A new perspective on the cortical laminar pattern of the primary visual cortex in the occipital lobes

Michiel Kleinnijenhuis

ISOCN 2012: the occipital lobes. Ragusa, 31 May 2012
V1 is the showcase for new methods in laminar investigations

• **Histology**
  – Annese et al., 2004; Eickhoff et al., 2007

• **Structural MRI**
  – Barbier et al., 2002; Blackwell et al., 2009

• **Functional MRI**
  – Logothetis et al., 2002; Koopmans et al., 2010

• **Stria of Gennari**
The new perspective: Diffusion Weighted Imaging

The Sulcus Calcarineus.

The most external layers of the cortex. The three granular and the intergranular layers consist really of mixed elementary forms, among which the granular ganglionic cells preponderate. The connection of the pyramids with the previously developed delicate radial medullary bundles of the cortex is easily recognized. The small fusiform (spindle) cells of these layers are contiguous beyond a doubt with transverse nerve fibres, which are by no means numerous enough, however, to constitute, as Kölliker would have it, the white substance of the intermediate strand in the cortex of the sulcus calcarineus.

To explain satisfactorily this white, intermediate strand, we must, because of its well-defined boundary, have recourse to the lack of pigment in the barren intergranular layers, for the nerve corpuscles evidently carry the pigment which is responsible for the deep tint of the gray substance. Besides, the effect of lack of pigment is intensified by radiating medullary bundles which are not prominent in other internal layers—in the seventh and eighth for instance,—where the impression gained from numerous pigment cells overshadows all else.

Heidemann et al., ISMRM 2011, P1957
Methods

Human brain tissue samples (1 × 1 × 3 cm)
- Cortex (V1/V2) + WM;
- post-mortem interval 15h

MRI:

<table>
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<th></th>
<th>11.7 T</th>
<th>11.7T</th>
<th>9.4T + CryoCoil</th>
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<tr>
<td>MGE</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1 mm</td>
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<tr>
<td>DWI</td>
<td>0.3</td>
<td>0.3</td>
<td>0.2 mm</td>
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<td>61</td>
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<td>650</td>
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<td>b-values</td>
<td>4000</td>
<td>4000</td>
<td>1000, 2000, 4000 s/mm²</td>
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<tr>
<td>reps</td>
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<td>1</td>
<td>1</td>
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</tbody>
</table>

Histology: myelin stain, Luxol Fast Blue
Diffusion properties are non-uniform over layers

- FA shows layers
- Cortical PDD mostly radial
- Cortical ODFs reveal multiple orientation over layers
- WM
  - U-fibers
  - Deep cortical layers
  - Gennari
- Superficial layers
  - Layer I fully tangential
- DT tractography resembles histology
Sample #2: spherical deconvolution
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Sample #3: V1 vs V2

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Discussion and Conclusion

• Our findings are a first step in understanding diffusion properties within the cortex

• Nondestructive microstructural assessment of cortical layers is feasible

• Usefulness for tractography and networks?
  ➔ informative for cortical endpoints
  ➔ presumed isotropic tangential component within layers

Conclusion:

“In the cortex, diffusion is anisotropic and layer-specific”
### Thanks!

**Anatomy:**
- Anne-Marie van Cappellen van Walsum
- Kees-Jan Sikma
- Valerio Zerbi
- Jos Dederen
- Dirk Ruiter

**DCCN:**
- Markus Barth
- David Norris

**Pathology:**
- Benno Küsters

**Radiology:**
- Andor Veltien

**MIRA/UTwente:**
- Kees Slump

**MPI Köln:**
- Dirk Wiedermann
- Matthias Höhn

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**Bruker BioSpec 11.7T:** Investment grants NWO middelgroot 40-00506-90-0602 and NWO BIG (VISTA) to A. Heerschap

**VIP Brain Networks**

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Recent studies

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