

Report on Neuroinformatics
from
The Global Science Forum Neuroinformatics Working
Group of the
Organisation for Economic Co-operation and
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EXECUTIVE SUMMARY

The Global Science Forum's Neuroinformatics Working Group (GSF-NI-WG) is pleased to submit this report to the Members of the Organisation for Economic Co-operation and Development (OECD), on the activities of the Working Group and the opportunities for advancing solutions to understand the nervous system through neuroinformatics research. This final report is submitted at the request of the GSF, which provided the two-year mandate for this working group.

Improvement of human well-being and the quality of life is one of the most important and urgent targets of modern science. This can be accomplished through understanding human beings and our society and understanding the principal organ that makes us human, the brain, a most complex organ. A key element to successfully accomplishing this is the integration of neuroscience with information sciences, making it now possible to utilize the collection of data and knowledge to understanding the human brain. The field, that studies the nervous system, Neuroscience, has responded to this exciting challenge with tremendous exuberance and in great numbers. Using the most sophisticated technologies neuroscientists experimentation now range from studies on the genome to those on brain imaging of behaviour in humans under different functional states, and at all intervening analytical levels. This effort, has resulted in large quantities of data, which are ever increasing at higher levels of granularity. The data produced are heterogeneous, coming from different levels of study. For example, cellular molecular studies or whole brain imaging, and the technologies used for collecting these data are different for each approach. In addition, the data may be static or dynamic and at different stages of development across the life span. Current approaches have produced exceedingly large numbers of highly focused research studies. To successfully understand the nervous system the scientific community should openly share these fractionated data and integrate them into broad new knowledge. To rise to this challenge of integration, and to ensure efficient and maximum use of these data, it is now necessary to: (i) develop neuroscience data- and knowledge bases; (ii) develop analytical and modelling tools; and (iii) develop computational models. This challenge is being met through the merging of information science with the neurosciences -- the field of Neuroinformatics.

The Neuroinformatics Working Group has the mandate to examine issues of critical import to furthering the development of Neuroinformatics. Three germane issues to create a global neuroinformatics capacity are, resources, guidelines and sustainability. Over the course of the two years this group existed, the group identified and discussed elements underlying these issues both in its entirety at the seven Working Group meetings and at individual interspersed focused task force meetings. Studying the brain requires many levels of description and organisation from genome through molecular, cellular, networks and circuits to the whole brain and behaviour. Each of these levels is associated with its own scientific community, methods, data formats and jargon.

- The issue of resources has been addressed by the creation of two web resources. (i) <http://www.neuroinf.org> site is situated in Antwerp, Belgium, offers primarily communication services to neuroinformaticians around the world. (ii) <http://his.biologie.hu-berlin.de> is located in Berlin, Germany and is developed in accordance with the recommendations for data and software sharing made by the Working Group. It is the entry portal to neuroscience databases and neuroinformatics tools available on the Internet.

- Guidelines have been drafted for electronic data and method sharing, and the NI-WG encourages the further development of these guidelines and ontologies by the full neuroscience community.
- Sustainability requires the creation of a new infrastructure to support the activities of neuroinformatics. This will require individual nations to continue to support research at the national level, to establish a national node for coordination of national activities and to interact and coordinate international activities. An International Coordinating Council, with representatives from each nation, will coordinate global activities to help guide and shepherd the development of full guidelines, ontologies and standards as required. Lastly, critical to this success, is the creation of a new international neuroinformatics funding mechanism to bring together the appropriate global combination of scientists to collaborate on systems research creating new databases, analytical tools and computational models. This new funding mechanism, while maintaining national funding independence, will overcome the lack of the critical mass of researchers in any one country to tackle difficult integrative problems from the three neuroinformatic areas of expertise.

The Neuroinformatics Working Group recommends that, to fully realize the scientific, economic and social potential of neuroinformatics, the governments of the OECD should continue to individually support and develop national neuroinformatics programs and to jointly support a global neuroinformatics research initiative to facilitate coordination of international neuroinformatics research and resources.

- ▶ National neuroinformatics research programs should be continued or initiated. Each country should have a national node to both provide research resources nationally and to serve as the contact for national and international coordination.
- ▶ An International Neuroinformatics Coordinating Council (INCC) should be established. This Council will coordinate the implementation of a global neuroinformatics network through integration of national neuroinformatics nodes.
- ▶ A new international funding scheme should be established. This scheme should eliminate national and disciplinary barriers and provide a most efficient approach to global collaborative research and data sharing. In this new scheme, each country will be expected to fund the participating researchers from their country.

Our capability to realize these opportunities will set the stage for enhancing the quality and quantity of life throughout the world. A direct impact of understanding the brain will be the amelioration and prevention of nervous system disorders. The Global Burden of Disease Study, conducted by the World Health Organisation, the World Bank and Harvard University, predicted in 1996, that in the 21st century nervous system disorders would rank first. This impact will be on both the numbers of individuals affected and the burden to family members and society. Indeed, even today, the cost for nervous system disorders are ten times higher than those associated with cancer. The relatively small investment in developing neuroinformatics by the global community will have an enormous impact and payback through the efficiency of understanding the normal working mechanisms of the nervous system and the alterations that occur in nervous system disorders.

1. Introduction

The human brain is by far the most complex system known, and understanding it is a crucial scientific challenge for the 21st century. This intellectually fascinating task is made urgent by its practical applications: advances in the understanding of the human brain will lead to breakthroughs in the prevention and cure of nervous system disorders and to improvements in the quality of life for millions of people.

Neuroscientists, having developed sophisticated methods to investigate the brain in the finest possible detail, now face the challenge of managing the enormous amounts of raw data and the many useful inferences drawn from them. It comes as no surprise that the amount of data is huge, given that the brain itself is responsible for controlling all patterns of behaviour, thoughts, perceptions, memories and emotions from within its 1.5-litre package using the 100 billion nerve cells, 3.2 million miles of nerve fibres and the million billion neural interconnections.

The data are of a breathtaking diversity. They may arise from chemical, biophysical, structural, morphological, physiological or behavioural sources -each domain generating data with its own characteristic parameters. Data are being taken at all levels of biological organisation, from the genetic, cellular and neural network levels up to whole-brain structure and function. And sophisticated new methods for measuring brain processes are generating a panoply of data on processes as disparate as genetic regulation, cellular development and plasticity, signalling in neural circuits and cognitive functions.

The time scales of all these data are diverse as well, for different brain processes operate on scales ranging from microseconds to days or even years, interacting with other processes and playing out against the background of overall nervous system development, which takes place over the lifetime of an individual.

A very large number of researchers working on many thousands of projects world-wide are accumulating these data. But measurements made by individual groups in the context of distinct research projects are often difficult to share in a form easily exploited by the rest of the neuroscience community. Journal publications -the current method of sharing data -present results in a highly condensed format of representative data or average values. The community urgently needs a way of sharing primary data.

Like other scientific domains (genetics, astronomy, earth sciences), neuroscience has reached a point where the data-intensive nature of the work and the complexity of its research subject leads ineluctably to the creation of a new scientific field: neuroinformatics, which stands at the intersection of neuroscience and information science. Databases in neuroinformatics will become as important for the neurosciences as those in bioinformatics have been for genomics. Additionally, physical and technological sciences have provided numerous examples of how theoretical and computational models are essential for understanding nature's complexity and how this understanding can be used for the benefit of mankind. Through Neuroinformatics, researchers will be able to share their primary data and to cooperate worldwide and across disciplines through exchanging tools and approaches for the analysis and integration of data. Data of any type can be integrated across different levels of biological organisation; researchers will be able to quantitatively validate their working hypotheses by means of computational modelling. Collaborative research efforts will be better equipped to study the brain at multiple levels of complexity.

Neuroinformatics research will enhance our understanding of how the brain is built and how it works. This will be a driving force for breakthroughs in designing simulations of brain functions. Reciprocally, beneficial spin-offs are anticipated for the information sciences in developing new computing paradigms.

The three principal aims of neuroinformatics are :

1. To optimise the accumulation, storage, and sharing of vast amounts of primary data and of large, structured neuroscience databases. As described above, the data are of an enormous diversity. The most immediate goal is to develop standards and mechanisms for sharing the vast amount of data among researchers.
2. To develop tools for manipulating and managing the data. Although many relevant techniques have already been developed in other fields, the neuroscience community must collectively design and develop special-purpose analytical tools and algorithms that are optimal for their needs. It is likely that, in the near future, large databases will play a similar role in neuroscience as they already do in genomics, where the existence of very large bodies of data, and of tools to navigate and manipulate these data, leads to breakthroughs in understanding and important commercial applications linked to human health. It is anticipated that some of these tools will, in turn, be of great benefit to researchers in various branches of the information sciences as they deal with problems (such as machine learning, robotic task planning, etc.) that are related to brain function in humans and other organisms.
3. To create computational models of brain structure and function that can be validated using the data. As in all of science, the understanding of the systems and phenomena under study involves the development of models that are not just descriptive but predictive and explanatory as well. In this case, the systems and phenomena are among the most difficult to model: from the molecular--/-cellular up to perception, learning, memory, reasoning, etc. The only way to validate models of these sophisticated phenomena is through confrontation with the data sets of neuroscience, using tools developed via neuroinformatics.

Naturally, the development of a new field requires that it establish its identity, create an organisation (especially at the international level), address issues of education and training, and gain the recognition of government and their support through funding. Acknowledging this, the Global Science Forum of the OECD established the Working Group on Neuroinformatics [with membership from 20 countries and EC, and chaired by Dr. Stephen Koslow, along with the co-chairs, Dr. Shun-ichi Amari and Dr. Sten Grillner].

1.1 OECD Activities

1.1.1 Megascience Forum: Neuroinformatics subgroup (1996--1998)

Recognising the enormous benefits of applying information technologies in the biological sciences, in January 1996, the OECD Megascience Forum established a Biological Informatics Working Group, with two subgroups, Biological Diversity and Neuroinformatics. The goal of the Working Group was to strengthen international cooperation through the creation of new, shared Internet-based capabilities for data and information management.

In December 1998, the findings and recommendations of the Working Group were submitted in a report on bioinformatics, "OECD Megascience Forum: Bioinformatics."

<http://www.oecd.org/EN/documents/0,,EN-documents-45-nodirectorate-no-4-no-18,00.html>

The newly identified field of neuroinformatics was strongly endorsed by the Neuroinformatics subgroup, who recommended that additional steps be taken to create a coordinated international neuroinformatics effort.

1.1.2 Global Science Forum: Neuroinformatics Working Group (2000--2002)

To accomplish these additional steps, a focussed Neuroinformatics Working Group with a two-year mandate was established by the new OECD Global Science Forum in January 2000. The goal of the GSF-Neuroinformatics Working Group was to strengthen links between neuroscience and the information sciences at a national level in order to promote the development of the needed infrastructure and scientific capability.

Specifically, the Working Group was directed to recommend (and to implement whenever possible) concrete initiatives in the areas of Resources, Guidelines and Sustainability. These initiatives are critical to achieving the global neuroinformatics capability across nations, scientific disciplines and individual institutions, and to promoting the continuation of the efforts beyond the OECD-mandated period.

The Neuroinformatics Working Group met seven times (Appendix C). In a number of cases, a neuroinformatics national symposium preceded or followed the working group meeting, thereby facilitating the sharing of the knowledge, goals and activities of the Working Group members at the national level. Some of the work was discussed by specialist subcommittees in other meetings, the results of which are summarized below and expanded in the Appendices.

Resources

Recognizing the web-based opportunities for ongoing exchange of data, tools and information, the Working Group has initiated two neuroinformatics portals. These are entry points to information and tools available on the Internet, providing, in addition, a way for users to communicate with one another. The Working Group has also influenced the Japanese Visiome project to expand to an international platform.

Guidelines

To provide optimal interoperability for data, knowledge and tools, the Working Group has developed draft guidelines for (i) the standardisation and sharing of electronic data and methods; and (ii) the development of a common ontology (a set of descriptive terms--and their interrelationships--for neuroscience).

Sustainability

The Working Group has developed proposals for the establishment of (i) a global neuroinformatics network with representation at the national level and (ii) a new funding mechanism which crosses national and disciplinary boundaries yet remains within national control and responsibility.

