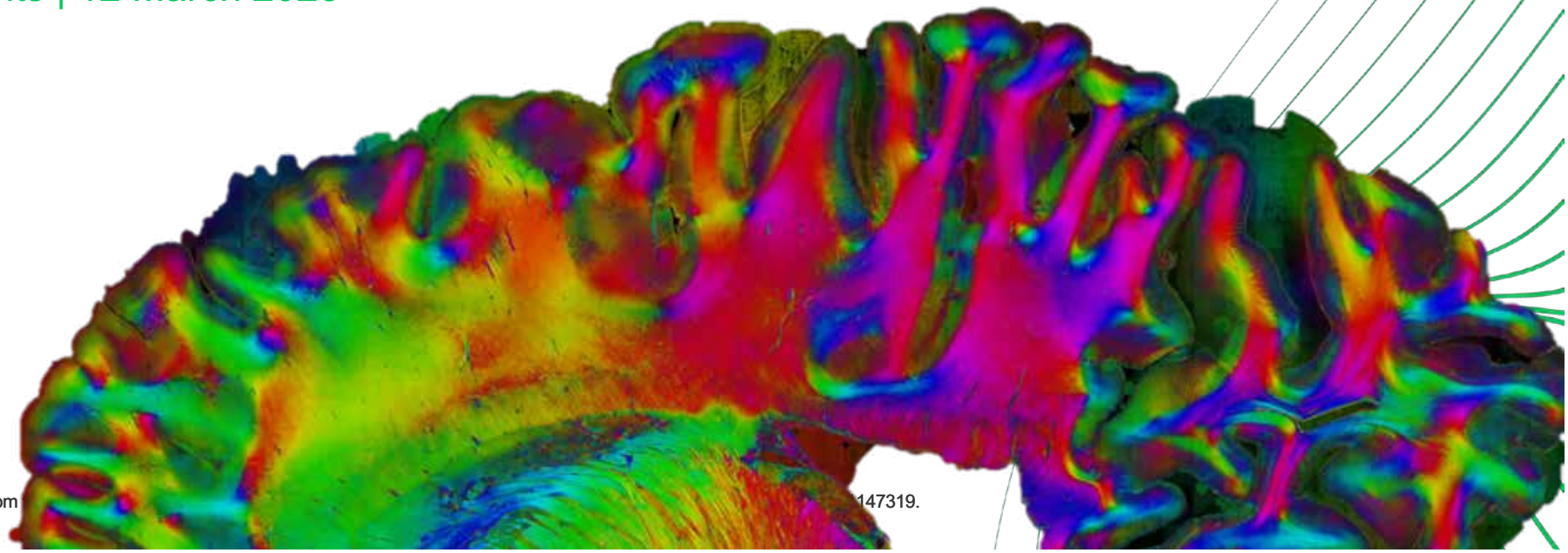
EBRAINS

Co-funded by the European Union

Research with EBRAINS

Available tools, workflows and applications

Katrin Amunts | 12 March 2025



EBRAINS 2.0 has received funding from [illegible] 147319.

EBRAINS Infrastructure: an outcome of the HBP

Framework Partnership Agreement (FPA)

Ramp up: 2013-2016 | SGA1: 2016-2018 | SGA2: 2018-2020 | SGA3: 2020-2023

12 Sub-projects with WPs and tasks

Platform release 1.0

URIS paper on platforms

Partnering Projects introduced

Co-Design projects cross SPs

HLST and voucher system introduced

FENIX / ICEI started

Platform release 2.0

HBP Joint Platform

EBRAINS Research Infrastructure launch

EBRAINS AISBL founded

WPs introduced

Modified SIB structure

Science Liaison Unit & Tech Coordination

EBRAINS @ ESFRI

Science vision paper developed

Co-funded by the European Union

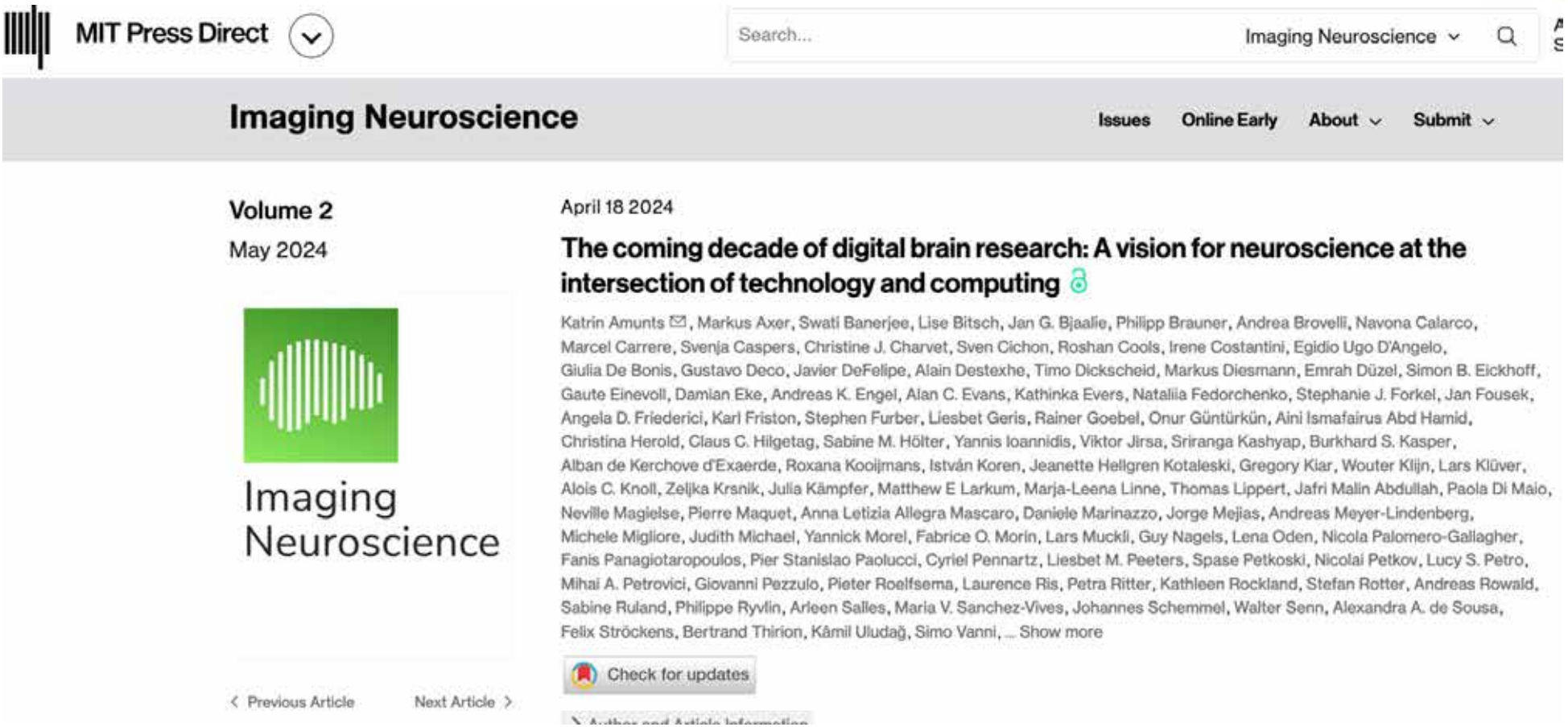
EBRAINS 2.0

EBRAINS

EBRAINS 2.0

- Further development and provision of EBRAINS research
- European partnership with 59 partner institutions from 16 European countries, with National Nodes, ESTC and EESC
- Goes hand in hand with the Virtual Brain Twin Project, lead by Viktor Jirsa

EBRAINS: Areas of research outlined in the vision paper



MIT Press Direct

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Volume 2

May 2024

Imaging Neuroscience

April 18 2024

The coming decade of digital brain research: A vision for neuroscience at the intersection of technology and computing

Katrin Amunts, Markus Axer, Swati Banerjee, Lise Bitsch, Jan G. Bjaalie, Philipp Brauner, Andrea Brovelli, Navona Calarco, Marcel Carrere, Svenja Caspers, Christine J. Charvet, Sven Cichon, Roshan Cools, Irene Costantini, Egidio Ugo D'Angelo, Giulia De Bonis, Gustavo Deco, Javier DeFelipe, Alain Destexhe, Timo Dickscheid, Markus Diesmann, Emrah Düzel, Simon B. Eickhoff, Gaute Einevoll, Damian Eke, Andreas K. Engel, Alan C. Evans, Kathinka Evers, Nataliia Fedorchenko, Stephanie J. Forkel, Jan Fousek, Angela D. Friederici, Karl Friston, Stephen Furber, Liesbet Geris, Rainer Goebel, Onur Güntürkün, Aini Ismafairus Abd Hamid, Christina Herold, Claus C. Hilgetag, Sabine M. Hölter, Yannis Ioannidis, Viktor Jirsa, Sriranga Kashyap, Burkhard S. Kasper, Alban de Kerchove d'Exaerde, Roxana Kooijmans, István Koren, Jeanette Hellgren Kotaleski, Gregory Kiar, Wouter Klijn, Lars Klüver, Alois C. Knoll, Zeljka Krsnik, Julia Kämpfer, Matthew E Larkum, Marja-Leena Linne, Thomas Lippert, Jafri Malin Abdullah, Paola Di Maio, Neville Magielse, Pierre Maquet, Anna Letizia Allegra Mascaro, Daniele Marinazzo, Jorge Mejias, Andreas Meyer-Lindenberg, Michele Migliore, Judith Michael, Yannick Morel, Fabrice O. Morin, Lars Muckli, Guy Nagels, Lena Oden, Nicola Palomero-Gallagher, Fanis Panagiotaropoulos, Pier Stanislao Paolucci, Cyriel Pennartz, Liesbet M. Peeters, Spase Petkoski, Nicolai Petkov, Lucy S. Petro, Mihai A. Petrovici, Giovanni Pezzulo, Pieter Roelfsema, Laurence Ris, Petra Ritter, Kathleen Rockland, Stefan Rotter, Andreas Rowald, Sabine Ruland, Philippe Ryvlin, Arleen Salles, Maria V. Sanchez-Vives, Johannes Schemmel, Walter Senn, Alexandra A. de Sousa, Felix Ströckens, Bertrand Thirion, Kâmil Uludağ, Simo Vanni, ... Show more

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EBRAINS is

Enabling the scientific community to access **state-of-the-art computing and data science** to help reach a **deeper understanding of the human brain**.

Providing **the most comprehensive set of services available anywhere** for multiscale brain research and atlasing.

Empowering the neuroscience community to take advantage of **Exascale computing**.

