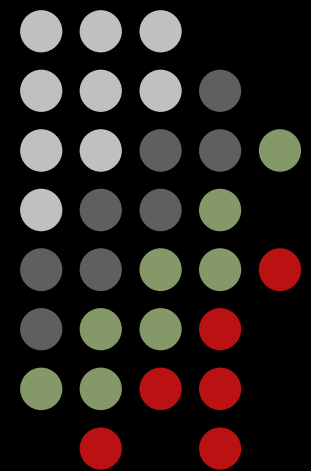
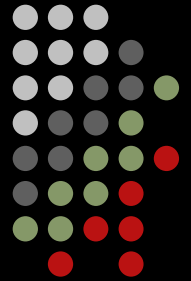


Risk and Reward in Adolescent Decision-making

Marie T. Banich, Ph.D.
University of Colorado at Boulder



Background

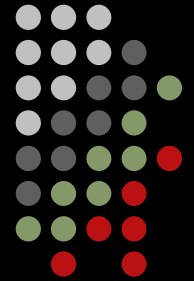


- 1 *Reward sensitivity* and *impulsivity* argued to contribute to substance use
 - 1 **Reward systems** of the brain “high-jacked” by substance of abuse
 - 1 **Impulsivity** (Behavioral disinhibition) leads to poor decisions
 - 1 Argued that there is a genetic component

- 1 What do we know about these processes in adolescence?

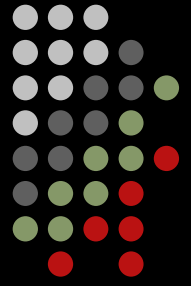
- 1 What other causative factors might be considered?

What I will talk about



- 1 Data from a large-scale study examining the cognitive processes underlying adolescent decision making
- 1 Data from a smaller-scale behavioral and imaging data in adolescents with severe substance and conduct problems
- 1 Consider what insights these data might provide

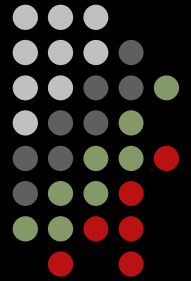
What do we know about decision-making in teens?



- 1 Culpability study - MacArthur Foundation Network on Adolescent Development and Juvenile Justice

- 1 Large multi-site study to examine this issue
 - 1 Laurence Steinberg, P.I. - Temple University
 - 1 Marie Banich - Univ. of Colorado
 - 1 Elizabeth Cauffman - Univ. of California Irvine
 - 1 Sandra Graham - UCLA
 - 1 Jennifer Woolard - Georgetown University

Three relevant domains of functioning



1 Risk Processing

- 1 Perception - “It’s not dangerous to drive 100 mph”
- 1 Preference - “It’s great fun to drive 100 mph”

1 Control of behavior

- 1 Ability to interrupt on-going activity, ability to control impulses, internal guiding of focus

1 Planning

- 1 Ability to organize behavior to a goal, ability to thinking about the future, ability to realize the consequences of one’s actions

Sample Characteristics



1 N=935

1 Age

1 10-11	12.5%
1 12-13	14.7%
1 14-15	13.8%
1 16-17	15.2%
1 18-21	15.9%
1 22-25	14.6%
1 26-30	13.2%

1 Age Groups comparable with respect to:

- 1 Race/ethnicity
- 1 Sex
- 1 Household Education
- 1 IQ

1 Household Education

1 < High School	11.9%
1 High School Grad	22.8%
1 Some College	34.1%
1 College Graduate	21.4%
1 Post-College	9.7%

1 Sex

1 Male	49.2%
1 Female	50.8%

1 Race/Ethnicity

1 African-American	29.2%
1 Asian-American	15.1%
1 Hispanic	21.2%
1 White	24.0%
1 Other	9.9%



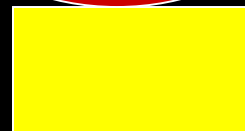
Random Reward

1 Series of balloons

Balloon Analog Risk Task (BART) (Lejeuz et al. 2002)