2. Resources, guidelines and sustainability

2.1 Resources and guidelines

Neuroscience data are increasingly being expressed in electronic form (databases and computational models) in addition to the traditional journal article format. Computational approaches are becoming more closely linked to data stored in these databases and are crucial for their interpretation. Although within the life sciences this trend is already widely acknowledged in the fields of genomics and proteomics, the implications for neuroscience are different and unique. Studying the brain involves many heterogeneous levels of description and organisation, from the genome, molecular, cellular and network levels all the way to integrated brain structure and function. At each level, there is a particular scientific community with its own methods, data formats and jargon. To cope with this, neuroscience needs to foster the development of methods for electronic data sharing and exchange across the various levels of complexity. These should match the highly successful bottom-up paradigm that is widely recognized in contemporary neuroscience (i.e., building up our understanding of the brain from knowledge of its component parts).

To address this problem, the Working Group identified and undertook specific work in four key areas: (i) integration of existing efforts; (ii) promotion of sharing of primary data by neuroscientists; (iii) technical guidelines for data and method sharing; and (iv) development of a common ontology.

2.1.1 Integration of existing efforts: web portals

An increasing number of neuroscience databases are being developed by separate groups to address many different levels of complexity and various brain systems. Each of these initiatives (and the data generated) is potentially useful to many neuroscientists, but they may not even be aware of the existence of these resources. This slows down the entire brain research enterprise and can lead to unnecessary duplication of effort. One objective of the Working Group was the development of web portals to address this problem. Portal sites are entry points to information and tools available on the Internet and can be a forum for communication. Two Neuroinformatics Portals (NiP1 and NiP2) have been developed cooperatively by Members of the Working Group:

- NiP1: <http://www.neuroinf.org> – With over 1,300 registered users, this site offers primarily communication services to neuroinformaticians around the world. It provides support for scientific meetings and summer schools and runs mailing lists on neuroinformatics and computational neuroscience.
- NiP2: <http://www.neuroinf.de> – This site is being developed as a pilot project in accordance with the recommendations made by the Working Group for data and software sharing (see section 5 in Appendix A). It is an entry point to neuroscience databases and neuroinformatics tools available on the Internet and is set up so that data and tool providers can upload information pointing to and describing their products.

2.1.2 Promotion of sharing of primary data

Most experimental data remain inaccessible because the majority of neuroscientists are not yet used to sharing data, even though the data may be in electronic form. Practical barriers to progress in this direction are the lack of easy-to-use software tools for data sharing and the

lack of funding and rewards for database construction and tool construction and database contributions.

Members of the Working Group are implementing different solutions to enable research groups to publish their data through the Internet. One example, is the Visiome platform at <http://neuroinformatics.gr.jp>. Such representation at the national level will play an important role in internationally disseminating and promoting these publication tools. Additionally, national funding agencies need to earmark funding to support electronic data publication.

2.1.3 Guidelines and standards for data and method sharing

The inherent complexity of neuroscience creates several problems specific to electronic data. Data are obtained by various technical methods and it is stored in variable electronic formats. Also, data and information by themselves are meaningless without extensive annotation describing how they were obtained. To be useful, the annotation should be readable by users and structured for automated processing. Efficient sharing of tools and methods requires good documentation and funding support for long-term maintenance.

The Working Group concluded that resolving these issues is essential for effective data sharing, requiring extensive community involvement and commitment. As a starting point, a draft of guidelines for electronic data and method sharing has been developed (Appendix A). The International Neuroinformatics Coordinating Council (INCC) proposed in section 2.2.1 will have an important role in the further establishment of internationally accepted standards.

2.1.4 Development of a common ontology

The growth of neuroscience in many different research communities has not been accompanied by the development of a universal terminology. The same area, structure or function within the brain can have different names, depending on the context or particular community. For example, identical areas in cerebral cortex have been given different names depending on the animal species being described or the laboratory in which the research has been carried out. This problem is complicated by the complexity of the brain, where structures are also described differently depending on the technique used. In addition, there is no clear scheme describing the relationship and hierarchy of names and technical terms used in neuroscience. These combined problems are referred to as the lack of a common ontology.

Until a common ontology is developed the Working Group has initiated the development of a structured keyword system for the hierarchical classification of the content of the neuroinformatics portals it has implemented. It did this in collaboration with the relevant scientific communities that are active in the common ontology area: for example, computational neuroscience, neuroanatomy and neuroimaging. In this area, follow-on work under the aegis of the International Neuroinformatics Coordinating Council (see below 2.2.1) can play a vital role.

Neuroanatomy ontology example

The brain is divided into numerous structurally and functionally different regions. Currently, around 8,000 Latin and English terms are used to describe structures in the brain, from larger regions to smaller cell groups. A major problem for future brain databases is that different terminologies are used to describe a given brain region and that boundaries of many regions and cell groups are not unambiguously defined. For example, one major cell group in the brain stem, linking the cerebrum and the cerebellum, is referred to by multiple names (pontine nuclei, pontine grey, basilar pons, basilar pontine grey, etc). Furthermore, the different names are not synonyms but describe largely overlapping and not identical regions. Therefore, names are not sufficient to identify information uniquely. An ontology for neuroanatomy will combine the different terminologies and thereby define the relationships (in 2-D planes and 3-D tissue volumes) among the different terms used to describe brain structures. The ontology will be constantly changing and updated to include new terms introduced as a result of new discoveries.

2.2 Sustainability

2.2.1 Organisation of national nodes for neuroinformatics with an International Neuroinformatics Coordinating Council (INCC)

Obtaining a deeper understanding of the brain, which will be facilitated through the use of neuroinformatics techniques, will require a large-scale, integrated international effort. As previously stated, this will involve the development of dedicated databases and analytical and modelling tools that extend from the genetic, anatomical and physiological levels to the behavioural and cognitive levels (including conditions of both health and disease). This effort will be markedly facilitated if the responsibility for the different aspects of the development of database and analytical and modelling tools is to be shared among groups across the world in an organised, coherent way, with a consensus for long-term perspective. Accordingly, the Working Group proposes the establishment of an international coordinating body with representation from all interested countries (Figure 1).

National involvement will be in the form of a national node. The national nodes will be made up of the leading neuroinformaticians, including neuroscientists, computer scientists and information scientists within a country. Each node will be supported by the national government and administered by the appropriate governmental department or research council. It is envisaged that the national government would fund the various national and international activities of the node. The tasks associated with each of the nodes are:

- (i) To promote and facilitate local neuroinformatics research at the national level through the dissemination and integration of primary information; and
- (ii) To provide advice and be a resource for the government and/or appropriate research council on Neuroinformatics.

At the global level, one representative for each national node, appointed by the respective research council/government, will form the International Neuroinformatics Coordinating Council (INCC). INCC will allocate responsibility for tasks in areas requiring global effort to the different national nodes.

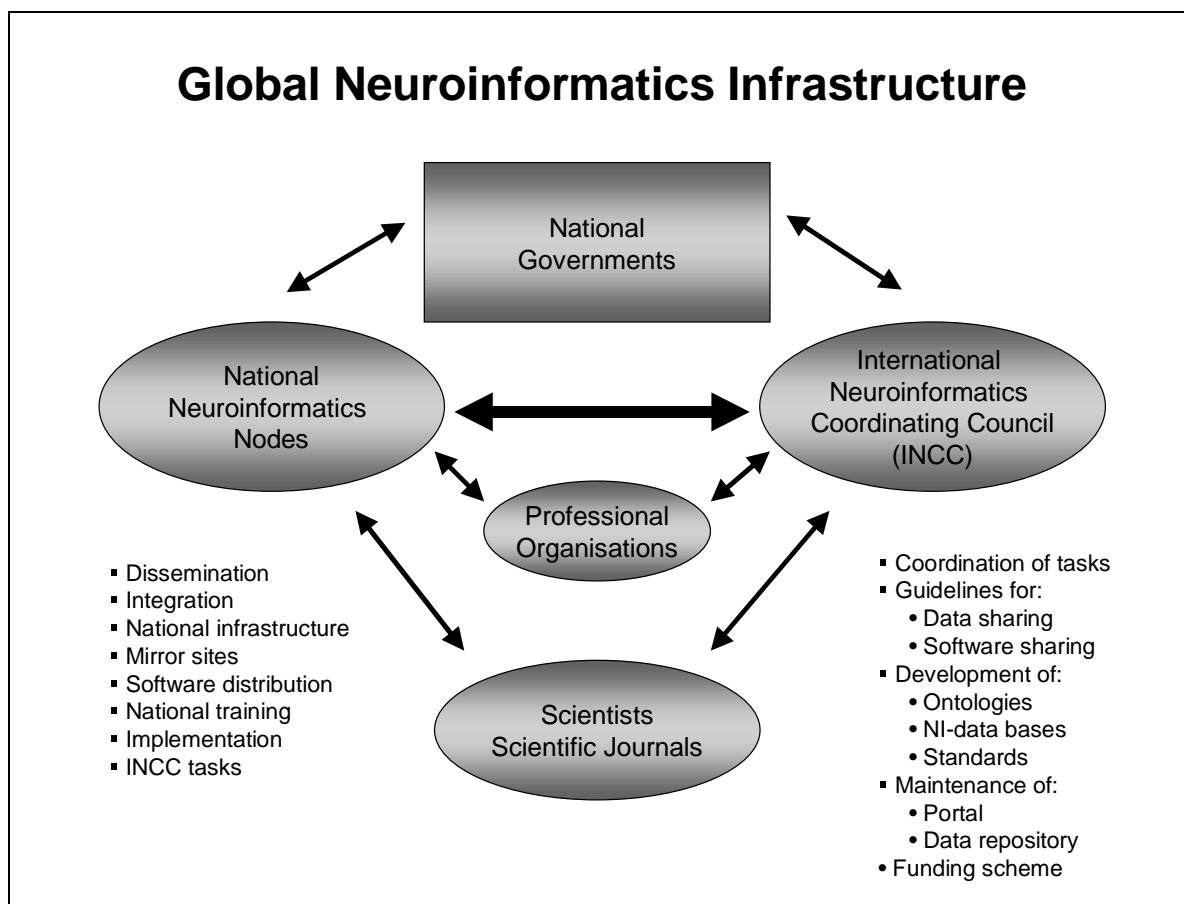


Figure 1: Infrastructure of the International Neuroinformatics Coordinating Council (INCC).

INCC will:

(i) Promote the development of Neuroinformatics databases concerned with different aspects of neural function from the molecular and cellular levels to the system and behavioural levels including disease mechanisms. One aspect is the development of a common ontology. This is of critical importance for the development of databases, capable of communicating with each other over different brain organisational levels. It represents a formidable task, requiring a coordinated effort. The responsibility for developing neuroinformatics databases for different areas of neuroscience will be shared across nodes, taking into account the different areas of expertise represented among the national nodes.

(ii) Be responsible for organising the funding scheme proposed in section 2.2.2.

(iii) Be responsible for the management and further development of the portal.

(iv) Have an important role in the further establishment of internationally accepted standards.

(v) Promote the development of Neuroinformatics tools for analyses and modelling.

(vi) Promote the sharing of data in the different areas of neuroscience.

INCC is planned as a government funded independent organisation, affiliated to different international research organisations in information sciences and neuroscience. INCC will meet four times each year. When appropriate video conferencing will be used to maximize flexibility and minimize travel costs. The Council will have an Executive Committee, composed of the Executive Secretary and three representatives from the national nodes, with a balanced geographical distribution. There will be an Administrative Office, headed by the Executive Secretary. The location of the office will be decided after competitive bidding from the member countries. There will be a cost-effective central administration financed by national governments. A mechanism will be developed for determining the costs to each participating government, considering the national spending on research and the size of the country and its GNP. It is recommended that the governmental organisations establish a budget for their national node.

2.2.2 International Neuroinformatics Funding

Neuroscience is a global multinational and multidisciplinary endeavour. It is therefore important for neuroinformatics researchers to develop a global-scale network to achieve their scientific goals. Unfortunately, funding agencies can be restricted by national borders in awarding grants, and, for administrative reasons, funding schemes are often defined along rigid disciplinary boundaries. As a result, neuroinformatics exists in a funding vacuum in most countries.

In some countries significant resources have already been allocated to the development of the neuroinformatics area, and they may have both expertise and good funding schemes. In most countries, however, there may be solitary groups of outstanding capacity, but as a rule no competent peer review framework. It is, therefore, important for researchers in these countries to develop an international network to further the research on a global scale.

