Human Brain Project

EBRAINS

Human Brain Project & EBRAINS

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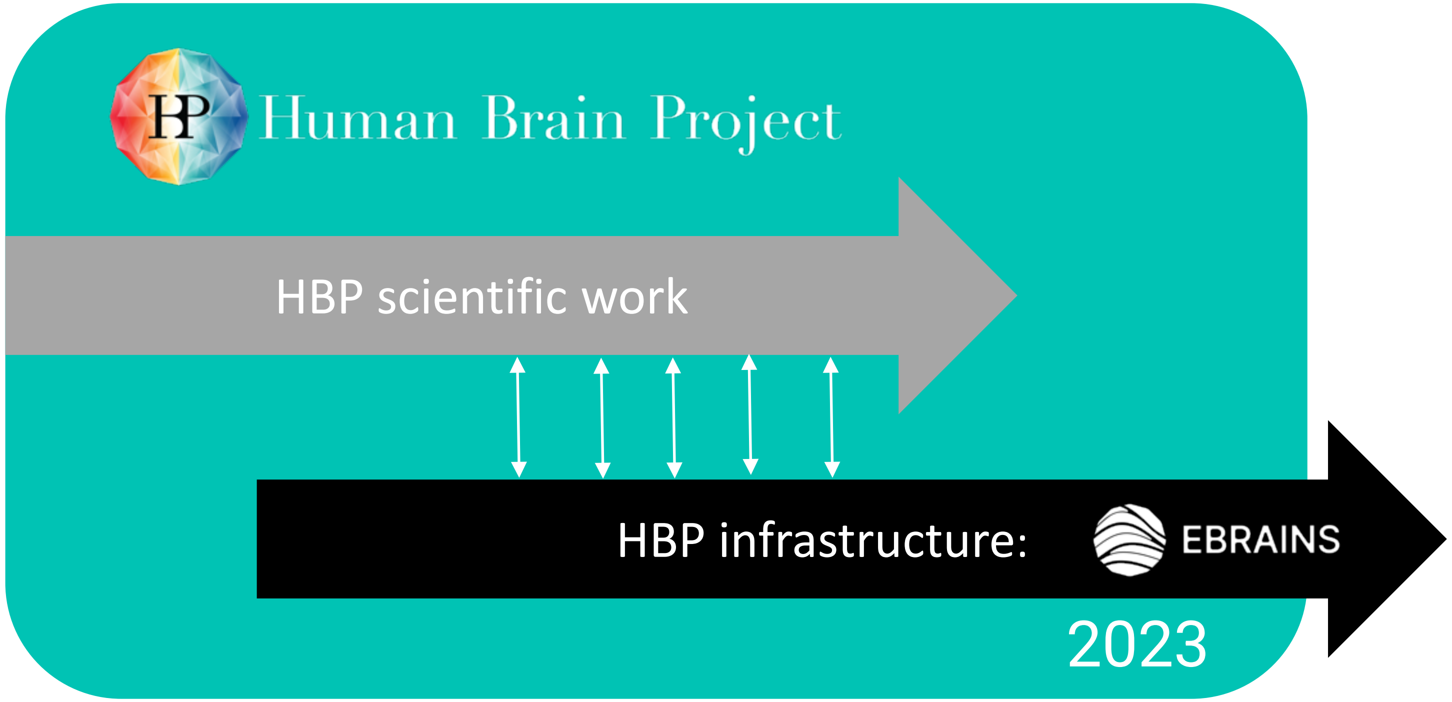
Inserm

EBRAINS enables brain research advances and innovation

EBRAINS was built by **the Human Brain Project and will continue beyond 2023 as its legacy**

HBP objectives

- Build better understanding of Brain Function
- Translate understanding into Brain Medicine
- Develop applications in Brain-derived technology

