Visite HCERES
ERL Empenn U1228

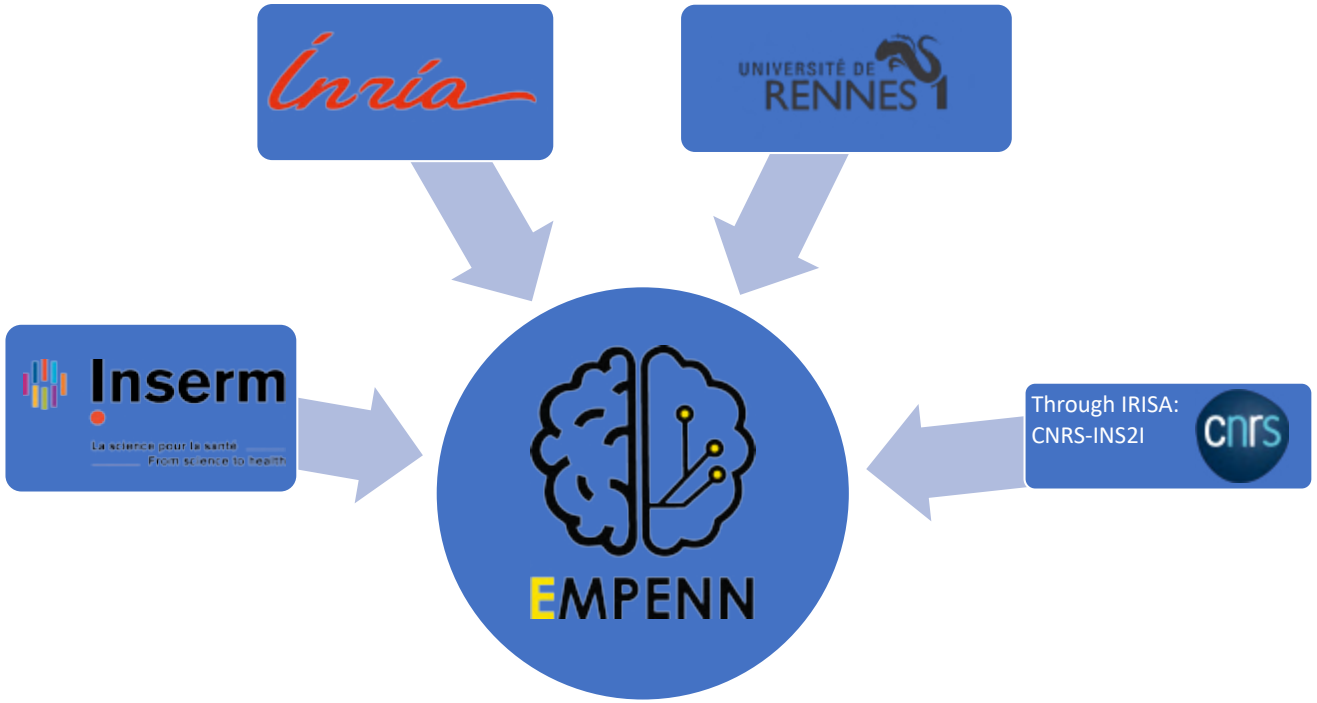
Pierre Maurel, MCF UR1

EMPENN

12/03/2021

Empenn's presentation

Empenn ERL U1228



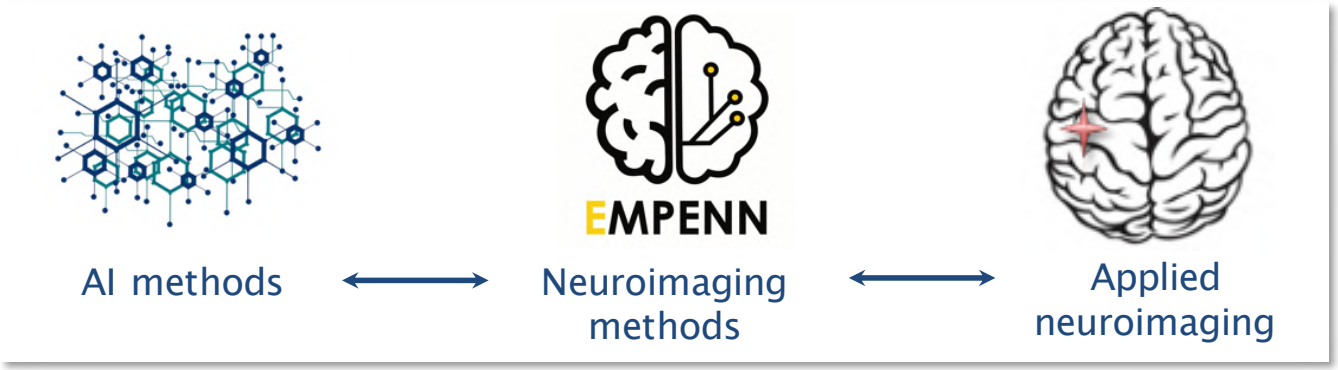
- 2006 → creation of VisAGeS U746, Christian Barillot
- 2017 → ERL U1228 (evaluation HCERES/Inserm)
- 2019 → Empenn (evaluation Inria)

Localization : Inria/IRISA center and CHU Pontchaillou, Neurinfo platform

↪ *presentation E. Caruyer*

Empenn Research Objectives

Better understand and treat the brain under **typical** and **pathological** conditions with **brain imaging** & **AI methods**



- Major Challenges
  - → Models and algorithms to reconstruct, analyze and transform
  - → Mass of data to store, distribute and "semantize"
- Pathologies: Multiple Sclerosis, Psychiatry, Neuropediatrics, Stroke, Parkinsonian Disorders, Dementia

Empenn Research Objectives

- Researches in medical imaging, neuroinformatics, population cohorts
- Detection and development of imaging biomarkers for brain diseases
- Translating this research to clinical practice and clinical neuroscience

Contributions & Skills

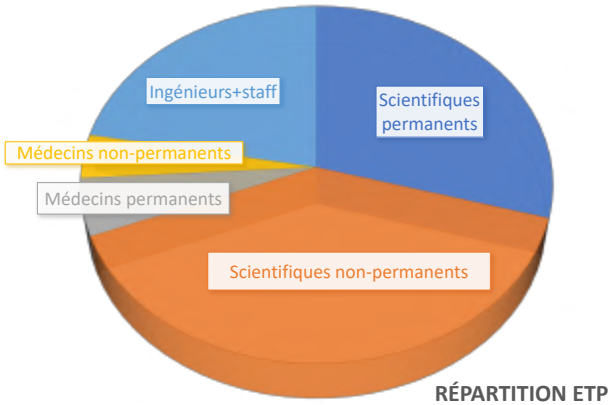
- Model Inference
- Statistical Analysis & Modeling
- Machine Learning
- Neuroinformatics
- Data fusion
- Image processing
- Brain computer interface
- Neurology, Radiology, Rehabilitation
- Image acquisition (sequence development, optimization and evaluation)

Members of the team (February 2021)

- Researcher/Teacher-Researcher
  - Isabelle Bonan, PU-PH (UR1-CHU), **HDR**
  - Emmanuel Caruyer, CR CNRS
  - Julie Coloigner, CR CNRS
  - Olivier Commowick, CR INRIA, **HDR**
  - Claire Cury, CR Inria
  - Gilles Edan, PU-PH (UR1-CHU), **HDR**
  - Jean-Christophe Ferré (UR1-CHU), **HDR**
  - Jean-Yves Gauvrit, PU-PH (UR1-CHU), **HDR**
  - Camille Maumet, CR Inria
  - Pierre Maurel, MCF UR1
- Administrative Assistant (INRIA/IRISA)
  - Armelle Mozziconacci, CNRS
- Neurinfo platform
  - Élise Bannier, IR CHU Rennes
  - Isabelle Corouge, IR UR1