1 Pop after a random # of pumps

1 Correlates with individual differences in self-reported risk taking



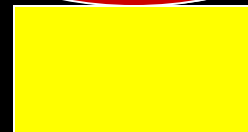
Collect \$\$\$

Click here to pump up the balloon

Total Score

Cents per Pump

5



Total
Score



Cents per
Pump

5

Collect
\$\$\$

Click here to pump up the balloon



Collect
\$\$\$

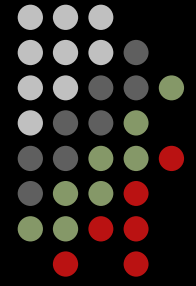
Click here to pump up the balloon

Total
Score

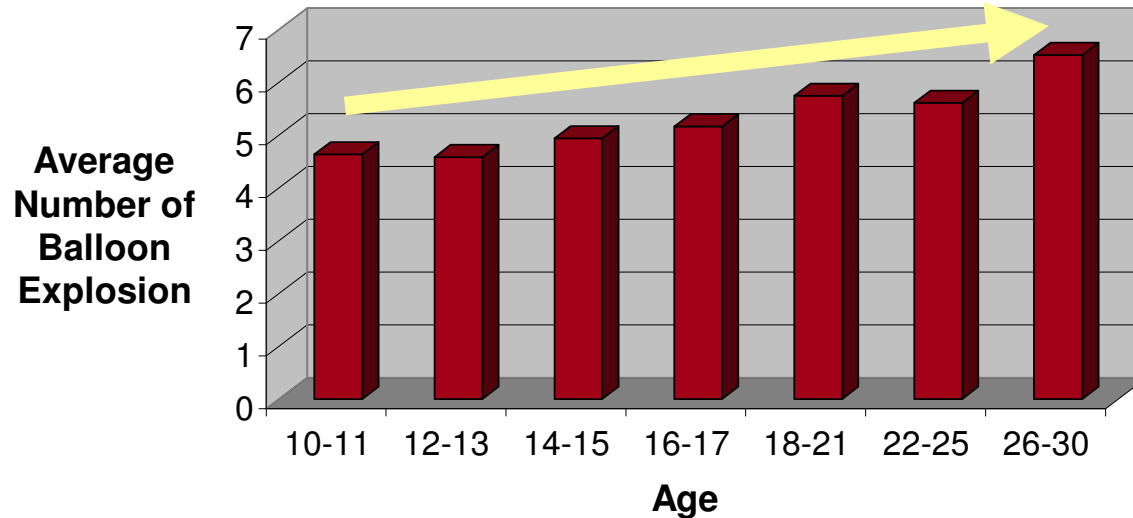
0.20

Cents per
Pump

5



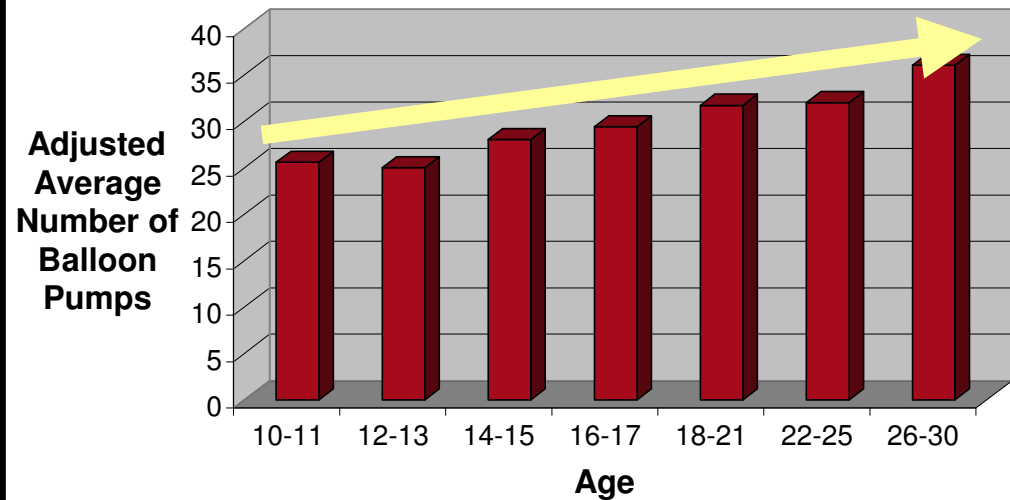
Balloon Analog Risk Task



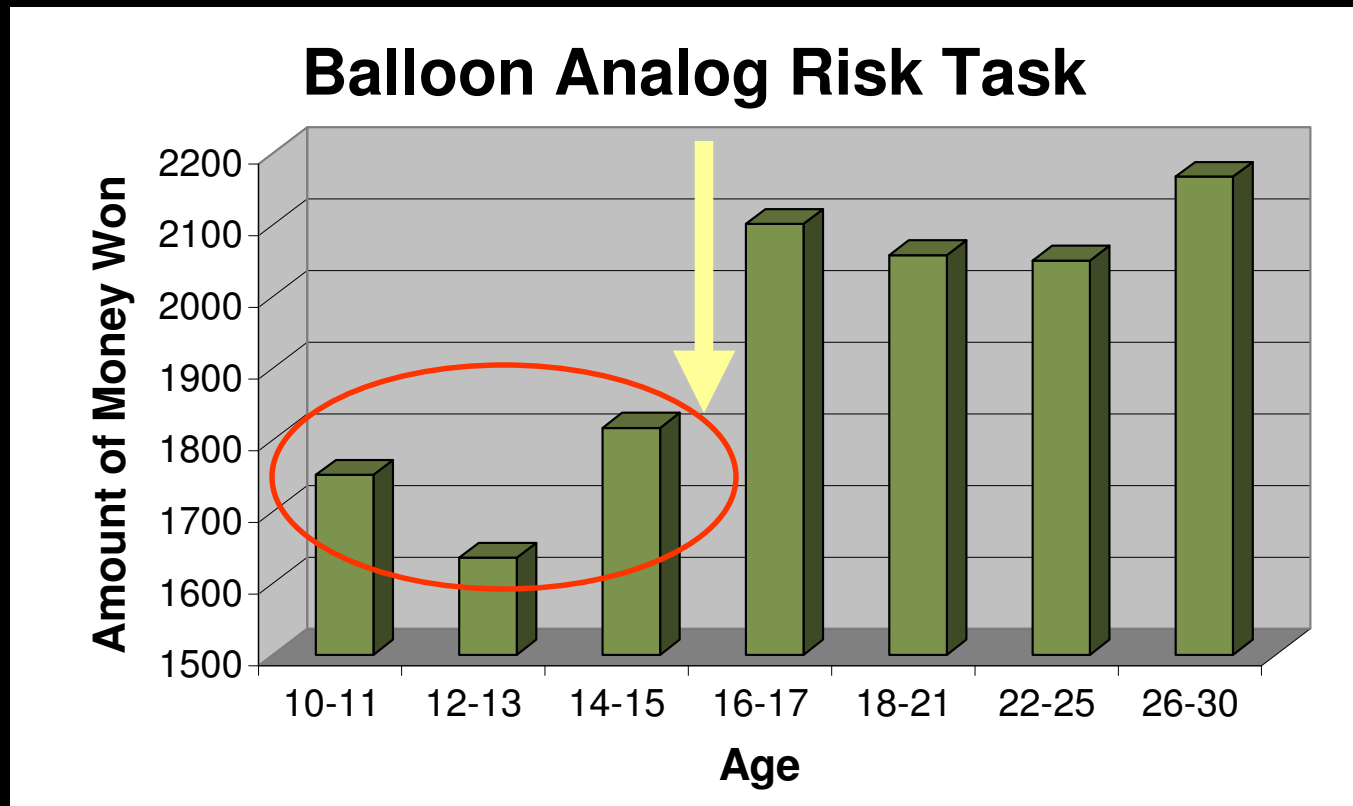
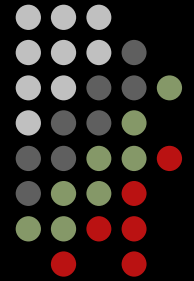
Not what we predicted!!!!

