencias in Alicante (UMH-CSIC) while being Associate Professor of Physiology. Her independent research has been supported by national and international agencies, including Human Frontier Science Program and EU projects. She is currently a partner of the Graphene Flagship and the coordinator of the FET EU project CORTICONIC. Author of over 80 articles in scientific journals and several book chapters, she often participates in international workshops and panels as speaker and often serves as reviewer for grant panels and journals.. She is chief co-editor of Frontiers in Systems Neuroscience since 2012 and currently member of the Program Committee of FENS and President of the Program Committee of the Spanish Society of Neurosciences (SENC).

Arthur Konnerth, Professor of Neuroscience, Director, Principal Investigator in the **Munich Excellence Clusters CIPSM and SyNergy**, Munich, Germany

Arthur Konnerth is the Friedrich Schiedel Chair and Director of the Institute of Neuroscience at the Technical University Munich, Germany. His current research is concentrated on a better understanding of the mechanisms underlying brain function in health and disease. His lab studies different types of neurons and circuits in the cortex, cerebellum and hippocampus, and uses a variety of techniques, including electrophysiology, molecular biology, optogenetics, behavioral analyses and high-resolution optical imaging. A major focus of the work is directed towards an exploration of behavior-determined synaptic signaling and dendritic integration in neurons of defined circuits in vivo. He and his team pioneered in vivo two-photon functional imaging at scales ranging from single synapses to cortical circuits with single cell resolution. Arthur Konnerth is a member of the German Academy of Sciences Leopoldina, the Academia Europaea and the Bavarian Academy of Sciences and Humanities. He received several awards, including the Max Planck Research Award, the Gottfried Wilhelm Leibniz Award, Adolf Fick Award, the Feldberg Award, an ERC Advanced Grant and the Brain Prize.

Alain Destexhe, **CNRS** Reseach Director (UNIC, Gif sur Yvette), and Director of the **European Institute for Theoretical Neuroscience**, Paris, France

Alain Destexhe leads a research team in theoretical neuroscience at the interface with experimental neuroscience, at the “Neurosciences, Information and Complexity” research unit (UNIC) of Gif sur Yvette. He obtained a PhD (University of Brussels, 1992) in the field of nonlinear dynamics and complex systems, followed by a postdoc with Terry Sejnowski at the Salk Institute (La Jolla, USA), and was Assistant Professor at the Laval University in Canada (1995-2000), where he founded a theoretical laboratory in a purely experimental environment. He was awarded a tenured position of Research Director at CNRS in 2000 and participated to the creation of the UNIC, which mixes theory and experimental research teams. Since 2014, he is also Director and scientific animator of the European Institute for Theoretical Neuroscience (www.eitn.org) in Paris. He is author of 120 publications in peer-reviewed journals, 2 monographs, 7 books as co- Editor, and 42 book chapters. He is also co-Editor in Chief of the Journal of Computational Neuroscience since 2005, and is in the editorial board of 5 other journals including The Journal of Neuroscience. He is also invited speaker in numerous international conferences and summer schools, and coordinates the theoretical neuroscience activities in the EU-funded Human Brain Project. He was awarded several prizes, including the 2008 CNRS Medal for interdisciplinary work.

Marcello Massimini, Associate professor of Human Physiology at the Department of Biomedical and Clinical Sciences, **University of Milan**, Milan, Italy

Physician and neurophysiologist is associate professor of Human Physiology at the University of Milan and Invited Professor at the Coma Science Group of Liege University (Belgium). He worked at Laval University (Quebec, Canada) in the laboratory of Mircea Steriade and subsequently moved to the Department of Psychiatry of the University of Wisconsin (USA) with Giulio Tononi. Dr. Massimini has been a partner in different EU grants and has received national and international prizes for his research and is recipient of the James S. McDonnel Scholar Award 2013. He is currently developing new tools to study non-invasively how human cortical excitability and connectivity change in physiological and pathological conditions. On these subjects he has published in high-ranking international scientific journals such as Science, Nature, Nature Neuroscience, PNAS, and Brain.

ORGANIZING COMMITTEE

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INVITED SPEAKERS

Wednesday, April, 29th, 2015

Mara Dierssen, Group Leader at **Centre for Genomic Regulation** (CRG), Barcelona, Spain

Chair of the SESSION 1: CORTICAL FUNCTION AND COMPUTATIONS

Dr. Dierssen research builds on multi-level exploration of neural networks and dynamical models to get insight in the integrative principles in brain cognitive systems, mainly using genetically modified mouse models of intellectual disability and other cognition disorders. The overall goal of her research is understanding how putative candidate genes for human complex genetic diseases impair the neuronal connectivity with consequences on brain cognitive systems. She is a world expert in the field of intellectual and has received several recognitions for her work (Ramón Trias Fargas, Jaime Blanco or Sisley-Lejeune Awards). Dr Dierssen is the President of the Spanish Society of Neuroscience, past president of the International Behavioral and Neural Genetics Society, and member of the Executive Committee of the Federation of European Neurosciences Societies, EDAB and Academia Europaea. She was associated professor of the University of Cantabria and the University Ramon Llull in Barcelona, and has organized a large number of courses and conferences. She is part of several Editorial Boards (Acta Neuropathologica, Genes Brain and Behavior, Frontiers in Behavioral Neuroscience, Down Syndrome Research and Practice, Amino Acids, Frontiers in Genetics and BMC).

Alain Destexhe, **CNRS** Research Director (UNIC, Gif Sur Yvette), and Director of the **European Institute for Theoretical Neuroscience**, Paris, France

See his CV at the Scientific Committee Section

Linking Scales of Brain Activity from Single Neurons to Field Potentials and Voltage-Sensitive Dye Imaging

Linking scales of investigation of brain activity is a very difficult problem because it typically involves very different expertises and fields who tend to be rather separated. In this talk, we overview a project that attempts to combine different scales, from cellular to large-scale systems. We focus on the voltage-sensitive dye (VSD) imaging technique, which reveals brain activity at fine temporal scales and over large spatial scales, typically one or several brain areas. To understand the VSD signals, one uses population models of activity, but such models are presently not hardly constrained by cellular and biophysical properties of neurons. We show that using single-cell dynamic-clamp experiments, one can extract the transfer function of cortical neurons, and formulate population models which are biophyically more realistic. Such models account for large-scale features of VSD imaging, such as the suppressive effect of propagating waves. We suggest that this approach of linking scales could be very powerful to understand macroscopic properties of brain activity.