Members of the team (February 2021)

- Researcher/Teacher-Researcher
  - Isabelle Bonan, PU-PH (UR1-CHU), **HDR**
  - Emmanuel Caruyer, CR CNRS
  - Julie Coloigner, CR CNRS
  - Olivier Commowick, CR INRIA, **HDR**
  - Claire Cury, CR Inria
  - Gilles Edan, PU-PH (UR1-CHU), **HDR**
  - Jean-Christophe Ferré (UR1-CHU), **HDR**
  - Jean-Yves Gauvrit, PU-PH (UR1-CHU), **HDR**
  - Camille Maumet, CR Inria
  - Pierre Maurel, MCF UR1
- Administrative Assistant (INRIA/IRISA)
  - Armelle Mozziconacci, CNRS
- Neurinfo platform
  - Élise Bannier, IR CHU Rennes
  - Isabelle Corouge, IR UR1
- Associated Faculty Members
  - Pierre-Yves Jonin, Neuropsychologist (CHU)
  - Gabriel Robert MCU-PH (UR1-CH G.Régnier)
  - Anne Kerbrat, Neurologist (CHU)
- Postdoctoral researchers
  - Francesca Galassi
  - Lou Scotto Di Covella
  - Renaud Hédouin
- PhD Students
  - Mathis Fleury
  - Stéphanie Leplaideur
  - Xavier Rolland
  - Raphaël Truffet
  - Giovanna Orrù
  - Thomas Durantel
  - Jean-Charles Roy
- Engineers
  - Benoît Combès
  - Quentin Duché
  - Michael Kain
  - Julien Louis
  - Florent Leray
  - Rémi Adon
  - Arthur Masson



33 people (26 ETP)

Evolution of the workforce

	Misc.	INSERM	INRIA	CNRS	U.Rennes 1	Evolution $2015 \rightarrow 2020$
Permanent Researchers			+2/-1	-1/+1	+1	+2
Associated Faculty	-1				-3/+3	-1
Engineers	-1/+1		-4/+4			=
Post-Doc.			-1/+2		+1	+2
Doc.	-3/+2		-4/+1	+1	+3	=

Total: +3

- 2017: Camille Maumet, CR Inria & Isabelle Bonan, PU-PH UR1/CHU
- 2018: Julie Coloigner, CR CNRS
- Nov. 2020: Claire Cury, CR Inria
- Leaving: Sylvain Prima, CR Inria & Christian Barillot, DR CNRS
- Expected arrivals, 2022: Gabriel Robert MCU-PH in psychiatry & Anne Kerbrat MCU-PH in neurology

Local Research Ecosystem

- CHU
  - → **Neurinfo platform**
  - → EA 4712 « Comportement et noyaux gris centraux » *psychiatry*
  - → clinical investigation unit CIC-P1414 INSERM *multiple sclerosis*
- IRISA/Inria center
  - → PANAMA, LACODAM, DIVERSE *machine learning*
  - → HYBRID, RAINBOW *human-machine interfaces / robotics*
  - → DYLISS, GENSCALE *omics*
- UR1's research poles: double affiliation (and two doctoral schools)
  - → "Mathématique-Numérique" (IETR, IRISA, IRMAR, IFOTON, LTSI, EMPENN, M2S)
  - → "Biologie-Santé" (BRM, COSS, ETHOS, IGDR, IRSET, MICMAC, NUMECAN, LTSI, EMPENN, M2S)

Scientific report

Publications

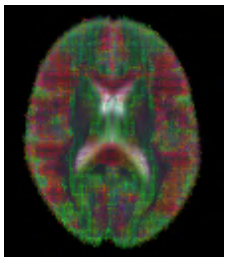
	2015	2016	2017	2018	2019	mid-2020	Total period
PhD & HdR Thesis	1	1	2	3	4	2	13
Journal	29	32	24	27	27	16	135
Conference Proceedings	16	7	11	28	32	2	96
Book & Book Chapter		2			1	1	4

- main journals: Neuroimage, Frontiers, Medical Image Analysis, J.MRI/MRM, Brain, PloS ONE, Nature
- main conferences: MICCAI, ISBI, ISMRM, OHBM, SPIE-MI

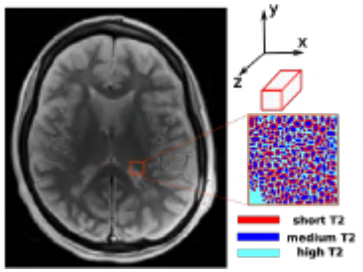
1) Medical image computing in neuroimaging

to identify complex imaging biomarkers → **image acquisition**, **image processing** (quality control, quality enhancement), **image analysis**

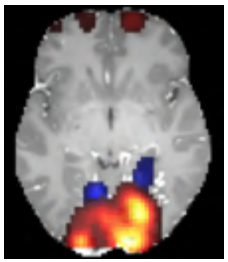
- Diffusion
  - distortion correction: block-matching registration (Hedouin et al., 2017), spinal cord images (Snoussi et al., 2019)
  - microstructure imaging: multi-compartment models (Stamm et al., 2016), novel sampling schemes (Truffet, Barillot, and Caruyer, 2019)



- Relaxometry
  - new multi-compartment model from T2 relaxometry & optimization technique to identify tissue types in a voxel (Chatterjee et al., 2018b)

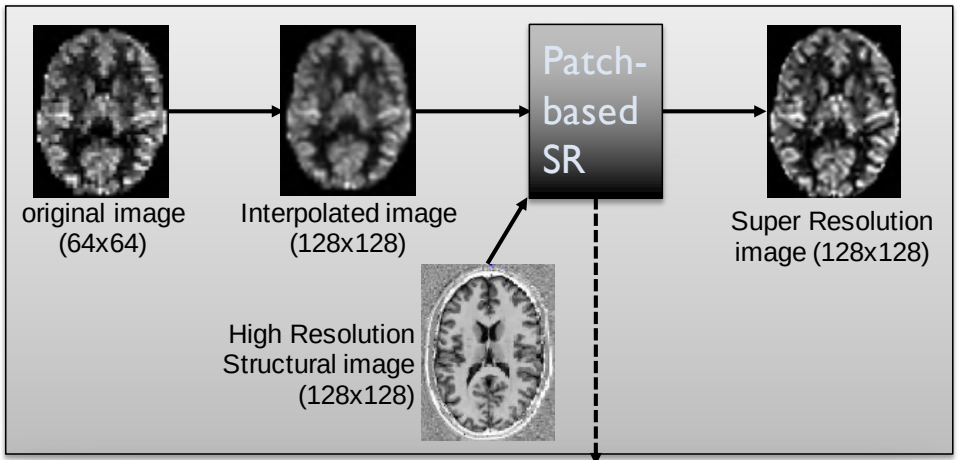


- Perfusion
  - detection of perfusion abnormalities (Maumet et al., 2016)
  - ASL super-resolution (Meurée et al., 2019)



Patch-based Super-Resolution for ASL MRI

- Context → Cédric Meurée's PhD thesis (CIFRE Siemens)
- Motivations
  - Obtain well detailed cerebral blood flow or perfusion maps
  - Reduce the influence of partial volume effects
- Contributions (Meurée et al., 2019)
  - Adaptation of a super-resolution approach to **Arterial Spin Labeling** images
  - **Increases the images dimensions** using information from a high resolution structural image, without increasing the acquisition time



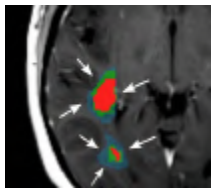
$$x_i^{t+1} = \frac{1}{Z_i} \sum_{j \in V_i} X_i^t \exp -\left(\frac{||N(X_{i,struct} - N(X_{j,struct})||_2^2}{2\sigma_{i,struct}^2} + \frac{||N(X_i^t) - N(X_j^t)||_2^2}{2\sigma_i^2}\right)$$

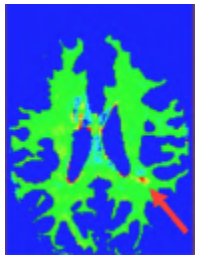
- Inclusion into MR ASL Perfusion Analysis Siemens' prototype

2) Applications to neuroradiology and neurological disorders

→ diagnosis, follow-up and treatment of a range of neurological disorders.