C**o-designing novel tools and services** with our colleagues from EAN, FENS, INCF, CSA – the Brain Health Partnership and others, reaching tens of thousands of **clinicians, researchers and developers worldwide.**

EBRAINS RI: Open Science Tool Suites

Atlases

Medical analytics

Modelling and simulation

FAIR data

Collaborative platform

Computing infrastructure

https://www.ebrains.eu

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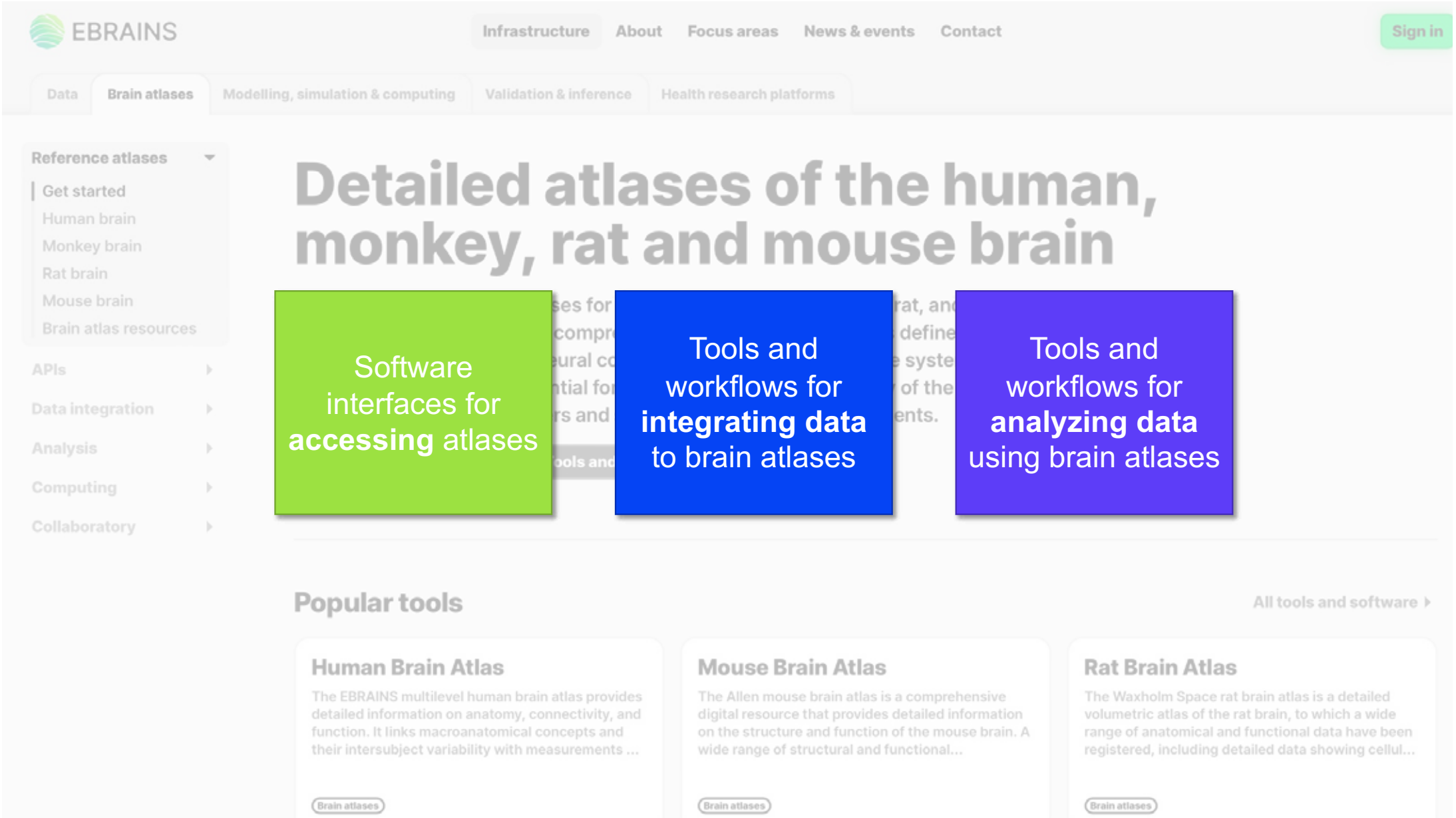
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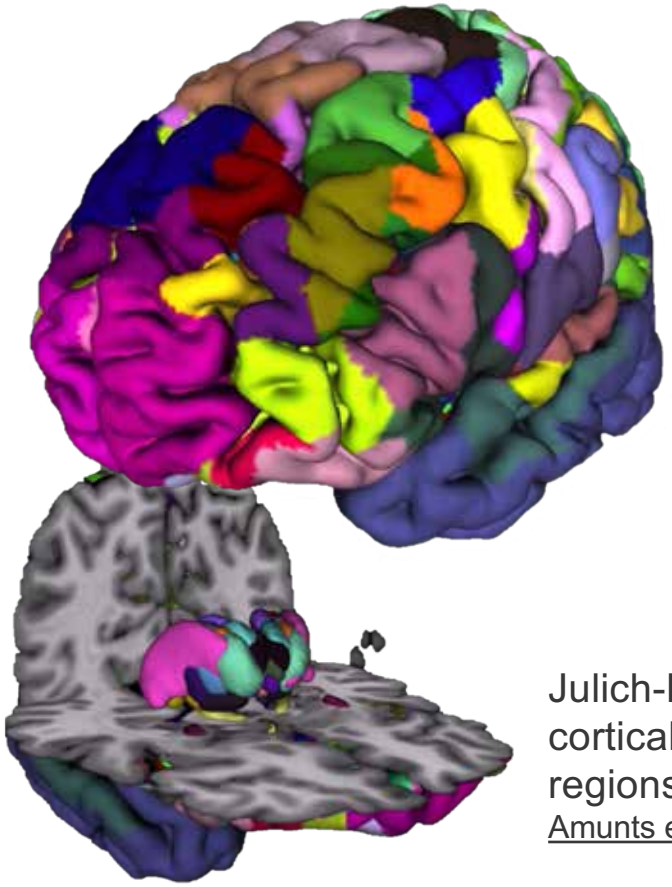
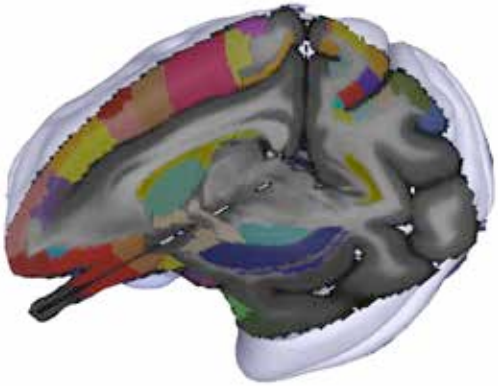
Reference atlases
Get started
Human brain
Monkey brain
Rat brain
Mouse brain
Brain atlas resources
APIs
Data integration
Analysis
Computing
Collaboratory
Detailed atlases of the human, monkey, rat and mouse brain
Software interfaces for accessing atlases
Tools and workflows for integrating data to brain atlases
Tools and workflows for analyzing data using brain atlases
Popular tools
All tools and software
Human Brain Atlas
The EBRAINS multilevel human brain atlas provides detailed information on anatomy, connectivity, and function. It links macroanatomical concepts and their intersubject variability with measurements ...
Brain atlases
Mouse Brain Atlas
The Allen mouse brain atlas is a comprehensive digital resource that provides detailed information on the structure and function of the mouse brain. A wide range of structural and functional...
Brain atlases
Rat Brain Atlas
The Waxholm Space rat brain atlas is a detailed volumetric atlas of the rat brain, to which a wide range of anatomical and functional data have been registered, including detailed data showing cellul...
Brain atlases

Recent versions of reference atlases



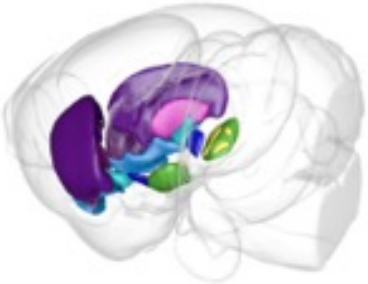
Julich-Brain 3.1 with 226 cortical and subcortical regions (52 new areas!)
Amunts et al., Science 2020

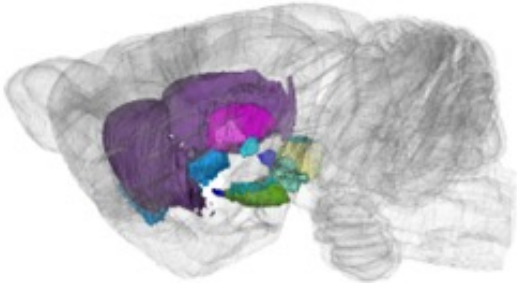
Macaque template published
Puiu et al., Imag Neurosc 2024



