Publishable Summary for the Periodic Report

Ramp-Up Phase (M1-12)

Overview. As described in greater detail below, the HBP achieved all its main objectives for the first reporting period, achieving a high public profile, and publishing more than a hundred high profile scientific articles. The three Subprojects dedicated to data analysis (SPs 1-3) created detailed plans for future experimental work, defined the required experimental methods and protocols, recruited subjects for experiments, obtained necessary ethical approvals and began experimental work, leading to important publications. In the Theory Subproject (SP4), the European Institute for Theoretical Neuroscience began operation in April 2014. Members of the Subproject created detailed plans for modelling work and began to implement the plans. The six Subprojects dedicated to creating the HBP Platforms (SP5-10) completed specifications for their respective Platforms and for a Unified Portal (UP) providing a single point of access and a unified User Interface for all the Platforms. The Subproject dedicated to High Performance Computing (SP7) completed the first phase of the Pre-Commercial Procurement Process, which will lead to the purchase of a large supercomputer supporting the other HBP Platforms. SP11 began work on the first prototype applications using the HBP Platforms. SP12 successfully set up the ethics committees (ELSA and REC), which will handle ethical issues arising within the project, and began planned research and outreach activities. SP13 completed the set-up of the project's governance and management structures, providing project management and administration and coordinating relations with the European Commission. SP13 also successfully managed a large Competitive Call, leading to the introduction of 32 new Partners to the Project.

Subproject 1: Strategic Mouse Brain Data. The goal of SP1 is to acquire strategic data on mouse brain molecules, cells, and cognitive capabilities, and in particular to develop technologies to acquire gene expression data on single cells, which can make a fundamental contribution to brain modelling. During the first reporting period, SP1 developed a proof-of-concept for cell-type transcriptomic analysis, completed cortex and hippocampus tissue scans of synapse densities, counted fluorescently stained neurons in whole brain and collected strategic data on neurons, axonal projections and blood vessels for brain modelling. The Subproject established a strategy for mapping protein distribution and proteomes, as well as a pipeline for linking molecular and cellular data, and preparing them for integration with the HBP Platforms. It also identified useful existing databases.

Subproject 2: Strategic Human Brain Data. SP2 generates human brain data that parallels the mouse brain data collected in SP1. During the first reporting period, SP2 published several key articles in major journals. The Subproject also identified strategic human brain data, and defined templates for the Human Brain Atlas. The Subproject provided mouse brain organisation data to SP1, cognitive architecture data to SP3, and Human Brain Atlas data to SP5. It also developed a technique to bridge scales between levels of brain organisation.

Subproject 3: Cognitive Architectures. The aim of SP3 is to define strategic experimental protocols ("localisers") to dissect associated patterns of brain activation and response dynamics in well-specified conditions, thus making it possible to identify the "cognitive architectures" underlying specific capabilities of the brain. In the first reporting period, SP3 delivered localisers for all cognitive functions under study. Members of the SP3 team reviewed the literature and ran new experiments to identify and document the best fMRI or MEG experiments to achieve the goals of the Subproject. Results from this work are now being transferred to SP2. Following the Competitive Call, SP3 added four new Tasks: Multi-scale data analysis and multi-scale transfer modelling, Development and validation of brain network models constrained by realistic physiological phase lags, Dissecting the brainstem

modulation of cortical decision computations, and Characterising the multi-scale brain architecture of decision related motivational states and values.

Subproject 4: Mathematical and Theoretical Foundations of Brain Research. SP4 is developing mathematical techniques to link different models and build bridges between different levels of brain organisation (e.g. the molecular level, the cellular level, and the circuit and systems levels. The Subproject is also studying plasticity rules explaining how experience modifies the configuration of brain circuits during development and learning. The Subproject is also using input from SP3 to characterise specific cognitive functions (e.g. learning and memory, spatial navigation etc.). A first description of all SP4 models (accompanied by programme codes where possible) will be posted in March 2014. A second key achievement was the successful set-up of the planned European Institute for Theoretical Neuroscience, which began operations in April 2014.