- Multiple sclerosis (MS)
  - prediction of the gadolinium-enhancement of lesions (Chatterjee et al., 2018a)
  - correlation between nanoparticle markers and tissue damage (Kerbrat et al., 2018)
  - assessment of spinal cord involvement (Chouteau et al., 2019; Combès et al., 2019; Kerbrat et al., 2020)





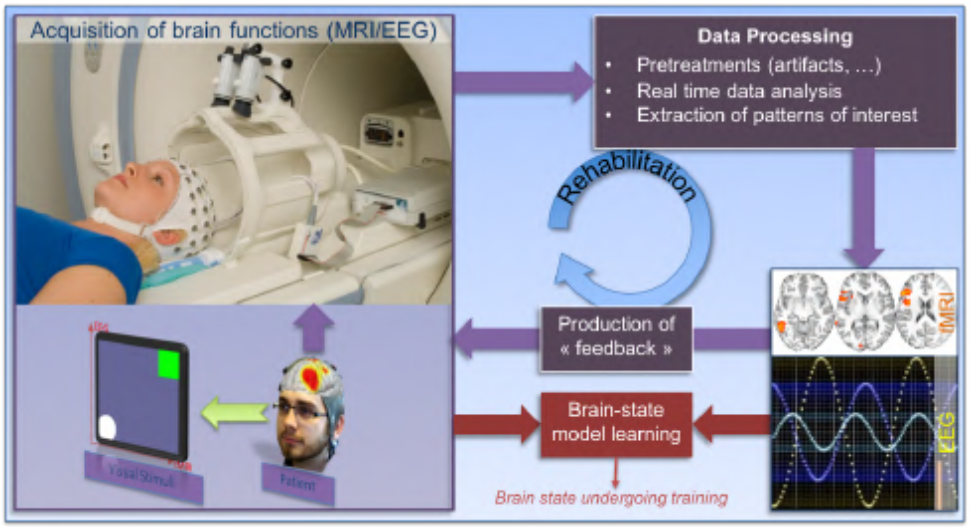
- Neurofeedback for rehabilitation

EEG-fMRI neurofeedback for brain rehabilitation 1/2

Hemisfer project

(start: 2014)

- Objective → investigate the impact of hybrid EEG-fMRI neurofeedback for neuro-rehabilitation
- Collaboration with IRISA/Inria teams → Hybrid and Panama

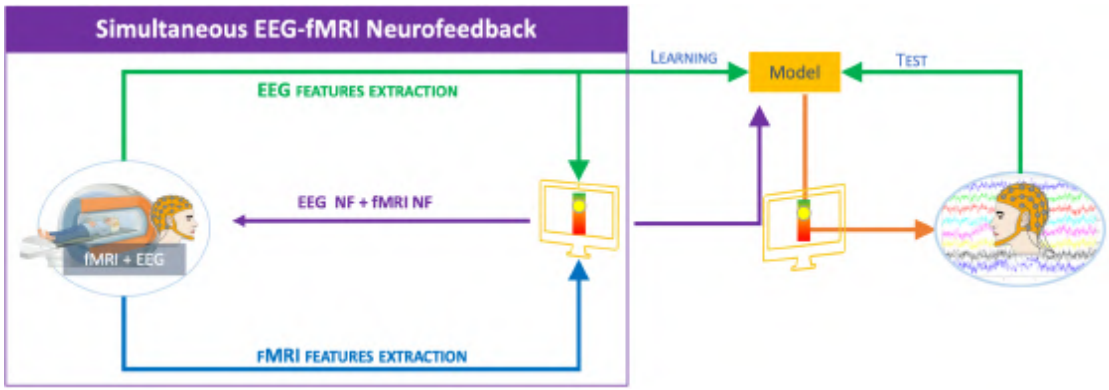


- **unique experimental and methodological framework** for joint EEG-fMRI NF (Mano et al., 2017; Perronnet et al., 2017)
- **first open-access bimodal neurofeedback dataset** (EEG and fMRI), motor imagery, 30 healthy subjects (Lioi et al., 2020)

EEG-fMRI neurofeedback for brain rehabilitation 2/2

A multifaceted project

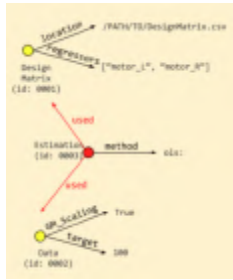
- Organization of the symposium "Multimodal Neurofeedback: The next generation of Neurofeedback for advanced brain self-regulation" at OHBM 2019
- A clinical study, Dec. 2018 → first **stroke patient**, after 4 years on healthy controls
- Methodological contributions → EEG-informed MRI model (Cury et al., 2020)
  - Goal: Reducing the use of fMRI, while keeping the quality of bimodal neurofeedback sessions.
  - Challenge: Propose a model able to imitate bimodal neurofeedback sessions, using EEG only



3) Management of information in neuroimaging

Increase of data volume and heterogeneity → definition of **international standards**, development of **software platforms**, **data reuse**

- Standards for brain imaging
  - contributors of BIDS and NIDM, bridge the gap between those two neuroimaging standards (Maumet et al., 2019)
  - collaboration with Institut du Thorax (Nantes) and Dyliss team at IRISA: data modeling in biomedical research (Cornet et al., 2020)

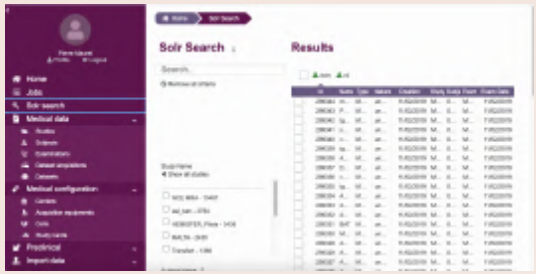


- Data management and processing platforms
  - challenge on multiple sclerosis lesion segmentation using a data management and processing infrastructure (Commowick et al., 2018)
    ↪ *presentation O. Commowick*
  - Shanoir (Sharing NeurOImaging Resources): an open source neuroinformatics platform designed to share, archive, search and visualize neuroimaging data (Barillot et al., 2016)

Software Development

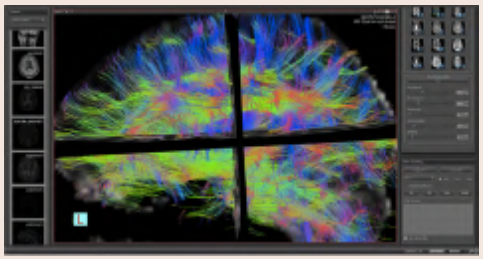
Shanoir-NG, Sharing NeurOimaging Resources `http://shanoir.org`

- web-based software platform for medical imaging data storage and sharing
- Based on a formal ontology
- Allow upload (PACS, derived data), download (Nifti), anonymization, access control, QC control, clinical scores
- 70 centers / 200 studies / 9 000 subjects connected on Shanoir@Neurinfo



