1. Brain development

3. Summary

2. Brain development and drug abuse vulnerability
1. Brain development

Emerging Science: Brain Imaging

New insights

- 1990’s information explosion due to the development of brain imaging techniques (e.g., CT, PET and MRI).
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!!!
An Immature Brain = Less Brakes on the “Go” System

Brain Weight by Age

Brain Development

I'm adult-size now!


Slide courtesy
Sion Kim Harris, Ph.D.

Rate of Change

Tapert & Schweinsburg (2005)
Maturation Occurs from Back to Front of the Brain
Images of Brain Development in Healthy Youth
(Ages 5 – 20)

Earlier:
Motor Coordination
Emotion
Motivation
Later:
Judgment

Blue represents maturing of brain areas


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.

Source: US News & World Report, 2005

An Immature Brain =
Low Brain Power
Taking the Same Ability Test at Age 11 & Age 80: Scottish Mental Survey 1932


An Immature Brain = Risky Judgment is Pervasive

Source: US News & World Report, 2005

Brain Development May Reveal These Tendencies (Dahl, 2004)

- 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
Standard View of Risk Taking

• Adolescents underestimate risk
• Adolescents believe they are invulnerable
• Adolescents engage deficient cognitive processes when making decisions
• Adolescents are unaware of the dangers associated with risky behavior

Newer View of Risk-Taking

• Based on science of brain development, a modern view suggests that risk taking during adolescence...
  • is normative; important to development
  • has evolutionary significance
  • is influenced by emotional and contextual, not cognitive, factors
  • is similar to adult risk-taking in terms of harm perception
• But adolescents may display more risk taking due to differences with adults in terms of impulse control

Several Findings in the Literature
(see Steinberg for a review, JMATE conference, 2010)

• Delayed Discounting
• Self-Reported Impulse Control (Barratt)
• Reward Sensitivity (Iowa Gambling Task)
• Waiting Before Acting (Tower of London)
• Self-Reported Sensation Seeking (Zuckerman)
• fMRI study of risk taking (Steinberg lab will be publishing this soon)
Young Adolescents Show Stronger Preference for Immediate Reward

Steinberg et al., 2009

Implications of Brain Development for Drug Abuse Vulnerability

Are adolescents more susceptible than adults to alcohol?

5 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)

Percentages of Past Year Alcohol Use Disorder (Abuse or Dependence) Among Adults Aged 21 or Older, by Age of First Use (SAMHSA, 2005)

The 22nd annual Partnership Attitude Tracking Study (PATS), sponsored by MetLife Foundation and The Partnership at DrugFree.org (2011)
Are adolescents more susceptible to alcohol than adults?

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

Are adolescents more susceptible to alcohol than adults?

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?

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.

4. Dopamine and addiction

Dopamine is a key neurotransmitter in the brain's reward pathway system

Dopamine is a key brain chemical that regulates our mood

Drugs "hijack" our dopamine activity
Sidebar: Drug Addiction and the Brain

ALL DRUGS OF ABUSE TARGET THE BRAIN’S PLEASURE CENTER

Brain reward (pleasure) pathways

All drugs of abuse increase dopamine

Typically, dopamine increase in response to natural rewards such as food. When cocaine is taken, dopamine increase is exaggerated, and consumption is altered.

Dopamine Neurotransmission

Dopamine D2 Receptors are Lower in Addiction
4. The developing brain has a robust dopamine system

- Drugs may be more reinforcing to the developing brain and thus, more subjected to the hijacking process.
Are adolescents more susceptible to alcohol than adults?

5. Alcohol may produce greater cognitive disruptions in adolescents.

Animal Data: Alcohol’s Effects on Memory

5. Adolescent rats more sensitive to...

5. Disruption in memory

6. Impairment of neurotransmission in hippocampus and cortex

Source: Spear, 2002

Human Data: Alcohol’s Effects on Memory

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

- Poorer memory performance
- 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

10% smaller volume

Teen Drinking & Brain Activation

Data courtesy of Susan Tapert, PhD.

