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## Neuroimagerie cognitive

Rapport Hcéres

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agence d'évaluation de la recherche  
et de l'enseignement supérieur

Section des Unités de recherche

Evaluation report

Research unit :

Neuroimagerie cognitive

Of the University Paris 11, CEA,

Collège de France, INSERM



March 2009



agence d'évaluation de la recherche  
et de l'enseignement supérieur

Section des Unités de recherche

## Evaluation report

Research unit :

Neuroimagerie cognitive

Of the University Paris 11, CEA,

Collège de France, INSERM



Le Président  
de l'AERES

Jean-François Dhainaut

Section des unités  
de recherche

Le Directeur

Pierre Glorieux

mars 2009



# Evaluation report )

## The research unit :

Name of the research unit : Neuroimagerie Cognitive

Requested label : UMR\_S INSERM, UMR CEA

N° in case of renewal : U562

Head of the research unit : Mr Stanislas DEHAENE

## University or school :

Université Paris 11

## Other institutions and research organization:

College de France

INSERM

CEA

## Date of the visit :

23 Janvier 2009



# Members of the visiting committee

## Chairman of the committee :

Mr Olaf BLANKE (Ecole Polytechnique Fédérale de Lausanne, Switzerland)

## Other committee members :

Mr Olivier BERTRAND (Institut Fédératif des Neurosciences de Lyon)

Mrs Nouchine HADJIKHANI (Harvard Medical School, Ecole Polytechnique Fédérale de Lausanne, Switzerland)

Mr Philippe MARTIN-HARDY (Centre de Recherche de l'Institut du Cerveau et de la Moelle épinière)

Mrs. Lilianne MANNING (Université de Strasbourg)

Mr Christoph SEGBARTH (Grenoble Institut des Neurosciences)

## CNU, CoNRS, CSS INSERM, représentant INRA, INRIA, IRD.....) representatives :

Mr Jean-François DEMONET, INSERM CSS representative

# Observers

## AERES scientific representative:

Mr Christian BARILLOT

## University or school representative:

Mr Michael SCHUMACHER, Université Paris 11

## Research organization representatives :

Mrs. Catherine LABBE-JULLIE, INSERM

Mr Jacques NEYTON, CEA



# Evaluation report

## 1 • Short presentation of the research unit

- Number of lab members : 46 including :
  - 1 researchers with teaching duties
  - 5 full time researchers
  - 6 others (Invited scientists)
  - 19 postdoctoral fellows
  - 7 PhD students
  - 8 engineers, technicians and administrative assistants
- Number of HDR : 3
- Number of students who have obtained their PhD during the past 4 years: 7
- Average length of a PhD during the past 4 years : 3.5
- Number of lab members with a PEDR ; 0
- Number of “publishing” lab members among permanent researchers : 6 out of 6

## 2 • Preparation and execution of the visit

Before the site visit, the committee had received the Report 2005-2008 and the project 2010-2014 of the Unit.

During the visit, the evaluation committee had the opportunity to listen to presentations about various aspects of the unit's activities, and to ask questions and discuss with several of its scientists. The director of the Unit gave a presentation about the organization and projects of the entire group (45 minutes). This was followed by 4 presentations given by each leader of each of the four research teams and one of each team's collaborators (Neuroimagerie des Fonctions Cognitives: team 1, 45 minutes; Neuroimagerie du Langage: team 3, 45 minutes; Neuroimagerie du Développement: team 4, 45 minutes; Neurophysiologie et Neuroimagerie: team 5, 45 minutes). The research report also included research performed by team 2 (Neuropsychologie et Neuroimagerie) that will not be part of the unit in 2010-2014.

A second part was devoted to 2 short visits. During the site visit MRI, MEG, EEG, and behavioral facilities were presented (30 minutes). During the coffee break the committee members also briefly visited the research unit and were presented a few ongoing projects. Finally, the commission split up in smaller groups to meet separately with the PhD and postdoctoral students, with the engineers, technicians, administrative assistants, and with the permanent researchers. The entire committee met with the observers from INSERM, CEA, and Université Paris 11 (30 minutes). This was followed by an internal discussion among the committee members and the Aeres representative (90 minutes). The entire visit lasted 9 hours.