MedInria `http://med.inria.fr`

- THE Inria medical image processing and display platform (6000 download/Year)
- Development from Epione, Athena & Empenn teams (PI: O. Commowick)
- Transfer research algorithms as individual plugins and workspaces (segmentation, diffusion, registration, filtering)
- Empenn plugins: NL-Means denoising, connect to Shanoir, registration, symmetry plane, ANIMA



→ two **consortiums** are being set up (via Inria)

Integration of software into large-scale national projects (PIA-ANR)

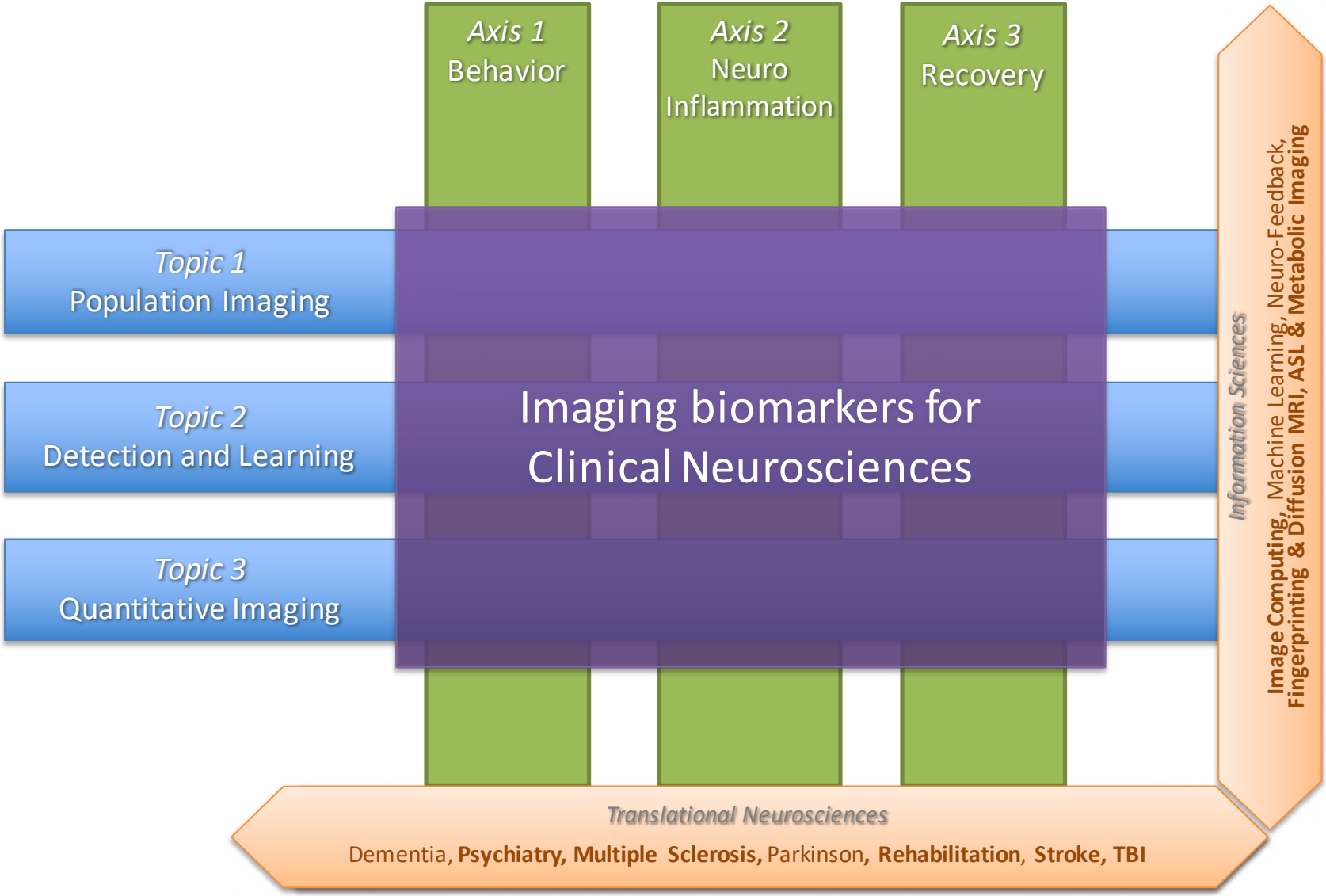
- OFSEP → the national cohort project in MS
  - Shanoir, image management solution of the cohort OFSEP HD (5000 patients)
  - 1 to 2 dedicated engineers in Empenn every year

- FLI-IAM → the digital infrastructure of "France Life Imaging"
  - C.Barillot, Scientific Chair of the Information Analysis and Management node ; M.Kain, Technical Manager; C.Maumet, now part of the COPIL
  - Empenn provides data storage solution via Shanoir
  - 15 engineers over the period (6 @ Empenn)

- MUSIC → collaborative project with b<>com, several CHUs and Biotrial
  - Empenn develops and provides the image analysis solutions for the follow-up of MS patients in a clinical context (Western France clinical network)

Five-Year Project

Empenn Research Project



Empenn Research Project : Basic Science

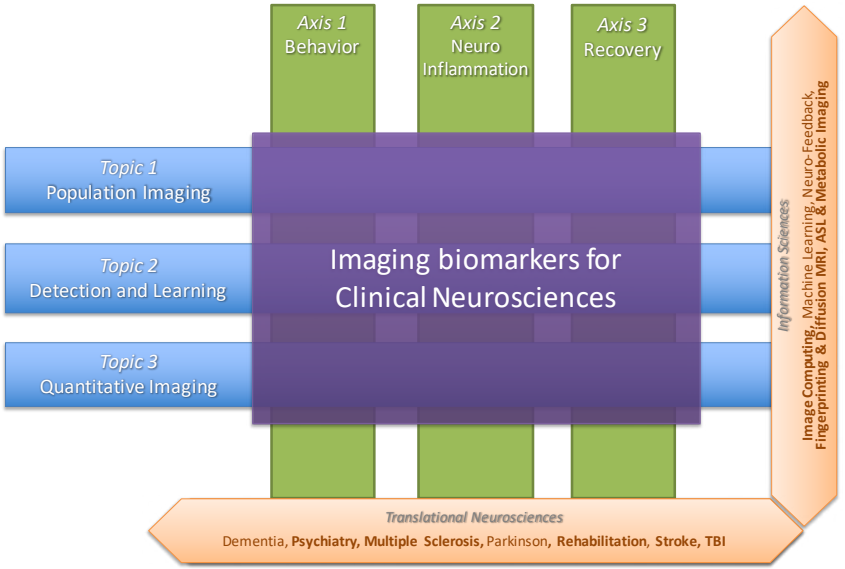
Topic 1 : Population Imaging

→ Dedicated atlases better adapted to group of patients

→ Big Data integration for management and processing of neuroimaging data

→ Statistical Modeling of analytical variability, better reproducibility

O.Commowick, G.Edan, C.Maumet



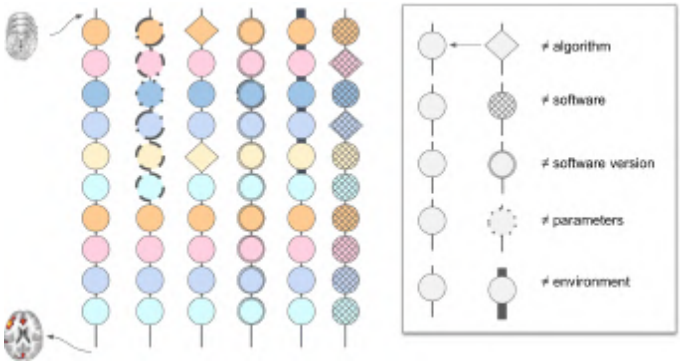
Study of variations induced by treatment chains

