



# Using Diffusion Tensor Imaging (DTI) to assess neural connectivity associated with complex skills



Adam Riggall

Undergraduate Research Assistant  
Gazzaniga Laboratory, Center for Cognitive and Educational Neuroscience  
Dartmouth College

## Background

Diffusion Tensor Imaging (DTI) is a neuroimaging technique that allows us, by tracking the movements of water molecules within the brain, to infer information about the underlying white matter pathways.

With DTI we can:

- Measure of the integrity of the axons in a given area
- Determine connections within the brain
- Monitor changes in either of the above over time

By combining DTI measures with behavioral measures, we can draw conclusions about the importance of different connections and brain regions in the performance of complex skills, such as reading.

The right visual field advantage (RVFA) is a behavioral measure of the extent to which the left hemisphere is specialized for reading, determined by comparing the difference in reaction time to words presented to the left and right visual fields.

Question: Does the magnitude of the RVFA correlate with measures from the DTI data within the corpus callosum?

## Methods

Imaging

- DTI images were collected by applying pairs of gradient pulses on top of a spin-echo, echo-planar pulse sequence ( $b=1000 \text{ s/mm}^2$ ,  $TR=9023\text{ms}$ ,  $TE=91\text{ms}$ ) on a Phillips Achieva 3.0T scanner.
- By altering the orientation of the gradient field we can measure the movement of water molecules along the different gradient directions.
- Using a collection of 32 different gradient directions we can generate a diffusion tensor which characterizes the diffusion characteristics of the water molecules in each voxel.

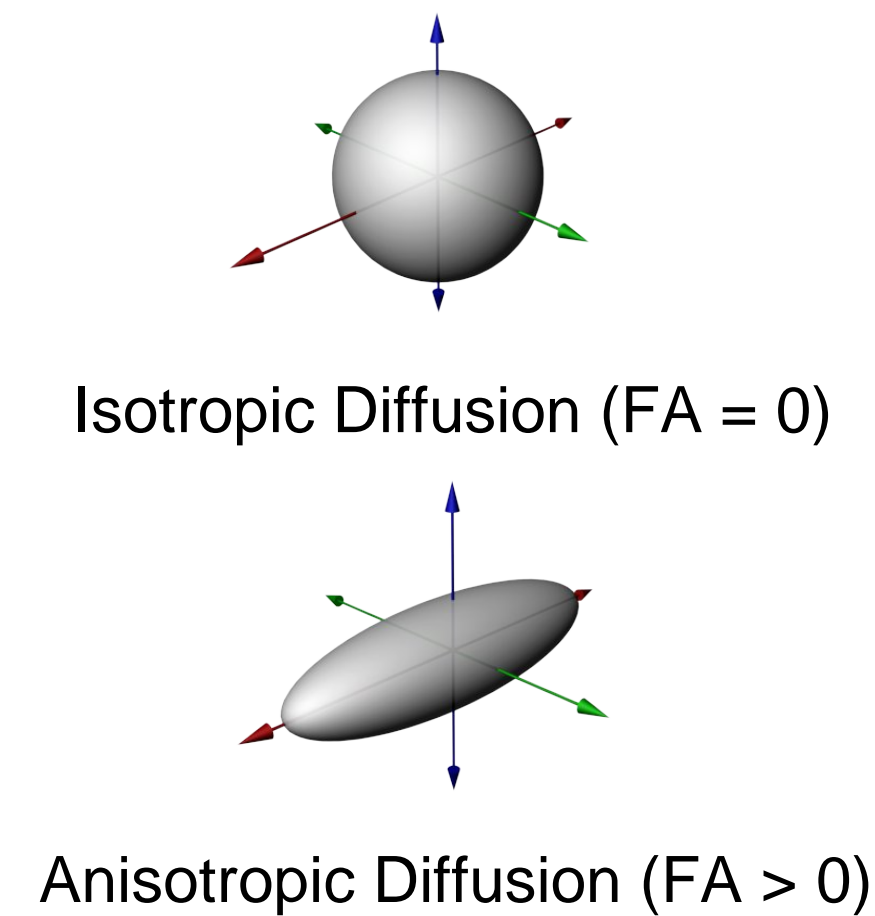
Behavioral

- Subjects were presented with words and pronounceable non-words, one at a time, to the left or right visual field while they remained fixated on a cross in the center of a screen
- They were asked to respond with a button press indicating which side of the visual field the stimulus was presented to and whether it was a real word or a non-word
- Subjects eye movements were recorded with an eye-tracker and only trials in which the subjects maintained fixation in the center were used in subsequent analyses