Maurizio Mattia, Researcher at the **Istituto Superiore di Sanità**, Rome, Italy

Researcher at the Istituto Superiore di Sanità (ISS, Italian Institute of Health) in Rome, Italy. Theoretical physicist (MSc) with a research doctorate in neurophysiology (PhD). Author of more than 30 articles in ISI-indexed journals. Partner in several EU-funded projects, including the ongoing CORTICONIC and CORONET FET projects. Past fellowships with the Istituto Nazionale di Fisica Nucleare (INFN, Italian Institute of Nuclear Physics) from 1997 to 2009. Research collaborator at the Institute for Neuroinformatics (ETH University of Zurich, Switzerland) during 2006. Research interests and activity in computational and systems neuroscience focused on the collective nonlinear dynamics of cortical networks underlying high cognitive functions and slow oscillations during sleep and anesthesia.

Computational Insights from the Multiscale Organization of Spontaneous Cortical Activity

Slow oscillations (SO) are a stereotyped activity pattern pervasively expressed during slow-wave sleep and deep anaesthesia by the cerebral cortex of many species. SO in sensorial cortices are known to mirror early neuronal processing of environmental stimuli, and occur simultaneously in cell assemblies at different cortical depths and positions as a concerted multiscale activity. Here, I will present some recent advances in the understanding of the mechanistic organization of such multiscale phenomenon, by following the chain of activations and inactivations of the different layers of the rat visual cortex under deep anaesthesia. I will show that Up states initiate in layer 6 spreading upward towards the cortical surface, and that layer 5 assemblies give rise to hysteresis loops like in flip-flop computational units. I will provide evidence that layer 6 activation originates from cortical input likely due to travelling up wavefronts, unravelling a hierarchy of cortical loops.

PITCH PRESENTATIONS OF POSTERS

Ramon Nogueira, Fundació Sant Joan de Déu, Barcelona, Spain

Diana Furcila, Instituto Cajal, Madrid, Spain

Mattia D'Andola, IDIBAPS, Barcelona, Spain

Belén Sancristóbal, Centre for Genomic Regulation, Barcelona, Spain

Luis Seoane

Gustavo Deco, ICREA Research Professor and Full Professor at the **Universitat Pompeu Fabra**, Barcelona, Spain

Gustavo Deco is ICREA Research Professor and Full Professor at the Universitat Pompeu Fabra, where he heads the Computational Neuroscience Group and directs the Center for Brain and Cognition. He studied Physics at the National University of Rosario. In 1987, he received his Ph.D. in Physics for his thesis on Relativistic Atomic Collisions. In 1997, he obtained his habilitation (maximal academical degree in Germany) in Computer Science at the Technical University of Munich for his thesis on Neural Learning. In 2001, he received his Ph.D. in Psychology at the Ludwig-Maximilian-University of Munich for his thesis on Visual Attention. His research interests include computational neuroscience, neuropsychology, psycholinguistics, biological networks, statistical formulation of neural networks, and chaos theory. He has actively contributed to the modelling and integration of experimental measurements through theoretical frameworks, and collaborates with many experimentalists to confront theory and experiments. Recognised as a world leader in computational neuroscience, he has led pioneering work in dynamical modelling of human brain activity. He is an ERC Advanced grantee and member of the Human Brain Project.

The Dynamics of Resting Fluctuations in the Brain

The grand average functional connectivity (FC) of a resting brain captures properly the well- structured spatial correlations between different brain areas. Whole-brain models explicitly linking spontaneous local neuronal dynamics with the tractography based anatomical structure of the brain are able to explain the emergence of those spatial resting correlations. Nevertheless, resting activity is not only spatially structured but also shows a very stereotypical temporal structure which is characterized by rapid transitions switching between a few discrete FC states across time. In this talk, we introduce a powerful theoretical framework, which allows us to demonstrate that resting functional connectivity FC dynamics (FCD) constrains more strongly the dynamical working point of whole-brain models. Further more, using a very general neural mass model based on the normal form of a Hopf bifurcation we are able to demonstrate that the temporal dynamics of resting state fluctuations emerges at the edge of the transition between asynchronous to oscillatory behavior. Even more importantly, at that particular working point the global metastability of the whole brain is maximized. By optimizing the spectral characteristics of each local brain node, we discover the dynamical core of the brain, i.e. the set of nodes, which drives by oscillations the rest of the whole brain. This dynamical core can be interpreted as the "memory" core of nodes sustaining consciousness.

Arthur Konnerth, Professor of Neuroscience, Director, Principal Investigator in the **Munich Excellence Clusters CIPSM and SyNergy**, Munich, Germany

See his CV at the Scientific Committee Section

Optogenetics and imaging Techniques in Cortical Circuits

Cortico-thalamic slow oscillations determine internal brain states, playing a major role in memory consolidation. Such oscillations occur spontaneously, but may also be evoked by sensory stimulation. They propagate over long distances in the brain and recruit both the cortex as well as the thalamus. Here we implemented an optogenetic approach to explore basic features of slow-oscillation generation and propagation in the in vivo mouse brain. We monitored the calcium transients associated with slow wave activity by using optic fiber-based fluorometric calcium recordings. We analyzed spontaneous slow waves as well as waves evoked by sensory or by local optogenetic (ChR2) stimulation. We demonstrate that pulse-like optogenetic stimulation (3 - 50 ms) of a small group layer 5 cortical neurons is sufficient for the induction of global brain Ca2+ waves. The temporal invariance and the globality of the Ca2+ waves suggest the presence of recurring large-scale neuronal 'signaling units' during which activity generated by local networks is distributed and processed throughout the cortex.