- Data analysis (e.g. fMRI) is often complex and requires **many choices**

Analytical variability

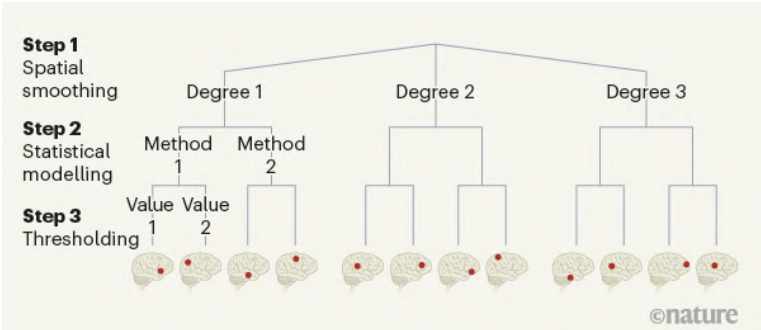
↓

Variability induced by these choices



First contributions

- Effect of the software (Bowring, Maumet, and Nichols, 2019)
- Large-scale collaboration (Botvinik-Nezer et al., 2020)



→ What was done? Standards for neuroimaging provenance

→ How to reuse data? Stat. methods to check compatibility & enable data reuse

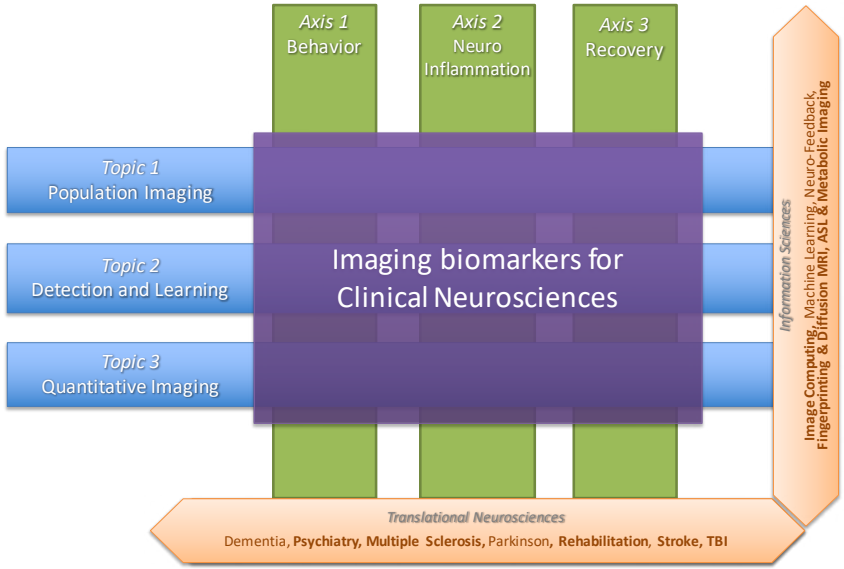
→ Which pipeline is good for my dataset? Checking pipeline assumptions & debugging

Empenn Research Project : Basic Science

Topic 1 : Population Imaging

- → Dedicated atlases better adapted to group of patients
- → Big Data integration for management and processing of neuroimaging data
- → Statistical Modeling of analytical variability, better reproducibility

O.Commowick, G.Edan, C.Maumet



Empenn Research Project : Basic Science

Topic 1 : Population Imaging

→ Dedicated atlases better adapted to group of patients

→ Big Data integration for management and processing of neuroimaging data

→ Statistical Modeling of analytical variability, better reproducibility

O.Commowick, G.Edan, C.Maumet

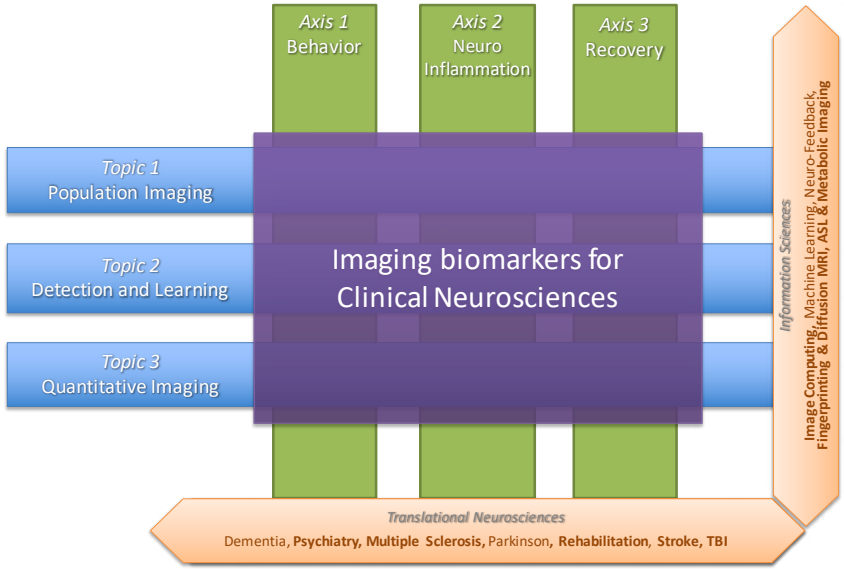
Topic 2 : Detection & Learning

→ From population imaging to patient imaging

→ Integration of machine learning for detection/characterization of pathologies in images

→ Learning coupling models for multimodal data

C.Cury, J.Coloigner, P.Maurel

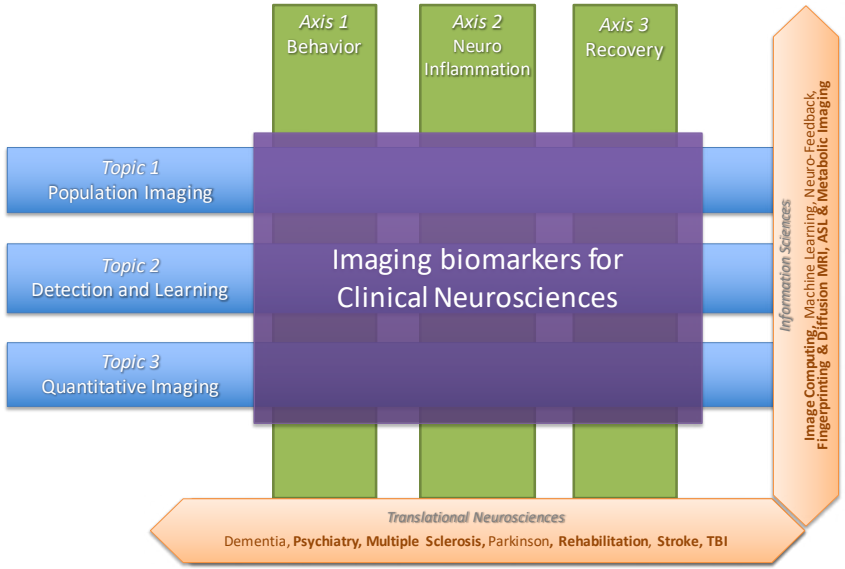


Empenn Research Project : Basic Science

Topic 1 : Population Imaging

- → Dedicated atlases better adapted to group of patients
- → Big Data integration for management and processing of neuroimaging data
- → Statistical Modeling of analytical variability, better reproducibility

O.Commowick, G.Edan, C.Maumet



Topic 2 : Detection & Learning

- → From population imaging to patient imaging
- → Integration of machine learning for detection/characterization of pathologies in images
- → Learning coupling models for multimodal data

C.Cury, J.Coloigner, P.Maurel

Topic 3 : Quantitative Imaging

- → Model inference in qMRI
- → Multi-parametric ASL, estimating functional and resting-state ASL from standard perfusion protocols
- → Multicompartment imaging (Diffusion, relaxometry)

