



Laboratory for Research in Neuroimaging

Department of Clinical Neurosciences, CHUV

Faculty of Biology and Medicine, UNIL

UNDERSTANDING BRAIN HEALTH & DISEASE

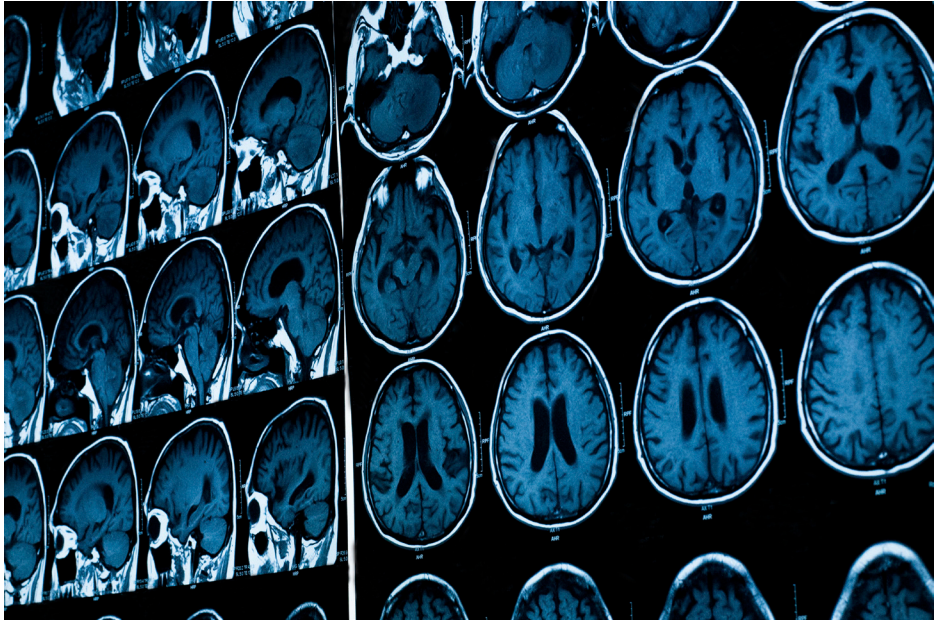
Unil
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Human Brain Project



APPLIED RESEARCH

EDITORIAL

«The human brain is one of the most sophisticated systems we know. Understanding is critical from a scientific perspective but also for the purpose of improving patient's care.

LREN is an imaging - neuroscience laboratory where clinical and basic researchers study human brain structure and function relevant to neurological disorders and normal cognition. We develop and apply non-invasive methods - magnetic resonance imaging and electro-encephalography to investigate topics including use-dependent brain plasticity, recovery of lost function and neurodegeneration.

The main goal of LREN is to translate basic research findings into clinical applications for early diagnosis of brain diseases and for prediction of clinical outcome.

LREN hosts a state-of-the-art neuroimaging platform featuring a high-end research-only Siemens Prisma 3T MRI scanner, sophisticated MRI compatible neurophysiological equipment and high-density EEG machines.

The launch of the Medical Informatics Platform of the Human Brain Project in March 2016 crowned the efforts of our team towards the development of analytical strategies with immediate relevance not only for the research community, but also for health practitioners, epidemiologists, patients and their carer.

LRENs has a very important mission in teaching and sharing know-how which goes beyond the supervision of young scientists at the Undergraduate, Masters and PhD level.

