Maps, Plasticity and Tracts in Visual Cortex

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Collaborators
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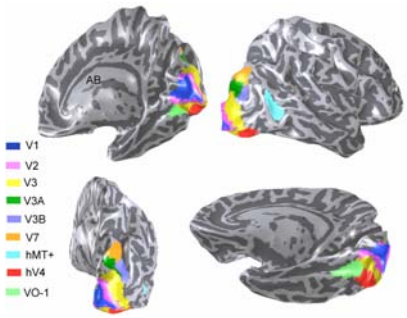
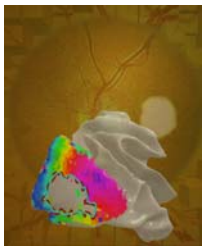
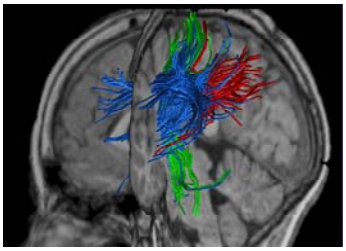
Overview

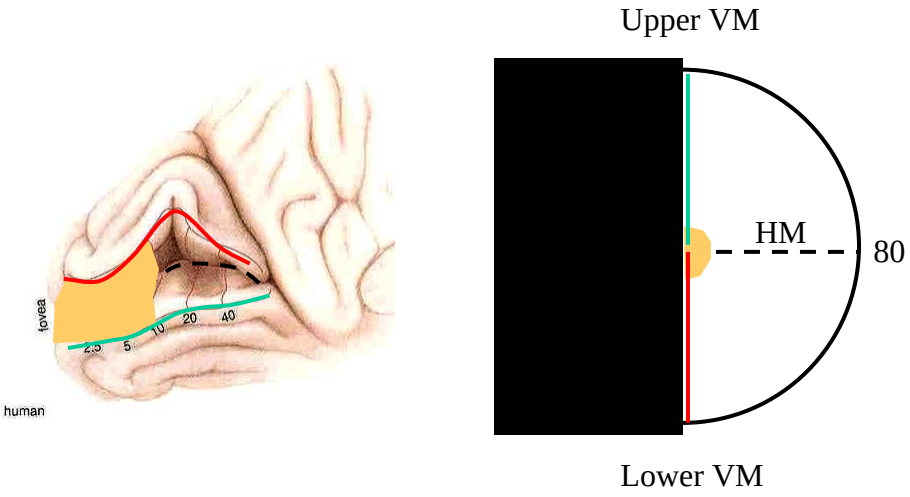


- Visual field maps and clusters
- Cortical plasticity
- Reading development (DTI-FT)



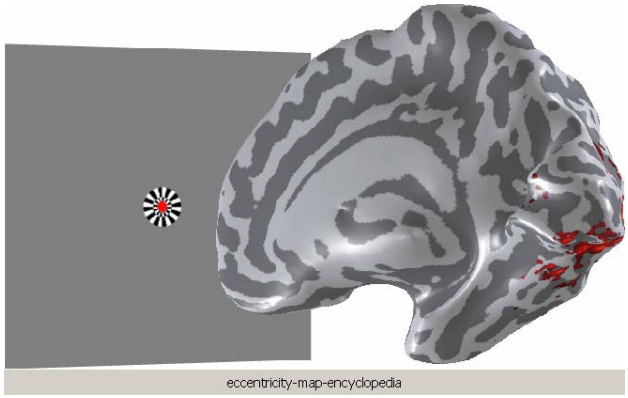


Primary visual cortex (V1) contains a visual field map

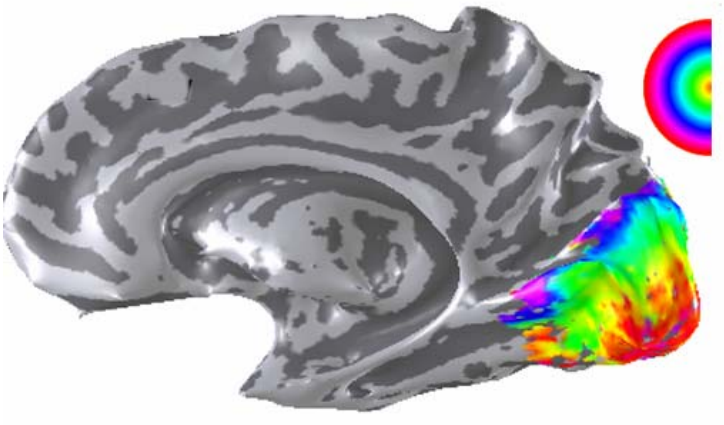


Human eccentricity mapping

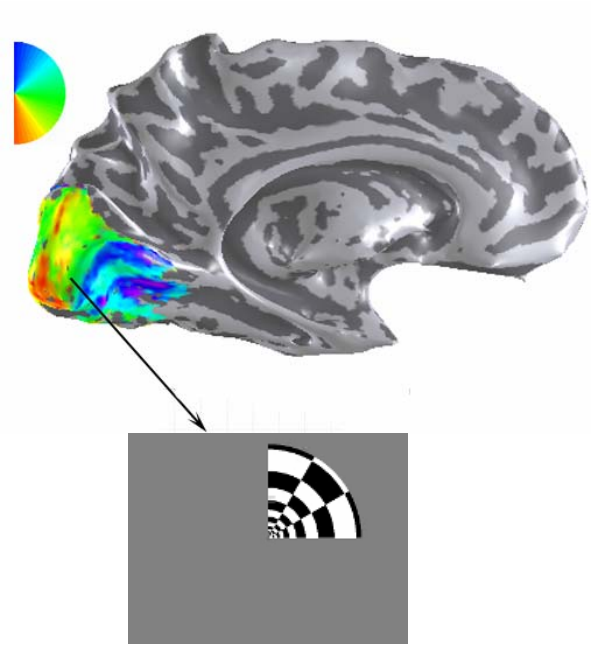
(Engel et al., 1994,1997; Sereno; DeYoe; Others)



