INRIA Saclay, Équipe Parietal http://team.inria.fr/parietal bat 145, CEA Saclay

Human Brain Project Proposal: Charting the human brain with fMRI

Position: Research Engineer
Duration & salary: 24 months, about 2100 €/month net
Research teams: Parietal (INRIA Saclay) and NeuroSpin (CEA)
Responsible: Bertrand Thirion
Contact: bertrand.thirion@inria.fr
Application: Interested candidate should send CV and motivation letter
Keywords: functional brain imaging, cognitive atlasing, systems neuroscience, brain parcellation

Context: Large-scale functional atlasing

Having a working model of brain organization has been a historical and major goal in neuroscience. With the advent of cognitive neuroimaging, it has become clearer that functional specificity is both a prominent marker of architectural differences in the brain and the most natural way to characterize the differences between brain regions [2]. To this end, many brain atlases have been inferred and released, based on various imaging modalities and experimental procedures. However, their justification has been weakened by the absence of concomitant release of data that backs up the available atlas, and by the large inter-subject variability that unavoidably blurs population models. Advances will be made possible by:

1. Acquiring a **large number of functional protocols** that probe as many cognitive processes as possible on a fixed group of subjects, so that each putative brain region (area or module) can be characterized unambiguously through a unique functional signature and position in individual brains.

2. Making the data and ensuing processing steps available to the community, so that the results of this mapping can be easily reproduced and compared to other data.

The **Human Brain Project** (HBP, http://www.humanbrainproject.eu) aims to develop a model of human brain organization; a bottom-up approach that consists of building a brain by going all the way from molecular to system-level organization. This needs to be informed by high-level constraints that shape the macroscopic organization of the brain.
Individual brain charting (IBC, https://project.inria.fr/IBC) is a part of the HBP and consists of repeatedly scanning a limited number of subjects with a large and varied set of functional protocols (retinotopic, tonotopic, somatotopic, visual categories, space and number, language, social cognition, resting state...) together with high-resolution anatomical and diffusion-weighted scans. The project was launched at the end of 2013 and data acquisition started in mid-2015.
The project has recently output an impressive number of high-resolution brain maps (http://neurovault.org/collections/6618), that provide an objective basis to inform the definition of brain regions. The richness of the dataset resides in the variety of cognitive functions probed.

Position roadmap

The engineer will be in charge of adapting a set of protocols and running them on the existing pool of 12 subjects. These protocols will be provided by the community, potentially from in-house developments, and are meant to cover a diverse array of cognitive processes (in the sense of