Tapert et al., 2001, 2004
1. Brain development

2. Brain development and drug abuse vulnerabilities

3. 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

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**WHY?**

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

Final Note

- There is a race to integrate this emerging science into prevention and treatment programs and practices
  - Watch for these developments!

THANK YOU!

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Suggested Readings


Implications of Adolescent Brain Development for Prevention and Treatment

Ken Winters, Ph.D.
Department of Psychiatry
University of Minnesota
winte001@umn.edu

2011 MARRCH Annual Conference Workshop
September 15, 2011
Youth

Youth is the period between the onset of puberty and the attainment of stable adult roles and responsibilities.

Dahl, 2002
Youth

A Tale of Two Systems: Incentive Processing System

These two systems are involved in how we value and predict potential rewards and punishments, and process emotional and social information.

- Key Nodes
  - Ventral striatum
  - Orbitofrontal cortex
  - Posterior cingulate cortex
  - Amygdala
  - Nucleus accumbens

Prefrontal Area

- Dorsolateral (reasoning and self-control)
- Ventromedial (gut-level decisions)
- Orbitofrontal (evaluating risk and reward)

- The CEO of the brain
  - Deliberative thinking
  - Logical reasoning
  - Planning ahead
  - Weighing costs and benefits
  - Regulating impulses
The Limbic System
• Processing emotions
• Associating emotions with memories
• Processing social information
• Experience of reward and punishment

Maturation Occurs from Back to Front of the Brain
Images of Brain Development in Healthy Youth
(Ages 5 – 20)

Earlier development:
Motor Coordination
Emotion
Motivation
Later development:
Judgment
Process:
Promotes puberty


Brain Development May Reveal These Tendencies (Dahl, 2004)
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Implications of Brain Development and Policies, Prevention and Treatment

- immediate rewards > perception of consequences
- peer influences > parent influences
- education about health risks not sufficient
- brain malleability can promote change

1. Review

2. Health policies

3. Prevention & Treatment

4. Summary

Smoking and Price: Relation Between Cigarette Consumption and Adjusted Price During 1972-92

Townsend J et al. BMJ 1994;309:923-927
25

Percent of fatally injured passenger vehicle drivers age 16 – 20 with positive BACs, by age 1982 – 2008 (Longthorne et al., 2010)

Minimum Legal Drinking Age (MLDA) and Vehicle Fatalities Among Young Drivers (16 – 20)

A Case for Zero Tolerance Laws: Motor Vehicle Crash and Age of Drinking Onset (N = 4,021; national sample)

<table>
<thead>
<tr>
<th>Age of Drinking Onset</th>
<th>Odds Ratio: Crash After Drinking</th>
<th>Odds Ratio: Crash After Not Drinking</th>
<th>Significance</th>
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</thead>
<tbody>
<tr>
<td>&lt; 14</td>
<td>9.3</td>
<td>1.5</td>
<td>&lt; .01</td>
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<tr>
<td>14 - 15</td>
<td>7.7</td>
<td>1.8</td>
<td>&lt; .01</td>
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<tr>
<td>16 - 17</td>
<td>4.3</td>
<td>1.3</td>
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<td>&lt; .05</td>
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<tr>
<td>21+</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

Hingson et al., 2009

Allstate ad, NY Times, May, 2007
Impact of Peer Presence on Risky Driving in Simulated Context

1. Review
2. Health policies
3. Prevention & Treatment
4. Summary

Opportunities for Prevention & Treatment

Because many teens begin using substances at a young age and because of their possible deleterious effects on the developing brain, the urgency for prevention and treatment is real.
Brain Development: Opportunities for Prevention & Treatment

Discuss with teenagers the science of the neurobiology of addiction.
Memory Effects

<table>
<thead>
<tr>
<th>Retention Rate %</th>
<th>Verbal Information</th>
<th>Nonverbal Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>96</td>
<td>97</td>
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<tr>
<td>70</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Brown et al., 2000

Brain Development: Implications for Prevention & Treatment

Teach important decision making skills not optimal for the teen brain
- impulse control
- “second” thought processes
- social decision making
- dealing with risk situations
- taking healthy risks

Childhood Self-Control as a Predictor of Adult Substance Use Dependence (Moffitt et al., in press)

Outcomes were converted to Z-Scores and childhood self-control is represented in quintiles.
Taking risks is not always unhealthy.

