UNICOG - Neuroimagerie cognitive

Rapport Hcéres

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

Department for the evaluation of research units

AERES report on unit:

COGNITIVE NEUROIMAGING UNIT

UNICOG

Under the supervision of the following research bodies:

Université Paris-Sud

Institut National de la Santé Et de la Recherche Médicale – INSERM

Commissariat à l'Énergie Atomique et aux Énergies Alternatives – CEA

December 2013

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

Department for the evaluation of research units

On behalf of AERES, pursuant to the Decree of 3 november 2006[1]*,*

- Mr. Didier HOUSSIN, president
- Mr. Pierre GLAUDES, head of the evaluation of research units department

On behalf of the expert committee,

- Mr Richard FRACKOWIAK , chair of the committee

[1] The AERES President "signs [...], the evaluation reports, [...] countersigned for each department by the director concerned" (Article 9, paragraph 3 of the Decree n ° 2006-1334 of 3 November 2006, as amended).

Evaluation report

This report is the result of the evaluation by the experts committee, the composition of which is specified below.

The assessments contained herein are the expression of independent and collegial deliberation of the committee.

Unit name:	Cognitive Neuroimaging unit
Unit acronym:	UNICOG
Label requested:	INSERM / CEA Cognitive Neuroimaging Unit
Present no.:	U 992
Name of Director (2013-2014):	Mr Stanislas DEHAENE
Name of Project Leader (2015-2019):	Mr Stanislas DEHAENE

Expert committee members

Chair:

Mr Richard FRACKOWIAK , Département des neurosciences cliniques, Hôpital universitaire, Lausanne, Switzerland

Experts:

Ms Daphné BAVELIER, Faculté de Psychologie et des Sciences de l'Éducation, Switzerland

Mr Olivier BERTRAND, Lyon Neuroscience Research Center

Mr Jean DAUNIZEAU, Institut du cerveau et de la moelle épinière, Paris

Mr Mathias PESSIGLIONE, Institut du cerveau et de la moelle épinière, Paris (representative of CSS INSERM)

Mr Tim SHALLICE, Cognitive Neuroscience Area, SISSA, Italy

Scientific delegate representing the AERES:

Mr Yves TROTTER

Representatives of the unit's supervising institutions and bodies:

Mr Jacques BITTOUN, Université Paris-Sud

Mr Gilles BLOCH, CEA

Ms Ghislaine DEHAENE (representative of the Doctoral School ED 3C")

Mr Etienne HIRSCH, INSERM

1 • Introduction

History and geographical location of the unit

The Cognitive Neuroimaging unit was created by INSERM in January 2002 and renewed in January 2006 and again in January 2010. It is a mixed unit affiliated to INSERM, the French Atomic Energy Commission (CEA, which provides the building and the brain imaging facilities) and Université Paris-Sud (which provides part of the funding). Through its director, who is also a professor at Collège de France, it is affiliated to the Institut de Biologie of the Collège de France, which also provides some permanent funding.

The unit was started as part of the Service Hospitalier Frédéric Joliot in Orsay, and then moved to the NeuroSpin facility, headed by Mr Denis LE BIHAN on the nearby Saclay campus, when this facility was opened in January 2007.

The Cognitive Neuroimaging Unit is the only life science core unit of NeuroSpin, which is almost entirely comprised of non-CEA researchers, most of whom are cognitive neuroscientists (the remaining staff are primarily physicists and computer scientists). Its primary role is to apply the remarkable brain imaging tools available at NeuroSpin to specific questions in cognitive neuroscience.

Management group

Director of the unit: Mr Stanislas DEHAENE

AERES nomenclature

SVE1_LS5 (primary)

SVE1_LS7 (secondary)

Unit workforce

Unit workforce	Number as at 30/06/2013	Number as at 01/01/2015
N1: Permanent professors and similar positions	1	1
N2: Permanent researchers from Institutions and similar positions	13	14
N3: Other permanent staff (without research duties)	2	2
N4: Other professors (Emeritus Professor, on-contract Professor, etc.)		
N5: Other researchers from Institutions (Emeritus Research Director, Postdoctoral students, visitors, etc.)	17	12
N6: Other contractual staff (without research duties)		1
TOTAL N1 to N6	**33**	**30**

Unit workforce	Number as at 30/06/2013	Number as at 01/01/2015
Doctoral students	15	
Theses defended	9	
Postdoctoral students having spent at least 12 months in the unit*	9	
Number of Research Supervisor Qualifications (HDR) taken	2	
Qualified research supervisors (with an HDR) or similar positions	4	5

2 • Assessment of the unit

Strengths and opportunities related to the context

This is a coherent unit composed of 4 excellent to outstanding groups:

- group 1: Neuroimaging of Human Cognitive Architectures (directed by Mr Stanislas DEHAENE, professor at Collège de France): to analyze, in the healthy subject, the architecture of cerebral networks involved in cognitive functions that are particularly developed in humans, including syntax in the linguistic and mathematical domains, access to consciousness, and introspection;

- group 2: Neuroimaging of Language and Symbols (directed by Mr Christophe PALLIER, DR2 CNRS): to analyze the neural bases of language and symbol processing, including the semantic processing of words and numbers;

- group 3: Neuroimaging of Development (directed by Ms Ghislaine DEHAENE-LAMBERTZ, DR1 CNRS): to examine human cognitive development in infants and children, both at the structural and functional levels, and to develop new imaging techniques adapted to human infants;

- group 4: Magnetoencephalography and Brain dynamics (directed by Ms Virginie VAN WASSENHOVE, CEA): to evaluate the processing of multisensory information, its temporal organization and particularly the representation of temporal information in the human brain, using magnetoencephalography (MEG) as a principal method.