Comparison of basal ganglia nomenclature and delineations in murine atlases

Kleven et al., SciData, 2024





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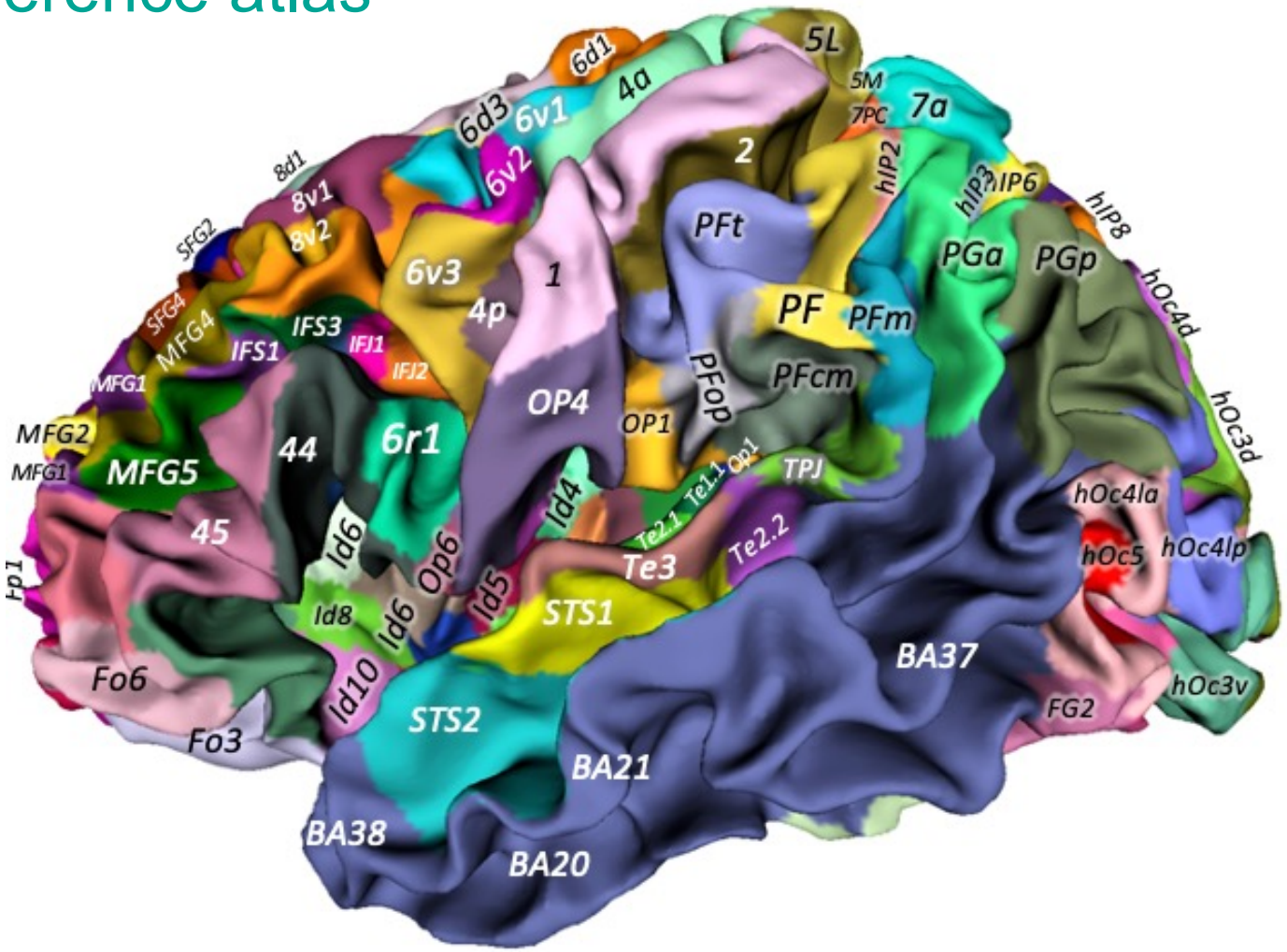
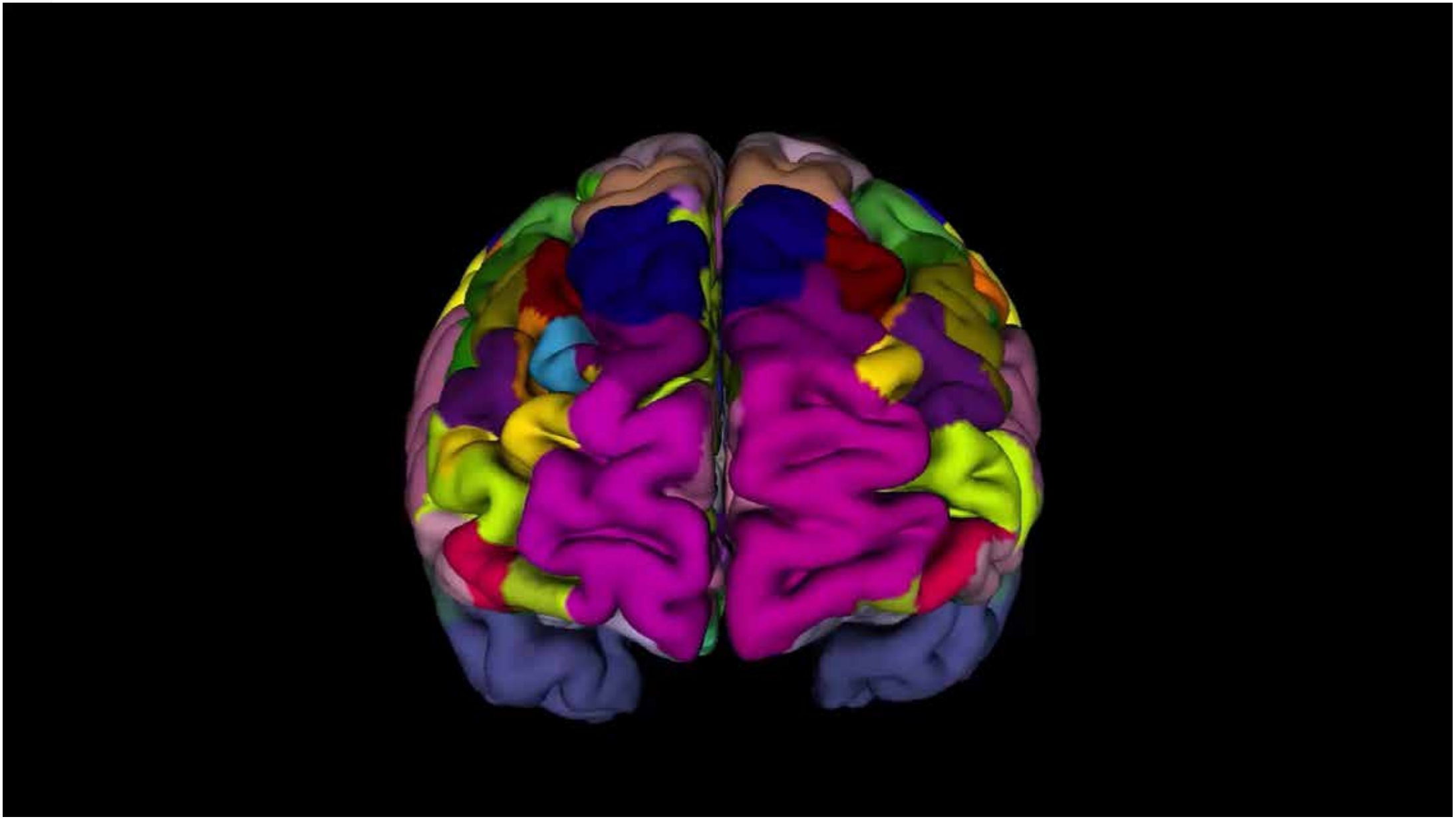
Cytoarchitectonic reference atlas

Detailed atlas for **the human, brain** with comprehensive maps of brain regions while considering intersubject variability of brain areas

Will be part of next Gray's Anatomy





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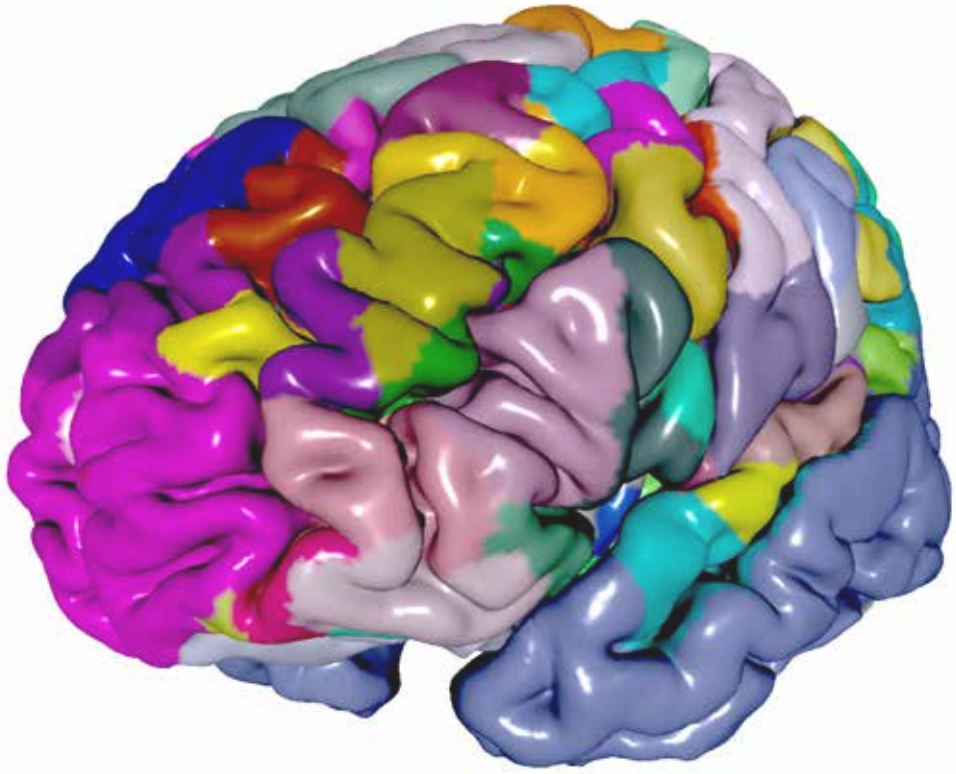
The Human Brain atlas

“Google Maps for the brain”

- **Built** on *Julich-Brain maps* and *BigBrain* high-resolution model
- **Enables** multimodal data integration
- **Makes data** usable in AI and simulation

