The German Network for Computational Neuroscience

Andreas V.M. Herz

Institute for Theoretical Biology, Humboldt Universität zu Berlin

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Bernstein Center for Computational Neuroscience Berlin

a.herz@biologie.hu-berlin.de

Abstract. The German Federal Ministry of Education and Research (BMBF) has recently started a new funding initiative, the "National Network for Computational Neuroscience", to intensify the investigation of the neural basis of cognitive functions by fostering the young and highly dynamic discipline of Computational Neuroscience. This discipline combines experiments with computer simulation and data analysis on the basis of well-defined theoretical concepts, making available a scientific language and methodology that can be used across disciplines ranging from neurobiology, cognitive science, systems biology to information technology. The "National Network for Computational Neuroscience" seeks to concentrate the neuroscientific expertise available in Germany and to closely integrate theoretical approaches, to create a common neuroinformatics structure for collecting and networking neuroscientific findings and to transfer these new findings to technological applications. The development of interdisciplinary training programs in the field of Computational Neuroscience is another integral part of the concept. Central elements of the National Network are the four new Bernstein Centers for Computational Neuroscience that will be connected through the exchange of data, tools for data analysis, computer models and theoretical approaches. The following text summarizes the main aspects of this funding initiative, as detailed in the BMBF announcement (July 2003), together with recent developments of the initiative.

1. Funding Purpose

Understanding cognitive functions on the basis of the structure of the brain and its neural dynamics is essential for the prevention and treatment of disorders of the nervous system, for a better general comprehension of biological processes, for developing new high-performing computers and, last but not least, for designing efficient strategies for teaching and learning. Major progress has been made in the study of fundamental neural processes over the last ten years. However, the thorough analysis of brain functions continues to be a challenge which, due to the complexity of the dynamic processes involved, is considered even more difficult than the study of structural and functional relations of the human genome. This task requires focussed interdisciplinary cooperation between neuroscientists, biologists, medical professionals, physicists, mathematicians and computer scientists. Specific software must be developed for the fast numerical analysis of large amounts of complex data,

for extensive computer simulation, and for the effortless exchange of the enormous amount of raw and processed data and the many different computational tools.

Major insight is expected from the field of Computational Neuroscience. It combines experiments with data analysis and computer simulation on the basis of well-defined theoretical concepts, and it makes available a scientific language which can be used across disciplines and levels for neurobiology, cognitive science, systems biology and information technology. In 2003, the German Federal Ministry of Education and Research (BMBF) has therefore started a funding initiative aimed at the further development, structural focussing and networking of existing regional capacities in the field of computational neuroscience under the lead vision "Understanding Thought Processes", which has been developed within the so-called “FUTUR” process. Support of young scientists is an integral part of this concept. Possible applications to be considered reach from the technical and biomedical fields to learning research and will benefit from an integration of neuroinformatics research.

The BMBF funding measure aims to pool outstanding neuroscientific expertise available in Germany while integrating theoretical approaches, in a joint effort with the *Länder* and universities. This will also help to create the necessary neuroinformatics structure for collecting and networking neuroscientific findings and for transfering the results to application-oriented areas. For that purpose the National Network for Computational Neuroscience has been established. The network consists of local centers, which will strengthen the concentration and further development of existing capacities. The centers are named **Bernstein Centers for Computational Neuroscience** after Julius Bernstein (1839-1917), whose “Membrane Theory” provided the first biophysical explanation of propagating action potentials. After a two-step review process through a panel of international experts in 2003/2004, four out of 18 submitted regional proposals were chosen: **Berlin**, **Freiburg**, **Göttingen** and **Munich**. Within the national network, these four Centers will be connected through the exchange of data, analytical methods, computer models and theoretical approaches – and will in turn make this information available to other researchers, both within Germany and abroad. The development of interdisciplinary training programs in the field of computational neuroscience and the establishment of expert counselling resources are an integral part of the concept. The funding measure is intended to give new impetus to neuroscience research and provide a basis for innovative and promising developments in application-oriented disciplines. To guarantee a lasting impact, funding will be provided only if additional measures are taken which ensure long-term integration of computational neuroscience into teaching and research opportunities offered by the participating institutions.

2. Bernstein Centers for Computational Neuroscience

As structural elements of the National Network, the four regional Bernstein Centers will enable theoretical and experimental research groups to engage in close and efficient interdisciplinary cooperation on complex neuroscientific problems. These problems should be of major relevance to application, mainly in the areas of information technology, biomedical research and learning research. Funding is aimed at supporting innovative research concepts of high scientific and technical quality, particularly those involving cooperation between universities and non-university research institutes or hospitals. Coordinated programs for qualifying young researchers are to be included. Furthermore, all Bernstein Centers are designed as interdepartmental structures with a critical mass of research groups so that synergy can be achieved. Each Center will appoint an international

advisory board to ensure scientific support and coordination, and after its establishment, it will closely interact with the other Bernstein Centers and external partners.

