

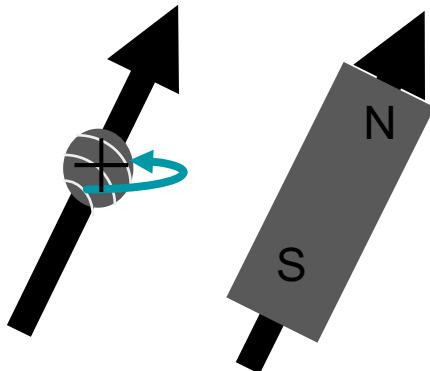
Introduction to MRI

27 June 2016

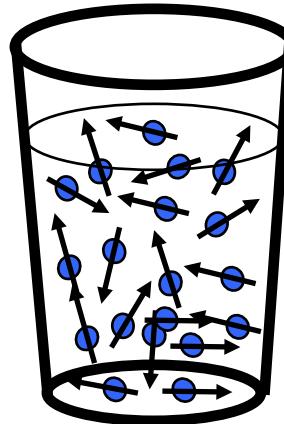
Basis of All MRI – Magnetic Properties of Protons

Protons spin and have angular momentum

This also gives them a magnetic moment



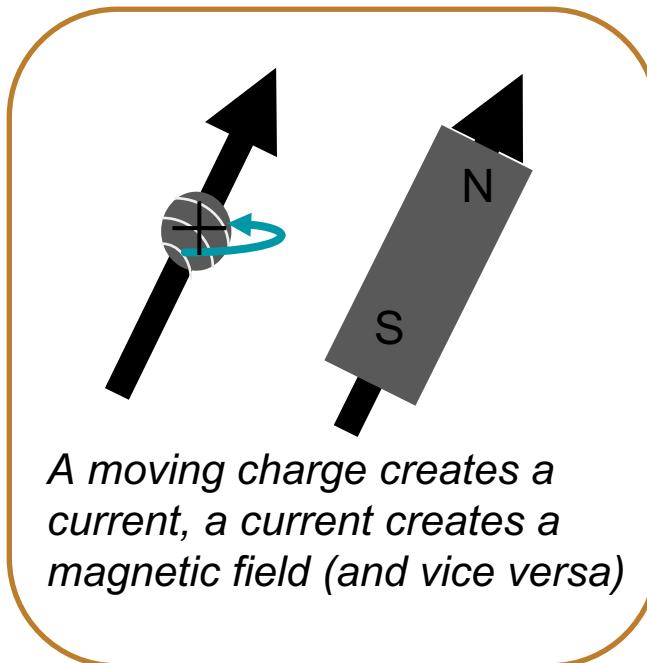
A moving charge creates a current, a current creates a magnetic field (and vice versa)



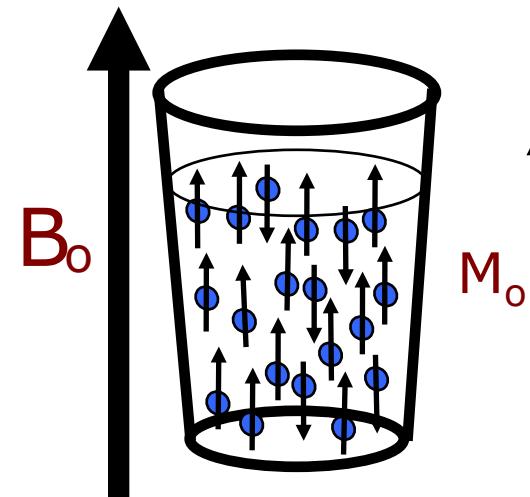
Think of brain as bulk matter with anisotropic distribution of magnetic moments (from H₂O atoms)

Why Do We Need a Big Magnet?

Protons spin and have angular momentum
This also gives them a magnetic moment

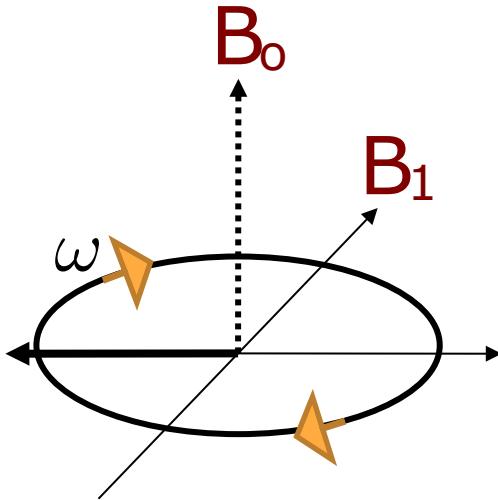


A moving charge creates a current, a current creates a magnetic field (and vice versa)



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

Generating Images – Stuff Happens!

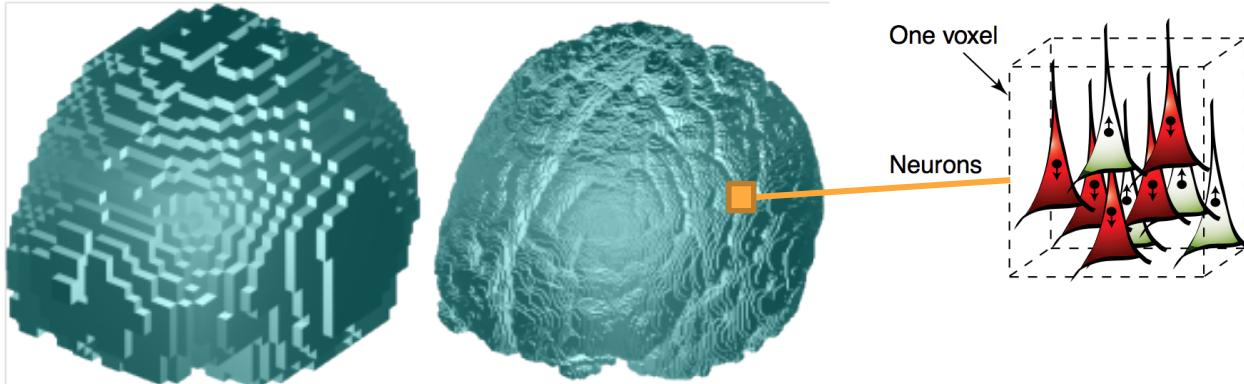


$$\omega = \gamma B$$

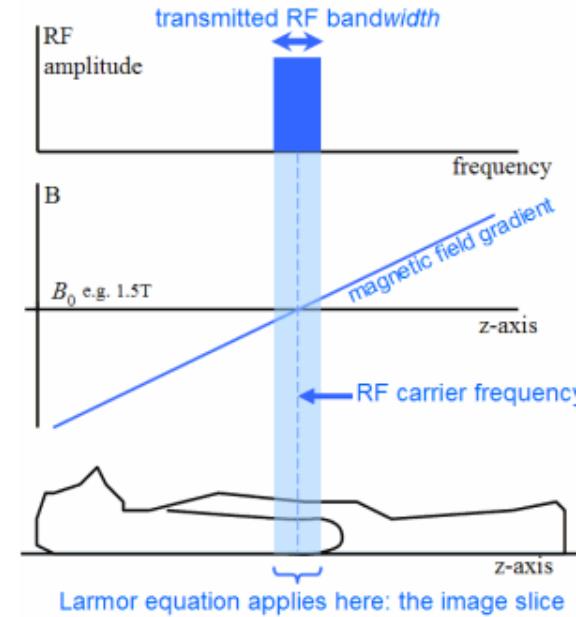
Larmor Frequency

- 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!

