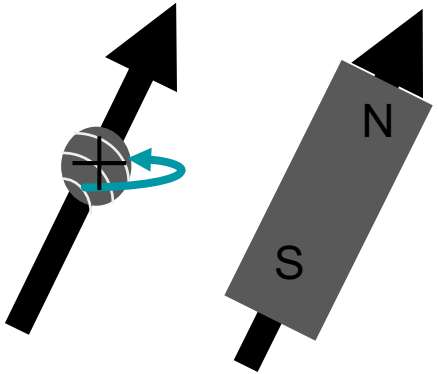
# Introduction to MRI

27 June 2016

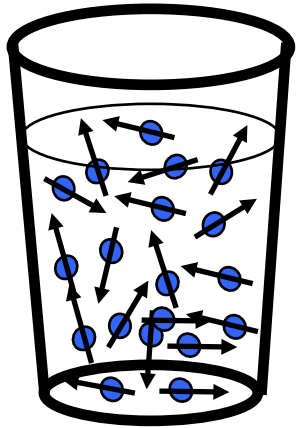
# Basis of All MRI – Magnetic Properties of Protons

Protons spin and have angular momentum

*This also gives them a magnetic moment*




*A moving charge creates a current, a current creates a magnetic field (and vice versa)*

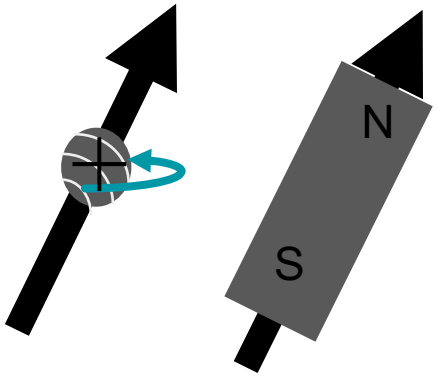


Think of brain as bulk matter with anisotropic distribution of magnetic moments (from $H_20$ atoms)

# Why Do We Need a Big Magnet?

Protons spin and have angular momentum

*This also gives them a magnetic moment*

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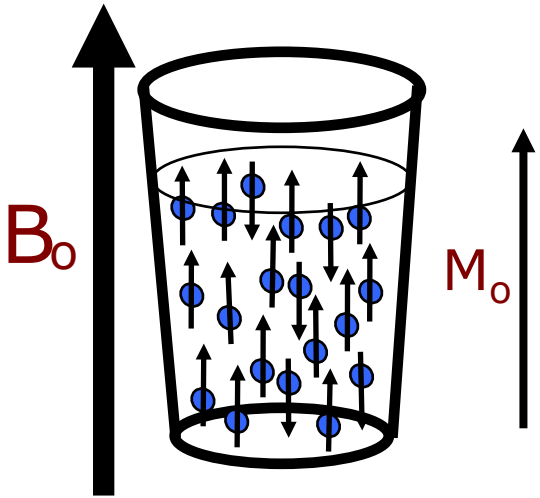
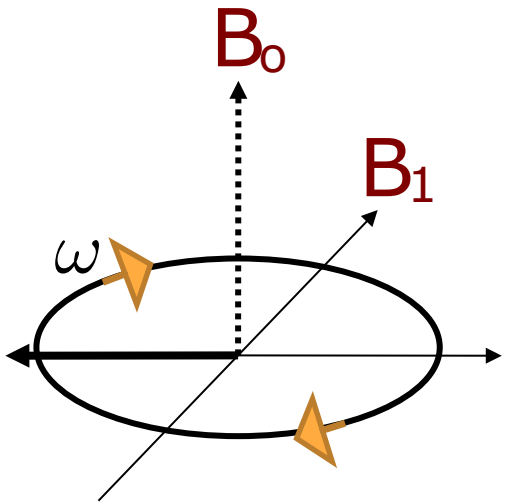



An externally applied magnetic field will align the net magnetic moment in it's own direction.

