EBRAINS

EBRAINS: supporting the future of brain science

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Neuroscience in full flourish

- ✓Centrality of brain health increasingly recognised at the level of policy
- ✓Significant scientific progress in understanding of the brain and brain function
- ✓Enabling technology in position to support advances

Technology Quarterly | Fixing the brain

After fallow decades, neuroscience is undergoing a renaissance

The toolkit for tackling brain dysfunction is expanding rapidly, says Natasha Loder

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Rationale: linking healthy, interconnected and diseased brain

- ✓Rising awareness of the importance of good brain health. Towards step-change in preventing brain disfunctions
- ✓Extent of brain disease becomes evident to all with the ageing of societies and progress in early diagnosis through identification of new biomarkers

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Policy momentum

- ✓Global Action Plan on epilepsy and other neurological disorders of WHO: May 2022
- ✓Healthier Together: Non-Communicable Diseases Initiative of the EU: 22 June 2022 with a chapter on mental health and neurological disorders
- ✓Community efforts such as OneNeurology
- ✓Emerging national Brain Plans
- ✓US Mental Health Strategy
- ✓New European Mental Health Initiative

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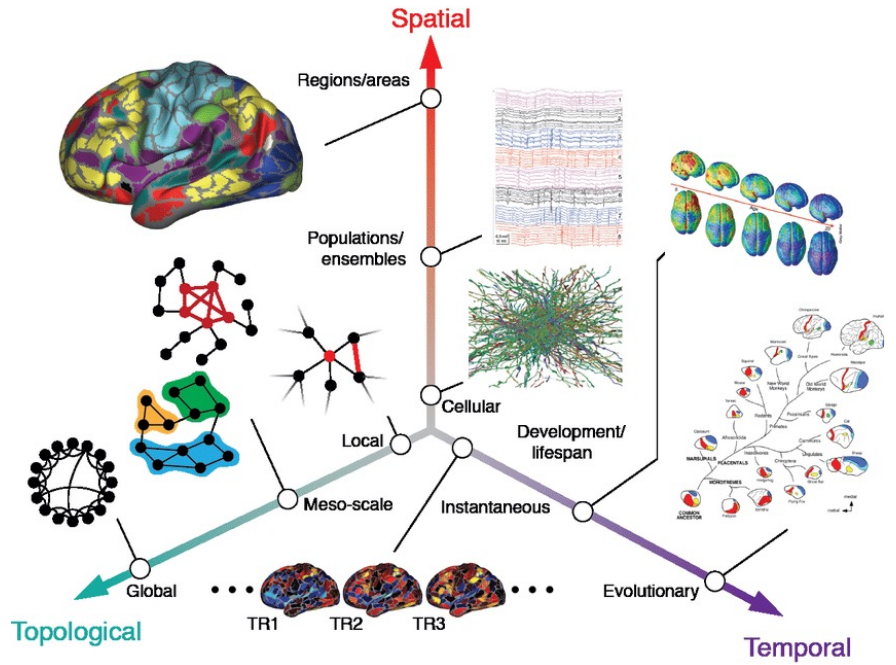
Digital brain research: decoding multiscale organization of the brain

- ✓ Unique richness and complexity with enormous volumes and types of data
- ✓ Multi-level brain organization
- ✓ Challenging scale integration
- ✓ Need to capture brain dynamics
- ✓ Large networks and cohorts



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The Human Brain in numbers

- Estimated number of nerve cells: about 86 billion, approximately the same number of glial cells, about 10.000 synapses per neuron. For comparison, a galaxy has about 100 billion stars.
- Type of signal transduction: electro-chemical, while digital computers use electrical signals.
- Total length of connections: 2-3 million kilometres of fibers - this is more than the diameter of the sun with 1.4 million kilometres
- Mass: 1200 – 1500 g, about 2% of the body weight
- Energy consumption: 20-30 Watt, i.e., about 20% of the total energy consumption of the body