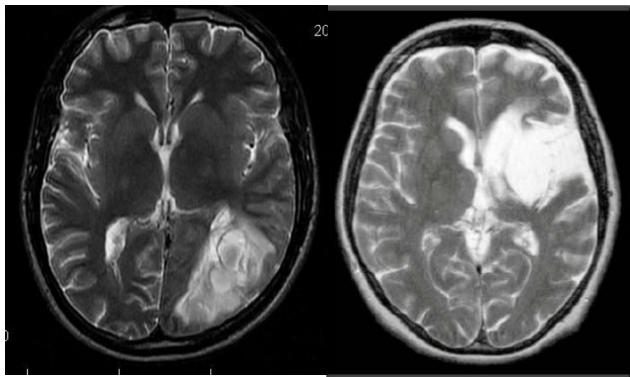
What is a voxel?



- 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

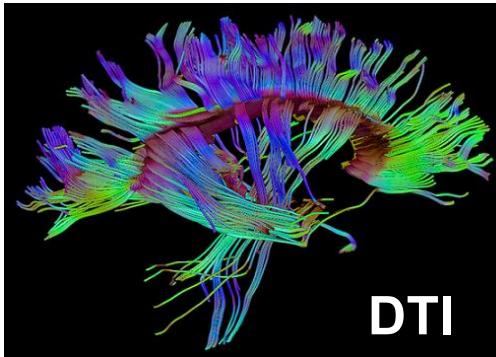


T2

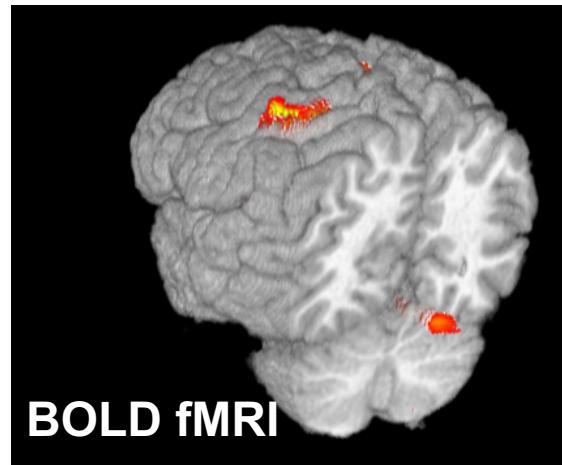
PD



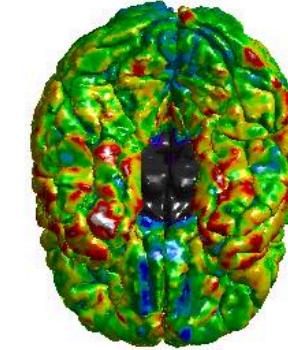
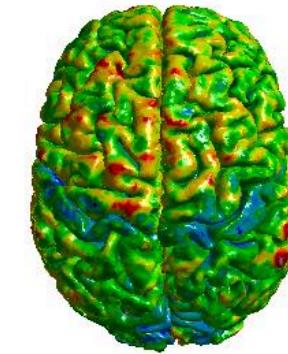
T1



DTI



BOLD fMRI



Cort Thck (mm), Shady



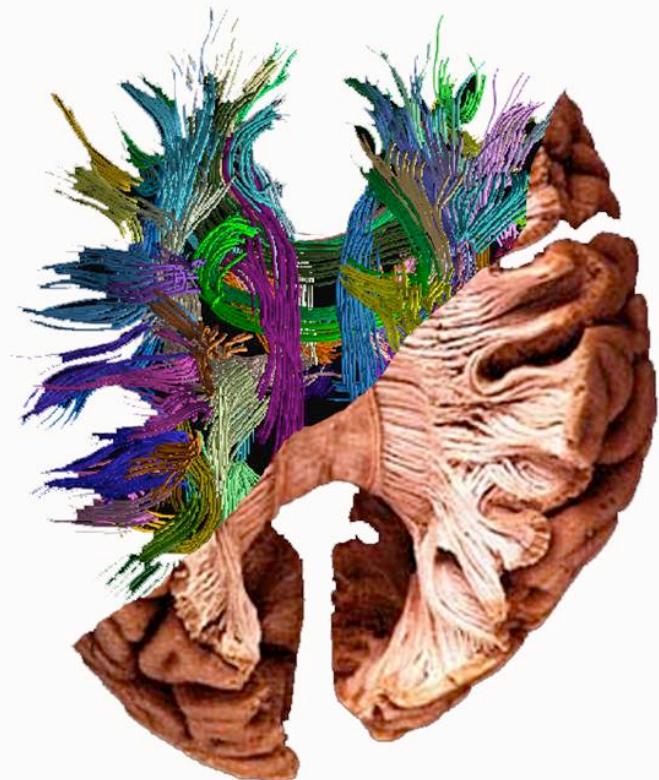
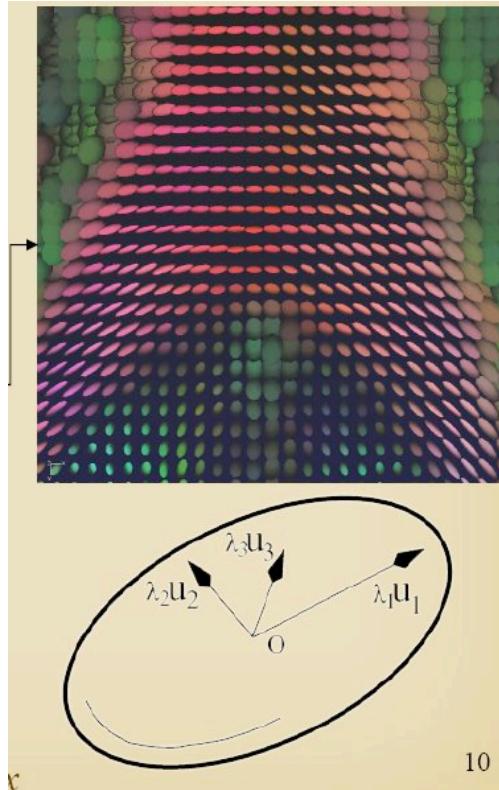
Cortical Thickness