# Generating Images – Stuff Happens!

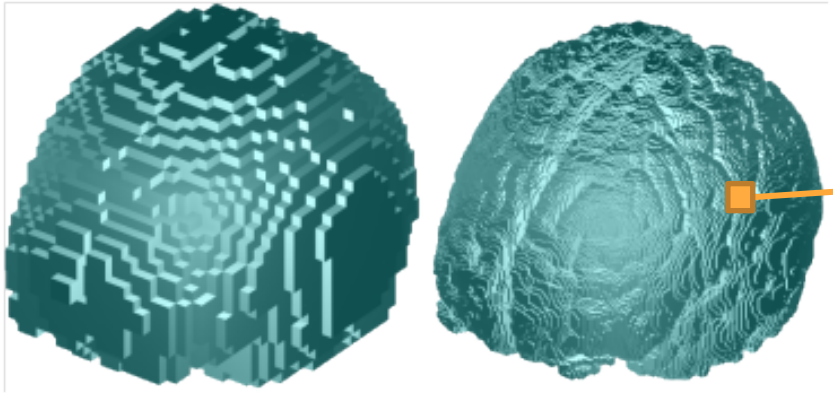


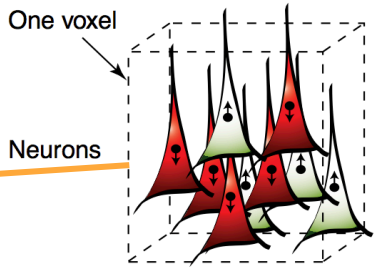

$$\omega = \gamma B$$

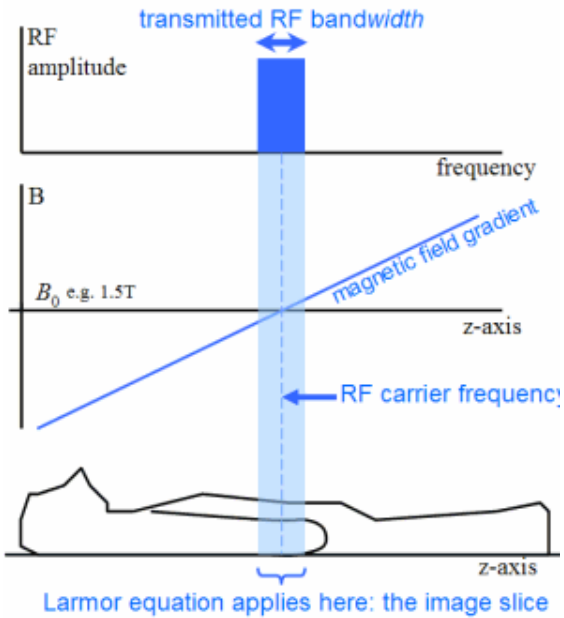
*Larmor Frequency*

- To generate an image, we excite protons with an RF pulse (magnetic field $B_1$) orthogonal to $B_0$
- Magnetization protons precesses about $B_0$ at a frequency proportional to the strength of $B_0$
- This creates a voltage in a receiver coil placed close to the head
- Gradients used to alter both frequency and phase of spinning protons, which allows us to localize (i.e., identify where) each of the protons are located => Make pictures!

# What is a voxel?

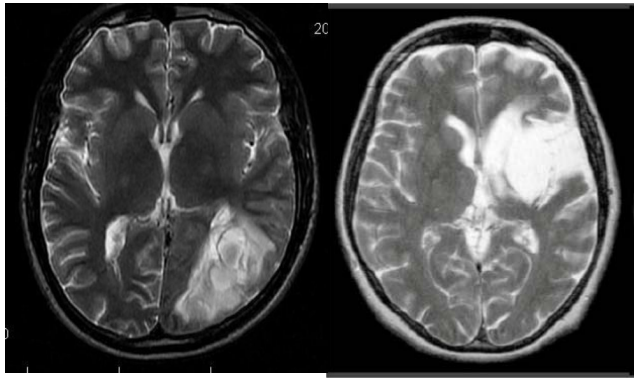




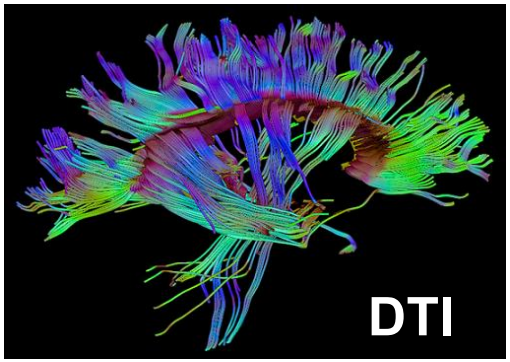

- In 2D MRI we make a single **slice** at a time
- For axial slices we apply a gradient along z-axis when we turn on the RF pulse
- Each **slice** is broken down into lots of **voxels (volume elements)** where x, y coordinate corresponds to a unique frequency & phase of relaxation (due to additional gradients)