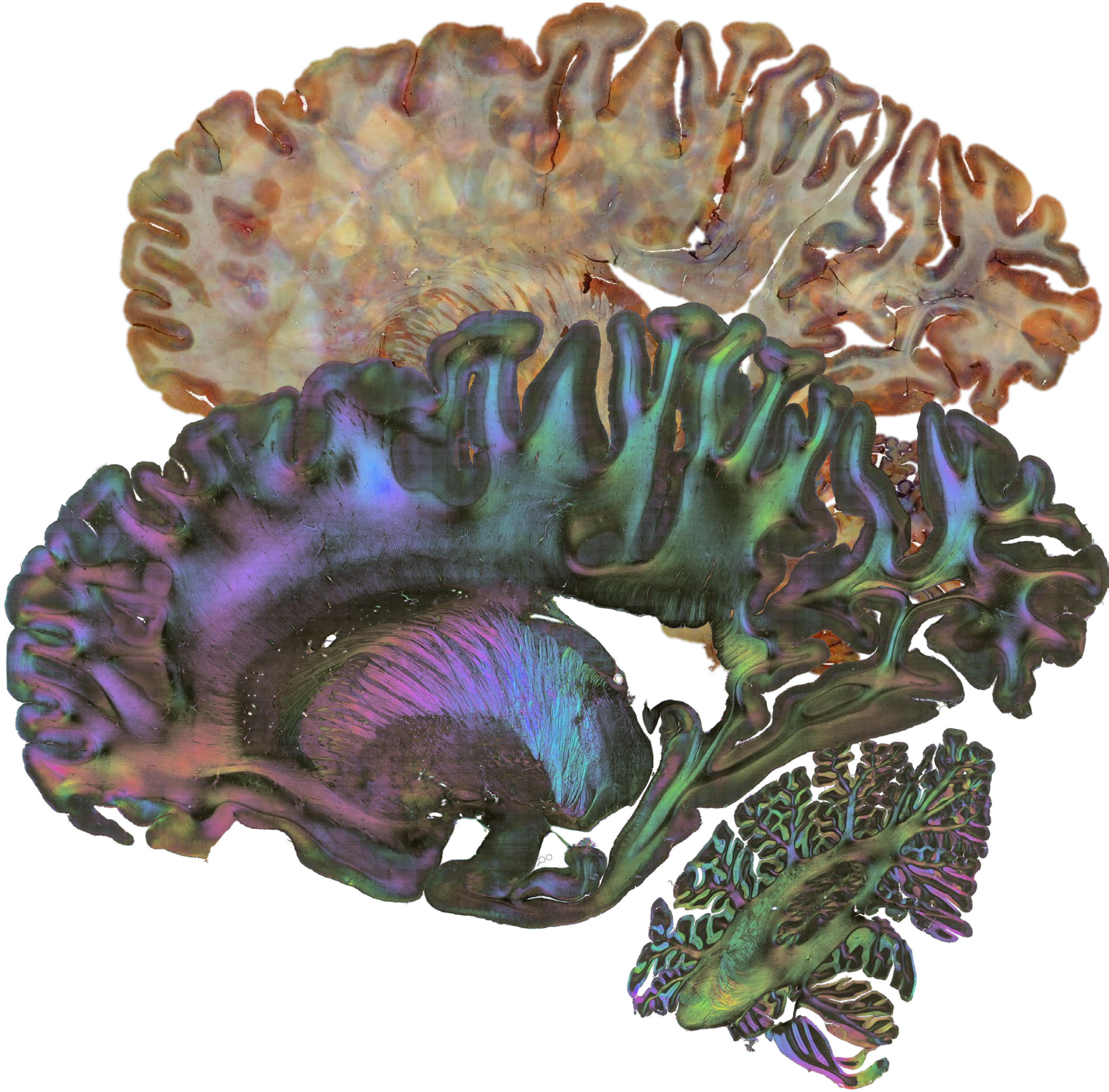


Key challenge

Multiscale

Mastering multiscale was at the core of the Human Brain Project

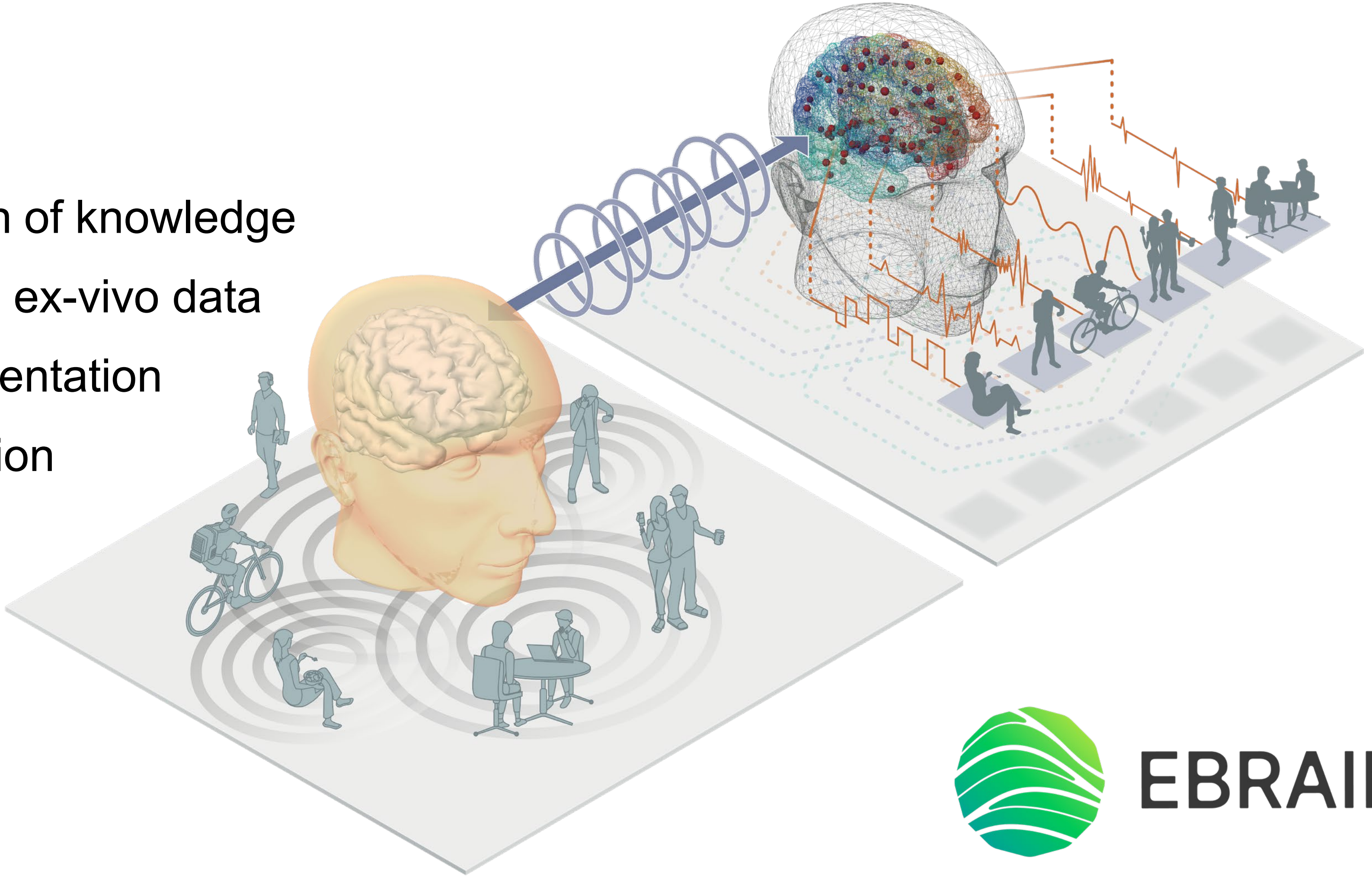
Integrating multiscale is the role of EBRAINS



Approach

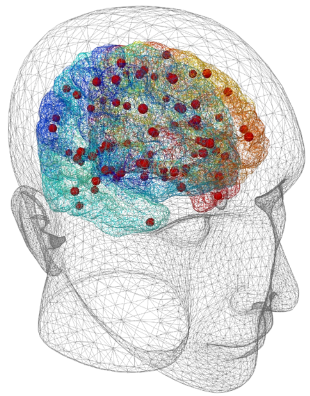
Digital Twin

- Digital representation of knowledge
- Fusion of in-vivo and ex-vivo data
- Cause-effect implementation
- Autonomous simulation