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

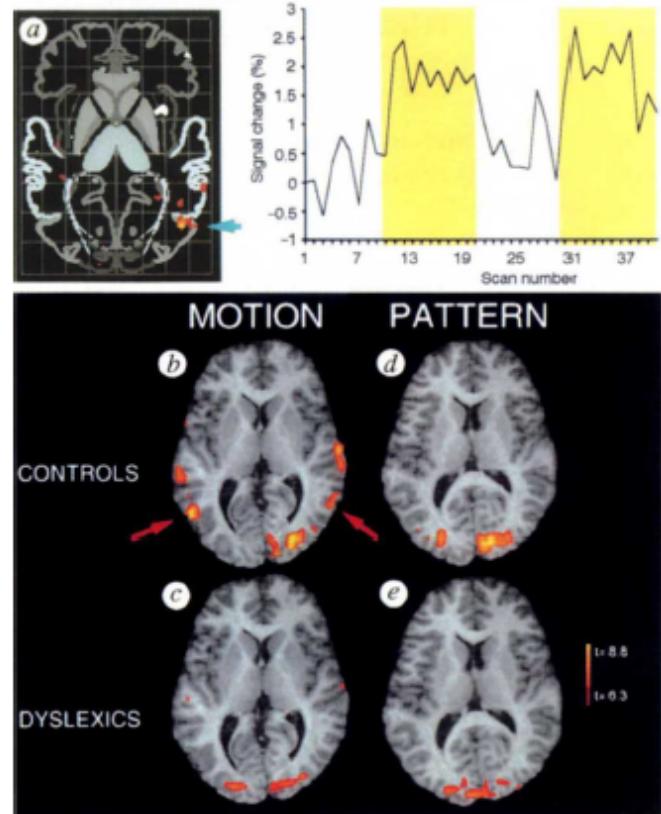


BOLD fMRI

Uses magnetic properties of blood
to infer neuronal activity

Thus – it is not a direct measure of
neuronal activity

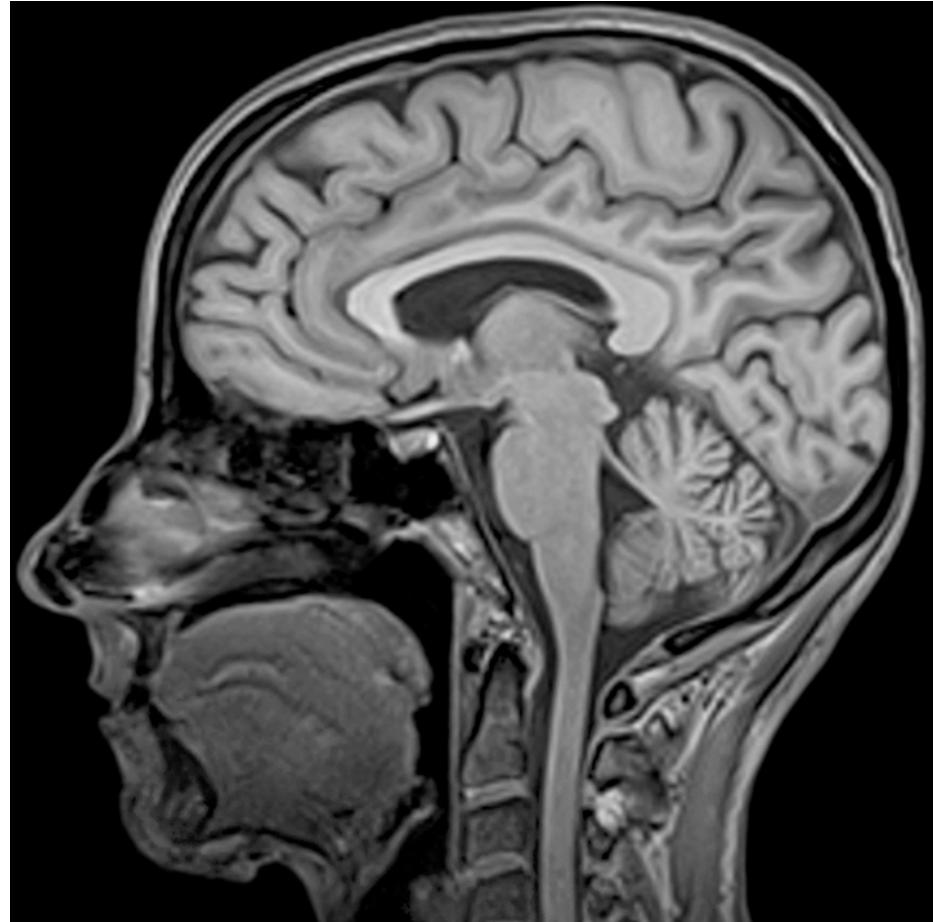
Very useful for non-invasively
measuring activity with relatively
high spatial resolution and fairly high
temporal resolution



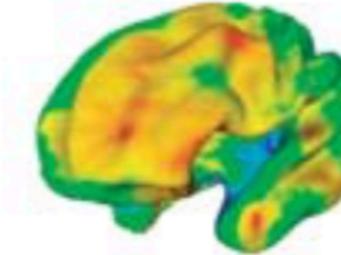
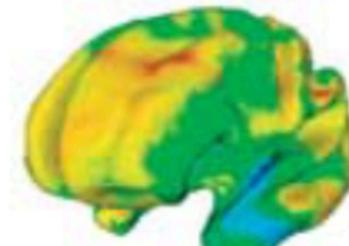
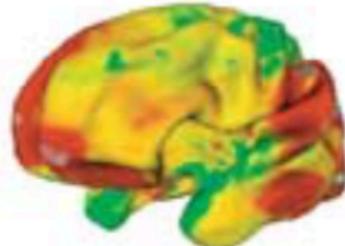
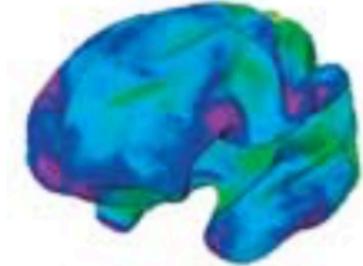
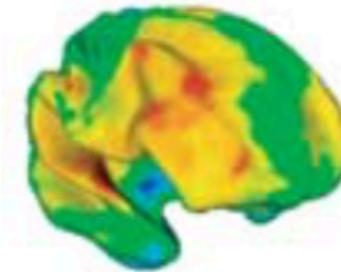
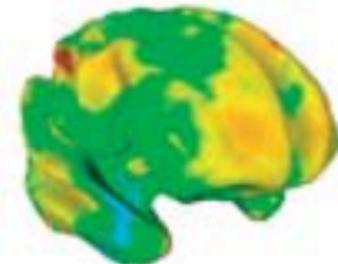
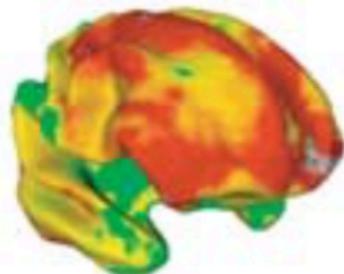
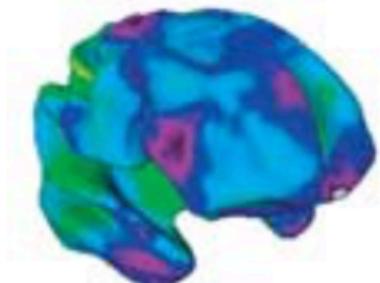
Eden, VanMeter et al., 1996