Pseudo-color representation of visual field map

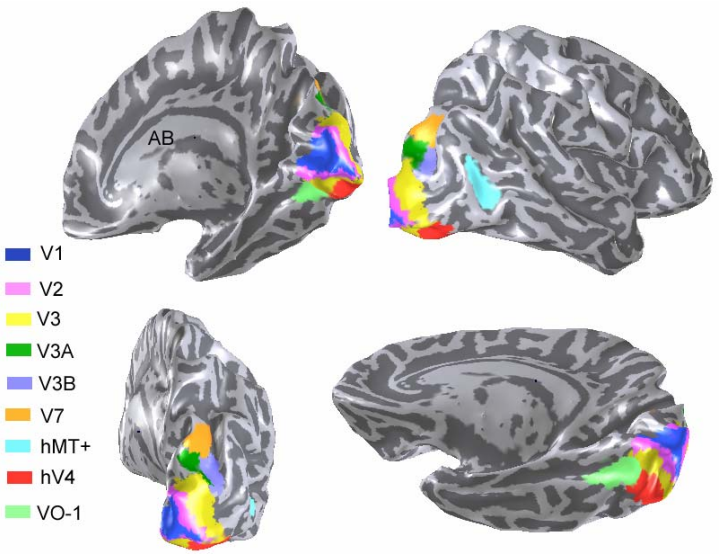


Angular measurements sharply delineate visual field map boundaries



More than nine visual field maps

Wandell et al. (2005) Phil Trans Royal Society

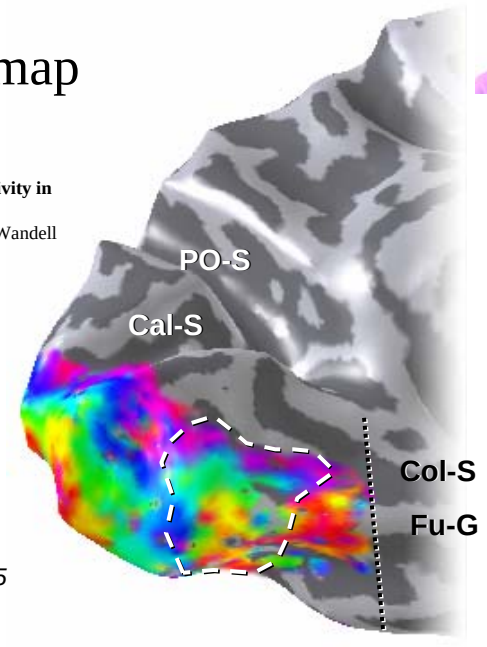


Visual field map clusters

Visual field maps and stimulus selectivity in human ventral occipital cortex.
A.A. Brewer, J. Liu, A.R. Wade, B.A. Wandell
Nat Neurosci., vol. 8 no. 8, pp. 1102-9

Brewer

Coherence = 0.25

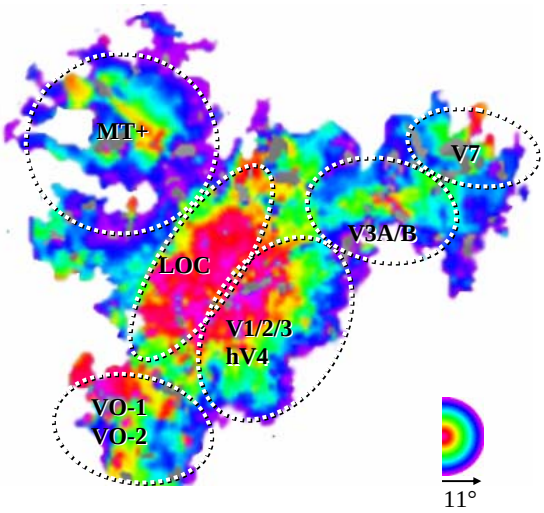


Visual field map clusters

(Wandell et al., 2005, Phil Trans Roy Soc)

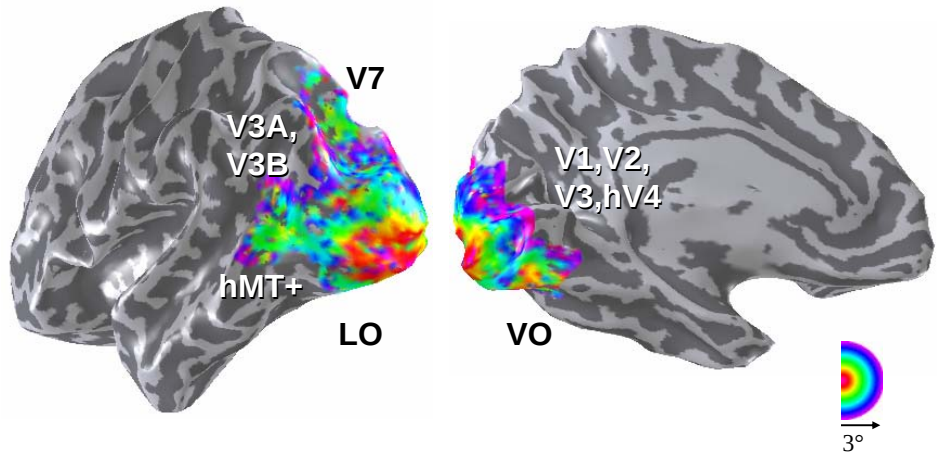
Clusters

- share a common circular or semi-circular eccentricity map.
- contain multiple angle maps within the eccentricity representation.
- may share similar computational resources.



Visual field map clusters

(Wandell et al., 2005, Phil Trans Roy Soc)

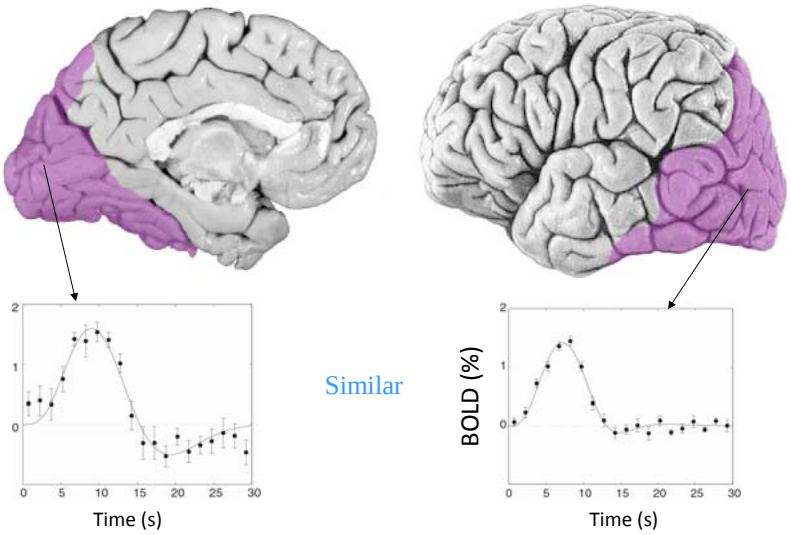


Coherence = 0.20

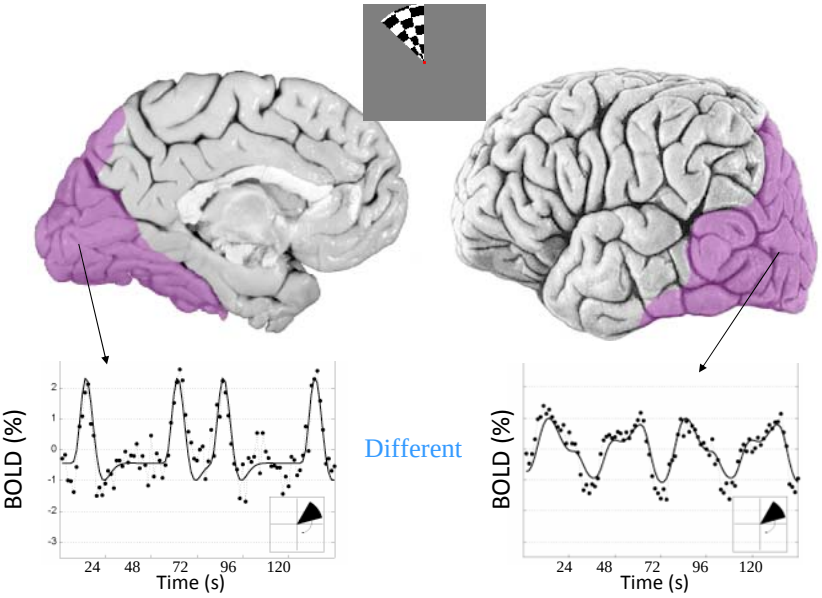
Visually responsive cortex (HRF)

