Riding the Rollercoaster: Understanding the Impact of Substance Use on Teen Brain Development

Poll Question
Which category best reflects your profession:
A. Prevention Specialist
B. Mental Health Specialist
C. Educator
D. Administrator
E. Other

Understanding the Teen Brain
New Experiences
Making Good Decisions
Becoming Independent
FREEDOM!

Poll Question
For your professional development:
What area do you identify as reflecting your greatest need for new information:
A. Substance Use/Addiction
B. Psychiatric Illness/Mental Health
C. Maintenance of Well-Being
D. Other

Research Trends
Pub Med Search: Adolescence and...

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National Consensus on Alcohol and Neurodevelopment in Adolescents, NCANA

Teens Needed for Paid Brain Imaging Research Study!
A Window into the Teen Brain

Magnetic Resonance Imaging (MRI)

The Developing Brain

- Brain size or weight of increases dramatically until age 5.
- Brain size plateaus, with no further changes in brain volume.
- Teen years: brain undergoes major, rapid remodeling.
- Emerging adults: brain changes detected between fall and spring semesters, in freshmen.

Brain Cells Under Construction

- Improving speed and efficiency of neuron communication: myelination
- Removing inefficient and unneeded neurons: pruning

Same Size, Different Brain

- Gray Matter
- Neuronal Pruning
- White Matter
- Myelination Connectivity

When is the Brain Adult?

"Neurobiological" adulthood occurs in the mid 20s

Gogtay et al., 2004
Bennett & Baird, 2006
**Response Inhibition/Cognitive Control**

**Go No Go Task**

- **GO**
- **GO**
- **GO**
- **NO GO!**

Teen's respond faster. Adults demonstrate better accuracy.

Greater brain response required to inhibit, "no go". Mediated by the frontal lobe. Improves with age.

Teens respond faster. Adults demonstrate better accuracy.

*Rubia et al., 2006*

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**Why Was That So Hard?**

Most people can read words even when the letters are mixed. The brain is excellent at language and reading.

**READING - AUTOMATIC**

**NAMING Colors - Less AUTOMATIC**

Brain has to work harder to hold back. This is the frontal lobe working. Gets better with age.

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**Teens & Cognitive Control**

**Year 2 vs Year 1**

- **13.7 yrs.** vs **12.6 yrs.**
- **Region of the Frontal Lobe**
  - Cingulate Gyrus

Developmental Brain Markers?

Measurable Inhibitory Neurotransmitter: **GABA**

12% improvement in response inhibition with age.

*Silveri et al., 2013*
Developmental Brain Markers?

Measurable Inhibitory Neurotransmitter: GABA

- 12% improvement in response inhibition with age
- 29% higher GABA levels with age in frontal lobe

Adolescent Depression: Low GABA

- 20 medication-free adolescents with MDD
- 8+ wk episode duration
- 21 healthy controls
- MDD: lower ACC GABA (p=.003), greatest difference in anhedonic MDD

Anhedonia: reduced capacity to experience pleasure, core symptom of MDD that is prevalent and highly variable in adolescents with MDD.

Faced with Tough Choices?

What Should I Do After Class?
What Should I Do After Class?
You Have a Math Test Tomorrow
You Have a Math Test Tomorrow

Quick Response
Hang Out with Friends
Hang Out with Friends

Think It Out for a Minute
Study for Tomorrow’s Test
Study for Tomorrow’s Test

Fail Test
Get an A on the Test
Get an A on the Test

WHAT WERE YOU THINKING?????
WHAT WERE YOU THINKING?????

Viewing Pictures of Fearful Faces

- Viewing Pictures of Fearful Faces
- Viewing Pictures of Fearful Faces

Faced with Tough Choices?

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WHAT WERE YOU THINKING?????
WHAT WERE YOU THINKING?????
Viewing Pictures of Food

Teen

Adult

Killgore and Yurgelun-Todd, 2005

In the Face of Tough Choices

- Frontal lobe provides inhibitory control over the more rapid amygdala responses.
- Brain developmental changes help improve cognitive control, which is coming online as teens are faced making difficult decisions and navigating emotional responsiveness.
- Brain changes are ongoing as teens are initiating alcohol and marijuana use.

Public Health Concerns: 2016

- Alcohol, marijuana and prescription pain meds

Adolescents More Affected

Teens who consistently use alcohol perform worse on memory tasks by 10%, and show less brain activity during memory tasks.

Role of Familial Alcoholism

Brain Activity: FH+ Teens > FH- Teens

Teens with a family history of alcoholism activate more frontal lobe regions during response inhibition prior to the initiation of alcohol use.


- Significant increases in marijuana use have been reported, almost a doubling in the past ten years.
- Along with greater use is higher levels of depression in teen marijuana users.