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



Young
childhood

Late
childhood

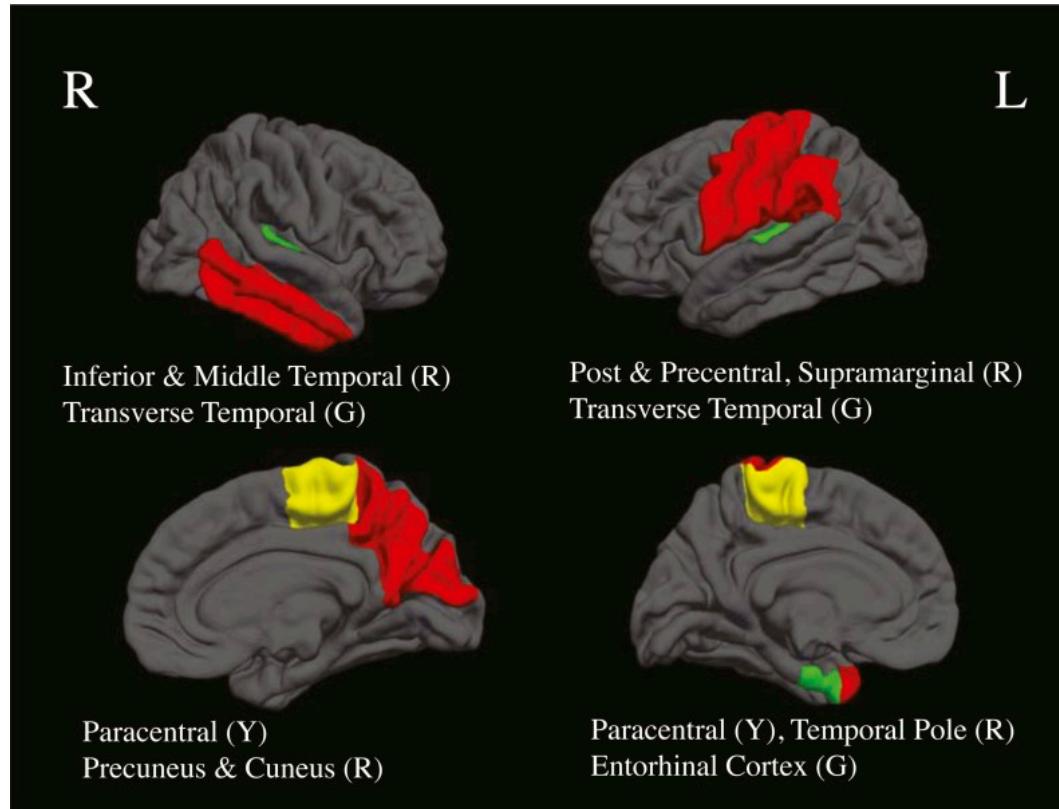
Early
adolescence

Early
adulthood

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)



Introduction to Adolescent Development Study (ADS)

27 June 2016

Aims/Goals of the Adolescent Development Study (ADS)

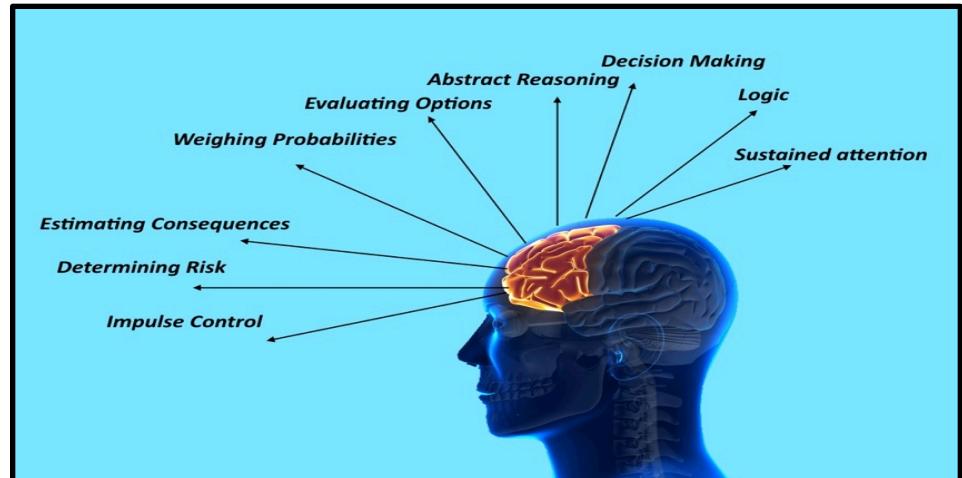
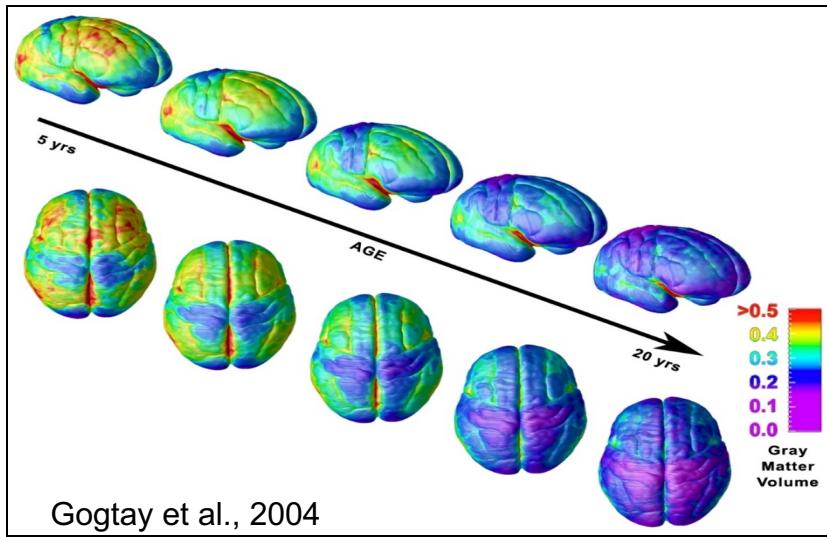
Aim 1: Identify neurodevelopmental factors that predict the initiation/escalation of substance use

Aim 2: Developmental Impact of Substance Use

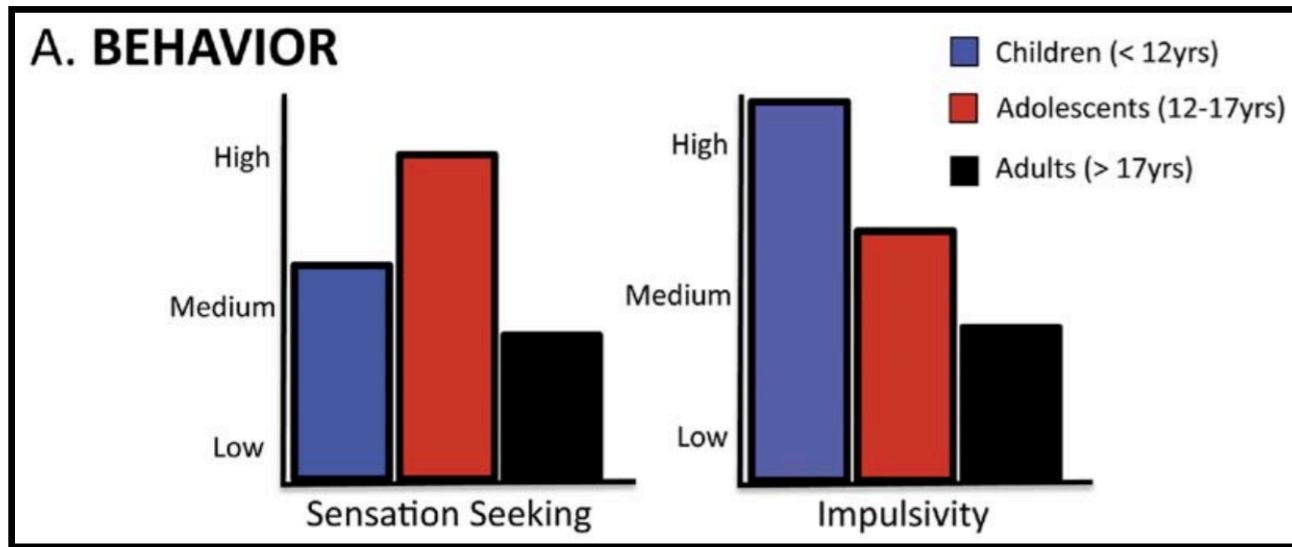
Expanded to also examine:

