

# Journal-Report

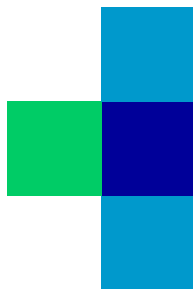
Wedeen VJ, Wang RP, Schmahmann JD, Benner T, Tseng WY, Dai G, Pandya DN, Hagmann P, D'Arceuil H, de Crespigny AJ.

## Diffusion spectrum magnetic resonance imaging (DSI) tractography of crossing fibers

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# Background

## Tractography

- highly **nonlinear representation** of diffusion contrast
- reflects maxima of orientation coherences within and between voxels

## Diffusion tensor imaging (DTI)

- unable to resolve multiple fiber orientations within an MRI voxel
- cannot resolve fiber crossings either in white matter or in the gray matter

## Diffusion spectrum MRI (DSI)

- describes diffusion **in each voxel** with the probability density function (PDF) which for each voxel specifies the 3D distribution of microscopic displacements of MR-visible spins that it contains

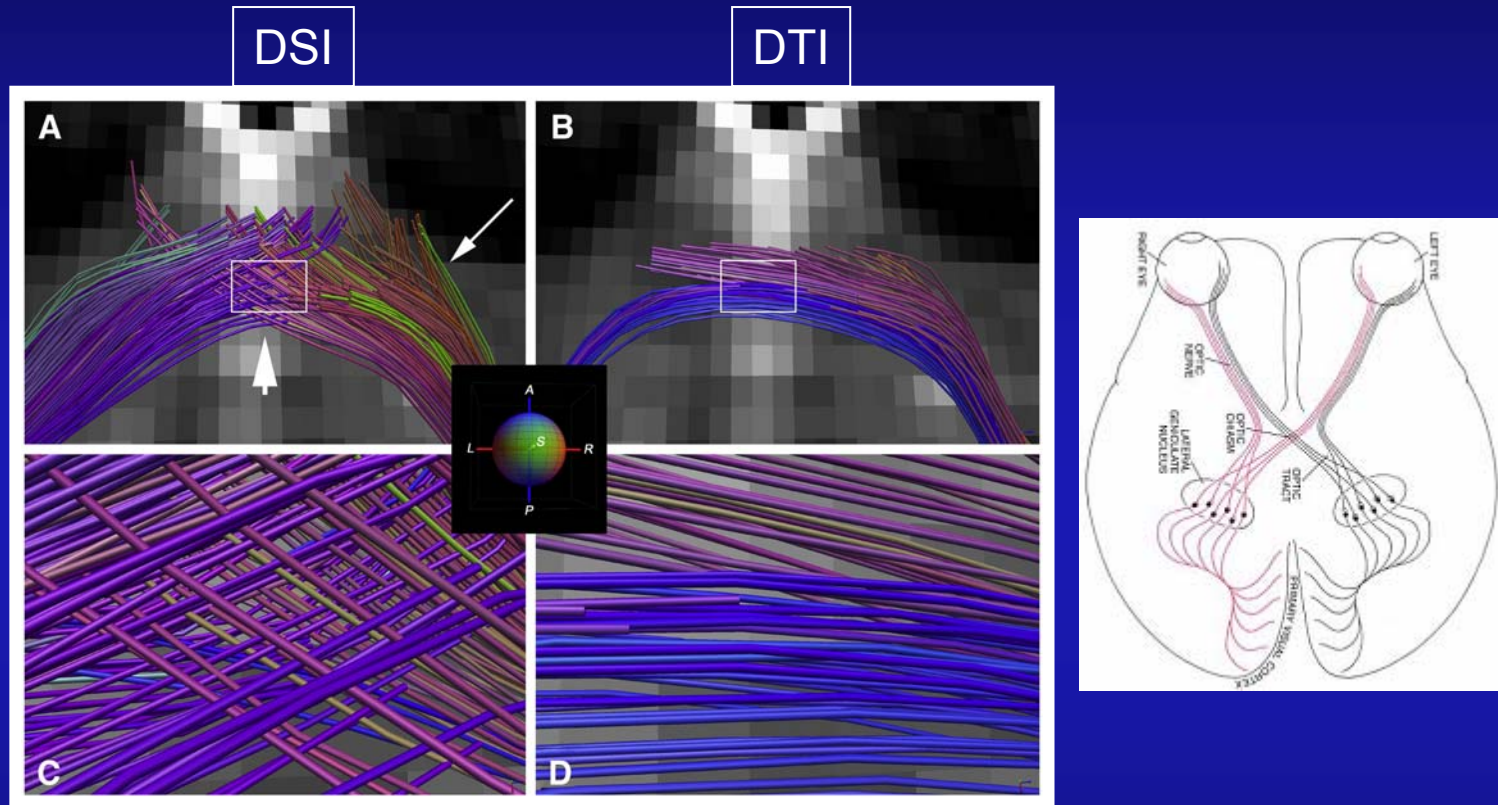
# Goal

- to image complex distributions of the intravoxel fiber orientation directly
- to compare the results of DSI and DTI

