

## ADOLESCENT BRAIN DEVELOPMENT AND ADDICTION:

### Research Findings Clinicians Should Know



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### Goals for Presentation

- Discuss **brain development** of youth
- Highlight research on **impact of alcohol on the brain/cognitive functioning** during adolescence
- Suggest general **alcohol and drug treatment implications** of adolescent brain development

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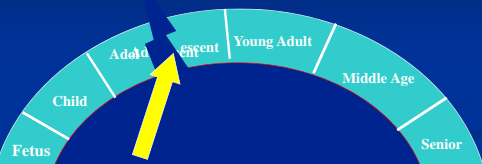
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### Adolescence in the Lifespan



The onset of Adolescence is demarcated by puberty and the offset by attainment of adult roles and responsibilities.

Progression involves developmental systems ranging from biology to behavior

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## Adolescent AUDs/SUDs Occur in the Context of Developmental Changes

- **Biological**
  - (pubertal, neuroanatomical)
- **Socioemotional**
  - (family/peer/intimate relations,
  - emotional lability and management)
- **Cognitive**
  - (information processing,
  - executive functioning)
- **Behavioral**
  - (risk taking, self-regulation)



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## Adolescent Development: What should we expect?

Across species---accelerations in:

- Activity level, Socialization, Experimentation and Risk Taking
- Move to Independence & New Roles
- **Development of Self-Regulation is Critical** - Neurocognitive
  - Affect management
  - Behavioral choice & control
  - Requires new environments



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## Youth Brain Development

- Size stable by late childhood/puberty onset
- Shift from broad activation to regional activation
- Specific regions change in structure and function in early adolescence
- Repeated periods of dendritic pruning
- Myelination proceeds into the early 20s

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### Brain Regulatory Systems Critical to Adolescent Success Begin to Develop Before Age 11

- Emotional Control
- Social Regulation
- Behavioral Control and Attendance to Social Rules
- Regulation of Sleep and Activation Cycles
- Regulation of Stress Response

Zucker, 2006

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### Neural Circuitry Underlies These Regulatory Developments

#### Suppress/inhibit prepotent responses

\*Right inferior frontal cortex to basal ganglia

#### Suppress irrelevant information

\*Dorsolateral prefrontal cortex and association areas (working memory) and anterior cingulate

#### Identify emotions and Discriminate emotional facial expressions

\*Amygdala

\* Differences in these areas are associated with early AUD/SUDs

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### Two Major Developmental Risk Pathways linked to Neural Substrates

- Undercontrol-externalizing behaviors, impulsivity, high activity, aggressiveness, rule breaking
- Negative Affectivity-intense response to stimuli, internalizing behaviors, anxiety, depression, social inhibition
- Pathways demonstrated in 7 longitudinal studies

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## Adolescent Brain Development

1. Expansion of the Cerebral Cortex –temporal, parietal, prefrontal
2. Maturation of Subcortical structure within the medial temporal lobe- hippocampus, amygdala- areas with high densities of sex steroid receptors
3. Reduction of Grey Matter/Increase in White Matter volume
4. Loss of 50% of neuronal connections
5. Repeated periods of Dendritic Pruning
6. Myelination proceeds posterior to anterior
7. Regional Response Changes - (eg, prefrontal, limbic regions) reflect connectivity changes & subservise emerging Cortical Control

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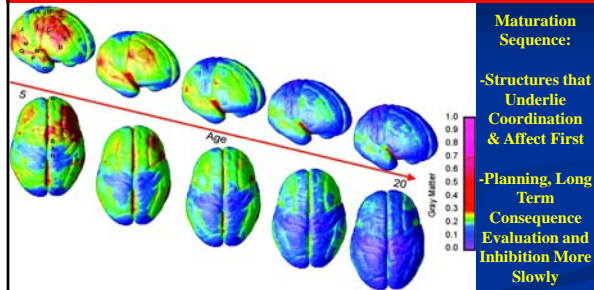
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## Structure and Function Changes as Brain Maturation Continues into the Early to Mid 20s



Gogtay, Nitin et al. (2004) Proc. Natl. Acad. Sci. USA 101, 8174-8179

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## Self Regulation = Acquired Skills for Mature Decision Making and Behavior

### ■ REQUIREMENTS:

- Cortical Control
- Affective Arousal/Motivation
- Behavioral Competence

### COGNITIVE PROCESSES:

- Bottom up:** affect alters information processing
- Top down:** cortical control of affective responses
- Inhibition:** initial/primary response
- Reappraisal:** evaluate own response

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### Adolescent Brain Development: Decision Making and Risky Behavior