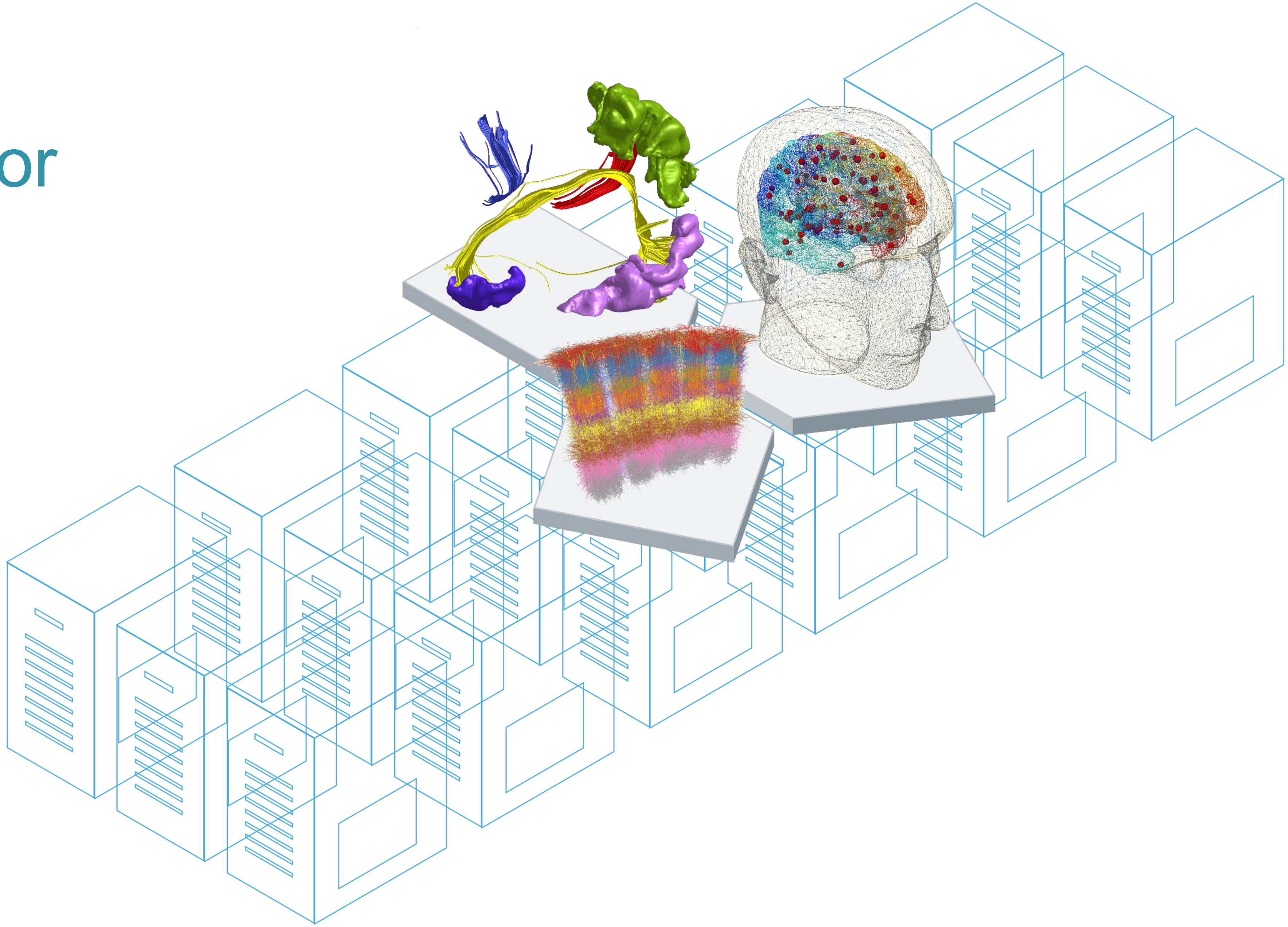
OUR GOAL

Building the Digital Twin Brain



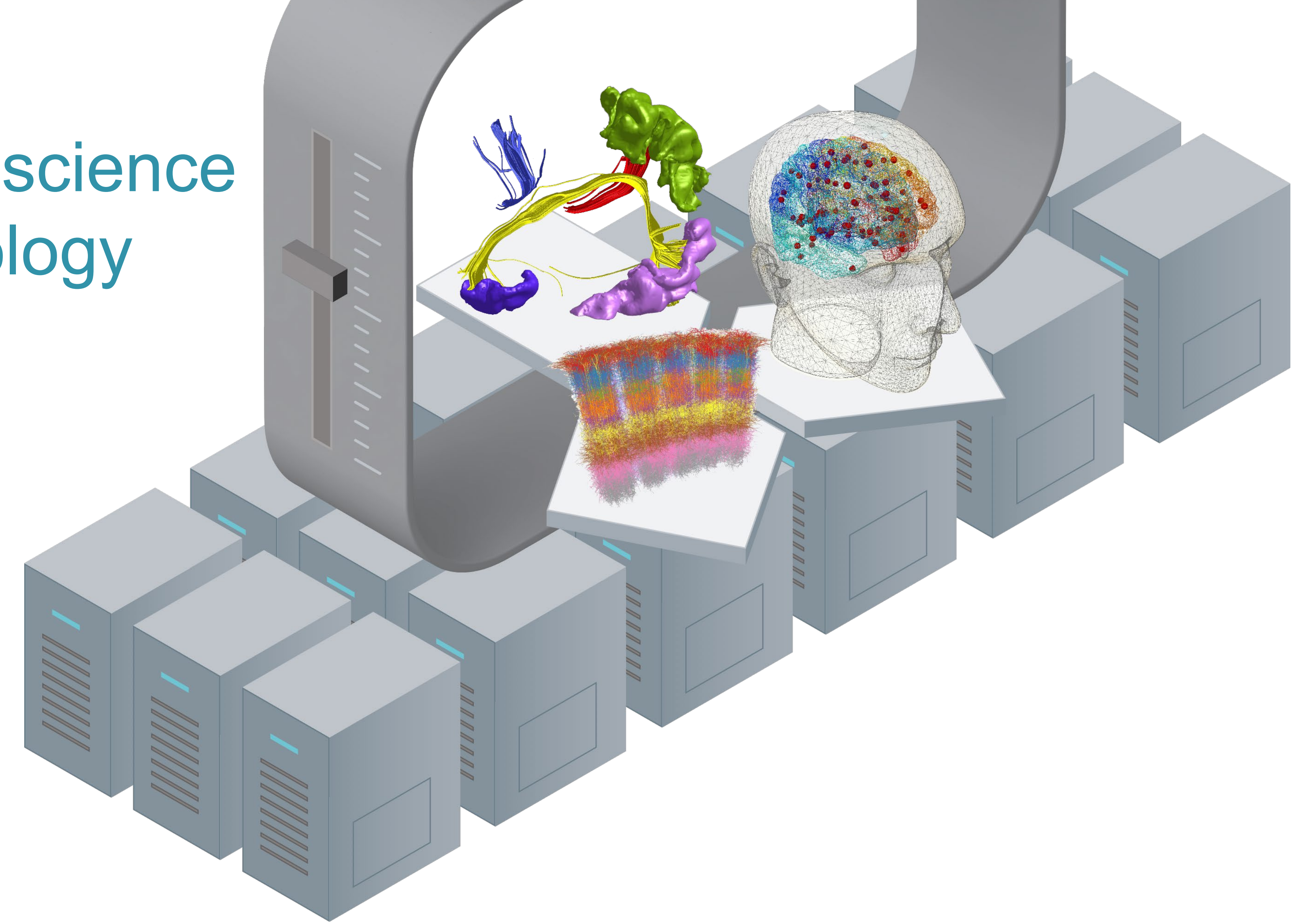
REQUIREMENTS

Support for multiple scales



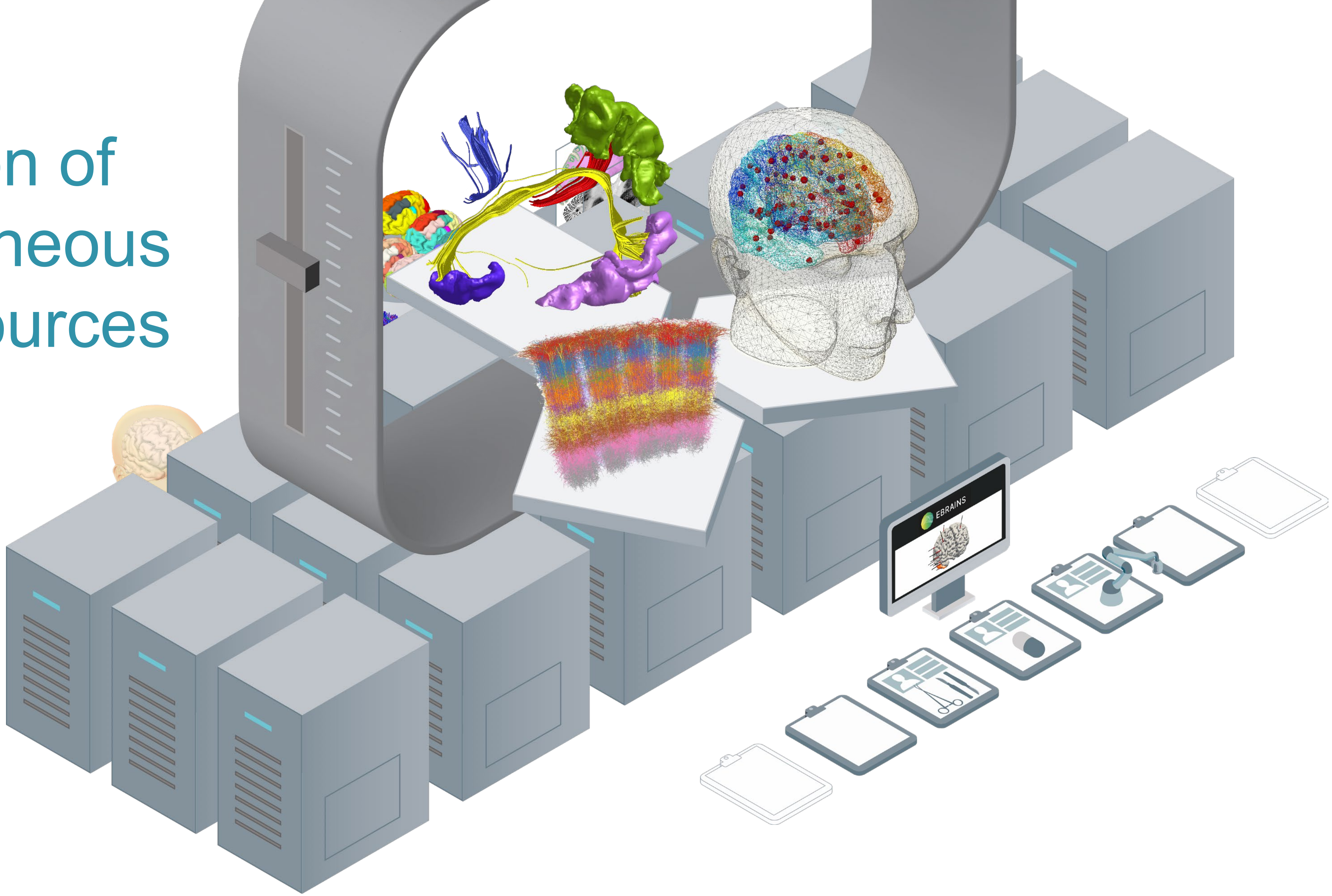
REQUIREMENTS

Merging science & technology



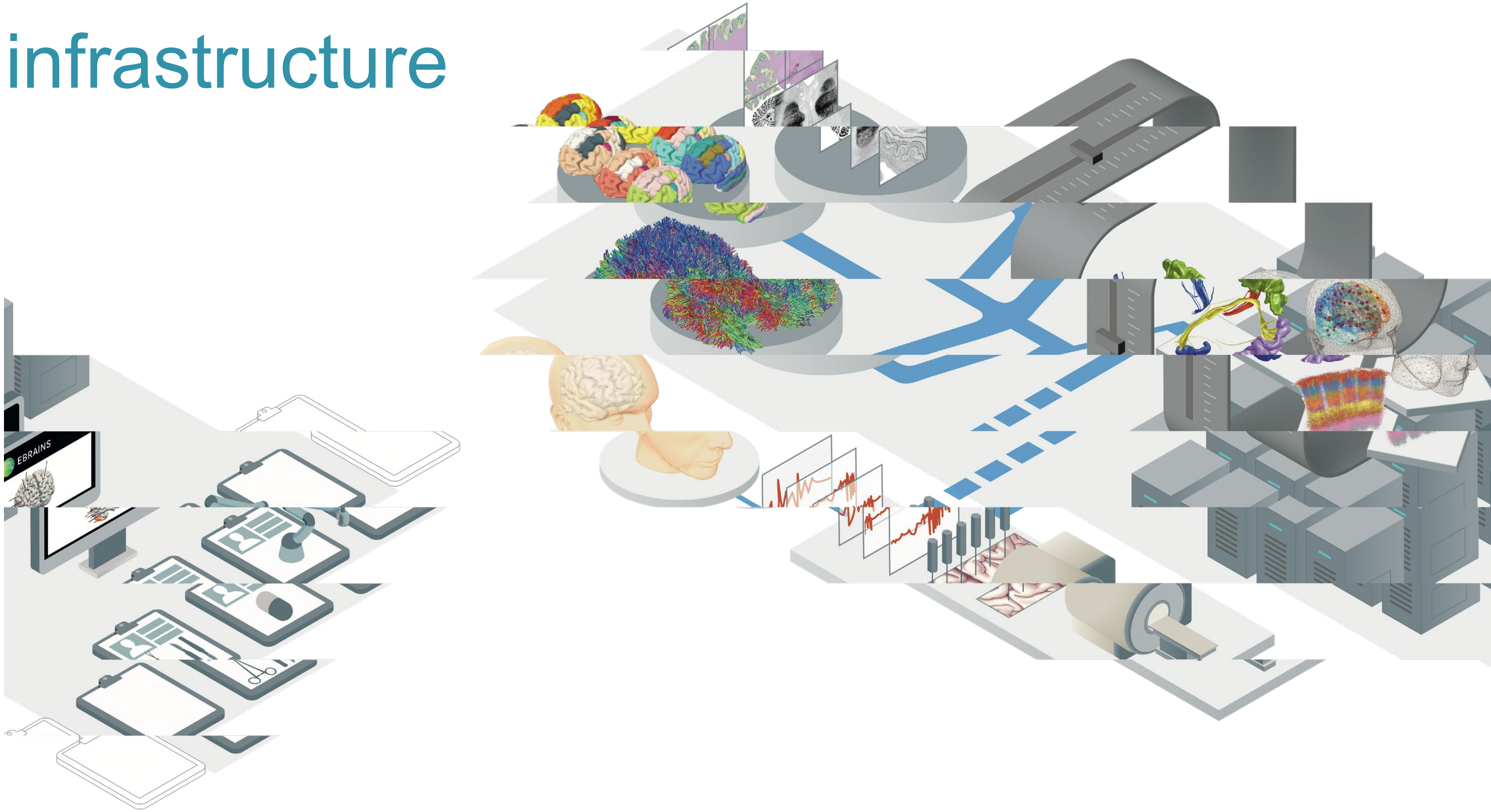
REQUIREMENTS

Integration of heterogeneous data & sources



A NEW PLATFORM

EBRAINS infrastructure



EBRAINS offers services navigating between Neuroscience and AI

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

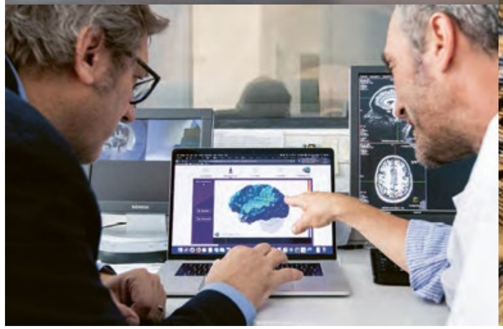