It works in a technologically ideal environment with excellent facilities that will in due course include some of the most powerful magnets used in human brain research, supported by an animal team, a clinical facility and outstanding physical and technological engineering expertise.

The doctoral students and post-docs have an excellent esprit de corps and clearly interact well across groups a well as within. There is little isolationism and an understanding of the need for inter-disciplinarity

There is a high degree of awareness about the external proselytisation of the unit's work which has high social importance in many ways. There are well managed interactions with the press, the educational community, popular science organisations and the local community. This activity intertwines with the scientific work and represents a refreshing public face of science that is paid for by the population and is to be congratulated.

The scientific output is outstanding and there seem no reasons to think it will not continue.

Weaknesses and threats related to the context

The site is remarkable (the "Notre Dame of Neuroimaging"). However it is isolated for both working staff and volunteers or patients. The strict CEA security rules at times interfere with working hours for the scientists and indeed seem to make group 3's and the Translational Unit's work more tedious than necessary.

There is a large number of temporary scientists associated with UNICOG – this could be perceived as a weakness but the experts committee feels this is in fact a major advantage giving a throughput of smart young scientists who can subsequently find work elsewhere thus raising the reputation of France in the field.

The management of NeuroSpin is clearly a major task – it seems that regular meeting of the heads of units with the director could benefit all in diminishing the administrative workload and giving opportunity for high-level interaction between the major units. There are significant outstanding administrative and managerial issues that make work difficult – for example, no access to computing from home or external collaborative sites; inability to scan 24 hours for 7 days in the week. Space is also becoming an issue – there are no plans in place yet to accommodate the people that will work in NeuroSpin for the Human Brain Project. The deployment of super-computing dedicated to the work requires planning too.

The links with the clinical community are sparse, which is remarkable given the quality of the work. A senior scientist left (Mr Andreas KLEINSCHMIDT) because an appropriate senior clinical position could not be found at the Salpétrière (a similar historical situation to that of Mr Denis LE BIHAN some years ago). There should be better coordination with that community through high level links to complement those that have developed with Mr Laurent COHEN and Mr Lionel NACCACHE.

The MRI Physics group of NeuroSpin that is developing the high performance magnets and other technologies is complemented by a Computational Science group that is perhaps too focused on abstract issues of image analysis – a component of this group's work could be associated with real-life problems as perceived from the angle of life sciences or cognition as opposed to the primary viewpoint of mathematics or algorithmics.

In terms of novel initiatives, the unit feels strongly that a non-human primate group should become established at NeuroSpin through the stabilisation of Mr Béchir JARRAYA. The experts committee agrees and urges steps to be taken to promote such a development. One of the UNICOG groups is relatively young with an appointment made to its leadership this year. The intellectual quality of the proposed programme in group 4 suggests that this was a wise appointment.

Finally, it is clear that the constant escalation of the internal costs of scans is beginning to be deleterious to work by the unit. A formal accord is needed stipulating how many free pilot studies are given to preparation of grants or for the testing of new collaborative groups.

Recommendations

The work of the unit should be supported fully and equally for all of its 4 constituent groups.

Plans need to be made for the accommodation of the HBP (Human Brain Project) Cognitive Architectures subproject.

High level communication with management, computation and physics needs to be made regular to promote interdisciplinary interaction in NeuroSpin at a higher level still than at present.

The CEA needs to rapidly provide procedures that maintain security whilst providing an appropriate academic environment at NeuroSpin for UNICOG. This should not be outside the competence of the world's foremost security experts.

3 • Detailed assessments

Assessment of scientific quality and outputs

Outstanding – world class (cognition) and in many ways, world leading in certain aspects (development).

Two groups are slightly further ahead than the remaining two, but both the latter have recently been formed or had new leadership. The experts committee is satisfied that the output in terms of numbers of publications, quality of journals and numbers of written outputs for general public consumption is first class.

Assessment of the unit's academic reputation and appeal

In a straw poll about 70 % of students and almost 100 % of post-docs came to NeuroSpin because of the reputation of UNICOG and its leader. The international collaborations are numerous and of high quality with people at the leading edge of the field which is also evidence for the unit's reputation scientifically.

Assessment of the unit's interaction with the social, economic and cultural environment

This is outstanding with activity that goes from online lectures from the Collège de France to proposals to interactions with teachers for texts and methods to help dyslexic children read. Of note also is the major contribution to the Cogmaster programme run from the ENS/EHESS.

Assessment of the unit's organisation and life

The relationships between scientists are excellent, the unit is "woman friendly" and the staffs appreciates the flat structure and the disposition of working places that often give opportunities to interact between as well as within groups.

Assessment of the unit's involvement in training through research

PhD students have their own mentors – there is no dual mentorship programme in place to deal with tensions and other personal issues. This is common practice now – principal supervisor and mentor (or co-supervisor). However, the école doctorale system in place in France may represent another way of guiding students that is equally effective. There are many opportunities to learn how to present at international meetings and the use of English for these occasions is supported. The students expressed a desire for a retreat(s) where they could meet in more social circumstances to talk about what they are doing and to familiarise themselves with the bigger scientific picture of the unit.