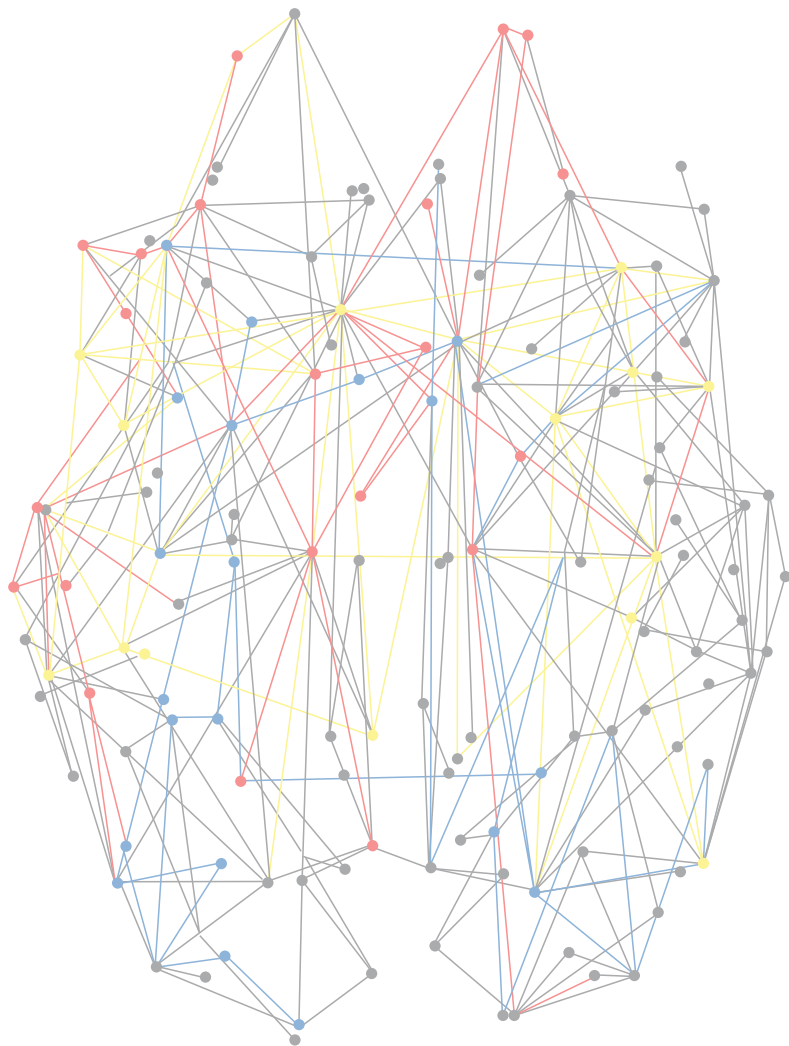
Providing a fruitful ground for many research fellows, clinicians and engineers, we are proud of our achievements in maintaining an exceptional mix of creative atmosphere and output-oriented research.



Professor Bogdan Draganski

Director of LREN and the MRI platform of the Department of Clinical Neurosciences, CHUV





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UNDERSTANDING

OUR MISSION

Understanding the structural and functional remodelling of the healthy and diseased brain.

LREN is an established world-class research laboratory with a unique methodological expertise in imaging neuroscience. Our scientific vision relies on an integrative and collaborative approach to research, building on state-of-the-art infrastructure and broad scientific expertise of its members.

We Develop cutting-edge scientific tools and methods to conduct and support high quality neuroimaging research through collaboration at the local and international levels.

The majority of our research activities are interdisciplinary, building upon the newest theoretical, methodological and hardware developments.

We produce innovative research with direct impact on patient care and medical decision making.

Our emphasis is on translational neuroscience projects that integrate observations at various levels – genes, molecules, cells, systems and their interaction with the environment.

The Laboratory for Research in Neuroimaging at the Department of Clinical Neurosciences – CHUV, Lausanne was founded in 2010.



CLINICAL RELEVANCE

We are building an ambitious educational activity.

« One of the main pillars in this challenging enterprise is our educational activity at the postgraduate level with active participation in UNILs Medical Biology Master of Science programme and the Lemanic Neuroscience Doctoral School. »

Our Human Brain seminars, courses and workshops create an interdisciplinary platform for scientific exchange.

We have established a network for studying the brain in the following contexts::

Genetic origins of autism

(Medical Genetics - CHUV,
Centre for Integrative Genomics - UNIL),

Neurodegeneration

(Neurology Service and
Centre Leenaards de la Memoire,
Department of Clinical Neurosciences - CHUV),

Mood disorders

(Department of Psychiatry - CHUV) and

Human behaviour

(Brain Mind Institute - EPFL).



In this endeavour LREN is supported by the CHUV Directorate, the Department of Clinical Neurosciences and the Faculty of Biology and Medicine at UNIL.