Subproject 5: Neuroinformatics Platform. SP5 will offer new tools to construct multi-level brain atlases and to analyse structural and functional data. The Platform will provide a single source of annotated, high quality data for the HBP modelling effort and for the international neuroscience community. The Platform will also support Predictive Neuroinformatics – the use of sparse data to predict features of the brain where experimental data is missing. The goal for the ramp-up phase is to to launch a first functional version of the Platform and populate it with data, models and ontologies for ion channels, cell types, synapse types and microcircuits. In the first reporting period, SP5 produced an operational prototype of the Neuroinformatics Platform, which is being used to test a range of functions, including large-scale data viewing, data registration, data curation and annotation, text mining and analysis. It has acquired key data sets and used them to develop initial brain atlases, extracting features and organising data in a semantic database. The development Platform already supports interactive viewing and navigation of multi-terabyte whole brain data sets for mouse, rat and human. SP5 expects internal release of version 1 of its Platform on schedule, in Month 18.

Subproject 6: Brain Simulation Platform. SP6 is developing the HBP Brain Simulation Platform (BSP) and the HBP Unified Portal (UP) – a portal that will provide a Single Point of Access and a single User Interface for all the HBP Platforms. The BSP will allow collaborative reconstruction and simulation of biologically detailed, multi-level models of the brain, at different levels of description, and should support continuous integration of biological data, allowing models to become progressively more accurate and detailed, up to multi-scale (simple to complex), multi-level (genes to whole brain) models of mouse and human brains. The UP will facilitate users' online interaction with the ICT Platforms. First versions of the BSP and UP will be released to HBP users by the end of the Ramp-Up Phase. SP6 has a first prototype of the BSP in operation, and is on schedule to achieve internal release of Version 1 to HBP users in Month 18. SP6 has used existing Platform components to create initial models of selected biochemical reactions, individual cells, microcircuits and areas of brain tissue. These initial models have provided useful feedback that has helped to refine the design of these components. SP6 has also advanced in modelling multi-scale molecular dynamics, different neuron types at the cellular level, the neuro-glia-vasculature loop, and detailed microcircuits of the cortex and cerebellum. SP6 has demonstrated that modelling principles developed for one brain region can be quickly adapted to generate a representative model of a section of another brain region.

Subproject 7: High Performance Computing Platform. SP7 builds, integrates and operates the hardware and software components of the supercomputing and data infrastructure required to run large-scale, data intensive, interactive brain simulations up to the size of a full human brain; to manage the large amounts of data used and produced by the simulations, and to concurrently manage workloads and workflows, data processing and visualisation. SP7 will make version 1.0 of the HPC Platform available to the HBP

Consortium in Month 18. The Platform will be made available to the wider scientific community in Month 30. In the first reporting period, SP7 conducted the HBP Pre-Commercial Procurement Call for Tender; developed software and numerical methods for concurrent interactive brain simulation, visualisation and analysis; developed early software prototypes for interactive visualisation and control in brain modelling, brain simulation and data analysis; developed technology to manage very large volumes of experimental and simulation data; and wrote the full specification of the HPC Platform. It also prepared for internal release of the first version of its Platform in M18.

Subproject 8: Medical Informatics Platform. This Platform will develop and deploy novel data management and query solutions providing researchers with unprecedentedly broad access to anonymized brain disease data in academic, industry and medical databases. The goal is to allow researchers to move from classifications of disease approach based on symptoms and syndromes to classifications that are grounded in biology. A key goal is to handle very large volumes of data without moving them from local servers and without compromising data privacy. In the first reporting period, computer scientists, neuroscientists, clinicians and statisticians working on the Platform, worked together to build the various components needed for the internal prototype due to be delivered in Month 18. To allow data integration, SP8 developed in situ querying and federation technology to pool information from different sources, and created differentiated data mining tools. In its first Deliverable, D8.6.1, SP8 specified different user needs and technological solutions to support Platform functionalities.