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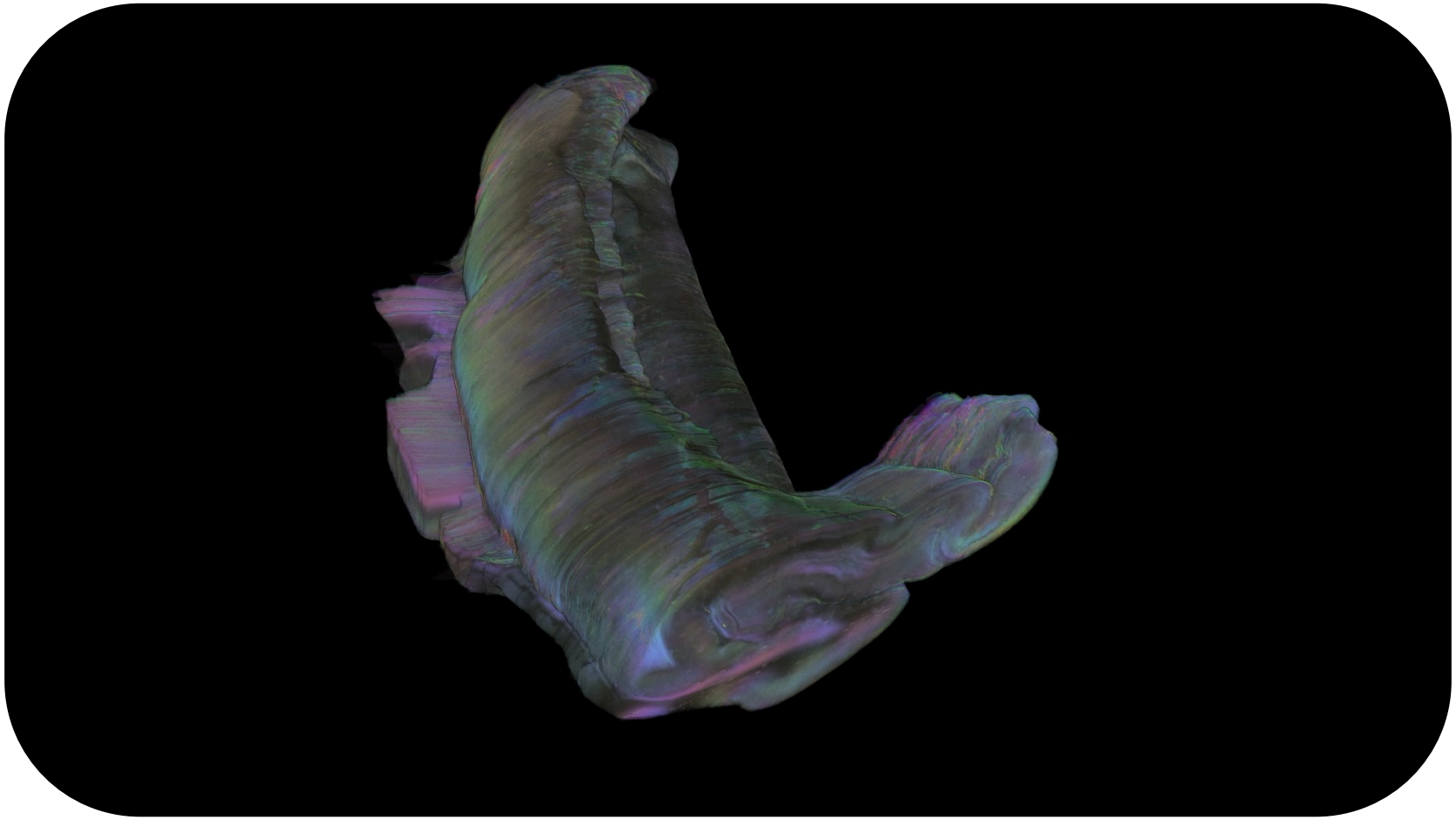
The Brain is one of the most complex data systems



3D-reconstruction of the human hippocampus based on 3D-Polarized Light Imaging based on 530 sections (80 GByte)
(Axer, Amunts et al. @FZ Jülich)

Estimates for computational demands to study the human brain

- An anatomical 3D model @ 1 micron resolution isotropic needs 2-3 PByte storage per brain
- Neuronal network training to extract structural features in images with a spatial resolution of 1x1x20 microns would require, for the whole brain, 100 days at whole brain level with current technology
- One second of simulation of a network of 450,000 cells with a high level of details of the hippocampus CA1 region requires at least 20,000 cores and needs 130,000 core hours on the Piz Daint supercomputer at CSCS.