To remedy this complex situation, the Working Group proposes an international funding scheme in which country's national research councils will contribute only when the INCC international peer review committee recommends funding for a research group from that country. Further, the peer review committee would seek to fund collaborative projects involving researchers from three or more different member countries. To best utilize synergistic potentials, the scheme will aim to fund a limited number of sizable grants rather than a larger number of smaller grants.

The funding mechanism can be outlined as follows:

- The scheme is open to all interested countries.
- Each participating country will have the prerogative of funding the work of its national research groups within the collaborative projects approved by the peer review committee (as defined below).
- There will be one annual call for proposals. The international review committee through e-mail interaction will screen brief preliminary proposals. A limited number (no more than 10) will be invited to submit a full application. These full applications will be ranked in order of excellence.

- A limited number (2--4) of the outstanding grant proposals will be awarded each year (in ranking order). Each grant could be awarded for a period of up to five years, depending on the policy of the participating funding agencies. As a rule, awards should be around K¥100–200 per year for each participant. However, the actual sum may vary from country to country depending on, for instance, the buying power of the national currency and national salary levels.
- The supported grants should all be of outstanding scientific quality within the area of neuroinformatics. They must, thus, address issues that pertain to the development of neuroinformatics data bases, neuroinformatics tools and infrastructure or the development of computational models existing at multiple levels of description from the genetic level to neural systems and behaviour.

2.2.3 Grant Administration

Administrative functions will be handled by the Secretariat of INCC, utilizing the experience and format developed by international granting agencies like the Human Frontier Science Program in Strasbourg.

- i. An annual call for proposals will be announced through the OECD neuroinformatics portal, International Brain Research Organisation (IBRO) web site, national agencies and the national nodes, and leading international journals and will be distributed broadly to scientific organisations.
- ii. There will be one peer review committee meeting per year, held in conjunction with a major neuroscience meeting.
- iii. The nominating committee of the IBRO will select a balanced international peer-review committee of leading, impartial experts in the different areas of neuroinformatics. The national research councils will be able to propose committee members to the IBRO nominating committee. Each committee member is appointed for a period of three years.
- iv. The INCC executive committee will monitor the progress of each project by assessment of a brief annual report provided by each principal investigator. In addition, each participant will submit an annual report to the national funding agency providing the support.
- v. The costs for administration of the grants and reviewing the applications will initially be covered by the governments supporting INCC, and in subsequent years by a fee taken annually from each funded grant.

3. National Neuroinformatics Activities

The OECD Neuroinformatics Working Group activities have already resulted in a growing national and international awareness and an impressive level of activity in developing neuroinformatics in many participating countries. Interest has increased to begin new neuroinformatics initiatives which will profit greatly from recent developments in computer science and communication technology. A summary of neuroinformatics activities by participants of the Working Group is provided in Appendix B.

4. Recommendations

- ▶ National neuroinformatics research programs should be continued or initiated. Each country should have a national node to both provide research resources nationally and serve as the contact for national and international coordination.
- ▶ An International Neuroinformatics Coordinating Council (INCC) should be established. This Council will coordinate the implementation of a global neuroinformatics network, through integration of national neuroinformatics nodes.
- ▶ A new international funding scheme should be established. This scheme should eliminate national and disciplinary barriers and provide a most efficient approach to global collaborative research and data sharing. In this new scheme, each country will be expected to fund the participating researchers from their country.

In conclusion, the Neuroinformatics Working Group recommends that, to fully realize the scientific, economic and social potential of neuroinformatics, the governments of the OECD continue to individually support and develop national neuroinformatics programs and to jointly support an international neuroinformatics research initiative to facilitate coordination of international neuroinformatics research and resources.

GUIDELINES AND RECOMMENDATIONS FOR DATA AND SOFTWARE SHARING IN THE
NEUROSCIENCES

1. Motivation for the development of a neuroinformatics portal for data and software sharing (NiP)

A primary objective of the OECD-GSF Working Group (WG) on Neuroinformatics was the development of a portal that would enable direct access to, and integration of, public domain databases, data collections, software tools and computational models in their native format. The first step towards this was the establishment of a pilot portal (NiP2, see also 3.1.1) and the development of a metadata framework that would help federate diverse neuroscience resources. We outline below the design principles of NiP2, the guidelines to resources for access through NiP2 and possible future developments of such infrastructures.

2. Design Principles

The design of NiP2 warrants the following considerations. First, it should make it as easy as possible for groups providing data, databases, tools and models to incorporate access through the portal. Second, it should allow for interoperability between databases that contain similar or overlapping content. Further, there should exist a basis for broad integration among diverse types of neuroscience data. The power of access to diverse data lies in the ability to retrieve and perform extensive analysis in a seamless manner and this requires integration of software with data. Finally, neuroscience relies heavily on model building with data and models at different levels of resolution, in order to provide valuable insights into the underlying mechanisms. This requires interoperability between data, tools and models. We utilize these principles in the design of NiP2.

For purposes of pragmatic distinction, the guidelines are divided into those for data providers, database repositories, software developers and software providers. In some instances, the Neuroinformatics Portal should also enable provision of computing resources coupled to the data, databases and tools.

3. Technical details of design

As is common practice with large database repositories, NiP2 adopts a three-tier approach. The presentation tier is developed on extant web standards, the middle tier employs a custom-developed parser that is coded in portable object-oriented languages and the data tier employs a metadata framework that relies on a well-established framework. However, NiP2 does not attempt to build extensive ontologies for neuroscience nor does it aim to provide guidelines for creation of primary data repositories. NiP2 is primarily an infrastructure that enables software and data sharing through interoperable links to the primary resources. Most importantly, the Working Group recognised that the Neuroinformatics Portal should serve as an effective communication channel for neuroscientists to facilitate dissemination of news and exchange of information and to provide a forum for collaboration, thus establishing an organisational framework for neuroinformatics activities.

3.1 General architecture and common ontology

Mechanisms and procedures need to be defined that enable the development of the above-mentioned common ontology and the general architecture of the knowledge-based system.

More specifically this involves:

- Agreement on the general architecture of the knowledge-based system; web-like (or web-service-like) versus more direct approaches to interoperable databases; where to use common standards versus own developments?
- Agreement to the level at which standardisation sets in (raw data formats, storage means, database-management systems, programming languages used, particular APIs, transfer protocols, access methods).
- Agreement on a metadata set:
 - Which elements shall be required (versus optional)?
 - To what level of detail shall metadata be collected?
 - How narrow or coarse shall classification be (including controlled vocabulary)?
- Agreement on metadata encoding scheme:
 - Qualified Dublin Core?
 - RDF or XML Schema (or both)?
 - Own developments?
- Agreement on specific access methods or how to make particular data types (metadata versus raw data -- could be size dependent or delayed -- versus software etc..) publicly available.

4. General guidelines for access through NiP2

For access through NiP-like infrastructures, data and software providers have to satisfy a minimum set of criteria. Such examples exist with guidelines provided by the World-Wide-Web Consortium and Object Management Group. Using the terminology and "do"/"do not" structure of guidelines from this community, we outline a set of such criteria below, while noting that these guidelines are an evolving entity and will require extensive community involvement and acceptance.

4.1 Guidelines for data providers

- Ensure persistent storage of the data.
- Accomplish persistence through perpetual access from the laboratory, or through a public repository.
- Make the data publicly accessible.
- Where available use open standard data formats.
- When using proprietary data formats provide annotations on formats and/or DTDs that would help translate formats.
- Provide appropriate annotations.
- Give all the information necessary to make sense of the data; this includes metadata, experimental preparation, stimulus protocol, etc. Rely on a common ontology whenever possible.

4.2 Guidelines for data repositories

- Provide the infrastructure necessary to accept and publish all appropriate submissions. This implies setting up and maintaining a powerful, scalable, preferably web-accessible database.
- Support data providers to adhere to the guidelines described above.
- Enable interoperability with other repositories, software tools and the portal.

- Rely on a common ontology whenever possible.
- Expose the ontology used.
- Expose the metadata of the content items, preferably in an automated, machine-readable way.
- Support existing technological standards for interoperability.
- Use standard interfaces (such as ODBC, web services,----), protocols (such as HTTP, SOAP---), data formats (plain text, pdf, png, HTML, XML,----), etc.

4.3 Guidelines for software developers

- Provide easy access to the software.
- In public domain accessible free software, make it available for download with source code or publish it via a computing service.
- Provide necessary and sufficient documentation
- Provide APIs where appropriate.
- Support standard data formats.
- Develop software to be platform independent.
- Provide input and output data sets along with the software for validation purposes.

4.4 Guidelines for computing services

- Provide the infrastructure necessary to accept and publish all appropriate submissions. Where possible use web as the presentation layer of the infrastructure.
- Support software developers to adhere to well-established guidelines.
- Enable interoperability, in particular, with data repositories, other software tools and the infrastructure.
- Implement existing technological standards for interoperability.

4.5 Guidelines for community infrastructures

- Provide the typical web-based services to be the entry point for the neuroinformatics community.
- Enable news and discussion services, provide a who's who in neuroinformatics.
- Establish and maintain a metadata database.
- Provide the infrastructure necessary to accept and publish all appropriate submissions to the metadata database.
- Employ a standard, well-documented reviewing process for quality control.

5 Future of NiP-like infrastructures The planned Neuroinformatics Portal is expected to provide a mechanism for data and tool sharing in neurosciences. The current NiP2 infrastructure will evolve with considerable input from the community, as well as with developments of ICT standards and protocols. We expect NiP to provide an impetus to the neuroscience community, to address the issues of data and software sharing, as well as to investigate the underlying paradigms of ontology development and database creation and standards. The OECD-GSF Working Group plans to establish National Nodes that will further enhance NiP capabilities and development. In some instances, these national nodes will serve as primary data repositories in addition to serving as a portal to other primary repositories. Further, in rare cases, these nodes will also provide computational service for neuroscience researchers.

6 Glossary of Terms

API - Application Programmer Interface. Provides a means to connect various different pieces of software to work together. Defines command names as well as input and output parameters so that a third party can integrate an existing software product into its own custom development.

DTD - Document Type Definition. Defines the legal building blocks of an XML document. It defines the document structure with a list of legal elements. A DTD can be declared inline in an XML document, or as an external reference.

Dublin Core - The Dublin Core Metadata Initiative (DCMI), an open forum engaged in the development of interoperable online metadata standards that support a broad range of purposes and business models. DCMI's activities include consensus-driven working groups, global workshops, conferences, standards liaison and educational efforts to promote widespread acceptance of metadata standards and practices. The standard set of metadata elements this initiative created is now commonly referred to as the Dublin Core.

HTML - HyperText Markup Language: the publishing language of the World Wide Web.

HTTP - HyperText Transfer Protocol. the main protocol for exchanging data between web browsers and web servers. HTTP was originally designed for remote document retrieval, but it can now also be used for more advanced applications like web services.

ICT - Information and Communication Technologies.

Interoperability - The ability to operate across different software platforms, operating systems and programming languages.

Metadata - Structured data about data encoded in a machine--understandable way.

NiP - Neuroinformatics Portal. The entry points for the neuroinformatics community on the World Wide Web that members of the working group are currently establishing.

OMG - Object Management Group. An international not-for-profit software consortium that is setting standards in the area of distributed object computing (an advanced software design principle).

ODBC - Open Database Connect (a Microsoft specification). provides a standard way of defining data sources and their data access methods. ODBC is designed around relational databases and their structured query language. The ODBC specification defines low-level API calls that any application can make use of for database queries. By writing calls to the API, a reporting writer or other tool can portably access heterogeneous data sources with one set of source code.

Ontology - In the context of knowledge sharing, a specification of a conceptualisation. That is, ontology is a description (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents. This definition is consistent with the usage of ontology as set-of-concept-definitions, but more general. And it is certainly a different sense of the word than its use in philosophy.

PDF - Portable Document Format. a well-established format for compact encoding of documents used in electronic publishing and on the web.

PNG - Portable Network Graphics. an extensible file format for the lossless, portable, well-compressed storage of raster images. PNG is patent-free and supports indexed-colour, grayscale, and true-colour images.

Portal - In the context of the World Wide Web a site that serves as an entry point for a particular community by providing various kinds of information as well as the infrastructure for effective communication across the web.

