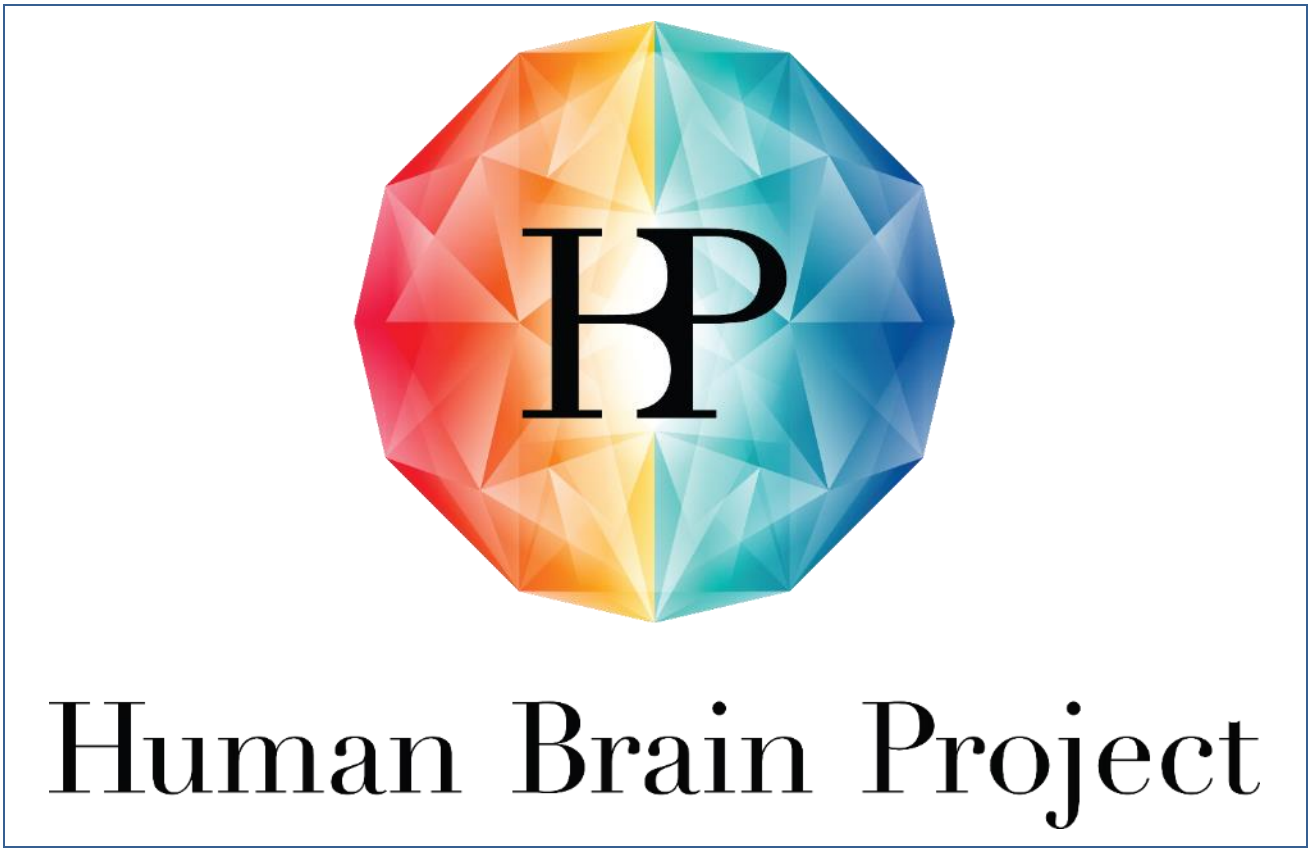
The HBP SGA3 Calls for Expression of Interest

Work Plan and Outcome Overview



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1. Introduction

The Human Brain Project (HBP) is set to transform neuroscientific research and culture of collaboration in Europe in the age of digitalisation, helping to decode one of the biggest mysteries: the human brain. Therefore, the HBP is developing and providing a European Infrastructure, the European Brain ReseArch INfrastructureS or EBRAINS. EBRAINS will allow creation of the necessary synergy between the (often fragmented) different national efforts to tackle one of the most challenging targets of research, the human brain. Such efforts are not only essential for obtaining a deeper understanding of the multi-level brain organisation, but are also highly relevant for decreasing the burden of brain diseases in an ageing population. What makes the HBP unique, however, is its approach towards computing the brain at the intersection of brain research, computing and technology: the HBP is aiming to compute the brain.