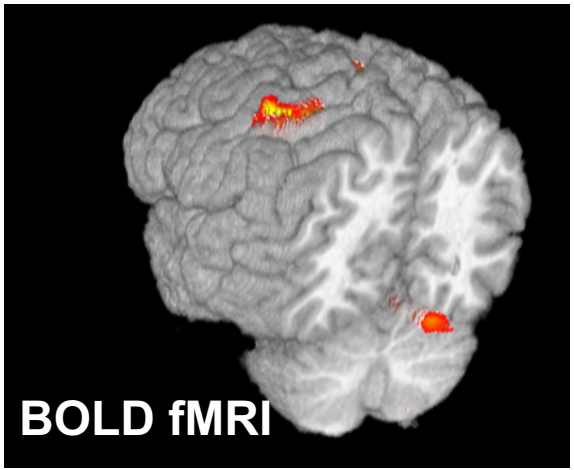
# MRI – Powerful Because So Many Contrasts

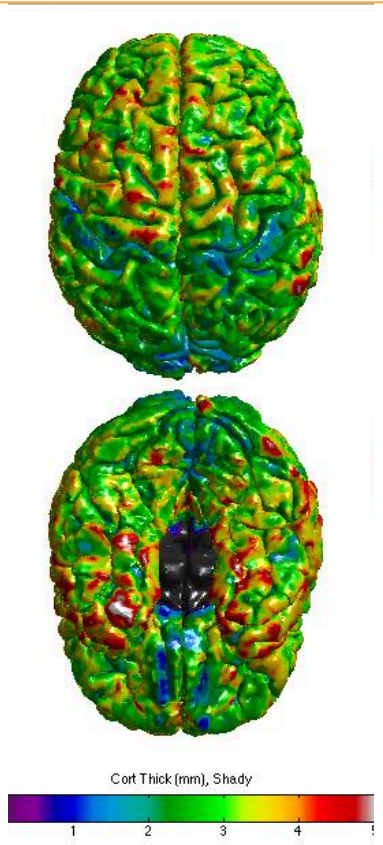


T2 PD

T1



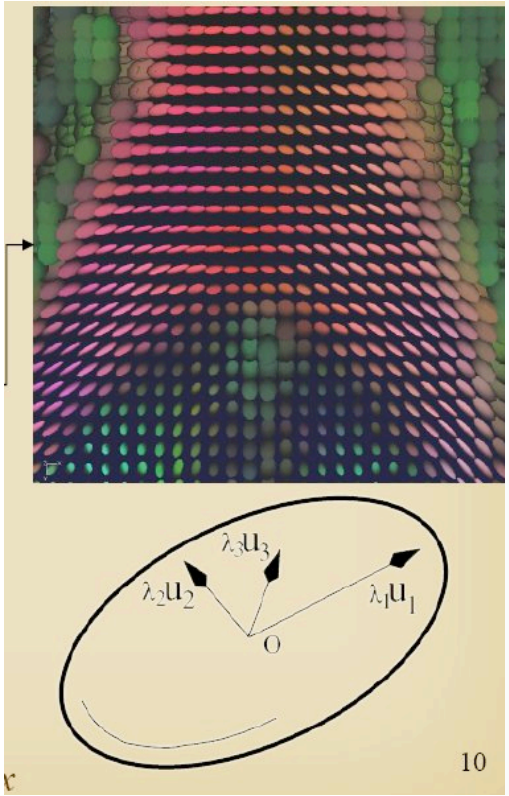

Cortical Thickness

# Diffusion Tensor Imaging (DTI)

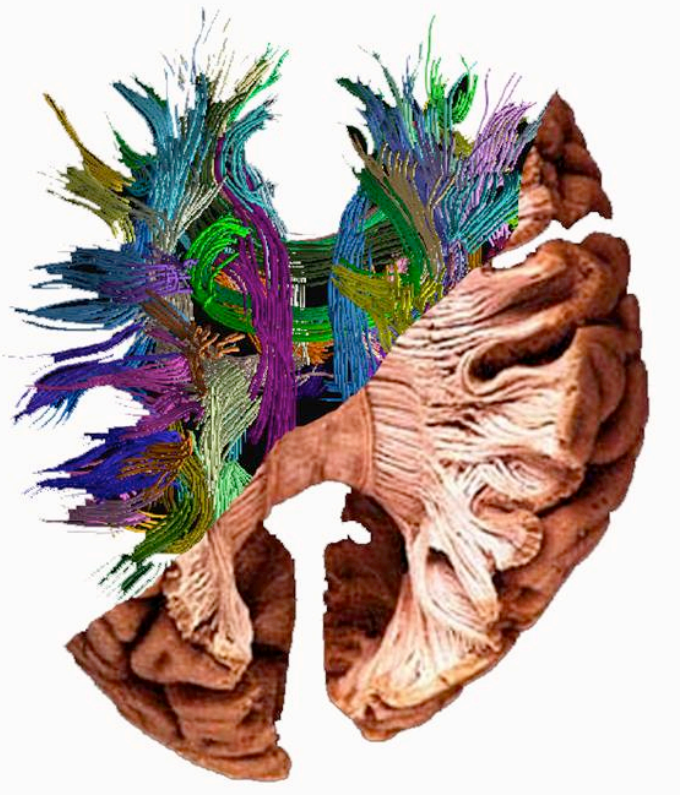
Measures mobility of water

Water inside an axon is very limited in directions it can move