Dumoulin

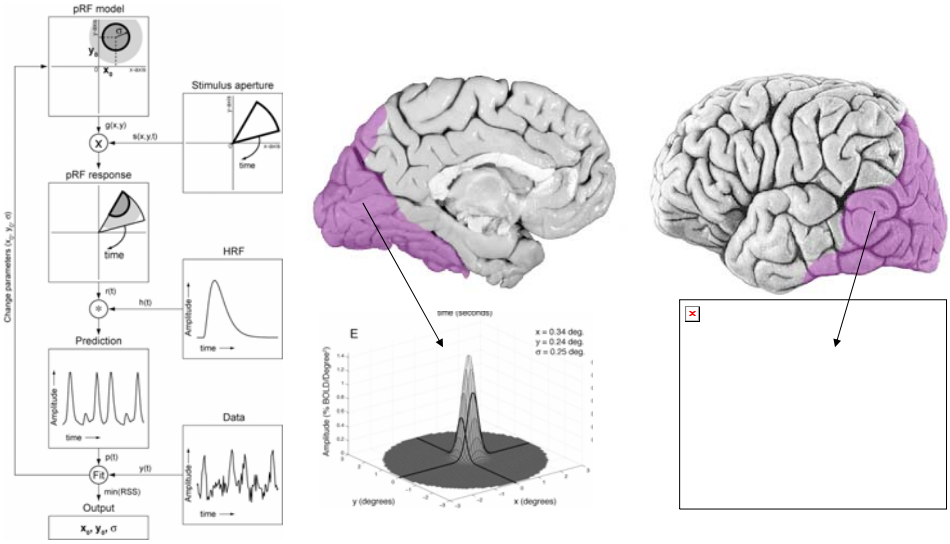


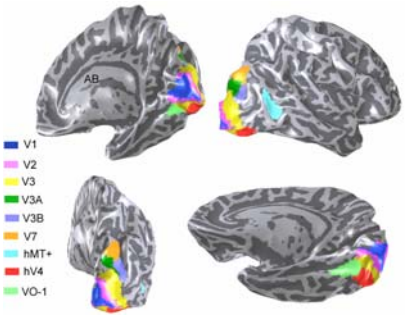
Visually responsive cortex



Population receptive field models



Conclusions Part I

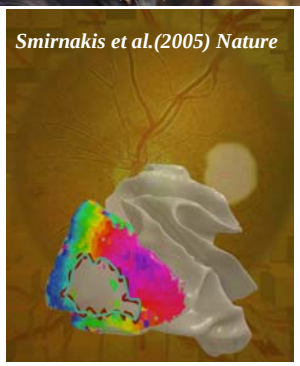


Visual cortex can be sub-divided into a multiplicity of visual field maps. Eleven are confirmed. More maps will be reported

Beyond V1/V2, homology between the human maps and those in other species is uncertain.

Maps are organized into distinct clusters that share a common eccentricity map but can be distinguished based on their angle maps.

Cortical Plasticity



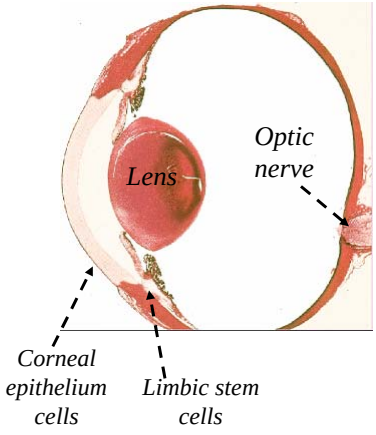
- **Recovered sight**
- **Retinal lesions**

Recovered sight

(Fine, Brewer, Wade, MacLeod, Wandell, Nature Neuroscience, 2002)

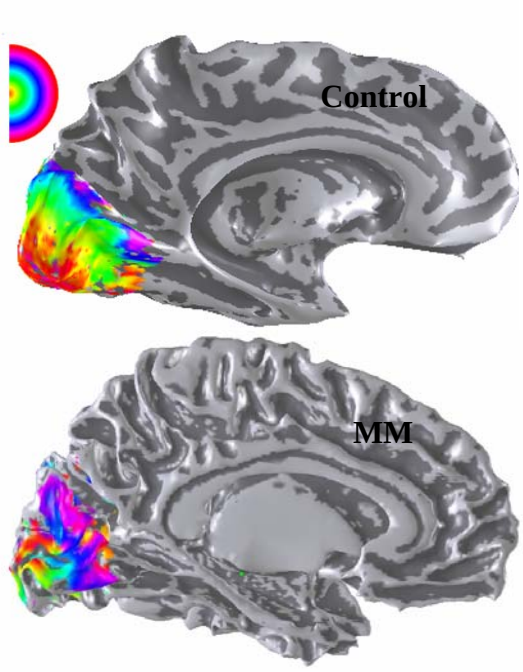
Ione Fine

- Chemical accident at 3 yrs
- One eye lost; other cornea destroyed
- Blind from age 3 through 46
- Stem cell replacement in right eye for both epithelium and stem cells



MM's visual field maps differ from normal controls

(May 1, 2001)



- *Smaller area*
- *Portions of visual cortex fail to respond*
- *Ask me about macular degeneration*

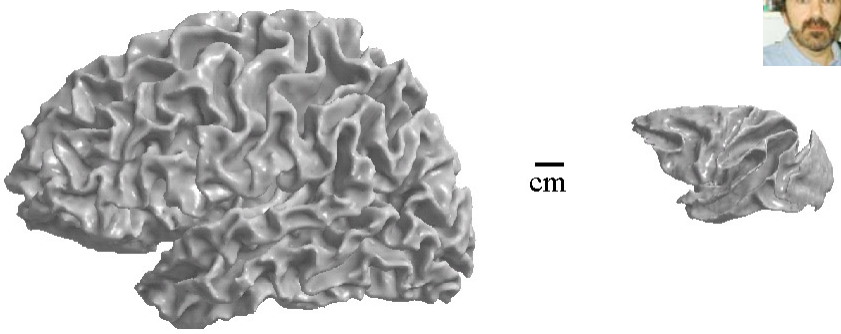
Macaque measurements

(Logothetis Lab)