Jordi Rumiá, Coordinator of the Functional Neurosurgery Programme for Adults (**Hospital Clínic de Barcelona**) and Children (**Hospital de Sant Joan de Déu**), Barcelona, Spain

Chair of the SESSION 2: STIMULATION TO EXPLORE AND CONTROL BRAIN ACTIVITY

Jordi Rumià. Senior Specialist in Neurosurgery. Coordinator, Functional Neurosurgery Programme for Adults (Hospital Clínic de Barcelona) and Children (Hospital de Sant Joan de Déu). Associate Professor of Neurosurgery of the Department of Surgery & Surgical Specialities, University of Barcelona School of Medicine. Co-author of 74 indexed articles and several book chapters. Main surgical activity since 1995 centred in surgical treatment of drug-resistant epilepsies and movement disorders, both by means of microneurosurgical resections and neurostimulation techniques, mainly deep brain stimulation (DBS). More than 700 patients operated of those conditions. Principal interests: Applying connectomics to pre-surgical decision-making and planning. Expanding clinical applications of neuromodulation for brain disease. Closed-loop systems. Brain activity-driven assistive robotics and sensory neuroprosthetics.

Marcello Massimini, Associate professor of Human Physiology at the Department of Biomedical and Clinical Sciences, **University of Milan**, Milan, Italy

Brain Stimulation and the Estimation of Consciousness

Theoretical considerations suggest that consciousness depends on the ability of neural elements to engage in complex activity patterns that are, at once, distributed within a system of interacting cortical areas (integrated) and differentiated in space and time (information-rich). We thus hypothesized that the level of consciousness could be estimated empirically by perturbing the cortex to engage distributed interactions and by measuring the information content (algorithmic complexity) of the resulting responses. We found that the algorithmic complexity of cortical responses to transcranial magnetic stimulation reliably discriminated the level of consciousness in single individuals across different conditions in which consciousness was altered physiologically, pharmacologically and pathologically. This theoretically motivated quantification of brain complexity allows establishing a reliable, graded measurement scale along the consciousness/unconsciousness spectrum and provides novel mechanistic insight on the neurophysiological mechanisms of loss and recovery of consciousness.

Mavi Sanchez-Vives, Team Leader, Systems Neuroscience, **IDIBAPS** (Institute of Biomedical Research August Pi i Sunyer), Barcelona, Spain

Controlling Spontaneous Cortical Emergent Activity

Non-invasive brain stimulation techniques, such as transcranial direct current stimulation (tDCS) or transcranial magnetic stimulation (TMS), play a growing role in the treatment of neurological disorders. Although positive outcomes have been reported over the last decades, the underlying network mechanisms are not always thoroughly understood. Here I will present quantitative data of the modulation of cortical slow (<1 Hz) and high (beta 15-30Hz, gamma 30-90 Hz) frequencies in neocortical slices by exposing them to uniform electric fields of varying amplitude and polarity. Our in vitro model gives us the opportunity to analyze the network dynamics in an accessible and controlled way. I will discuss the network mechanisms playing a role in the resulting activity and the implications that these results may have for different applications.

Marom Bikson, Professor, Department of Biomedical Engineering, **The City College of New York**, New York City, USA

Catell Professor of Biomedical Engineering at The City College of New York. Co-Director of the Translational Medical Device Development Program and Neural Engineering group at the New York Center for Biomedical Engineering. Fellow American Institute for Medical and Biological Engineering. Author of more than 140 articles and 30 patents. Co-inventor of High-Definition transcranial Direct Current Stimulation (HD-tDCS) and Limited Total Energy tDCS (tDCS-LTE). Co-founder and CEO of Soterix Medical Inc. Scientific Advisory Board of Boston Scientific Inc. and consultant to numerous medical device companies and agencies. Technology Editor for Brain Stimulation Journal. Founding chair Neuromodec NYC Neuromodulation conference and co-director Neuromodec tDCS Workshop.

Modulating Brain Processing and Learning with Targeted Non-Invasive Electrical Stimulation

Abstract: Over the past decade, new technologies that allow painless non-invasive modulation of brain function with electricity have been investigated to treat a broad range of neurological and psychiatric disorders, facilitate rehabilitation after brain injury, and enhance cognitive performance in healthy individuals. In particular, transcranial Direct Current Stimulation (tDCS) is investigated in over 500 clinical trials. This talk explains the cellular mechanisms by which weak

electrical current can modulate brain processing and enhance plasticity. "Functional Targeting" allows tDCS to boost specific brain networks activated by adjunct interventions such as rehabilitation and cognitive training. State-of-the-art techniques for clinical grade tDCS are presented including High-Definition tDCS (HD-tDCS) and methods to optimize and individualize stimulation.

Igor Timofeev, Full professor, Department of Psychiatrie et Neurosciences at **Université Laval**, Québec, Canada

Dr.Timofeev received his PhD from Bogomolets Institute of Physiology (Kiev, Ukraine) in 1993. He was employed as Lecturer in the Department of Human and Animals Physiology at Odessa State University (Odessa, Ukraine). From 1994 till 2000 he was postdoctoral fellow in Dr. Mircea Steriade laboratory at Université Laval (Quebec, Canada), since then he holds independent position and now Igor Timofeev is a full professor in the department of Psychiatrie et Neurosciences at Université Laval. His current research activities are located in the Centre de recherche de l'Institut universitaire en santé mentale de Québec. His laboratory investigates cellular mechanisms of sleep and epilepsy within thalamocortical system. He authorized over 100 original papers, over 30 review paper/chapters and he edited a book.