- Genetics and epigenetics
- Environmental factors: dietary factors (omega3 fatty acids and iron) and alcohol related advertising

Frontal Cortex is Last to Develop



Behavioral Consequences



Dual Systems Model of Adolescent Development

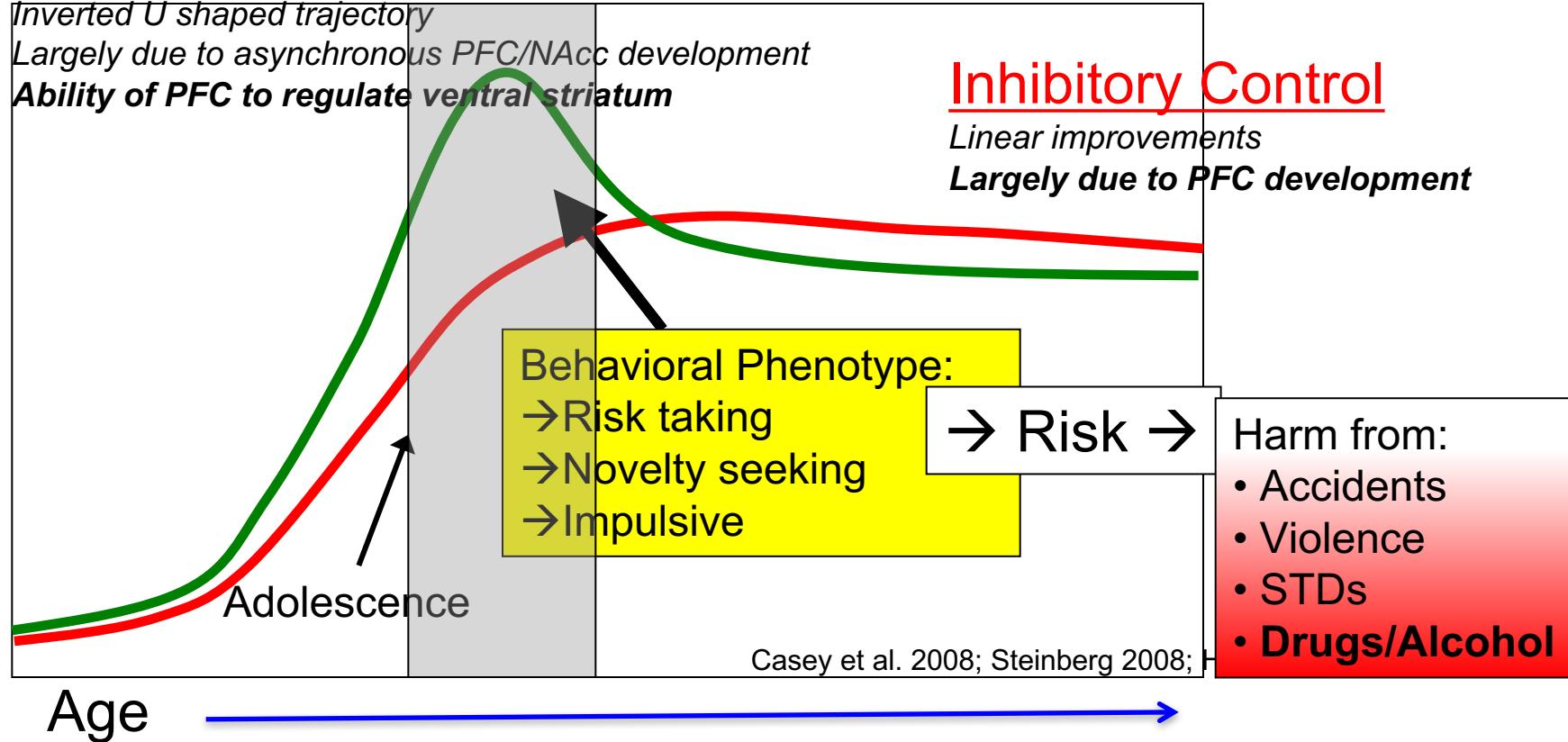
Reward Sensitivity

Inverted U shaped trajectory

Largely due to asynchronous PFC/NAcc development

Ability of PFC to regulate ventral striatum

Development



ADS Study Design

	Wave1	Wave2	Wave3
N:	135	111	~105
Age:	11.0-13.0 yo	12.5-14.5 yo	14.0-16.0 yo
Users:	0	19	32



Adolescent Measures (~6 hrs)

MRI Structural & Functional (~1.5 hrs)
DTI MRI (white matter integrity)
fMRI – Continuous Performance Task
fMRI – Wheel of Fortune Task
fMRI – Emotional Counting Stroop
fMRI – Resting State
High resolution structural (**cortical thickness**, volume)

Outside scanner (~4.5 hrs)
Temporal Discounting, Facial Emotion recognition Task
KBIT, Trail Making, Spatial WM, Stockings of Cambridge
DUSI (Drug Use Survey Instrument)
Diet assessment (relative DHA intake)
Alcohol advertising exposure

Parent Measures (~2 hrs)

Demographics, factors related to Social Economic Status (SES)
AUDIT (self report of alcohol use)
Family History of Drug/Alcohol Use
Perinatal questionnaire
BRIEF (parent report of child's executive function and impulsivity)
ADHD Rating Scale (parent rating of child)
Temperament Scale (parent rating of child)

ADS Sample Characteristics

Sample of 142 adolescents very representative of the racial and SES makeup of the D.C. metro region

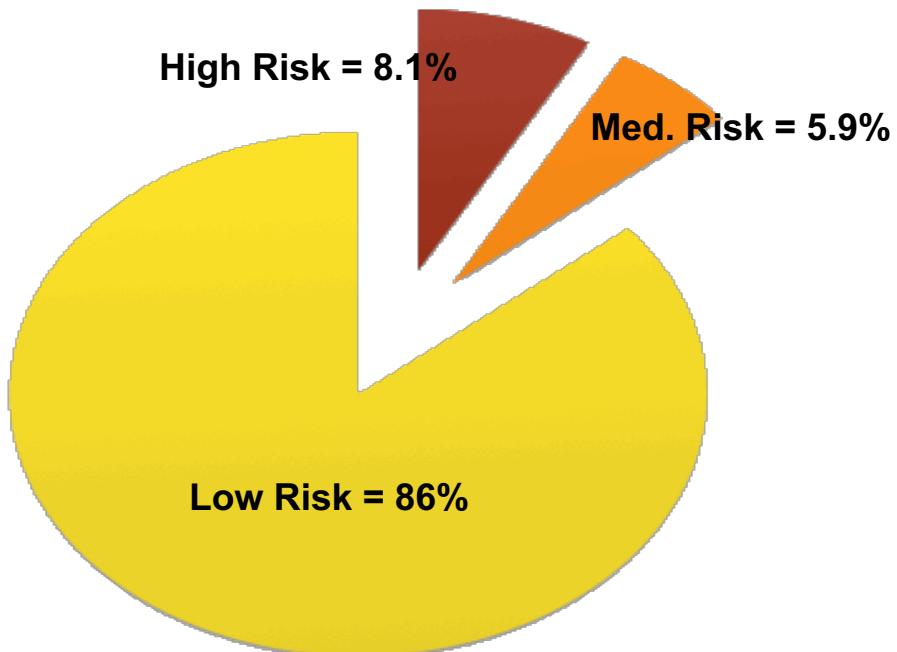
Wave 2 116 completed (~82%)

Wave 3 108 completed (last ones tested this past weekend!)