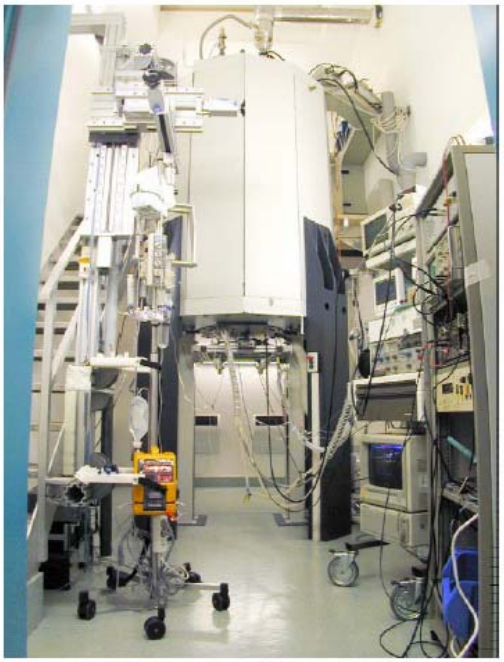
Potential for molecular and pharmacological studies of cortical plasticity

Smirnakis

Logothetis



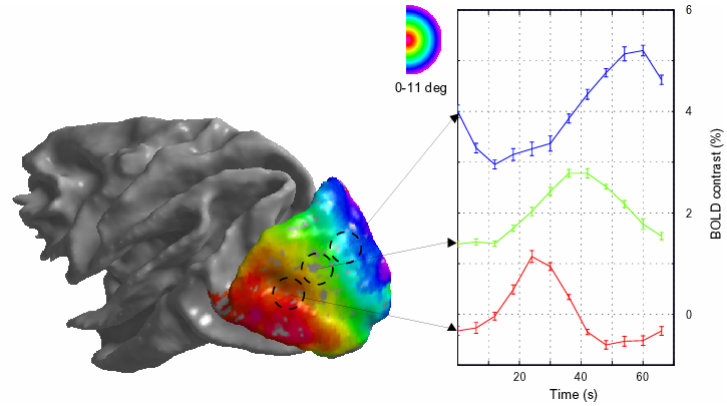
Logothetis rig for monkey fMRI (4.7T)



Applications of visual field mapping to retinal dystrophies

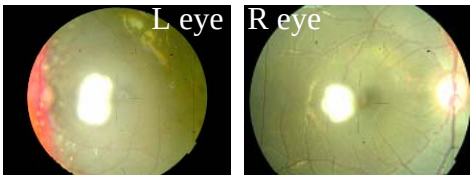
Visual field mapping in macaque

(Brewer et al., 2002, J. Neuroscience)

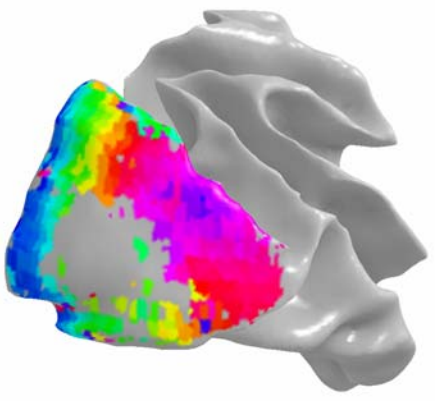


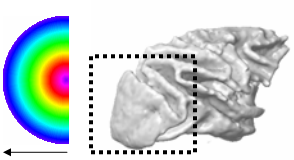
Retinal lesions eliminate activity in the projection zone

(Smirnakis et al., 2005)



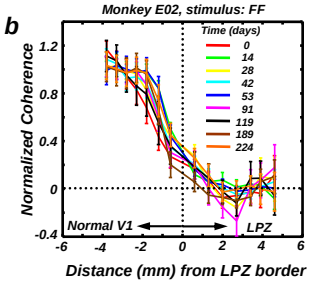
$4^0 - 12^0$ eccentricity

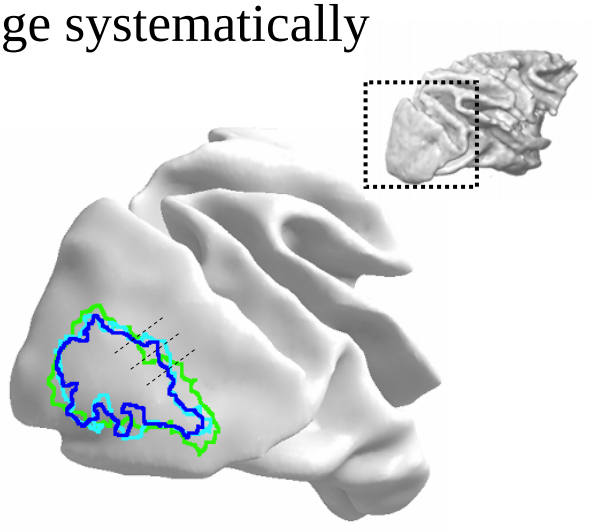




11 deg

The margins of the scotoma did not change systematically



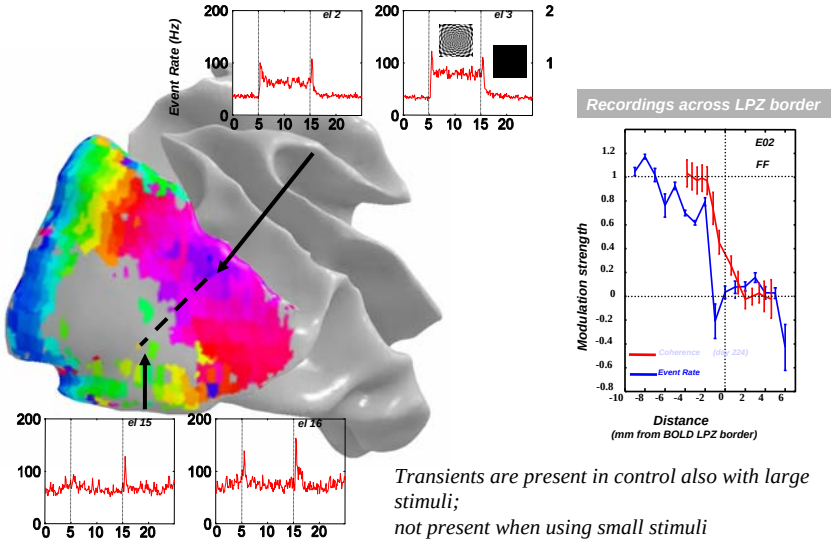


Scotoma at 0 days

Scotoma at 2 wks

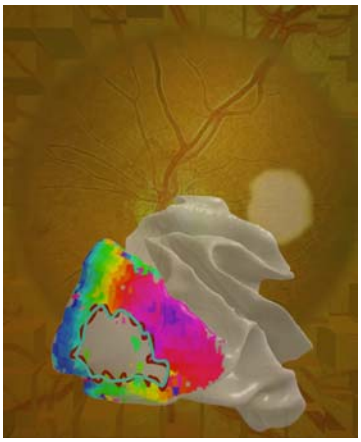
Scotoma at 4 months

Single-Unit recordings confirm



Transients are present in control also with large stimuli;
not present when using small stimuli

