

# Digital Medicine: Brain, Cognition and Behavior (MNC3)

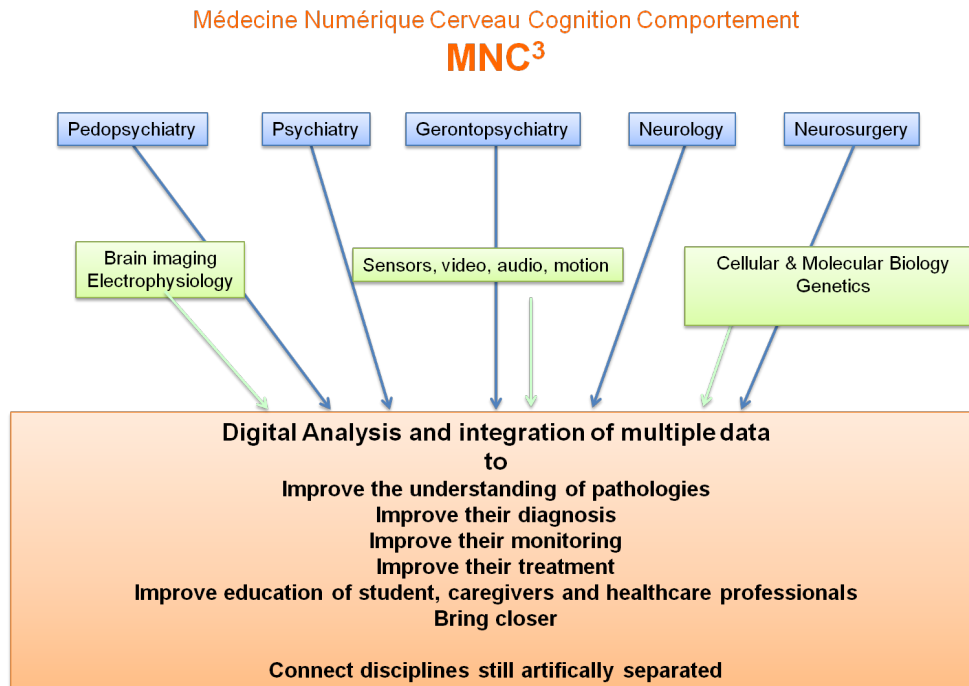
## Médecine Numérique : Cerveau, Cognition et Comportement (MNC3)

Project responsables: Nicholas Ayache and Philippe Robert

### Abstract

MNC3 is a digital medicine excellence project focused on neurological and psychiatric diseases. This collaborative project will allow, for the first time, to analyze together neuroimaging, behavior/cognition and biological/genomic data to improve patients' diagnosis and care management. It will significantly strengthen collaborations between Inria, UNS, CHU and IPMC by creating new links, new databases, and new research topics with international visibility. This project, which naturally fits into the interdisciplinary axis of the UCA Neurosciences, involves major players from the two FHU labeled by the CHU in 2015. It is supported by 15 multidisciplinary teams.