- Relative decreases in binge drinking and increases in marijuana use are influenced by changes in perceptions of harm by teens.
- Teens are reporting binge drinking as more risky, whereas teens are reporting marijuana as less risky.

Adolescents & Emerging Adults: Marijuana Use Associated with Poorer Cognition

- 1,037 individuals followed from birth to age 38
- Cannabis use ascertained at ages 18, 21, 26, 32, and 38
- Neuropsychological testing was conducted at age 13, and again at age 38
- More persistent use was associated with greater decline, and stopping use did not fully restore functioning
- 40 adolescents, ages 15-19; 19 marijuana, 21 non-users
- In marijuana group:
  - Age of weekly use: 15.6
  - # days of use in the last month: 16

Marijuana Use Affects Cognitive Control

- More neurons recruited to perform task at same level

Marijuana Use Affects Memory

- Identify when targets appear in same location
- Brain activates when repeat target appears in repeat location
- More brain activity while at rest

Marijuana Use Affects Reward Circuit

- Disrupted brain circuitry may result in poor regulation of motivation, including difficulty enhancing positive affect, pursuing goals or focusing on future reward

Adolescent Marijuana Use: Low GABA

- Adolescent marijuana (MJ) users
- Age-matched non-using controls
- MJ: lower ACC GABA (p=.03), trend towards predicting total MJ use
- Important neurochemical necessary for response inhibition, rapidly matures in the adolescent frontal lobe
- Low GABA levels observed in depression, anxiety, alcohol and marijuana dependence
Public Health Concerns: 2016

- Alcohol, marijuana and prescription pain meds
  
  - 22% of first time illicit drug users start with controlled medications (e.g. Vicodin®, OxyContin®, Adderall, second to marijuana. The rise in prescription drug abuse appears highly related to access via friends and family.
  
  - Adolescents prescribed opioids or who used nonmedically had more substance abuse and psychological symptoms than youth who had never received a prescription for an opioid antagonist.

Prescription Drugs: Brain Effects

- There is very limited data available on the effects of prescription drugs on the human adolescent brain.
  
  - One study conducted in animals showed that adolescents exhibit greater sensitivity than adults to the rewarding effects of oxycodone, which was indicated as an increased release of dopamine at the lowest dose tested.
  
  - Greater sensitivity could lead to greater use.
  
  - Adolescent exposure to the active ingredient in marijuana (THC) recently was shown to be associated with enhanced sensitivity to heroin.

Prescription Drugs: Brain Effects

- Heroin acutely reduced left amygdala response to fearful faces. Amygdala activity was related to anxiety, stress hormones, and heroin craving.
  
  - Drug users claim to use oxycodone to dampen physical and emotional pain.
  
  - Oxycodone attenuates connectivity of the frontal lobe with other important brain areas, which may impair the perception and appraisal of internal pain states.
  
  - Alterations in these neural pathways may underlie the pathophysiology of drug abuse.

Cycle of Addiction

- Where is Science Headed...
  
  - Adolescent alcohol exposure can alter genes
  
  - Parental exposure to drugs can transcend generations

Poll Question

What information presented during this keynote do you envision will have the biggest impact on your work:

A. Understanding Brain Development
B. Impact of Alcohol on Brain Function
C. Impact of Marijuana on Brain Function
D. Impact of Opioids on Brain Function
E. Overlap between Substance Use and Mental Health
Second Decade of Life:

Period of Opportunities & Vulnerabilities

Google News Alert
“adolescent”, “adolescence”, “teen”, “teenager”
10/21/08
Party a Painful Reminder of Teen Drinking Dangers
~The Sun Chronicle

The recent death of a 17 year old is another bitter reminder that alcohol and young people do not mix, experts on teenage drinking said Monday.

They said drinking by teenagers brings on a whole host of possible problems ranging from driving accidents, unwanted pregnancies, illness & injury.

Google News Alert
“adolescent”, “adolescence”, “teen”, “teenager”
Posted by scooter at 4:13PM on Monday, 3/31/08

I had three close high school friends whose "cool" parents let them and others drink at home.

The ol' "it's better to know where they're at" motto.

Two of those kids are now raging alcoholics, and the third is dead (yes, alcohol related).

It’s better to tell kids that drinking is a choice to be made when you turn 21. Until then, let “youth” be the only thing impairing your judgment.

In Their Own Words

Very rapid brain development in a short period of time, second decade of life

Biggest leaps in cognitive abilities occur between ages 10-18 years old

Time when emotions are strong/can be hard to manage

Teen brain more vulnerable to insults such as alcohol and drug use compared to the adult brain, which may be further elevated by family history

By sharing science, we can help teens protect the brain, which will lead to better decision making
Neurodevelopmental Laboratory on Addictions & Mental Health

Brain Imaging Center, McLean Hospital
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