This document is a summary of the proposed Work Plan for the final phase of the HBP FET Flagship, or 3rd Specific Grant Agreement (SGA3), funding period April 2020- March 2023. The Human Brain Project Outcomes in SGA3 can be found in Annex: The Human Brain Project Outcomes in SGA3.

The science Work Packages (WP1, WP2 and WP3) are cross disciplinary, and make sure that neuroscientific research makes optimal use of EBRAINS, and contributes to its development. They comprise:

- The human multi-scale connectome and its variability (WP1)
- Networks underlying brain cognition and consciousness (WP2)
- Adaptive networks for cognitive architectures (WP3)

The infrastructure Work Packages (WP4, WP5 and WP6) comprise:

- EBRAINS Data Services (WP4), responsible for user support, hosting, the High-Level Support Team (HLST) and providing the HBP Data Curation and Data Sharing services and Atlases
- EBRAINS Modelling Services (WP5), responsible for modelling, simulation, a specialised medical informatics application and neurorobotics
- EBRAINS Computing Services (WP6), taking care of basic infrastructure with the High-Performance Computing and analytics, as well as neuromorphic computing

1.1 WP1 The human multiscale brain connectome and its variability - from synapses to large-scale networks and function

1.1.1 Description

WP1 aims to build a brain reference framework, comprising workflows that organise and map neuroscience data upon models, providing end-to-end modelling of multiscale neural activity of human brain networks via simulation and validation. WP1 is organised into 14 Tasks, which will perform activities in the same brain reference space, thus enabling interoperability.

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1.2 WP2 Networks underlying brain cognition and consciousness

1.2.1 Description

One of the aims of WP2 is to implement a data-driven complex model that carries out multiple cognitive tasks by the integration of differentiated cortical areas, characterised by realistic connectivity and detailed neural dynamics. Such a model should be able to perceptually represent stimuli in their spatiotemporal context, detect change, process surprise, and learn.

WP2 models will be integrated in WP1 global brain models (TVB), further enriching the structural connectome generated in WP1. WP2 cognitive model will be also at the base of the cognitive architectures used in WP3 and will be trained using learning principles developed by the WP2 and WP3 teams, involving prediction errors and principles of representation learning. A neuromorphic implementation of a restricted perceptual integration model will be built and its validity will be tested in an *in vivo* model of perceptual function.

Finally, a unique aspect will be the development of an advanced philosophical and ethical framework for the experimental and computational explorations of cognition and consciousness. This empirically based conceptual framework will include methods and criteria to analyse broadly relevant issues on the relationships between the emergence of complexity in networks and consciousness as well as between human and artificial intelligence.

1.2.2 Contact Persons

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1.3 WP3 Adaptive networks for cognitive architectures: From advanced learning to neurorobotics and neuromorphic applications

1.3.1 Description

This WP has the ambition to achieve a measurable step forward in our understanding of how biological learning networks enable human cognitive functions. This will be pursued by emulating the architecture and operation of the brain that support these functions and applying them to address visuo-motor and cognitive problems in an embodied setting and on neuromorphic platforms. This is made possible by the unique, complementary expertise in the project, synergies between the work undertaken in all three scientific WPs, and the functionalities provided by the EBRAINS RI. This combination of factors will allow the development of open cognitive architectures with an unprecedented combination of biological realism and efficacy of performance for a number of selected visuomotor and cognitive tasks.

1.3.2 Contact Persons

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1.4 WP4 EBRAINS Data Services

1.4.1 Description

WP4 supports the activities of the entire HBP and the broader neuroscience community by providing

- EBRAINS Data Services for organising, managing, visualising, analysing, and sharing multi-level and multi-modal research data, atlases and computational models (Service Categories 1, 2, and 5)
- Support for users of all EBRAINS services (Service Categories 1 – 6) through a Coherent User Experience team and through a Voucher programme
- Measures for inclusive EBRAINS community building

1.4.2 Contact Persons

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1.5 WP5 EBRAINS Modelling Services

1.5.1 Description

WP5 handles on one hand the implementation of modelling services, as per Service Categories 3 and 4, and delivers on the other hand the necessary e-Infrastructure for operating the Service Categories of the Project on the physical infrastructure allocated to them.

