

*The HBP Calls for Expression of Interest for SGA3*

*The SGA3 Proposal - Summary*



Human Brain Project

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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 digitalization, 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 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 2020-2023.

The science Work Packages (WP1, WP2 and WP3) will be cross disciplinary, and make sure that neuroscientific research is making optimal use of EBRAINS, and contributes to its development. They will comprise: The human multi-scale connectome and its variability (WP1), Networks underlying brain cognition and consciousness (WP2), and Adaptive networks for cognitive architectures (WP3).

The infrastructure Work Packages (WP4, WP5 and WP6) will 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, and EBRAINS Computing Services (WP6), taking care of basic infrastructure with the High-Performance Computing and analytics, as well as neuromorphic computing.

## 1.1 WP01 The human multiscale brain connectome and its variability - from synapses to large-scale networks and function

### 1.1.1 Description

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

### 1.1.2 Contact Persons

**WP Leader:** Viktor Jirsa (viktor.jirsa@univ-amu.fr)

**WP Deputy leaders:** Egidio D' Angelo (dangelo@unipv.it)

Svenja Caspers (s.caspers@fz-juelich.de)

Alain Destexhe (destexhe@unic.cnrs-gif.fr)

**WP Managers:** Lisa Otten (lisa.otten@univ-amu.fr)

Anastasia Eghiaian (anastasia.eghiaian@univ-amu.fr)

## 1.2 WP02 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, characterized 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 analyze 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

**WP Leader:** Maria-Victoria Sanchez Vives (msanche3@clinic.ub.es)

**WP Deputy leader:** Cyriel Pennartz (c.m.a.pennartz@uva.nl)

**WP Managers:** Patricia Carvajal-Vallejos (pkcarvajal@clinic.cat)  
Angelica da Silva Lantyer (a.dasilvalantyer@uva.nl)

## 1.3 WP03 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

**WP Leader:** Rainer Goebel (r.goebel@maastrichtuniversity.nl)

**WP Deputy leader:** Sacha Van Albada (s.van.albada@fz-juelich.de)

**WP Manager:** Victoria Neumann (victoria.neumann@in.tum.de)

## 1.4 WP04 EBRAINS Data Services

### 1.4.1 *Description*

WP4 supports the activities of all of 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*

**WP Leader:** Jan Bjaalie (j.g.bjaalie@medisin.uio.no)

**WP Deputy leaders:** Timo Dickscheid (t.dickscheid@fz-juelich.de)

Anna Kreshuk (anna.kreshuk@iwr.uni-heidelberg.de)

**WP Managers:** Sofia Strand (s.a.strand@medisin.uio.no)

Roman Volchenkov (EBRAINS manager, roman.volchenkov@medisin.uio.no)

Martha Elisabeth Brigg (m.e.brigg@medisin.uio.no)

## 1.5 WP05 EBRAINS Modelling Services

### 1.5.1 *Description*

Work Package 5 handles on one hand the implementation of modelling services, as per SC3 and SC4, and on the other hand it delivers the necessary e-Infrastructure for operating the service categories of the project on the physical infrastructure allocated to them.

### 1.5.2 *Contact Persons*

**WP Leader:** Yannis Ioannidis (yannis@di.uoa.gr)

**WP Deputy leaders:** Fabrice Morin (morinf@in.tum.de)

Susanne Kunkel

**WP Managers:** Evita Mailli (e.mailli@di.uoa.gr)

Anne Elfgen (Deputy Manager)

## 1.6 WP06 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 platform 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.

## 1.6.2 Contact Persons

**WP Leader:** Thomas Lippert (th.lippert@fz-juelich.de)  
**WP Deputy leaders:** Steve Furber (steve.furber@manchester.ac.uk)  
Dirk Pleiter (d.pleiter@fz-juelich.de)  
**WP Managers:** Anna Lührs (a.luehrs@fz-juelich.de)  
Björn Kindler (bjoern.kindler@kip.uni-heidelberg.de)  
Boris Orth (b.orth@fz-juelich.de)  
Anne Carstensen (a.carstensen@fz-juelich.de)

## 1.7 WP09 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 portion 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 RRI, in the HBP and in the resulting EBRAINS infrastructure.

### 1.7.2 Contact Persons

**WP Leader:** Lise Bitsch (lb@tekno.dk)  
**WP Deputy leader:** Arleen Salles (arleensalles@gmail.com)  
**WP Manager:** Sara Christina Martinez

## 2. Service categories of the HBP Research Infrastructure in the next funding period starting 2020

In the next funding period starting in 2020 the HBP Research Infrastructure, called EBRAINS, will comprise three pillars:

Data, Models and Computing Infrastructure. Each will be constructed around a **Work Package (WP)** and **six Service Categories** will be offered.

**The 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

## **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.

## **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) organize 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.

## **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.

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

The EBRAINS Closed-Loop Neuroscience 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.



## **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.

## **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 for simulating large and complex neuronal network models and analysing the simulation and/or experimentation results. Neuromorphic Computing within HBP complements the HPC-based interactive workflows by providing access to different kinds of specialized hardware systems, targeting aspects of the emulation of spiking network models difficult to approach by standard simulation methods.