Optogenetic Cortical Stimulation to Increase Sleep Slow Oscillation and to Improve Memory Consolidation in Mice

Throughout life, brain generates multiple forms of activities. Multiple studies suggest that slow oscillation of slow wave sleep contributes to memory consolidation. Therefore, an increase in slow oscillatory activity should promote memory consolidation. Transcranial direct current stimulation with frequency of slow oscillation demonstrated some improvement of memory consolidation. This method of stimulation does not consider brain microstates. For more efficient interaction with brain, we propose to use optogenetic approach. Thy1 mice contain channelrhodopsin 2 in a large number of pyramidal neurons and a subset of interneurons enabling to use low intensity optical stimuli to activate a subset of neurons. Low intensity stimulation of frontal cortex was able to induce slow waves, which were propagating during quiet wakefulness and slow-wave sleep, but not active wakefulness. Low frequency stimulation in the first hours of light period was able to increase significantly power of EEG in slow-wave range and highly significantly increased memory consolidation in novel object recognition test.

Mikhail Lebedev, Senior Research Scientist, **Duke University**, Durham, USA

Co-chair of the DEBATE ON AUGMENTATION OF BRAIN FUNCTIONS: FACTS, CONTROVERSY AND FUTURE

Mikhail A. Lebedev is a senior research scientist at Duke University. He received a MSci from the Moscow Institute of Physics and Technology, Moscow in 1986 and a Ph.D. from the University of Tennessee, Memphis in 1995. He worked at the Institute for the Problems of Information Transmission, Moscow, (1986–1991), the International School for Advanced Studies, Trieste (1995–1997) and the National Institute of Mental Health (1997–2002). Scientific interests include neurophysiology and brain–machine interfaces. Lebedev has authored more than 70 papers. He is also an editor in several scientific journals.

Marcello Massimini, Associate professor of Human Physiology at the Department of Biomedical and Clinical Sciences, **University of Milan**, Milan, Italy

See his CV at the Scientific Committee Section

Co-chair of the DEBATE ON AUGMENTATION OF BRAIN FUNCTIONS: FACTS, CONTROVERSY AND FUTURE

INVITED SPEAKERS

Thursday, April, 30th, 2015

Arthur Konnerth, Professor of Neuroscience, Director, Principal Investigator in the **Munich Excellence Clusters CIPSM and SyNergy**, Munich, Germany

Chair of the SESSION 3: INTERFACING WITH THE CEREBRAL CORTEX: NEW TECHNOLOGIES

See his CV at the Scientific Committee Section

Michele Giugliano, Principal Investigator at the **Antwerp University**, Antwerpen, Belgium

Associate Professor of Computational Neuroscience at the University of Antwerpen and visiting academic at the Department of Computer Science of the University of Sheffield (UK) and at the Brain Mind Institute of the Swiss Federal Institute of Technology of Lausanne (Switzerland). Trained as an Electronic Engineer, specialized in Biomedical Engineering, received a 5 years laurea-degree summa cum laude, from the University of Genova and a PhD in Biophysics and Computational Neuroscience in 2001 from the Politecnico di Milano (Italy) with a PhD in Bioengineering. Long-term postdoctoral fellow of the Human Frontier Science Program Organization was postdoc at the Faculty of Medicine of the University of Bern (Switzerland) and Junior Group Leader at the Brain Mind Institute of the EPFL. President of the Belgian Society for Neuroscience from January 2014 to December 2015, partner and coordinator in several EU-funded projects, including the ongoing BRAINLEAP, ENLIGHTENMENT, MERIDIAN and NAMASEN projects.

Probing Neuronal Dynamical Response Properties

He will discuss conventional approaches and future enabling technologies to probe dynamical response properties of neurons, particularly focusing on the way fast or spatially correlated input fluctuations are conveyed in neuron output spike trains.

Guglielmo Fortunato, Acting Director of the Institute for Microelectronics and Microsystems of the **Italian National Research Council** (IMM-CNR), Rome, Italy

Guglielmo Fortunato is research director at IMM-CNR Roma Unit, where he leads the Devices for Large Area Electronics Group. His main scientific activity is on the physics and technology of inorganic (amorphous, micro- and polycrystalline silicon) and organic thin film transistors (TFTs). He has given a substantial contribution to the physics of polysilicon TFTs and has pioneered the use of excimer laser annealing for polysilicon TFTs and ultra-shallow junction formation. Recently he focused on low temperature process for flexible electronics, including sensor applications and microelectrode arrays for brain signal recording. He has been responsible of several National and European Research projects and also of industrial research contracts with ST-Microelectronics, Philips and THALES. He has authored more than 220 papers published on ISI-indexed journals, more than 140 contributions to International Conferences, 35 invited talks in International Conferences and is author of 5 invited chapters on books and holds 10 patents.

Ultra-flexible Microelectrode Arrays with Integrated Control Electronics for Electrophysiology Applications

Electrocorticography (ECoG), thanks to its low degree of invasiveness, has received in recent years an increasing attention for chronic brain-machine interface (BMI) applications. High-resolution microelectrode arrays (MEAs) are of interest for both current clinical applications, providing access to more precise neural activity localization, and novel applications, such as neural prosthetics. Developing such MEAs is not trivial because their small contact area increases the electrode impedance, which seriously affects the signal-to-noise ratio, and adhering such an electrode to the brain surface becomes critical. The most straightforward approach requires increasing the array conformability with flexible substrates while improving the electrode performance. In this work, we present a process to fabricate ultra-flexible and conformable polyimide-based MEAs of sub-millimeter recording sites. The MEAs have been integrated with a digital electrophysiology interface, able to filter and amplify 32 analog channels and specifically designed to match the impedance of a passive MEAs. Moreover, the board was equipped with independent stimulation channels that allow to locally stimulate through two independent output channels by means of AC or DC voltage and currents applied by an external source. In this way, it is possible simultaneously to stimulate during the recordings in order to investigate and

develop closed loop control algorithms. In addition, the board is equipped with a microcontroller, that has the main advantage of integrating USB communication directly on the board and manages also other peripherals. The NeuroDaq smart system has been successfully validated with in-vivo tests performed at IDIBAPS and Local field Potential (LFP) from the left motor-somatosensory cortex of Wistar male rat were recorded.