Assessment of the strategy and the five-year plan

The 5-year plan is thorough, builds on the past, suggests new avenues and was considered scientifically exciting. The main initiatives relate to opportunities provided by the restructuring into 4 groups. Secondly, the technological advantages promised by the 7T and 11.5T magnets and by an established non-human primate physiology team that will provide mechanisms at the physiological level to complement those being elaborated by the MEG group seem to constitute a very coherent methodological blueprint.

The consciousness programme that will become more important in Mr Stanislas DEHAENE's project (group 1) is well validated with a prominent output already including consciousness signatures with EEG techniques that could be ready soon for clinical use (The procedure for obtaining a patent has commenced, which is to be applauded).

The strengthening of group 2 by two permanent engineers opens up new perspectives for the Linguistic work. The proposals here may be very taxing at the level of spatial resolution. This group is likely to use the 7T machine soon and possibly quite intensively.

Group 3 is world leading and not just because it is easier to do such studies in France nor because the field is small. Many theories of mental disease currently depend on knowing what happens during the development of the brain. This group is doing an amazing amount of descriptive work, mainly because the field is not scoped yet. Out of

the results are merging new hypotheses that suggest a very productive period ahead. The cross-talk between non-human primate and infant brain investigation may be especially fruitful.

Group 4 is very neuroscience driven – indeed to the experts committee it seemed that much of the proposal for the next five years was very innovative for the MEG field. The ability to look out of the box was much admired and the rationale for the plan in terms of multisensory integration and interfacing with internal representations suggested that the risky nature of this work was well justified and worthy of support.

We were not provided with the Annual Report of NeuroSpin and so are unable to comment on the internal distribution of resources and on plans for the future in this regard.

In summary, an oustanding unit with excellent groups, an integrated and justified plan for the next 5 years and a workforce that seems enthusiastic, competent and proud of their discoveries.

4 • Group-by-Group analysis

Group 1: Cognitive architectures

Name of group leader: Mr Stanislas DEHAENE

Workforce

Group workforce	Number as at 30/06/2013	Number as at 01/01/2015
N1: Permanent professors and similar positions	1	1
N2: Permanent EPST or EPIC researchers and similar positions	1	1
N3: Other permanent staff (without research duties)	0.5	0.5
N4: Other professors (PREM, ECC, etc.)		
N5: Other EPST or EPIC researchers (DREM, Postdoctoral students, visitors, etc.)	7	6
N6: Other contractual staff (without research duties)		1
TOTAL N1 to N6	**9,5**	**9,5**

Group workforce	Number as at 30/06/2013	Number as at 01/01/2015
Doctoral students	7	
Theses defended	2	
Postdoctoral students having spent at least 12 months in the unit	3	
Number of Research Supervisor Qualifications (HDR) taken		
Qualified research supervisors (with an HDR) or similar positions	1	1

• Detailed assessments

Assessment of scientific quality and outputs

From a basic research perspective group 1 is undoubtedly one of the leading cognitive neuroscience groups in the world. This is shown by the breadth and importance of the intellectual problems on which they have made advances, and by the high quality of the journals in which their many findings have been published.

Mr Stanislas DEHAENE and his collaborators have made many discoveries in a wide range of fields, but in particular on number processing, word processing (particularly with Mr Laurent COHEN) and consciousness (particularly with Mr Jean-Pierre CHANGEUX). Of greatest impact has probably been the work on consciousness, where he and his

collaborators have honed the first proper scientific theory, in the field in that the theory is both realised (in part) in a computational model and has been tested by his group in a wide variety of empirical contexts.

In all three areas we have seen a partial move in the last five years from the establishment of the empirical plausibility of Mr Stanislas DEHAENE's theories to their application in a variety of contexts. Thus his group have applied his theories to the neural changes occurring when one learns to read, to the processes occurring when one carries out mental arithmetic and to methods to monitor consciousness in those who are unable to speak or act. Findings have appeared in Science (4 papers), PNAS (5 papers), Neuron (1paper) and Current Biology (1 paper) and many other journals (85 in total). At a time when most cognitive neuroscientists are specialists in one or possibly two related cognitive domains and tend to use well tried experimental paradigms or ill-controlled ones, what is perhaps most remarkable is the ability of Mr Stanislas DEHAENE to launch novel and very well designed experiments in a variety of cognitive domains. In this respect his intellectual fertility and flexibility is probably greater than that of any other cognitive neuroscientist currently active.

Assessment of the unit's academic reputation and appeal

From a basic research perspective group 1 is undoubtedly viewed as one of the leading cognitive neuroscience groups in the world. This is shown by the honours awarded to Mr Stanislas DEHAENE, who is only 48, was the second winner of the Heineken Prize for Cognitive Science awarded in 2008 by the Dutch Academy of Sciences and has since received many academic honours including election to the Collège de France and the awarding of an honorary degree this year at the University of Lisbon. He has also been selected to lead the Cognitive Architectures pillar of the European FET "Human Brain Project".

Assessment of the unit's interaction with the social, economic and cultural environment

Especially given the parallel research productivity, this has been excellent with preparation of a major permanent exhibit on the human brain at Cité des Sciences, authorship of two popular books on different aspects of cognition, and participation in TV and radio shows. Moreover software games and a website have been produced to help dyscalculic children, and a new consciousness monitoring method developed.

