

Mapping Brain Maturation

Toga, A.W., Thompson, P.M., & Sowell, E.R.

Nicole Depowski

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Background: Basic NeuroDev

- Proliferation
 - ~100 billion neurons at birth!
- Migration
 - Neurons reach final destination

Background: Basic NeuroDev

- Pruning
 - Different time frame for different areas of the brain
- Myelination
 - More basal structures tend to myelinate earlier
 - Not all parts of the brain myelinate equally

Background: Disorder in the Court!

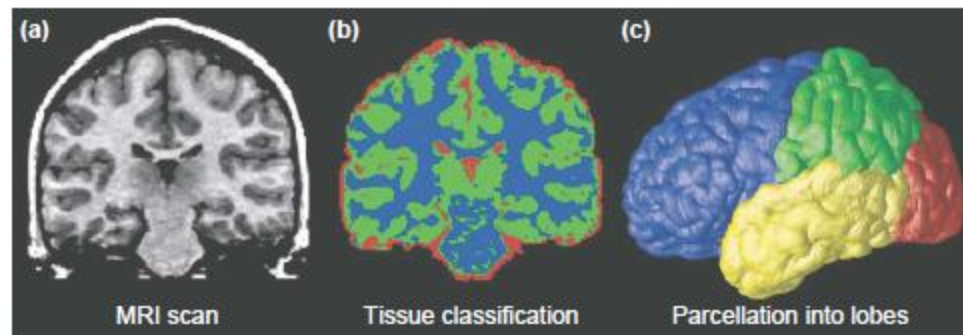
- Schizophrenia
 - Typical onset 20s-30s
 - Hallucinations, delusions, paranoia, disordered speech, severe dysfunction
- Williams syndrome
 - Deletion of ~20 genes on chromosome 7
 - Mild to moderate mental retardation, BUT greater language skills, musical proficiency, and social abilities, no racial bias

Background: Disorder in the Court!

- ADHD
- FAS
 - Caused by prenatal exposure to alcohol
 - Developmental delays, facial abnormalities, small head size, limb defects, mental retardation

Background: fMRI

- Picks up subtle MR differences in oxygenated/deoxygenated blood
- 3D, real-time images
- Algorithms allow for greater analysis of brain matter



Background: fMRI

- Limitations:
 - Participant must be completely still
 - Low signal-to-noise ratio
 - Expensive
 - Difficulties with white/grey matter border
 - Not for people who have metal medical devices

Overview

- Normal changes in white and gray matter
- Normal changes in cortical thickness
- Neuropsychological profile of disorders
- The role of genetics in neuropsychological development

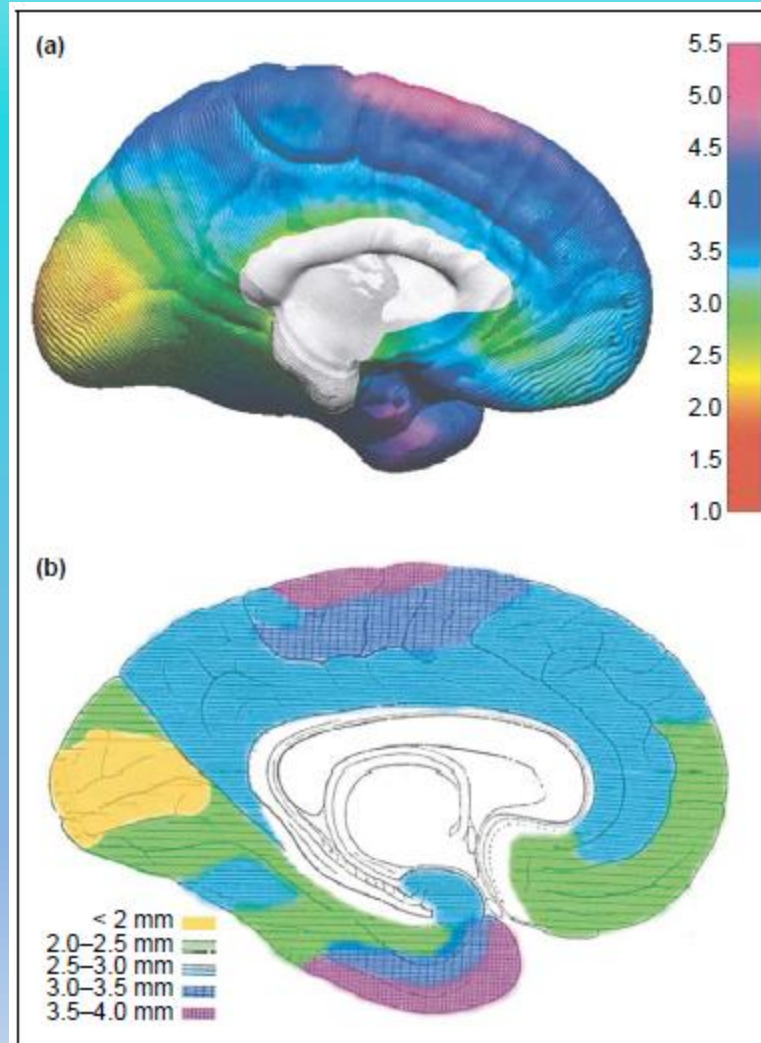
White and Gray Matter

- Inversely related
 - Linear increase in white matter up to age 20, but non-linear changes in gray matter
- Gray matter loss:
 - Sensorimotor region (7-8 yrs), temporal cortices, prefrontal areas (adolescence)
- White matter gain:
 - Sensorimotor, parietal lobes (puberty), prefrontal cortex