### 3 • Overall appreciation of the activity of the research unit, of its links with local, national and international partners

The research unit is an international leader in human cognition and cognitive neuroimaging. The unit is led by a strong director with a highly original line of research in human cognition. The unit cooperates efficiently with other groups locally, nationally, and internationally. The unit director and the unit as a whole actively promotes interactions between its 4 different teams and this is probably one of the reasons for the many fruitful inter-unit collaborations. The scientific output of the unit is outstanding and the review panel had the impression that the proposed topics of the ambitious research projects will allow the unit to remain at the forefront of cognitive neuroimaging, worldwide.

### 4 • Specific appreciation team by team and/or project by project

#### Team 1 : Neuroimagery of Cognitive Functions

Team 1 is composed of one full-time researcher with a permanent position (Collège de France), two full-time researchers with permanent positions (CR1 INSERM; IR2 INSERM), one 'Maitre de Conference', and two partial researchers, as well as several non-permanent members including 7 post-docs and 3 PhD students.

Team 1's previous research was highly original and of great importance and covered three key domains of human cognition: numeracy, reading, and consciousness. The team is well-known for their work on all three aspects and is a world leader on the cognitive and neuroimaging aspects of numeracy. The team's publication record is truly outstanding (including 2 Science, 4 PLOS Biology, 1 Nature Neuroscience, 5 PNAS, 6 Neuron among many others). The team cooperates efficiently with other groups locally, nationally, and internationally with a good balance between cutting-edge and more basic research projects. The team has a high number of postdoctoral and PhD students and researchers of which several have assured fixed research positions in France, Europe, or the US.

On reading the work has defined the Visual Word form area and its role in reading. Moreover, the unit investigated its function prior to reading in humans. This research has been carried out using cognitive psychology, modelling, as well as neuroimaging. The group's work on numeracy and number processing has made several outstanding discoveries within the last 4 years. Using fMRI the function of a small parietal brain region was further defined including adults and human infants. This was combined with the analysis of numeracy in Amazonian Indians and integrated into a model. The work on consciousness investigated the limits between subliminal and conscious access by means of ERPs and different masking paradigms. The central contribution of the team in this field is the demonstration that phenomena thought to be the hallmark of conscious access are but the early condition needed to modulate accessibility of information into a prefrontal-parietal workspace global network. Conclusions on conscious access were applied to two pathological conditions: schizophrenia and multiple sclerosis. A further contribution consisted in the account of the psychological refractory period. The work on consciousness projected by Team 1 for the next four years is based on tests that can be presented to the largest possible variety of populations up to comatose patients. In this way, they propose to test different predictions of their global network workspace model. The other projects for 2010-2014 concerning numeracy and reading were very well presented and feasible. Of great importance are planned future interactions with the recently formed novel research team at Neurospin working with non-human primates and neuroimaging techniques in awake and anesthetized monkeys on consciousness. Based on the outstanding performance in the previous period it is likely that the team will succeed in the different studies described in the research project with novel and important scientific insights. The committee has no doubts that this internationally well-know team will continue to make outstanding contributions to science.

Strong points: A truly outstanding research team.

Weak points: There are no weak points to indicate.

Specific recommendations: none.



Nom de l'équipe : Neuroimagery of Cognitive Functions

Note de l'équipe	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A+	A+	A+	A+	A+