Gemma Gabriel-Buguña, Researcher at the Biomedical Applications Group, **Microelectronics Institute of Barcelona**, (IMB-CNM, CSIC), Barcelona, Spain

Gemma Gabriel is permanent researcher in the Biomedical Applications Group of the IMB-CNM (CSIC) since 2010. She obtained a chemistry degree from the Autonomous University of Barcelona in 2000, and her PhD in Materials Science in 2005. The main mission of the group, where she is undertaking her investigations, is to take advantage of technological capacities that the Clean Room Facilities of IMB-CNM offers in order to create microsystems, developing technologies and to craft innovative devices capable of providing novel solutions to different applications in the biomonitoring field. In the last seven years Gemma Gabriel has been involved in several projects related to the development of multisensing platforms for biomonitoring for cell culture detection and in neural applications. Gemma Gabriel expertise is related to the sensor design, fabrication with microelectronic technology and characterization of the sensors. Her background also is related to the use of different biocompatible electrode materials such as platinum, black platinum, carbon nanotubes or graphene in substrates such as silicon, pyrex, and SU8.

Rosa Villa, Principal Investigator at the Biomedical Applications Group, **Microelectronics Institute of Barcelona**, (IMB-CNM, CSIC), Barcelona, Spain

She obtained the medical degree from the Universitat de Barcelona (1981) and the Ph.D. in Medicine by the Universitat Autònoma de Barcelona (1993), and specialized in nuclear medicine. Since 1986 she works at the Microelectronics Institute of Barcelona, and since 2006 as permanent member of CSICs scientific staff. Currently she leads the Biomedical Application's Group of the IMB-CNM, which main research interests are the design and fabrication of Micro and Nano Systems for Biomedical Applications. Her training and experience in the biomedical field has driven the group to focus its research in the final applications in order to develop different biomedical devices. She has participated in more than 30 National and European projects, in 10 of them as principal investigator. Two of these projects have been awarded by the Premio Ciudad de Barcelona [City of Barcelona Award], in its Technical modality and in the field of Technological Research. She has more than 50 international publications in high-impact journals and book chapters and h-index of 15, and more than 10 patents, two of them being licensed to companies.

Graphene as Brain Interface

Neural interfaces are still nowadays a challenge from the technological and biological point of view, because there is still a need to optimize the biological-artificial interconnection. Just because these devices will allow to study and learn about brain functions in acute or chronical experiments, make of them one of the major research lines in the coming years. Aspects such as improvements in biocompatibility, signal noise, electrodes decreasing the surface area, improving the electrode-electrolyte interface, etc are some of the most important key aspects to be improved. One of the most important research lines of our group has been always related with the design and manufacturing of neural interfaces for in vivo and in vitro recordings. New manufacturing techniques, new materials, new designs etc have been incorporated in the last years. The new research line initiated in the group is related with the study of graphene as a neural interface. It pursues the validation of this material as neural interface, as well as the fabrication of devices on flexible substrates that minimize brain damage, and can be used for both neuronal recordings and stimulation. Prototypes of microelectrode arrays are being fabricated in order to study if the properties and advantages of graphene such as flexibility, biocompatibility and capacitance allow improvements in the complex world of the neural interfaces.

Stephen Dunne, Director of Neuroscience Research at Starlab, Barcelona, Spain

Mr. Stephen Dunne began his studies in the Galway Technical College where he obtained a National Certificate in Instrument Physics. From there he moved to the University of Wales in Aberystwyth where he obtained a BSc (Honours) in Planetary and Space Physics. Following this he obtained a Masters in Optoelectronics and Information Processing from Queens University in Belfast, carrying out a research thesis at the Instituto de Astrofísica de Canarias. In 2003 He joined Starlab, where he is currently Director of Neuroscience Research. His group developed the prototype Starstim and Enobio devices that were later successfully spun-out to Neuroelectrics. His research interests include BCI, HCC, User Affective & Cognitive State, EEG Signal Analysis and Neuromarker discovery. He is also developing business models for the transfer of this research to the market with a strong focus on Neuromarkers.

Non-invasive neurotechnologies: Closing the loop

During the past 10 years we have been developing a platform for monitoring and modulating the electrical brain based on non-invasive technologies. In this talk we will present an overview of both our work and the work of our partners in EEG and tCS and conclude with an exploration of their combination in closed-loop systems.

Pau Gorostiza, ICREA Research Professor at the Institute for Bioengineering of Catalonia (**IBEC**), Barcelona, Spain

Pau Gorostiza graduated in physics at the Universitat de Barcelona (UB), where he also obtained his Ph.D. (European Doctorate) in the field of semiconductor electrochemistry. He also worked at the microscopy facility of the UB, where he gained experience in AFM and STM of biological samples, as well as in nanotechnology applied to materials science. He has visited the CNRS and the Université Pierre et Marie Curie in Paris (France), and the University of California at Berkeley (USA). His recent works include the development of optical switches for remotely controlling neuronal activity. He obtained a Young Biomedical Investigator Award of the Francisco Cobos Foundation, a Career Development Award of the Human Frontier Science Program (HFSP) and Starting and Proof-of-Concept grants of the European Research Council (ERC). He is currently ICREA Research Professor at the Institute for Bioengineering of Catalonia (IBEC).

Optopharmacology to Control Neural Activity with Light

The large number of photoswitchable biomolecules discovered and developed in recent years covers a great variety of cellular functions like catalysis of metabolic processes, cytoskeletal polymerization and motors, nucleic acids dynamics, intracellular signaling and perhaps most dazzlingly membrane excitability, which has been at the focus of optogenetics and optopharmacology. The dream of precisely and remotely photocontrolling every aspect of the cell's inner workings in intact tissue appears within reach and offers the promise of interrogating complex cellular processes to discover their molecular mechanisms. In this talk I will review recent and ongoing projects in the lab focused on optopharmacology, including the development of peptide inhibitors of protein-protein interactions, allosteric modulators of G protein-coupled receptors and photoswitchable tethered ligands of ionotropic receptors.