Younger individuals are more conservative

Balloon Analog Risk Task



Actual performance



At age 16 performance begins to look like adults

“Rationale” exuberance

Risk Processing with Random Reward



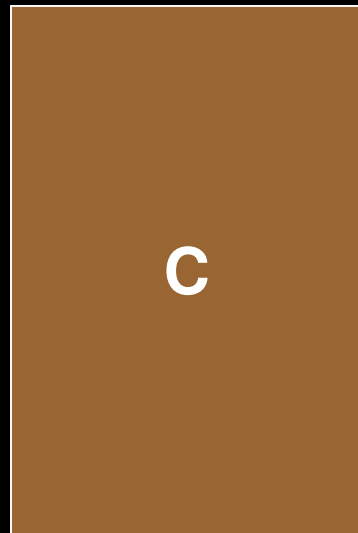
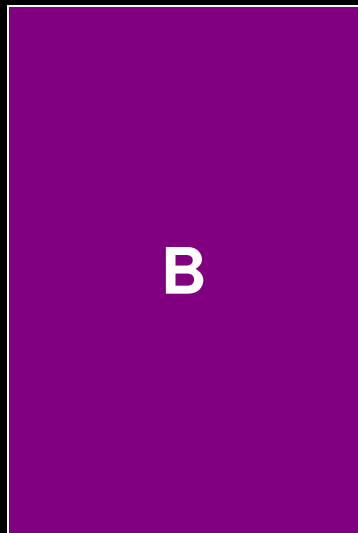
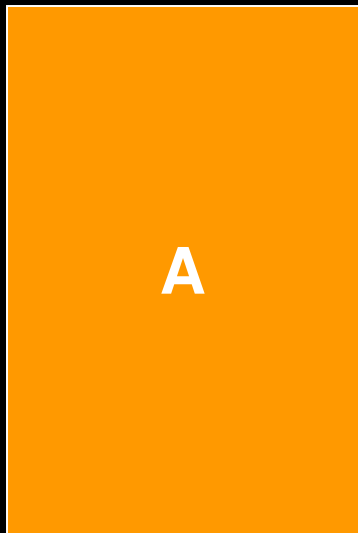
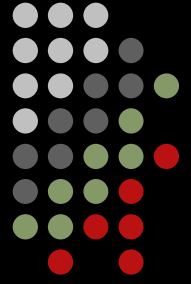
- 1 In this task, there is nothing to learn
- 1 Younger individuals are just more cautious
- 1 A change around 16
 - 1 More exploration that in this case is adaptive
- 1 **Important Lesson:** Must distinguish between
 - 1 *Developmental Processes*
 - 1 *Individual Differences*
- 1 Both are likely to be important for substance abuse