### Team 3 : Neuroimagery of Language

Team 3 involves one full-time researcher with permanent position (CR1 CNRS), one 'Maitre de Conference', and several non permanent members including 3 post-docs and 2 PhD students. The main line of research relates to the brain substrates of language comprehension and processing mainly studied using fMRI and structural MRI (VBM). In this domain, different topics have been addressed including the influence of bilingualism and various aspects of such an ability (e.g. phoneme perception, prosody acquisition) and cross-species (Human vs Monkey) studies of speech perception. Of special interest has been the study of sentence processing and the neural processes relating respectively to the diverse (e.g. lexicon vs syntax) structural levels of language. This latter line of research prompted the members of the team to the studying the dynamics of syntax processing; the absence of clear-cut effects of priming from syntax structures yielded questions relating to both theoretical models of these language processes (representations in long-term memory vs rule-based on-line process) and methodological aspects of the experimental paradigm. An interesting parallelism with the structural components of music and the corresponding brain substrates has been presented. Based on these grounds the project will explore in more details the brain substrates related to the processing of hierarchical structures; the brain bases of processing hierarchical structures will be studied using either (language) sentences, musical sequences or sequences based on artificial grammar.

The past activities and the project take place in the context of active European and international collaborations. The team leader has got some financial support from either National or European grants.

From the year 2004, the team leader authored or co-authored 15 articles in 'rang A' journals; these papers published in high-quality journals in the domain of cognitive neuroscience and neuropsychology are well focused on the research themes described in the activity report and the project.

Strong points: The team's line of research is excellent and timely.

Weak points: In spite of great scientific interest, Team 3 and its research is less visible than all other teams at U562. It would be of interest to develop potential applications to language pathologies.

Specific recommendations: The team leader should obtain the HDR title, a step that although formal would facilitate and fasten the turn-over of the PhD process and the global attractiveness of the team.

Nom de l'équipe : Neuroimagery of Language

Note de l'équipe	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A	A	A	B	A





#### Team 4 : Neuroimagerie of Developpement

Team 4 (“Developmental neuroimaging” in the U562 unit as well as in the new project) is composed of a single scientist with tenure position (CNRS Director of Research; Director of the team), of two engineers (both computer scientists, one having a permanent, INSERM “IE”, position, the other being hired with budget from ANR), of one postdoc and one PhD student. During the past four-year period, a second postdoc, a second PhD student and a research assistant were equally members of the team. Recruitment of one or two researchers is hoped for in a near future. Overall, the review panel felt that the points of excellence of team 4 were the great originality and interest of the research in very young children, cutting edge projects in developmental neuroimaging and the strength of social and scientific interactions of team 4.

Past activity was developed along two axes. Along the first one, studies were focused on the assessment of structural asymmetries in infant brain and on the functional description of the neuronal networks involved at the beginning of human life in complex cognitive functions such as language, visual recognition of conspecifics, number perception. Studies have revealed early structural asymmetries as well as a highly organized brain from the first months of life on. Cortical regions similar to those observed in adults are involved in language, face and number perception. Long-range connectivity is equally functional from early on. The infant brain appears however parceled and heterogeneous, due to differences between maturational time-scales from different regions. The infant brain appears thus in no way to be a small-scale adult brain - in contrast, it possesses numerous specificities that need to be explored.

Along the second axis, new methodological tools were developed in order to improve brain imaging in infants. Specific problems and difficulties have been (and are being) addressed including small brain size, short data collection times, subject motion, impossibility to train or instruct subjects to perform specific tasks, low MRI image contrast between grey and white matter due to poor myelination, heterogeneity of the populations due to fast changes occurring in the brain during early childhood, etc. Exploration and development of new imaging techniques, paradigms and data processing methods was - and is - done in close collaboration with the methodological teams present at NeuroSpin.

Scientific production over the past four years counts 18 peer-reviewed papers in international journals, such as *NeuroImage* (3), *Human Brain Mapping* (4), *Journal of Cognitive Neurosciences* (2), *Journal of Neurosciences* (1), *PNAS* (1), *TINS* (1), *Cerebral Cortex* (1), *PLoS Biology* (1), *Cognition* (1). Also some six educational reviews have been published.

The project for 2010-2014 was well presented and will build on previous findings using MR-based techniques and EEG. The review panel was less convinced of the testing of young children with MEG, but estimates that the team’s research project will lead to important scientific insights. Future activity will focus on the development of language and consciousness in infants and in young children. Particular focus will be put on precursors of language networks, their structural organization, their temporal dynamics and its relation to the underlying anatomical connectivity as assessed by diffusion tensor MR imaging. Studies will rely upon functional measurements with ERP, MEG as well as with fMRI, all techniques available at NeuroSpin.