Cortical Thickness

- $n = 45$, (5-11), studied twice in 2 yr interval
- Thickest in dorsal frontal and parietal regions, thinnest in visual cortices
- Thinning in dorsal frontal and parietal regions, thickening in language areas
 - Why?

Cortical Thickness

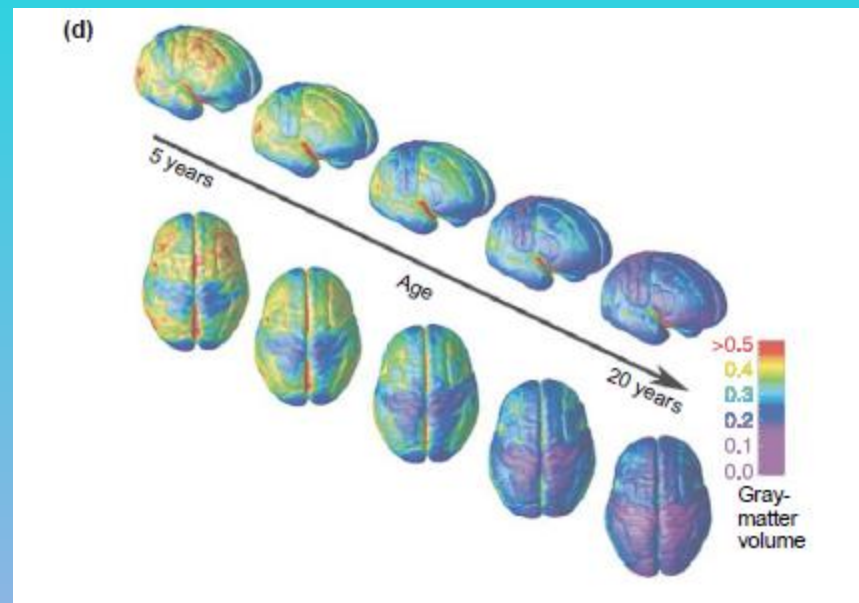
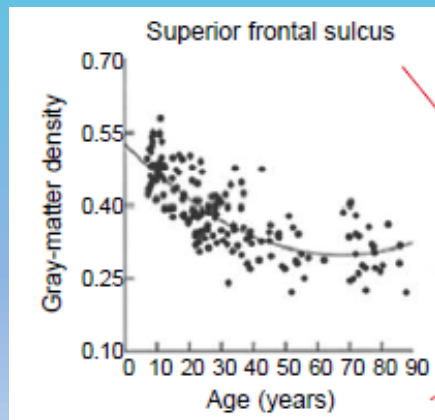
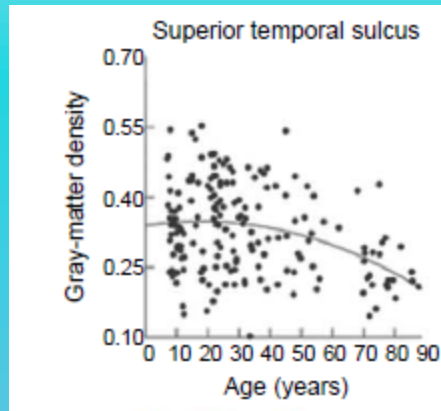


Toga, Thompson, & Sowell, 2006

Lifespan Imaging Study

- $n = 178$, (8-87), longitudinal study
- Different areas of the brain lose gray matter at different rates
 - Orbitofrontal cortex: Dramatic decline from 7-60, with levelling off afterwards
 - Lateral portions of posterior temporal and inferior parietal lobes: Subtle increase until ~ 30 , followed by steep decline

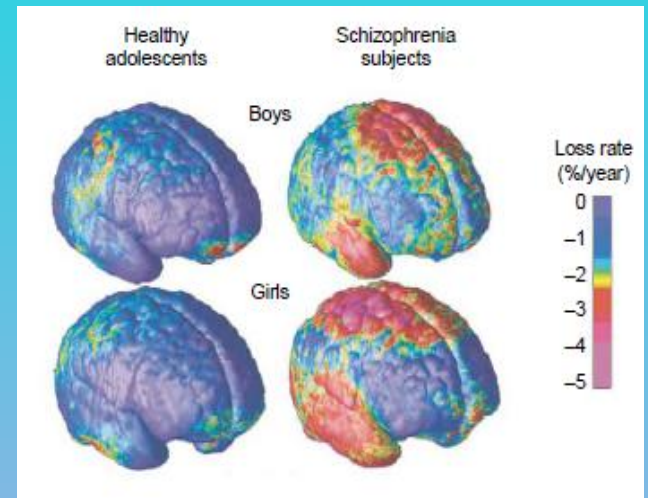
Lifespan Imaging Study



Toga, Thompson, & Sowell, 2006

Disorders: Schizophrenia

- 50 clinical, 500 controls
- Rapid loss in frontal/pre-frontal cortices
- Parietal defects that spread into temporal lobes
- Genetic or environmental?