## Information Provided by DTI

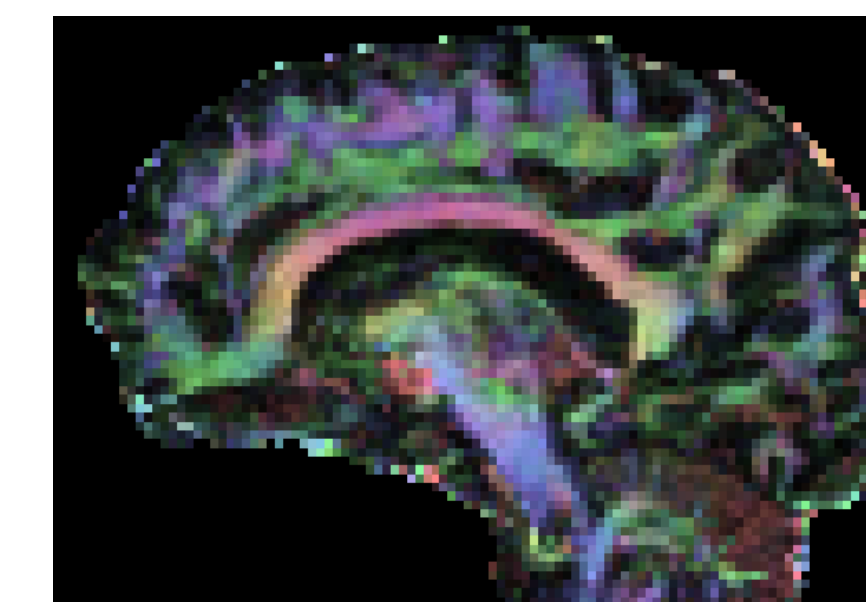
Fractional Anisotropy (FA) provides information about the shape of the diffusion of water molecules at each voxel.

- $FA = 0$  refers to motion that is purely spherical, or isotropic
- $FA = 1$  refers to motion that is purely linear, or anisotropic
- Measurements of FA allow us to gain insight into the extent of myelination, axon density, or changes in an axon's radius



The principle diffusion direction provides information about the main direction in which the water molecules diffuse in each voxel.

- The principle diffusion direction can be represented in an image by coloring each voxel differently depending on its direction
- In this image, right to left diffusion is red, anterior to posterior is green, and inferior to superior is colored blue



Sagittal slice showing the principle diffusion direction at each voxel.