E.Bannier, E.Caruyer, O.Commowick, I.Corouge, J-C.Ferré, P.Maurel

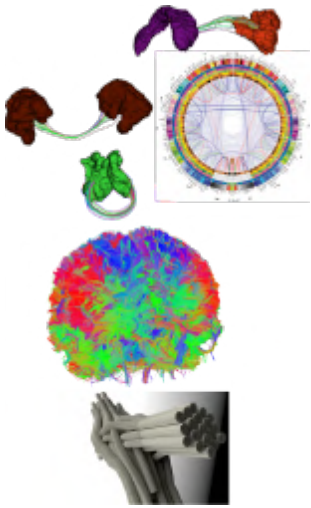
Inria International Labs: MMINCARAV

2012-2017 "Boston and Rennes, a Brain image Analysis Team" (BARBANT) with the Computational Radiology Laboratory at the Boston Children's hospital (Harvard Medical School)

2019 → Multimodal Microstructure-Informed Neuronal Connectivity: Acquisition, Reconstruction, Analysis and Validation

Principal Investigators → Emmanuel Caruyer, Empenn / Jean-Philippe Thiran, LTS5, EPFL

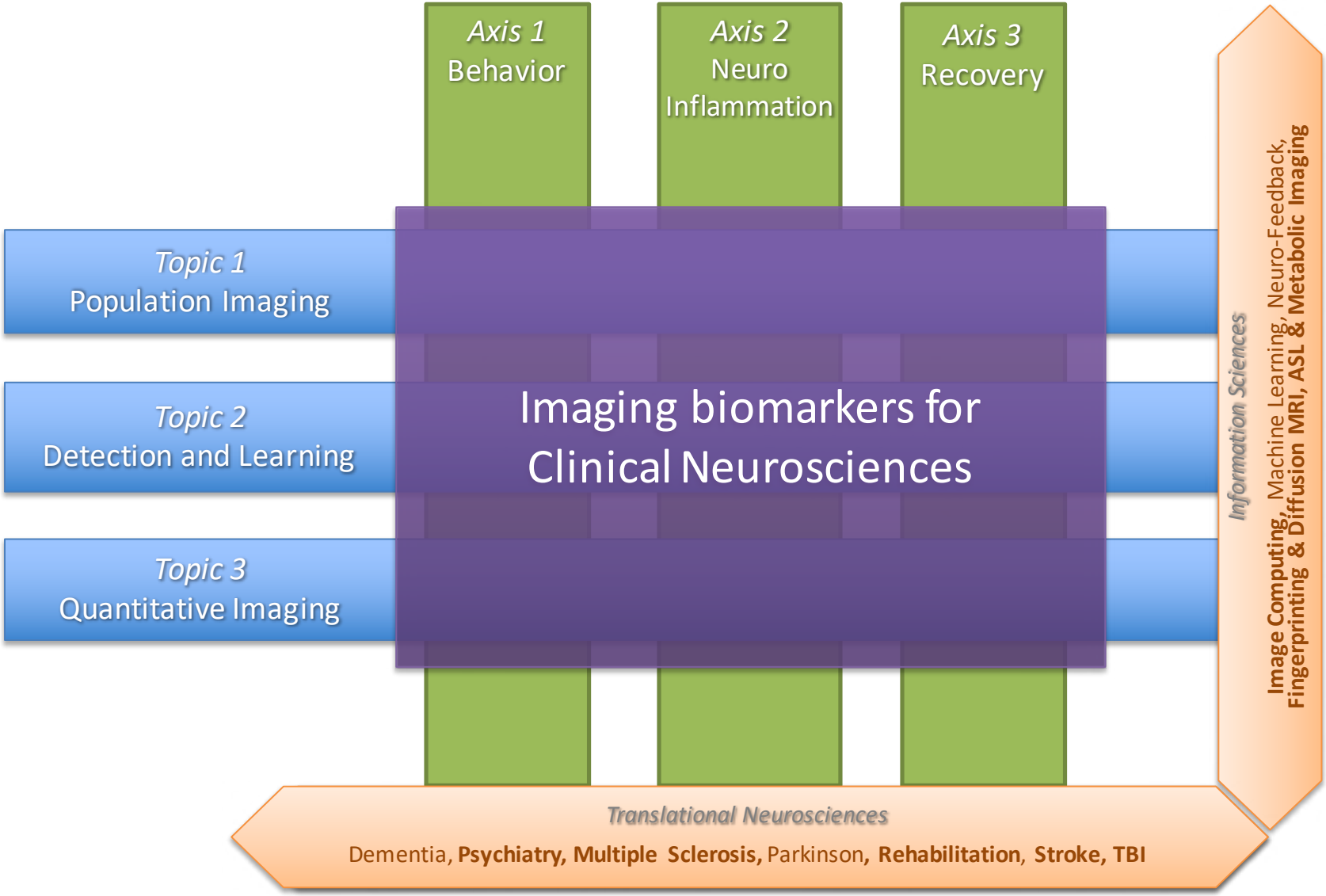
- Scientific objectives
  - Acquisition design → increase sensitivity of MRI to microstructure
  - Connectome analysis → use graph theory to analyze multi-valued brain connectome
  - Validation → with the help of simulated phantoms
- 2 associate team workshops (1 in Lausanne, 1 in Rennes), 2 PhD students' visit



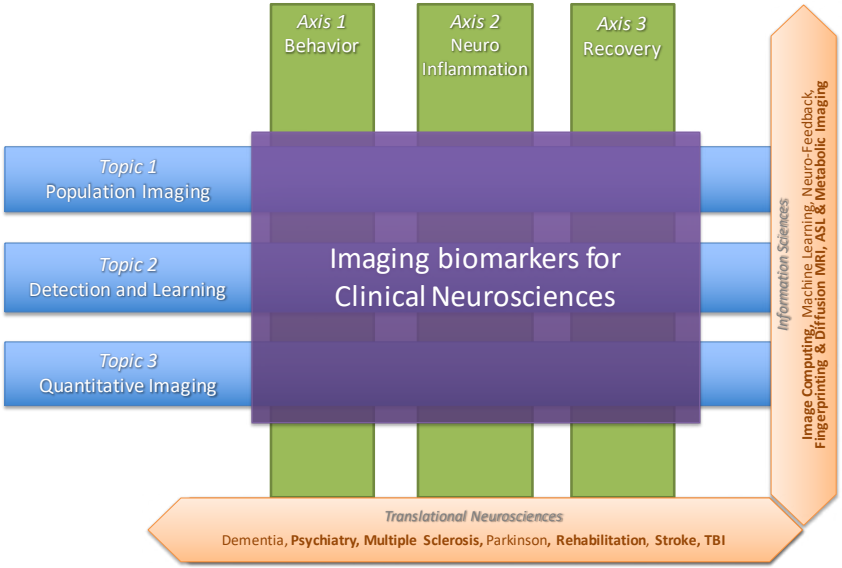
→ Organization of an intl challenge at MICCAI'2021: *"Diffusion-Simulated Connectivity Challenge"*

→ Application to Alzheimer's disease, call JPND co-Fund w/ University of Liège and DTU (Denmark)

Empenn Research Project



Empenn Research Project : Translational Research



Axis 1 : Behavior

→ New imaging markers of depression, combining perfusion, metabolism and microstructural information

→ New mixture of molecular and micro-structural imaging markers

→ New targets of neurofeedback for rehabilitation

J.Cologner, I.Corouge, C.Cury, J-Y. Gauvrit, G.Robert

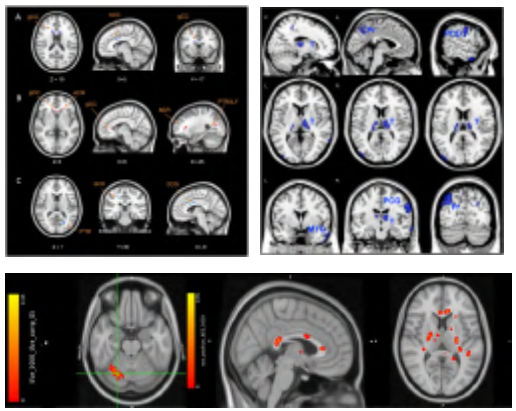
Neuroimaging biomarkers in depression

New imaging markers of depression, combining **metabolism**, **functional** and **microstructural** information

Objective → improve the efficacy of diagnostic and treatment strategies.