# Method

- 4 post-mortem fixed **macaque** brains scanned immersed in perfluorocarbon (4.7 T)
- brains of 6 healthy **human** adults *in vivo* (3 T)
- **DSI** (diffusion spectrum MRI)
- DSI data were re-processed by **DTI** tractography
  - tensors were fit to the complete set of DSI data by linear least-squares
  - tractography was performed with the same algorithm

# Results



**Fig. 1: Formalin fixed monkey brain**

**A, C:** Lateral optic nerve fibers of the **optic chiasm** maintain their lateral location. Medially situated fibers decussate in the chiasm before progressing caudally into the optic tract.

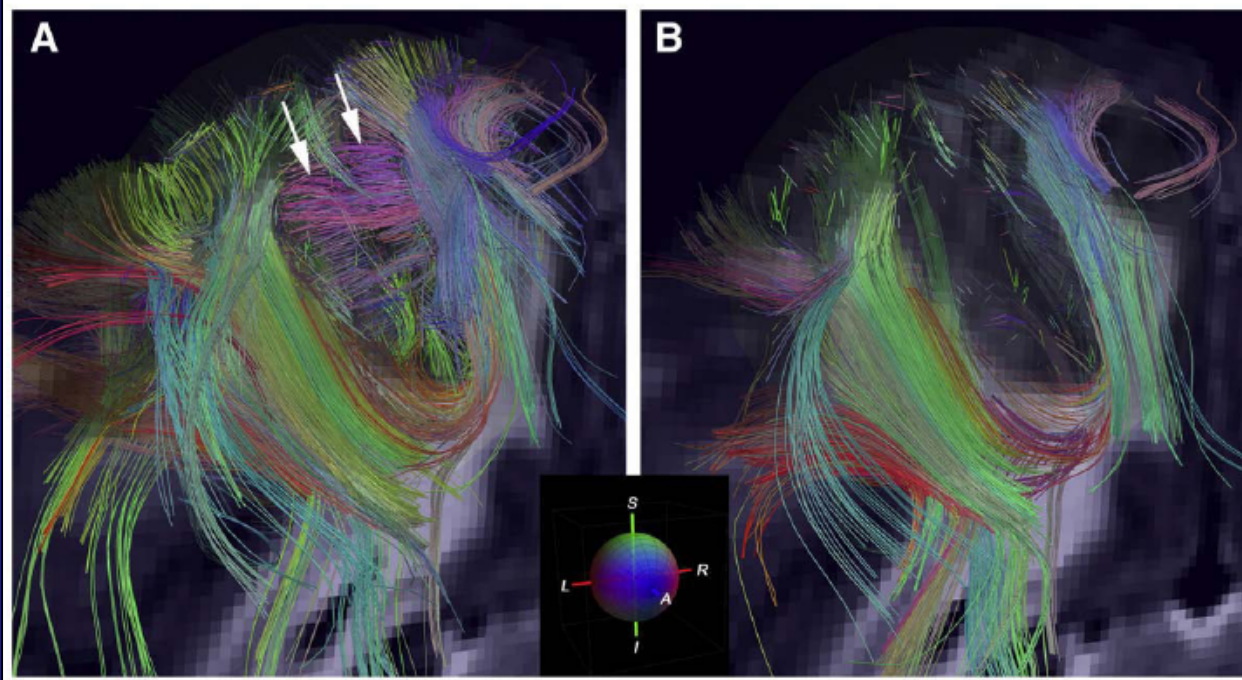
**B, D:** DTI reconstruction fails to show decussation of fibers at all, leading to clearly erroneous topology.

**Inset figure:** The convention for the 3D fiber orientation color code in this and subsequent figures is that each fiber has constant color representing the orientation vector between its endpoints.