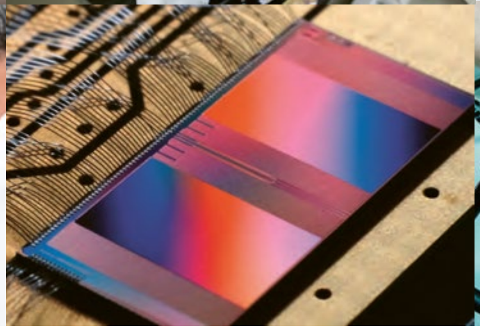
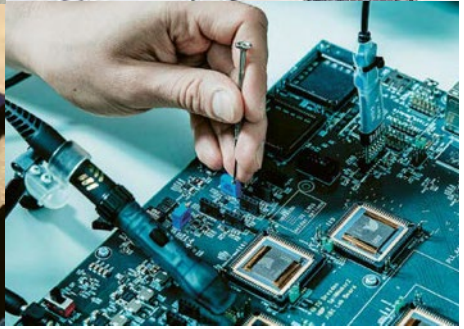
The Medical Data Analytics service provides two unique EBRAINS platforms, covering key areas in clinical neuroscience research

New implant offers promise for the paralysed
Rowald et al (2022). Nat. Med. 28(2): 260-271. doi: 10.1038/s41591-021-01663-5

Measuring consciousness
Goldman et al (2023). ront. Comput. Neurosci. https://doi.org/10.3389/fncom.2022.1058957

Powerful supercomputing for the community at large
Amunts, Lippert (2021). Science 374(6571):1054-1055. doi: 10.1126/science.abl8519