Assessment of the unit's organisation and life

There were no suggestions on the site visit that there were any problems in the relations within the group.

Assessment of the unit's involvement in training through research

This appears to be good with 8 Collège de France courses available on-line, contributions to the Cogmaster course at the ENS and a variety of courses given abroad.

Assessment of the strategy and the five-year plan

Of the three proposed lines of work for group 1, the work on consciousness is in part an extension of the types of studies previously carried out. However a major application is the development of EEG paradigms for assessing patients in apparent vegetative state. This would be clinically very useful since the main current methods employ fMRI, a much more expensive and less transportable technology. One surprising lacuna is that nothing is said on paper about the source of the patients; it is difficult to see how the research program could succeed without a steady reliable source. However it became apparent on the site visit that the collaborations with Mr Lionel NACCACHE and Mr Laurent COHEN at the Salpetriere, which will be an important source of such patients, are clearly very solid, so in practice this should not cause a problem.

The work on literacy/mathematics and education is again an extension, but a considerable one, of existing work on the effects on the brain of learning to read and so-called cultural recycling; in this respect one of the aims is to look at the brains of people with extensive training in mathematics when carrying out different types of mathematical/arithmetic operations. Investigation of this latter cognitive domain is potentially very fruitful.

What is really novel is the proposed work on the brain bases of recursion. This is particularly exciting, as it will look at recursion outside as well as within the domain of language. Outside language, recursion has hardly been experimentally investigated at all. Yet it is an important element in many of the greatest human achievements such as mathematics. In addition this is a process that is probably not possible to study in animals.

Conclusion

- **Strengths and opportunities:**

The great intellectual fertility and flexibility of Mr Stanislas DEHAENE's scientific style.

The possibility of exploring a range of novel problems of wide significance and depth using highly creative and appropriately rigorous methods.

- **Weaknesses and threats:**

Mr Stanislas DEHAENE having to spend an increasing amount of his time not on science but on scientific management. This danger is being exacerbated by the need to prepare an increasing number of grant proposals for the unit in part due to the greater cost of scanning.

- **Recommendations:**

The group should be provided as smoothly as possible with the support necessary to carry out their planned excellent program of research.

In summary, a group led most ably by one of the leading cognitive neuroscientists in the world, currently producing research of great originality and importance to his field.

Group 2 : Neuroimaging of language and symbols

Name of group leader: Dr Christophe PALLIER

Workforce

Group workforce	Number as at 30/06/2013	Number as at 01/01/2015
N1: Permanent professors and similar positions		
N2: Permanent EPST or EPIC researchers and similar positions	4	5
N3: Other permanent staff (without research duties)	0.5	0.5
N4: Other professors (PREM, ECC, etc.)		
N5: Other EPST or EPIC researchers (DREM, Postdoctoral students, visitors, etc.)	3	1
N6: Other contractual staff (without research duties)		
TOTAL N1 to N6	**7,5**	**6,5**

Group workforce	Number as at 30/06/2013	Number as at 01/01/2015
Doctoral students	2	
Theses defended	2	
Postdoctoral students having spent at least 12 months in the unit	1	
Number of Research Supervisor Qualifications (HDR) taken	1	
Qualified research supervisors (with an HDR) or similar positions	1	2

• Detailed assessments

Assessment of scientific quality and outputs

The group has contributed mostly to the basic understanding of the brain structure-function mapping of language processing.

A central question here was whether the brain actually relies on abstract constructs originating from theoretical liguistics (such as syntactic trees) to process sentences. Although the theoretical framework that serves to tie the different studies together is rather qualitative and vague, it has enabled a great diversity of work that clearly stands out in terms of originality and breadth. Also, the methodological know-how in imaging neuroscience clearly meets the standards of the international community (e.g., the use of repetition-suppression paradigms in fMRI).

One of the most original study addresses the comparison of brain responses to vocal utterances across primate species (humans and monkeys). This naturally lends itself to an evolutionary perspective on the functional segregation

of the language network. More precisely, it complements group 1's "neuronal recycling hypothesis", which essentially states that the human language subnetwork engaged in reading borrowed brain computational resources that were well-suited to process language but were selected to serve a different purpose. Major achievements of the group also include the identification of language processing bottlenecks (e.g., time scales, conscious access), which consitute a distinguished contribution to the field. Note that most of these studies were published in high-impact international academic journals (e.g., PNAS, J. Neurosci., Neuroimage, etc). Taken together, this explains the high national and international visibility of the group leader (Mr Christophe PALLIER 's h-index=33).

Assessment of the unit's academic reputation and appeal

The reputation of the group regarding language processing in the brain has enabled tight collaborations with international groups that share related interests. For example, a series of studies on biliguism has been successfully conducted with colleagues from the University Pompeu Fabra in Barcelona (Spain). Another example is the study on subliminal speech priming, which was conducted in collaboration with the Catholic University of Leuven (Belgium).

In terms of academic reputation, the group leader has been invited to give seminars at UCLA, Vitoria, Barcelona, Taipei, Leipzig. He chaired the Journée "l'aire de Broca: 150 ans après" at the Pitié-Salpétrière hospital in Paris, and was a keynote speaker in two international workshops.

Assessment of the unit's interaction with the social, economic and cultural environment

Outside its main research stream, the most salient contribution of the group is its contribution to the French Lexicon Project, an open database of lexicon decision times for 40000 words obtained across 1000 participants.