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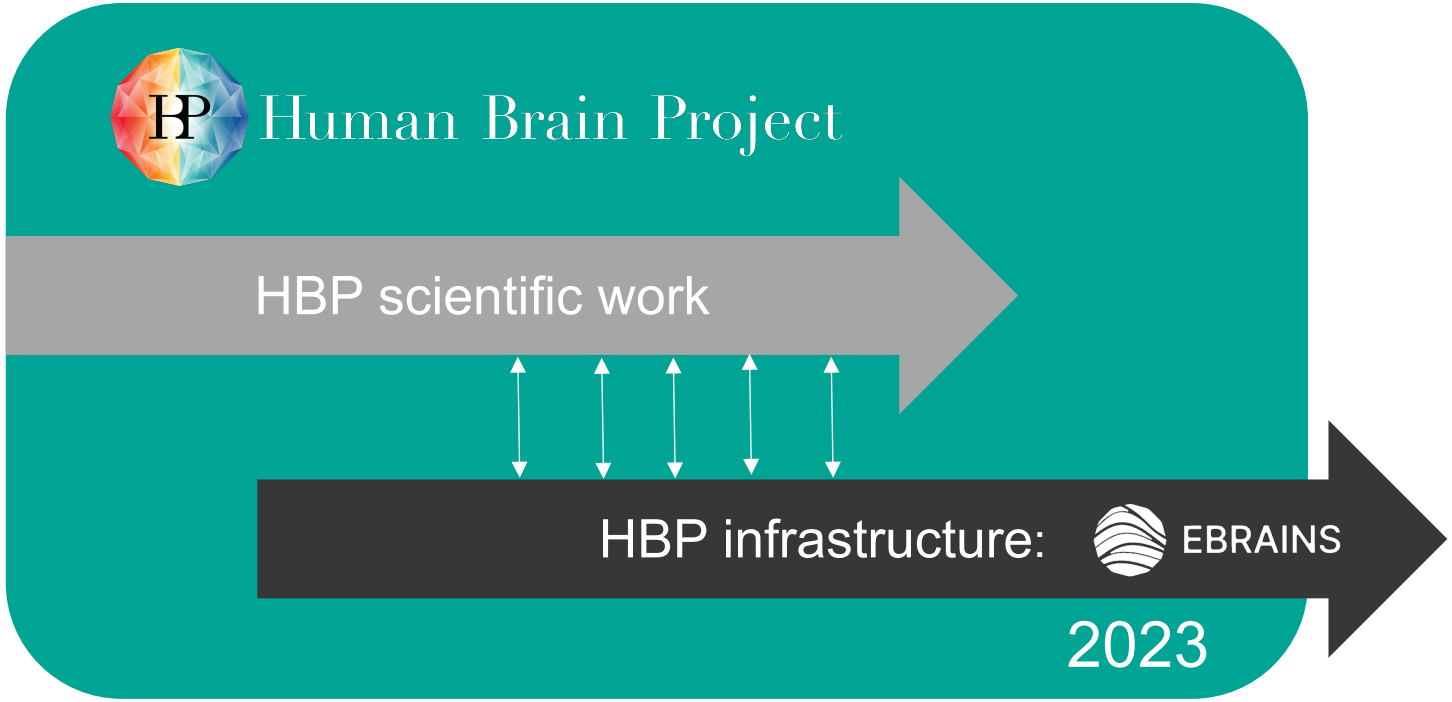
EBRAINS is a digital Research Infrastructure to enable breakthroughs in brain science

The RI has been developed by **the Human Brain Project, an EU flagship launched in 2013**

EBRAINS offers the science community **state-of-the art**

- Brain data
- Bran atlases
- Simulation and modelling tools
- Access to (super) computing resources



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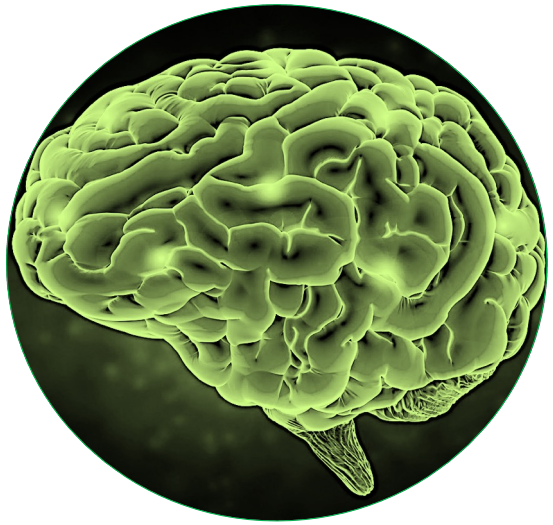
EBRAINS: enabling breakthroughs in brain science

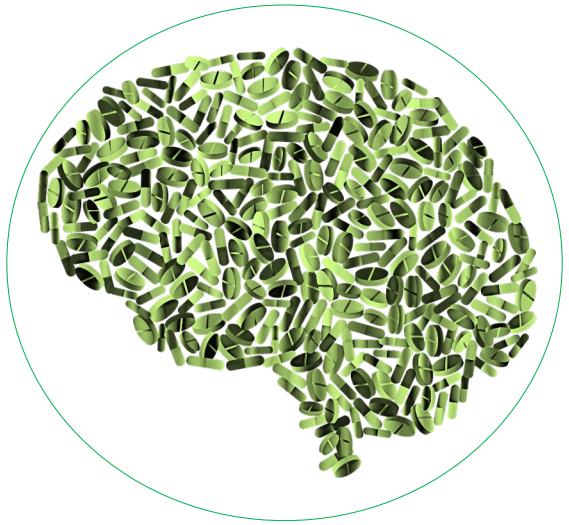
Covering and ensuring equilibrium between three areas:

Neuroscience

Brain Medicine

Brain-inspired technologies





EBRAINS offers a focused and deep range of services

EBRAINS aims at **accelerating collaborative brain research** with a comprehensive package of data, tools and facilities.