RDF - Resource Description Framework. Integrates a variety of applications from library catalogs and worldwide directories to syndication and aggregation of news, software and content to personal collections of music, photos and events using XML as an interchange syntax. The RDF specifications provide a lightweight ontology system to support the exchange of knowledge on the web.

Repository - an impartial, comprehensive, community resource for the dissemination of information.

SOAP - Simple Object Access Protocol. an XML-based protocol for exchanging information between computers. It is platform-independent and therefore enables diverse applications to communicate with one another over a network connection.

Three-tier architecture - a common software design principle for web-based applications where one distinguishes between (i) a presentation tier responsible for the appearance of the site on the web, (ii) a data tier, usually a database management system, that holds the data to be processed and presented and (iii) a middle tier that connects the two and implements the desired functionality.

Transfer protocol - a set of specifications that allows for the correct transfer of data across a network connection. Examples are the transfer protocol the World Wide Web based upon (the HyperText Transfer Protocol HTTP) or the Simple Mail Transfer Protocol (SMTP) that underlies e-mail.

W3C - World-Wide-Web Consortium. Develops interoperable technologies (specifications, guidelines, software and tools) to lead the web to its full potential. W3C is a forum for information, commerce, communication and collective understanding.

XML - eXtensible Markup Language. universal format for structured documents and data on the web.

NATIONAL NEUROINFORMATICS ACTIVITIES

Australia

Summary -- Neuroinformatics research in Australia has concentrated on data-basing and modelling in three main areas of neuroscience research: neuroimaging, neurogenomics and cellular neurophysiology. Neuroinformatics is being aimed at assisting the rapid development of neuroimaging-based research by providing supporting infrastructure and expertise to facilitate collaboration between members of the neuroinformatics, neuroimaging, neurogenomics and cellular neurophysiology research communities. Emphasis has been placed on allowing sharing of data and expertise between laboratories; standardising the existing neuroinformatics facilities; and generating a critical mass of neuroscience researchers with intellectual property suitable for significant venture capital investment.

Neuroinformatics related grants

- Awarded – Neuroinformatics Platform Technology, awarded to NeuroSciences Victoria Ltd by Victorian State Government - Strategic Technology Initiative; A\$930,000; 2002--2004.

National conferences, symposia

- Databasing the Brain, Invited Symposium, Australian Neuroscience Society Annual Scientific Meeting, Sydney, February 2002.
- From Genes to Cells to Brains, Neuroscience Informatics Symposium, Howard Florey Institute, University of Melbourne, February 2002.

Training programs, workshops

- Brain Mapping Analysis Training Course, University of Melbourne, February 2000.
- Neuroimaging Analysis Training Course (Statistical Parametric Mapping & Electromagnetic Source Estimation), University of Melbourne, May 2001.
- Neuroimaging Analysis Training Course, University of Melbourne, June 2002.

New national schemes related to neuroinformatics

- National Neuroscience Informatics consortium (funded by Major National Research Facilities grant to establish National Neuroscience Facility) 2002--2006.

Specific national contributions to OECD Working Group activities

- OECD GSF Neuroinformatics Working Group 6th Meeting at University of Melbourne, February 2002.

National neuroinformatics database and/or tools developments

- Establishment of National Neuroimaging Database, funded by the National Neuroscience Facility.

Other

- Commercialising activities – Brain Resource Company floated in Australia, with objectives of commercializing integrative neuroscience clinical applications.

Belgium

The Belgian government has been following the activities of the working group on neuroinformatics closely, but, has not yet implemented specific funding programs or initiatives. Research in neuroinformatics is funded through regular funding programs at the national, regional and university levels. To assess the state of the field, a national neuroinformatics meeting was organized at the University of Antwerp on March 2002 where 10 research groups from seven universities presented their recent work, spanning the full spectrum from database development, to imaging analysis tools, to computational modelling at different levels of complexity. Several projects presented were part of large European collaborations. A general consensus among the participants of the meeting was that Belgium lacks multi-disciplinary funding initiatives at present. The suggestion was made to investigate a joint Bioinformatics-/Neuroinformatics initiative as a possible solution.

China

In the spring of 2001, interested scientists in China were brought together to discuss the field of Neuroinformatics and to develop a one-year plan. Projected research projects include database, Imaging, Acupuncture, Language development, Perception, Motor Learning, Attention and Brain Disease. Also, in 2001, neuroscientists in China organized an expert forum and discussion meetings in Beijing where the GSF-NI-WG's work plan and activities as well as other achievements in the world, were reported. The government realizes that the Human Brain Project (HBP) and NI are very important for China and the world. Xiang Shan Science NI Conference supported by the Chinese government was held in September 2001. Government representatives participated from the National Science Foundation of China (NSFC) and the Ministry of Science and Technology (MOST). Forty-two experts from neuroscience, computer science, mathematics, informatics, engineering, etc. participated and gave lectures. Dr. Stephen H. Koslow, from the United States (NIH), was invited to visit Dalian University of Technology, 301 Hospital and Xiang Shan Science Conference in China. He gave three presentations on the HBP and NI, one at each of these sites. He also had private meetings with the vice president of NSFC and the director of MOST where discussion focused on the HBP & NI and the role for China.

In November 2001, a Pan Asian NI workshop was held in Hangzhou, which had representatives from China, Japan, Korea and India. Future plans for HBP and NI in China include the following:

- China's first HBP & NI conference will be held in Beijing or Dalian, 2002.
- NI session or workshop will be held during the annual Chinese Neuroscience conference, 2003;
- An international NI conference in China with support from NSFC. Chinese NI scientists are seeking opportunities for an international collaborative project with the HBP & NI initiatives, similar to those organized for the Human Genome Project for which the Chinese government funded several, 2003 or 2004.

Positive response for establishing a NI portal and node occurred in China.

Neuroinformatics related grants

The first NI project granted by the Chinese government, "Neuroinformatics Research on Neuroimaging of Acupuncture and Chinese Cognition," was awarded by MOST in November 2001. The second NI project was granted by the Ministry of Education in China, "The Brain Mechanism and Holistic Intervention Methods for Adolescent Anxiety and Depression Based on

Neuroinformatics," was sanctioned in January 2002, and projected to be awarded in October 2002.

- Principal Investigator: Tang Yiyuan, Director, Laboratory for Brain and Mind, Institute of Neuroinformatics, Dalian University of Technology
- Pending grant – "Human brain atlas project" to the NSFC.

National conferences, symposia

- A National Conference was held in September 2001 and two symposia were held in February and May 2001.
- Neuroinformatics Symposium at the International Conference on Neural Networks and Information Processing, November 2001, Shanghai, China.
- Neuroinformatics Symposium at the Conference for National Biophysics Society of China will be held in Dalian in May--June 2002.
- A National NI Conference will be held in December 2002.

Training programs, workshops

The first NI training program will be held in Beijing in 2002, with the second NI training program and workshop to be held in Dalian in 2003.

New national schemes related to neuroinformatics

Several Chinese scientific societies support efforts for NI organisation.

- Planning is underway to establish an NI organisation to be affiliated with the National Neuroscience Society of China, 2002.
- Planning is underway to establish an NI committee to be affiliated with the National Biophysics Society in China, in 2002.
- Planning is underway to establish a National NI Centre.

Other information

- The first Neuroinformatics Research Institution in China, the Institute of Neuroinformatics, Dalian University of Technology, was established in Dalian in April 2001.
- Neuroimaging Acupuncture and Chinese language cognition databases will be established.
- A database of Chinese herbs used for the treatment of neuropsychiatric disorders is in the planning stages of development.
- NI groups will provide e-services for scientists and governments.
- Two websites for Chinese HBP/NI, obtained in May 2001, are www.neuroinformatics.net.cn, www.neuroinformatics.org.cn, The first URL will be developed and made available in mid-2002.

Czech Republic

The proposal of the organisation of the Czech National Node for Neuroinformatics was accepted by the Ministry of Education of the Czech Republic. The scientific bimonthly journal Neural Network World, related to the field of neuroinformatics, is published by the Institute of Computer Science and the Czech Technical University, Faculty of Transportation Sciences.

The main NI interest has focused on problems of the reliability of interaction between human subject and artificial system (namely of the transportation nature), especially concerning the system operators (driver, pilot, dispatcher) attention degradation and micro-sleep appearance.

A set of methods based on EEG analysis suitable for micro-sleep detection and prediction was developed and tested in the laboratory and also on-board the vehicle. The Micro Sleep Base (MSB) project composed as one of the functional blocks of the international "Neurobase" was prepared and distributed to those universities, institutes and laboratories around the world that are expected to be interested in MSB subsequent filling out and usage. The first version of MSB and the respective MSB portal were created and tested in the Joint Laboratory of System Reliability, Department of Control Engineering and Telematics, Faculty of Transportation Sciences, Czech Technical University, Prague and the Institute of Computer Science, Academy of Sciences of the Czech Republic, Prague. The first draft of the project on drug (especially alcohol) influence on the human system operator attention, reaction time and decision correctness was prepared. The Czech Ministry of Education granted national support of the research in Neuroinformatics by awarding a five-year grant.

In the Institute of Computer Science, Academy of Sciences of the Czech Republic, scientists developed and tested for medical applications the advanced methods for data-mining based on the GUHA methodology, working automatically, searching for data to test the hypothesis and performing exploratory analysis using logic and statistical principles.

A search for brain science-oriented databases suitable for acceptance in the "Neurobase" created in the Czech Republic was made. More than 10 such databases concerning neurology, which could be interesting for this purpose were found.

European Community

Neuroinformatics related grants

General principle.

- The European Commission (EC) awards grants on a competitive basis to consortiums of several laboratories/institutions that are members of the 15 EU countries or associated states. The particularity of the EC funding process is, therefore, the mandatory multinational aspect of the projects. Most of the Consortiums are composed of five to ten partners coming from three to six countries.
- Other countries, such as Switzerland, Australia, Canada and the US are welcome to take part in those Consortiums, but they are not legally allowed to receive funds from the EC.
- Two EC Directorates are active in funding research in neuroinformatics : the Research Directorate (DG RTD, via the Life Programme) and the Information Society Directorate (DG INFSO, via the IST Programme). Scientific Officers responsible for neuroinformatics grants at those two Directorates have regular contacts and some common initiatives have already been organised.
- Typically, two types of activities can be funded to a Consortium : a research(RS) project and a coordination/training (CA and TN) project. An RS project supports research activities, while a CA or TN project can support coordination of national policies, training and organisation of workshops and conferences.
- The DG RTD has funded projects in neuroinformatics since the 4th Framework Programme and with a certain continuity, since this funding has been maintained through the whole 5th framework Programme. In addition, neuroinformatics will be an open field for submission of expression of interest in the 6th framework Programme. Some additional details about the projects granted can be found below.

DG RTD : 4th Framework Programme (1994--1998)

- Two research lines were dedicated to neurosciences and informatics, but no research line was specifically dedicated to the emerging field of neuroinformatics. Nevertheless, five projects linked to neuroinformatics themes were funded under the BioTech II Programme for a total of 4.6 millions. One of these projects addressed the development of a computerised human brain database.

DG RTD : 5th Framework Programme (1998--2002)

- Two research lines were specifically dedicated to neurosciences and bioinformatics. In particular, the neurosciences research line contained an area specifically devoted to neuroinformatics and described as follows: Brain theories, computational neuroscience and neuroinformatics, covering three domains: (i) Development and validation of theoretical concepts and models of brain functions at various levels; (ii) Understanding of how real networks of neurones solve problems; and (iii) Construction of databases with the potential of integrating data from molecular to behavioural levels.
- A total of six projects have been funded for 6.8 millions, which represents about 8 % of the resources allocated to the neurosciences in the programme¹. There were four RS projects and two CA/TN (see Table I).

Table I : List of DG RTD neuroinformatics projects under the 5th Framework Programme

Title	EC funding (€)	Total costs (€)	Start (d.m.y)	End (d.m.y)
Thematic network on computational neuroscience and neuroinformatics	182.000	182.000	30.12.99	29.12.02
A database generator for the neuroimaging community: Neurogenerator	1.780.000	1.860.000	01.02.00	01.02.03
Neural network model of cortical and spinal operations for motor control	500.000	500.000	01.02.00	31.01.03
Principles of real interactions in primate visual cortex	816.081	1.290.000	01.02.00	31.01.03
Cortical, cerebellar and spinal neuronal networks - Towards an interface of computational and experimental analysis	1.717.298	1.887.141	01.12.01	30.11.04
Computation and plasticity in the cerebellar system : Experiments, Modeling and Database	1.804.310	2.053.012	01.12.01	30.11.04

One RS project is the follow-up of one of the BioTech projects and is called Neurogenerator, coordinated by Per Roland (Karolinska Institute, Stockholm, Sweden). It aims to set up a standardised database available to the scientific community (Trends in

¹ Note that the total budget allocated to the « neuroscience » research line in the 5th Framework Programme was about 80 millions over 5 years. As a general indication, the EC DG RTD contributes to 2 % of the total R&D expenditure from the 15 EU member states, the 98 % left being spent by the national programmes and private sector.