- Incomplete neural development leads to risky decisions
- Presence of peers alters decisional process
- Strong emotions may override rational decision-making
- Risk-taking is good – facilitates transitions, necessary exploration and autonomy

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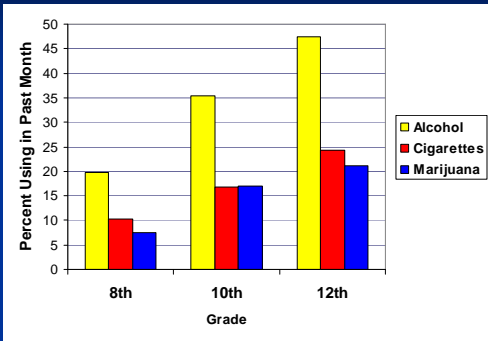
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### Alcohol's Unique Role in our Society: Preferred Drug of Youth



Source: Monitoring the Future, 2007

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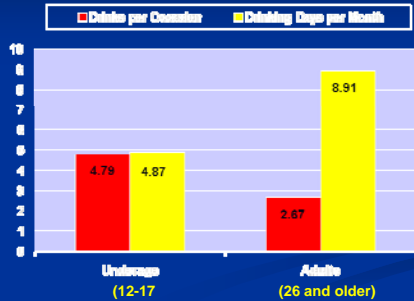
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### Youth Drink More Dangerously than Adults: Half as often but Twice as Much



SAMHSA National Survey on Drug Use and Health, 2002

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## Adolescent Alcohol Use

- **DRINKING ONSET** typically begins at 12-14
  - At 16: 60% of boys and girls
  - At 18: 85% of boys and girls
- **BINGE** (4+ /5+) Drinking at age 16  
 Past 30 days at age: Girls = 62% Boys=68%
- **PEAK BINGE**  
 Girls=17/18 yrs (67%) Boys=19/20 yrs (83%)

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## Youth Who Drink Commonly Report Alcohol Related Problems in Domains Critical to Successful Development

- 38% of 12-17 year olds who drank last year –
- 1 or more alcohol related problems  
National Household Survey on Drug Abuse, SAMHSA
- 53% of HS seniors drank 10 or more times last year and
  - 2/3 had at least 1 alcohol problem
  - 1/3 had 3 or more problems

Monitoring The Future: O'Malley, Johnston & Bachman

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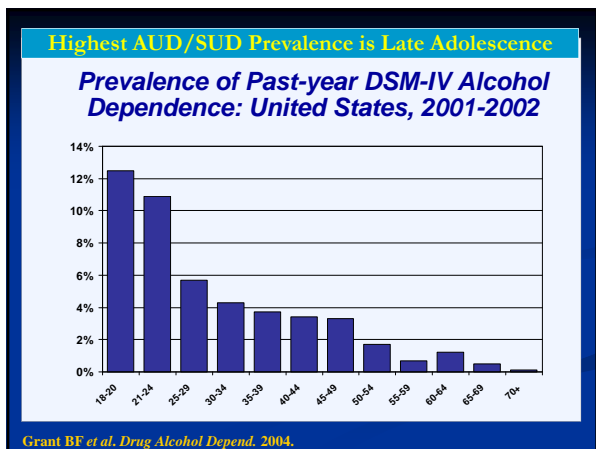
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## Progress through School

- Enter and Complete High School



**1 IN 3 REPORT ALCOHOL HURT GRADES**

**Alcohol: Integrated into school activities**  
Academic Problems  
Low Involvement

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## Drivers License

- Permit
- License



**1 IN 5 UNSAFE DRIVING**  
**½ SINGLE VEHICLE CRASHES RELATED**

**Alcohol: Accidents Injuries Deaths**

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## New Types of Relationships

- Stable Friendships
- Romance
- Sex
- Children



**1 in 2 regret behavior**  
**1 in 5 relationship problem**

**Alcohol: Early/Risky/ Unwanted Sex Dysynchronies**

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### Why Be Concerned about Alcohol During Adolescence? ANIMAL STUDIES

Compared to Adults, Adolescent animals are:

- Less sensitive to acute sedative effects
- More sensitive to disruption of memory, impairment of neurotransmission in hippocampus and cortex, and social facilitation

Binges produce long-lasting memory effects, damage frontal-anterior cortical regions and reduce neuronal repair

Prolonged ethanol exposure enhances withdrawal and produces long term changes in cortex and hippocampus.