Myriam Pannetier-Lecoeur, Senior Scientist at Service de l'Etat Condensé at **CEA Saclay**, Saclay, France

Myriam Pannetier-Lecoeur is Senior Scientist at Service de l'Etat Condensé at CEA Saclay since 2001. She has a long expertise in the area of magnetism, of magnetic sensor development and has been involved in several European and National projects for magnetic sensor development, in particular in the area of medical applications, such as Magneto-Encephalography, Magneto-cardiography or low field MRI. She has authored of more than 60 articles and is inventor of 14 patents on magnetic technologies. She has been awarded the James Zimmerman Prize of the International Federation for Medical and Biological Engineering Society (2014) and the Aymé Poirson Prize from the French Academy of Sciences (2008) for magnetic field sensors development for medical applications. She currently coordinates the Magnetrodes project (FP7-FET 2013-2016) on magnetic probes for neuronal activity recordings.

Magnetrodes for brain interfacing

Spin electronics offers nowadays the possibility to create very sensitive, micrometer-scale magnetic field detectors. 'Magnetrodes' is an FP7-FET project, started in January 2013, aiming to exploit this technological advance to create novel tools for probing neuronal magnetic fields at the cellular level. The first goal of the project is to develop the magnetic equivalent of an electrode, a 'magnetrode', sensitive enough to detect the very small magnetic fields induced by the ionic currents flowing within electrically active neurons, and small enough to probe a limited number of cells. We target also to adapt magnetrodes also for local nuclear magnetic resonance spectroscopy (MRS); thus, they could record both electromagnetic and chemical activity of neurons. The magnetrodes will be tested in vitro and in vivo at various spatial scales, from brain areas down to single neurons. In parallel, based on the measurements with magnetrodes, we will augment existing computational models and develop new ones to characterize the electromagnetic fields emitted by neurons and neuron assemblies. We will use these models to bridge from the activity of single neurons to macroscopic non-invasive measurements such as electroencephalography (EEG) and magnetoencephalography (MEG).

Alain Destexhe, **CNRS** Reseach Director (UNIC, Gif Sur Yvette), and Director of the **European Institute for Theoretical Neuroscience**, Paris, France

Chair of the SESSION 4: DECODING BRAIN ACTIVITY AND THE FUTURE OF BRAIN COMPUTER INTERFACES

See his CV at the Scientific Committee Section

Nick Ramsey, Head of the Cognitive Neuroscience Research Programme of the Department of Neurology & Neurosurgery, **UMC Utrecht**, The Netherlands

Nick Ramsey has a degree in Psychology and a PhD in neuropsychopharmacology, both form the university of Utrecht. He became a specialist in cognitive neuroimaging in the US (National Institutes of Health), and applies modern techniques, including fMRI and intracranial EEG, to questions on working memory, language and sensorimotor function. His primary goal is to acquire and translate neuroscientific insights to patients with neurological and psychiatric disorders, with a focus on brain-computer interfacing. He is full professor in cognitive neuroscience at the department of neurology and neurosurgery of the UMC Utrecht since 2007. He has been awarded several personal grants fro the Dutch Research Foundation including a VIDI (2002) for elucidating working memory, and a VICI (2006) for developing intracranial BCI concepts for paralyzed people. The latter resulted in an implantable prototype for locked-in patients for which a clinical trial started in 2014. He received an ERC Advanced grant in 2013 for developing methods of decoding inner speech intracranial Brain-computer Interfaces.

Cortical Activity Pattern Decoding for Human Intracranial BCI

Recording and decoding brain activity from the surface of the cortex is an alternative approach to brain-computer interfacing in humans compared to indwelling electrodes. Proof of concept research is conducted in patients with surface electrodes implanted for diagnostic purposes but also in healthy volunteers with advanced functional MRI technology. In the first part I will present research leading up to a clinical study with a fully implantable BCI system for locked-in patients. In the second part I will discuss how ultra-high field fMRI opens new avenues for future implantable BCI solutions, including decoding of inner speech.

José del R. Millán, Defitech Professor, **Swiss Federal Institute of Technology**, Lausanne, Switzerland

José del R. Millán is the Defitech Professor at the Ecole Polytechnique Fédérale de Lausanne (EPFL) where he explores the use of brain signals for multimodal interaction and, in particular, the development of non-invasive brain-controlled robots and neuroprostheses. In this multidisciplinary research effort, Dr. Millán is bringing together his pioneering work on the two fields of brain-machine interfaces and adaptive intelligent robotics. He received his Ph.D. in computer science from the Univ. Politècnica de Catalunya (Barcelona, Spain) in 1992. He was a research scientist at the Joint Research Centre of the European Commission in Ispra (Italy), a senior researcher at the Idiap Research Institute in Martigny (Switzerland), and a visiting scholar at the Universities of Stanford and Berkeley as well as at the International Computer Science Institute in Berkeley. His research on brain-machine interfaces was nominated finalist of the European Descartes Prize 2001 and he has been named Research Leader 2004 by the journal Scientific American for his work on brain-controlled robots. He is the recipient of the IEEE-SMC Nobert Wiener Award 2011 for his seminal and pioneering contributions to non-invasive brain-machine interfaces. Dr. Millán has coordinated a number of European projects on brain-machine interfaces.

Translating Brain-Computer Interfaces to End-Users

In the framework of the European project TOBI, we have developed a variety of BCI prototypes that have been extensively tested by motor-impaired users after a short training period. A substantial number of tests have been carried out at end-users' home and clinics, outside well controlled laboratory conditions. Equally significantly, non-BCI experts (assistive technology professionals and therapists) have run many of these tests independently or with a minimum of remote assistance from researchers. A central concern in our research is how to facilitate the operation of brain-controlled devices over long periods of time. This is a challenging problem due to the limited (and variable) information carried by brain signals we can measure, no matter the recording modality. I will argue that efficient brain-computer interaction, as the execution of voluntary movements, requires the integration of several parts of the CNS and the external actuators.In this talk he will summarize this work and the main lessons learned from this major effort, highlighting new principles incorporated in the brain-controlled devices.