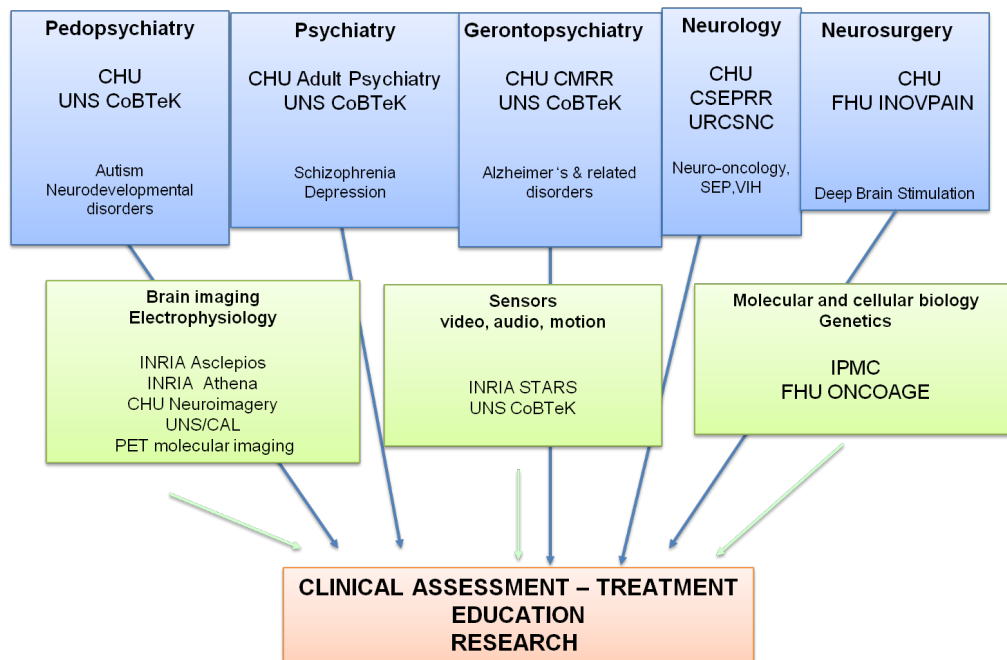
### MNC3 project



The aim of the MNC3 project is to promote the use of computational sciences and of new technologies to support clinicians and healthcare professionals in the diagnosis, treatment and therapeutic follow-up of neurological and psychiatric diseases, and of their consequences at the cognitive and behavioral level. Indeed, the majority of neurological and psychiatric disorders do not have sufficiently sensitive and specific biological markers allowing facilitating their diagnosis and follow-up. Furthermore, the interactions between those biological markers and objective and subjective clinical markers are not sufficiently explored.

To complement clinical observations it is therefore important to acquire anatomical and functional data from the brain (multimodal medical imaging, electrophysiology), biological and genomic data, as well as dynamic measures of cognitions, behaviors and emotions through video, audio and motion sensors (Information and Communication Technologies - ICT). These different data will then be analyzed together through sophisticated algorithms in order to better understand and quantify the disease progression, as well as the effectiveness of the ongoing therapies. The project will also allow evaluating and quantifying objectively new therapeutic approaches.

The collection of all of these measures on patients with neurological and psychiatric diseases and their joint and automated analysis has never been done before. It is therefore a very original project combining medicine, computer science and biology.



MNC3 is based on previous strong collaborations between the CHU, UNS, Inria and the IPMC which cover certain aspects of this unifying project:

- Collaborations CoBTek - STARS: The UNS CoBTek team brings together different teams of the Nice University Hospital for the evaluation and stimulation of patients. The goal is to use ICT sensors (video, audio, motion sensors) in different pathological populations to objectively detect behavioral, emotional and cognitive disorders. CoBTek promotes the links:
  - with the CHU Memory Research Center (CMRR) for patients suffering from Alzheimer's disease and related disorders;
  - with the university neurosurgery service for patients treated with deep brain stimulation (Parkinson, Alzheimer, etc.)
  - with the academic department of psychiatry for patients suffering from schizophrenia or depression
  - with the University Department of Child and Adolescent Psychiatry (SUPEA) for autism.
- Collaborations Asclepios - CMRR - CoBTek: fine-grained temporal and spatial analysis of cerebral atrophy in Alzheimer's disease and related disorders and psychiatric disorders starting from longitudinal data of structural magnetic resonance images.

- Collaborations Athena - Neurosurgery: construction of an anatomo-functional representation of the connectivity graphs of the brain using diffusion-weighted MRI and electrophysiology.
- Collaborations STARS - Asclepios - CoBTeK: analysis of the relationship between the behavioral, cognitive and functional patterns measured through ICT sensors (video, audio ...) and brain imaging data in neurological and psychiatric pathologies, in very diverse populations (children, adults, seniors).
- Collaborations Asclepios - Neurology - CSEPRR - URCSNC - Neuro Oncology: spatiotemporal analysis of the evolution of multiple sclerosis lesions starting from longitudinal sequences of multi-sequence magnetic resonance images. Objective measures of the links between cognition and anatomy in HIV patients starting from magnetic resonance imaging data and cognitive tests. Quantification of the evolution of gliomas from multi-sequence MRI data.
- Collaborations IPMC - CoBTeK - SUPEA: research on genetic alterations in children with autism and associated early schizophrenia and their parents (study trios), as well as in neurodevelopmental disorders with psychiatric signatures.