In addition, the group leader was invited to give lectures to language school teachers. Mr Christophe PALLIER also took part in multiple extra-scientific public debates about scientific, philosophical and ethical issues of neuroscientific research within the local environment of the institute.

Assessment of the unit's organisation and life

The group has a well-defined central focus, namely: language processing in the brain. This is a vast theme of research, which the group leader has chosen to address from many different perspective over the past few years. This could have incurred a cost in terms of scientific coherency, but the overall impression contradicts this idea, for two reasons. First, most studies are nurtured from theoretical linguistics, which provides conceptual guidance for both experimental design and results interpretation. Second, the relative dispersion of group 2's research interests serves the overall consistency of the research unit, through the many collaborative links it shares with the other groups. The latter point is also important for enabling the successful pooling of scientific, human, financial and material resources (e.g., joint group meetings, IT, co-application on grants, MRI scanners, etc) across the institute.

Assessment of the unit's involvement in training through research

First, note that the group gathers three post-doctoral trainees and three PhD students, who benefit from weekly meetings chaired by the unit's group leaders.

The group leader is a member of the CogMaster pedagogic board (MSc in cognitive sciences @ École Normale Supérieure, Paris). Note that this is not the sole contribution of Mr Christophe PALLIER's contribution to the CogMaster, since he is also lecturing on neuroimaging data analysis.

Assessment of the strategy and the five-year plan

The group's research project aims at identifying the neural representations of atomic cognitive constructs, following a gradient of abstract complexity (beginning with words and numbers, and culminating in the syntactic structure of language). The three permanent researchers have slightly different interests (e.g., language vs number sense), but share similar methodological tools (fMRI, multivariate decoding techniques). Importantly, many research questions rely on the notion of hierarchical processing, e.g., the representation of a given word depends upon the syntactic context. Such hierarchical processing hypothesis appears at different scales (e.g., phonemes in a word, words in a sentence, etc). This relates to an overarching and transversal research question of the unit, namely: the representation of recursive structures (i.e. structures that are self-similar). This is one of the most original aspects of the unit's project, to which group 2 is likely to significantly contribute.

One has to acknowledge the fact that two new permanent researchers are joining the group, which brings along its own promises and risks. On the one hand, the scientific complementarity of the three permanent reearchers is evident from their respective research interests. For example, an exciting extension to the group's past expertise is clinical interest in dyscalculic children of one permanent investigator. First, this will bring additional neuropsychological insights steming from the nature of the pathological impairments to the number sense. Second, this will largely augment the group's contribution to translational research (cf. epidemiological study of dyscalculia and dyslexia, in collaboration with Dr. F. RAMUS). Also, the project on high-field (7T) fMRI of a another investigator is very appropriate, given the strong local deployment of MR physics resources. Last but not least, her involvement in the Human Brain Project holds great promises in terms of the group's international visibility. On the other hand, there is a risk of lack of convergence between the different research agendas. This is because this convergence relies on a central tenet, namely: the existence of a common brain structure for manipulating hierachical (recursive) structures of words and numbers. The critical point here is that it is yet unclear how the group will re-organize and adapt its strategic direction if this assumption happens to be unjustified.

In general though, the objectives are credible, both in scientific terms, and with regards to the human, financial and material resources that they require.

Conclusion

- **Strengths and opportunities:**

- synergetic scientific expertises of the three main researchers;

- opportunities for translational research;

- novel research program based upon high-field MRI.

- **Weaknesses and threats:**

- no apparent knowledge in quantitative modelling of cognitive processes;

- no apparent link with group 4 (electrophysiology);

- diluted research program (language and number sense).

- **Recommendations:**

Engage in thorough collaborations with computational neuroscientists with adequate background on linguistics/number sense.

Promote local cutting-edge neuroimaging facilicities, in the aim of diversifying experimental methods (EEG/MEG platform, advanced data analysis, etc).

In conclusion, the group's past achievements are of high quality and its current research projects are ambitious, novel and timely. In addition, the group is likely to both strongly benefit from and contribute to the local scientific environment. In addition to its strong potential for translational research, these merits call for a very positive overall evaluation.

Group 3: Brain development

Name of group leader: Ms Ghislaine DEHAENE-LAMBERTZ

Workforce

Group workforce	Number as at 30/06/2013	Number as at 01/01/2015
N1: Permanent professors and similar positions		
N2: Permanent EPST or EPIC researchers and similar positions	5	5
N3: Other permanent staff (without research duties)	0.5	0.5
N4: Other professors (PREM, ECC, etc.)		
N5: Other EPST or EPIC researchers (DREM, Postdoctoral students, visitors, etc.)	3	4
N6: Other contractual staff (without research duties)		
TOTAL N1 to N6	**8,5**	**9,5**

Group workforce	Number as at 30/06/2013	Number as at 01/01/2015
Doctoral students	3	
Theses defended	2	
Postdoctoral students having spent at least 12 months in the unit	2	
Number of Research Supervisor Qualifications (HDR) taken		
Qualified research supervisors (with an HDR) or similar positions	1	1

• Detailed assessments

Assessment of scientific quality and outputs

The scientific quality and output of group 3 lead by Ms Ghislaine DEHAENE-LAMBERTZ is outstanding. This is reflected through its publication record with more than 35 peer-review publications, most of these in top scientific journals such as Science, PNAS or J. Neuroscience, as well as the numerous invitation that the group members have received from national and international organizations.

