1. Brain imaging: addiction as brain disease
Emerging Science: Brain Imaging

- New insights because….
  - 1990’s information explosion due to brain imaging techniques (e.g., CT, PET and MRI).
Imaging Modalities

- CT
- SPECT
- FDG PET
- Ligand PET
- Anatomic MRI
- MR Spectroscopy
- fMRI
- Diffusion MRI
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.

FOOD

COCAINEN
Dopamine D2 Receptors are Lower in Addiction

Cocaine

Alcohol

Heroin

Drug Abuser

Non-Drug Abuser

Reward Circuits

DA D2 Receptor Availability

control
addicted
1. Brain imaging: addiction as brain disease

2. Brain imaging: brain development
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 24!!!
An Immature Brain = Less Brakes on the “Go” System
Brain Development

RATE OF CHANGE

Volume
Metabolism
Myelination
Blood Flow
Receptors
Synaptic Refinement

Prenatal  Post-birth Age

1  2  7  16  30

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)

Brain areas where volumes are smaller in adolescents than young adults

Last to develop is judgment!
It is understandable that adults may over-assume that adolescents will show judgment at a mature-level.
Judging the Judgment of Youth

- Teenagers physically look like adults
Judging the Judgment of Youth

- They can excel at physical challenges

Before he became a star at UCLA, Lew Alcindor was unbeatable at Power Memorial High School.
Judging the Judgment of Youth

- They impress us with their comfort and skill with high-tech
Judgment Gets Better with Age

- By age 18, the adolescent’s judgment for structured challenges is roughly equal to that of adults.

- But judgment that involves resisting impulses or delaying gratification is still under construction during late adolescence and early adulthood.
Implications of Arrested Development for Adolescent Behavior

We can infer:

- Preference for physical activity
- Preference for high excitement and low effort activities
- Preference for activities that trigger high intensity feelings and arousal
- Poor planning and judgment
- Minimal consideration of negative consequences
- More risky, impulsive behaviors
Evidence accumulating that **being in a group** accentuates risk taking in youth more so than with adults

- Drug use with peers is the norm, not the exception
  - This one of the more reliable and long standings findings in the adolescent drug abuse literature (e.g., Clayton, 1992)
Evidence accumulating that **being in a group accentuates risk taking in youth more so than with adults**

- **Co-offending and youth**
  - Studies indicate that offenders 13 and under are more likely to commit crimes in pairs and groups compared to 16- and 17-year-old offenders (McCord & Conway, 2005)
1. Brain imaging: addiction as brain disease

2. Brain imaging: brain development

3. Developing brain & alcohol risk
Research Question Addressed in the Literature:
Are adolescents more susceptible than adults to alcohol?

4 lines of evidence

Unethical to give human adolescents alcohol in the laboratory; much of the best evidence comes from adolescent rat studies.
Implications of Arrested Development for Drug Abuse Vulnerability

1. Evidence from epidemiological studies

Alcohol use starts early and peaks in the teen years
1. 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

<table>
<thead>
<tr>
<th>Age Started Drinking</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;12 yrs</td>
<td>16</td>
</tr>
<tr>
<td>12-14 yrs</td>
<td>15</td>
</tr>
<tr>
<td>15-17 yrs</td>
<td>9</td>
</tr>
<tr>
<td>18-20 yrs</td>
<td>4.2</td>
</tr>
<tr>
<td>21+ yrs</td>
<td>2.6</td>
</tr>
</tbody>
</table>
1. Percentages of past year alcohol use disorder among those with a recent onset (prior 2 years; \( n = 4074 \)) of alcohol use (Winters & Lee, in press)

Lower Rates with Older Recent Users

* \( p \leq .05 \); compared to 22-26y group
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”
2. Survey Data Suggest that Adolescents Are Less Sensitive to Alcohol’s Effects

Monitoring the Future, 2001

Less sensitive

- 5+ drinks in row, past 2 weeks
- Been drunk past month

8th Graders: 14 (5+ drinks), 8 (Been drunk)
10th Graders: 26 (5+ drinks), 24 (Been drunk)
12th Graders: 30 (5+ drinks), 32 (Been drunk)
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
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.
Binge Alcohol Use in the Past Month by Age Group
(SAMHSA, 2005)

Binge = 5+ drinks same occasion on at least one day in the past 30 days.
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 produces greater cognitive disruptions in adolescents.
Animal Data: Alcohol’s Effects
(Spear, 2002)

4. Adolescent rats more sensitive to.

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

Where is my cheese?
4. Adolescents with a history of alcohol use disorder....

- Hippocampus volume (10%)

- Memory retention

Not known if restoration or recovery will occur.
MRI: Hippocampal Size

- Hippocampus
  - Encodes new info
  - Left smaller in AUD teens ($p < .01$)

Nagel, Schweinsburg, Pham, & Tapert, 2005
Human Data: Alcohol’s Effects
(Brown et al., 2000)
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 cognitive disruptions in adolescents.

5. Hyperexcitability trait among those at high-risk
1. Brain imaging: addiction as brain disease

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3. Developing brain & alcohol risk

4. Summary
Evidence in support that youth are highly vulnerable to the effects of alcohol

SUMMARY

1. Greater rates of alcohol use disorders at earlier ages
2. Reduced sensitivity to intoxication
3. Increased social disinhibition
4. Increased cognitive disruption
More INDIRECT evidence in support that youth are highly vulnerable to the effects of alcohol

Neurodevelopment likely contributes to:

- Risky, impulsive behavior
- Planning and judgment
- Ability to weigh consequences
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
  - risk taking
  - proclamations of sheer boredom
Summary

• The brain undergoes a considerable amount of development during the teen years.
• The last area to develop is the prefrontal cortex, which is involved in planning, decision making and impulse control.
• Alcohol - and likely other drugs - affects the young person more profoundly than its effects on adults.
• Repeated alcohol exposure may harm adolescent brain development.
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 effects of alcohol on the developing brain.

**T** = Tolerate the “oops” behaviors due to an immature brain.
THANK YOU!

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Suggested Readings

- [www.duke.edu/%7Eamwhite/Adolescence/index.html](www.duke.edu/%7Eamwhite/Adolescence/index.html)

- [www.drugabuse.gov/Published_Articles/](www.drugabuse.gov/Published_Articles/)

- *Why do they act that way? : A survival guide to the adolescent brain for you and your teen*

- *What makes teens tick?*

- *The adolescent brain and college drinker: Biological basis of propensity to use and misuse alcohol.*