Data and Knowledge

Online solutions to facilitate sharing of and access to research data, computational models and software

Atlases

Navigate, characterise and analyse information on the basis of anatomical location

Simulation

Solutions for brain researchers to conduct sustainable simulation studies and share their results

Brain-Inspired Technologies

Understand and leverage the computational capabilities of spiking neural networks

Medical Data Analytics

The Medical Data Analytics service provides two unique EBRAINS platforms, covering key areas in clinical neuroscience research

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EBRAINS data amplification capacity

Reuse leads to standards and standards lead to reuse

Accompanying the user journey and amplifying what the researcher is working with

Developing solutions with the use of high-end analytics

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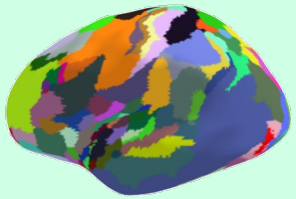
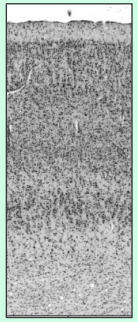
Knowledge Loop - when is Big Data big enough?

Data collection

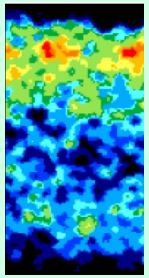


Cytoarchitectonic maps

Structural & functional connectivity

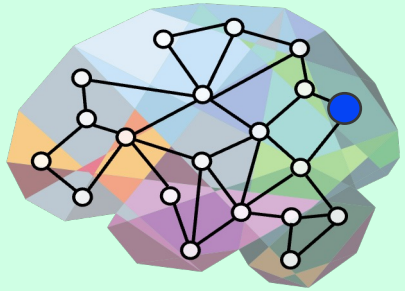


Cell densities



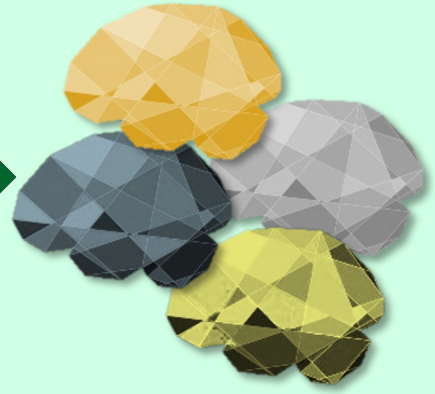
Receptor densities

Model construction

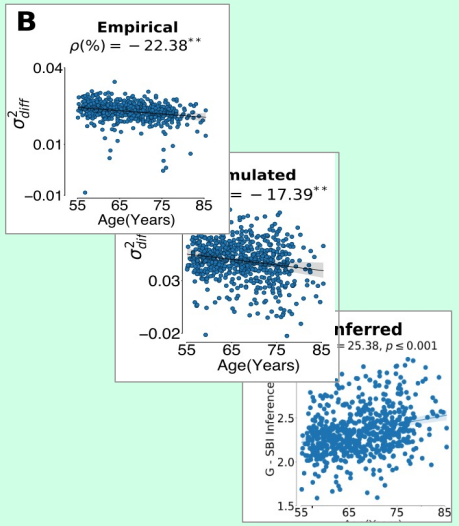


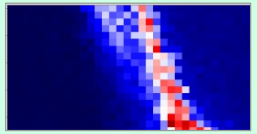
TVB: Brain Network Model

Optimization & Inference



Visualization & Analysis





HBP/EBRAINS scientists aim to demonstrate that cutting edge datasets on structural variability can be used to explain functional variability of age effects with whole brain models.