We are extremely grateful to the Roger De Spoelberch Foundation and the Partridge Foundation - a John and Polly Guth charitable fund, for their generous contribution for the departmental MRI platform.



RESEARCH AIMS

Our systems neuroscience approach for the study of the brain relies on geneticists, psychologists, MRI physicists and statisticians working side-by-side with clinicians.

We develop and apply non-invasive neuroimaging methods - magnetic resonance imaging and electro-encephalography, to investigate use-dependent brain plasticity, rehabilitation of lost function and neurodegeneration.

During the last six years, research at LREN comprised five research programmes.

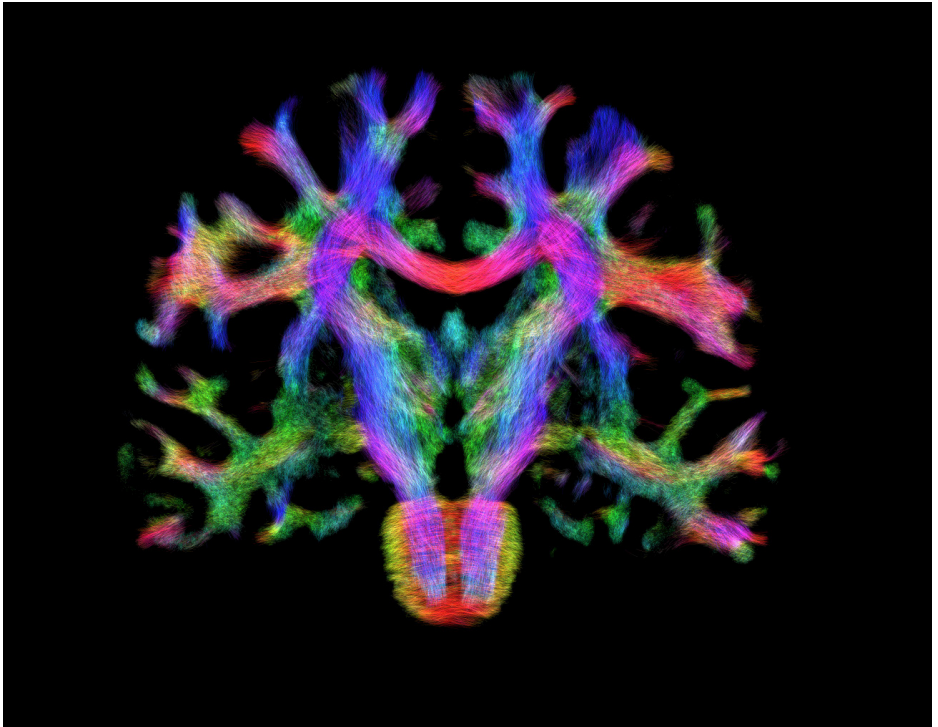
- Prediction of coma outcome
- In vivo brain histology using MRI
- Use-dependent brain plasticity
- Prediction of recovery of lost function
- Early biomarkers of Neuro-degeneration

Given that world-class imaging neuroscience requires similarly advanced methodological expertise, LRENs research strategy encompasses all methodological developments needed to support the goals of clinical and pre-clinical projects.

The cornerstone of this strategy is LRENs Methods group with unique expertise in the fields of novel MRI acquisition techniques and statistical analysis that provide new ways to study the patho-physiological basis of brain disorders and to monitor novel treatment strategies.

The LREN manages four ground-breaking platforms:

- Pre-Clinical Platform
- Neuroimaging Platform
- EEG Platform
- Medical Informatics Platform



CREATING KNOWLEDGE

PRE-CLINICAL PLATFORM

The Preclinical platform is at the interface between leading-edge imaging neuroscience technologies and best clinical practice. Our main interests are in investigation of the trajectories of brain maturation and ageing to differentiate these from abnormal processes of neurodegeneration leading to Alzheimer's disease, Parkinson's disease and epilepsy, to name but a few. Similarly, we make efforts to evaluate the impact of well-established and novel treatments in brain disorders – electro-convulsive treatment for depression, deep brain stimulation for obsessive-compulsive disorder and movement disorders. With data entries from more than 2500 individuals we are building on recent advances in biomedical imaging technology and analysis to extract characteristic features from behavioural and neuroimaging data using sophisticated neuro-informatics methodologies and clinically relevant information.