The scientific mission of the Bernstein Centers for Computational Neuroscience is the systematic study of the neural basis of cognitive processes ranging from the processing of complex sensory stimuli to learning processes and the retrieval of stored information to the planning and precise coordination of motion patterns relevant to behavior. The research program will elucidate the interaction between neural dynamics and information processing at the level of individual neurons, local networks and large-scale neural systems. Each Bernstein Center concentrates on one common scientific theme and was responsible for selecting the specific topic on which it will focus. The following themes were chosen:

- Berlin: “Behavioral Reliability despite Neural Variability”
- Freiburg: “Neural Dynamics”
- Göttingen: “Adaptive Neural Systems”
- Munich: “Neural Representations of Space-Time”

Research at the Bernstein Centers will mainly consist in the following, partly parallel or intertwined activities:

- analysis of complex neural data
- modeling of the dynamics of neural systems
- modeling of neural information processing (from coding of sensory stimuli, storage, learning and memory to planning and motion control)
- development of mathematical theories concerning the function of neural systems
- modeling of behavioral context and neural adaptation.

It is expected that such work be interdisciplinary and involve experimental and theoretical research groups. Integrating theoreticians (mainly post-docs) in the experimental research groups seems particularly promising. In addition, the projects should be innovative and their results should provide a basis for work in application-related disciplines. An efficient exchange of experimental data, analytical methods, computer models and theoretical approaches will be ensured to facilitate the integration of the Bernstein Centers into the envisaged network. Coordinated software development and data management activities will be of special importance in this regard. It is expected that the neuroinformatics standards established by the OECD will be applied. One of the Bernstein Centers will act as national contact for the International Neuroinformatics Coordinating Facility planned by the OECD.

The following criteria were of special importance in selecting the four Bernstein Centers for Computational Neuroscience:

- availability of outstanding experimental and theoretical expertise
- quality of the integrated training concept and of the structures already established in the field of computational neuroscience

- synergy potentails with existing funding programs (e.g. Imaging Centers in Clinical Neuroscience; Bioinformatics; Systems Biology; Bioanalogous Information Processing)
- interfaces between the research activities and possible applications within the “FUTUR” program, with emphasis on information technology, biomedicine, and learning research
- prospects for commercial success, for scientific and/or technical success, and for scientific and commercial follow-up projects
- agreement of the participating institutions to ensure continuation of the Center's work following the BMBF funding period.

The Bernstein Centers will exchange their latest research results at annual workshops and status seminars to ensure close links and intensive communication. External partners (German research community, international guests) will be involved in these events. Additional contributions to networking will be made by guest researchers, mainly at the doctoral student and post-doc levels, as well as by exchanges of data and methods. Project-related collaborations with national and international groups outside the Centers will serve the transfer of knowledge beyond the network.

Taking into account the local research capacities, start-up funding will be provided over an initial period of five years for the establishment of a Bernstein Center. During this period, the funds can be used not only in support of posts for young researchers (doctoral students and post docs) but also for professorships advertized in the field of computational neuroscience; appointments to such chairs will be made by a committee which includes external experts. The focus of the professorships will be directly related to the local research priorities and may include experimental approaches. Funding will only be provided if the higher education institutions concerned assume responsibility for the chairs when start-up funding by the BMBF has expired.

Supplementing these measures for improving the interdisciplinary training of young researchers, the research groups involved in the four Bernstein Centers will now set up a consistent teaching program for Computational Neuroscience, including the development and establishment of special courses, seminars and practicals. In addition, special method-related courses and guest programs will be offered in order to draw on available international expertise. Together, all these measures will generate a new generation of neuroscientists that will combine theory and experiment in their everyday work and thus achieving major breakthroughs in the understanding of the neural basis of cognitive functions Their joint scientific language, i.e. Computational Neuroscience, will help to unify theoretical concepts across many life-science disciplines ranging from neurobiology and cognitive science to systems biology and will also strengthen connections with information technologies.

Detailed information about the specific scientific program of each Bernstein Center can be obtained from the coordinators or the four Centers:

Berlin:	Andreas V.M. Herz	see also www.bccn-berlin.de
Freiburg:	Ad Aertsen	see also www.bccn-freiburg.de
Göttingen:	Theo Geisel	see also www.bccn-goettingen.de
Munich:	Ulrich Büttner	see also www.bccn-munich.de

Additional information about the program and the FUTUR Lead Vision is provided at www.bernstein-centers.de