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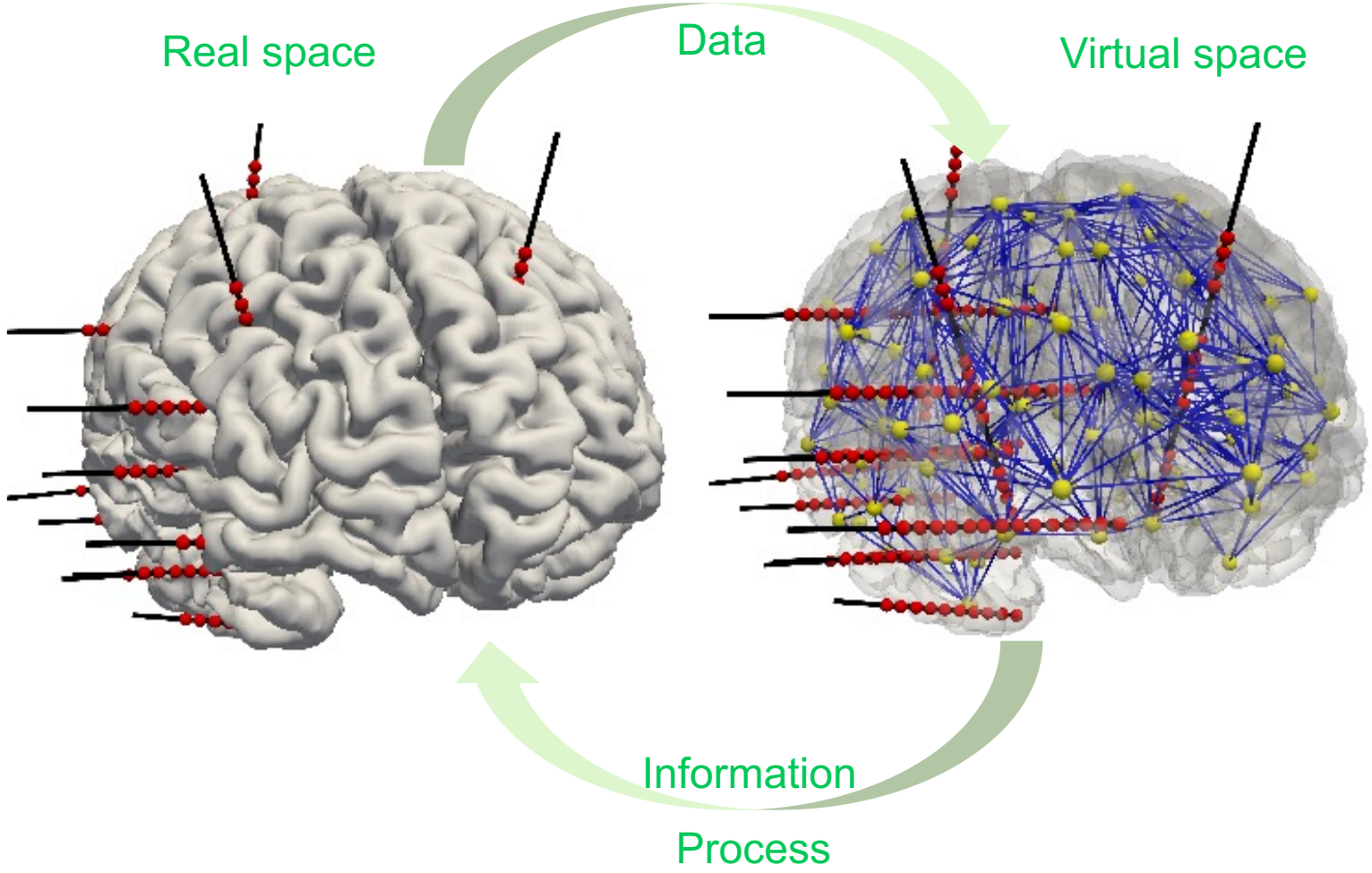
EBRAINS

Integrating neuroscience knowledge for better understanding and translation to brain medicine and technology

Virtual models designed to adequately represent an object or process that **is constrained by data** from its physical counterpart, and that **provides simulation data to guide choices and anticipate their consequences.** Validation tools can then support **knowledge inference.**



Data sharing in brain research: where next?

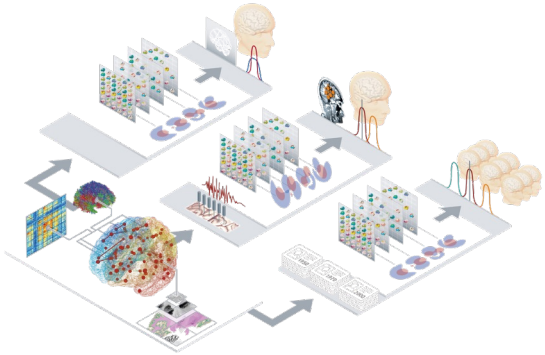
Where we are

Many projects develop tailored solutions

- Data indexing and FAIR publication
- Large data set processing
- Spacial reference systems
- Data privacy/Sensitive data
- Federated data sharing and processing