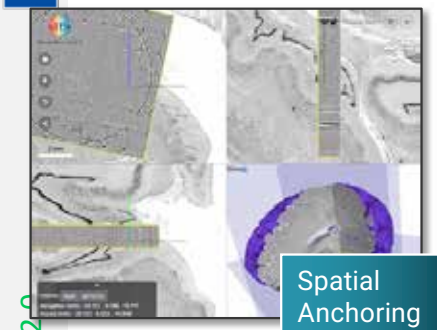


Access of reference parcellations (last 8 months) in total numbers at

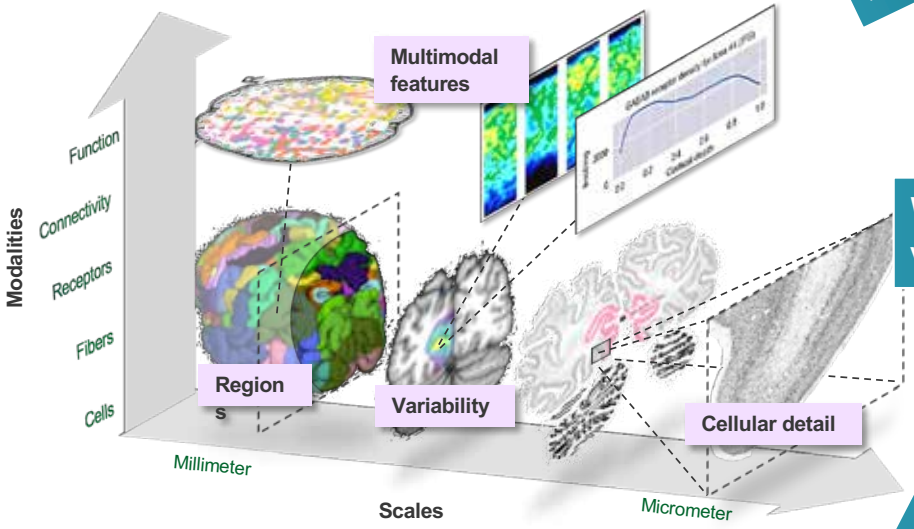
EBRAINS: **180.623**

Amunts et al., *Science*, 2020

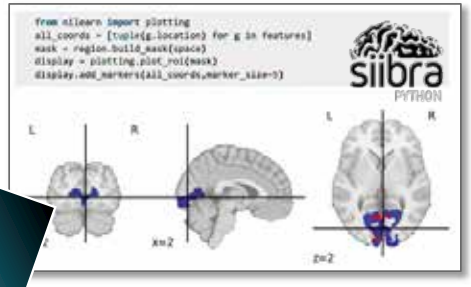
Bridging scales and modalities



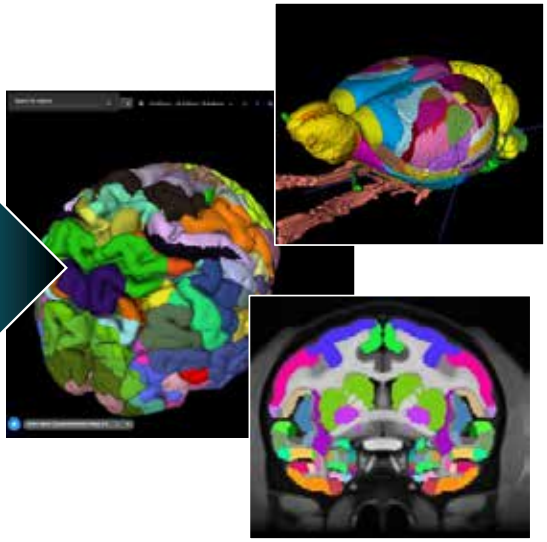
Spatial Anchoring tools



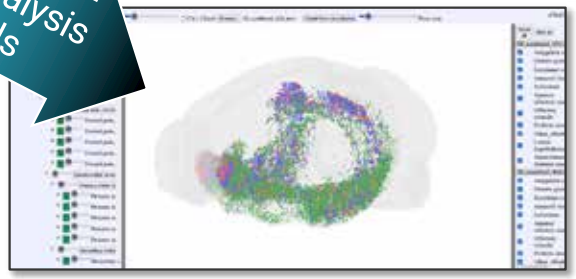
Python interface



Web viewers



Analysis tools



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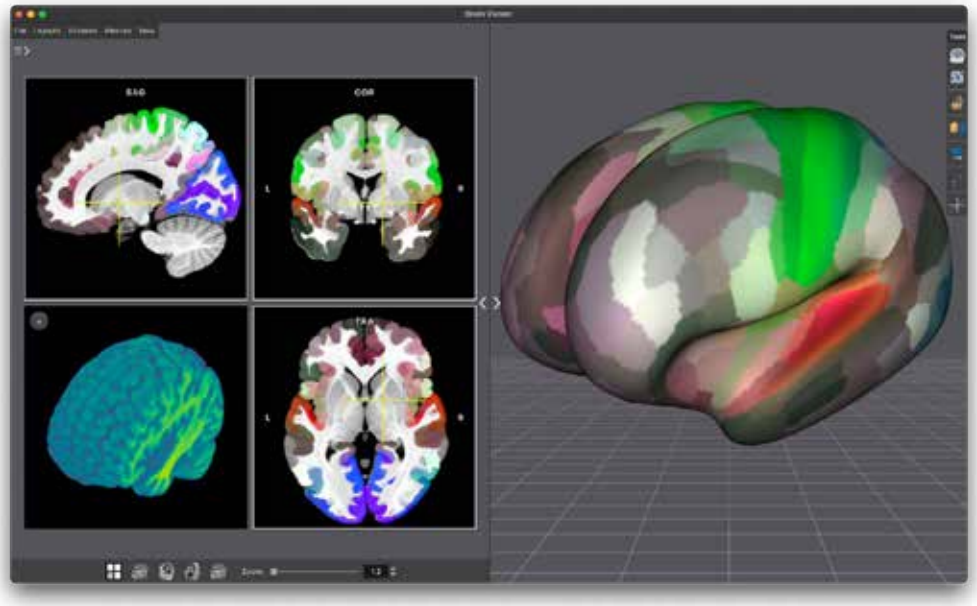
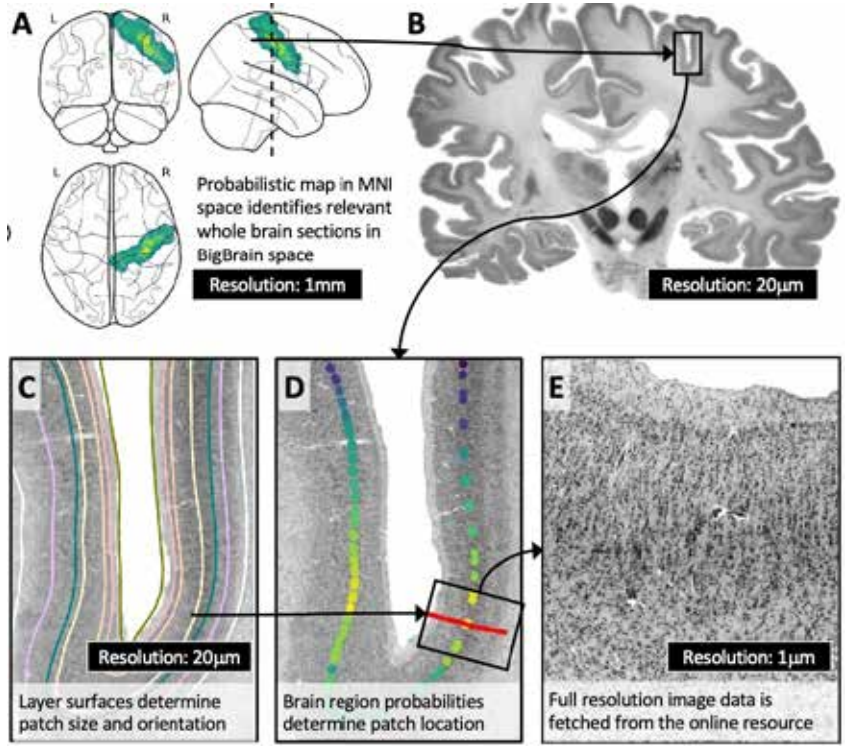
Current highlights



Under development: Desktop apps for atlas-based neuroimaging analyses

```
import siibra
cytomaps = siibra.get_map("julich", "mni152", "statistical")
regionmap = cytomaps.get_volume("4p left")
patches = siibra.features.get(regionmap, "BigBrain1MicronPatch")
```



siibra-python: Sample 1 micron image data in few lines of code!

Dickscheid, Amunts et al., in prep

https://siibra-python.readthedocs.io

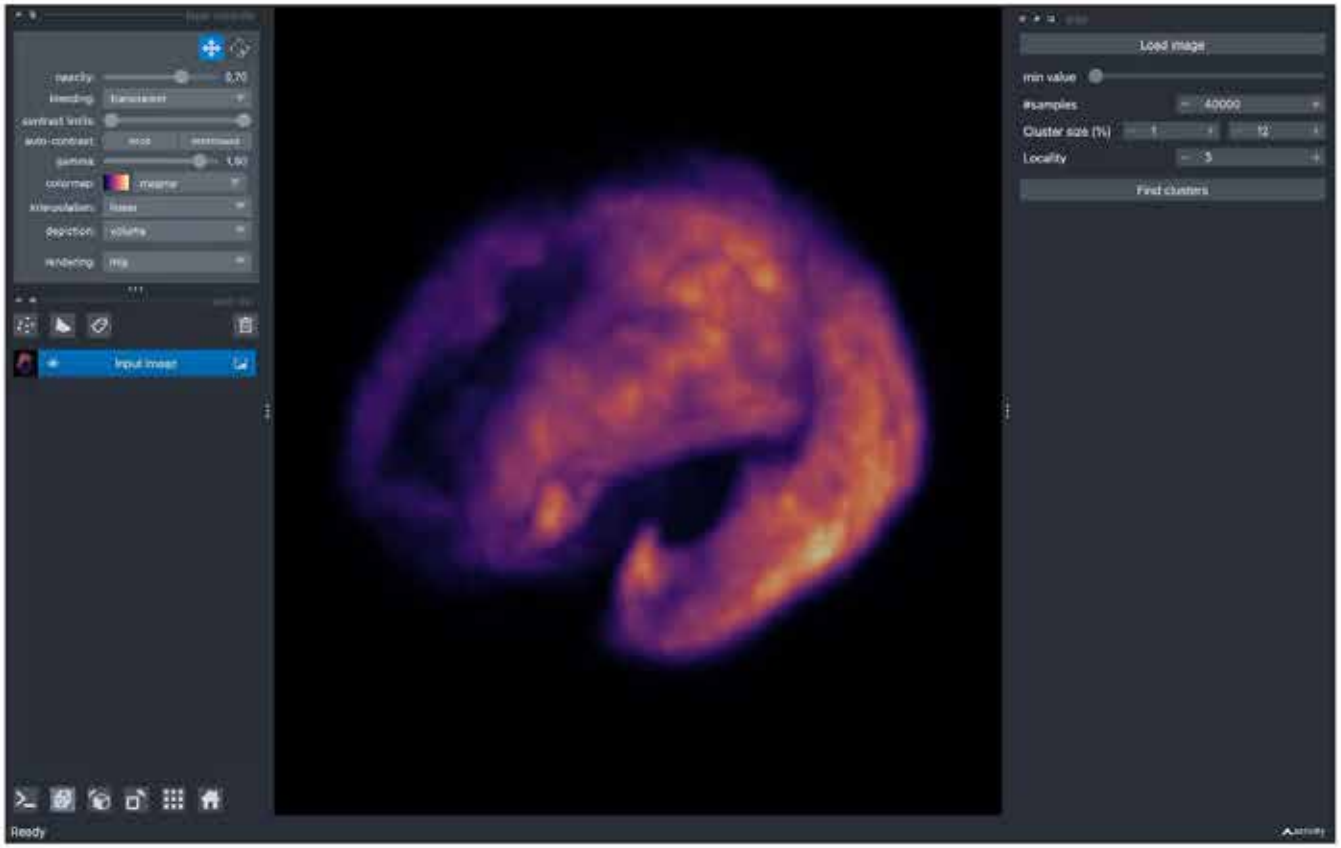
siibra PYTHON

Upcoming highlight

siibra PYTHON

Using the siibra tool suite:

1. Load PET image volume



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Services for sharing human sensitive data linked to EBRAINS

Onboarded:

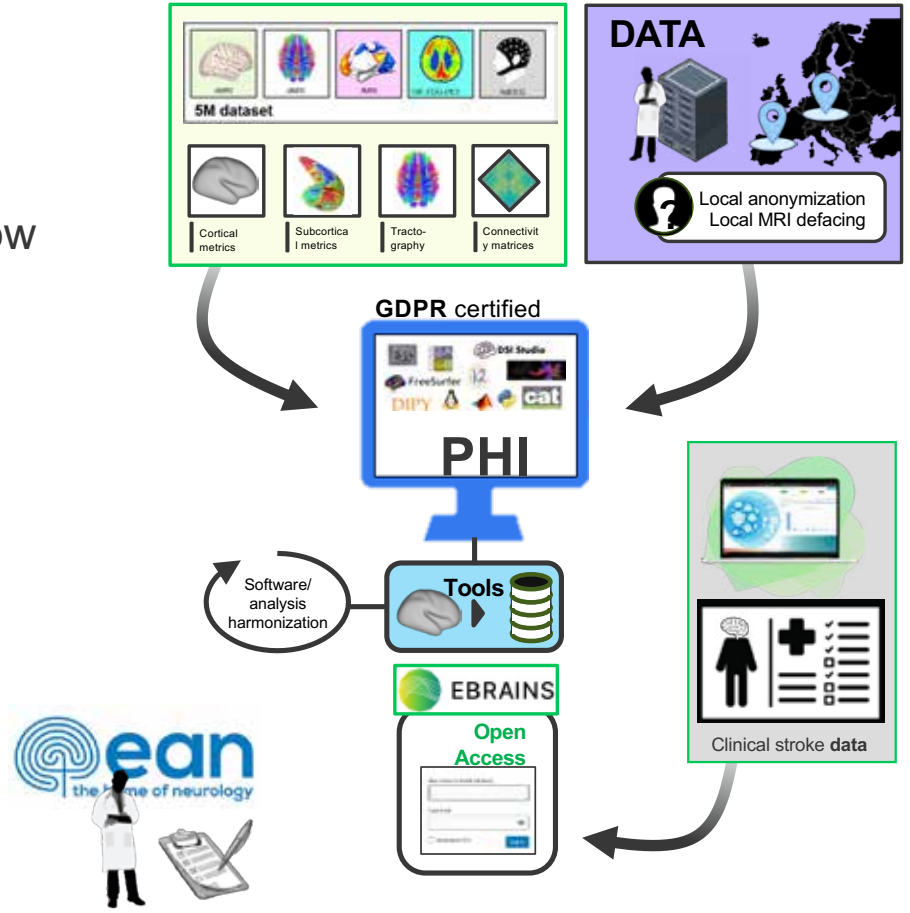
- **Health Data Cloud (HDC):** Federated research data ecosystem that enables research consortia across Europe and beyond to collect, process and share sensitive data with GDPR-compliance.
- **HIP**: The Human Intracerebral EEG Platform is an open-source platform designed for collecting, managing, analysing, and sharing iEEG data.
- **MIP**: The Medical Informatics Platform is designed to help clinicians, clinical scientists, and data scientists aiming to adopt advanced analytics for clinical research.

Onboarding in progress :

- **public nEUro**: organization/repository that allows brain imaging data to be shared publicly following GDPR.
- **TSD**: The Service for sensitive data: secure platform in Norway for researchers to collect, store and analyse sensitive research data.