Toga, Thompson, & Sowell, 2006

Disorders: Williams Syndrome

- Genetic origin
- Cortex overall thinner, except in language areas
- Larger cells in Heschl's gyrus

Disorders: ADHD

- Subtle reductions in total brain volume
 - Local reductions in right frontal lobe volume
- Abnormal morphology in frontal cortices
- Increased gray-matter density in posterior temporal and inferior parietal cortices

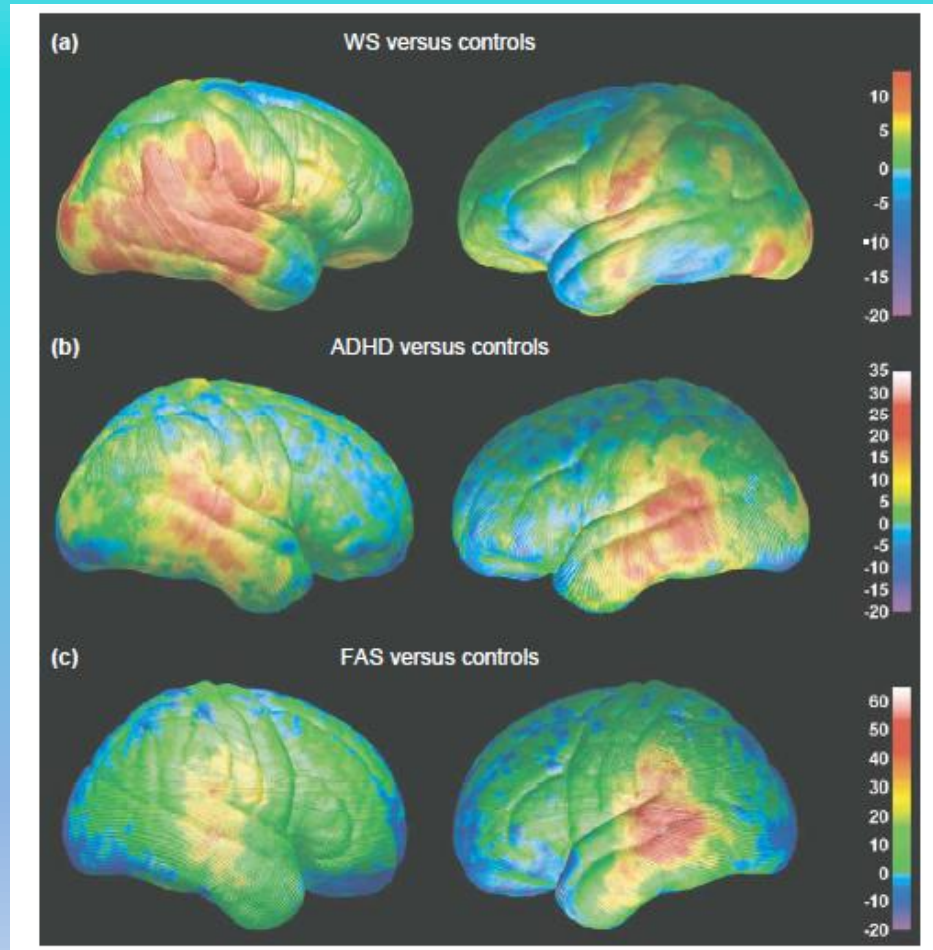
Disorders: FAS

- Reduced parietal lobe volume
 - With matched controls, reduced frontal lobe volume
- White and gray matter hypoplasia (white more significant)
 - GM increase in inferior parietal and posterior temporal lobes
 - Bad plasticity!!!

Disorders: Comparison

- GM increases in ADHD and WS in language area
 - Bilateral GM increases in ADHD and FAS, but not WS
- Why is this important?
 - ADHD often co-morbid with FAS

Disorders: Comparison



Toga, Thompson, & Sowell, 2006

Evaluating the Role of Genetics

- Twin studies!
- GM volumes in frontal lobes more closely matched in identical twins
 - Implication: Process and rule-learning parts of brain more genetically controlled, while experiential parts of brain are not

Conclusions

- MRI is useful technology, but limited
 - Sample sizes with rare disorders
 - Very algorithmic
 - Must still be compared with histological studies
- **What does a change in brain volume of a particular region actually mean???**

Questions?