Post-doc Proposal: Fine-scale functional neuroanatomy of symbolic categories in ventral visual cortex

Summary

Within the context of the Human Brain Project, a post-doc position for a duration of two years is proposed at the Neurospin Center to conduct functional imaging research related to the processing of objects in human ventral visual cortex, with a particular focus on symbolic categories (e.g., letters, words, digits). One line of the project will be to describe the layout of category preferences for both natural and symbolic categories at high resolution in individual subjects undergoing repeated scanning, with the aim of deriving a set/combination of functional and structural markers that allow to predict the location where activation foci for symbolic categories are found within individual subjects. A second line will be to use fMRI pattern recognition methods to understand representational characteristics and their transformations along the cortical hierarchy (for example position invariance, conjunction sensitivity) as well as potential differences in the type of visual representations used by the two hemispheres relevant for the development of symbol selectivities.
The postdoc will be involved in designing and running the protocols to map the ventral visual cortex and analyze the data on the cortical surface, for which she/he will be co-supervised by members of the Parietal (B. Thirion) and Unicog (E. Eger, S. Dehaene) teams. Among the ideal skills of the candidate are the following:

- [Mandatory] experience in conducting fMRI studies, in particular studies of visual cortex.
- [Mandatory] PhD in cognitive neuroscience.
- [Desired] Good programming skills in Matlab or Python
- [Desired] Prior experience with cortical surface-based analysis
- [Desired] Prior experience with multivariate pattern analysis
- Enthusiasm for working in a multi-disciplinary environment (cognitive neuroscience, MRI acquisition, computer science).

Context

The post-doc project will be part of the **Human Brain Project** (HBP, http://www.humanbrainproject.eu/), subproject 2.1.1. The HBP aims at developing a model of the human brain organization; the bottom-up approach that consists in building a brain by going all the way from molecular to system-level organization needs to be informed by high-level constraints that build the macroscopic organization of the brain.
A particular task consists in designing a new generation of functional atlases that represent the details of functional sensitivities in the human cortex. The proposed investigation of category layout in the ventral visual cortex will thus provide the start of a long-term atlasing project, together with various lower-level localizers that will delineate some functionally-specific regions and networks and map topographically-organized functional responses of the cortex (retinotopy, motion direction, visual orientation, colour, ..., tonotopy, somatotopy, etc), high resolution anatomy and diffusion-weighted acquisitions [Assaf et al. 2013], together with high level cognitive functions (using e.g. social cognition, language syntax). This whole set of acquisitions will be performed on a limited pool of 12 subjects, as the interest is on the joint observation of high-resolution maps in the individual subject space, as opposed to the inter-subject mapping. The conjunction of these maps will yield an unprecedented description of the spatial organization of the main cognitive functions.

Project

In humans, ventral occipito-temporal cortex contains not only functional areas that appear specialized for processing certain natural object categories (e.g., faces and bodies), but also symbolic categories that do not have a long evolutionary history, such as written words. What determines why for some but not all visual categories such macroscopic activation foci develop, and as well as the factors determining the regions exact location, are not entirely understood.

Recent work has characterized the fine-scale layout of selectivities for natural categories (faces, body parts) in ventral visual cortex, and has shown that the layout of multiple face and body selective foci is more consistent than previously believed and can in some, but not all, cases be related to specific anatomical markers [Weiner et al. 2013]. Responses to alphabetical stimuli such as the visual word form area [Cohen et al., 2002] have mostly been studied by a different community (the one interested in reading) and have not been described at a comparably fine-grained level. Therefore, the way in which activation preferences for letters, words, and potentially other symbolic categories such as digits [Shum et al., 2013] fit into the above mentioned detailed category layout remains to be determined.

One part of this project will be to run an extended set of localizers for both natural and symbolic object categories in the same group of subjects together with other functional mapping paradigms (retinotopy, color, motion, ...) as well as anatomical, structural and functional connectivity data. From this extended set of data, we are aiming at deriving the most relevant combination of markers (e.g., gyri, sulci, particular functional or structural connections, relation with respect to or distance from other functional activations, ...) that best predict the location of visual letter, word, and potentially number responses in individual subjects. In addition to a better understanding of general organizational principles, this work may provide a model to be used in the future for a reasonable approximation of regions of interest without individual functional localizers.

The second part of the project will be dedicated to better understanding the level of representation at which individual alphabetical and numerical stimuli are coded in different subregions of the ventral visual cortex hierarchy, and in how coding principles show similarities with, or differences from, the ones used for other kinds of objects. Different projects along this line will make use of multivariate pattern recognition on high-resolution fMRI data and may focus on the development of position invariance and conjunction sensitivity for symbolic stimuli across the cortical hierarchy on one hand, and on exploring potential differences in the shape representations used by the two hemispheres that could contribute to the left-hemispheric preference for alphabetic stimuli, on the other hand.

The post-doc working on this project will be supervised by a combination of two complementary teams with expertise in fMRI analysis and machine learning methods on the one hand, and in the cognitive neuroscience of high-level vision / reading /numerical cognition, on the other hand. He or she will be welcome to collaborate in the longer term to the brain charting sub-project of the Human Brain Project (2013-2023).

References

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