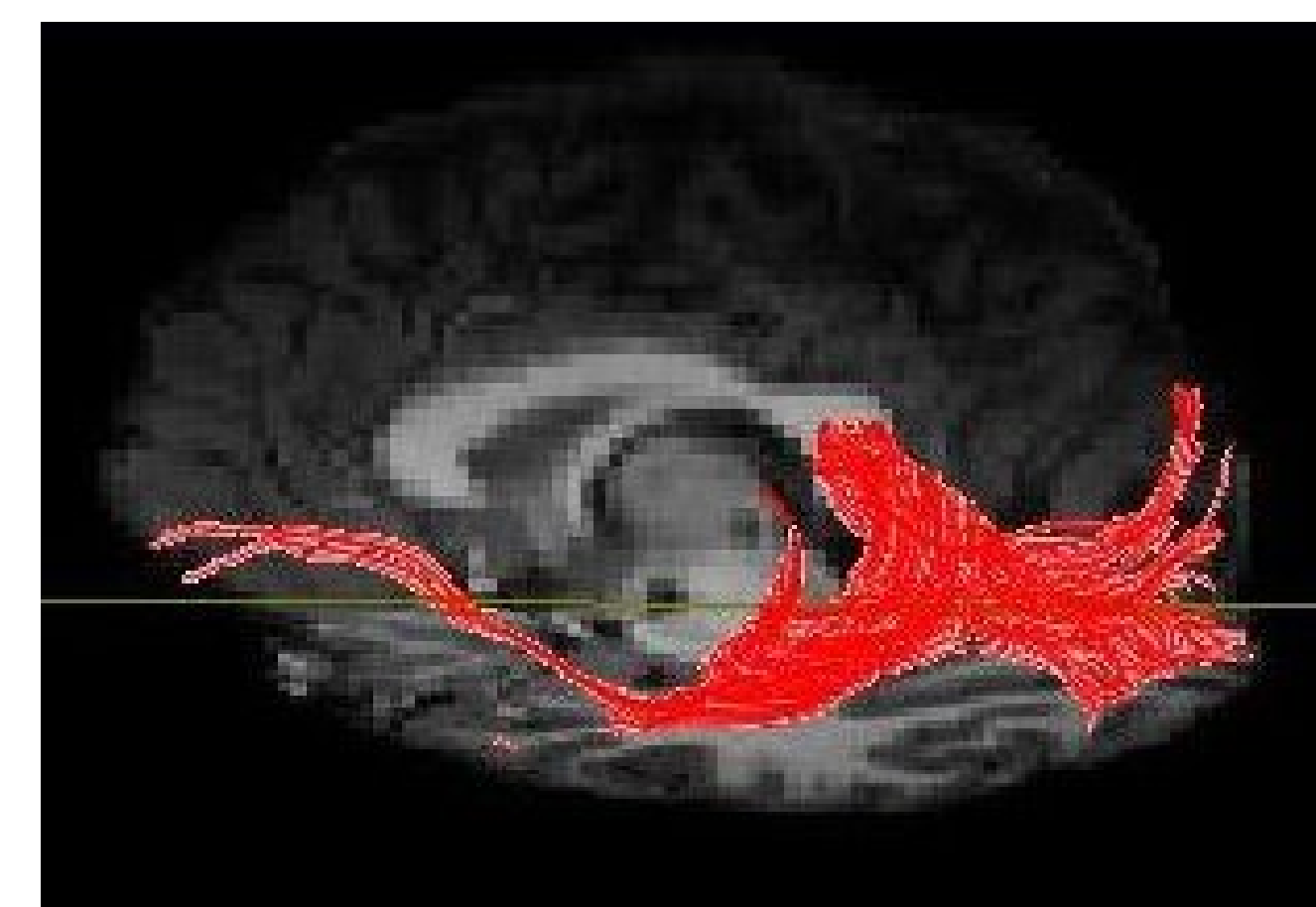
## Tractography

By tracing through voxels that share similar principle diffusion directions we can generate maps of white matter tracts.

Focusing on areas correlated with behavioral measures, we can map out the relevant pathways and brain areas involved in specific complex tasks.



Whole-brain tractography results, shown from a ventral view.