DTI essentially measures that limited mobility




www.greyc.ensicaen.fr

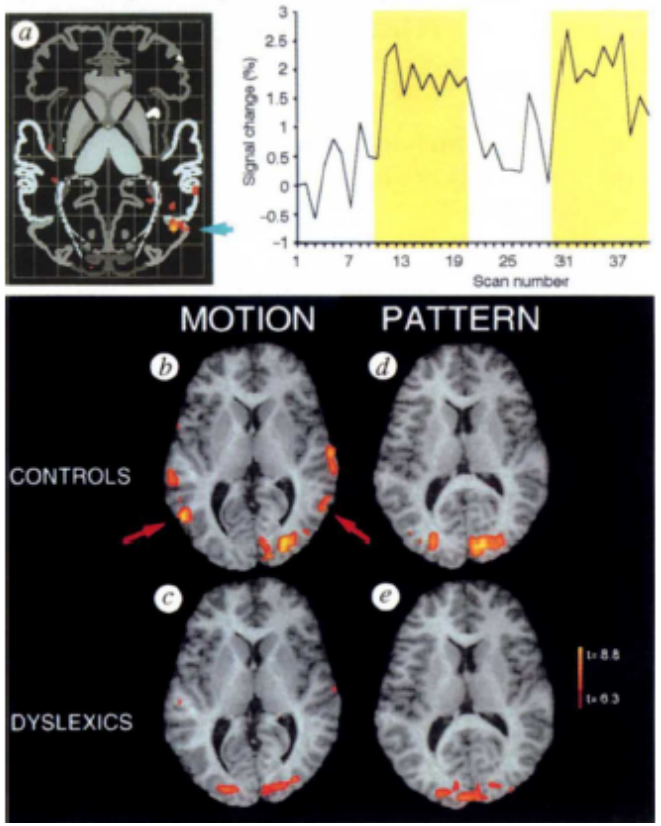


# BOLD fMRI

Uses magnetic properties of blood to infer neuronal activity

Thus – it is not a direct measure of neuronal activity

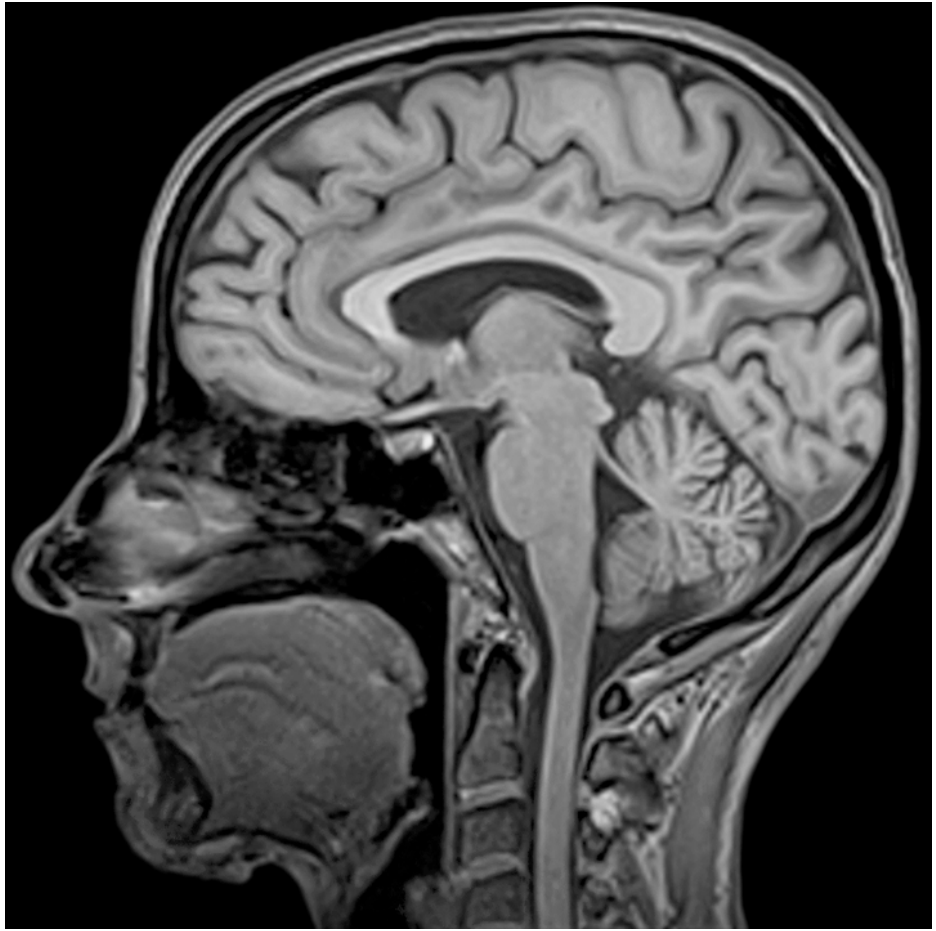
Very useful for non-invasively measuring activity with relatively high spatial resolution and fairly high temporal resolution