Where we want to be

- Move from shared data to activatable data
- See a reduction of the replication crisis on all levels
- Enable cross-border access to date sets and link fragmented European neuroimaging databases



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How we get there

Dialoge with wide range of health data stakeholders

- Data generation facilities
- Health Care Practitioners, Researchers, Patient organisations
- National Data Regulators
- European Research Infrastructures
- Leaders of large-scale initiatives
- Pharma, Med-tech, Insurance Companies
- OECD, WHO

Channel needs into multi scale actions

- From data standards to data management policy
- From development to training

- Use case capture and realization

1. **Develop** by implementing workflows defined by needs of a small number of stakeholders
2. **Scale** by adapting developed solutions against and with RI services

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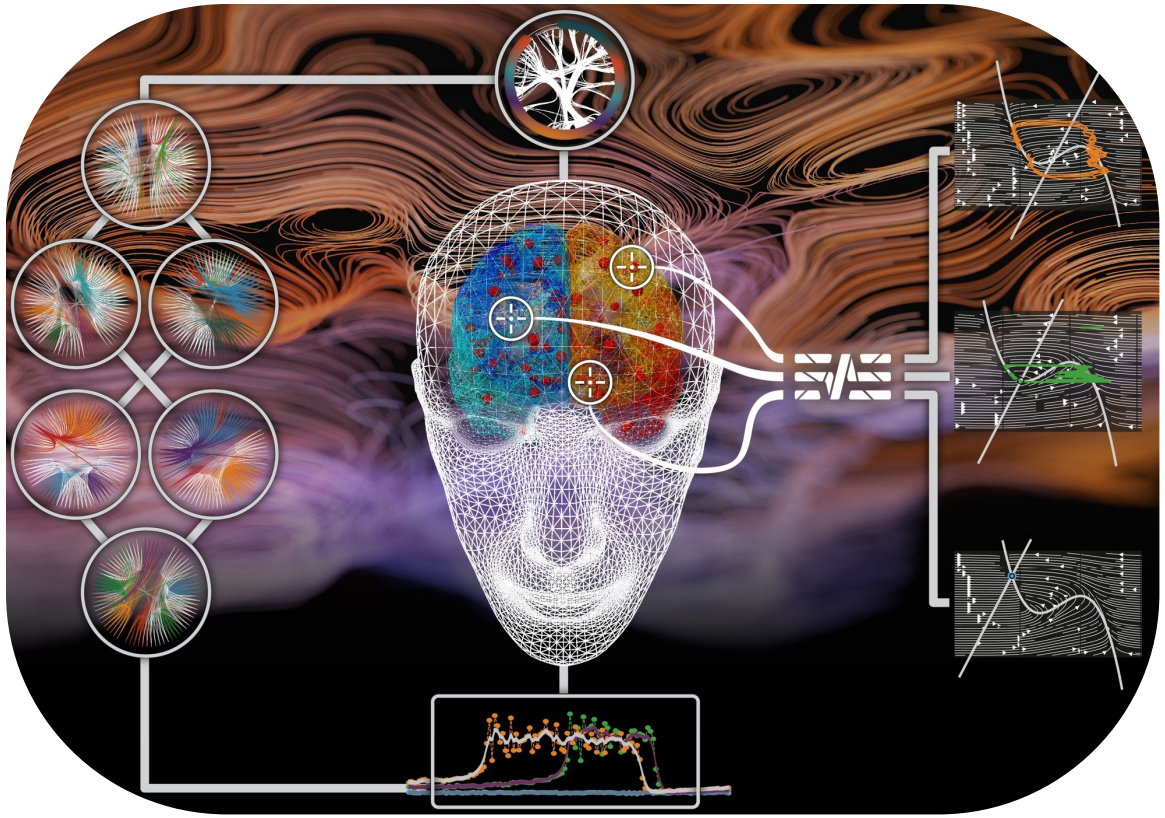
Towards federated infrastructure for brain health data

- Create a governance and business model for capturing brain health data and exploitation
- Form a federated network of data sources and tools for distributed data analysis
- Ensure support by AI, HPC and cloud tools
- Support the creation of new data sets and extension of existing ones
- Make tools developed in other EU projects available and ensure their sustainability
- Align with developments in the European Health Data Space