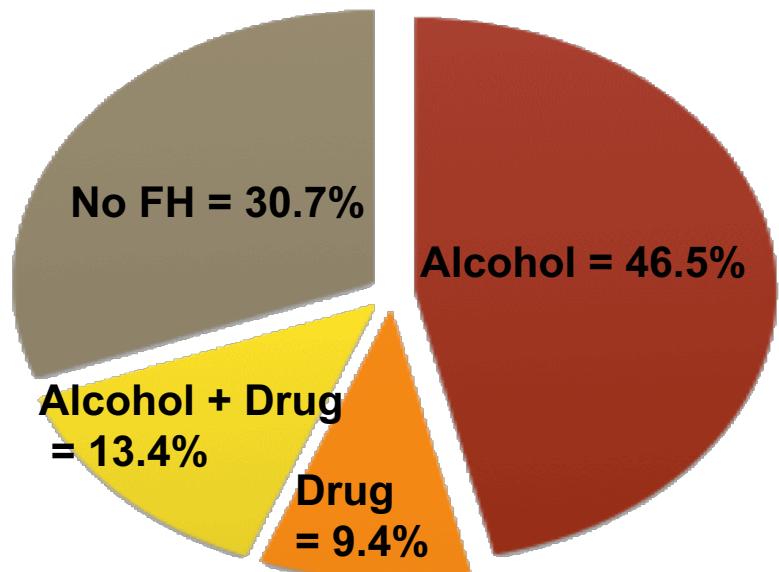
N	135 (73F,62M)
Age	12.7(0.8)
Pubertal status	2.2(0.70)
Race and Ethnicity	
African American	45 (33%)
Caucasian	70 (51.9%)
Hispanic/Latino	9 (6.7%)
Other	11 (8.1%)
Socioeconomic Status	
Parent cumulative years education, mean	16.2(2.9)
Household income	
Mean	\$50,000 -\$74,999
Median	\$100,000-\$149,000
IQ (KBIT)	108.8(15.3)
Alcohol Risk distribution (from DUSI-QS)	
Low (%)	116 (85.9%)
Medium (%)	8 (5.9%)
High (%)	11 (8.1%)

