Alcohol and Other Drug Use and Adolescent Brain Development

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Prevention, Law Enforcement and Coalitions: Developing Lasting Partnerships to Advance Environmental Prevention

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1. Addiction as brain disease

2. Brain development

3. Drug susceptibility

4. Summary

5. Clinical opportunities
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Emerging Science: Brain Imaging

New insights because:

• 1990’s information explosion due to the development of brain imaging techniques (e.g., CT, PET and MRI).
1. Addiction as brain disease
ALL DRUGS OF ABUSE TARGET THE BRAIN’S PLEASURE CENTER

Brain reward (dopamine) pathways

These brain circuits are important for natural rewards such as food, music, and art.

All drugs of abuse increase dopamine

Typically, dopamine increases in response to natural rewards such as food. When cocaine is taken, dopamine increases are exaggerated, and communication is altered.
Dopamine Neurotransmission

- Frontal cortex
- Nucleus accumbens
- VTA/SN

Graphs showing the percentage of basal release over time after amphetamine and food intake.

- Amphetamine:
  - Time After Amphetamine: 0, 1, 2, 3, 4, 5 hr
  - % of Basal Release: 0, 1, 2, 3, 4, 5

- Food:
  - Time (min): 0, 60, 120, 180
  - % of Basal Release: 0, 50, 100, 150, 200

Di Chiara et al.
Your Brain on Cocaine

PET scan

Yellow = cocaine is binding or attaching itself to areas of the brain
Dopamine D2 Receptors are Lower in Addiction

Cocaine
Meth
Alcohol
Heroin

control
addicted

DA D2 Receptor Availability

Drug Abuser
Non-Drug Abuser
What about recovery?
Your Brain After Cocaine

Normal

Cocaine Addict - 10 days

Cocaine Addict - 100 days

Yellow = normal brain functioning
1. Addiction as brain disease

2. Brain development
Cautions

• Brain imaging studies are based on small samples
  • gender, ethnic and cultural differences may be significant.
Adolescence is a period of profound brain maturation.

We thought brain development was complete by adolescence.

We now know... maturation is not complete until about age 25!!!
Why do most 16-year-olds drive like they're missing a part of their brain?

BECAUSE THEY ARE.

EVEN BRIGHT, MATURE TEENAGERS SOMETIMES DO THINGS THAT ARE "STUPID."

But when that happens, it's not really their fault. It's because their brain hasn't finished developing. The underdeveloped area is called the dorsal lateral prefrontal cortex. It plays a critical role in decision making, problem solving and understanding future consequences of today's actions. Problem is, it won't be fully mature until they're into their 20s.

It's one reason 16-year-old drivers have crash rates three times higher than 17-year-olds and five times higher than 18-year-olds. This is why virtually all states have given 16-year-olds restricted licenses, or Graduated Driver License (GDL) laws. These laws restrict the more dangerous kinds of driving teens do, such as nighttime driving and driving with teen passengers. Since North Carolina implemented one of the most comprehensive GDL laws in the country, it has seen a 25% decline in crashes involving 16-year-olds.

To find out what the GDL laws are in your state, visit Allstate.com/teen. Help enforce them—and if they aren't strong enough, ask your legislator to strengthen them.

Let's help our teenagers not miss out on tomorrow just because of their brain.
An Immature Brain =
Less Brakes on the “Go” System
Brain Development

Rate of change for:
- Volume
- Metabolism
- Blood Flow
- Receptors

Prenatal to Post-birth Age

Adolescence

Tapert & Schweinsburg (2005)
Brain Weight by Age


Slide courtesy Sion Kim Harris, Ph.D.
Brain Development

Myelination

Synaptic Refinement

Volume

Metabolism

Blood Flow

Receptors

Rate of change

Prenatal

Post-birth Age

Adolescence

Tapert & Schweinsburg (2005)
Construction Ahead

- When the pruning is complete, the brain is faster and more efficient.