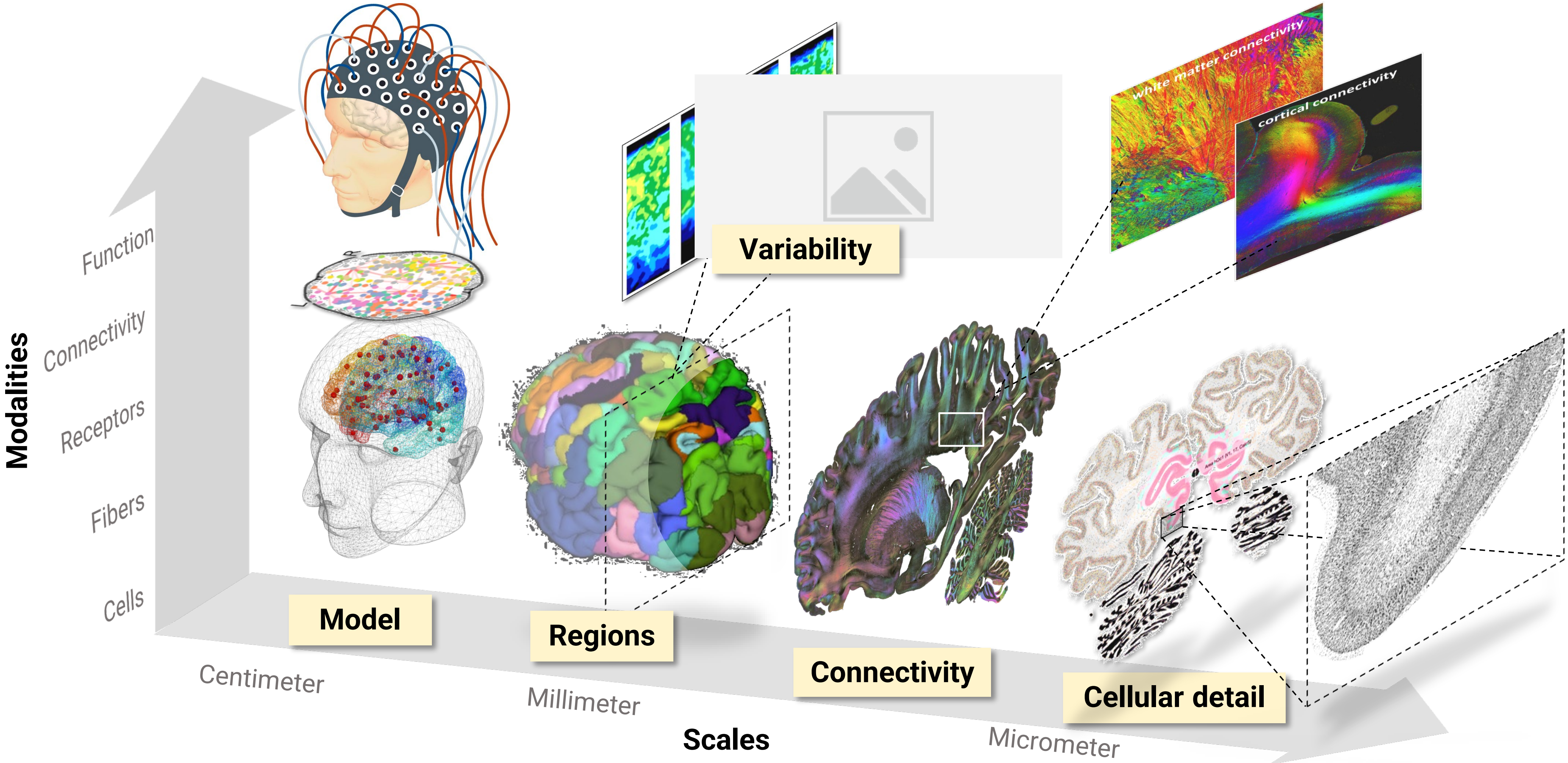





Improving health care with digital brain models
Jirsa et al (2023). Lancet Neurol. https://doi.org/10.1016/s1474-4422(23)00008-x

Mimicking the brain to make AI more energy-efficient
Yin et al (2023). Nat Mach Int https://doi.org/10.1038/s42256-023-00650-4

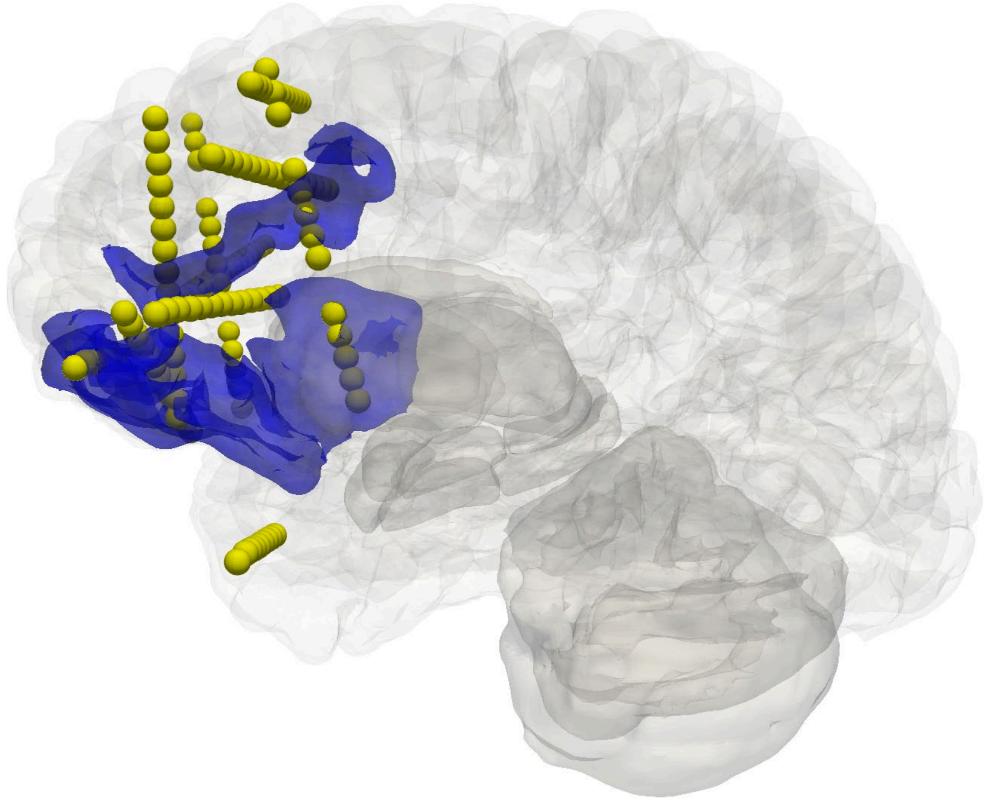
Progress in neuromorphic technologies
Bellec et al (2020).Nat. Commun. doi: 10.1038/s41467-020-17236-y

Anchoring in the multi-scale and multi-modal atlas



Use case: Epilepsy

- **Drug resistant focal epilepsies** are severe diseases affecting young people (1% of the world population, high morbidity and mortality)
- **Epilepsy surgery** is the only potential curative treatment and consists in the removal of the most epileptogenic brain regions
- Includes depth electrodes implantation to record the intracerebral EEG signals (stereoelectroencephalography, **SEEG**)
- Failures (complete or partial) in about 40% (particularly in extra temporal lobe epilepsy)
- No significant improvement of surgery success rate in 50 years



Blue: Clinical hypothesis for epileptogenic Zone (EZ)

Wang et al Science Trans Med (2023);
Jirsa et al The Lancet Neurology (2023)

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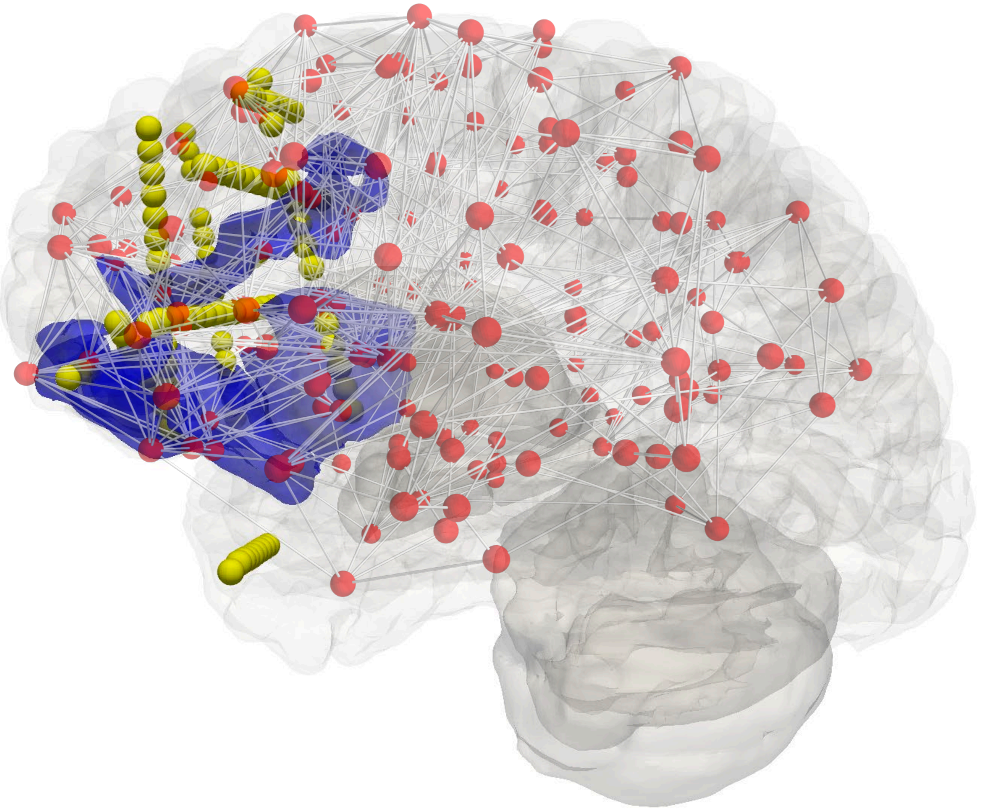