Mikhail Lebedev, Senior Research Scientist, **Duke University**, Durham, USA

See his CV at the Debate on Augmentation of Brain Functions: Facts, Controversy and Future chair's section

Brain-machine interfaces for movements, sensations and more

Brain-machine interfaces (BMIs) hold promise to treat neurological disabilities by linking intact brain circuitry to assistive devices, such as robots that enact functionality of body parts. BMIs have experienced very rapid development in recent years, facilitated by advances in neural recordings, computer technologies and robotics. BMIs are commonly classified into three types: sensory, motor and bidirectional, which subserve motor, sensory and sensorimotor functions, respectively. Additionally, cognitive BMIs have emerged in the domain of higher brain functions. BMIs are also classified as noninvasive or invasive according to the degree of their interference with the biological tissue. Although noninvasive BMIs are safe and easy to implement, their information bandwidth is limited. Invasive BMIs hold promise to improve the bandwidth by utilizing multichannel recordings from ensembles of brain neurons. BMIs have a broad range of clinical goals, as well as the goal to enhance normal brain functions. Moreover, BMI technology in the future may be used to establish communication between individual brains.

Christoph Guger, CEO of **GTEC Medical Bioengineering**, **Guger Technolgoies**, Austria

Mr. Christoph Guger, Dr. studied biomedical engineering at the University of Technology Graz and Johns Hopkins University in Baltimore, USA. He then carried out research work at the Department of Medical Informatics (Prof. Pfurtscheller) at the University of Technology Graz and received his PhD degree in 1999. The topic of his PhD work was the design of an EEG-based brain-computer interface. This was the first real-time BCI system with continuous feedback. He also developed the real-time analysis with common spatial patterns, which is still the fastest and most accurate approach for oscillatory BCIs, and also developed a P300 BCI with very high accuracy and speed. In recent years, he also worked with ALS and tetraplegic patients in different countries.

Current and Future Applications of BCIs

Research groups all over the world have been working enthusiastically on Brain-Computer Interfaces (BCIs), which provide a direct connection from the human brain to a computer. BCIs translate brain activity into control signals for numerous applications, including tools to help severely disabled users communicate and improve their quality of life. BCIs have been used to restore movement, assess cognitive functioning, and provide communication and environ-mental control. Current and future applications based on the three major BCI approaches motor imagery, P300 and steady state visual evoked potentials (SSVEP) will be explained. Furthermore new directions like active and dry electrodes, invasive ECoG systems and advanced VR control will be discussed.

Mavi Sanchez-Vives, Team Leader, Systems Neuroscience, IDIBAPS (Institute of Biomedical Research August Pi i Sunyer), Barcelona, Spain

See her CV at the Scientific Committee section

Co-chair of the DEBATE ON AUGMENTATION OF BRAIN FUNCTIONS: FACTS, CONTROVERSY AND FUTURE

Michele Giugliano, Principal Investigator at the **Antwerp University**, Antwerpen, Belgium

Co-chair of the DEBATE ON AUGMENTATION OF BRAIN FUNCTIONS: FACTS, CONTROVERSY AND FUTURE

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***Invited speakers in blue** *****Scientific leader of the event**

PRACTICAL INFORMATION

DEBATES VENUE

CAIXAFORUM BARCELONA

Avinguda Francesc Ferrer i Guàrdia, 6-8
Barcelona, Spain
http://obrasocial.lacaixa.es

Scientific presentations and debates: AULA 1 (2nd Floor)
Posters and demos (Wednesday, April 29th); AULA 2 (2nd Floor) 16:00pm – 16:30pm and 18:45pm – 20:00pm

Demos by GTEC (**www.gtec.at**) and Neuroelectrics Barcelona (**www.neuroelectrics.com**)

Coffee breaks: CAFETERIA (1st Floor)
Lunchs: CARRERS MODERNISTES (1st Floor)

CaixaForum Barcelona
Obra Social "la Caixa"

CaixaForum, the Social and Cultural Centre of "la Caixa" Out Reach Projects, is housed in one of Barcelona's chief Art-Nouveau building that stands as a unique example of Catalan Art-Nouveau industrial architecture of the early twentieth century. The building was designed by Josep Puig i Cadafalch and completed in 1911. It first operated as a spinning mill and textile factory but closed down just seven years after its opening. After that, it was pressed into service as a warehouse during the Barcelona World Fair of 1929, and in 1940 it was converted into stables and garages for the National Police Force. Awarded in 1912 with the City Council's prize for the best industrial building, it has been declared in 1976 Historical Artistic Monument. CaixaForum opened in 2002 and was designed as a space for dissemination and debate on culture and its many manifestations. With this aim, it offers a wide range of activities for all kind of public (exhibitions, familiar activities, concerts, poetry, literature, conferences, videoart, festivals, courses, new medias, etc.).

More info: http://obrasocial.lacaixa.es

ORGANIZERS

B·DEBATE International Center for Scientific Debate BARCELONA

AN INITIATIVE OF: biocat "la Caixa" Foundation

B·Debate International Center for Scientific Debate Barcelona is a **Biocat** initiative with support from **"la Caixa" Foundation**. It drives first-rate international scientific debates, to foster dialogue, collaboration and open exchange of knowledge with prestigious national and international experts, to approach complex challenges of high social interest in life sciences. B·Debate sees debate as a powerful, effective way to generate knowledge and strives to help position Barcelona as a benchmark in generating knowledge and Catalonia as a country of scientific excellence.