Neuroscience, (2001); 24 : 562--564). The CA/TN projects have organised workshops, conferences and have awarded individual fellowships. In addition, the TN of Erik De Schutter (University Antwerp, Belgium) is also involved in the set-up of one of the neuroinformatics portal web site (www.neuroinf.org).

DG RTD : 6th Framework Programme (2002--2006)

- The 6th Framework Programme has proposed Bioinformatics and Brain Research as two priorities. However, the final content of those two research lines will be based on a « bottom-up » approach. For this purpose, the scientific community has been invited in March 2002 to submit an expression of interest, with a deadline fixed at 7 June 2002. Those expressions of interest will be evaluated and it is on this basis that the final work programme will be elaborated.
- A novelty of the 6th Framework Programme will be its more ambitious projects and consortiums mixing the research aspect with the coordination and training aspects. The funding and duration of the projects should also be increased (five years).

DG INFSO: 5th Framework FET (Future and Emerging Technologies)

- Under the FET (Future and Emerging Technologies) research line, DG INFSO has funded a large number of projects for a total of €36.5 millions (Table II).
- In addition, a Thematic Network is under construction in order to co-ordinate collaboration between these projects. Its progress can be followed at <http://www.cordis.lu/ist/fetni-nt.htm>.

Table II : List of DG INFSO neuroinformatics projects under the 5th Framework Programme

Initiative	Title	EC funding (€)	Total costs (€)	Start (d.m.y)	Duration (months)
ALG	Artificial Mouse	1.333.000	2.944.860	01.09.01	48
ALG	Artefact Structural Learning through Imitation	1.717.000	1.716.572	01.10.01	36
ALG	3D shape and material properties for recognition	2.025.000	2.339.763	01.09.01	36
ALG	Mirror neuRons based RObot Recognition	720.000	1.099.940	01.09.01	30
ALG	Reconfigurable POEtic Tissue	900.000	1.593.840	01.09.01	36
ALG	Systemic Intelligence for GrowiNg up Artefacts that Live	1.242.000	1.451.729	01.09.01	36
ALG	A fleet of artificial chemosensing moths for distributed environmental monitoring	1.665.000	2.346.764	01.01.02	48
ALG	Bayesian Inspired Brain and Artefacts: Using probabilistic logic to understand brain function and implement life-like behavioural co-ordination	1.622.000	3.787.237	01.09.01	48
ALG	Artificial vision systems based on early cognitive cortical processing	2.336.000	2.869.743	01.01.02	36
ALG	Living Building Blocks for Self-Designing Artefacts	1.848.000	2.386.000	01.11.01	36
ALG	Progressive and adaptive learning of	1.395.000	1.846.000	01.11.01	36

	object manipulation: a biologically inspired multi-network architecture.				
NOS	Neurons and Modified CCMOS integrated Circuit interfacing	1.989.000	3.009.000	01.09.00	36
NOS	Information Processing by Natural Neural Networks	894.200	2.072.000	01.01.01	36
NOS	A bioartificial brain with an artificial body: training a cultured neural tissue to support the purposive behaviour of an artificial body	1.653.000	3.218.000	01.05.02	36
LPS	Approximately Periodic Representation of Stimuli	408.000	688.000	01.05.02	36
LPS	BIO-mimetic structures for Locomotion in the Human body	1.498.675	1.649.650	01.05.02	36
LPS	Convolution AER vision architecture for real-time	1.220.000		01.05.02	48
LPS	Cricket and spider inspired perception and autonomous decision automata	1.740.000		01.06.02	36
LPS	Chiroptera-Inspired Robotic Cephaloid: a Novel Tool for Experiments in Synthetic Biology	2.142.000		01.04.02	36
LPS	Development of a CYBERnetic HAND prosthesis	1.688.000	2.508.000	01.05.02	
LPS	MirrorBot: Biomimetic multimodal learning in a mirror neuron-based robot	1.537.000		01.06.02	36
LPS	Representation Of Stimuli As Neural Activity	1.205.000	1.515.044	01.05.02	
LPS	Sensemaker: A multi-sensory, Task-specific, Adaptable Perception System	1.606.000	2.174.000	01.06.02	36
LPS	Real-time Spiking Networks for Robot Control	2.097.000		01.06.02	36

ALG = projects within the Artefacts that live and grow initiative

LPS = projects within the Life like perception initiative

NOS = Neurone on Silicon projects

Conferences, symposia and workshops supported by EC

DGs RTD and INFSO have supported several international workshops and conferences on neuroinformatics by sponsoring various projects, including the CATN projects granted in neuroinformatics. Those workshops included :

- Information Workshop Neuroinformatics, Potsdam June 1998.
 - Organizer : Andreas Herz
 - Supported by : EC FP4 (BioTech II, Esprit 4)
- 1st EC Project Meeting Neuroinformatics, Antwerp April 2000. CINF 2000: XXIInd Congress of the Collegium Internationale Neuro-Psychopharmacologicum, Session Neuroinformatics : an enabling capability for understanding and integrating data on brain function, July 2000 Brussels
 - Organizer : Erik De Schutter
 - Supported by : EC FP5 (Life, IST)
 - Organizer : Julien Mendlewicz, NIH and EC

- Supported by : EC FP5 (Life : Accompanying Measure)
- Computational Neuroscience Meeting, Brugge July 2000.
 - Organizer : Erik De Schutter
 - Supported by : EC FP5 (Life : Accompanying Measure)
- Workshop on Neural Simulation Software, May 2000 Edinburgh.
 - Organizer : Nigel Goddard
 - Supported by : EC FP5 (Life).
- EC – US Workshop Databasing the Brain, Oslo June--July 2001.
 - Organizer : Jan Bjaalie, Rolf Kötter, Jaap van Pelt
 - Supported by : EC FP5 (Life).
- Workshop Quantitative Neuroanatomy Tools, Amsterdam October 2001.
 - Organizer : Jaap van Pelt, Jan Bjaalie, Harry Uylings
 - Supported by : EC FP5 (Life).
- Workshop Computation and Plasticity in the Cerebellar System, Antwerp October 2001.
 - Organizer : Erik De Schutter, Jan Bjaalie
 - Supported by : EC FP5 (Life).
- Workshop Neural and Artificial Computation, Zürich February 2002.
 - Organizer: Paul Verschure
 - Supported by : EC FP5 (Life).
- Workshop Functional Brain Connectivity, Düsseldorf April 2002.
 - Organizer : Rolf Kötter, K. Friston
 - Supported by : EC FP5 (Life).

Future workshops

- FENS 2002 Meeting: satellite symposium Neuroinformatics: Bioinformatics for the Neurosciences, July 2002 , Paris.
 - Organizer: Erik De Schutter
 - Supported by : EC FP5 (Life)

EC conferences, symposia and workshops

DGs RTD and INFSO have also directly organised several workshops and conferences on neuroinformatics, including :

- Neuroinformatics workshop, Brussels February 2000.
 - Organizer : EC – DG RTD (Line Matthiessen) and DG INFSO (Jacques Lacombe)
 - Supported by : EC FP5 (Life, IST)
- Information workshop on neuroinformatics, Brussels June 2000.
 - Organizer : EC – DG RTD (Line Matthiessen) and DG INFSO (Jacques Lacombe)
 - Supported by : EC FP5 (Life, IST)
- EC Conference Synergy between Research in Medical Informatics, Bio-informatics and Neuroinformatics, Brussels December 2001.
 - Organizer : EC – DG INFSO (Jean-Claude Healy) and DG RTD (Carlos Martinez)
 - Supported by : EC FP5 (IST, Life)

Future workshops

- FENS 2002 Meeting : technical workshop Databasing the Brain, Paris July 2002.
 - Organizer : EC – DG RTD (Philippe Cupers & Jürgen Sautter)

- Supported by : EC FP5 (Life : Accompanying Measure)

EC training programs

- o EC has awarded training fellowships by the Marie Curie programme, dedicated to pre- and post-doctoral students, as well as for Training Centres.
- o In addition, EC is funding the Thematic Network Brain Theories, Computational Neurosciences and Neuroinformatics, coordinated by Erik De Schutter (University of Antwerp, Belgium), whose one objective is to award short-term fellowships.
- o EC has also supported the EU Advanced Course in Computational Neuroscience, Trieste August -September, 2000.
Organizer : Klaus Obermayer
Supported by : EC FP5 (Life : Accompanying Measure)

New EC schemes related to neuroinformatics

- o DG RTD : As mentioned above, the 6th Framework Programme (2002-2007) has proposed Bioinformatics and Brain research as fundable research lines. The precise final content of those two research lines will be decided based on a bottom-up approach, via an invitation to the scientific community to submit expressions of interest.
- o DG INFSO : The IST programme will be pursued and an informal electronic consultation and call for expression of interest has been launched before awarding a Thematic network on neuroinformatics. The plan is to start this network towards mid-2002 with four years duration.

European neuroinformatics database and/or tools developments

- o DG RTD : As mentioned above, the 5th Framework Programme is funding a project entitled Neurogenerator : a Database Generator for the Neuroimaging Community, coordinated by Per Roland (KI, Sweden). This project has been presented several times (a summary is available in Trends in Neuroscience, (2001); 24 : 562--564) and could interest a larger community than EC.

Contact points

- o DG RTD (in the 5th Framework Programme) :
 - Manuel Hallen (Head of Unit)
 - Philippe Cupers
 - Jürgen Sautter
 - (Line Matthiessen) ²
- o DG INFSO :
 - Jacques Lacombe
 - Pekka Karp

Finland

In Finland, a national-level working group aiming at multi-disciplinary and multi-regional involvement of interested research groups, has been operating since January 2001. The short-term aims of this working group are to promote neuroinformatics by (i) arranging meetings and symposia, (ii) introducing researcher training opportunities, and (iii) influencing the emergence of specific funding opportunities. The first national neuroinformatics symposium was arranged

² Line Matthiessen, who has initiated most of the EC-activities in neuroinformatics, has recently moved to another research line and is therefore no longer responsible for the neuroinformatics section. Manuel Hallen, Philippe Cupers and Jürgen Sautter want to acknowledge her contribution to this research line.

by the working group in Helsinki in June 2001. There have been discussions on introducing Neuroinformatics as a topic into the neuroscience graduate schools, and a national level research program is under tentative consideration by the Finnish government agency responsible for providing basic research funding. In the latest meeting of the Working Group in October 2001, the goals were further refined as specifically promoting neuroinformatics as a paradigm shift within the existing Finnish neuroscience efforts. Overall, much interest has been generated nationally. That this interest has been somewhat limited to systems-level neuroscientists can be seen as a problem that needs to be tackled in the near future.

Germany

Neuroinformatics related grants

- EU Thematic Network Computational Neuroscience and Neuroinformatics. Bundesministerium für Bildung und Forschung(BMBF) (Federal Ministry for Education and Research)-/Deutsch-Israelisches Programm (DIP) (German-Israeli Program) "METACOMP - Models and Experiments towards Adaptive Control Of Motor Prosthesis," Freiburg/Jerusalem, 2002--2006 (plus further activities sponsored via the German-Israeli Foundation).
- Deutsche Forschungsgemeinschaft (DFG) (German Research Foundation) Sonderforschungsbereich (Collaborative Research Centre)SFB 517 "Neurocognition."
- DFG program4-554 95(2) "NeuroWebIntegration."
- DFG graduate program "From Gene to Behaviour," Düsseldorf.
- DFG graduate program "Signal Cascades in Living Systems," Berlin.
- Volkswagen Foundation "Dynamics and Adaptivity of Neuronal Systems."
- Boehringer Ingelheim Foundation "Functional Connectivity Workshop."