The project MNC3 will significantly extend these collaborations, create new links between the different actors, and between the domains of ICT for evaluation or stimulation and the biological markers used in these different pathologies. It will enhance the ability to analyze the evolution of many neurological and psychiatric diseases such as:

- Neurodegenerative diseases (Alzheimer's, Parkinson's, Huntington's, multiple sclerosis, etc.),
- Neuro-oncologic diseases (gliomas, etc.),
- Psychiatric pathologies (schizophrenia, depression, anxiety, autism).

MNC3 will also allow to investigate new therapeutic approaches, and to evaluate their efficacy in an objective and quantified way. For example,

- the use of new drugs,
- deep brain electrical stimulation of certain areas of the brain in neuropsychiatric pathologies and pain management,
- transcranial magnetic stimulation of certain regions of the brain,
- the use of ICT applications to stimulate cognition, behavior and motor skills.

MNC3 project will connect fields of knowledge that are still artificially separated. It will have important consequences in terms of teaching, by multiplying the links between the activities already in place (UNS Master 2 International CBB, CHU medicine, paramedical disciplines, UNS social sciences, technology), and would naturally fit into a future UCA Index of the ESPER type in «Digital Medicine».

A first circle of partners of the MNC3 project includes Inria, CHU/UNS and IPMC. A second circle will integrate other teams of the University in the fields of technology, human sciences and medicine. On these themes, the project partners have close partnerships with leading **academic and industrial players** worldwide (Universities of Stanford, USC (Los Angeles), UCSF (San Francisco), MIT (Boston), UCL and ICL (London), TUM (Munich), as well as with Microsoft Research (Cambridge), Siemens (Princeton), Philips and IBM.

The MNC3 project naturally fits into the UCA's interdisciplinary research axis "Neurosciences". It involves partners of the two FHUs approved at the end of 2015. This interaction is very strong in terms of the tools set up in MNC3, and complementary projects proposed by the INOVRAIN FHU. This is also of great interest in the context of the ONCOAGE FHU for populations of elderly people.

**List of MNC3 first circle partners:**

| INRIA     | UNS                  | CHU                             | IPMC   |
|-----------|----------------------|---------------------------------|--|
| Asclepios | CoBTeK               | Neurology                       | Functional genomic platform                      |
| Athena    | Imagerie moléculaire | Neurosurgery                    | Cellular and molecular biology of aging          |
| Stars     |                      | Neuroimaging                    | Physiopathology of mental retardation and autism |
|           |                      | Pain                            | Dynamics of membrane and protein coats           |
|           |                      | Adult psychiatry                |  |
|           |                      | Child and adolescent psychiatry |  |
|           |                      | Gerontopsychiatry               |  |
|           |                      | CMRR                            |  |

- Inria: Asclepios (Medical images analysis) : Nicholas Ayache, Xavier Pennec, Hervé Delingette, Marco Lorenzi, Maxime Sermesant
- Inria: Athena (computational neuroimaging) Rachid Deriche, Maureen Clerc, Demian Wassermann, Théo Papadopoulos
- Inria: Stars (spatio-temporal analysis of intelligent sensors) François Bremond et al.
- CHU: Memory Center (Philippe Robert, Renaud David)
- CHU: Department of Psychiatry (Michel Benoit, Bruno Giordana, Laurent Gugenheim, David Bensamoun)
- CHU: Department of Child and Adolescent Psychiatry (Florence Askenazy, Suzanne Thummler)
- CHU: Neurosurgery and FHU INOVRAIN - DEDT (Denys Fontaine, Michel Lantéri-Minet)
- CHU: Neurology CSEPRR - URCSNC (Christine Lebrun-Frenay, Mikael Cohen)
- CHU: Neuroimaging (Stéphane Chanalet, Lydiane Mondot)
- UNS CAL: PET molecular imaging (Jacques Darcourt)
- UNS: CoBTeK (Valeria Manera, Jeremy Bourgeois, Philippe Robert)
- IPMC: Functional Genomics Platform (Pascal Barbry)
- IPMC: Cellular and Molecular Biology of Normal and Pathological Brain Aging (Fredéric Checler)

- IPMC: Physiopathology of Mental Retardation and Autism (Barbara Bardoni)
- IPMC: Dynamics of membranes and protein coats (Hélène Barelli)
- FHU OncoAge (Paul Hofman)

A second circle of partners will allow to extend the experience acquired to other pathologies, and to associate other disciplines in the field of human and social sciences and sustainable innovation.