**Strong points:** This team has a very original line of research linking developmental psychology with neuroimaging. Strengths lie in the team being one of the few ones worldwide being able to study the infant brain by means of a combination of MRI, ERP and MEG techniques. The team may thereby rely upon the exceptional instrumental infrastructure and methodological expertise in neuroimaging and data processing available at NeuroSpin, as well as upon the possibility to exchange with the high-level cognitive neuroscientists present at the laboratory. The team’s strength further lies in its own ability to address appropriately all difficulties inherent to functional and structural imaging of the infant brain.

**Weak points:** The committee felt that team 4 is somewhat isolated compared to the other unit teams that focus on adult cognitive psychology and neuroimaging. Main team weakness lies in the geographical isolation of NeuroSpin, rendering difficult efficient patient recruitment and management.

**Specific recommendations:** Based on the geographical isolation mentioned above, the Committee recommends the team leader to put further efforts in developing an efficient network permitting to ensure efficient subject recruitment.



Note de l'équipe	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A	A	A	B	A

#### Team 5 : Neurophysiology and Neuroimagerie

Team 5 is composed of one full-time researcher with a permanent position (DR 2 INSERM), one CEA, one CDD and two non-permanent members including 1 post-doc and 1 PhD student. Team 5's work on the resting or default network using different neuroimaging techniques is well-known internationally and has been applied to several domains within the cognitive neurosciences. Several high-visibility publications have resulted in the evaluated research period. The management and focus of the team are excellent, although the research topic of team 5 seems to be less well integrated into the research agenda of U562, but this is certainly due to the later arrival of team 5 in U562 compared with the other teams. The novel MEG platform at Neurospin is part of team 5.

The project for 2010-2014 was well presented and builds on previous findings using MR-based techniques. The general and innovative concept pursued by this team is to develop a brain-based view of cognition, as opposed to a stimulus-based approach in their fMRI experiments. In addition, the team plans to investigate multisensory processing using the newly installed MEG platform. Both lines of research are innovative and of high quality. Interactions with other teams include the study of subliminal sensory effects and their impact on perception (together with team 1), the emotional modulation of audiovisual integration (with team 1), the neural bases of numerical cognition (with team 1), and the development of predictive mechanisms in speech and of speed processing (with team 3).

**Strong points:** The research is innovative and highly original. The team leader is well-known internationally for his work linking electrophysiology and neuroimaging approaches. The quality of the projects is excellent and innovative.

**Weak points:** The committee felt that the research topic of team 5 is somewhat distinct (auditory or visual perception; multi sensory perception) compared to the other unit teams.

**Specific recommendations:** The number of researchers/engineers working at the MEG platform is low (n=2). Due to the installation of the MEG platform and planned increase in future projects from the unit as well as other researchers at Neurospin it is desirable that the number of researchers be increased at the MEG platform (see also next point). However, the development of common projects with teams 1 and 3 will certainly improve integration of team 5.

#### Nom de l'équipe : Neurophysiology and Neuroimagerie

Note de l'équipe	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A+	A+	A	A	A+



## 5 • Appreciation of resources and of the life of the research unit

### – Management :

The unit is led by a strong director with a highly original line of research in human cognition. The unit cooperates efficiently with other groups locally, nationally, and internationally. The unit director and the unit as a whole actively promotes interactions between its 4 different teams and this is probably one of the reasons for the many fruitful inter-unit collaborations.

### – Human resources :

The unit has a high number of postdoctoral and PhD students revealing its attractiveness to carry out graduate work in the unit. These students have varying academic backgrounds and come from France, other European countries or from overseas. Several of the unit's past researchers have assured fixed research positions in France, Europe, or the US speaking for the excellent level of education of the group.

### – Communication :

The unit's research is presented at major scientific conferences. The scientific output is outstanding. The unit's director is Professor at the College de France. The unit has published several books directed at the general public and is actively involved in knowledge dissemination.