Pending grant applications

- EU Project VR-BRAIN.
- Wellcome Trust: "A federated network for developing informatics solutions for multi-level integration in an organ system: a demonstration platform focussed on eye, brain, and colour vision."

Conferences, symposia

- International Workshop on Neuroinformatics Potsdam, June, 1998 International Workshop "Aspects of Neural Coding" Hanse Institute for Advanced Study, Delmenhorst, March 1999.
- International Workshop "Aspects of Neuronal Dynamics" Hanse Institute for Advanced Study, Delmenhorst, April 2000.
- Special symposium "Computational Neuroscience" at the 28th Goettingen Neurobiology Conference, Goettingen, June 2001.
- International Workshop on Neural Coding and Natural Stimuli, Potsdam, June 2001.
- 1st Symposium of the Volkswagen Foundation "Dynamics and Adaptivity of Neuronal Systems - Integrative Approaches to Analysing Cognitive Functions," Bremen, September 2001.
- International Workshop "Concepts for Complex Adaptive Systems" Hanse Institute for Advanced Study, Delmenhorst, March, 2002.
- International Workshop "Computational Neuroscience: Positions and Perspectives" Max-Planck-Institute for Brain Research, Frankfurt, May 2002.

Training programs, workshops

- Co-organisation of the EU summer course "Computational Neuroscience."
- Berlin Winter School on Computational Neuroscience (yearly since 1998).
- International Graduate School for Neuroscience, Bochum.
- German Neuroscience Society: Methods Course in Computational Neuroscience, Bochum.
- Interdisciplinary College in Günne.
- Graduiertenkolleg "From Gene to Behaviour."
- Interdisciplinary Institute for Cognitive Science (Osnabrück).
- Technical Meeting on Neuroinformatics Web Sites Humboldt-University Berlin, November 2000.
- Technical Meeting on Co-coordinating Web-Based Neuroinformatics Activities Humboldt-University Berlin, December 2001.

New national schemes related to neuroinformatics

- New section "Computational Neuroscience" within the German Neuroscience Society.
- DFG Initiative "Bioinformatics at Universities."
- BMBF Training and Technology Initiative "Bioinformatics."

Specific national contributions to OECD working group activities

- Internet Platform Neuroinformatics - A pilot study for the OECD neuroinformatics Internet portal (funded by BMBF). <http://www.neuroinf.de>
- Co-organisation of the EU/US Workshop "Databasing the Brain," Oslo.

National neuroinformatics database and/or tools developments

- Collations of Connectivity data on the Macaque brain. <http://www.cocomac.org>
- Forum on Computational Neuroscience. <http://www.hirnforschung.net/cneuro>
- MEA Tools (MATLAB Tools for the analysis of multi-neuronal data recorded with multi-electrode arrays).
<http://www.brainworks.uni-freiburg.de/projects/mea/meatools/overview.htm>
- BLISS/SYNOD (a joined effort of several labs to create a simulation environment for neural systems which ensures reproducibility of results and allows for close collaboration down to the software level). <http://www.brainworks.uni-freiburg.de/projects/synod/>

Other neuroinformatics related activities

- The Max-Planck-Society set up a new Department for Systems and Computational Neurobiology at the Max-Planck-Institute of Neurobiology in Munich as well as a new Department for Neuroinformatics at the Max-Planck-Institute of Biological Cybernetics in Tübingen.

India

India has talented human resources in computational neuroscience and a major challenge is to bring about an awareness about Neuroinformatics, greater interaction between the computational scientists and neuroscientists and develop multidisciplinary-/multi-institutional collaboration, which can bridge across disciplines to help generate a new knowledge base in neuroinformatics. The National Brain Research Centre (NBRC), a recently established autonomous research institute funded by the Government of India is the apex co-ordination centre for neuroscience research in the country. NBRC took the initiative to bring together

computational scientists and neuroscientists to generate awareness about neuroinformatics. In the past two years, there have been several activities coordinated by NBRC throughout the country, including training programmes and workshops in computational neuroscience. These workshops have been very successful in generating tremendous interest in neuroinformatics and have had the participation of faculty members from several countries around the world. In addition, several research projects have been initiated within India between institutions in India, including the Indian Institute of Science, Bangalore, Indian Statistical Institute, Calcutta and the National Brain Research Centre, Delhi, as well as establishing international collaborations with scientists from the U.S. The expertise in India in mathematical modelling and computational skills in the areas of development of imaging tools and, generation of federated data bases, fast signal processing can be exploited to generate a valuable resource in neuroinformatics. Efforts are also developing in this important research area of neuroscience for close research collaboration with scientists in the Asia Pacific region. The ultimate goals of neuroinformatics activities in India are :

- i. To develop computational tools for better analysis and added value to the existing information obtained by classical methods such as electrophysiology, imaging, etc.
- ii. To generate interoperable data-bases for facilitating the conversion of existing information into knowledge.

Neuroinformatics related grants

- o A Distributed Information Centre has been sanctioned by the Department of Biotechnology for NBRC.

National conferences, symposia

- o Indo US Symposium in March 2002.

Training programs, workshops

- o December 1999 Computational Neuroscience workshop for two weeks.
- o December 2000 Computational Neuroscience workshop for two weeks.

New national funding schemes related to neuroinformatics

- o Several Pos- Doctoral Fellowships have been awarded around the country.
- o Several Research Projects are being initiated.

Specific national contributions to OECD Working Group activities

- o Development of Neuroinformatics Portal.

National neuroinformatics database and/or tools developments

- o Tools for Imaging – Collaborative project with Indian Institute of Sciences, National Brain Research Centre, and Indian Statistical Institute.

Italy

Neuroinformatics related grants

- o The Italian Ministry of Education, University and Research, inside the National FIRB (Basic Research Funding) program, has awarded a two year, K€500 grant for creating the Italian Neuroinformatics Node. Furthermore, a second FIRB grant, NeuroGRID, is under evaluation. NeuroGRID aims are to exploit GRID inside the Neuroinformatics application domain.

Specific national contributions to OECD Working Group activities

- OECD GSF Neuroinformatics Working Group 1st Meeting at University of Genoa, May 2000.

Other

- There have been requests from the Italian government for basic research proposals, including the development of centers of excellence in NI, and a data grid between Italy and the rest of Europe. Many Italian universities are starting degree courses in Neuroengineering.

Japan

In 1995, the Japanese Council of Scientists submitted a recommendation "On Promotion of Brain Science" to the Japanese Government. The report emphasized the viewpoint of integrating biological science and information science and specified three strategic areas, "understanding the brain," "protecting the brain" and "creating the brain" and their integration. This report is based on the same principle as neuroinformatics. Since then, the government has made a big effort to promote brain science. The brain science committee was established to supervise the promotion.

The main outcomes for these five years have been summarized as follows:

- i. Foundation of RIKEN Brain Science Institute: It includes the three areas and now has approximately 40 laboratories and 400 researchers, with an annual budget of about US \$80M.
- ii. Target-Oriented Research And Development For Brain Science grants on brain science. Three proposals were selected each year for the past four years by the brain science committee. A program, once accepted, will continue for three plus two more years, with approximately US \$2M per year for each proposal.
- iii. Three areas have been specified in the program of Core Research for Evolutional Science and Technology (CREST), namely, the areas of understanding, protecting and creating the brain. Three to five proposals were newly accepted each year in each area. An accepted proposal continues for five years, with US \$800,000 on average per year.
- iv. The Ministry of Education has promoted a number of brain science programs.

There was a government reorganization in the last year. The Minister of Education and the Science and Technology Agency have been merged into one ministry, MEXT (Ministry of Education, Culture, Sports, Science and Technology). The Science and Technology Council was renewed and is endowed with the mission of planning the fundamental national policy in science and technology. The council has recommended an increase in the science and technology budget by 30 % to 40 % for the next five years. The brain science committee has been dissolved due to the reformation. Target-oriented research grants and CREST grants have stopped accepting new applications in the brain science area. A new large-scale research project named "Research revolution 2002" has been announced. It includes a program for developing and integrating research areas, in particular the area integrating brain science and learning-acting systems is specified.

The brain science subgroup has been founded in the Bioscience Committee in the MEXT to discuss the research plan of brain science. The subgroup has proposed a new strategic plan on the promotion of brain science, which guides the developments in the coming five years. The plan is a further development of the previous one. A new area, "nurturing the brain" has

been proposed in addition to the three existing areas. The importance of neuroinformatics is specifically mentioned, and a new paradigm integrating neuroscience and information science-technology is emphasized. The plan mentions the promotion of computational neuroscience, creation of mathematical and computational theories of brain-style computation, integration of brain science/technology with artificial intelligence and robotics, and establishment of neuroinformatics.

RIKEN Brain Science Institute is also under governmental reformation. RIKEN BSI is also planning the generation of "nurturing the brain area." A new "Laboratory for Neuroinformatics" was started (head Shiro Usui) in April 2002. The Target-Oriented Research and Development for a Brain Science grant directly connected to Neuroinformatics is The Neuroinformatics Research in Vision (NRV) Project (PI: Shiro Usui).

Conferences, symposia/workshops on neuroinformatics held in Japan

- Symposium on Neuroinformatics in Vision at the Japanese Neuroscience and Neural Network Societies Joint meeting in Yokohama. September 2000.
- Symposium on Neuroinformatics in Vision at the Japanese Physiological Society Meeting in Kyoto. March 2001.
- International Symposium: Genome, Physiome and Neuroinformatics at the Biomedical Engineering Society meeting in Nagoya. May 2001.
- Special Session on Visual Neuroscience and Neuroinformatics at the Vision Forum, Kitakyushu, July 2001.
- International Workshop on Neuroinformatics - from Gene to Brain - at RIKEN BSI May 2001.

Training programs, workshops in Japan

- Neuroinformatics Summer School (NISS) by Japanese Neural Network Society: August--September 2001.
- RIKEN BSI Summer School: June --July 2001. <http://summer.brain.riken.go.jp/>

Specific national contributions to OECD Working Group activities

- OECD GSF Neuroinformatics Working Group 4th Meeting at RIKEN BSI, May 2001.
- Operating OECD GSF Neuroinformatics Working Group web page at: <http://www.mns.brain.riken.go.jp/OECD/home.html>

National neuroinformatics database and/or tools developments

- The first step has been undertaken to establish the Visiome Platform under the NRV Project. (<http://neuroinformatics.gr.jp> and <http://www.visiome.org/>)

Additional activities

- A Mini-Workshop on Neuroinformatics was organized during ICONIP2001-Shanghai, November 2001. (Organized by Dr.Viji Ravindranath and Shiro Usui).
 - Neuroinformatics - Shun-ichi Amari (RIKEN BSI, Japan).
 - Neuroinformatics - an approach to understanding brain function Vijayalakshmi Ravindranath (NBRC, India).
 - Neuroinformatics research in vision - Shiro Usui (Toyohashi University of Technology, Japan).
- IEEE World Congress on Computational Intelligence 2002, Honolulu, Hawaii, 2002. <http://www.wcci2002.org/> (Organized by Shiro Usui).

- Three-Dimensional Structure of Synapses in the Brain and on the Web, John C. Fiala (Boston University, Massachusetts, USA).
- Functional neuroimaging (PET, fMRI) of cognitive and motor function, Peter Fox (University of Texas, San Antonio, Texas, USA).
- Realistic modelling applied to cerebellar function, Eric De Schutter (University of Antwerp, Belgium).
- Neuronal Signal Processing in Parkinson's Disease, E. Micheli-Tzanakou, P. Wojnicki and J. Hamilton (Rutgers University, New Jersey, USA).
- Neuroinformatics in vision: VISIOME Platform, Shiro Usui (Toyohashi University of Technology, Japan).
- Internet platform Neuroinformatics - A Pilot Study for the OECD Neuroinformatics Portal, Raphael Ritz (Humboldt University, Germany).
- o Special Session on Neuroinformatics Researches in Asian and Pan-Pacific will be held at International Conference on Neural Information Processing--2002 (ICONIP-2002) at Singapore, November 2002 (Organized by Shiro Usui, So-Young Lee and Vijayalakshmi Ravindranath).
- o A special issue on Neuroinformatics - Brain and Neurosciences in the IT age (edited by Shiro Usui) has been published in Brain Science, Vol. 24, no. 1, 2002 (in Japanese).
- o Neural Networks (official journal edited by International Neural Networks Society, European Neural Networks Society and Japanese Neural Networks Society) will publish a special issue on Neuroinformatics in 2003 (Guest Coeditors, S. Amari, M. A. Arbib, R. Kotter).