First contributions

- White matter abnormalities in depression (Cologner et al., 2019)
- Structural abnormalities associated with poor outcome of depression (Batail et al., 2020)
- Multimodal brain imaging connectivity analyses in depression among women (Robert et al., in press)

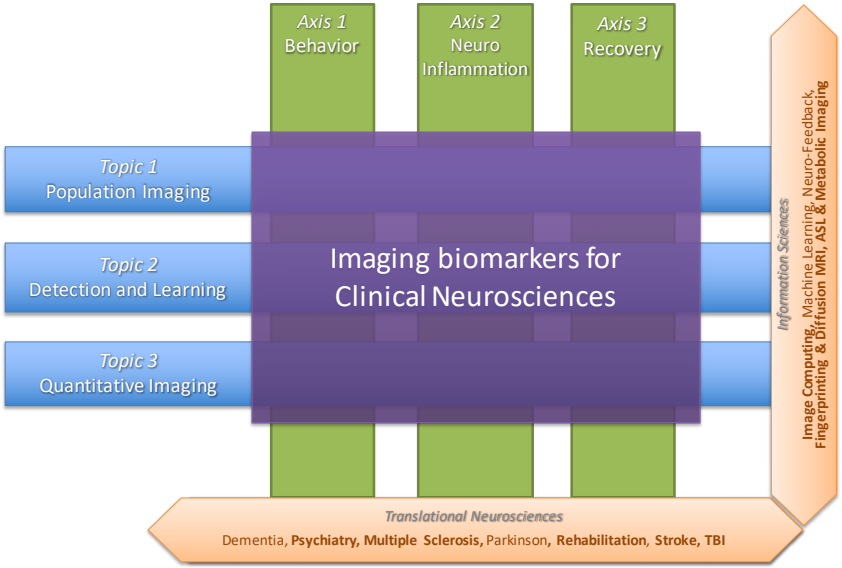


→ National project "Fondation de France" with Inserm U1000 (Paris Descartes univ.)

Identify early microstructural and functional biomarkers of amygdala and its network

→ Investigation of neurofeedback rehabilitation on depression

Empenn Research Project : Translational Research

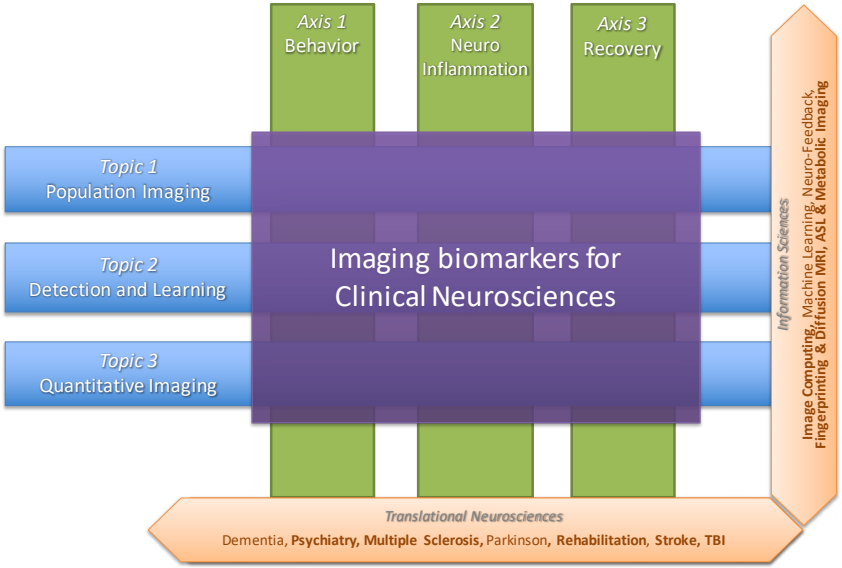


Axis 1 : Behavior

- → New imaging markers of depression, combining perfusion, metabolism and microstructural information
- → New mixture of molecular and micro-structural imaging markers
- → New targets of neurofeedback for rehabilitation

J.Coloigner, I.Corouge, C.Cury, J-Y. Gauvrit, G.Robert

Empenn Research Project : Translational Research



Axis 1 : Behavior

- → New imaging markers of depression, combining perfusion, metabolism and microstructural information
- → New mixture of molecular and micro-structural imaging markers
- → New targets of neurofeedback for rehabilitation

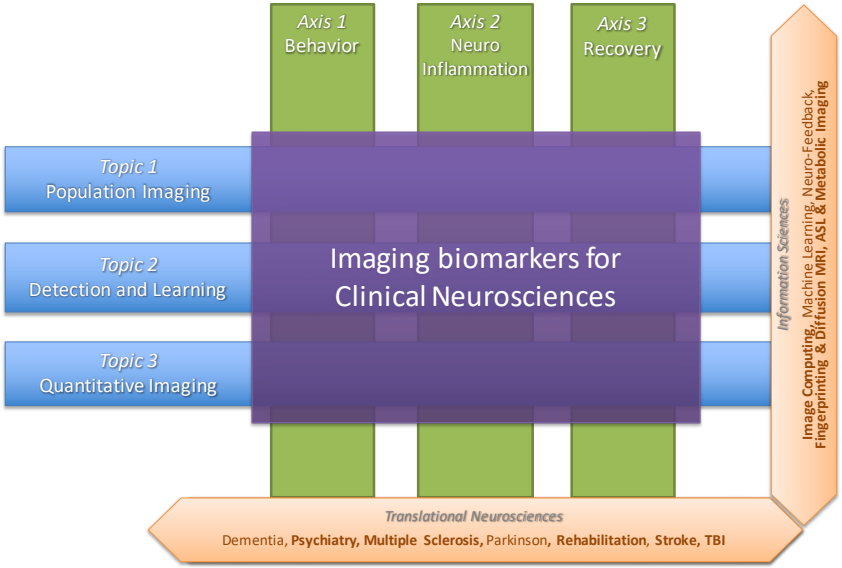
J.Coloigner, I.Corouge, C.Cury, J-Y. Gauvrit, G.Robert

Axis 2 : Neuroinflammation

- → Integration of automatic image analysis and management for population studies
- → Evaluation metrics to assess the efficacy of new drugs on the follow-up treatment of a large population of patients.
- → New mixture of molecular and micro-structural imaging markers

E.Bannier, O.Commowick, G.Edan, J-C.Ferré, A.Kerbrat

Empenn Research Project : Translational Research



Axis 1 : Behavior

→ New imaging markers of depression, combining perfusion, metabolism and microstructural information

→ New mixture of molecular and micro-structural imaging markers

→ New targets of neurofeedback for rehabilitation

J.Coloigner, I.Corouge, C.Cury, J-Y. Gauvrit, G.Robert

Axis 2 : Neuroinflammation

→ Integration of automatic image analysis and management for population studies

→ Evaluation metrics to assess the efficacy of new drugs on the follow-up treatment of a large population of patients.