## 6 • Recommendations and advice

### – Strong points:

The review panel has the impression that research in the unit actively promotes interactions between its different teams. This approach has been highly successful in the past. The review panel supports this vision and would like to encourage that further actions are taken to promote these interactions. We also hope that collaborations with the former team 2 ("Neuropsychologie et Neuroimagerie") will be actively pursued as that collaboration has been very successful. The strong guidance of the group is excellent and probably one reason for these fruitful inter-unit collaborations as well as international collaborations. The scientific output of the unit is outstanding and the review panel had the impression that the proposed topics of the ambitious research projects will allow the unit to remain at the forefront of cognitive neuroimaging, worldwide.

### – Weak points:

It was mentioned to the review committee that the unit should consider hiring a full-time MRI engineer maintaining/assuring the different projects running at the different MR-scanners in the unit. The risk of not having long-term contracts with engineers is that they may leave the lab taking with them a 'savoir-faire' that has been built up over many years and will slow down ongoing research projects.

### – Specific recommendations:

The number of researchers/engineers working at the MEG platform is low (n=2). Due to the installation of the MEG platform and planned increase in future projects from the unit as well as other researchers at Neurospin it is desirable that the number of researchers be increased at the MEG platform (see also next point).

Next to the MEG platform another new research theme (cognitive neuropsychiatry) was presented, initially as part of team 1, which could potentially evolve into an additional team. The development of a group studying psychiatric patients seemed more demanding to the review panel as it will have to involve careful patient recruitment and organization. Also, MR and MEG investigations of psychiatric patients will also involve practical issues that have to be carefully considered. Finally, the committee notes that there are already many research groups at the local, national and international level in this very active and competitive field of research.



Note de l'unité	Qualité scientifique et production	Rayonnement et attractivité, intégration dans l'environnement	Stratégie, gouvernance et vie du laboratoire	Appréciation du projet
A+	A+	A	A	A+



Le Président de l'Université Paris-Sud 11

à

Monsieur Pierre GLORIEUX  
Directeur de la section des unités de recherche  
**AERES**  
20, rue Vivienne  
75002 Paris

Orsay, le 17 avril 2009.

N/Réf. : 141/09/GCo/LM/LS

Objet : Rapport d'évaluation d'unité de recherche  
N° S2100012404

Monsieur le Directeur,

Vous m'avez transmis le trois avril dernier, le rapport d'évaluation de l'unité de recherche « Neuroimagerie cognitive » - UMR S 562, et je vous en remercie.

L'université se réjouit de l'appréciation portée par le Comité sur cette unité et prend bonne note de ses suggestions.

Veillez trouver ci-joint un message du directeur d'unité précisant les données factuelles et ajoutant quelques commentaires.

Je vous prie d'agréer, Monsieur le Directeur, l'expression de ma sincère considération.

Guy COURRAZE  
Président



P.J. : Commentaires de M. DEHAENE

Saclay, Thursday, 09 April 2009

Dear Colleagues,

I would like to start by thanking the AERES visiting committee for its in-depth evaluation of the research unit that I am directing.

The report is overall very positive and calls for very few remarks on my side.

Concerning team 3 (*Neuroimaging of language*), we gladly note the committee's remark that "the team's line of research is excellent and timely". The team leader has written up his HDR project and should receive the formal habilitation to direct research during this summer. As suggested by the committee, extensions of the research to brain-lesioned patients are currently examined, in collaboration with the Salpêtrière Hospital, and data from a first intracranial patient has been recorded using the team's main linguistic paradigm.

Concerning team 4 (*Developmental Neuroimaging*), we are following the advice of the committee and are recruiting a "lab manager" to facilitate subject recruitment and increase the scientific through-put of the team.