Korea

Neuroinformatics related grants

The Brain Neuroinformatics Research Program will coordinate neuroinformatics activities in Korea.

- Sponsor: Korean Ministry of Science and Technology.
- Period: From August 2001, through May 2004.
- Budget: about US \$2,0.07 million for the first 10 months.
- Principal Investigator: Soo-Young Lee, Director, Brain Science Research Centre (BSRC), Korea Advanced Institute of Science and Technology.
- Main Projects:
 - Brain signal measurement and analysis (mainly for fMRI data and Korean standard brain template).
 - Modelling human visual pathways and its applications to artificial vision systems.
 - Modelling human auditory pathways and its applications to artificial auditory systems.
 - Modelling human cognitive functions and its applications to artificial agents.
 - Modelling human behaviour functions and its applications to intelligent machines.

National conferences, symposia

- o BSRC Workshop on Brain Science and Engineering, Daejeon, Korea, January 2001.
- o 1st International Workshop on Functional MRI, Daejeon, Korea, July 2001.
- o Two Symposia for OECD GSF Activities, Seoul, Korea.

Training programs, workshops

- o BSRC Workshops for fMRI Users, Daejeon, Korea, October and November, 2001.

New national funding schemes related to neuroinformatics

- Korean Ministry of Science and Technology will launch a new national program for Bioinformatics in 2002.
- Korea Advanced Institute of Science and Technology, the only science and engineering school belonging to Korean Ministry of Science and Technology, will have a new department on BioSystems from February 2002. The Department of BioSystems Engineering will educate graduate students with both biology/-neuroscience and engineering background. Neuroinformatics is one of the main education and research tracks of the department.

National neuroinformatics database and/or tools developments

Within the Brain Neuroinformatics Research Program Korea will develop a Korean standard brain template and software for brain signal analysis and visualization. Also, mathematical models will be developed for human visual, auditory, cognitive, and behaviour systems. All these data and software will be integrated as a neuroinformatics database.

The Netherlands

National meetings and workshops

- Major Session "Computational Neuroscience," 4th International Conference of the European Society for Mathematical and Theoretical Biology, Amsterdam, July 1999.
- National meeting "Computational Neuroscience," Amsterdam, April 2001.
- Workshop Quantitative Neuroanatomy Tools, Amsterdam, October 2001. This workshop was one in a series organized in the context of the EU Thematic Network Neuroinformatics.
- Winterschool on Mathematical Biology, Wageningen, December 2001.
<http://www.cwi.nl/projects/NWO-jaarthema/>

National meetings planned

- National Meeting on Neuroinformatics, 2002 .

Training programs

- Workshops "Computational Approaches in Neuronal Development and Network Formation," PhD Course Principles of Neuroscience. Graduate School Neurosciences Amsterdam, February 2000/2001/2002.

Grants and reports

- Submission of a report "Neuroinformatics in the Netherlands," to the Netherlands Organisation for Scientific Research (NOW), September 1999.
- Project "3D reconstruction of Human Brain Prefrontal Cortex," in the context of the European Computerized Human Brain Database program.

New National Funding Schemes related to Neuroinformatics

- Netherlands Organisation for Scientific Research (NWO): Broad and multidisciplinary "Program on Cognition," initiated September 2001. This program includes a theme, "From neuron to cognition," emphasizing theoretical and empirical foundations of cognition.
- A special year on Mathematical Biology was organised through a monthly series of seminars supported by NOW, 2001. <http://www.cwi.nl/projects/NWO-jaarthema/>

Norway

In Norway, proposals for Centres of Excellence are currently under review. One proposal, with significant NI components, has been selected for a final proposal evaluation. The Norwegian Consortium for High Performance Computing has awarded grants to support NI and is currently working with two neuroscience research laboratories on good demonstration projects. The Universities in Norway have proposed a new neuroscience initiative to the government that has clear statements regarding the need for the support and development of NI. Reactions to this proposal should be forthcoming within the next year. Multiple neuroscience laboratories in Norway are engaged in NI activities, particularly tool development and computational modelling.

Poland

There is currently no national neuroinformatics program in Poland. Five to seven groups are working in the field, mainly on development of analytical tools. The neuroscience community in Poland is comprised of about 500 scientists and the field of informatics is made up of a few thousand individuals. The neuroinformatics activities described below would not have occurred without the OECD WG on Neuroinformatics.

Neuroinformatics related grants

- "Organization of interactive portal on field potentials (EEG, LFP, EP) in mammalian brain. Analytical tools, databases and models." Joint grant by the Department of Physics, University of Warsaw and Nencki Institute of Experimental Biology, Polish Academy of Sciences (positively evaluated but forwarded for 2003--2004 because of budgetary constraints and freeze of investments in science).

National conferences, symposia

- 1st European Interdisciplinary School on Nonlinear Dynamics for System and Signal Analysis EUROATTRACTOR 2000.
 - Organizer W. Klonowski, Warsaw, June 2000.
 - Key contributors: H. Haken (Germany), W. Ebeling (Germany), W. Klonowski (Poland), J. Kurths (Germany), Rosario N. Mantegna (Italy), V. A. Makarov (Spain), I. V. Miroshnik (Russia), P. J. Plath (Germany).
- 2nd European Interdisciplinary School on Nonlinear Dynamics for System and Signal Analysis EUROATTRACTOR 2001.
 - Organizer W. Klonowski, Warsaw, June 2001.
 - Key contributors: V. S. Anishchenko (Russia), M. Ausloos (Belgium), M. Barbi (Italy), G. Casati (Italy), A. Cichocki (Japan), H. Kantz (Germany), M. Sonis (Israel), W. Weidlich (Germany).
- Symposium on the Fifth International Congress of the Polish Neuroscience Society: "What is neuroinformatics."
 - Organized by A. Wróbel, Torun, September 2001.
 - Contributors: A. Wróbel (Poland), Z. Kowalik (Germany), W. Duch (Poland), S. Kasicki (Poland). About 50 participants.

Training programs, workshops

- The Spring School of Polish Neuroscience Society: "Integrative mechanisms of the neocortex with the introduction to neuroinformatics."

- Organizer: A. Wróbel, Warsaw, Poland, May 2000.
- Contributors: G. Niewiadomska (Poland), S. Lindström (Sweden), G. Hess (Poland), R. Eckhorn (Germany), W. Szelenberger (Poland), Z. Kowalik (Germany), M. Abeles (Israel), W. Duch (Poland). About 100 participants.

Specific national contributions to OECD Working Group activities

- o A special neuroinformatics grant is under consideration in order to support the NI centre hosting a specialized server linked to www.neuroinf.org and devoted to EEG and local field potential data.

National neuroinformatics database and/or tools developments

- o The first steps were undertaken to organize an interactive portal on field potentials.
 - Organizers: K. Blinowska and P. Durka (Department of Physics, University of Warsaw) and A. Wróbel (Institute of Exp. Biology, Warsaw). See www.EEG.pl web-page.

Sweden

International conferences

- o A Computational Neuroscience conference, sponsored by the Swedish Foundation for Strategic Research (SSF) was held in Stockholm, 2001.
- o The Peter Wallenberg foundation sponsored a conference in September, 2001 on "Brains, genes and chips" directed to the research community and administration.

The Swedish Science Research Council

- o A limited number of grants in computational neuroscience have been provided during the last decade. These groups are also funded by the EU and other sources.

National funding schemes related to neuroinformatics

- o The Wallenberg foundation is implementing a program to support postdoctoral fellows in Bioinformatics and Neuroinformatics.

Other

- o There is an initiative to create an Institute for Cognitive and Computational Neuroscience and Robotics in Sweden sponsored by the SSF and other foundations. This is based on the extensive and longstanding interaction between researchers at the Computer Science department at the Royal Institute of Technology and the Neuroscience department at the Karolinska Institute in Stockholm and other research groups. These groups provide the backbone of the different aspects of Neuroinformatics research.

Specific national contributions to OECD Working Group activities

- o OECD GSF Neuroinformatics Working Group 5th Meeting at Karolinska Institute, October 2001.

Switzerland

Neuroinformatics related grants

- The first Swiss Institute of Neuroinformatics (University/ETH Zurich) was founded in 1995 largely supported through a national special program for bioinformatics. This institute has established itself as one of the leading centres for NI.
- Swiss NI research has received strong support through the EU 5th framework program.

National conferences, symposia

- The Swiss NI community takes an international view on NI research and focuses on organising and participating only in international workshops and meetings.

Training programs, workshops

The Institute of Neuroinformatics (University/ETH Zurich) plays a leading role in central international workshops and symposia on NI, i.e., the ESF workshop of Neuroinformatics, the EU summer school of computational neuroscience and the annual NSF workshop on Neuromorphic Engineering in Telluride (USA). In addition, the workshop "Natural and Artificial Computation" (Zurich) was organised as part of the European network of NI.

New national schemes related to neuroinformatics

The support of NI research is a priority area for the Swiss National Science Foundation. However, no special programs have been implemented. Both federal universities (Zurich and Lausanne) have developed and support new initiatives in NI and related areas.

Specific contributions to OECD Working Group activities

3rd OECD-GSF NI Working Group meeting at the Swiss Federal Institute of Technology, Zurich, February 2001.

National neuroinformatics databases and/or tool development

The Institute of Neuroinformatics (University/ETH Zurich) plays a leading role in the development of methods and tools for the design of Neuromorphic hardware and simulation tools supporting the study of large-scale real-time neuronal systems.

Other

At the Swiss National exhibition Expo.02, one of the two science related projects, "Ada: The intelligent space" by the Institute of Neuroinformatics (University/ETH Zurich) presents Neuroinformatics research.

United Kingdom

Only current/recent UK Research Council funded activities have been reported.

Neuroinformatics related grants

- Engineering and Physical Sciences Research Council (EPSRC) and Medical Research Council (MRC), renewable. Interdisciplinary Research Collaboration (from data to medical images), to 2004.
- MRC – note: neuroinformatics forms a part of a wider strategic priority of 'bioinformatics'.

Support specifically for Neuroinformatics

Studentships and Fellowships.

1999 1 Special neuroinformatics Studentship (three year award).

20001 Special neuroinformatics Studentship (three year award).
1 Neuroinformatics Training Fellowship (four year award).
20011 Neuroinformatics Training Fellowship (four year award).

Research grants

- Selective perception and action – a computational neurosciences approach, Co-operative Group Grant, renewable to 2002.
- Emergent properties of neuronal networks – an experimental and computational neuroscience approach, Co-operative Group Grant, renewable to 2004.
- The computational basis of neuronal connectivity, Programme Grant, to 2002, with renewal for a further five years under consideration.

Pending grant applications

- Possible UK National Network for Neuroinformatics, pump-primed with joint UK Research Council funding. Aims, membership and funding currently under development.

National conferences, symposia

- Joint MRC, EPSRC, Biotechnology and Biological Sciences Research Council (BBSRC) Workshop on Neuroinformatics, 2000.
- MRC-supported workshop in Edinburgh organised by David Willshaw and Nigel Goddard to assess current activities and develop ideas from UK for inputting into OECD activity, September 2001.

Training programs, workshops

- MRC highlighted Neuroinformatics as a priority area for studentships. In addition, MRC offers target personal awards via its Special Training Fellowships in Bioinformatics and Neuroinformatics (details of recent MRC awards made are above), 2001--2002.
- Grant from EPSRC for three annual summer schools on simulation tools, 2002--2004.
- EPSRC/MRC supported International Workshops on high performance neuroinformatics over two years. These include ties-in with the US (Human Brain Project) and interested groups in Europe.

New national schemes related to neuroinformatics

In the 2000 Spending Review (SR2000), the UK Government announced a major initiative in e-science (i.e., science undertaken through distributed global collaborations enabled by the Internet, involving large or complex data collections, terascale computing resources and high performance visualisation). A sum of UKP 98 million was allocated over three years to the Research Councils to both facilitate informatics and e-science approaches (including "grid" technologies) within individual disciplines and to develop core underpinning technologies. EPSRC has been charged with developing the generic core e-science technologies on behalf of all the Councils. Each Council will develop programmes to address issues relating to its particular remit; joint Council working will be prosecuted where appropriate. MRC's SR2000 allocation under this heading was awarded specifically for bioinformatics, health informatics and e-science applications; MRC's e-science contribution will encompass computational and data grid applications and middleware developments.