Conclusions Part II



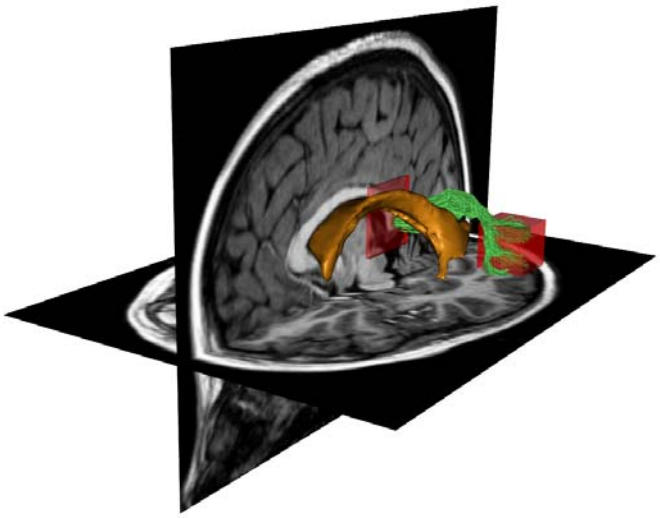
(Smirnakis et al., 2005)

• Plasticity exists in some cases (MM) but not all.

• "Over a period of 4-7 months, we observed no significant change in the position of the BOLD-defined LPZ border. Abnormal BOLD responses in the LPZ were confirmed by electrophysiological measurements of multi unit action potentials. Together, these experiments suggest that little long-term reorganization occurs in the LPZ, and that neuronal responses in the LPZ do not recover to anything approaching their normal state."

Stelios M. Smirnakis[1,2], Alyssa A. Brewer[3]*, Michael C. Schmid[1]*, Andreas S. Tolias[1], Almut Schüz[1], Mark Augath[1], Werner Inhoffen[4], Brian A. Wandell[3] & Nikos K. Logothetis[1].

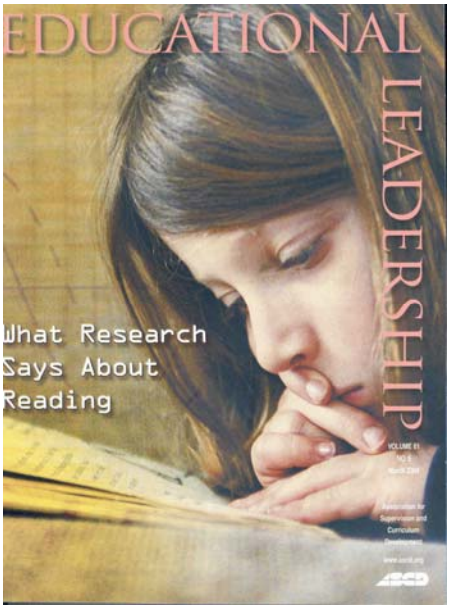
Diffusion tensor imaging and fiber tractography of human brain pathways

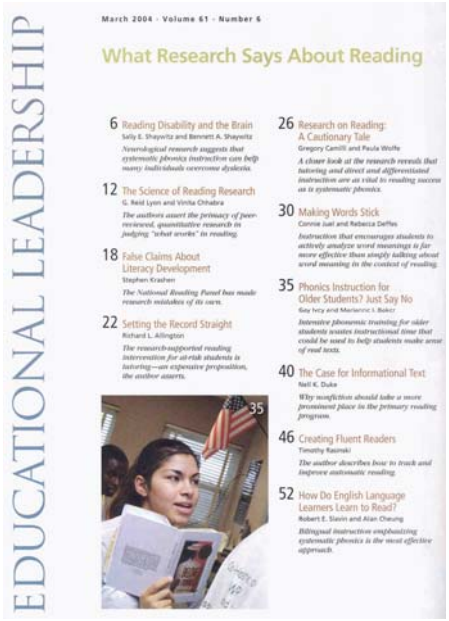


Dougherty

Ben-Shachar

Sherbondy

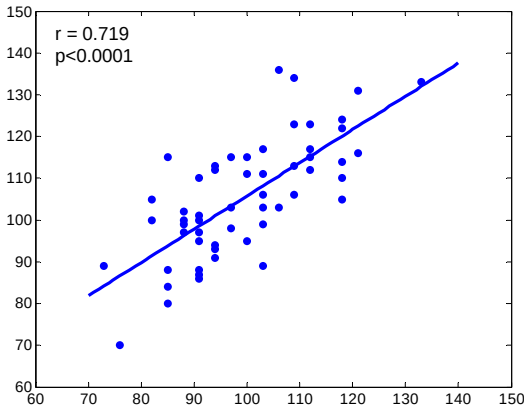




Word reading correlates with phonological awareness

(Ben-Shachar, Deutsch, Dougherty, Wandell)

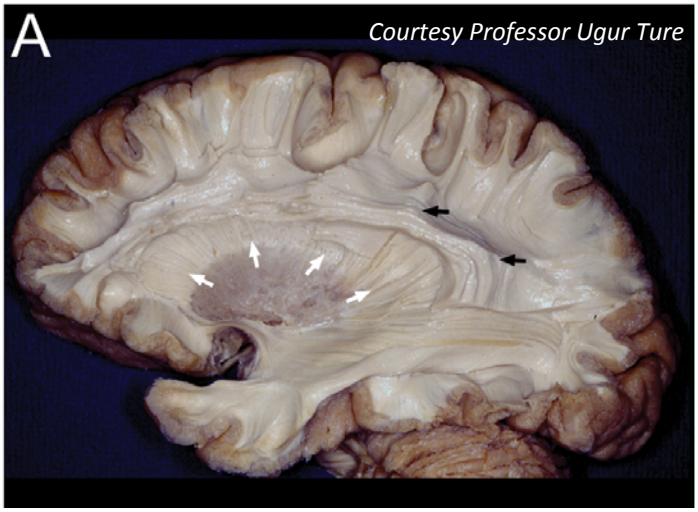
Reading
(Word ID)
read aloud:
'..together,..
enough, ..'