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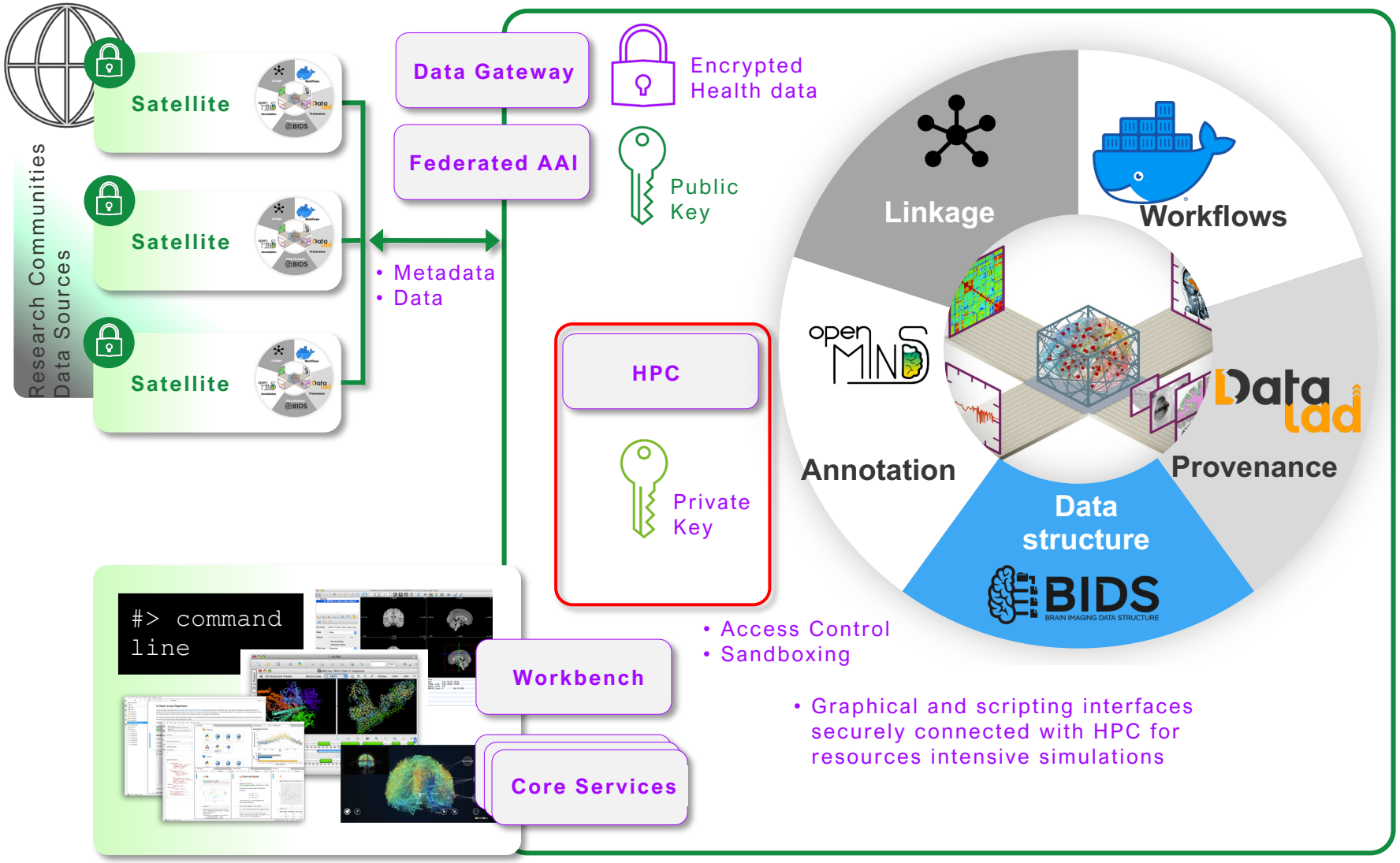
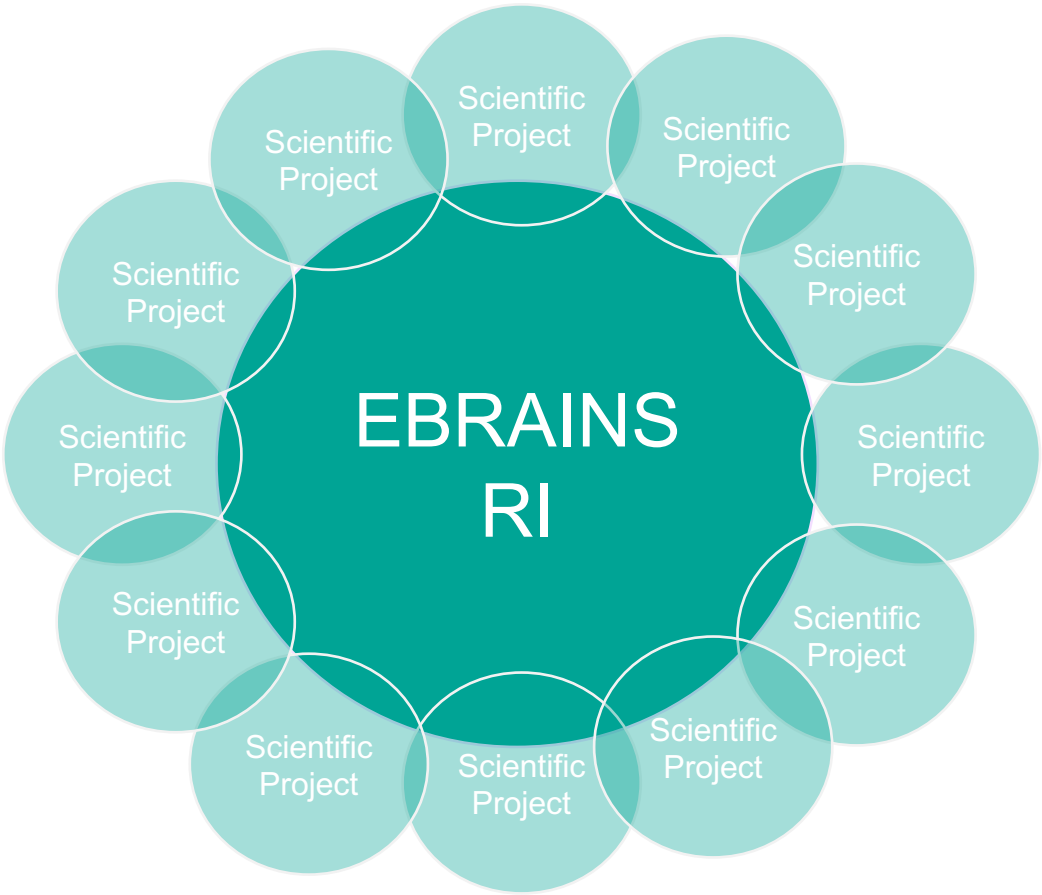
Interoperable data



