How Adolescents Make Decisions:

New Discoveries About the Adolescent Brain

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Risk Taking in Adolescence is Common and Pervasive

- Compared to adults, adolescents ...
  - Commit more crimes
Crime

Rate per 100,000 persons

Age

Rate per 100,000 persons

Violent Crime

Property Crime

Bureau of Justice Statistics, 2010
Compared to adults, adolescents …

- Have more car crashes
Compared to adults, adolescents …
  - Drown more often
Compared to adults, adolescents ...
- Attempt suicide more often
Compared to adults, adolescents …
- Are more likely to begin experimenting with drugs
Age of Onset of Illicit Drug Abuse or Dependence

Compton et al., 2007
Compared to adults, adolescents …

- Are more likely to have unintended pregnancies
Unintended Pregnancies

Rate per 1,000 Sexually Active Women

Finer, 2010
What Do These Age Patterns Have in Common?

Adolescence is Always the Most Risky Time
Adolescence is the Most Common Age of Onset for Major Psychiatric Disorders

Paus et al., 2008
Common Myths About Adolescent Risk-Taking

- Adolescents are illogical
- Adolescents underestimate risk
- Adolescents believe they are invulnerable
- Adolescents think poorly when making decisions
- Adolescents are unaware of the dangers associated with risky behavior
If Adolescents Are So Smart, Why Do They Do Such Stupid Things?
Brain Development in Adolescence: Four General Principles

- Adolescence is a period of heightened brain plasticity
- Brain maturation continues until a later age than previously believed
- Different systems mature at different points in time and at different rates
- The different developmental timetables of different regions creates unique characteristics of adolescence
Brain Regions Showing Most Change in Adolescence

- Prefrontal Cortex
- Limbic System

Sowell et al., 1999
Prefrontal Cortex
Some Implications of Immaturity in the Prefrontal Cortex

- Adolescents are less likely than adults to consider the future consequences of their actions.
- Adolescents are less likely than adults to plan ahead.
- Adolescents are less able than adults to control their impulses.
- Adolescents are less able than adults to simultaneously consider the risks and rewards of a decision.
The Limbic System

- Cingulate cortex
- Septal area
- Hypothalamus
- Hippocampus
- Amygdala
Some Implications of Heightened Limbic System Arousal

- Adolescents experience higher “highs” and lower “lows”
- Adolescents are especially sensitive to emotional cues
- Adolescents are especially sensitive to social information
- Adolescents are especially sensitive to rewards
Timing is Everything

- The arousal of the limbic system occurs early in adolescence
- The maturation of the prefrontal cortex is very gradual, and is still ongoing well into the 20s
- Starting the engine before a good braking system is in place
Juvenile Capacity Study

- Studied age differences in capacities affecting judgment and decision-making
- Focused on reward-seeking and self-control
- 935 individuals from ages 10 to 30, socioeconomically and ethnically diverse
- Age groups matched on gender, ethnicity, SES, IQ
Sensation Seeking is Highest in Mid-Adolescence

“I sometimes like to do things that are a little frightening.”

Steinberg et al., 2008
Risk Preference is Highest in Mid-Adolescence

“How would you compare the benefits of [unprotected sex] with the risks?”

Steinberg, 2009
Iowa Gambling Task

- Subject presented with four decks of cards
- Told that two decks are “good” and two are “bad”
- Cards contains information about outcome
- Administered in 3 blocks of 40 trials
- Goal: Maximize winnings by choosing from correct decks
Iowa Gambling Task

Play or Pass?
You win!!!
Your total is $2100
Iowa Gambling Task

- Bad decks: larger gains, but larger losses
- Good decks: small gains with small losses
- Deck choice is tracked over time
- Paying attention to the good decks shows sensitivity to potential rewards
- Paying attention to the bad decks shows sensitivity to potential costs
Reward Sensitivity is Highest in Mid-Adolescence

Cauffman et al., 2010
Cross-Cultural Replication

- China (Shanghai)
- Cyprus (Nicosia)
- Colombia (Medellin)
- India (Delhi)
- Italy (Naples/Rome)

- Jordan (Amman)
- Kenya (Maseno)
- Philippines (Manila)
- Sweden (Trollhattan)
- Thailand (Chiang Mai)
- U.S. (Durham)
Reward Sensitivity in the Iowa Gambling Task Non-U.S. Sample

Unpublished data
Delay Discounting

- Would you rather have $200 today or $1,000 in six months?

- Lower figure raised or lowered to middle point depending on answer, and question repeated until indifference point reached.

- Repeated with 9 trials (with varying immediate amounts) in each of 6 different time intervals.

- Lower amount accepted short-term indicates stronger need for short-term gratification.
Young Adolescents Show Stronger Preference for Immediate Reward

Steinberg et al., 2009
Preference for Immediate Reward
Non-U.S. Sample

Amount Accepted Now
Versus 1,000 in One Year

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<thead>
<tr>
<th>Age</th>
<th>10-11</th>
<th>12-13</th>
<th>14-15</th>
<th>16-17</th>
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<td>520</td>
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Cognitive Control
Impulse Control Matures Gradually

“\textit{I think before I act.}”

Steinberg et al., 2008
Tower of London

Start

Goal

Place Holders
With Age, Longer Time Spent Thinking Before Acting

Steinberg et al., 2009

<table>
<thead>
<tr>
<th>Age</th>
<th>Easiest Problems</th>
<th>Hardest Problems</th>
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Tower of London
Time Before First Move
Cross-National Sample

Unpublished data
Stroop Test

Press the button that matches the color of the word, while ignoring what the word says.