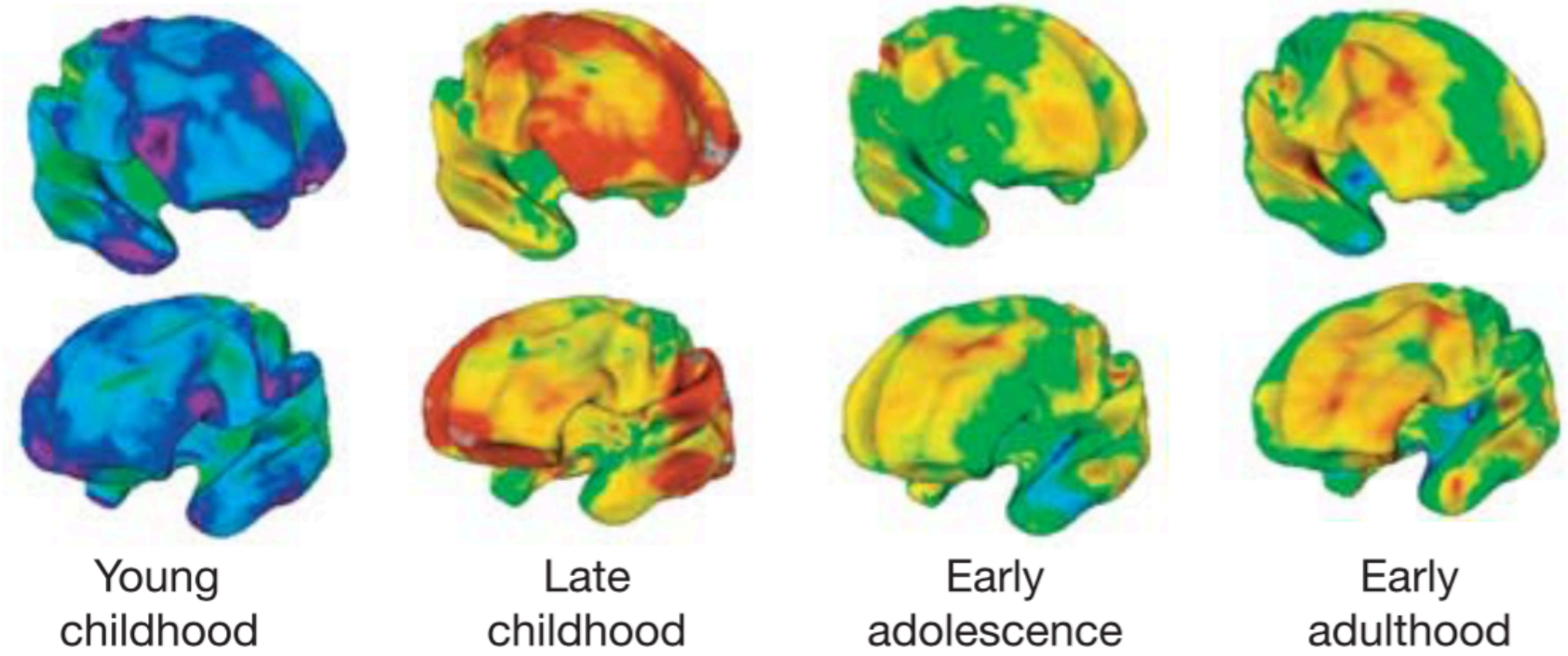

Eden, VanMeter et al., 1996

# MPRAGE – Main Type of Image Used in FreeSurfer

- Magnetization Prepared Rapid Gradient Echo
- Provides great contrast between gray and white matter (T1-weighted)
- Unfortunately, parts pial surface have about the same intensity as gray matter
  - ***This confuses FreeSurfer!!***