The Preclinical platform incorporates a flexible framework where data processing and analysis tools are divided into different workflows and computing modules depending on the researchers' demands. Our implementation of standardised computational anatomy algorithms allows for unbiased raw data processing and further feature reduction without losing informative characteristics. The use of open source software (Statistical Parametric Mapping – www.fil.ion.ucl.ac.uk/spm, FreeSurfer – <https://surfer.nmr.mgh.harvard.edu> and FSL – <https://www.fmrib.ox.ac.uk/fsl>).



Bogdan Draganski, MD

*Director of LREN
Principal investigator
and head of the pre-clinical
platform of the Department
of Clinical Neurosciences,
CHUV*

ACCURATE DIAGNOSIS

ox.ac.uk/fsl) provides a flexible framework for automated tissue classification, cortical thickness estimation, brain tissue property quantification and reliable lesion detection in the following workflows:

- Voxel-based morphometry and cortical thickness
- Voxel-based quantification of tissue properties
- Automated lesion detection
- Diffusion-based microstructure estimation and tractography

For data analysis we carry out univariate and multivariate statistical analyses that provide as output voxel-based statistical summaries or multivariate latent variables, which we use to build models. The models define the combination of brain areas that best predict disease related changes or a continuous behavioural variable. Our methods range from descriptive and quantitative measurements to statistical inferences and machine learning

approaches. They also include simulation based approaches where meta-models can be stored, tested, validated and refined by multiple users.

«*The platform provides a unique and innovative way to study the properties of cerebral tissues in dementia patients.*»



Pr JF Demonet, Director of the Leenards Memory Center at the Department of Clinical Neuroscience, CHUV

THE NEUROIMAGING PLATFORM

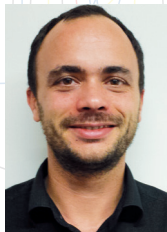
The Neuroimaging platform of the Department of Clinical Neurosciences at the CHUV is the very core of our strategy for translational neuroscience and has a direct impact on clinical decision making and patient care.

The mission of the platform is to provide an integrative framework for the world-class neuroimaging expertise of the Lemanic area (CHUV, UNIL, HuG et EPFL).

The platform was established at the end of 2013 thanks to the generous support from the charitable Foundation Roger de Spoelberch and the Partridge Foundation, a John and Polly Guth charitable Fund.

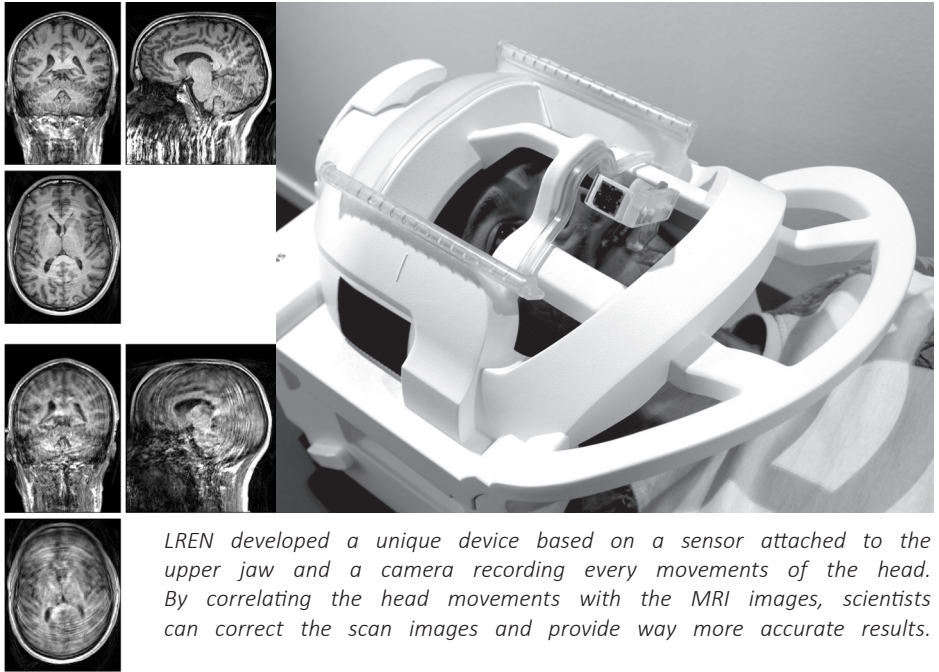
The Neuroimaging platform provides cutting-edge equipment and expertise covering all methodological aspects of neuroimaging - from study design, through acquisition of high quality behavioural and MRI data, state-of-the-art automated data preprocessing and statistical analysis.