- **But...** during the pruning process, the brain is not functioning at full capacity.
Maturation Occurs from Back to Front of the Brain
Images of Brain Development in Healthy Youth
(Ages 5 – 20)

Earlier: Limbic system
• Processing emotions
• Processing social info
• Experience reward, punishment

Later: Prefrontal cortex
• Deliberative thinking
• Logical reasoning
• Planning ahead
• Weighing costs and benefits
• Regulating impulses

Limbic System
Tests measuring different forms of executive function skills indicate that they begin to develop shortly after birth, with ages 3 to 5 a window of opportunity for dramatic growth in these skills. Development continues throughout adolescence and early adulthood.

Source: Weintraub et al. (Submitted for Publication)
Implications of Brain Development for Adolescent Behavior

• Preference for ....
  1. physical activity
  2. high excitement and rewarding activities
  3. activities with peers that trigger high intensity/arousal
  4. novelty

• Less than optimal..
  5. control of emotional arousal
  6. consideration of negative conseq.

• Greater tendency to...
  7. be attentive to social information
  8. take risks and show impulsiveness
Risk-Taking

• Based on science of brain development, a modern view of risk taking in adolescence is...
  • normative; important to development
  • evolutionarily adaptive
  • significant individual differences
  • is due primarily to emotional and contextual, not cognitive, factors
Impact of Peer Presence on Risky Driving in Simulated Context

Chein et al., in press
An Immature Brain ≠ Low Brain Power

Source: US News & World Report, 2005
An Immature Brain ≠
Risky Judgment is Pervasive

reward incentives >
perception of consequences

Source: US News & World Report, 2005
1. Addiction as brain disease

3. Developing brain & drug risk
Are adolescents more susceptible than adults to drugs?

4 lines of evidence
(acknowledgement to Linda Spear, Ph.D.)

Unethical to give human adolescents alcohol in the laboratory; much of the best evidence comes from adolescent rat studies.
Cautions

- **Animal data** - interpret cautiously
  - We are assuming commonality across species pertaining to .....
    - key characteristics of the adolescent developmental stage
    - acute effects of intoxication

- Lab rats are administered ethanol via injection or directly into the stomach
  - stress - impacts absorption and behavioral effects
Cautions

- Human data - incomplete picture
- Other developmental factors, such as hormonal changes, are also biomedical contributors to drug sensitivity.
1. Evidence from epidemiological studies

Drug use starts early and peaks in the teen years
(Grant, B.F., et al., Drug and Alcohol Dependence, 74, 223-234, 2004)

% of population


12.2 11 5.8 4.1 3.9 3.8 3.7 1.9 0.3 0.2
Percentages of Past Year Alcohol Use Disorder (Abuse or Dependence) Among Adults Aged 21 or Older, by Age of First Use (SAMHSA, 2005)

Fewer Problems in Those Who Start Later

Age Started Drinking:
- <12 yrs: 16%
- 12-14 yrs: 15%
- 15-17 yrs: 9%
- 18-20 yrs: 4.2%
- 21+ yrs: 2.6%
Percentages of Current Cannabis Dependence as a Function of Cannabis Use Onset (National Household Survey on Drug Abuse, 2000-2001)

Fewer Problems in Those Who Start Later
Are adolescents more susceptible to alcohol than adults?

1. Epidemiological data

Comparing adolescent and adult rats, both having no prior exposure to alcohol and matched on temperament....

2. Adolescent rats are less sensitive to the sedative and motor impairment effects of intoxication.
   - more drinking before “signals to stop”
The Water Maze Test

- Saline vs alcohol
- Measures
  - Swimming speed
  - Time to find platform

Slide courtesy
Sion Kim Harris, Ph.D.
Are adolescents more susceptible to alcohol than adults?

1. Epidemiological data
2. Adolescent rats are less sensitive to the sedative and motor impairment effects of intoxication.
3. Adolescent rats are more sensitive to the social disinhibition effects of alcohol.
   - greater social comfort from intoxication
Wanna look for some cheese with me?

Sure!
Are adolescents more susceptible to alcohol than adults?

1. Epidemiological data

2. Adolescent rats are **less sensitive** to the sedative and motor impairment effects of **intoxication**.

3. Adolescent rats are **more sensitive** to the social disinhibition effects of alcohol.

#2 and #3 : May contribute to **binge drinking** and increased risk to **alcohol dependence**.
Are adolescents more susceptible to alcohol than adults?