Phonological Awareness
(elision, blending)

elision (strain-/r/ = stain)
blending (/t/+/oi/ = toy)

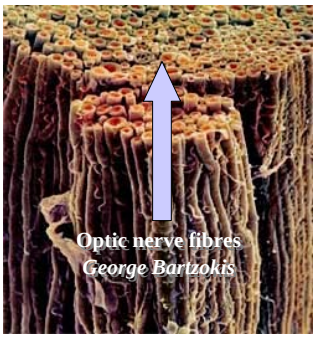
Human fiber tracts

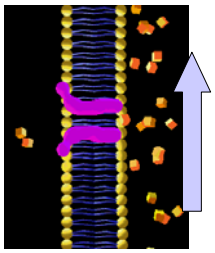


Human fiber tracts

Taken from course notes at UCLA, Neurobiology 104
http://neuromedia.neurobio.ucla.edu/campbell/nervous/wp_images/182_TS_LP.gif

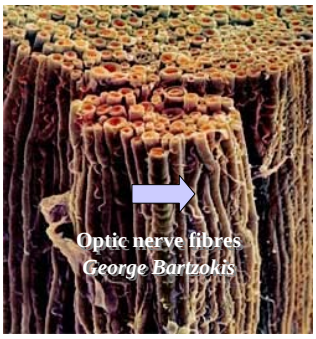
H_2O diffusion probes membrane properties in the brain

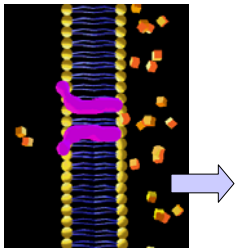




Along the axon, within the cytoskeleton, there is a large Apparent Diffusion Coefficient (ADC)

H_2O diffusion probes membrane properties in the brain

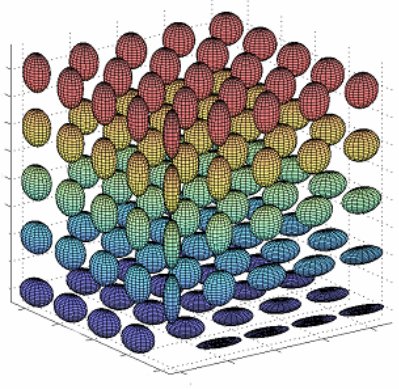




Bi-lipid cell membranes limit diffusion. Hence, perpendicular to the length the ADC is smaller

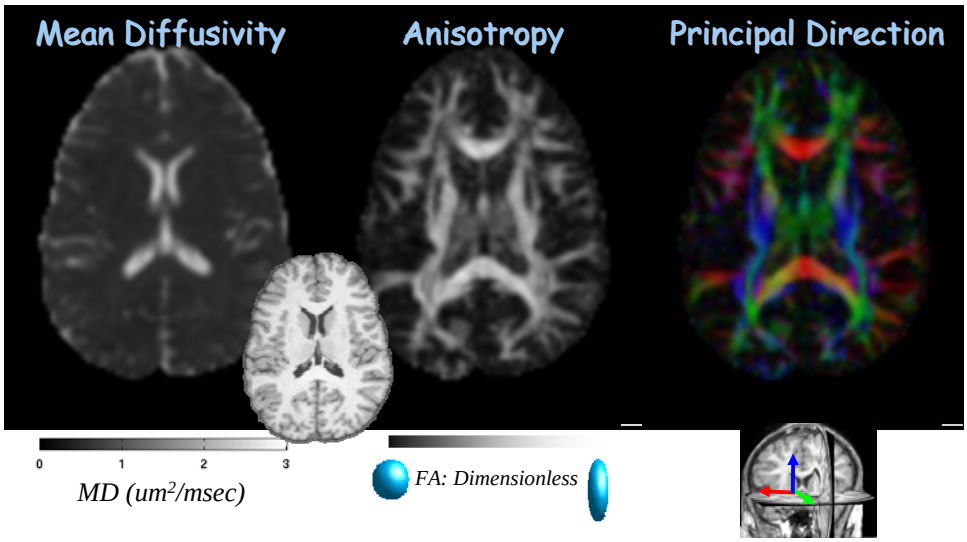
DTI data sets are volumes of diffusion surfaces

Diffusion data are surfaces



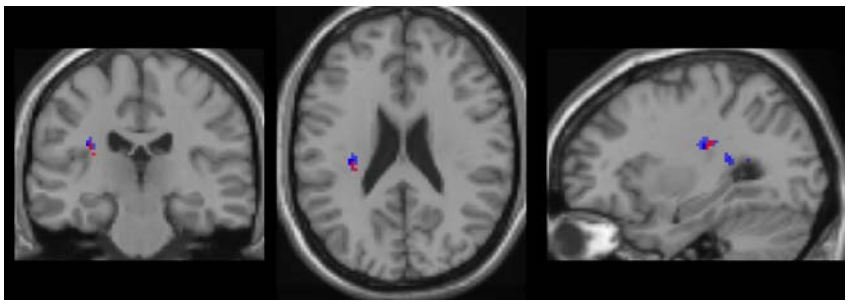
Conventional MR volumes are real-valued

DTI Analyzes White Matter Structure

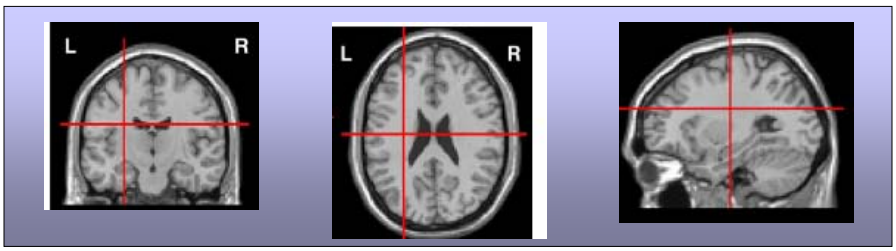


In children FA correlates with reading skill

Deutsch, Dougherty, Bammer, Siok, Gabrieli, Wandell (2005)

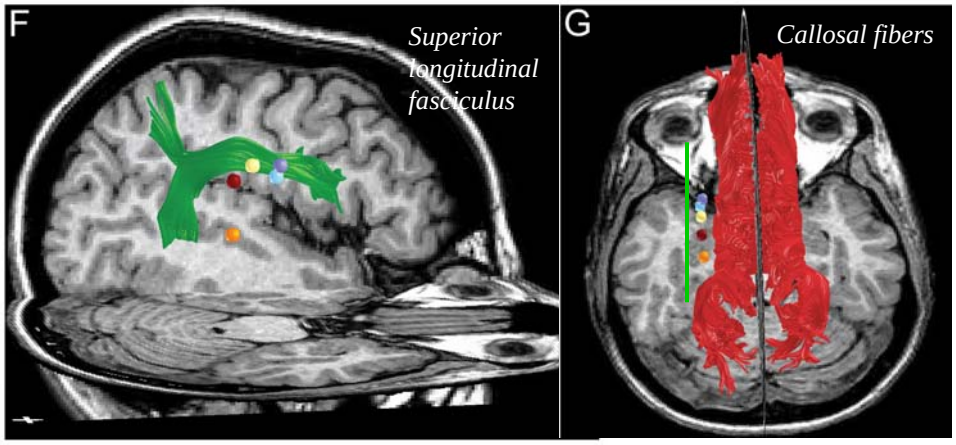


Beaulieu C, Plewes C, Paulson LA, Roy D, Snook L, Concha L, Phillips L. (2005).