Concerning team 5 (*Neurophysiology and Neuroimaging*):

- The committee may want to correct the formulation of the sentence on page 7 "the novel MEG platform at Neurospin is part of team 5." In reality, MEG is a cross-team and cross-laboratory platform that is made available to all teams. Only its executive director is a newly hired researcher who, for her research projects (70% of her time), is part of team 5. She arrived in November 2008, but her collaboration with teams 1 and 3, as suggested by the committee, is already very strong.
- The committee's suggestion to increase the number of engineers working on MEG is very well taken. Thanks to the INSERM TechnoSanté program, we will recruit an electronics engineer in 2009. Also, we currently have no less than 5 PhDs and post-docs working on the MEG tools, some of whom have engineering or physics degrees (Polytechnique, Princeton, Riken...). Finally, in the framework of the IFR 49, we are benefitting from considerable help from the existing MEG center in Salpêtrière and its two expert engineers. Thus, I am confident that by the summer, the main MEG analyses will be operational and up to international standards.

Concerning our fMRI activities, we appreciated the committee's proposal that we hire an MRI engineer. We do not know whether this will be possible in the next few years, but in the meantime, the NeuroSpin context should help us pursue our MR projects at the highest international level. We have tight collaborations with several CEA engineers who are very helpful for MR developments.

Finally, concerning Cognitive Neuropsychiatry, the committee correctly noted that this is only a subpart of the activity of team 1. We share the view that it is not yet clear whether this program will achieve sufficient strength and autonomy in the next four years to become a separate team. At the moment, we simply feel that the potential impact of our cognitive tests and models for neuropsychiatry is real. It is therefore quite natural, as an INSERM laboratory, to experiment in this field and examine how observations in psychiatric patients inform our models of normal cognitive architecture. We are not geared up to perform large-scale studies of schizophrenic patients, treatment, or genetics, but we can contribute to the understanding of the neuro-cognitive basis of some of their impairments.

In terms of autonomy of the psychiatry subgroup, it can be noted that it now has its own funding (45 k€ from the FondaMental Foundation dedicated to psychiatry research), a specific convention with the Fondation Elan Retrouvé for patient recruitment, and a dedicated ethical approval for EEG, MEG and fMRI experiments. ERP and fMRI data have been acquired and are in the pipe-line for publication in 2009.

Overall, I am grateful for the highly positive yet lucid comments that we received from the committee, and which will help us organize our laboratory for the next four years.

Sincerely yours,

Stanislas Dehaene

A handwritten signature in black ink, appearing to read 'S. Dehaene', with a long horizontal stroke extending to the left.

Member, French Academy of Sciences  
Professor, Collège de France  
Director, INSERM-CEA Cognitive Neuroimaging Unit

L'Administrateur Général



Monsieur Pierre GLORIEUX  
Directeur de la Section des Unités

AERES  
20, rue Vivienne  
75002 Paris

Saclay le 20 avril 2009

**Objet :** Observations du CEA sur le rapport d'évaluation du Laboratoire de neuro-imagerie cognitive, U562  
(Référence : EVAL-0911101C-S2100012404-UR-RPRELIM)

**N/Réf. :** DPG/AN/mos/2009-122

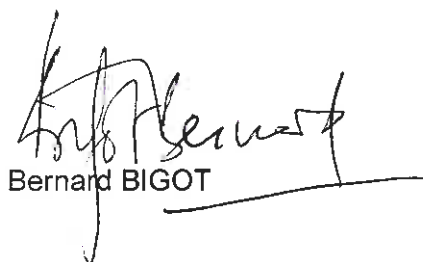
Monsieur le Directeur,

Je remercie tout d'abord l'AERES pour la qualité du rapport d'évaluation et pour la pertinence des recommandations qui ont été faites.

Vous trouverez, ci-joint, les commentaires faits par Monsieur Stanislas Dehaene, directeur du Laboratoire de neuro-imagerie cognitive (UMR CEA, UMR\_S INSERM, U562), sur ce rapport d'évaluation.

En tant qu'Administrateur Général de l'Etablissement CEA, ce rapport n'appelle pas de commentaires particuliers de ma part. Je prêterai la plus grande attention à la mise en œuvre des actions qui permettront de répondre aux recommandations formulées par l'Agence.

Je vous prie d'agréer, Monsieur le Directeur, l'expression de mes meilleures salutations.

  
Bernard BIGOT