# Results

DSI

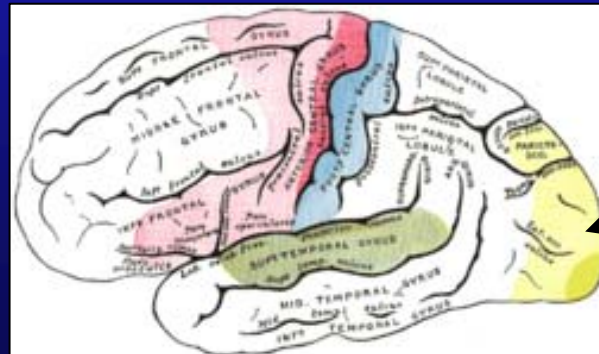
DTI



**Fig. 4: Formalin fixed monkey brain**

**A:** Fibers within the white matter of the cortical gyrus and radiate fibers within adjacent gyri of the cerebral cortex (arrows). There is also some artifactual propagation of solutions across the sulcal space between opposing gyri

**B:** Tractography of the DTI data shows fewer fibers within the white matter of the gyrus and no radiate fibers within the cortex



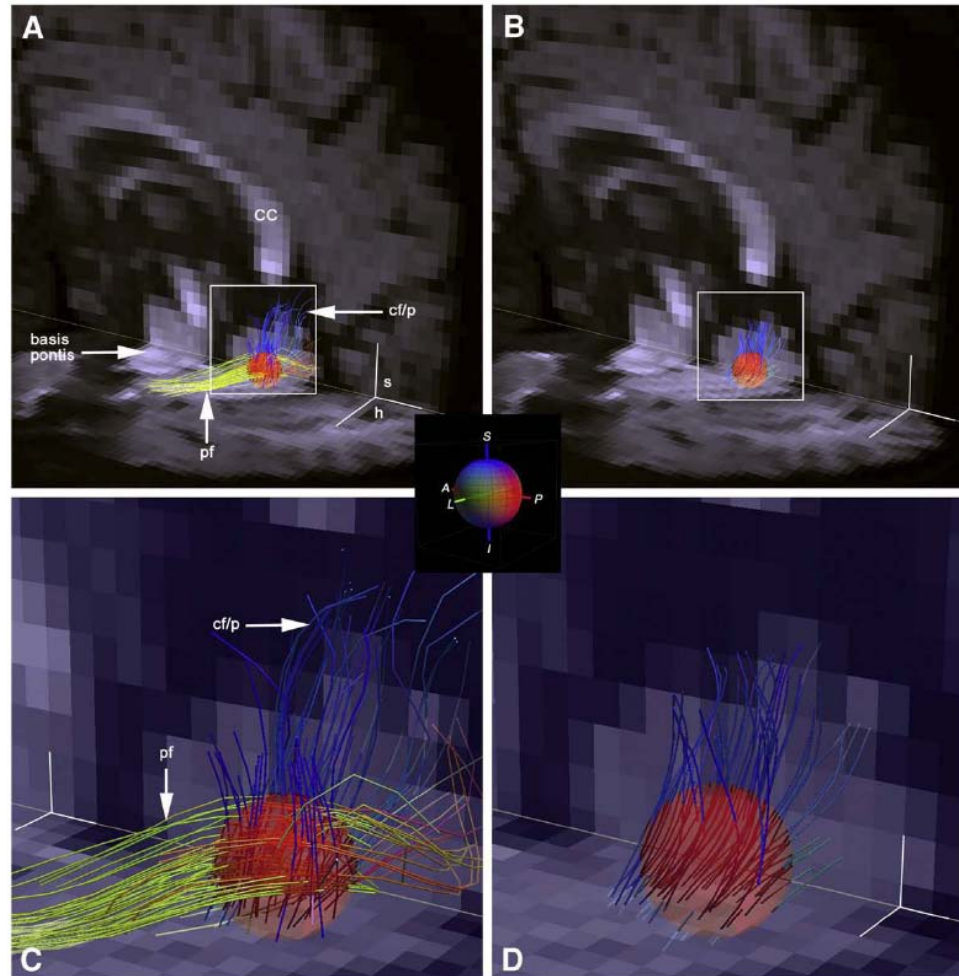
Visual cortex



# Results

DSI

DTI



**Fig. 9: Cerebellar cortex of human *in vivo***

**A, C:** identification of both corticopetal/corticofugal fibers (blue) and parallel fibers (yellow/green)

**B, D:** no identification of the cortical fibers oriented parallel to the long axis of the folium.

CC, corpus callosum  
cf/p, corticofugal/corticopetal fibers  
pf, parallel fibers

# Summary

- **DSI tractography** shows
  - ▶ fiber crossings in the optic chiasm
  - ▶ fiber intersections in gray matter
  - ▶ radial fiber architecture in the cerebral cortex
  - ▶ displays the **three-dimensional** nature of anatomical structures
  - ▶ results are **in good agreement with known anatomy** of the selected brain regions
  
- **DTI tractography**
  - ▶ did not identify fiber crossing and complex structures in the examined brain areas



**To keep in mind:**

**Virtual reality of functional images**

**versus**

**anatomical reality**