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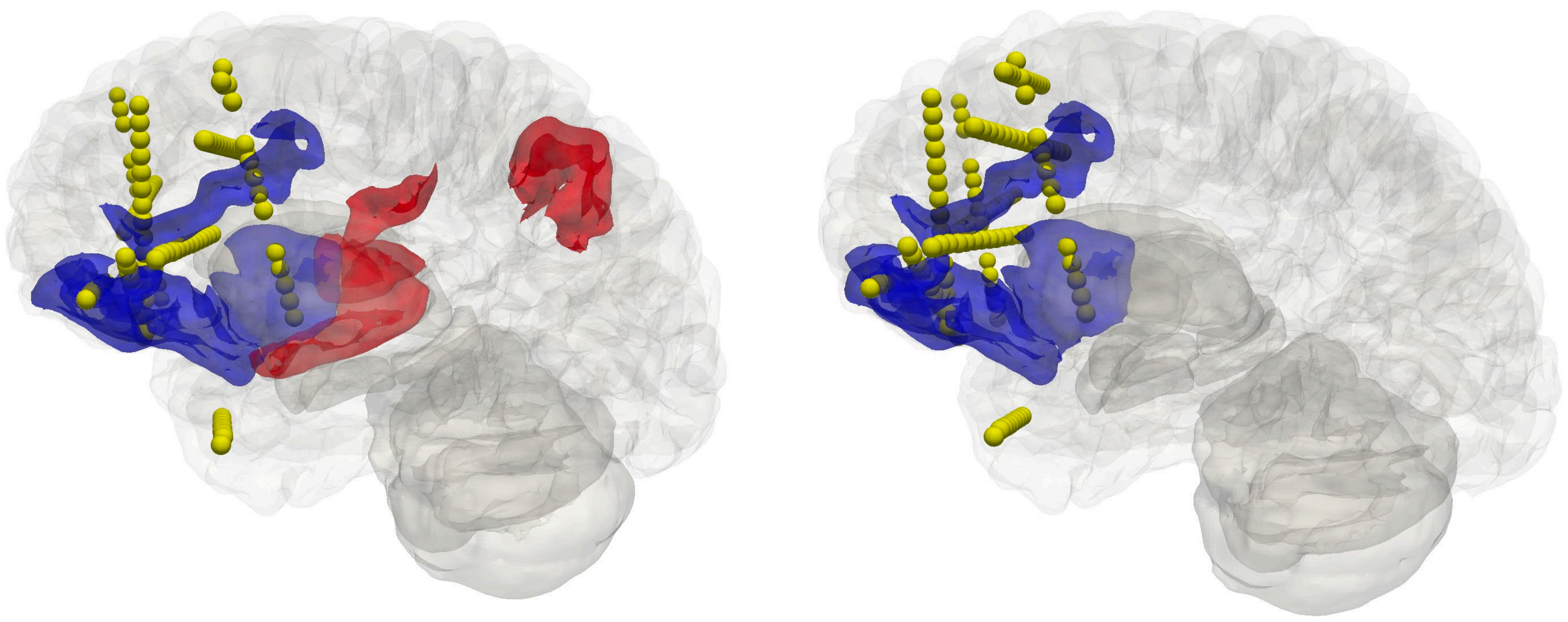

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Red: Additional EZ brain areas by virtual brain

Wang et al Science Trans Med (2023)
Jirsa et al The Lancet Neurology (2023)

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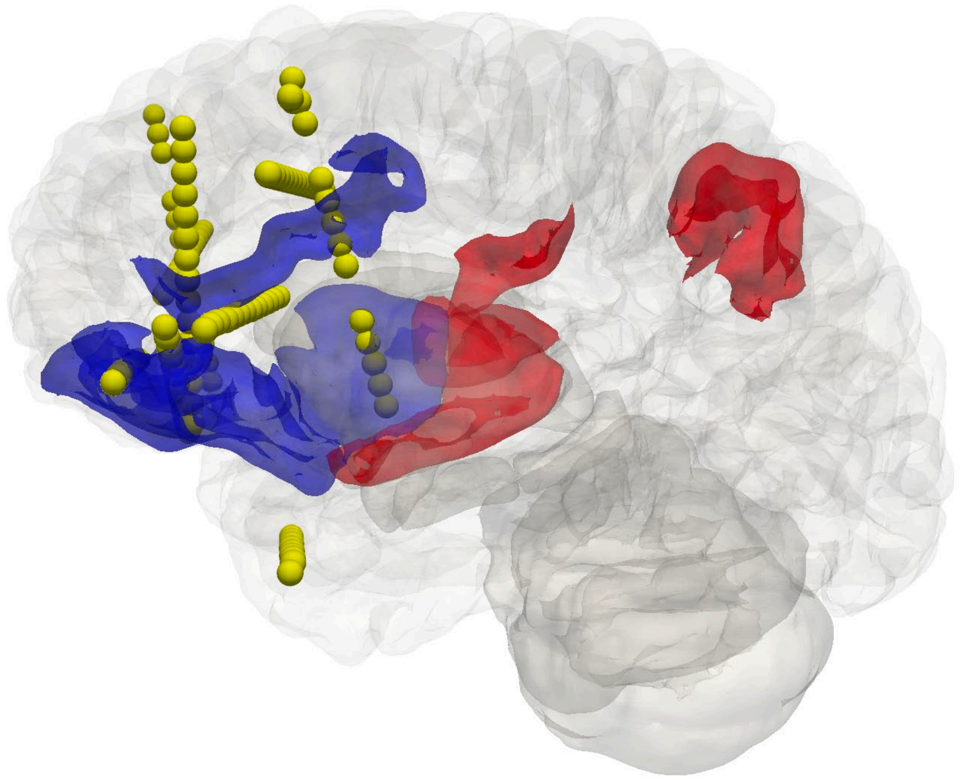