Source: Brown, et al 2008

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### Neurodevelopmental Models for Adolescent Alcohol Problems

- Neurodevelopmental Delay (Benegal et al, 2007)
- Generalized Disinhibitory Complex (Begleiter & Porjesz, 1999)
- Psychological Disregulation (Clark, Thatcher & Tapert, 2008)

FOCUS ON: FRONTAL, LIMBIC AND REWARD CIRCUIT DEVELOPMENT  
MANY THEORIES WITH FEW REPLICATIONS

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### Neurocognitive Impact of Alcohol on Youth: > 100 Drinking Episodes

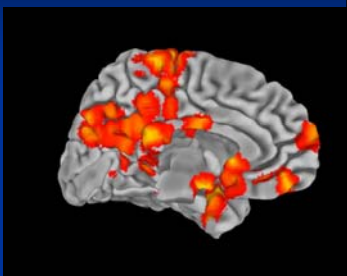
Middle Adolescence  
-Fewer Learning Strategies

-Memory Impairment

Late Adolescence  
-Attention Decrement

-Visuospatial Impairment

Withdrawal May Impact Different Abilities than Use



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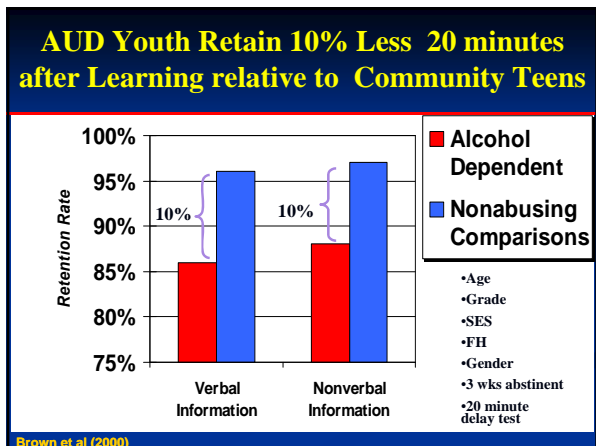
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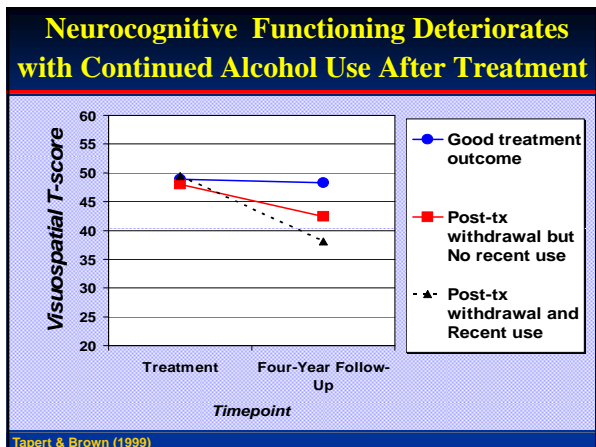
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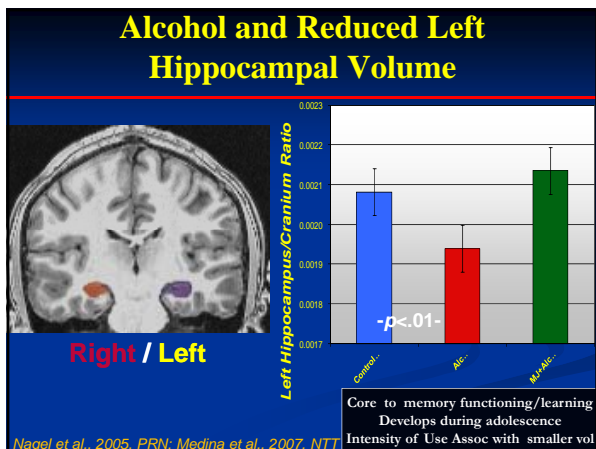
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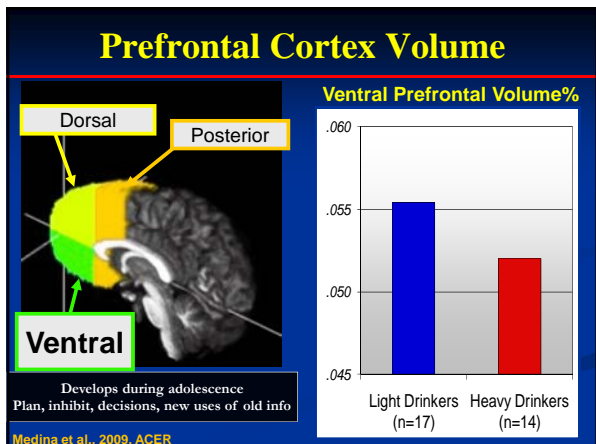
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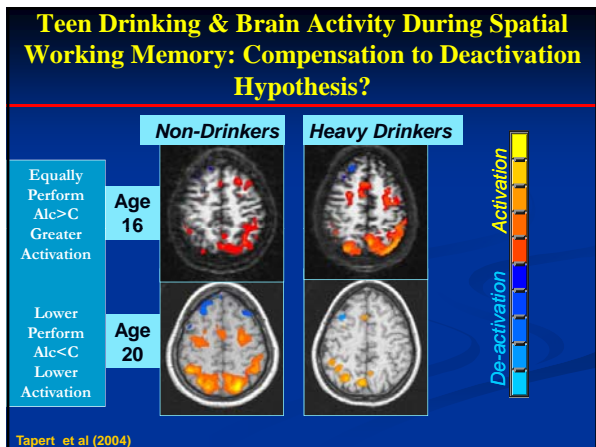
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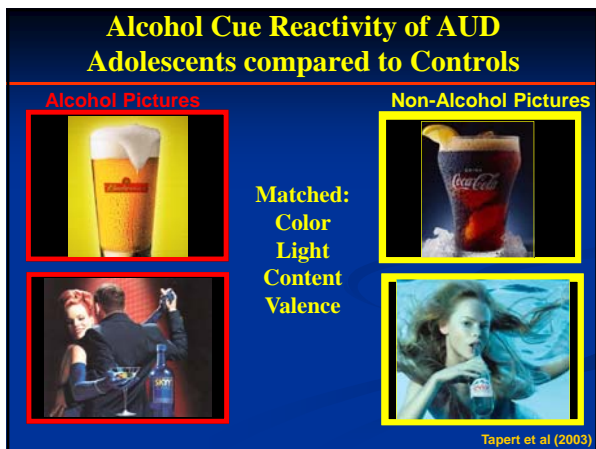
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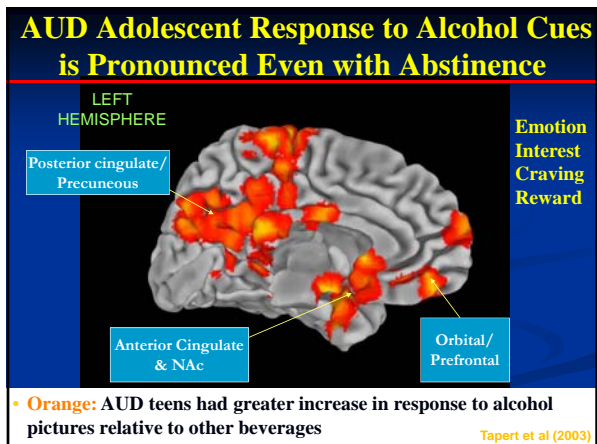
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### Neurodevelopmental Changes Follow AOD Use - Impacts Development