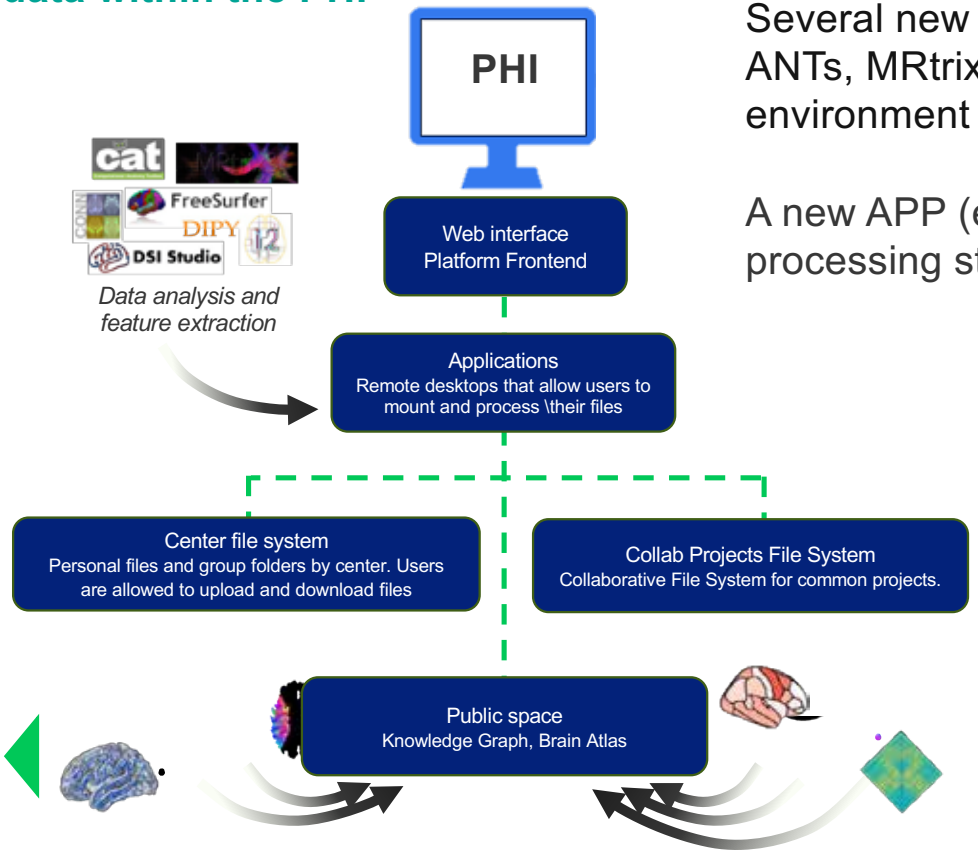
Linking new multi-scale human datasets and connectomes in the healthy and pathological brain to atlases and models

- EBRAINS 2.0:
  - New **Platform for Human Imaging (PHI)** now available.
  - App integration now fully operational
  - Database for dataset listing now available
  - Data Management Plan for clinical data developed
  - Open calls completed



THE PHI Platform

INTEGRATION of imaging data within the PHI



THE PHI PLATFORM

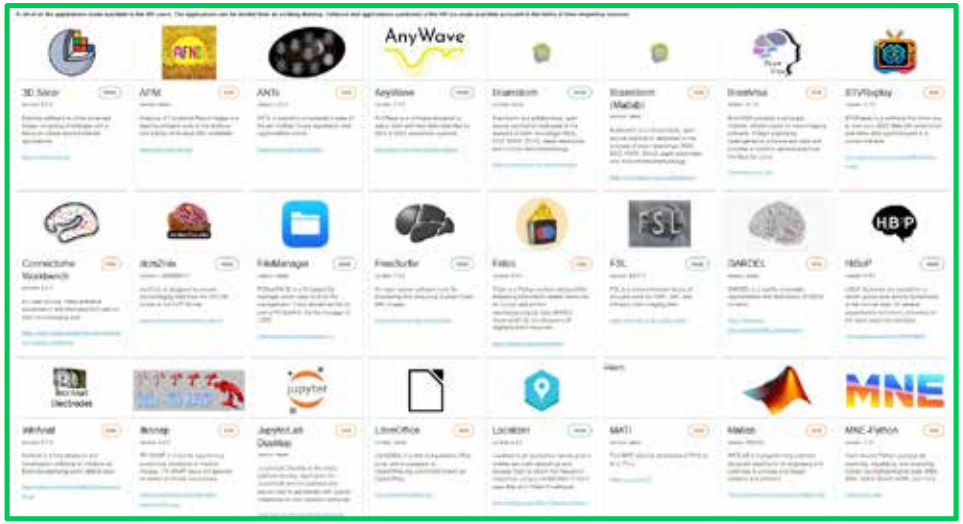
PHI

The Padova Computing Platform (PHI) based on the HIP v.1 (CHUV) is hosted at InfoCamere, on dedicated HW and storage;

Several new applications were added for the Italian deployment: ANTs, MRtrix3, AFNI, Matlab toolboxes and a new jupyter lab environment with tools like Nilearn, Nibabel, Dipy, DeepBrain.

A new APP (end-to-end) was implemented in the PHI platform for processing structural, diffusion, and functional clinical data

The App catalogue



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EBRAINS RI: Open Science Tool suites

Atlases

Medical analytics

Modelling and simulation

FAIR data

Collaborative platform

Computing infrastructure

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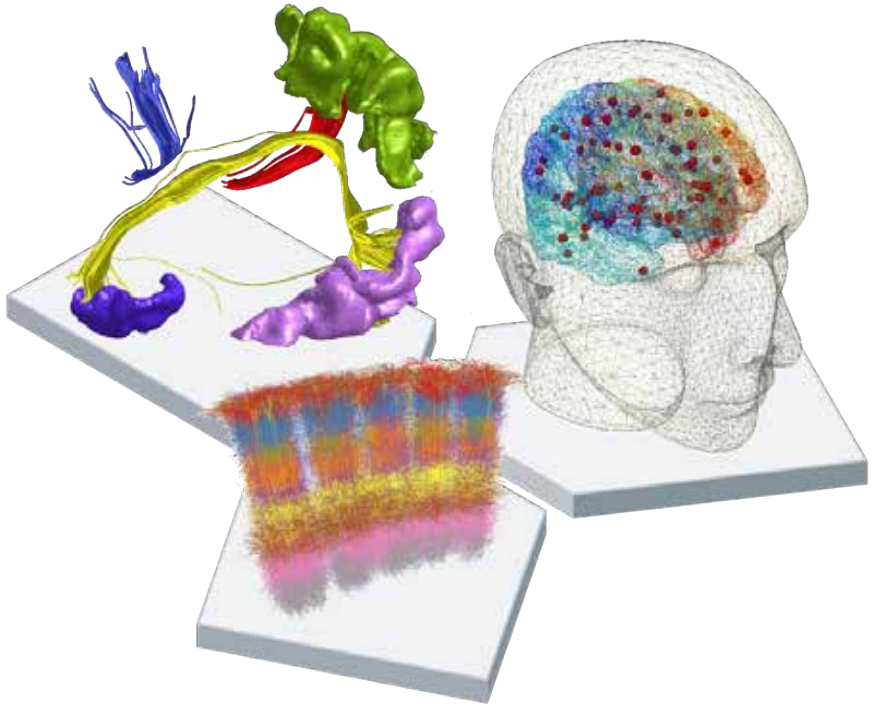
Software for model building and simulation

THEVIRTUALBRAIN.

nest::

arbor

NEURON



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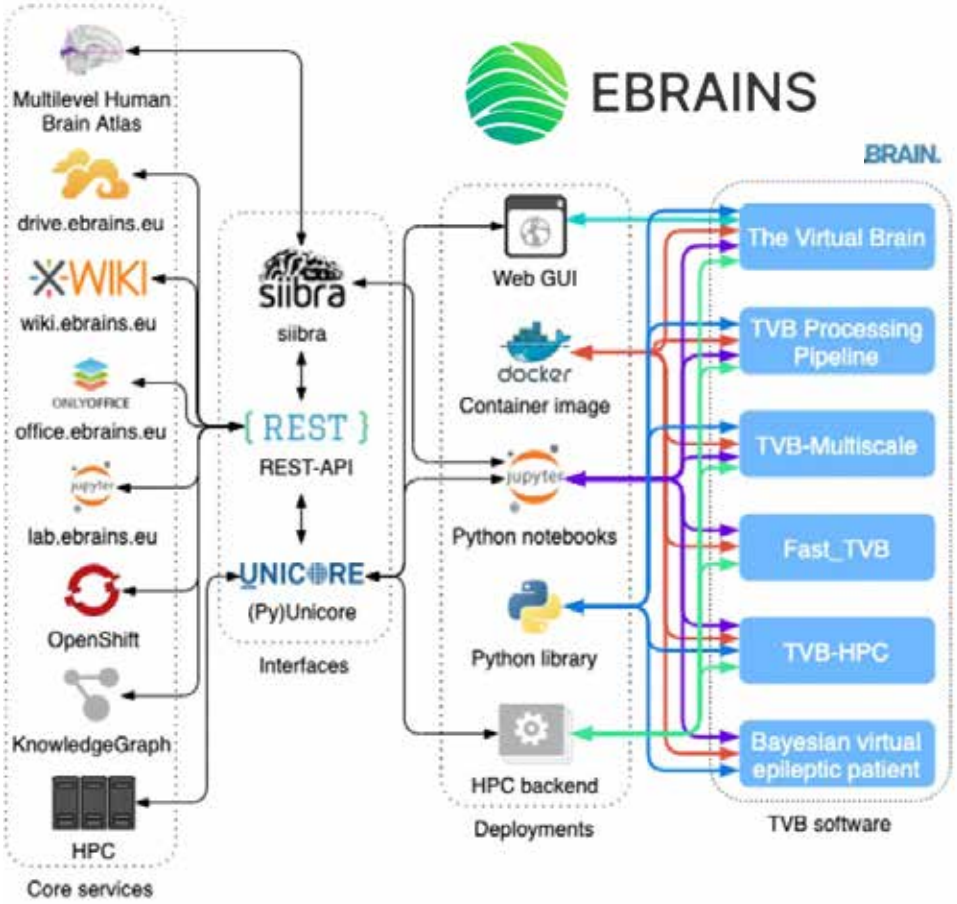
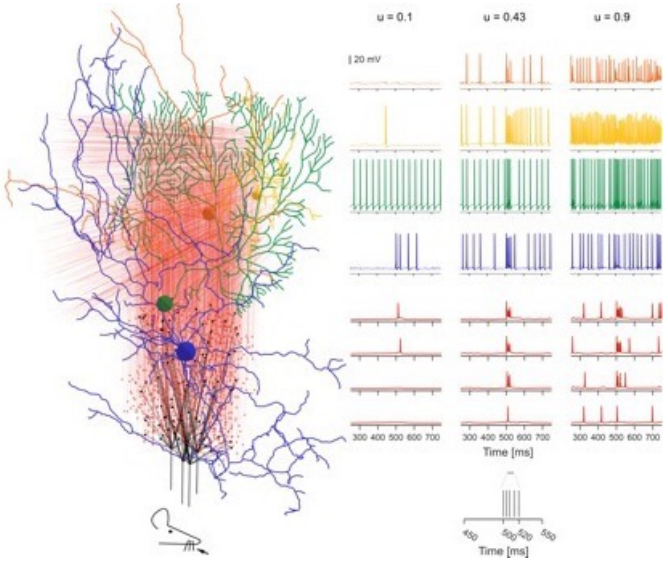
Support software for model building and operation