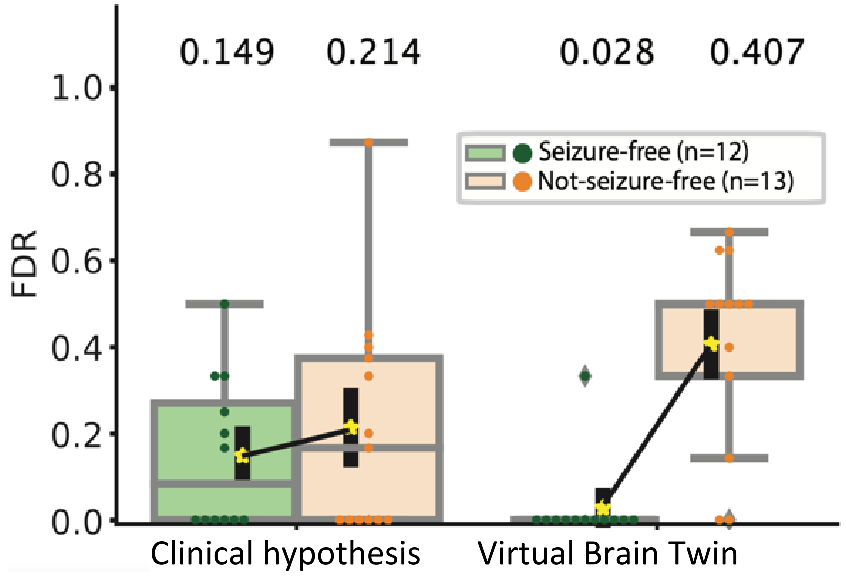

29% of all cases fall in the red EZ areas and are not accessible via SEEG

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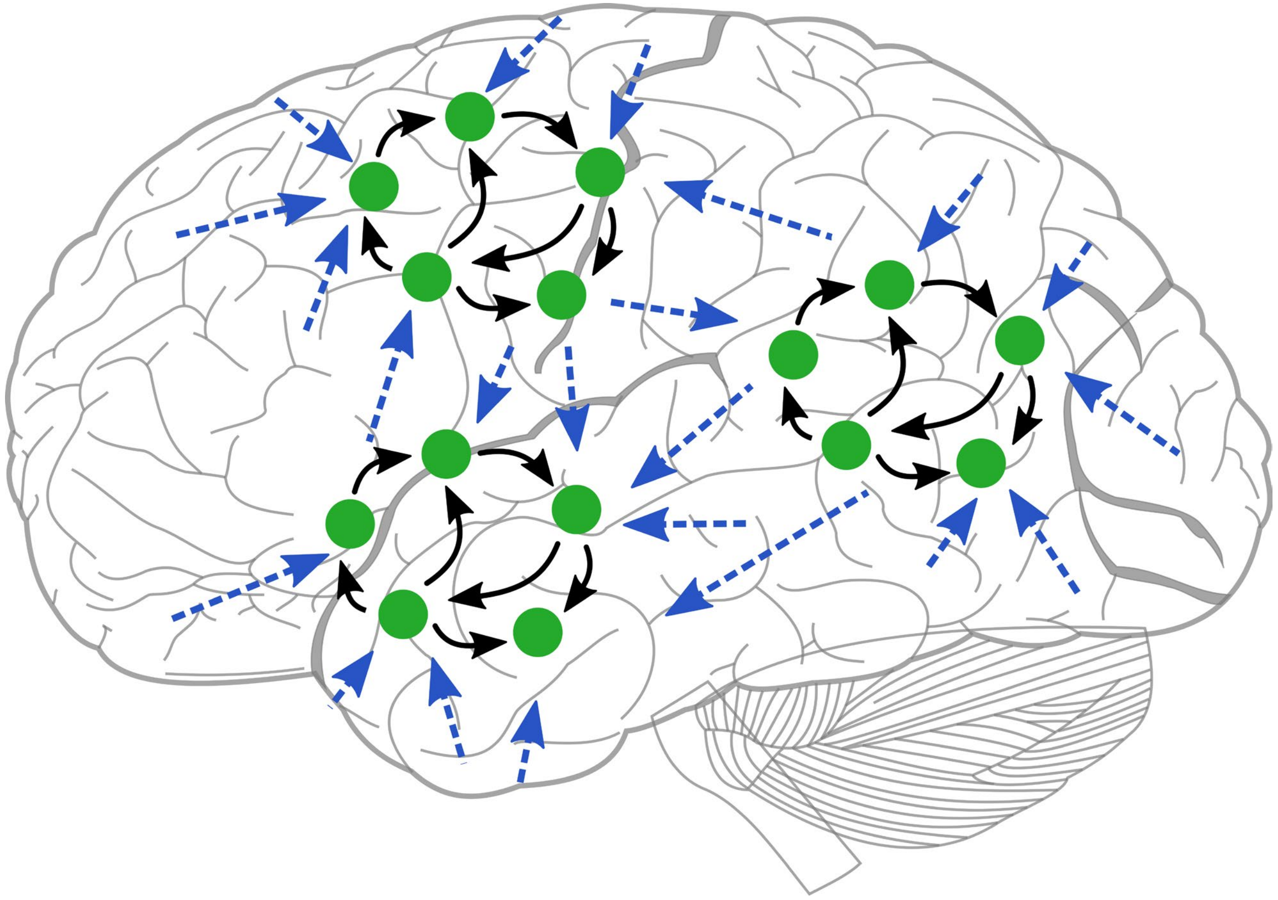
Red: Additional EZ brain areas by virtual brain

Wang et al Science Trans Med (2023)
Jirsa et al The Lancet Neurology (2023)

Use case: Brain-Inspired Cognitive Architectures

Objective: To emulate the architecture and operation of the brain in relevance to visuo-motor and selected cognitive functions, and to apply developed multi-area models to perform tasks in an embodied setting.

Main Goal: Learn about the brain from (embodied) brain-derived modelling.



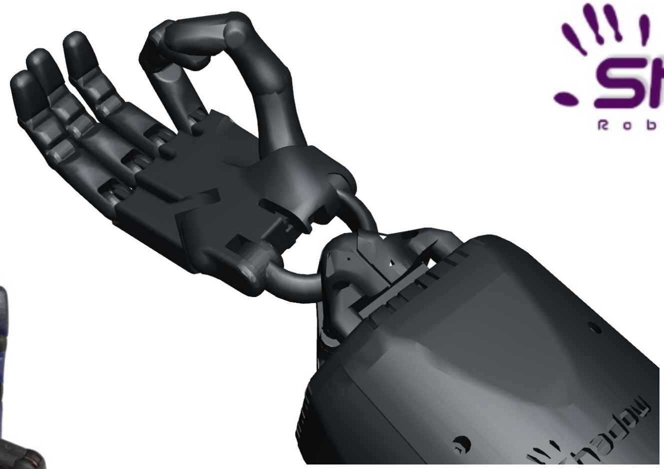
Use case: Brain-Inspired Cognitive Architectures

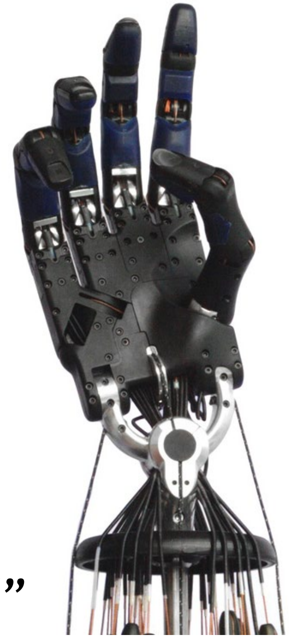
Anthropomorphic Robot Hand

- 24 joints
  - 2 in wrist
  - 5 in thumb
  - 5 in little finger
  - 4 in every other finger
- 20 degrees of freedom
- 92 touch sensors
- actuators move joints

“The World’s Most Dexterous Humanoid Robot Hand”