Clearly, the group led by Ms Ghislaine DEHAENE-LAMBERTZ has become an international leader in human cognitive development in infants and children, both at the structural and functional levels, as recognized by various prizes to group members.

Finally, the scientific quality of the group is also highlighted by the variety of public and private grants it has received in the last 5 years.

Assessment of the unit's academic reputation and appeal

Group 3 is one of the leader in the field of human development not only nationally but also internationally, rivaling with groups such as the one of Graffman at NIH or Stiles Davis at UCSD for example. It provides a rare center of excellence where both a structural and functional understanding of human brain development is being pushed through a combination of ingenious behavioral paradigms and new frontiers in brain imaging. The combination of such skills is rare on the international scene and places group 3 ahead of most human developmental center around the world.

Assessment of the unit's interaction with the social, economic and cultural environment

The impact of the unit on society is already visible and will only increase in the next few years. The unit has already produced a number of books for parents and teachers, and is quite active in the dissemination of knowledge about human brain development and its consequences for best practices in education. Its conversion of academic content into educational games for dyspraxic children illustrates perfectly the dedication of this group to translating lab research into useful tools for society.

It is a source of information for the national and international press being sought out by French media. It has also very strong links with the medical community and in particular best practice in the treatment of pre-term infants. The planned atlas of the baby's brain and its functional organization will be a huge contribution for both the scientific community and society at large, with practical implications for domains as varied as health, education and parent-children relationships.

Assessment of the unit's organisation and life

Excellent access to a dynamic, rich and multidisciplinary environment, with international speakers series. Outstanding support of group member and smooth integration of the various skills and background needed to excel.

Assessment of the unit's involvement in training through research

Group 3 provides a very strong inter-disciplinary environment to its trainee, a key asset in a field that calls for skills as varied as excellence in experimental design and insights in ethological method to probe behavior all the way to knowledge of state of the art in machine learning and big data management. The group provides an ideal setting to training young researchers and future stars in the domain. This is reflected in the numbers of excellent PhD and postdoctoral fellow that have come through the units, as well as the very large network of fruitful collaborations the group has established.

Assessment of the strategy and the five-year plan

The five year plan is well thought out with clear objectives and reachable deliverable, while at the same time being quite ambitious. The breadth and depth of the international collaboration established over the years is commandable, with the group being now centrally positioned to being at the fore front of the development of new imaging techniques adapted to human infants.

Conclusion

- **Strengths and opportunities:**

- pushing the limits of functional and structural approaches to brain development;

- excellent group dynamics and collaborative work;

- outstanding outreach.

- **Weaknesses and threats:**

Ease of access to MR facilities: this group is among the rare such groups in the world that can push forward the limits of functional brain imaging in infants and children. Yet access rules and CEA regulations make it very difficult for NeuroSpin to be a parent-and children-friendly environment.

Cost of access to MR facilities: it is well know that paediatric populations are difficult to scan as they cannot be as easily instructed to cooperate, stay still and be quiet. This type of research requires an experimenter be patient and seize the opportunity when the infant or child is ready to cooperate. These requirements are not well aligned with an MR cost structure based on booking precise scan slots ahead of time. This procedure requires more flexibility to be efficient, so that this research is not limited by unfair costing in relation to other groups.

- **Recommendations:**

It would seem advantageous for NeuroSpin to take advantage of its unique facilities, entirely dedicated to MR research and the proximity of such an outstanding group, to continue breaking new ground in paediatric functional MR imaging and enlarging our understanding of human brain development.

Group 4: MEG and Brain Dynamics

Name of group leader: Ms Virginie VAN WASSENHOVE

Workforce

Group workforce	Number as at 30/06/2013	Number as at 01/01/2015
N1: Permanent professors and similar positions		
N2: Permanent EPST or EPIC researchers and similar positions	3	3
N3: Other permanent staff (without research duties)	0.5	0.5
N4: Other professors (PREM, ECC, etc.)		
N5: Other EPST or EPIC researchers (DREM, Postdoctoral students, visitors, etc.)	4	1
N6: Other contractual staff (without research duties)		
TOTAL N1 to N6	**7,5**	**4,5**

Group workforce	Number as at 30/06/2013	Number as at 01/01/2015
Doctoral students	3	
Theses defended	2	
Postdoctoral students having spent at least 12 months in the unit	3	
Number of Research Supervisor Qualifications (HDR) taken	1	
Qualified research supervisors (with an HDR) or similar positions	1	1

• Detailed assessments

Assessment of scientific quality and outputs

The group was originally lead by Mr Andreas KLEINSCHMIDT who moved to Geneva in Spring 2012. Ms Virginie VAN WASSENHOVE, who joined the unit in 2008, officially became the new leader of the group in September 2012, and the only permanent researcher. This scientific assessment therefore does not include Mr Andreas KLEINSCHMIDT's production which was not performed in collaboration with the present members of the group.

Group 4's activity had two facets:

1) Setting up and running the Magnetoencephalography (MEG) Lab since the end of 2008 with two INSERM research engineers dedicated to this activity not only at the group or unit level but also as part of the Neurospin facilities. This includes ensuring reliable recordings and deploying state-of-the-art methods for signal analysis and

dynamic source reconstruction. This activity is transverse to the other groups since 4 papers using MEG have been published by group 1's members, and 2 by physicists from another CEA laboratory developpping new MEG instrumentation.