MRC called for outline proposals in 2001 for Strategic Grants in which bioinformatics, neuroinformatics, computational biology, health informatics and/or e-science are applied to two

areas of strategic priority, namely cancer and brain sciences.

Specific national contributions to OECD Working Group activities

Related to OECD WG: Edinburgh Workshop held in September 2001 as described above.

United States of America

Period of 2000-2002 for the Office on Neuroinformatics, NIMH, NIH and the Human Brain Project.

Summary --In 1993, in the USA, the Human Brain Project, a broadly based federal research Neuroinformatics initiative was initiated by fifteen federal organizations from four federal agencies and coordinated by the National Institute of Mental Health (NIMH), National Institutes of Health (NIH) through the activities of the Federal Interagency Coordinating Committee of the Human Brain Project. The Agencies (and their components) include the National Institutes of Health (National Institute of Mental Health, National Institute on Drug Abuse, National Institute on Aging, National Institute on Child Health and Human Development, National Institute on Deafness and Other Communication Disorders, National Library of Medicine, the National Heart, Lung, and Blood Institute, the National Institute of Dental and Craniofacial Research, the National Institute on Alcohol Abuse and Alcoholism, the Fogarty International Center, the National Institute of Neurological Disorders and Stroke, and the National Cancer Institute), the National Science Foundation, the National Aeronautics and Space Administration and the Department of Energy. The Human Brain Project has the responsibility of stimulating and supporting research and training to develop the field of Neuroscience Informatics - Neuroinformatics. <http://www.nimh.nih.gov/neuroinformatics/index.cfm>

Funding opportunities

Human Brain Project/Neuroinformatics

A broad-based initiative, that supports research and development of advanced technologies, and infrastructure support, through cooperative efforts among neuroscientists and information scientists (computer scientists, engineers, physicists, and mathematicians). The goal is to produce new digital capabilities providing a World Wide Web-based information management system in the form of interoperable databases and associated data management tools.

- Human Brain Project: Phase I and Phase II. The purpose of this grant initiative is to encourage and support investigator-initiated Neuroinformatics research that will lead to new digital and electronic tools for all domains of neuroscience research reflecting normal and diseased states across the life span.
- Short Courses In Neuroinformatics. The purpose of this grant Program is to encourage and support short-term Education Grants in Neuroinformatics Research. Support is provided for the development of short courses, seminars and workshops on interdisciplinary Neuroinformatics education.
- Neuroinformatics Institutional Mentored Research Scientist Development. The purpose of this grant program is to encourage and support the development of applications from U.S. educational institutions for Institutional Mentored Research Scientist Development Awards. These awards are intended to foster the career development of individuals with interdisciplinary expertise bridging the fields of neuroscience and behavioural science research with that in informatics.

- Curriculum Development Award In Neuroinformatics Research And Analysis. The purpose of this grant program is to encourage and support applications from individuals with the requisite scientific expertise and leadership for the development of courses and curricula designed to train interdisciplinary Neuroinformatics scientists at U.S. educational institutions.

Human Brain Project/Neuroinformatics grant awards

The grants reported reflect only those applications awarded during this period and do not reflect the entire portfolio of the program. The information listed is the principal investigator, grant title and grant receiving institution.

Research

- Cohen, Jonathan, Advanced Methods for Neuroimaging Data Analysis. Princeton University.
- Ellisman, Mark, Brain Imaging Research Network. University of California, San Diego.
- Gardner, Daniel, Databases and Data Models Enabling Neuroinformatics. Cornell University.
- Jacobs, Gwen, NeuroSys: Neuroinformatics for Neural Systems. Montana State University.
- Jones, Edward G., Informatics of Human and Monkey Brain Atlases. University of California, Davis.
- Kimberg, Daniel Y., A Flexible Architecture for Neuroimaging Data Analysis. University of Pennsylvania.
- Mori, Susumu, Human White Matter Tract Mapping by Diffusion MRI. Johns Hopkins University.
- Mazziotta, John C., A Probabilistic Reference System for the Human Brain. UCLA.
- Mountain, David, EarLab: A Virtual Hearing Laboratory. Boston University.
- Rottenberg, David, Spatial and Temporal Patterns of Functional Activation. VA Medical Center, Minneapolis.
- Shepherd, Gordon, Sense Lab: Integration of Multidisciplinary Sensory Data. Yale University.
- Smalheiser, Neil R., Arrowsmith Data Mining Techniques in Neuroinformatics. University of Illinois at Chicago.
- Strachan, Tom, Electronic Atlas of Human Fetal Brain Gene Expression. University of Newcastle, UK.
- Williams, Robert, Informatics Center for Mouse Neurogenetics. University of Tennessee.

Training and Education

- Beatty, Jackson T., Scalable Instruction in Neuroinformatics at UCLA. University of California Los Angeles.
- Fox, Peter T., International Conference on functional Mapping of the Human Brain. University of Texas Health Science Center, San Antonio.
- Haacke, Mark E., Workshop on Understanding the Bold Phenomena and its Application. MRI Institute for Biomedical Research.

Neuroinformatics meetings and presentations

- Neuroinformatics and Electrophysiological Neuroimaging I, Carmel, January 2000.

- National Academy of Sciences, Washington, D.C., "Bioinformatics: Converting Data to Knowledge," January 2000.
- International Cooperation from agency to Investigator. Operational Digital Brain Atlases and their International Cooperation. 20th European Winter Conference on Brain Research, March 2000.
- Round Table: Biological Informatics, Neuroinformatics and Biodiversity Informatics. Tebio, 1st International Exhibition and Congress on Biotechnology, Genoa, Italy, May 2000.
- The Human Brain Project/Neuroinformatics Annual Spring Meeting, June 2000.
- Advancing Neuroinformatics via the Human Brain Project. Conference on Mathematics and Engineering Techniques in Medicine and Biological Sciences. Las Vegas, Nevada, June 2000.
- Neuroinformatics: an enabling capability for understanding and integrating brain function, Collegium Internationale Neuro-Psychopharmacologicum, Brussels, July 2000.
- Information Technology Applications In Biomedicine - IEEE EMBS Third International Conference. Round Table: Neuroinformatics. Arlington, Virginia, 2000.
- Recent trends in Bioinformatics October 2000.
- Conference on Mathematics and Engineering Techniques in Medicine and Biological Sciences the 17th International CODATA Conference, October 2000.
- Information Technology Applications In Biomedicine - IEEE EMBS Third International Conference, November 2000.
- Society For Neuroscience Meeting, satellite symposium, "Web Accessible Databases and Analytical Tools For Neuroscience Research," November 2000.
- Human Brain Diagnosis Symposium. The Human Brain Project: Neuroinformatics. University Reggio Calabria, Italy, December 2000.
- Neuroinformatics and Electrophysiological Neuroimaging II, Carmel, a workshop focused on practical, non-scientific, implementation issues, with particular emphasis on ethical and legal concerns that arise in the context of a data-sharing environment, January 2001.
- Lake Tahoe Symposium on Molecular Diversity. Neuroinformatics: An enabling approach to Sharing Data on Brain Structure and Function, Lake Tahoe, California, January 2001.
- Second ICSU-UNESCO International Conference. Electronic Publishing in Science. Neuroinformatics: a new enabling field of neuroscience research in the IT area, Paris, France, February 2001.
- Database Development Workshop, New York, New York, April 2000.
- Japanese Society of Medical Electronics and Biological Engineering, Symposium on Genome, Physiome and Neuroinformatics. Neuroinformatics: An enabling Approach toward understanding nervous system function and structure through data sharing and modelling, Nagoya, Japan, May 2001.
- International Workshop on Neuroinformatics, from Gene to Brain. Neuroinformatics: An enabling mechanism for sharing data in the field of Neuroscience, RIKEN, Wako-city, Japan, May 2001.
- The Human Brain Project (HBP)/Neuroinformatics Annual Spring Meeting, Bethesda, Maryland, May 2001.
- The First National Symposium on Neuroinformatics, Academy of Finland. Neuroinformatics: What, why, how? Helsinki, Finland, June 2001.
- A Joint US-EC Workshop, Databasing The Brain, Oslo, Norway, July 2001.
- Neuroanatomy Ontology Workshops six meetings in 2000 -- 2002.

- International Joint Conference on Neural Networks. Neuroinformatics: Human Brain Projects and funding opportunities, Washington, D.C., July 2001.
- International Joint Conference on Neural Networks. From Decade of the Brain to The Human Brain Project: Neuroinformatics. Washington, D.C., July 2001.
- Bioinformatics in Neuroscience and Sleep Research, American Academy of Sleep Medicine. Opportunities for Sharing Data through a Federation of Databases, Bethesda, Maryland, July 2001
- Dalian University of Technology and the Dalian Institute of Neuroinformatics, Dalian, China, and Beijing University of Technology, Beijing, China, and The First Chinese Neuroinformatics Meeting, Beijing, China, Neuroinformatics: A new growth field for Neuroscience, August - September 2001.
- The New Neuroinformatics: Opportunities and Challenges. World Congress on Neuroinformatics, Vienna, Austria, September 2001.
- International Society of Chromaffin Cell Biology Conference, "Neuroinformatics Workshop: Computing the Chromaffin Cell," September 2001.
- Annual Society for Neuroscience, Satellite symposium, "Neuroimaging Databases and Analytical Tools," November 2001.
- Winter Conference on Brain Research, "Structural Databases," January 2002.
- Australian Neuroscience Society Symposium on Databasing the Brain, "The Human Brain Project: Data to Knowledge," Sydney, Australia, February 2002.
- Neuroscience Informatics - From Genes to Cells to Brain, "Overview of the Human Brain Project," Howard Florey Institute, University of Melbourne, Melbourne, Australia, February 2002.
- National Academy of Sciences, Community Standards for Sharing Publication-Related Data and Materials, Washington, D.C., February 2002.

Neuroinformatics publications

- Neuroscience in the new Millennium. Koslow, S.H. and Hyman, S.E. *Einstein Quarterly*, 17: (1) 7-15, 2000.
- Prospect of data sharing gives brain mappers a headache. *Nature*, 406:445-446, 2000.
- Databasing the brain. *Nature*, 406:822-825, 2000.
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National Institutes of Health policy

NIH is developing a new statement on sharing research data that will expect and support the timely release and sharing of final research data from NIH-supported studies for use by other researchers. Investigators submitting an NIH application will be required to include a plan for data sharing or to state why data sharing is not possible. This is an extension of NIH policy on sharing research resources. NIH invites comments on this draft statement. For more information, see the March 1, 2002 NIH Guide Notice and http://grants2.nih.gov/grants/policy/data_sharing/index.htm

National Academy of Sciences Study

The Board on Life Sciences, of the Division on Earth and Life Studies has currently undertaken a study of "Responsibilities of Authorship in the Biological Sciences." The project scope includes a major workshop, which will evaluate the responsibilities of authors of scientific papers to share data and materials referenced in their publications. The workshop will examine requirements imposed on authors by journals, identify common practices in the community, and explore whether a single set of accepted standards for sharing exists. The workshop will also discuss whether more appropriate standards should be developed, including what principles should underlie them, and what rationale there might be for allowing exceptions to them. The committee will prepare a report describing the central issues raised at the workshop. The sponsors of the study are: the National Cancer Institute, the National Human Genome Research Institute, the National Science Foundation, and the Sloan Foundation. <http://www4.nationalacademies.org/cp.nsf>

Specific national contributions to OECD Working Group activities

- Initiated the GSF Neuroinformatics Working Group and Chaired the Working Group.
- OECD GSF Neuroinformatics Working Group 2nd Meeting at The Ronald Reagan Trade Center, Washington, DC, September, 2000.

Appendix C

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Co-Chair, Shun-ichi Amari, Japan
Co-Chair, Sten Grillner, Sweden

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Appendix D

NEUROINFORMATICS WORKING GROUP CALENDAR

January 2000 -- December 2000

GSF Recommends NI-WG, January 2000
Genoa, Italy, May 2000
Washington, DC, USA, September 2000

January 2001 -- December 2001

Zurich, Switzerland, February 2001
Tokyo, Japan, May 2001
Stockholm, Sweden, October 2001

January 2002 -- June 2002

Melbourne, Australia, February 2002
Prague, Czech Republic, April 2002
Final Report, June 2002