Growth experiences and extending one's talents may involve risk-taking.

What Features Make Prevention and Treatment Programs Teen-Brain Friendly?

Elements of Effective Prevention Programs (Winters, Fawkes et al., 2007)

1. Curriculum organized around risk and protective factors and processes that contribute, promote or cause drug use behaviors.
2. Assume the validity of the “gateway hypothesis” and focus on preventing the onset of alcohol and tobacco use.
3. Take a multidimensional approach.
4. Program curriculum spans multiple grades and extends several developmental periods.
5. Activities and curriculum are developmentally and culturally adjusted.

6. Programs expend great deal of resources and effort in youth and family engagement.
7. Youth component focuses on building social skills.
8. Parent component focuses on discipline and support parenting behaviors.
9. Program structure enlists broad-based involvement in decision making, including ongoing opportunities by stakeholders to refine and shape the program.
10. Several aspects of the program are infused with features that promote its sustainability.


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Selected Examples of Prevention Programs Meeting Rigorous Outcome Criteria: www.nrepp.samhsa.gov

- Raising Healthy Children
  (Catalano et al. (2003); Brown, Catalano, Fleming, Haggerty, & Bobek (2003); depts.washington.edu/sdrg)
- Life Skills
  (Botvien et al.)
- The Incredible Years
  (Reid, Webster-Stratton, & Beauchaine (2002); Webster-Stratton & Taylor (2001); www.incredibleyears.com)
- Triple P-Positive Parenting
  (Heinrichs et al. (2006); Sanders, Markie-Dadds, Tully, & Bor (2000); www.triplep.net)
- Family Matters
  (Maumbe et al. (2002); http://familymatters.sph.unc.edu/index.htm)
- Families That Care: Guiding Good Choices
  (Park et al. (2002); Spoth et al. (2004); http://www.dsgonline.com/mpg)


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Prevention: Classroom Resources

There are now some age-appropriate resources to educate youth about their developing brain.

New resource from www.BSCS.org: ten classes
Drug Abuse, Addiction and the Adolescent Brain

Hazelden’s new resource: www.hazelden.org: eight mini lesson presentations

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Prevention: Reaching Parents

Working with Parents

\[ P = \text{Promote} \] activities that capitalize on the strengths of the developing brain.

\[ A = \text{Assist} \] children with challenges that require planning.

\[ R = \text{Reinforce} \] their seeking advice from adults; teach decision making.

\[ E = \text{Encourage} \] lifestyle that promotes good brain development.

\[ N = \text{Never} \] underestimate the impact of a parent being a good role model.

\[ T = \text{Tolerate} \] the “oops” behaviors due to an immature brain.

Remind parents: Do not expect much impact from….

1. Reasoning with your child
2. Educational-only programs
3. Pledges not to engage in risky behavior
Prevention Smart Parents
www.prevention-smart.org

Prevent_Intervene_Get Treatment_Recover
www.drugfree.org
Treatment

Responses on a Continuum
Adapted from Broadening the Base of Alcohol Treatment (IOM)

Primary Prevention

Brief Intervention

Intensive Tx

Abstinence

Recreational use

Moderate

Severe

Drug Use Severity

Treatment

Two major treatment approaches seem accommodating to the teen brain:

- Cognitive – behavioral therapy (CBT)
- Motivational interviewing
Characteristics of CBT

- Focus on immediate, relevant and specific problems
- Solutions are realistic, conc

Characteristics 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

Treatment

- Is the traditional 12-Step program conducive to the developing brain?
Treatment

Teen-brain friendly features of the 12-Step Model

- abstinence
- novelty – new approach to life
- structure
- spiritual component
- fellowship

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

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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
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Suggested Readings