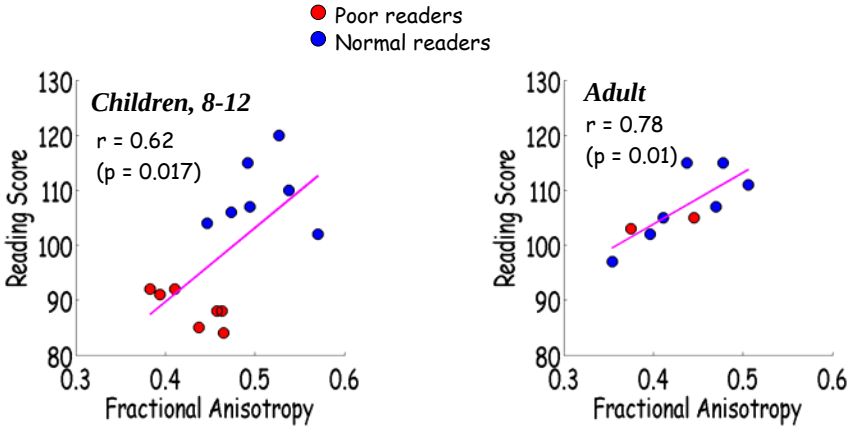


Location of FA difference with respect to major bundles

(Ben-Shachar et al., 2007)



A correlation is present in children and adults

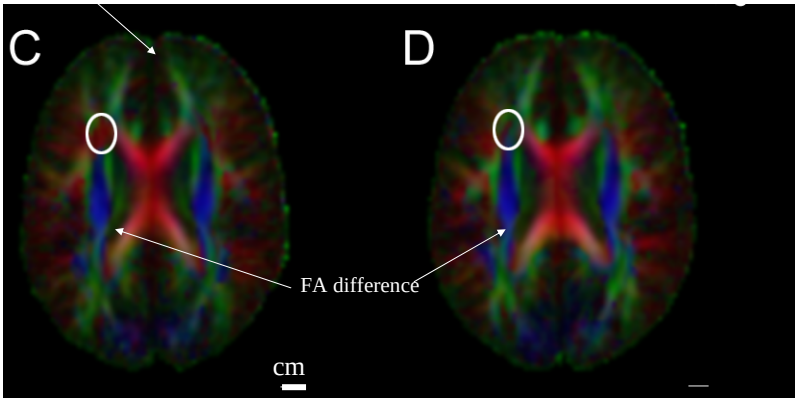


There is a directional difference in anterior cortex (N=14)

(Ben-Shachar et al., 2007)

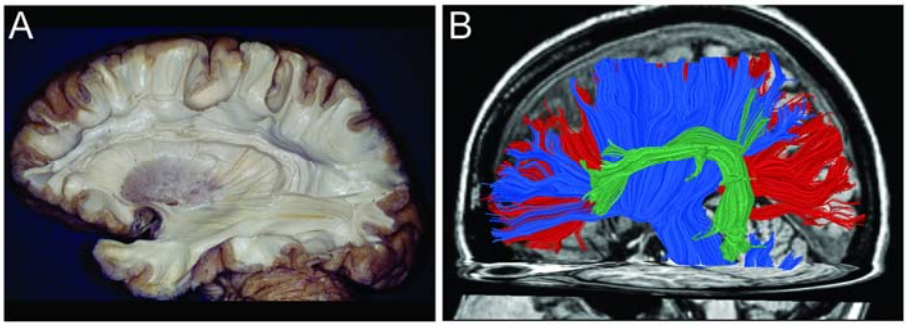
Dougherty

Good Readers *Poor Readers*

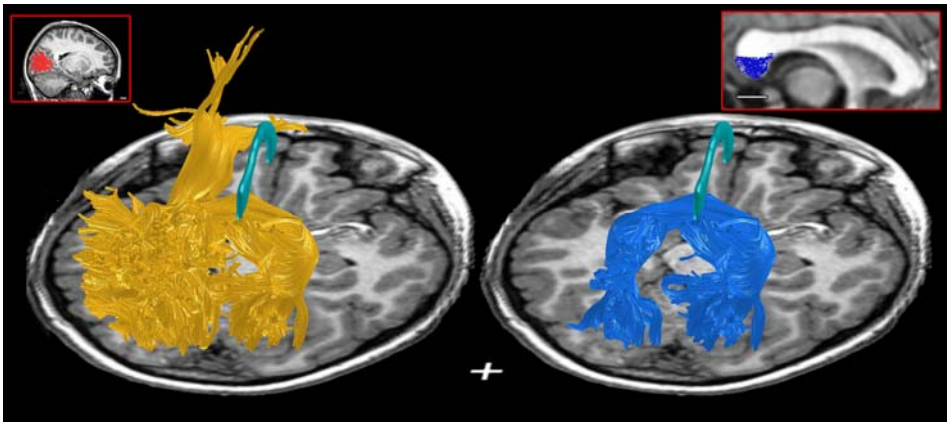


Relating diffusion imaging to white matter tracts

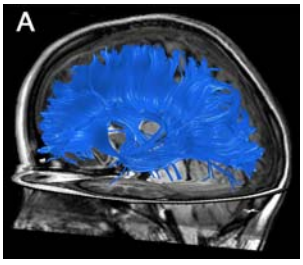
(Ben-Shachar et al., 2007, Current Opinions Biology)



