In vivo visualization of axonal connectivity in high-order Human occipito-temporal cortex

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Synopsis

For an integrated understanding of the brain's functional architecture, in vivo correlation between functional areas and the pattern of neuronal connectivity is necessary. Such correlation studies were difficult to perform in the past, however, as most anatomical techniques necessitated invasive and/or terminal procedures. In the present study, we used the technique of the Diffusion Tensor Magnetic Resonance Imaging (DT-MRI) in combination with high-resolution functional MRI in Human high order visual area.

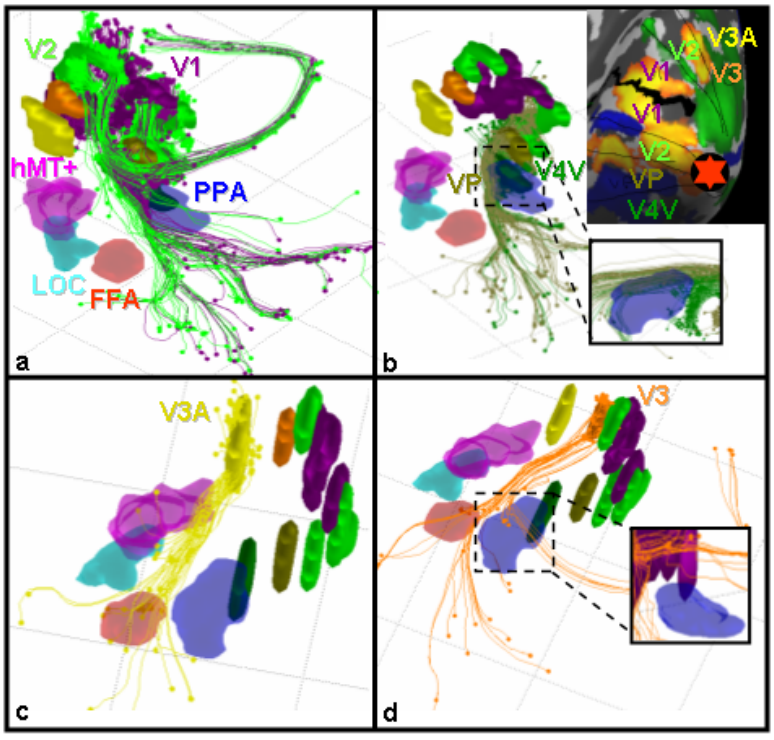
Introduction

The primate visual system is parceled into *two different "streams"*: the ventral stream for object recognition ("what" stream) and the dorsal stream for object locations ("where" stream). This dual stream configuration is particularly well studied in the visual system of non-human primates, such as macaques. In humans, recent non-invasive fMRI data suggest the existence of multiple visual areas. Similar to non-human primates, visual areas in humans are clustered around "streams" diverging ventral and dorsal from the occipital pole, respectively. However, whether these areas form indeed separate processing streams, is much harder to address in the human cortex, due to the difficulty in obtaining in vivo connectivity information in human cortex. In the present study, we used the technique of **Diffusion Tensor Magnetic Resonance Imaging (DT-MRI)** in combination with **high-resolution functional MRI** to simultaneously and non-invasively assess the relationship between functional activity and neuronal connectivity between the high order visual areas in the human ventral stream.

Methods

The functional areas (FFA, LOC, PPA, and hMT+) including primary/higher order organization of the both hemispheres of the human visual cortices were obtained using standard stimuli. We used 3T whole body scanner (Trio, Siemens). Typical MR parameters for fMRI: gradient-echo Echo-Planar Imaging (GE-EPI); TE=40ms; TR=3000ms; 128×128 in a FOV of 256×256 mm^2, 30 slices, 2 mm of slice thickness, native resolution: 2×2×2 mm^3/voxel. Parameters for DT-MRI: spin-echo EPI; TE=111ms; TR=11500ms; 128×128 in a FOV of 256×256 mm^2, native resolution: 2×2×2 mm^3/voxel with b=1000s/mm^2. Diffusion-weighted images were obtained for 12 gradient encoding directions. FMRI data was analyzed with BrainVoyager (Brain Innovation, Netherlands), and custom-written Matlab (Mathworks) software was used for diagonalization, fiber tracing, and visualization. The areas identified using functional imaging were used as seeding ROIs for DTI based axonal fiber reconstructions. Subsequently, corresponding fMRI and DTI tracing data were superimposed on three-dimensional anatomical images.

Results



1. Functional areas in high order human visual areas were successfully used as "seeding points" for DTI based fiber reconstructions *in vivo*.
2. FFA and LOC do not receive direct connections from V1/V2. There are however direct connections between V1/V2 and PPA.
3. There are strong connections between FFA and V3A/V3.
4. Among all ventral areas, LOC has the strongest projection to/from hMT+.
5. FFA, LOC and PPA project strongly to the areas anterior to the temporal lobe.
6. There are "trans-stream" projections between FFA and areas of dorsal cortex (most likely IPS). No such trans-stream connections where observed for PPA.

Figure: DTI fiber reconstructions originating from V1/V2 (panel a), VP/V4V (panel b), V3A (panel c), and V3 (panel d).

Conclusion

We conclude from our study, that the combined use of fMRI and DTI has the potential to provide novel and valuable insights into the functional architecture of the human brain.

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