ADS Sample by Risk

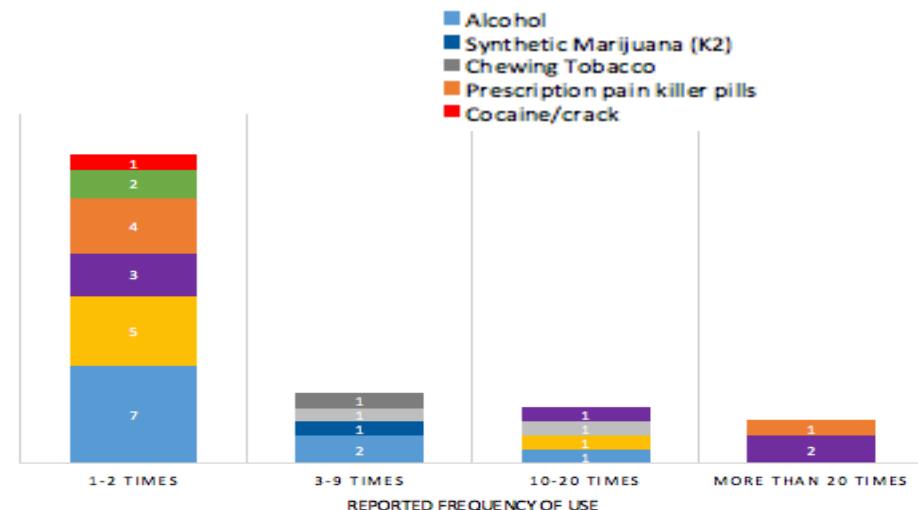
DUSI-QS*



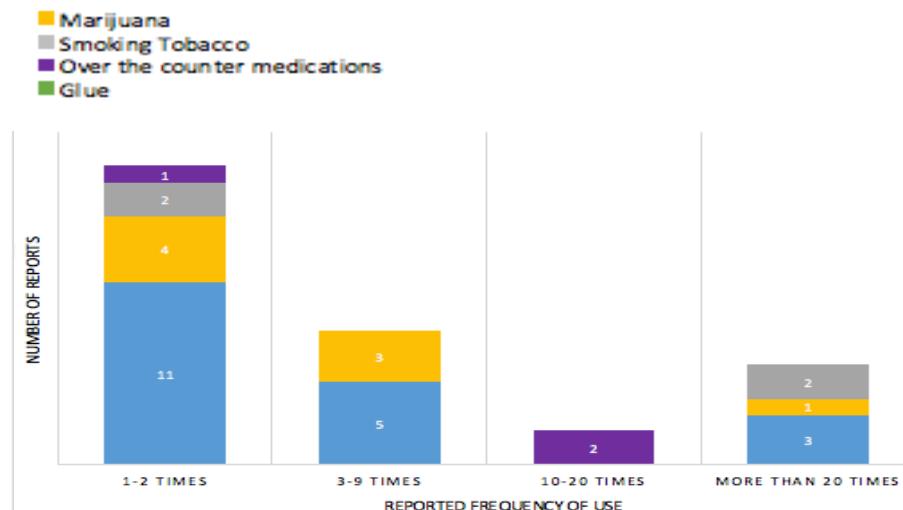
Family History



Frequency of Use by Substance



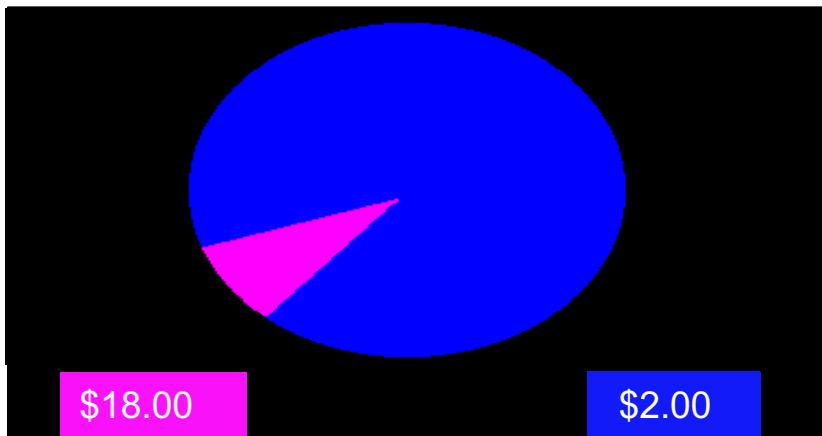
Wave 2



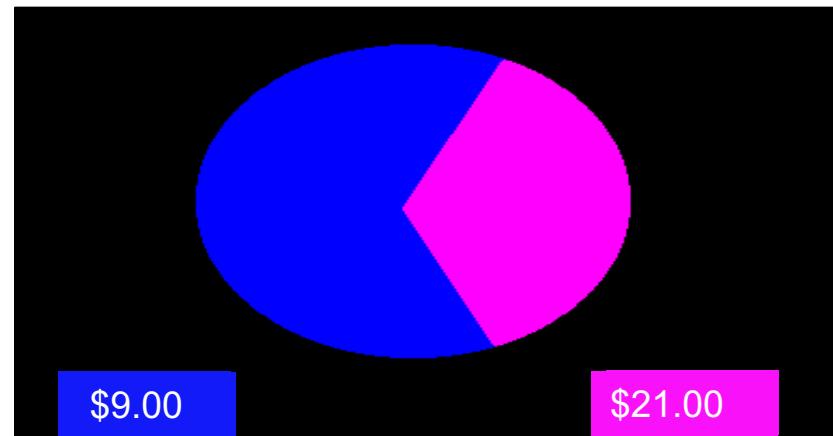
Wave 3

Wheel of Fortune (Gambling Task) fMRI

10% vs 90% trials



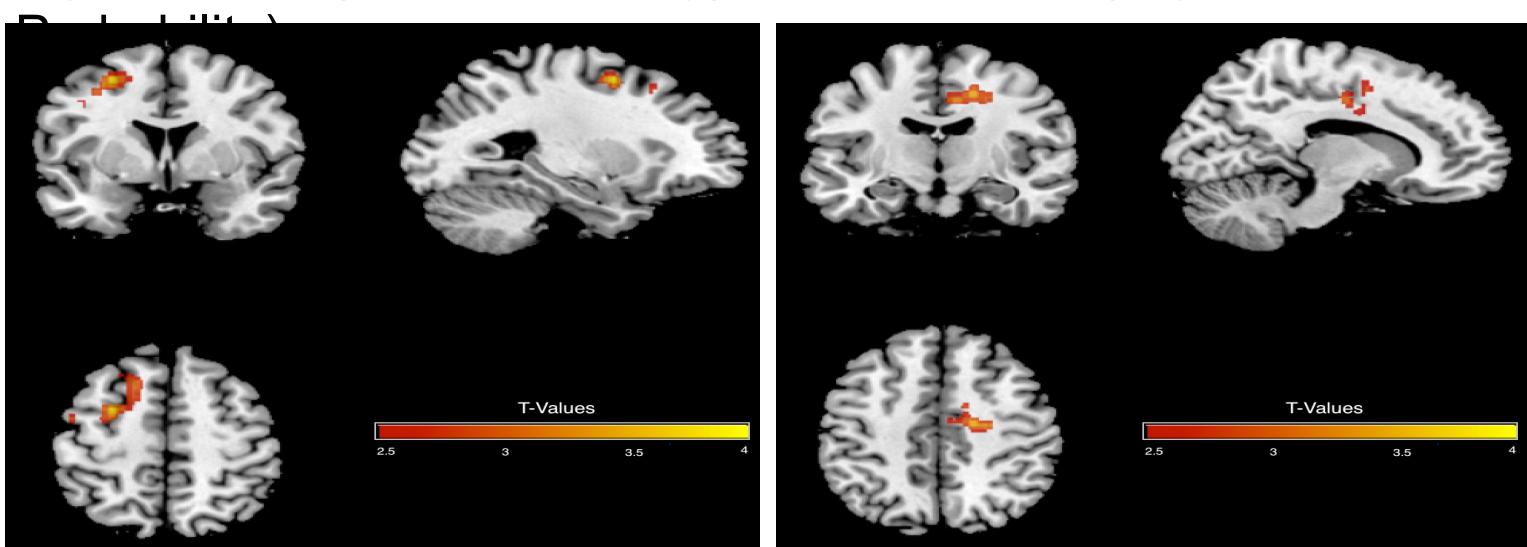
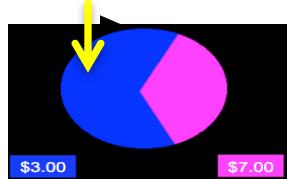
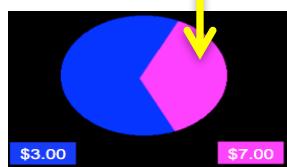
30% vs 70% trials



Wheel of Fortune (Gambling Task)

Non-Users > Users

Contrast: High Reward (Low Probability) > Low Reward (High Probability)



Left Superior/Middle Frontal Gyri

Right Mid-Cingulate

p < 0.05 Cluster Corrected

Wheel of Fortune (Gambling Task)

Non-Users > Users

Contrast: Wins > Loses

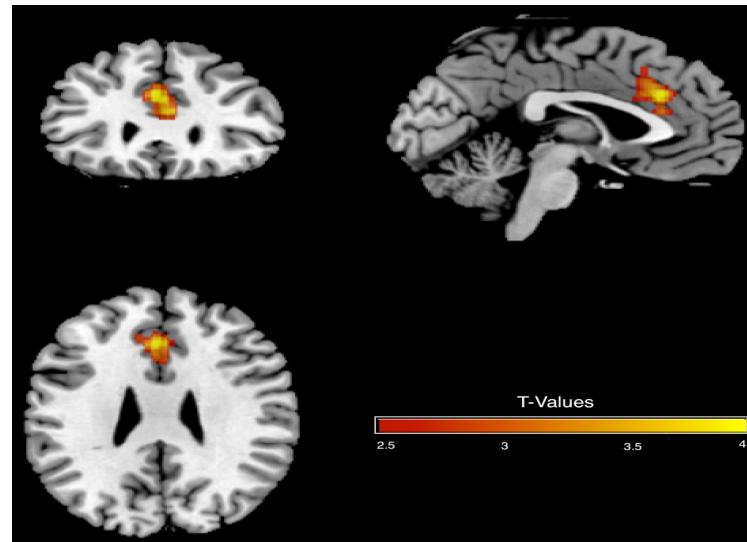
You won \$9!!