DTI-FT Limitations

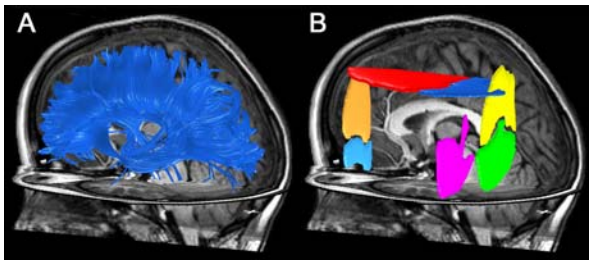


Segmentation of the callosum based on projection zones



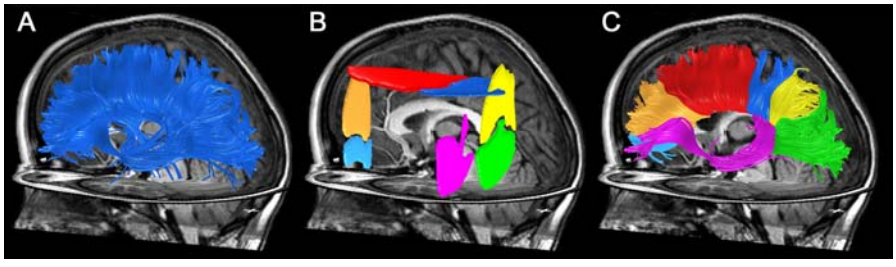
All callosal fibers

Segmentation of the callosum based on projection zones



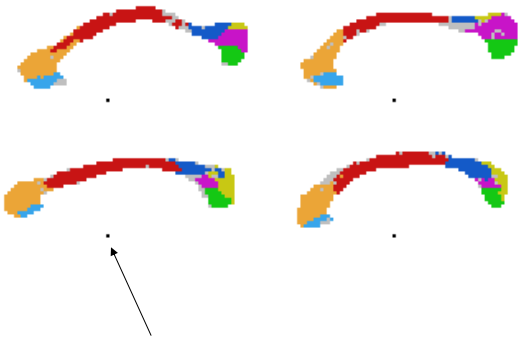
All callosal fibers ⇒ **Regions of interest**

Segmentation of the callosum based on projection zones

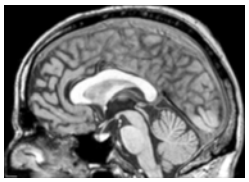


All callosal fibers ⇒ **Regions of interest** ⇒ **Segmented fibers**

Segmentation of the callosum



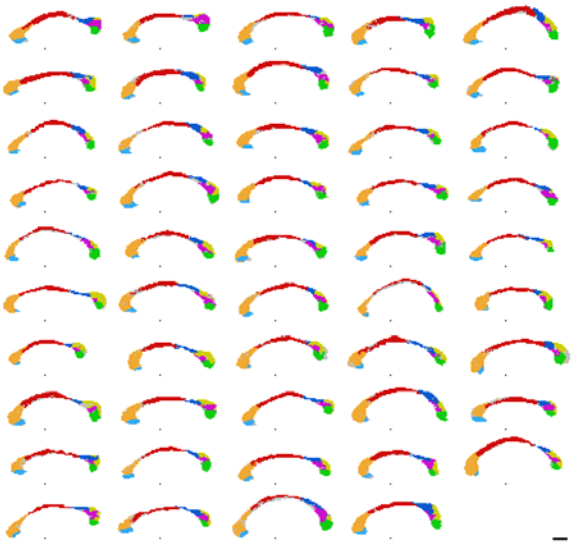
Anterior commisure

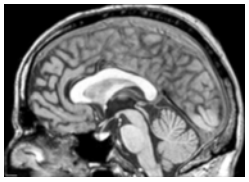


Projection zones

- Occipital
- Temporal
- Posterior Parietal
- Superior Parietal
- Superior Frontal
- Anterior Frontal
- Orbital Frontal
- Indeterminate

Shapes differ, segmentation is possible, N=49 children

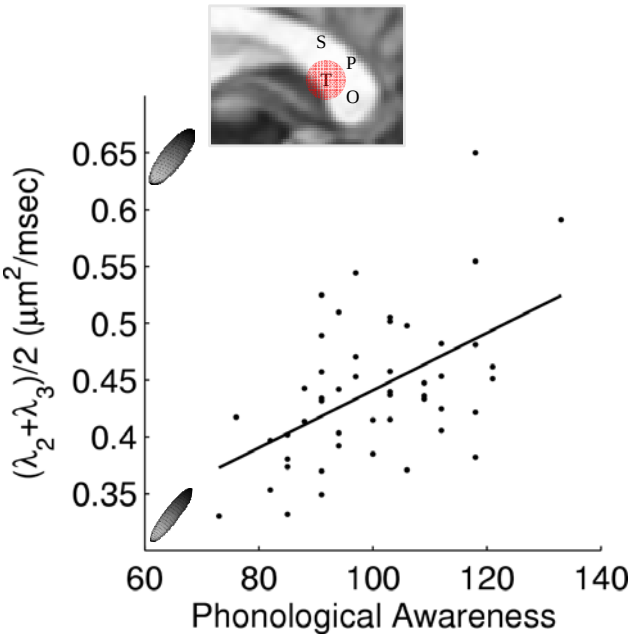




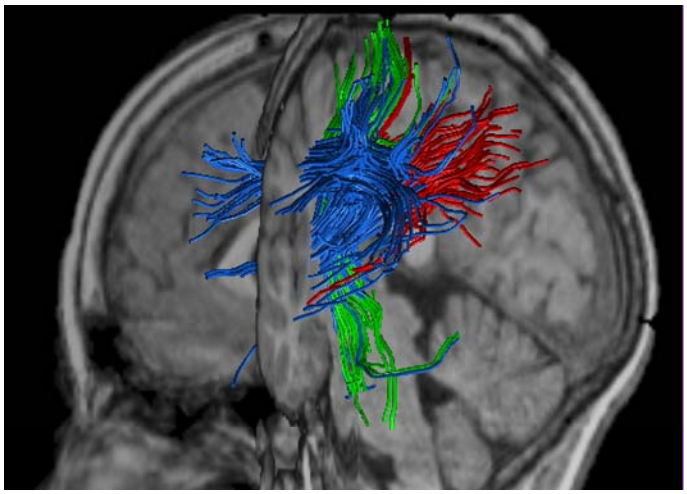
Projection zones

- Occipital
- Temporal
- Posterior Parietal
- Superior Parietal
- Superior Frontal
- Anterior Frontal
- Orbital Frontal
- Indeterminate

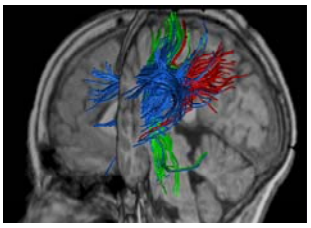
Radial diffusivity in callosum that projects to temporal lobes correlates with phonological awareness
(Dougherty et al., PNAS, 2007)



Exuberant Growth -Pathway Shift Hypothesis
(interactive demo)



Conclusions, Part III



Diffusion tensor imaging can be used in a variety of ways, ranging from FA maps, direction maps, and fiber tracts

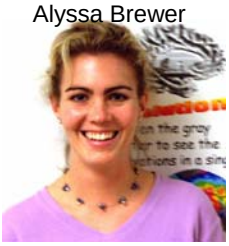
There is excellent agreement that certain white matter differences correlate with reading skill.

Interpreting these differences, by describing the data with respect to the natural brain structures (fiber bundle positions and properties) is underway, but still in its infancy.

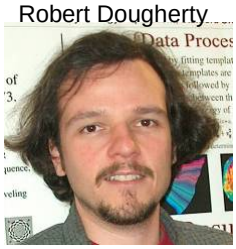
The DTI method has great promise. Must get back to work.

Collaborators

Alyssa Brewer



Robert Dougherty



Michal Ben-Shachar

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