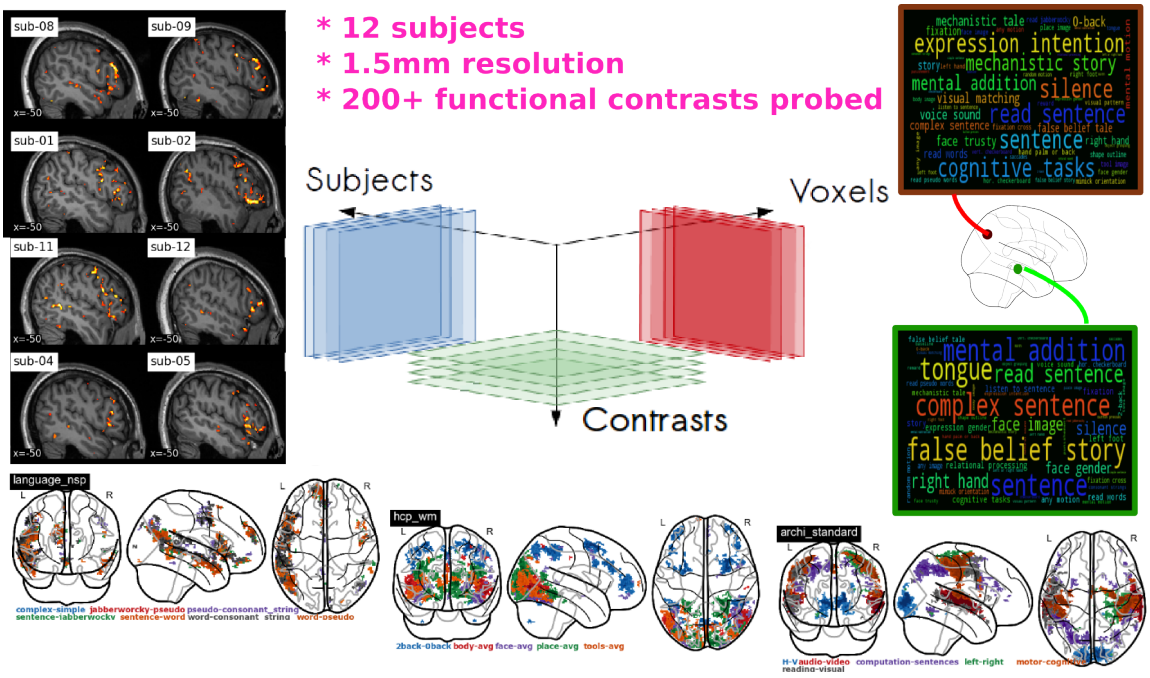

Figure 1: IBC project principle: High resolution brain images on a fixed cohort make it possible to accurately map brain reponses. The accumulation of these data lead to a much more complete description of the functional organization of the brain.

http://www.cognitiveatlas.org). The validation, necessary adaptations, and implementations of these protocols will be carried out in close collaboration with the Unicog lab at Neurospin (http://www.unicog.org).

The engineer will participate in the acquisitions conducted on the Neurospin 3T (and, possibly later, the 7T) scanner. The data are acquired at high resolution (1.5mm) and will be analyzed using a pipeline provided by the lab. S/he will be involved in the improvement of this pipeline and will obtain activation maps related to the various contrasts, with support from technical experts. The data will be analyzed both at the volume level and on the cortical surface. Detailed reports will be provided to assess the quality of the data, motivate the participants and document the content of the database.

The data will also systematically be compared with existing resources (Openneuro, NeuroVault, Neurosynth, Human Connectome Project). The methodological aspects will be developed in close collaboration with the Parietal team at Neurospin (http://team.inria.fr/parietal), that has recently developed specific techniques to perform brain parcellation effectively [4, 1] and to discriminate between distributed activation patterns [3]. The engineer will also re-use the existing pipeline and quality checking tools of the Parietal team.

Output:

All the raw and processed data, stimuli, as well as the functional atlases inferred from the data will be made available on the EBRains (http://kg.ebrains.eu/search), Neurovault (http://

neurovault.org) and Openneuro (http://openneuro.org) platforms to become a **reference for the neuroimaging community**, together with exhaustive documentation on the acquisition and processing parameters. The engineer will have a role in the decisions pertaining to the choice of functional localizer experiments that are undertaken to ensure completeness and accuracy of the functional brain atlas.

Skill set:

- **Mandatory**: Experience designing/adapting, running and analyzing an fMRI protocol, in particular localization-related protocols (retinotopy, tonotopy, somatotopy etc.).
- **Mandatory**: Training in cognitive neuroscience.
- **Desired**: Experience working/programming in Python, Matlab.
- **Desired**: Experience with experiment-building tools like E-Prime, Presentation.
- **Mandatory**: The candidate should be willing to work in a multi-disciplinary environment (cognitive neuroscience, MRI acquisition, computer science).

[1] Danilo Bzdok, Gaël Varoquaux, Olivier Grisel, Michael Eickenberg, Cyril Poupon, and Bertrand Thirion. Formal Models of the Network Co-occurrence Underlying Mental Operations. *PLoS Comput Biol*, June 2016.

[2] Matthew F. Glasser, Timothy S. Coalson, Emma C. Robinson, Carl D. Hacker, John Harwell, Essa Yacoub, Kamil Ugurbil, Jesper Andersson, Christian F. Beckmann, Mark Jenkinson, Stephen M. Smith, and David C. Van Essen. A multi-modal parcellation of human cerebral cortex. *Nature*, advance online publication, July 2016.

[3] Yannick Schwartz, Bertrand Thirion, and Gaël Varoquaux. Mapping cognitive ontologies to and from the brain. In *NIPS (Neural Information Processing Systems)*, United States, December 2013.

[4] Bertrand Thirion, Gael Varoquaux, Elvis Dohmatob, and J Poline. Which fMRI clustering gives good brain parcellations? *Name: Frontiers in Neuroscience*, 8:167, 2014.