B·Debate sees debate as a powerful, effective way to generate new knowledge. The debates are top-notch international scientific meetings featuring a selection of experts of renowned international prestige and scientists that work in Barcelona and Catalonia, moderated by scientific leaders. Since 2009 B·Debate has invited about 1000 recognized speakers and over 6.000 attendees. B·Debate seeks out answers to the challenges and needs of society in the field of life sciences, taking into account the complex, ever-changing conditions of this global world. The debates foster the integration of different disciplines of science and deal with such diverse topics as ageing, new therapeutic approaches to various diseases, innovative technology to improve knowledge of the human genome, food resources, new tools to integrate knowledge management, clinical genomics, neurosciences, climate change, and new energy sources, among others. The knowledge and results obtained through these events is spread throughout both the scientific community and general society through the various **B·Debate** channels and instruments.

More information: www.bdebate.org/en

IDIBAPS Institut D'Investigacions Biomèdiques August Pi i Sunyer

The **Institute of Biomedical Investigations Albert Pi i Sunyer** (IDIBAPS) is a research centre devoted to translational research, innovation and technological progress in the field of biomedicine through different programmes addressing diseases with a high prevalence, morbidity and mortality. The research activities of the centre are divided into six different areas, which group over 60 research teams. One of this areas is clinical and experimental neuroscience.

More information: www.idibaps.org

COLLABORATORS

CORTICONIC is a FET European Project (600806) devoted to the identification of computational principles of the cerebral cortex underlying network dynamic patterns. The approach and technologies developed in this project are relevant for areas including brain-computer interfaces, brain repair, brain modelling and massive scale computing.

More information: **www.corticonic.org**

Neurographene (604391 FP7-ICT-2013-FET) is a project part of the **GRAPHENE FLAGSHIP** dedicated to the validation of graphene as a brain interface material, to develop devices for both recording neural activity and for brain stimulation.

More information: **www.neurographene.eu** and **graphene-flagship.eu**

GTEC develops hardware and software for biosignal acquisition and analysis (mainly EEG and ECG). G.TEC sells biomedical equipment in more than 50 countries and is the main worldwide supplier of brain-computer interface technology. The G.TEC technology has received several innovation Awards such as the 2007 European Information and Communication Technology price (ICT-price) and the Well-Tech Award 2007 and the Fast-Forward-Award for its innovative new product MINDbeagle, consciousness assessment software for coma patients in 2014.

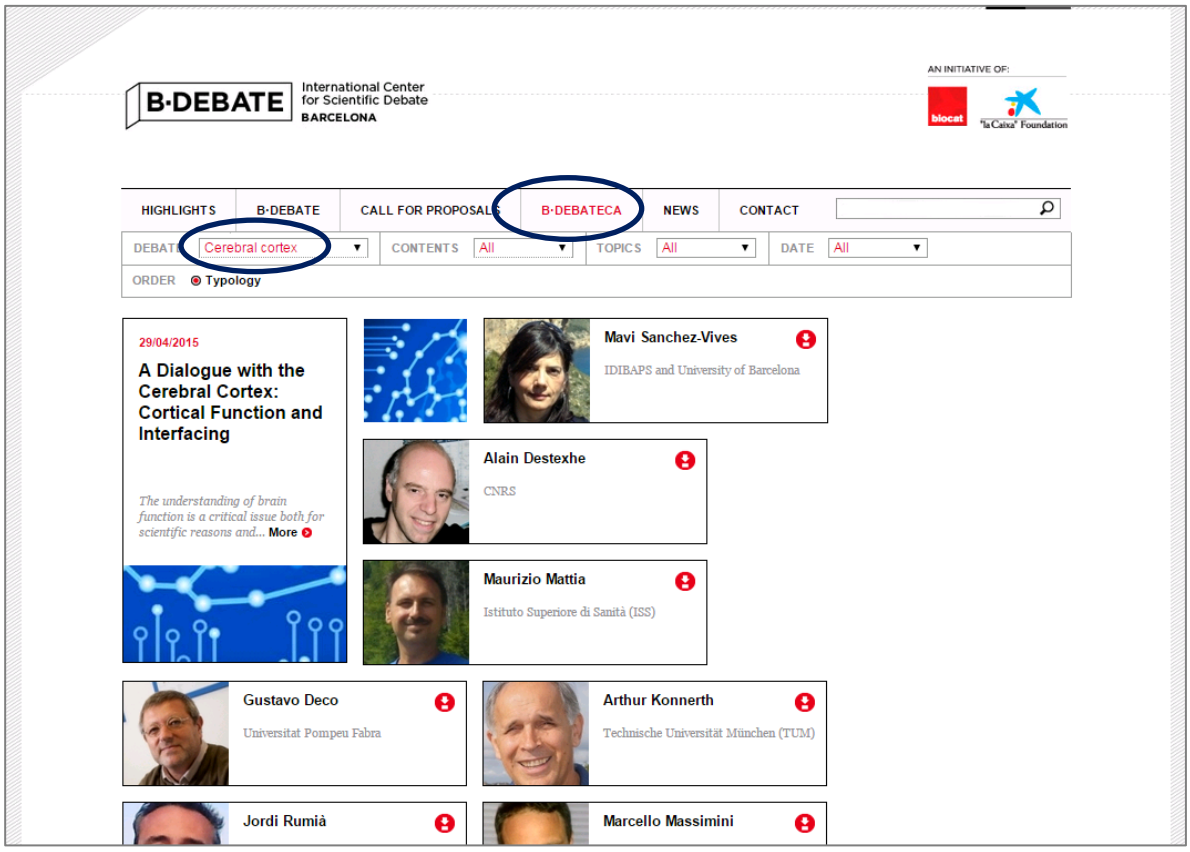
More information: **www.gtec.at**

OUTCOMES

On the website of **B·Debate**, you will find all the information related with the celebration of the meeting that includes reports, conclusions, scientific documents, interviews with the experts, speaker's BIOs, presentations, videos, images, press documentation and other related materials.

We invite you to visit the section **B·Debateca** on www.bdebate.org!

Contents of the meeting "A DIALOGUE WITH THE CEREBRAL CORTEX: CORTICAL FUNCTION AND INTERFACING".



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