→ New mixture of molecular and micro-structural imaging markers

E.Bannier, O.Commowick, G.Edan, J-C.Ferré, A.Kerbrat

Axis 3 : Recovery

→ New rehabilitation protocols from multimodal neurofeedback (visual, but also haptic, auditory, . . .)

→ More portable protocols (e.g. EEG-fNIRS)

→ Application to stroke and depression

I.Bonan, C.Cury, J-Y.Gauvrit, P.Maurel

SWOT analysis

Empenn, in summary

Major Strengths

- Close integration in both scientific & medical research environments
- Deep interdisciplinarity: project, staff
- Well focused on imaging biomarkers and clinical neurosciences
- Strong integration to national infrastructures / cohorts
- Complementarity between the different national partners (Inserm, Inria, CNRS) and close relations with the stakeholders (hospital, industry)

Major Opportunities

- Participation to several "investiss. d'avenir" projects (1 LabEx, 1 IRT, 1 Infrastructure, 1 Cohort)
- Potentiality of the Neurinfo Platform to develop new cutting-edge projects
- High support of the local institutions
- Recent recruitments / Youth of the team's member
- Involvement in the local master programs to attract students, whether medical residents or engineers

Major Weaknesses

- Lack of professorship position without clinical duties
- No Inserm permanent staff (many candidates, not interviewed but recruited at CNRS/Inria)
- Lack of tenure technical staffs

Major Threats

- Maintaining interdisciplinary balance
- Heterogeneity of the academic culture
- Processing clinical research studies data : high demand / little funding
- Number of HDR (MathStic ED)

Thank you for your attention

2016

2017

2018

2019

References I

Barillot, Christian et al. (Oct. 2016). “Shanoir: Applying the Software as a Service Distribution Model to Manage Brain Imaging Research Repositories”. In: *Frontiers in information and communication technologies*. MAPPING: MAnagement and Processing of Images for Population ImagiNG.

Batail, Jean-Marie et al. (Aug. 2020). “Structural abnormalities associated with poor outcome of a major depressive episode: the role of thalamus.”. In: *Psychiatry Research: Neuroimaging* 305, pp. 1–10.

Botvinik-Nezer, Rotem et al. (May 2020). “Variability in the analysis of a single neuroimaging dataset by many teams”. In: *Nature* 582.7810, pp. 84–88.

Bowring, Alexander, Camille Maumet, and Thomas E. Nichols (2019). “Exploring the impact of analysis software on task fMRI results”. en. In: *Human Brain Mapping* 40.11. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/hbm.24603, pp. 3362–3384.

Chatterjee, Sudhanya et al. (2018a). “Identification of Gadolinium Contrast Enhanced Regions in MS Lesions Using Brain Tissue Microstructure Information Obtained from Diffusion and T2 Relaxometry MRI”. en. In: *Medical Image Computing and Computer Assisted Intervention – MICCAI 2018*. Ed. by Alejandro F. Frangi et al. Lecture Notes in Computer Science. Cham: Springer International Publishing, pp. 63–71.

— (Apr. 2018b). “Multi-compartment model of brain tissues from T2 relaxometry MRI using gamma distribution”. In: *2018 IEEE 15th International Symposium on Biomedical Imaging (ISBI 2018)*. ISSN: 1945-8452, pp. 141–144.

Chouteau, Raphaël et al. (Sept. 2019). “Joint assessment of brain and spinal cord motor tract damage in patients with early RRMS: predominant impact of spinal cord lesions on motor function”. en. In: *Journal of Neurology* 266.9, pp. 2294–2303.

Cologner, Julie et al. (2019). “White matter abnormalities in depression: A categorical and phenotypic diffusion MRI study”. eng. In: *NeuroImage. Clinical* 22, p. 101710.

Combès, Benoît et al. (June 2019). “Measurement of magnetization transfer ratio (MTR) from cervical spinal cord: Multicenter reproducibility and variability”. In: *Journal of Magnetic Resonance Imaging* 49.6, pp. 1777–1785.

Commowick, Olivier et al. (Dec. 2018). “Objective Evaluation of Multiple Sclerosis Lesion Segmentation using a Data Management and Processing Infrastructure”. In: *Scientific Reports* 8.1, p. 13650.

Cornet, Aurélien et al. (Apr. 2020). *État des lieux MoDaL (Multi-Scale Data Links)*. Research Report. IRISA, Inria Rennes.

Cury, Claire et al. (2020). “A Sparse EEG-Informed fMRI Model for Hybrid EEG-fMRI Neurofeedback Prediction”. English. In: *Frontiers in Neuroscience* 13. Publisher: Frontiers.

Hedouin, Renaud et al. (2017). “Block-Matching Distortion Correction of Echo-Planar Images With Opposite Phase Encoding Directions”. In: *IEEE Transactions on Medical Imaging* 36.5, pp. 1106 –1115.

References II

Kerbrat, Anne et al. (Oct. 2018). “USPIO-positive MS lesions are associated with greater tissue damage than gadolinium-positive-only lesions during 3-year follow-up”. In: *Multiple Sclerosis Journal* 24.14, pp. 1852–1861.

Kerbrat, Anne et al. (July 2020). “Multiple sclerosis lesions in motor tracts from brain to cervical cord: spatial distribution and correlation with disability”. eng. In: *Brain: A Journal of Neurology* 143.7, pp. 2089–2105.

Lioi, Giulia et al. (June 2020). “Simultaneous EEG-fMRI during a neurofeedback task, a brain imaging dataset for multimodal data integration”. en. In: *Scientific Data* 7.1. Number: 1 Publisher: Nature Publishing Group, p. 173.

Mano, Marsel et al. (Mar. 2017). “How to Build a Hybrid Neurofeedback Platform Combining EEG and fMRI.”. In: *Frontiers in Neuroscience* 11, p. 140.

Maumet, Camille et al. (July 2016). “An a contrario approach for the detection of patient-specific brain perfusion abnormalities with arterial spin labelling”. In: *NeuroImage* 134.

Maumet, Camille et al. (June 2019). “The best of both worlds: using semantic web with JSON-LD. An example with NIDM-Results & Datalad”. In: *OHBM 2019 - 25th Annual Meeting of the Organization for Human Brain Mapping*. Rome, Italy.

Meurée, Cédric et al. (Jan. 2019). “Patch-Based Super-Resolution of Arterial Spin Labeling Magnetic Resonance Images”. In: *NeuroImage* 189, pp. 85–94.

Perronnet, Lorraine et al. (Apr. 2017). “Unimodal Versus Bimodal EEG-fMRI Neurofeedback of a Motor Imagery Task”. In: *Frontiers in Human Neuroscience* 11.

Robert, G et al. (in press). “Multimodal brain imaging connectivity analyses of emotional and motivational deficits in depression among women”. In: *Journal of Psychiatry and Neuroscience*.

Snoussi, Haykel et al. (Apr. 2019). “Geometric Evaluation of Distortion Correction Methods in Diffusion MRI of the Spinal Cord”. In: *2019 IEEE 16th International Symposium on Biomedical Imaging (ISBI 2019)*. ISSN: 1945-8452, pp. 1696–1699.

Stamm, Aymeric et al. (2016). “Comprehensive Maximum Likelihood Estimation of Diffusion Compartment Models Towards Reliable Mapping of Brain Microstructure”. en. In: *Medical Image Computing and Computer-Assisted Intervention - MICCAI 2016*. Ed. by Sebastien Ourselin et al. Lecture Notes in Computer Science. Cham: Springer International Publishing, pp. 622–630.

Truffet, Raphaël, Christian Barillot, and Emmanuel Caruyer (May 2019). “Optimal selection of diffusion-weighting gradient waveforms using compressed sensing and dictionary learning”. In: *ISMRM 2019 - 27th Annual Meeting & Exhibition*. Montréal, Canada, pp. 1–3.