Schirner et al Neuroimage 2022

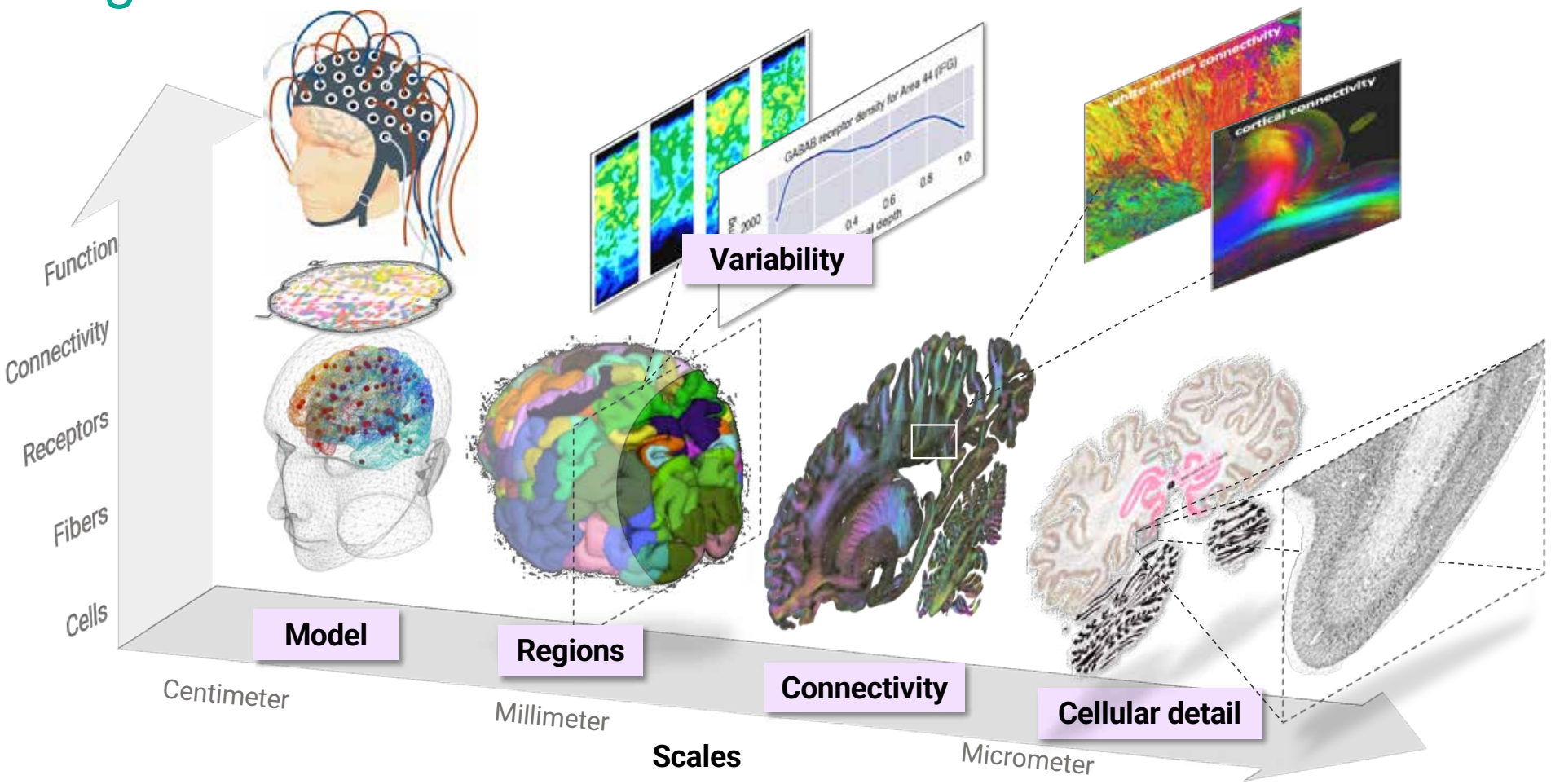
BSB



Snudda

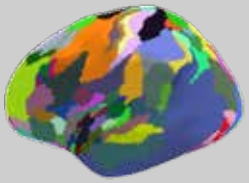
De Schepper *et al* - Nature Comms Biol, 2022

Integration of models and atlas



Integration of models and atlas

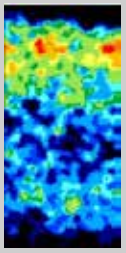
Data collection



Cytoarchitectonic maps

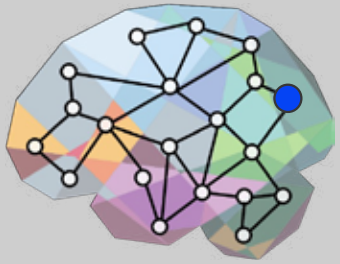
Structural & functional connectivity

Cell densities



Receptor densities

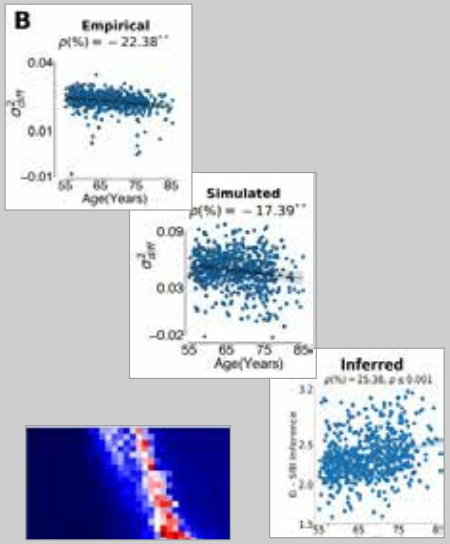
Model construction



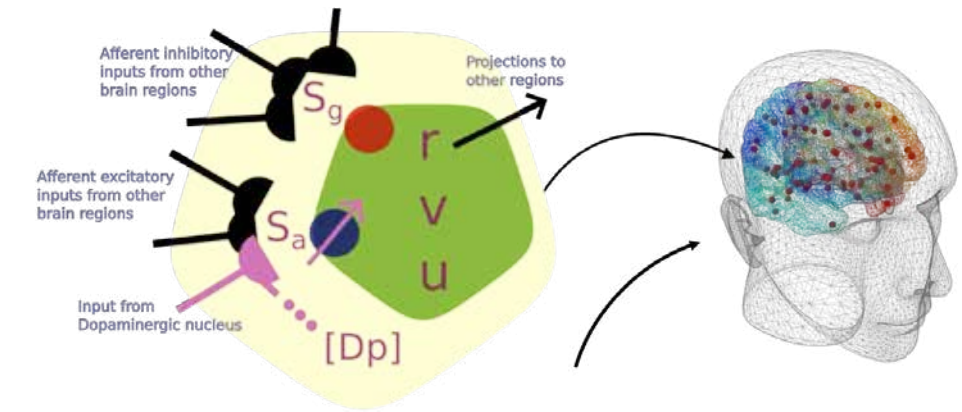
TVB: Brain Network Model

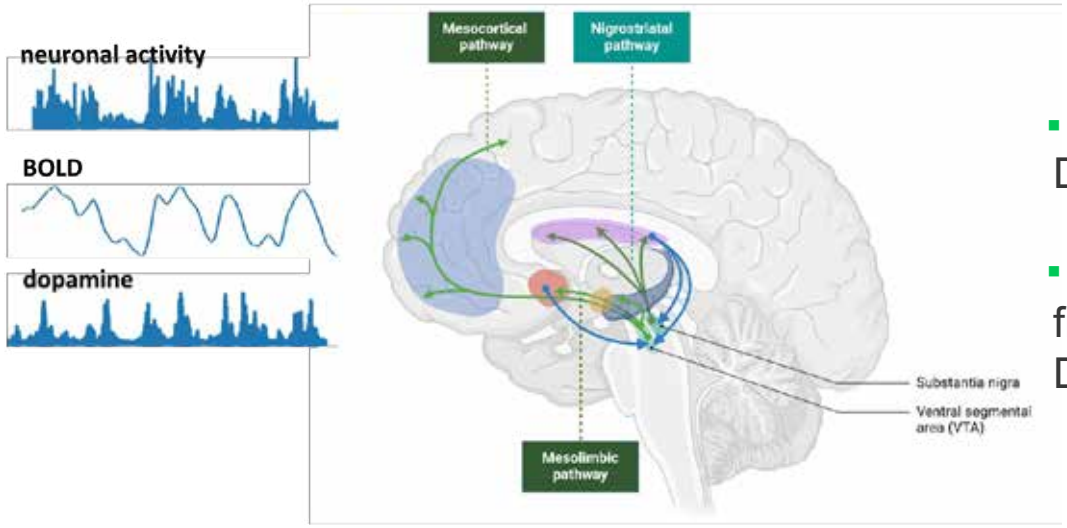
Optimization & Inference

Visualization & Analysis



EBRAINS 2.0: The Virtual Brain with Neuromodulation





- Network model upgrade to allow multiple long-range projections (excitatory, inhibitory and dopaminergic). Major dopaminergic pathways are implemented.
- Mean-field of Izhikevich neurons with modulation of AMPA and GABA synapses.
  - supports various spiking neurons (pyramidal, stellate..).
  - collaboration with WP1 micro-to-macro scale standards for brain atlases
- Large potential for applications in Parkinson's Disease, psychiatric disorders, aging..
- The **open call winner** will use the novel model framework for specific application to Lewy Body Dementia.

Depannemaecker et al. (2024) The Virtual Parkinsonian Brain. medRxivn. bioRxiv
Angiolelli et al. (2024) The Virtual Parkinsonian Brain. medRxiv.

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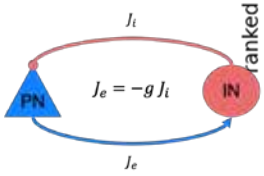
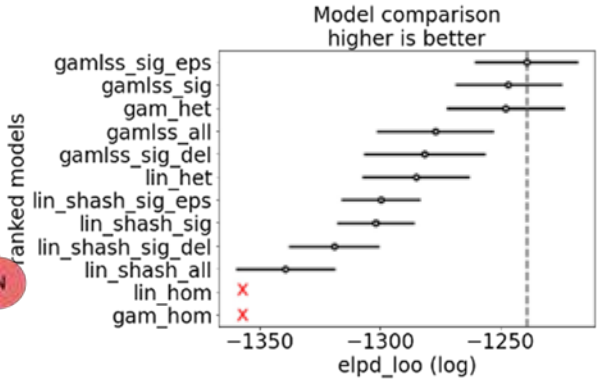
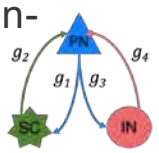
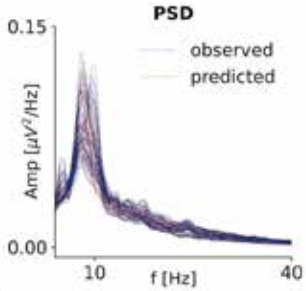
Workflows to OPERATE Digital Twins

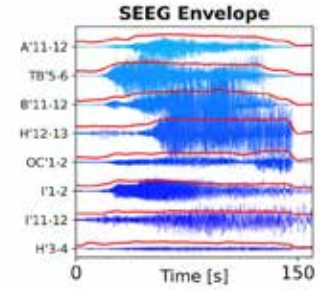
- New Toolbox **Virtual Brain Inference (VBI)** is published
  - Simulation-based inference across scales (neurons, neural masses, whole brain)
  - Simulation-based inference across modalities (EEG/MEG/fMRI)
  - Comparison of optimization and inference schemes (Simulation-based inference vs Markov Chain Monte Carlo) and benchmarking
- Improved applicability through implementation of automated and reproducible workflows on EBRAINS
- **Normative modelling** of longitudinal data is established (e.g., healthy aging)
- **Collaborative work with WP2 on pentamodal dataset is in progress:** Modelling of clinical stroke data