1. Epidemiological evidence
2. Adolescent rats are less sensitive to the sedative and motor impairment effects of intoxication.
3. Adolescent rats are more sensitive to the social disinhibition effects of alcohol.
4. Alcohol may produce greater cognitive disruptions in adolescents.
Human Data: Alcohol’s Effects on Memory

4. Adolescent rats more sensitive to...

- disruption in memory
- impairment of neurotransmission in hippocampus and cortex

Source: Spear, 2002
Human Data: Alcohol’s Effects on the Hippocampus

4. Adolescents with a history of alcohol use disorder....

Hippocampus volume (10%)

Hippocampus converts information to memory

Source: Tapert & Schweinsburg, 2005
Human Data: Alcohol’s Effects

Retention Rate %

Source: Brown et al., 2000
MRI: Hippocampal Size

Nagel, Schweinsburg, Pham, & Tapert, 2005

- Hippocampus encodes new info
- Left smaller in AUD teens (p < .01)
- But no relationship with cognitive functioning (due to less severe alcohol group than Brown et al. sample?)

10% smaller volume
Teen Drinking & Brain Activation

Non-Drinkers

Heavy Drinkers

Age 16

2 yrs drinking

5 yrs drinking

Activation

De-activation

Age 20

Tapert et al., 2001, 2004

Slide courtesy of Susan Tapert, PhD.
Are adolescents more susceptible to cannabis than adults?

4. Cannabis may produce greater cognitive disruptions in adolescents.
Fig. 2. Adolescent vulnerability. Shown is change in full-scale IQ (in SD units) from childhood to adulthood among study members with 1, 2, or 3+ diagnoses of cannabis dependence as a function of age of onset of cannabis dependence. Individuals with adolescent-onset cannabis dependence (black bars) experienced greater IQ decline than individuals with adult-onset cannabis dependence (gray bars). IQ decline of approximately $-0.55$ SD units among individuals with adolescent-onset cannabis dependence in the 3+ group represents a decline of 8 IQ points. Error bars = SEs.

Meier et al., 2012; *PNAS*
1. Addiction as brain disease

2. Brain development

3. Developing brain & alcohol risk

4. Summary
Summary

• Adolescence is an extended period of transition from reliance on adults to independence

• Normal adolescence is characterized by....
  • increase in conflicts with family members
  • desire to be with one’s friends
  • resistance to messages from authority
  • irritability
  • proclamations of sheer boredom
  • risk taking
  • reward incentive-biased decision making
Summary

• The brain undergoes a considerable amount of development during the teen years.

• The last area to mature is the prefrontal cortex region; involved in planning, decision making and impulse control.
Summary

reward incentives > perception of consequences
Brain Development: Reinforcing the Need for Prevention and Treatment

• Youth is a particularly vulnerable period for developing a substance use disorder.

• Prevention and treatment programs are vital.
Implications for Prevention and Treatment

• I favor programs that focus on teaching skills associated with thoughtful, planful decision making
  • impulse control
  • “second” thought processes
  • social decision making
  • dealing with risk situations
  • taking healthy risks
New 12-Step Program for Adolescents?

12-Steps of Self-Regulation

1. impulse control
2. “second thought” processes
3. social decision making
4. dealing with risk situations
5. taking healthy risks
6. attention regulation
7. anger control
8. modulating reward incentives
9. choosing options
10. considering consequences
11. minimizing arousal
12. dealing with peer influences
Advantages of Motivational Interviewing

- De-emphasize labels
- Emphasis on personal choice and responsibility
- Therapist focuses on eliciting the client's own concerns
- Resistance is met with reflection and non-argumentation
- Treatment goals are negotiated; client’s involvement is seen as vital
‘I attend as many parenting classes as I can - anything to get away from my children’
Parent Take Home Summary

P = **Promote** activities that capitalize on the strengths of the developing brain.

A = **Assist** children with challenges that require planning.

R = **Reinforce** their seeking advice from adults; teach decision making.

E = **Encourage** lifestyle that promotes good brain development.

N = **Never** underestimate the impact of a parent being a good role model.

T = **Tolerate** the “oops” behaviors due to an immature brain.
Prevent_Intervene_Get Treatment_Recover

www.drugfree.org
THANK YOU!

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Suggested Readings