2) Developping a specific experimental research project aiming at evaluating the processing of multisensory information, its temporal organization and particularly the representation of temporal information in the human brain. The group leader has obtained in 2011 an ERC Starting Grant to understand the neural dynamics underlying the representation of time. Original results have been obtained on automaticity in multisensory processing and in temporal cognition, mostly based on behavioral and fMRI measures performed in collaboration with former group leader's host laboratories, and more recently with MEG recordings. This has lead to to a very good production: 12 papers, and 6 international conference proceedings, in journal such as Plos One (2), Philos Trans R Soc Lond B Biol Sci (3), Frontiers (3), and Neuropsychologia (1).

Assessment of the unit's academic reputation and appeal

From a technological and methodological point of view, the MEG Lab is well connected to national and international MEG community and is now attracting various MEG projects.

On the scientific side, group 4 is a young and emerging group. It is attracting PhD and post-doc students thanks to a succession of grants (Marie-Curie reintegration grant, ANR young researcher, and ERC starting grant). It is also involved in the european flagship Human Brain Project for the characterization of the brain architectures for time representation and manipluation.

The group leader has been invited to ~25 national or international conferences or seminars in reknown institutes (Montreal, MIT Boston, Konstanz, Tübingen). She is on the editorial board of Plos One, Frontiers in Auditory Cognitive Neuroscience, and Timing and Time Perception.

Assessment of the unit's interaction with the social, economic and cultural environment

The group leader produced several interviews on internet media for the public at large. She also made a TED presentation in Paris on Time and the Brain.

Assessment of the unit's organisation and life

Group 4 is clearly structured around the MEG facility. Thanks to two permanent engineers, this MEG platform is very well organized. State-of-the-art signal analysis softwares are made available to the users and, importantly, the development of new methodological tools is in progress (including real-time MEG).

Although, the group is still young, the general atmosphere was perceived as both friendly and effective, with a strong sense of inter-disciplinarity. The group 4 members are experienced in collaborating with other groups' members and external partners.

Assessment of the unit's involvement in training through research

The group leader is lecturing Advanced Cognitive Neuroscience Graduate course at École Normale Supérieure, Paris, and is a guest lecturer in various advanced courses (École Polytechnique, ENS Lyon, École des Oscillations). She obtained her habilitation to supervise research (HDR) in 2013. Two PhD students already defended their thesis in 2013, with several articles related to their work, and two will finish in 2014.

Assessment of the strategy and the five-year plan

The strategy for the next 5 years focusses on time perception research and temporal dynamics, mostly using MEG recordings. It will largely correspond to the group leader's ERC starting grant and to an ANR Young Researcher grant recently obtained. This should definitely help the group to develop and expand over the next 5 years. Several, still poorly explored questions, will be adressed: are neural oscillations critical for the encoding of time ? Does time perception require an internal clock ? Is Time another mental magnitude such as space and numbers ? What are the neural basis of mental time travel ? How a multiscale representation of time is established in the human brain ? The design of experimental paradigms will capitalize on the expertise of the group on multisensory integration and interfacing with internal representations.

In addition, to further develop their expertise in MEG signal analysis, they will develop and/or adapt novel methodological approaches (e.g., decoding techniques, real-time analysis, functional connectivity, scale-free analysis, graph theory analysis). The two recently recruited INSERM engineers have an essential role for that objective, including supervising students.

Due to the very small size of the group in terms of permanent researchers, the plan appears rather ambitious. However, the group leader has secured excellent fundings to achieve her goals, including a participation to the FET Human Brain Project.

Conclusion

- **Strengths and opportunities:**

- to have set up the MEG Lab facilities at Neurospin and for the unit with dedicated permanent engineers;

- opportunity to develop interactions with other groups or units taking advantage of the MEG expertise;

- to have developped a novel research project on the representation of time in the brain, only poorly explored in other french research laboratories;

- excellent fundings.

- **Weaknesses and threats:**

- small size of the group (only one permanent researcher);

- running costs for the MEG platform requested by CEA seem to increase abruptly.

- **Recommendations:**

Collaborations with the other groups and external research groups should be increased for a better exploitation of the MEG facility.

A strategy for recruiting an additional researcher should be considered over the next 5 years to consolidate the cognitive neuroscience side of the group.

5 • Conduct of the visit

Visit date:

Start:	06/12/2013 at 8.45 am
End:	06/12/2013 at 5.45 pm
Visit site :	INSERM-CEA Cognitive Neuroimaging Unit
Institution:	Neurospin
Address:	CEA/SAC/DSV/I2BM/NeuroSpin
	Bâtiment 145 - Point Courrier 156
	F-91191 GIF SUR YVETTE Cedex FRANCE

Conduct or programme of visit:

08h45-09h00	Door closed meeting - Presentation of AERES to the experts committee by the Scientific Delegate (DS)
09h00-09h15	Presentation of the experts committee and of AERES to the unit by the DS
09h15-10h00	Presentation of the unit, scientific assessment and projects: UNICOG (including brief tour of the installations (Mr Stanislas DEHAENE))
	Team presentations (including half time for discussion)
10h00-10h30	Scientific assessment and projects, team 1: Neuroimaging of human cognitive architectures (Mr Stanislas DEHAENE)
10h30-10h45	**Break**
10h45-11h15	Scientific assessment and projects, team 2: Neuroimaging of Language and Symbols (Mr Christophe PALLIER)
11h15-11h45	Scientific assessment and projects, team 3: Neuroimaging of Development (Ms Ghislaine DEHAENE-LAMBERTZ)
11h45-12h15	Scientific assessment and projects, team 4: Magnetoencephalography and Brain dynamics (Ms Virginie VAN WASSENHOVE)
12h30-13h30	**Lunch** Including representatives of the institutions (Mr Jacques BITTOUN-Paris Sud, Mr Gilles BLOCH-CEA and Mr Etienne HIRSCH-INSERM)
	Meeting with permanent and non-permanent staff
13h30-14h15	Three demonstrations by lab researchers and engineers: - Ms Jessica DUBOIS, Mr François LEROY and Ms Caroline HURON on children studies (anatomical and behavioral work) - Mr Marco BUIATTI, Ms Leila AZIZI-ROGEAU and Mr Sébastien MARTI on the MEG facility and MEG decoding - Ms Evelyn EGER and Ms Manuela PIAZZA on number decoding.
14h15 -14h45	Meeting with the technical staff *Audience: members of the expert committee, DS and ITA representatives of the organisms* Meeting with PhD students and post-docs and/or fixed-term contract researcher, engineers. *Audience: members of the expert committee and DS*
14h45-15h00	Meeting with the representative of the "École Doctorale ED3C": Ms Ghislaine DEHAENE *Audience: members of the expert committee and DS*
15h00-15h15	**Break**
15h15-15h45	Meeting with the head of the UMR *Audience: members of the expert committee and DS*
15h45-17h45	Door closed meeting *Audience: members of the expert committee and DS*

6 • Supervising bodies general comments

UNIVERSITÉ PARIS SUD

Comprendre le monde,
construire l'avenir®

Le Président de l'Université Paris-Sud

à

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

Orsay, le 25 février 2014

N/Réf. : 31/14/JB/LM/AL

Objet : Rapport d'évaluation d'unité de recherche
N° S2PUR150007888

Monsieur le Directeur,

Vous m'avez transmis le 5 février dernier, le rapport d'évaluation de l'unité de recherche NEUROIMAGERIE COGNITIVE n° S2PUR150007888 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.

Les points à améliorer seront discutés avec le directeur d'unité, Monsieur Stanislas DEHAENE, dans un esprit constructif pour l'avenir de la recherche à l'université.

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

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Président

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DE LA RECHERCHE À L'INDUSTRIE

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www.cea.fr

Monsieur Pierre Glaudes
Directeur de la section des unités de l'AERES
20 rue Vivienne
75002 Paris France

Fontenay-aux-Roses, le 26 février 2014
Objet : Rapport AERES E2015-EV-0911101C-S2PUR150007888-004771-RT, Unité de NeuroImagerie Cognitive
N/Réf. : DSV/DIR/2014-

Monsieur le Directeur,

Je vous remercie pour l'envoi du rapport d'évaluation de l'unité mixte de recherche NeuroImagerie Cognitive (UNICOG) dirigée par Monsieur Stanislas Dehaene, dont le CEA, l'Université Paris-Sud et l'Inserm exercent la tutelle. Le comité de visite a réalisé un remarquable travail d'évaluation et souligne la très grande qualité scientifique de cette unité. Le CEA se réjouit de l'appréciation portée par le Comité sur cette unité et prend bonne note de ses suggestions.

UNICOG, localisée sur le site de Saclay, est partie prenante du centre de recherche NeuroSpin, dont le CEA assure également la tutelle scientifique. C'est à ce titre que je souhaite apporter quelques éléments d'éclairage à la remarque du Comité de visite concernant notamment l'accueil des enfants et de leurs parents sur le site de Saclay. La localisation de cette unité sur un site CEA induit certaines contraintes d'accès, propres à tous les sites du CEA, qui engendrent parfois des désagréments (horaires, autorisations, etc). Neurospin a été construit à l'extérieur de l'enceinte sécurisée du centre CEA Saclay afin de limiter au maximum ces contraintes.

NeuroSpin est une installation d'imagerie de recherche de haut niveau, qui rassemble sur un même site des compétences exceptionnelles de méthodologistes de l'imagerie et du traitement de signal, et de neurobiologistes. La proximité de NeuroSpin avec les physiciens de Saclay permet le développement de technologies d'imagerie au meilleur niveau.

Pour réaliser des protocoles de recherche chez les volontaires, et notamment chez l'enfant,

Commissariat à l'énergie atomique et aux énergies alternatives
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Direction des sciences du vivant
Le Directeur

NeuroSpin a été doté des locaux spécifiques, comme une salle de jeu pédiatrique et une salle de démonstration de l'IRM (maquette à taille réelle) afin de familiariser les volontaires avec les équipements. Quatre chambres, disposant chacune de deux lits, sont à disposition des familles et des enfants ainsi que des berceaux et lits à barreaux adaptés aux plus jeunes âges, viennent compléter ce dispositif d'accueil indispensable au bon déroulement des études. Le niveau de satisfaction des familles accueillies dans le cadre des protocoles réalisés à NeuroSpin est excellent.

Je regrette donc que le Comité AERES n'ait pas eu le temps de visiter NeuroSpin et l'infrastructure d'accueil des enfants volontaires et de leur famille, afin de pouvoir apprécier à sa juste valeur l'environnement qui leur est offert.

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

Gilles BLOCH