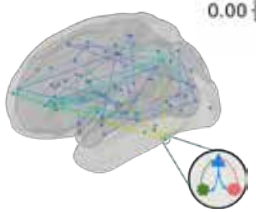




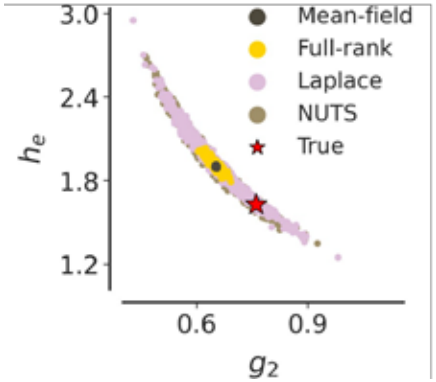








Algorithmic comparisons



1. Baldy et al. Inference on the Macroscopic Dynamics of Spiking Neurons. Neural Comput. 36, 2030–2072 (2024).
2. Baldy et al., Dynamic Causal Modeling in Probabilistic Programming Languages. bioRxiv (2024) doi:10.1101/2024.11.06.622230.
3. Esmaeili, et al. Probing other's Presence: Probabilistic Inference Across Brain Scales Reveals Enhanced Excitatory Synaptic Efficacy. bioRxiv (2024) doi:10.1101/2024.09.09.612006.
4. **Ziaee et al. Virtual Brain Inference (vbi): a flexible and integrative toolkit for efficient probabilistic inference on virtual brain models. bioRxiv (2025) doi:10.1101/2025.01.21.633922.**
5. Hashemi, et al. Simulation-based inference on virtual brain models of disorders. Mach. Learn. Sci. Technol. 5, 035019 (2024).
6. Hashemi, et al. Principles and Operation of Virtual Brain Twins. bioRxiv 2024. doi:10.1101/2024.10.25.620245.
7. Rabuffo, et al. Probing the Mechanisms of Global Brain Reconfiguration after Local Manipulations. PNAS (accepted).
8. Sorrentino, P. et al. The virtual multiple sclerosis patient. iScience 27, (2024).

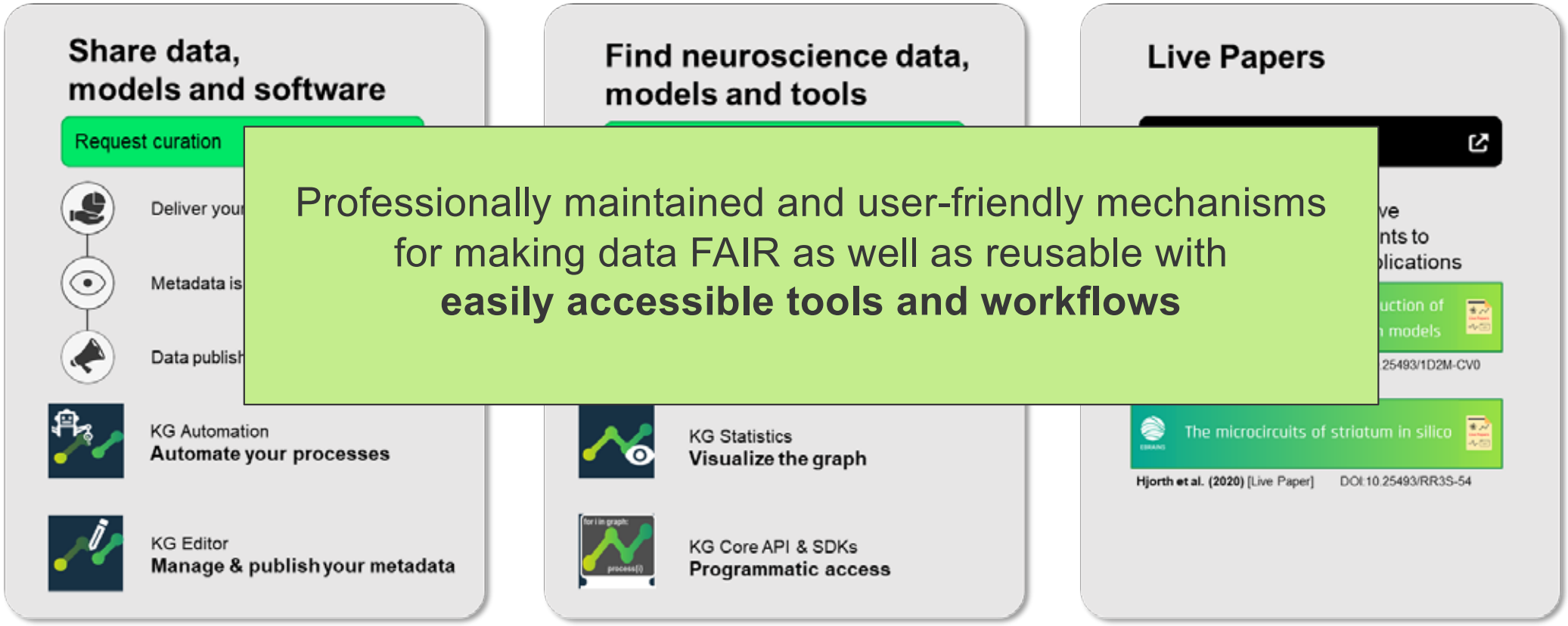
EBRAINS RI: Open Science Tool Suites

- Atlases
- Medical analytics
- Modelling and simulation

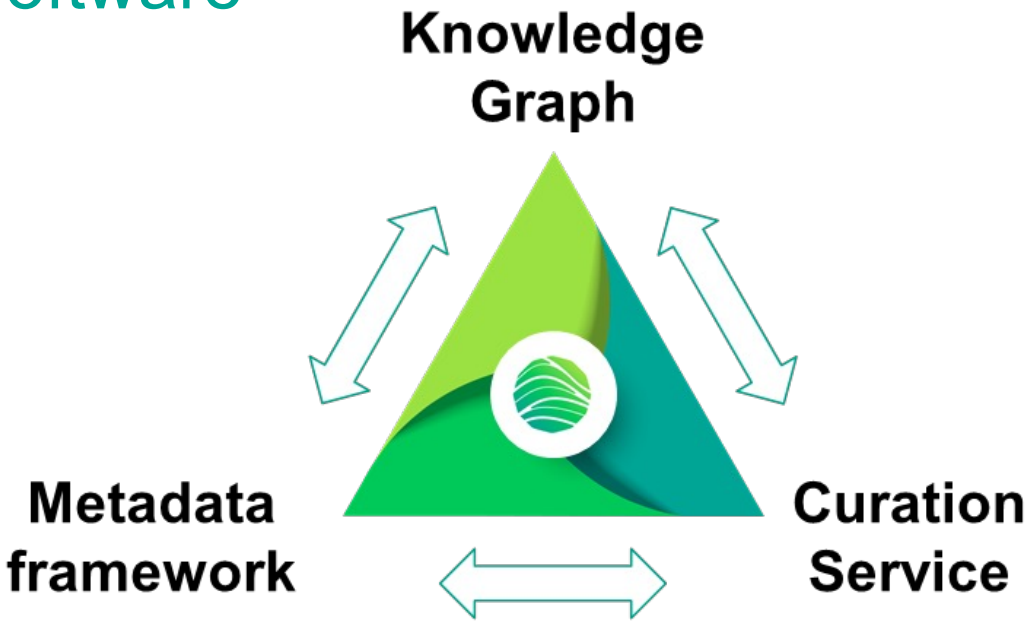
- FAIR data
- Collaborative platform
- Computing infrastructure

https://www.ebrains.eu

FAIR data and Knowledge with 3 main user facing services



Data and Knowledge services: SHARE and FIND Data, Models and Software



Graph database for metadata management

Controlled vocabularies and ontology-driven terminologies

Tools and workflows for data and metadata submission and quality control

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Data and Knowledge services: **SHARE**

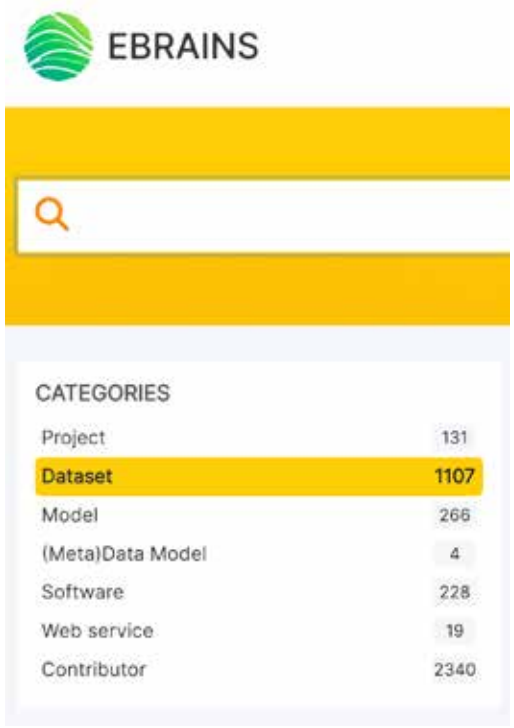
- High-profile online resource for publishing neuroscience data, models and software
- Metadata management support in line with the FAIR data principles
- Integration of the data in the EBRAINS Knowledge Graph via community-driven metadata standards and ontologies
- Compatible with other EBRAINS services, including visualisation tools and analysis workflows
- Citable DOI for your work
- Prepared for publication of data alongside scientific paper

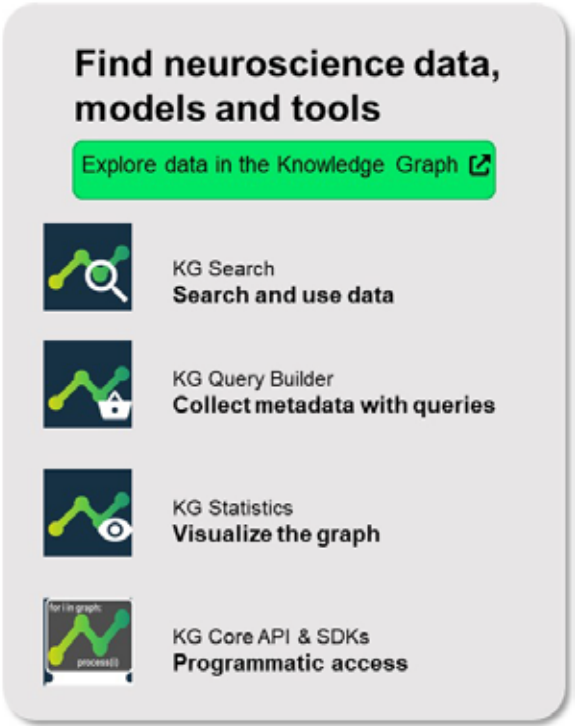
The SHARE service employs the ***openMINDS*** metadata framework

- standardized metadata descriptions for sharing neuroscience data
- facilitating the exchange of data within the neuroscience community
- ensuring that datasets are accompanied by rich, consistent, and machine-readable metadata

Data and Knowledge services: **FIND**

- Detailed search interface with faceted filters for species, experimental methods, brain regions etc.
- Find data, models and software based on contributors
- Resources connected by input-output relationships, e.g. raw data -> derived data
- Data files mapped to software for viewing and processing
- Advanced and automated search functions via the KG Query Builder & KG REST API





Google Dataset Search Beta

DataCite

Knowledge Space

EBRAINS RI: Open Science Tool Suites

Atlases

Medical analytics

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FAIR data

Collaborative platform

Computing infrastructure

https://www.ebrains.eu

EBRAINS Software Distribution (ESD)

Unified software ecosystem *that includes all EBRAINS tools (simulators, data analysis, visualization tools)*

- automated dependency management, consistent and reproducible software environments, versioned, tested releases, continuous validation of tool interoperability
- available to users on the EBRAINS Lab and HPC systems
- ESD container images, enabling user-deployed workspaces and facilitating HPC deployment process