RED
Stroop Test

Press the button that matches the color of the word, while ignoring what the word says.

ROCK
Stroop Test

Press the button that matches the color of the word, while ignoring what the word says

RED
Response Inhibition

Relative Performance

Age

10-11 12-13 14-15 16-17 18-21 22-25 26-30
Response Inhibition
Non-U.S. Sample

Relative Performance vs Age

- 10-11
- 12-13
- 14-15
- 16-17
- 18-21
- 22-25
- 26-30
The Task of Adolescence
Balancing Arousal and Self-Control
During Adolescence, the Balance Changes

Childhood

Arousal

Regulation

Adolescence

Arousal

Regulation
A Model of Adolescent Risk-Taking

Smith, Chein, & Steinberg, 2013
The Gap Between Arousal and Self-Control is Greatest in Mid-Adolescence

Shulman et al., submitted
Sex Differences in Impulse Control and Sensation Seeking

Shulman et al., submitted
The Peer Effect
Resistance to Peer Influence

e.g., “Some people think it's better to be an individual even if people will be angry at you for going against the crowd.”

Steinberg & Monahan, 2007
Resistance to Peer Pressure
Non-U.S. Sample

Age

10-11 12-13 14-15 16-17 18-21 22-25 26-30

2.50 2.55 2.60 2.65 2.70 2.75 2.80

Unpublished data
Adolescent Risk-Taking Usually Occurs With Peers

- Sexual risk-taking occurs with someone else
- Most experimentation with alcohol and illicit drugs occurs with peers
- Risk of a serious automobile accident significantly increases with presence of same-aged passengers
- Adolescents are more likely than adults to commit crimes in groups than by themselves
Crashes per 10,000 Trips

Age of Driver

- 16-17
- 18-19
- 30-59

No passengers
1 Passenger
2 Passengers
3 Passengers

Williams, 2003
Proportion of Solo Versus Group Crimes By Age of Offenders

National Crime Victimization Survey, 2011
The Stoplight Task

- **Goal:** Drive to destination as quickly as possible down a straight road with multiple intersections

- **Three possibilities:**
  - Brake at intersection (some time lost)
  - Run light successfully (no time lost)
  - Run light and crash (much time lost)
Impact of Presence of Peers on Risky Driving

Gardner & Steinberg, 2005
Probabilistic Gambling Task

3:1
Reward: Loss
Low Risk

2:3
Reward: Loss
Ambiguous

1:3
Reward: Loss
High Risk
Peer Effect is Actually Stronger When Risk is Known to Be Greater

Smith et al., in press
Average change in brain activity among adolescent participants (14-18 years) playing the driving game, either with friends watching, or with no audience.

There is significantly greater activation in reward centers when friends are watching.

No such effect is seen among adults

Chein et al., 2011
Striatal Activation Correlated With Running the Yellow Light

Chein et al., 2011
Peers Increase Preference for Immediate Rewards

Steinberg et al., 2009
Peers Increase Preference for Immediate Rewards

Steinberg et al., 2009

O’Brien et al., 2011
High/Low Card Guessing Task

Smith et al., in prep
Correct Trials: Reward vs. Non-Reward

% Signal Change (Reward-NonReward)

Adolescents

Adults

Left VS

-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8

-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8

Alone
Peer
Correct Trials: Reward vs. Non-Reward

% Signal Change (Reward-Nonreward)

Adolescents

Adults

Right VS

Alone

Peer
Possible Explanations for the Peer Effect

- Adolescents simply do everything more in groups (ruled out by experimental design)

- Adolescents encourage each other to behave in certain ways (ruled out by prohibiting communication)

- Adolescents put pressure on each other to take risks (ruled out by studies of reward processing with no risk involved)

- Adolescents are trying to impress or please friends
Created Peer Groups of Three Mice Raised Together

Half Tested as Adolescents

- Half Tested Alone
- Half Tested With Peers

Half Tested as Adults

- Half Tested Alone
- Half Tested With Peers
Adolescent Mice Spend More Time Drinking Alcohol When With Peers

Logue et al., in press
Summary

- Risk-taking in adolescence is the product of an imbalance between developing brain systems
- Accelerator activated before a good braking system is in place
- Presence of peers accentuates the imbalance between systems and increases chance of risky behavior
- These may be hard-wired features of adolescence
- Adolescent risk-taking is hard to stop because it is normative
One Possible Solution

I would there were no age between ten and three-and-twenty, or that youth would sleep out the rest; for there is nothing in the between but getting wenches with child, wronging the ancientry, stealing, fighting.

Would any but these boiled brains of nineteen and two-and-twenty hunt in this weather?

“Go to your room and stay there until your cerebral cortex matures.”
Practical Implications

- Information alone will not diminish risk-taking
  - Limited impact of most health education efforts
- Change the context, not just the teenager
  - Make it less likely that teens will be in harm’s way
- Provide opportunities for healthy risk-taking
  - Not all risk taking is bad
- Work on building self-control
  - Strengthen development of self-regulation
- Provide external control until self-control is mature
Thanks

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Why Adolescents Take Risks: New Discoveries About the Adolescent Brain

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