Total: \$40

>

You lost \$1

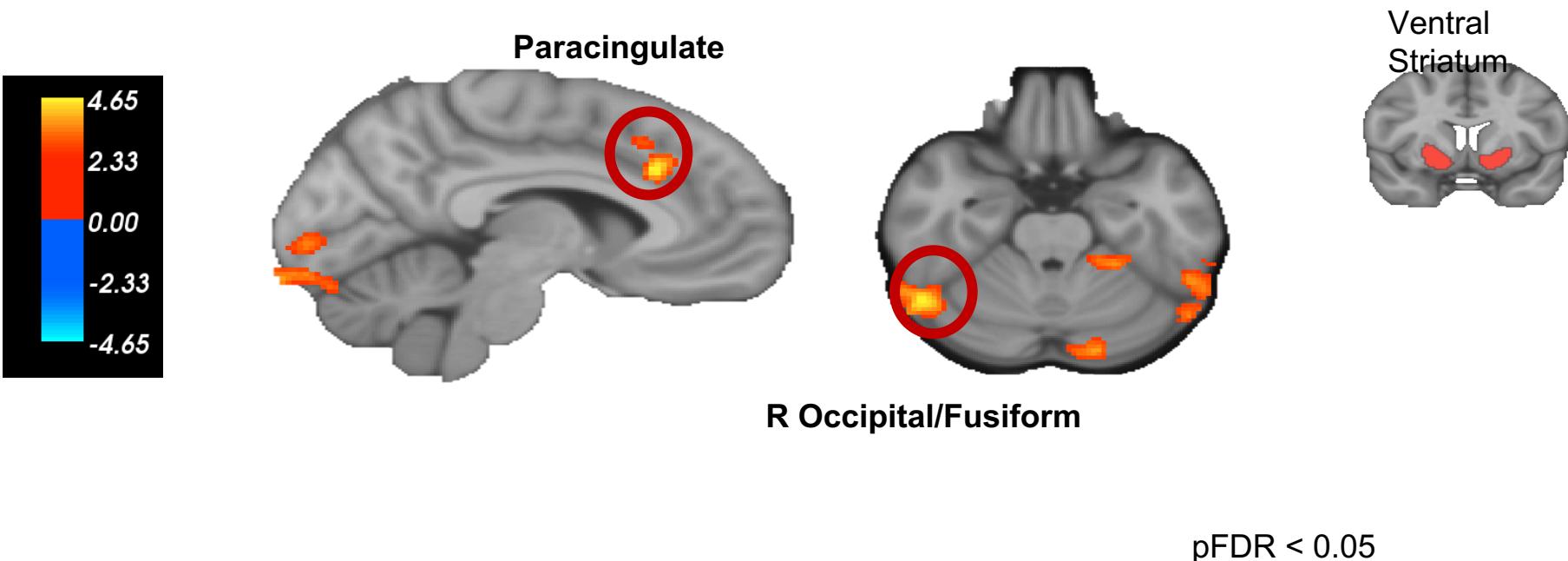
Total: \$30



Dorsal-Anterior Cingulate

p < 0.05 Cluster Corrected

Striatal-Cortical Resting-State Connectivity Non-Users > Users



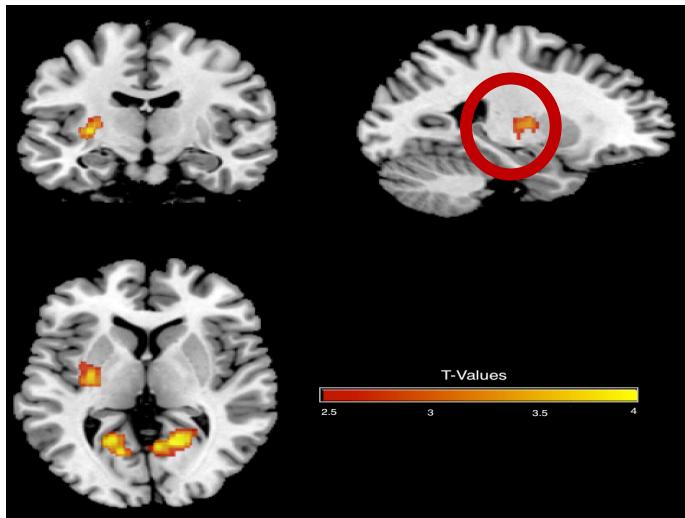
Wheel of Fortune (Gambling Task)
GABA α 2 (rs279826) Risk Genotype:
High risk for AUD (G/G) > Low Risk (A/A and A/G)

Contrast: Wins > Loses

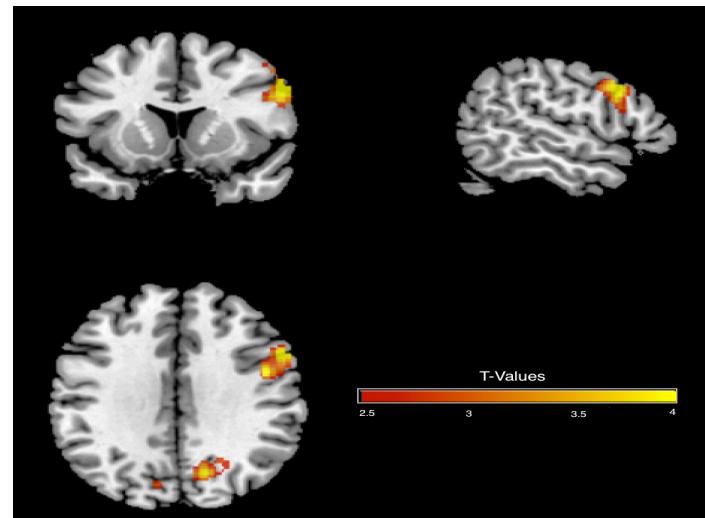
You won \$9!!
Total: \$40

>

You lost \$1
Total: \$30



Left Striatum



Right Inferior Frontal Gyrus
Right & Left Inferior Parietal Lobe

p < 0.05 Cluster Corrected

Wheel of Fortune (Gambling Task)

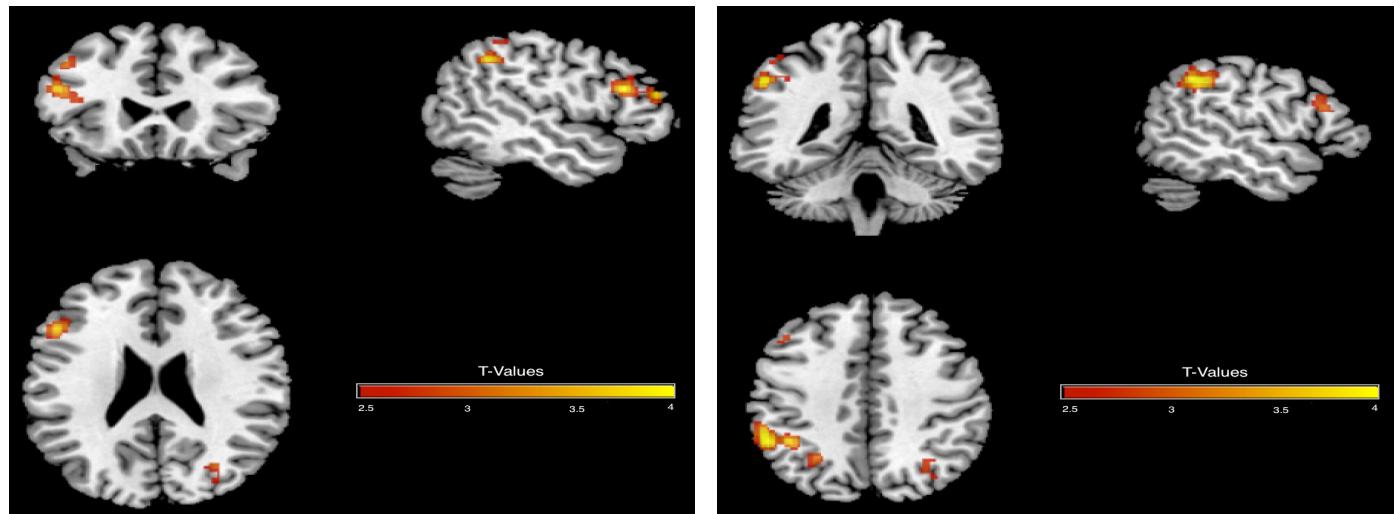
Main Effect of DRD2 (rs6277) Risk Genotype:
Low Risk (T/T and T/C) > High Risk (C/C)

Contrast: Wins > Loses

You won \$9!!
Total: \$40

>

You lost \$1
Total: \$30



Left Middle/Inferior Frontal Gyrus

Right & Left Inferior Parietal Lobe

p < 0.05 Cluster Corrected