In Vivo Diffusion Tensor Magnetic Resonance Imaging (DT-MRI) and Fiber Tracking of the Mouse Brain

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Our department has long standing experience in DW- and DT-MRI concerning theory, sequence development and post processing [1-4]. This expertise in human MRI is currently being translated to the 9.4T and 7T animal systems [5, 6].

DT-MRI and Fiber-tracking

Brain connectivity studies in small animals are challenging but achievable in our group using state-of-the-art MRI technologies (high field scanners and Cryoprobe technology for the acquisition) and cutting-edge post-processing algorithms [1]. High-resolution DT-MRI and fiber tracking of the living mouse brain (Fig. 1) provides details of the fine cytoarchitecture of the nervous tissue and delineates the fiber tracts organization. Figure 1: In-vivo whole mouse brain fiber tracking. DT-MRI data was acquired at 7T, using an adapted mouse brain CryoProbe. Fiber-tracking was performed using a global optimization algorithm developed in our group by Reisert et al. [1]. Remarkable details of mouse brain fiber architecture are noticed. Abbreviations: bsc – brachium superior colliculus; cc – corpus callosum; cb – cerebellum; cg – cingulum; cp – cerebral peduncle; cx - cortex ; ec - external capsule ; fi – fimbria; hc – hippocampal commissure; hp – hippocampus; ic – internal capsule; ml – medial lemniscus; opt – optic tract.

Additional to the global tracking algorithm we comparatively use deterministic and probabilistic tractography to investigate connectivity pathways in brain regions belonging to the limbic or sensory systems. Figure 2 demonstrates the projection pathways from the core structure of the limbic system, the amygdala, to the mouse cortices and to the bed nucleus of stria terminalis. Revealing in-vivo this type of neural pathways represents a breakthrough for studies related to depression, fear or addiction behavior in rodents. Figure 2: Mouse brain fiber pathways reconstructed from in-vivo DT-MRI acquisition at 9.4T using a quadrature mouse brain room temperature coil. A: Frontal view, B: Lateral view. Blue: stria terminalis. Red: Amygdala-cortex. Green: Thalamocortical projections.

Probabilistic tractography and its validation

We demonstrate here a quantitative validation of mouse brain probabilistic tractography with correlative histological axonal tracing (Micro Ruby – MiR axonal tracing) of the thalamocortical pathway (Fig. 3), performed in the same animals. Fine grained mapping of the thalamocortical connectivity is shown, and more precisely the connectivity between the ventrobasal thalamic nucleus and the mouse somatosensory cortex. Figure 3: Probabilistic mapping (B, D) of the thalamocortical pathway (TCP) validated with histological axonal tracing (A) in the same animal. A: TCP representation using axonal density (AD) maps generated from MiR histological tracing. B, D: TCP representation using in-vivo probabilistic mapping (PM). C: Merged AD/PM maps

Projects using DT-MRI for mouse brain investigations:

- Sexual Dimorphism in Demyelination and Recovery: In Vivo Brain Magnetic Resonance Imaging of a Mouse Model of Multiple Sclerosis
- In Vivo Brain Imaging of the Reeler mutant mouse
- Patterns of neurocircuitries modification in animal models of alcohol addiction

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