« LREN provides assistance to all platform users, facilitates the optimal use of advanced image acquisition and analysis techniques additional to providing education and training in handling of MRI data. The MRI platform is built on two main pillars - high-performance data acquisition and advanced automated data processing. »

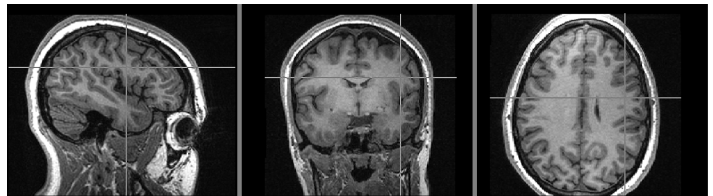


Antoine Lutti, PhD

Principal investigator
LREN and head of the
Neuroimaging platform of
the Department of Clinical
Neurosciences, CHUV



LREN developed a unique device based on a sensor attached to the upper jaw and a camera recording every movements of the head. By correlating the head movements with the MRI images, scientists can correct the scan images and provide way more accurate results.



QUANTIFYING

THE EEG PLATFORM

The EEG platform aims at providing an inspiring research environment for the use of electroencephalography as investigative technique in functional studies of the human brain.

Available equipment allows recording high density electroencephalography in a clinical environment at patients' bedside and at the laboratory space at the LREN. Advanced hardware solutions with active electrodes provide high quality data with limited setting up time and with a wide input sensitivity. The concomitant measurements of several physiological signals including EEG, electrocardiogram and electrooculography are recorded at high temporal resolution and oversampling acquisition rate to ensure optimal noise reduction.

The platform was established in 2015 based on the support of g.tec in the context of the

Eurostars project ComAlert with the aim of developing EEG based tools for outcome prediction in comatose patients.

The EEG platform provides advanced expertise in EEG data acquisition and analysis through existing open source packages and in house signal processing tools with special emphasis on single subject and single patient data analysis.



Marzia De Lucia, PhD

*Principal investigator LREN
and head of the EEG platform
of the Department of Clinical
Neurosciences, CHUV*

PREDICTING

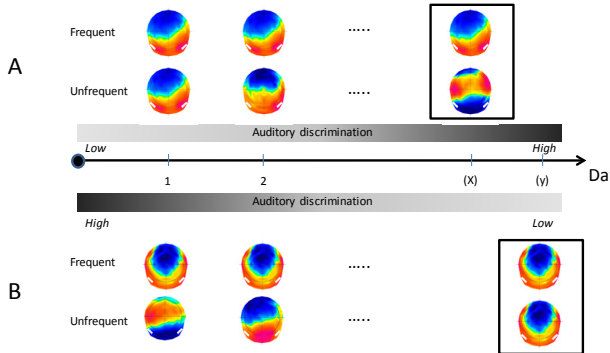


One of our research topic aims at predicting comatose patients' outcome.

Patient A shows similar EEG response to frequent and unfrequent sounds on the first day of coma. Later in time his neural responses to sounds get different: his brain can discriminate the two stimuli.

Patient B, on the other end, started with a better initial state, but his auditory discrimination decreases over time.

The study highlights a very significant correlation between the evolution of auditory discrimination and the patients' chances to wake up from Coma.



THE MEDICAL INFORMATICS PLATFORM

The Medical Informatics Platform provides the infrastructure, tools and algorithms for researchers and clinicians to make their data available to the global community, keeping them on-site and preserving patient confidentiality.