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1.6 WP6 EBRAINS Computing Services

1.6.1 Description

This Work Package will develop, deploy, integrate, and operate a variety of basic IT services within a distributed e-infrastructure. It integrates the HPC/Cloud computing and storage services of the Fenix infrastructure, which are made available through the ICEI project, and novel neuromorphic computing services. This diversity of services reflects the diversity of the needs of the brain research community. Major parts of the development efforts in this Work Package are related to the improvement of the current generation of neuromorphic system SpiNNaker-1 with integration into a joint infrastructure layer and of chip-based, BrainScaleS-2. During SGA3, the SpiNNaker-1 and BrainScaleS platforms will be used to support both large-scale scientific work, such as the functional modelling of multiple brain regions, and more application oriented developments in machine learning.

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1.7 WP9 Responsible Research and Innovation

1.7.1 Description

The major societal investment for the HBP is justified by the societal benefit it should generate for: Europe, its citizens, research, industry and other stakeholder and professional research communities. A significant part of these benefits will be realised by HBP's Research Infrastructure, designed to facilitate neuroscientific and related research and innovation. WP9 builds on past achievements of the HBP in developing a broad and comprehensive approach to Responsible Research and Innovation (RRI), in the HBP and in the resulting EBRAINS infrastructure.

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2. Service categories of the HBP Research Infrastructure in SGA3, April 2020 – March 2023

In SGA3, from April 2020 – March 2023, the HBP Research Infrastructure, called EBRAINS, comprises three pillars: Data, Models and Computing Infrastructure. Each is constructed around a **Work Package (WP)** and **six Service Categories** are offered.

These Work Packages are:

- WP4: EBRAINS Data Services
- WP5: EBRAINS Modelling Services
- WP6: EBRAINS Computing Services

The Service Categories (SCs) are:

- SC1: Curated and shared data: EBRAINS FAIR data services - neuroscience data publishing
- SC2: Brain atlas services: navigate the brain in 3D - find, contribute and analyse brain data, based on location
- SC3: Brain modelling and simulation workflows: integrated tools to create and investigate models of the brain
- SC4: Closed loop AI and robotics workflows: design, test and implement robotic and AI solutions
- SC5: Medical brain activity data platform: human intracerebral EEG database and analysis service
- SC6: Interactive workflows on HPC or NMC: Europe-wide access to scalable and interactive compute services

2.1 SC1: Curated and shared data: EBRAINS FAIR data services neuroscience data publishing

EBRAINS users will have access to comprehensive tools and services for shared data and computational models. The services provide long-term data storage, citable DOIs for data, defined conditions and licenses for use of data, tags to make the data discoverable, and additional metadata and descriptions making the data interpretable and re-usable. EBRAINS users can share their data through the FAIR data service and thereby obtain greater exposure of their research, or access the shared data assets and boost their productivity.

2.2 SC2: Brain atlas services: navigate the brain in 3D - find, contribute, and analyse brain data, based on location

EBRAINS brain atlas services will enable users to work with neuroscientific data according to well-defined 3D locations and regions of the brain, comparable to the way Geographical Information Systems (GIS) organise data in 2D maps of the Earth's surface. The services establish detailed 3D reference atlases of the human, non-human primate, and rodent brains that will be continuously enriched by a growing collection of multi-modal and multi-scale experimental data that are spatially linked in the reference atlases.

2.3 SC3: Brain modelling and simulation workflows: integrated tools to create and investigate models of the brain

EBRAINS integrated workflows at multiple scales allow users to perform complex computational experiments, including estimation of model parameters, model validation and large-scale simulations including analysis and visualization. Workflows addressing the needs of scientists across disciplines and levels of expertise will be accessible through pre-configured web applications or flexible digital notebooks.