Responsiveness to science

- Advancing tools and techniques needs to go hand-in-hand with the progress of theory and understanding. We cannot afford “the risk of being able to measure every cell in the brain in a theoretical vacuum”, to paraphrase Luiz Pessoa



Need for methodological and conceptual rigour

- ✓ Clarity on the scientific assumptions
- ✓ Enabling sufficiently large samples to be studied
- ✓ Assuring correction for multiple tests
- ✓ Adjusting the number of variables
- ✓ Publication of both postive and negative results

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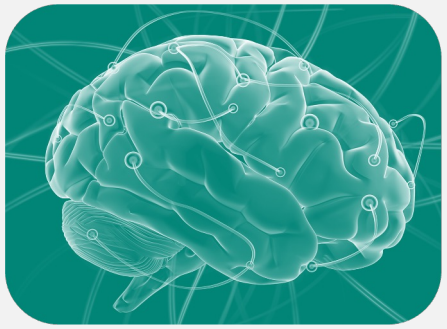
Step-change in accessibility of health data: European Health Data Space

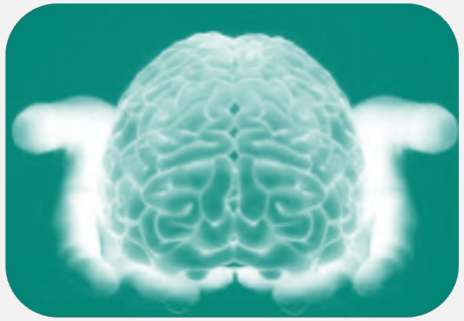
- ✓ Common European approach for the use and re-use of health data that complements and builds on the GDPR
- ✓ Towards step change in accessibility of health data
- ✓ 15 mandatatory categories of data to be defined
- ✓ Data access bodies to be set up to provide access in a secure environment
- ✓ One request to be sufficient for all required data sets in the different European countries
- ✓ Pilot project plannned to test infrastructural support

Broader European Brain Initiative



Brain Knowledge Hub

Increased commitment to research, pulling of research findings, coordination of research agendas and avoidance of duplication.



Brain Health Partnership

Benefiting from greater predictive power of integrated brain models in personalised medicine
Brain Health Data System

Neurotechnology and Brain-inspired Technology

A network of neurotechnology platforms
Brain-inspired AI Laboratory

EBRAINS as a member of the EOSC ecosystem

- ✓ Firm commitment to Open Science as a collective, community-wide endeavour.
- ✓ Preparing tools and services to be interoperable and discoverable via EOSC. Relevant technical dialogue ongong.
- ✓ EBRAINS AISBL has applied to become a member of the European Open Science Cloud Association
- ✓ EBRAINS plans to become an EOSC Service Provider with a catalogue of Services and perform efforts on policy alignment.

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