LREN is responsible for setting up the Medical Informatics Platform of the Human Brain Project under the leadership of Dr. Ferath Kherif. The platform federates hospital and other clinical data on all brain diseases and across multiple levels of biology.

The HBP's Medical Informatics Platform will enable researchers and clinicians to access and analyse anonymised multi-modal patient data federated across multiple hospitals and research centers.

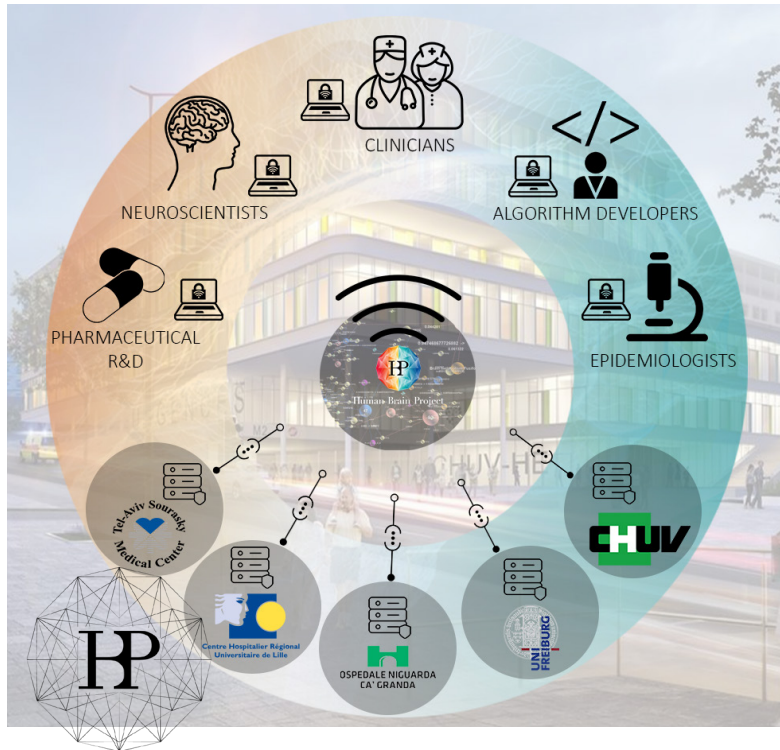
The iterative refinement and reuse of models and analyses will lead to identification of Biological Signatures of Diseases and novel classifications of brain disorders, thus more accurate diagnoses and personalized medicine.

In the long run our vision is that unlocking the wealth of information in medical and research databases will provide a credible and rapid path to precision (or personalized) medical care. Our interaction with the computing and neuroscience components of the HBP will serve to test with lesion models the functional and structural brain models and artefacts they produce.



Ferath Kherif, PhD

*Vice director of LREN
Principal investigator
Leader of the Human Brain
Project Medical Informatics
Platform*



Human Brain Project

INNOVATING

EDUCATION

LREN offers a wide range of ex-cathedra and hands-on teaching courses with the main aim to close the gap between basic and clinical neuroscience. We are actively involved in the Master of Sciences programmes of the Faculty of Biology and Medicine - UNIL, University Geneva and the Life Sciences Department of the EPFL.

Project presentation

Our weekly Project presentations offer an excellent opportunity for a researcher to present a planned neuroimaging study and get feedback from the specialised audience. The goal is to maximize the chance that the proposed project will answer the specified research question.

Human Brain seminar

The weekly seminar series has already a 5 years history attracting both young and established neuroscientists to present their most recent achievements in the field.

Annual SPM course

With the 7th Lausanne SPM course ahead, LREN attracts young scientists from all over Europe to provide beginners and advanced users an unique hands-on workshop. At all instances LRENs faculty are supported by our friends and colleagues from the Wellcome Trust Centre for Neuroimaging, UCL London, aka "the FIL".

Clinical Neuroscience programme

LRENs Clinical Neuroscience course is a joint effort of LREN, clinicians from the Neurology service, DNC - CHUV and our colleagues from the Centre for Sleep Investigation to introduce the topic to the students enrolled in the Lemanic Doctoral School.



TRANSMITTING