2.4 SC4: Closed loop AI and robotics workflows: design, test and implement robotic and AI solutions

The EBRAINS Closed loop AI and robotics workflows service allows users to connect neural models (brains) with physical agents (bodies), to address tasks in a physically realistic environment. This allows neuroscientists to investigate model structure and function simultaneously. It affords robotics a direct connection to neuroscience, allowing exploring the use of functional (including spiking) neural models, supported by HPC resources and two different Neuromorphic Computing (NMC) platforms, to address problems in robotics and AI.

2.5 SC5: Medical brain activity data platform: Human intracerebral EEG database and analysis service

The Human Intracerebral EEG data Platform (HIP) is a unique EBRAINS infrastructure that will provide the scientific community access to the largest and most advanced solution worldwide for storing, curating, sharing, and analysing multiscale neurophysiological data directly recorded from the Human brain. By leveraging the capacity to generate new research projects based on human intracerebral EEG (iEEG) data through its large consortium of iEEG expert centres, HIP also provides a key deliverable for future researchers and the EU society.

2.6 SC6: Web-based, interactive workflows on HPC: Europe-wide access to scalable and interactive compute services

High-performance computing (HPC) has become an important aspect in neuroscience research, to process and analyse high-resolution data sets, or to simulate large and complex neuronal network models and analyse simulation and/or experimentation results. Neuromorphic Computing within the HBP complements HPC-based interactive workflows by providing access to different kinds of specialised hardware systems, targeting aspects of the emulation of spiking network models difficult to approach by standard simulation methods.

3. Annex: The Human Brain Project Outcomes in SGA3

Table 1: Human Brain Project Outcomes in SGA3

Human Brain Project Outcomes in SGA3
OC1. Thanks to the HBP achieving PO1, EBRAINS will facilitate access to and the enrichment of research tools, allowing constantly updated knowledge on brain function and brain-derived AI to be quickly shared across Europe, leading to a considerable increase in the amount of scientific data, educational material and research on advanced AI produced by the communities.
OC2. Thanks to HBP activities that support massively parallel execution of virtual experiments on high-performance computers (including modelling and simulation of the brain as well as neurorobotics), basic brain science will explore new avenues and new industry-driven research will be launched on devices such as implants and prostheses, as a direct outcome of PO1, PO3 and PO5.
OC3. Thanks to EBRAINS simulation services (including their many analytical workflows (PO3) and data security measures), there will be a rapid change in how the brain research community manages and uses its data and, consequently, an increase in research into multi-level brain complexity (in space and time), hopefully leading to related new discoveries.
OC4. Thanks to EBRAINS Atlas tools for combining, analysing and integrating brain data in 3D space (PO2), interventions in patients' brains will be better guided. In particular, thanks to the Human Brain Atlas, neurologists and neurosurgeons in clinical practice will be able to develop a wide range of tools for preparing personalised brain models for patients undergoing surgery (such as the TVB application for epilepsy patients). They will also start to provide software for stereotaxic interventions, such as deep brain stimulation (DBS) in patients with Parkinson's, or to support surgery on brain tumors, by providing microstructurally plausible information on target brain regions.
OC5. Thanks to the building blocks offered by the EBRAINS Neurorobotics Platform (PO1), roboticists will be supported throughout the whole robot development process; from initial design, to simulation for the development of controllers, through to the final 3D print. As a result, they will be able deliver new, low-cost, special-purpose robots built on demand; particularly for medical use-cases, where they might simply be discarded after a single use.
OC6. Thanks to the HBP's contributions and leading role envisaged in PO7, the International Brain Initiative will deliver solid neuroethics guidance to neuroscience projects in the world; in particular, regarding the ethics of large neuroscience research infrastructures.
OC7. Thanks to HBP findings, including theoretical models and related simulations, new clinical settings will be explored to assess the level of consciousness in patients with consciousness disorders (e.g. comatose patients) and sets of information will be proposed for supporting prognosis and therapeutic decision-making (PO4, PO6).
OC8. Thanks to HBP efforts in translating neuroscientific knowledge into medicine (PO6), a new clinical procedure will be trialled for epilepsy patients, building on the current EPINOV study in France, and a multi-centre, preclinical study of rare diseases will be launched.
OC9. Thanks to EBRAINS making available new, high-performance, closed-loop functions based on insights into human cognition (PO5), industry will be able to develop advanced prototypes for industrial and service robots, advanced autonomous systems, or protheses, e.g., for the visually impaired.