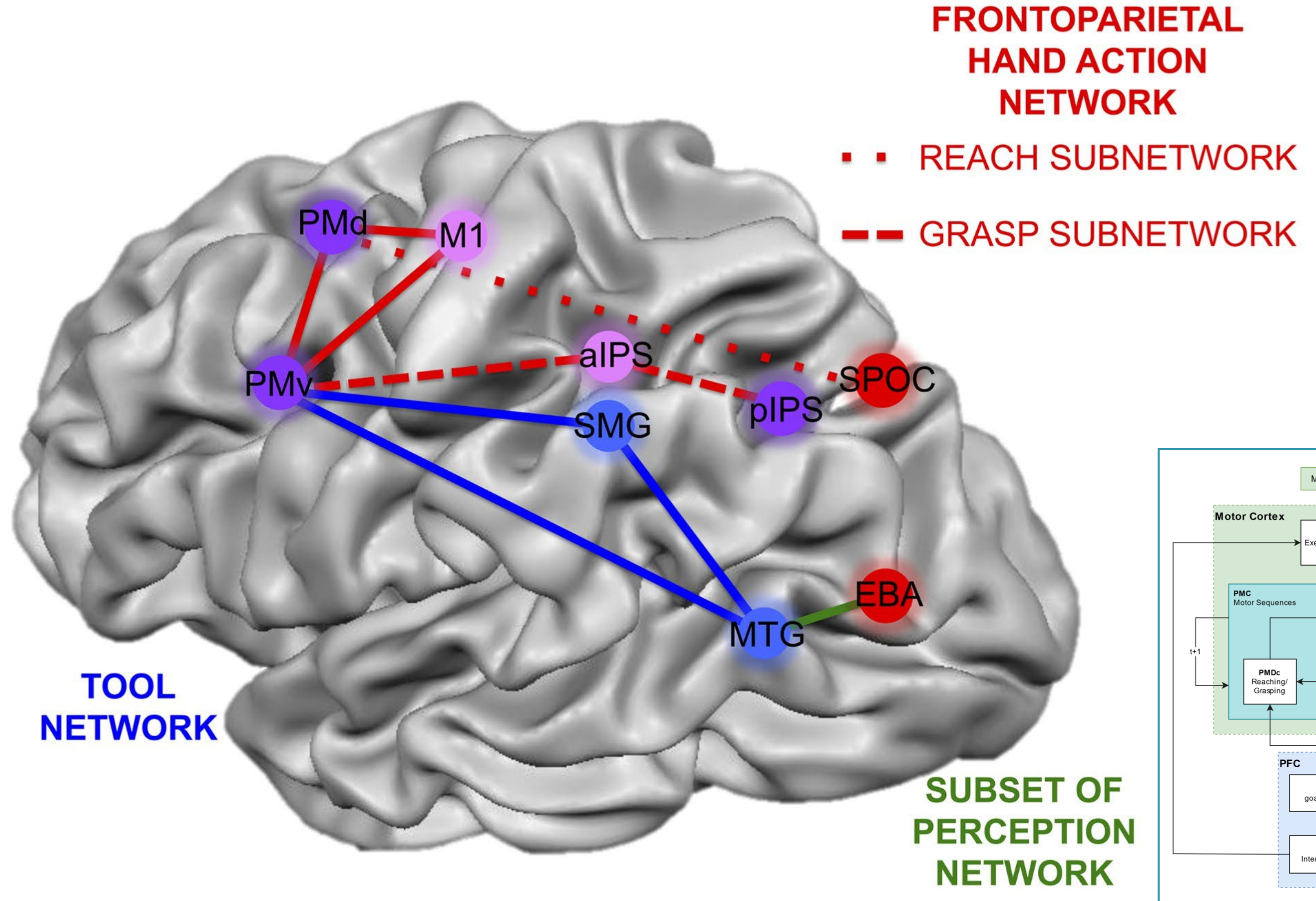
Shadow Robot Company





Use case: Brain-Inspired Cognitive Architectures

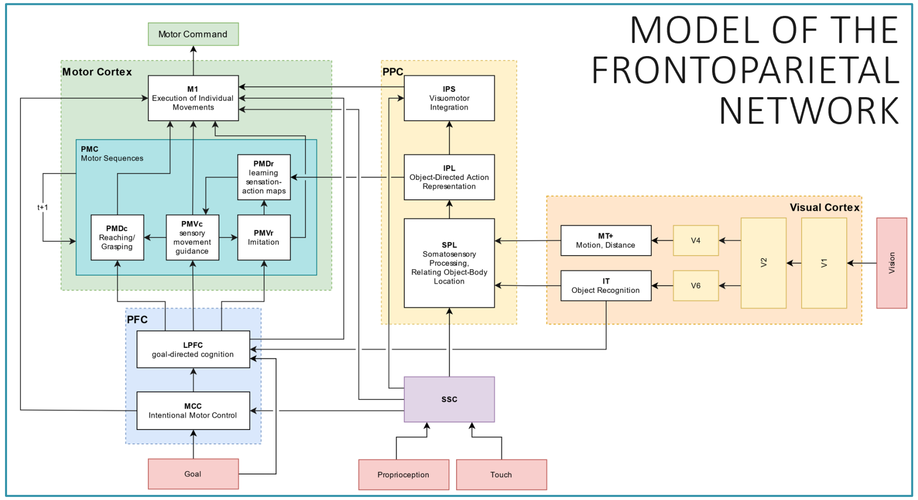
NEURO-TECHNOLOGY: fMRI → modeling → simulation → virtual robotics



Gallivan et al. (2013), eLife, e00425.

Preparatory Decoding

- Hand actions only
- Tool actions only
- Separate hand and tool actions
- Common hand and tool actions



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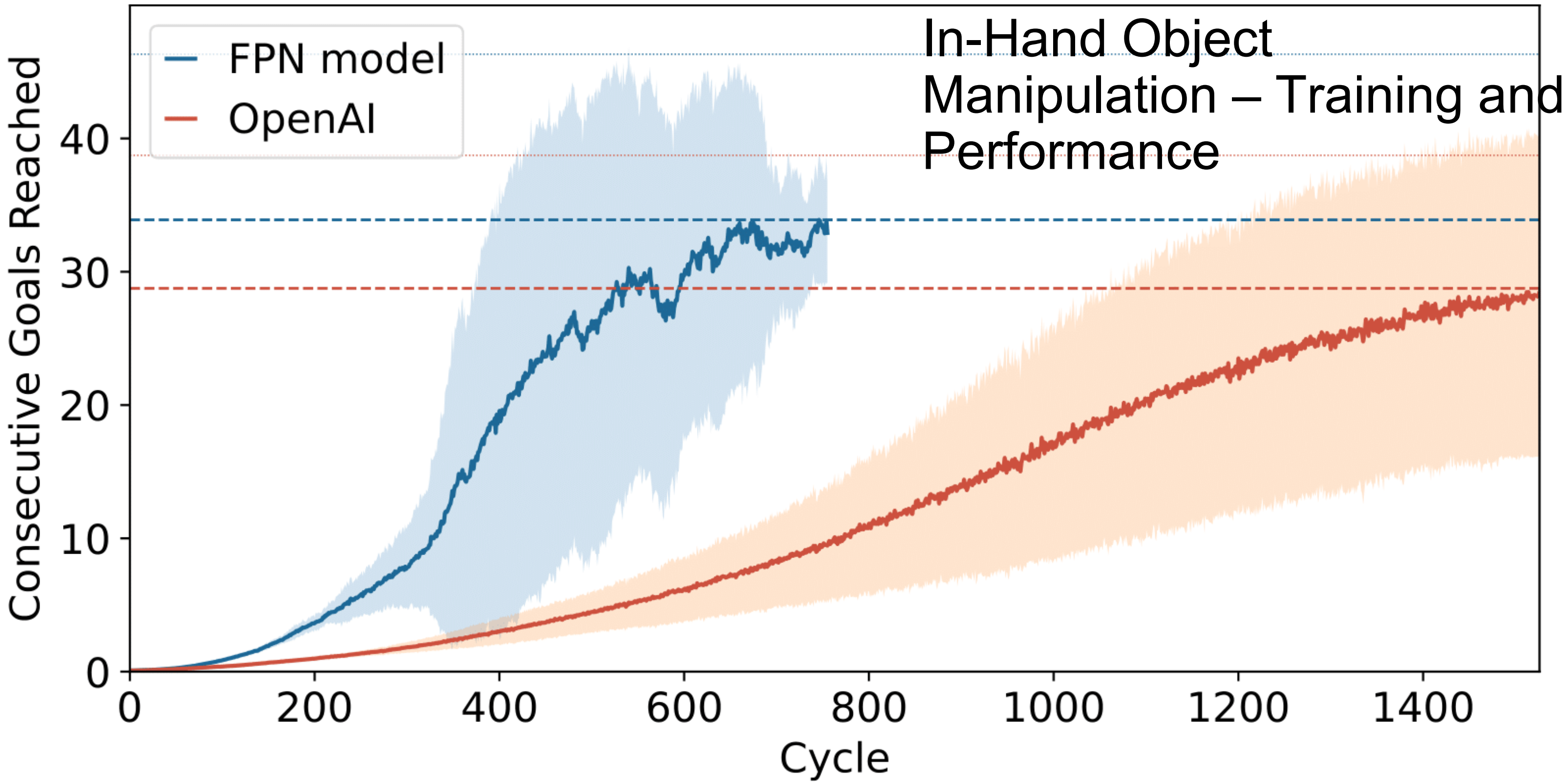

Performance of FPN model surpasses state-of-the-art model established by OpenAI both in terms of speed of learning and performance.

Human Brain Project

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NATIONAL ACADEMIES Sciences Engineering Medicine

Exploring the Bidirectional Relationship Between Artificial Intelligence and Neuroscience

The fusion of data, models, and tools generates knowledge that is not accessible otherwise.

“What I cannot create, I do not understand” – Richard Feynman

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Thank you

Prof. Katrin Amunts

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Prof. Philippe Vernier

Director of the Institut des Sciences du Vivant Frédéric-Joliot (France), Director of Research at Centre National de la Recherche Scientifique (CNRS) and Joint-CEO of the EBRAINS AISBL