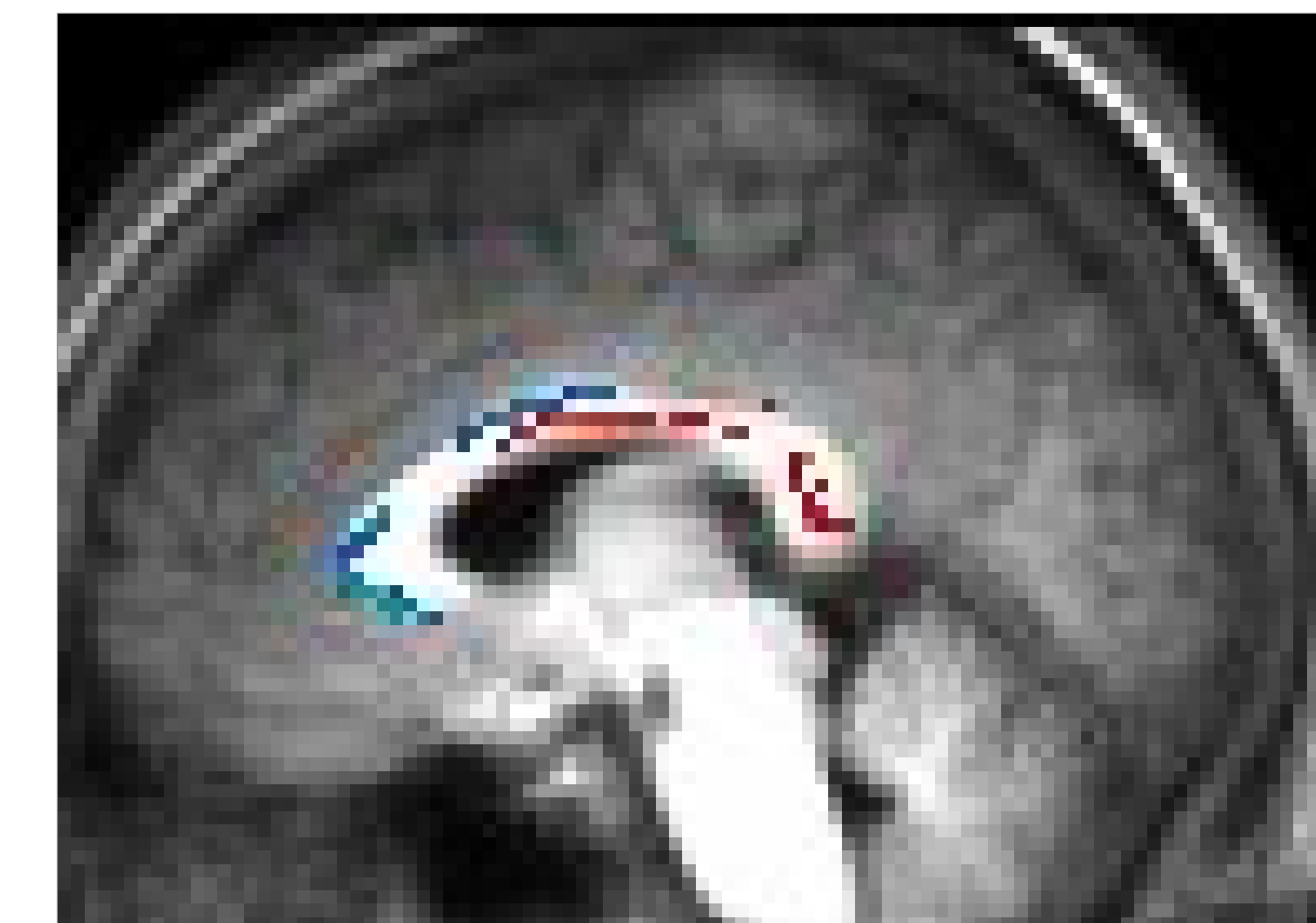


Sagittal slice showing tractography pathways which pass through the areas of splenium of the corpus callosum which correlate positively with the magnitude of the right visual field advantage.

## Results

By correlating the magnitude of the right visual field advantage of each subject with the FA information provided by the DTI data and looking specifically at the corpus callosum, we found several interesting areas.

- Areas of the splenium showed a positive correlation between the magnitude of the RVFA and the FA values
- Areas in the genu showed a negative correlation between the magnitude of the RVFA and the FA values



Areas of the corpus callosum where white matter integrity, as measured by the fractional anisotropy, correlates with measures of the magnitude right visual field advantage. Areas in red are positively correlated, those in blue are negatively correlated.

## Summary

- DTI is a technique that allows for *in vivo* viewing of white matter integrity and connectivity
- Using DTI we can examine many properties of white matter, as well as reconstruct probable pathways within the brain
- When combined with behavioral measures, DTI can be used to assess the neural connectivity associated with complex skills

## References/Funding

Le Bihan, et al. (2001). Diffusion Tensor Imaging: Concepts and Applications. *Journal of Magnetic Resonance Imaging*, 13, 534-546.

Behrens, T.E.J., Woolrich, M.W., Jenkinson, M., Johansen-Berg, H., Nunes, R.G., Clare, S., Matthews, P.M., Brady, J.M., and Smith, S.M. (2003).

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