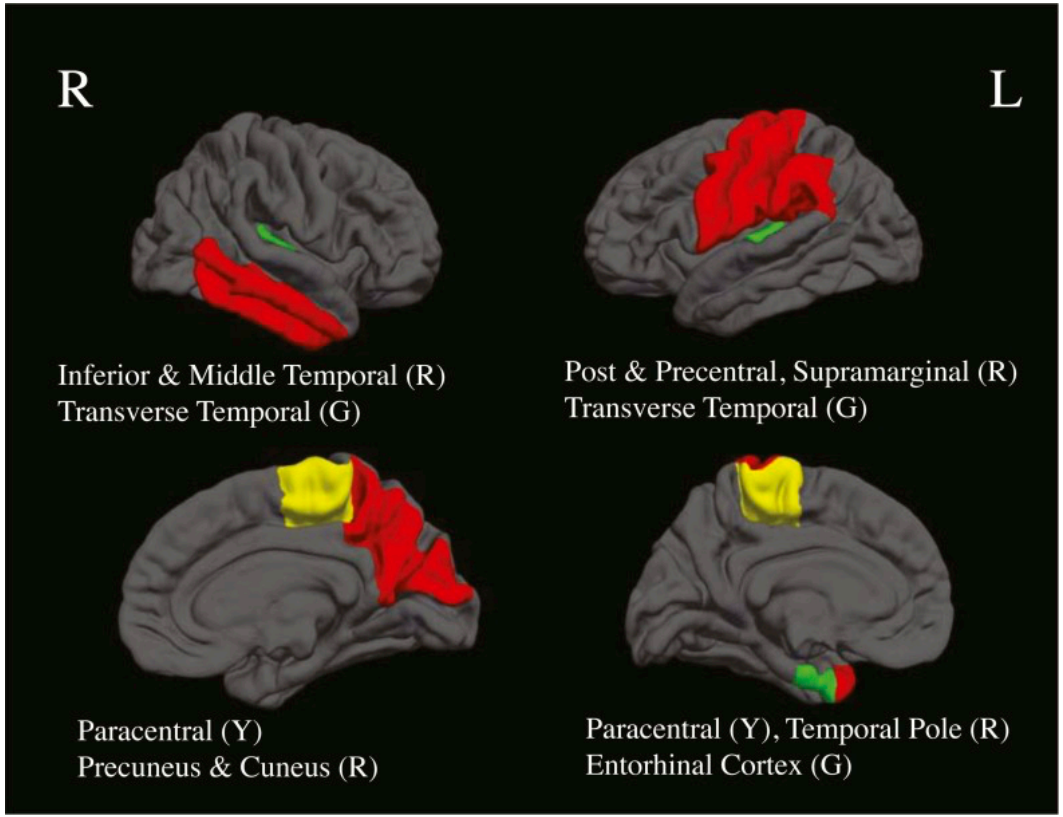
# Cortical Thickness – Changes with Age




Shaw et al. 2006

# Cortical Thickness in MJ & Alcohol Users

- MJ, Alcohol compared to non-users
- Mean age 17.4 yo
- Reduced thickness in Alcohol users (red)
- Reduced thickness in MJ users (green)
- Reduced in both users (yellow)




Jacobus et al. 2014