**Adolescent Heavy AOD use:**

- ✓ poorer neurocognition (memory, learning, attention, VS)
- ✓ abnormal brain structure (hippocampus, frontal, myelination)
- ✓ abnormal brain response
  - Early Compensation But Protracted Use ↓ performance & activation
- ✓ Disruption of real life developmental tasks

**More questions than answers**

- Duration and Recovery
- Vulnerable subgroups/differential impact
- Longitudinal & Experimental Challenge Studies Needed

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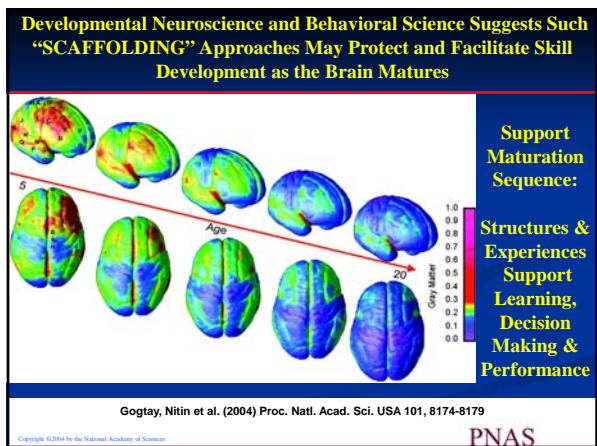
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### Brain Development: Implications for Treatment and Prevention

- The earlier the intervention, the better
- Skills are Learned - experience & practice (Planning, Evaluate Consequences, Control Impulses)
- Tailor Design, Format & Content to Teen Needs/Preferences (Novelty, Emotions, Peers, Motivation, Structure & Consequences)

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### Questions?




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### UCSD ADDICTION RESEARCH LAB




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