Subproject 9: Neuromorphic Computing Platform. This Platform will enable users to run simulation/emulation experiments on two neuromorphic computing systems: Heidelberg's Physical Model system (NM-PM) and Manchester's Many Core system (NM-MC). While NM-PM and NM-MC employ different technical approaches, they both offer advantages in terms of configurability, low-energy consumption, scalability and upgradability. The Platform will also facilitate hybrid computing solutions that bring together neuromorphic computing with conventional computing technology. A key goal is to ensure that non-expert users can experiment with the Platform. In the first reporting period, SP9 designed all the PM printed circuits boards and assembled a PM hardware prototype, complete with rack, power and cooling infrastructure. This is now ready for the installation of 20 wafer modules. For the MC system, a complete rack with 100,000 ARM cores has been assembled and is now being tested. The Platform's unified software framework was demonstrated in September 2014, providing non-expert users with seamless access to both the PM and MC systems – a unique achievement in neuromorphic computing. SP9 is collecting benchmark computing tasks that can be used to quantify neuromorphic computing performance and relate it to traditional supercomputing. In preparation for post-Ramp-Up development, designs for prototype Phase 2 PM and MC chips have been completed, with the involvement of many Partners. This broadens SP7's technological base beyond the SpiNNaker and BrainScaleS architectures used in Ramp-Up Phase machines.

Subproject 10: The Neurorobotics Platform. SP10's Platform is a virtual robotics simulation system for experiments in *in silico* cognitive and behavioural neuroscience. The Platform connects HBP brain models to simulated robot bodies. Experiments using the Platform should provide new insights into the causal relationships linking basic neural components to perception, cognition and behaviour. The Platform builds on well-established open-source projects with solid developer and user communities. Suitable projects have been found for all parts of the Platform, and these have been successfully integrated into the development system. SP10 published its Platform architecture and user specifications in Deliverable D10.4.1. Platform development is on track for internal release in Month 18. SP10 successfully met the challenges of integrating the Competitive Call Partners within a very tight timeframe.

Subproject 11: Applications. The aim of SP11 is to prepare, evaluate and test early applications of the six HBP Platforms. One Work Package is dedicated to applications in Future Neuroscience (use of the neurorobotics Platform to explore problems in visual perception), another to Future Medicine (use of the Medical Informatics Platform to identify biological signatures of disease in dementia patients, and a third to Future Computing (data mining using neuromorphic technologies)

Subproject 12: Ethics and Society. The goal of SP12 is to set up and manage the HBP's ethical governance structures and a Foresight Lab, to explore conceptual and philosophical implications related to HBP activities. SP12 will also engage in public dialogue and engage in activities to improve awareness of ethical and social issues among HBP researchers. During the first reporting period SP12 successfully set up the planned Ethics, Legal, Social Aspects Committee (ELSA) and the Research Ethics Committee (REC). The planned Foresight Lab also began its activities and will deliver its first report (on the implications of the HBP for future medicine in Month 18). The team working on philosophical and conceptual issues has begun investigations of the implications of brain simulation, and the possible impact of the HBP on consciousness research. The group responsible for public awareness has held its first consultation exercises on issues related to medical informatics, data privacy and informed consent. The group responsible for ethical awareness has conducted a baseline survey of ethical perceptions among HBP researchers.

Subproject 13: Management. SP13 provides the HBP with its governance and management structures and manages the project administration and HBP relationships with the European Commission. SP13 manages the project's dissemination activities, its technology infrastructure (internal and external web sites), the HBP Education Programme, and the European Research Programme Office. During the first reporting period, SP13 set up the HBP's Governance bodies, drew up plans for the HBP beyond the Ramp-Up Phase, and managed a Competitive Call which brought in 32 new Partners and a broad range of new research. It also produced a number of key planning documents, detailing actions to be undertaken in the Ramp-Up Phase, included a Dissemination Plan, a Plan for the Use of Results, a Data Management Plan, a European Research Plan and a curriculum for the HBP Education Programme.

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Human Brain Project

Figure 1: HBP official Logo