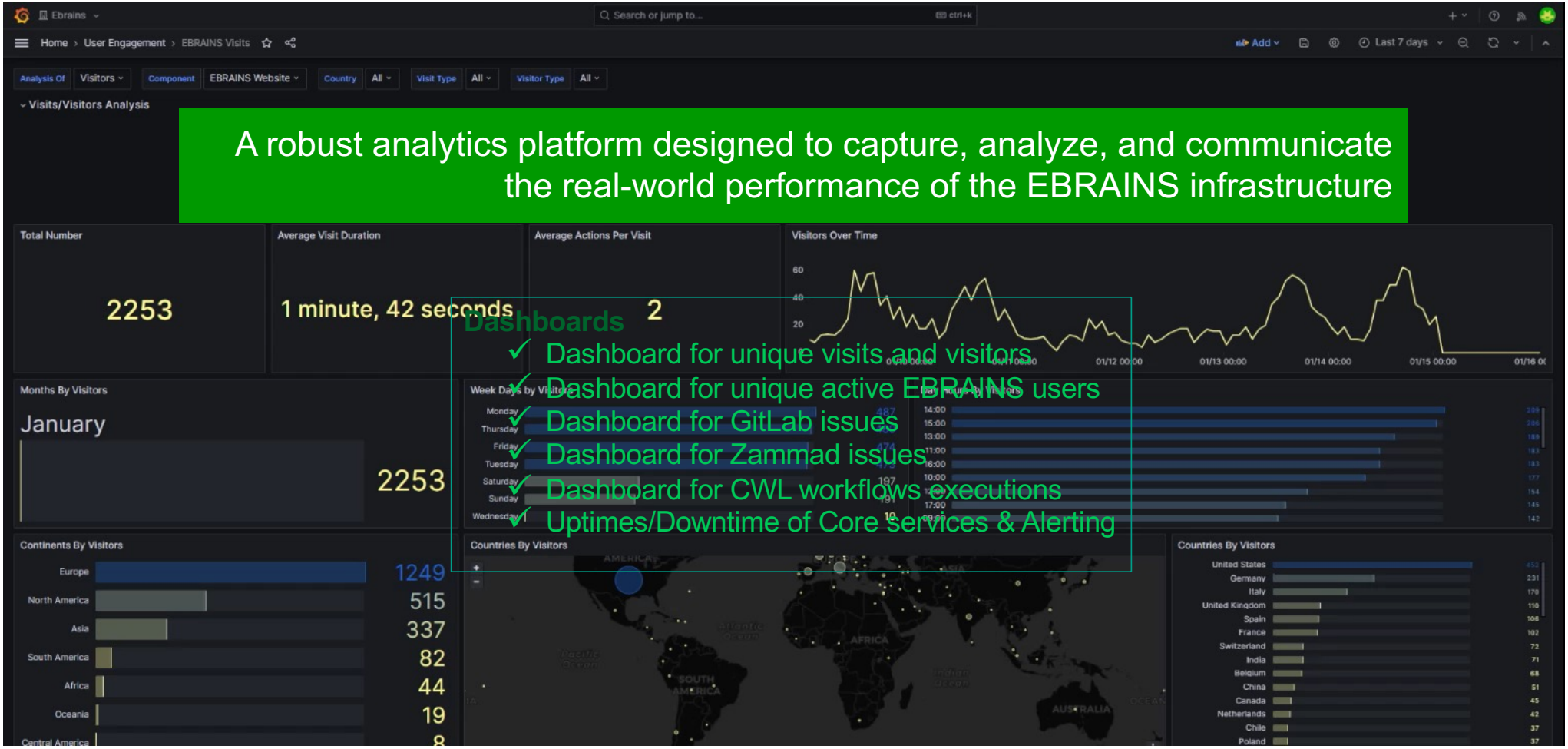
New Release in progress

EBRAINS-25.02

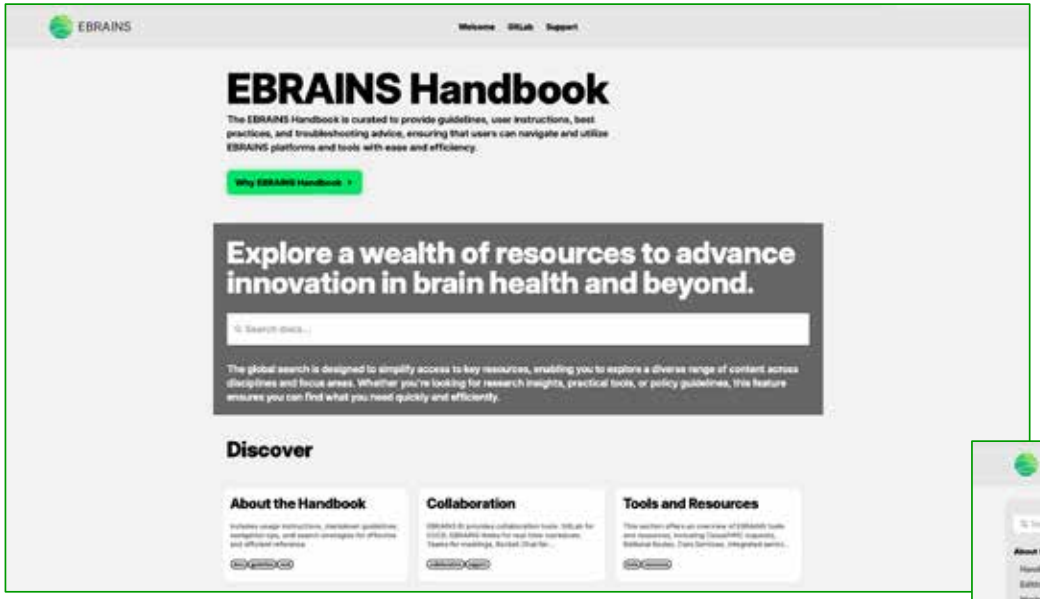
64 EBRAINS tools

Co-funded by the European Union

The Open Metrics Framework



The First Centralized EBRAINS Technical Handbook



https://handbook.ebrains.eu

A **centralized repository** for processes, tools, and best practices.

Released by the **Technical Coordination**

Q4 2024

EBRAINS RI: Open Science Tool Suites

- Atlases
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https://www.ebrains.eu

Base Infrastructure

Access to **base infrastructure**, including Cloud Resources, Storage, High-Performance Computing and Neuromorphic Computing Resources:

- Operation and maintenance of base infrastructure resources
- Allocation and management of resources for EBRAINS users (ebrains.eu/hpc)
- Development of standard processing workflows using the base Infrastructure
- EBRAINS Helpdesk

Highlights

EBRAINS Community Engagement:

- EBRAINS Support Team
- Google Summer of Code
- EBRAINS Software Distribution

Provisioning of Resources:

- HPC and Cloud
- Neuromorphic Computing (BrainScaleS and SpiNNaker)

Publications:

- Lu.i -- A low-cost electronic neuron for education and outreach, Yannik Stradmann, Julian Göltz, Mihai A. Petrovici, Johannes Schemmel, Sebastian Billaudelle, https://doi.org/10.48550/arXiv.2404.16664
- Closing the loop: High-speed robotics with accelerated neuromorphic hardware, Yannik Stradmann, Johannes Schemmel, http://dx.doi.org/10.3389/fnins.2024.1360122

OSCA2 „*Who's data is this anyway? …*“
Meet with the EESC **25 March 12-13:30**

- Jan Bjaalie EBRAINS2.0 Leadership Board
- Teresa Sanchís, Karen Jongsma, Cyril Pernet, Hervé Chneiweiss EEESC
  - Feedback on the WP specific Ethics Reports and follow up steps
  - Involving Users, Healthy Subjects, Patients? First Steps on a long road ahead
  - Beyond GDPR: The Ethic of Informed Consent and Thoughts on a Potential Standard for EBRAINS

Join, invite, collaborate on your WP Ethics Report!

Register via QR-Code or link:

https://us06web.zoom.us/meeting/register/2wG-MxiIQbChjee0n2rHDQ#/registration

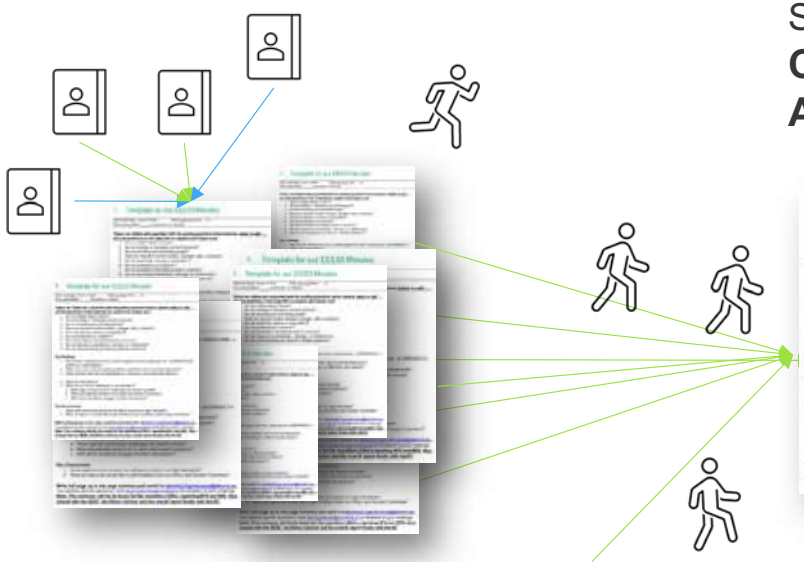
EEEDI Reporting is a continuous, beneficial process

EEEDI = ethics and gender equality, equity, diversity, inclusion

A „quick-check" support to identify potential topics for further reflection

List of Guiding questions provided, meetings and reports can be facilitated by Karin

5-10 min
Individual Reflection



30-60 min
Work Package
specific reflections
1 Page Report

Dialogue with EEESC
EBRAINS2.0 Ethics and Society Committee
Capacity Building, Action Plans

120 min
OSCA Open Space for Collaborative Achievements - all Work Packages

Living Document
WP specific reports
Summary of Actions Taken

M18, M35
Ethics Report
https://wiki.ebrains.eu/bin/view/Collabs/ebrains2-osca/Drive

What else to build a community?

Education & Training

- EBRAINS-wide Education Task Force
- Save the Date! 1st EBRAINS Student Conference, 11-13 March 2026, Nice
- Upcoming education events & available resources: https://www.ebrains.eu/page/education-and-training

Community Building

- First meeting of RI Wide User Strategy Task Force in February

Coordination with National Nodes

- National Node Agreements in progress

Facility Hubs

- Position Paper in progress - discuss salient points and gather feedback in Heidelberg

Publication highlight: Geminiani, A. et al. (2024), Interdisciplinary and collaborative training in neuroscience: Insights from the Human Brain Project Education Programme. Neuroinformatics. Springer.

Co-funded by the European Union

EBRAINS Open Calls – A warm welcome on board!

- Integrating a Neurovascular morphology database into the EBRAINS Human Brain Atlasa

- Imaging biomarkers of thrombosis as a support tool for endovascular therapy in ischemic stroke patients

- 3D Convolutional Neural Network for Parkinson's Disease

- Virtual brain twins for trajectories of Dementia with Lewy Bodies

- Integrating ALFA+ cohort study in EBRAINS for Neurodegenerative Research

- Sharing FAIR non-human primate data through EBRAINS

- High-resolution Rat Local Field Potential Atlas

- Bringing Marmoset to EBRAINS

EBRAINS

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EBRAINS 2.0

Thank you

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