Learning about reward and punishment

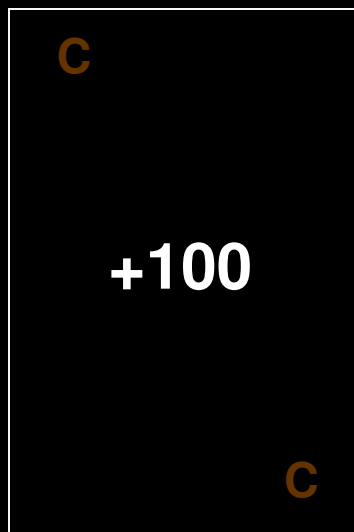
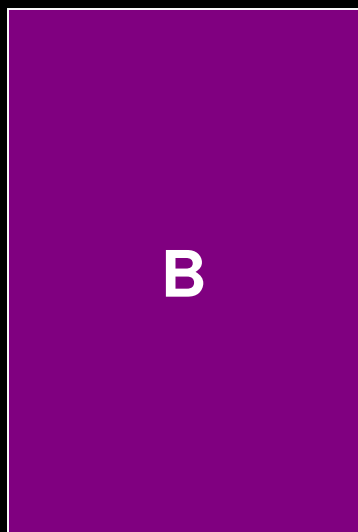
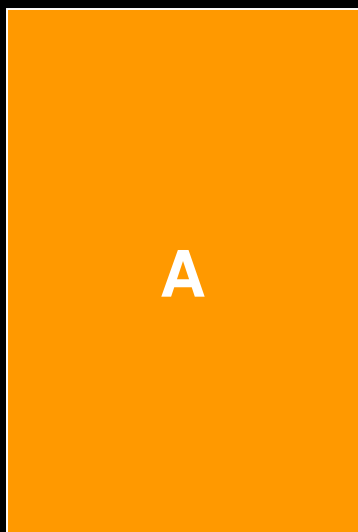


- 1 Modified Iowa Gambling Task (Bechara & colleagues)
- 1 Task to examine the linkage of affective signals of learning to current decision making
 - 1 Poor performance
 - 1 Patients with orbitofrontal damage
 - 1 Individuals with substance abuse
- 1 **Play/Pass Version for developmental reasons**
 - 1 Not confounded by search strategies
 - 1 Can differentiate whether the person's performance is driven by:
 - 1 Choosing rewards
 - 1 Avoiding punishments

Iowa Gambling Task

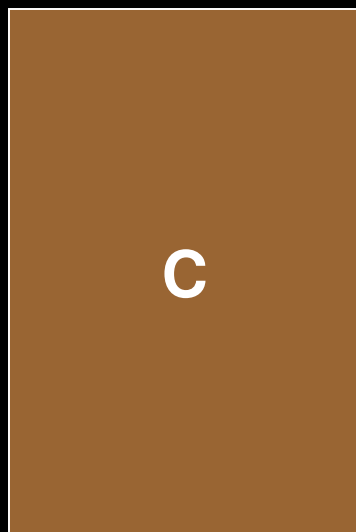
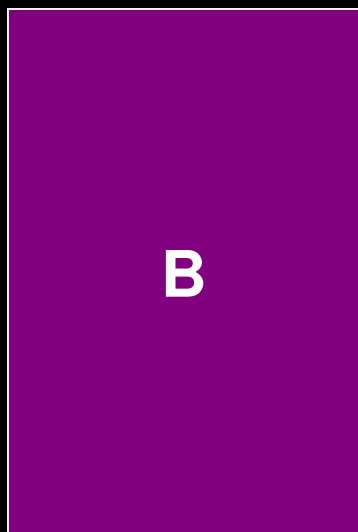
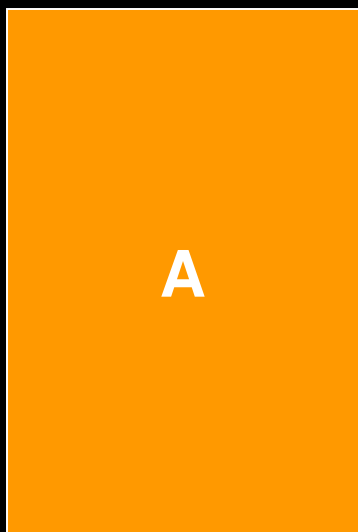


Play (1) or
Pass (2)

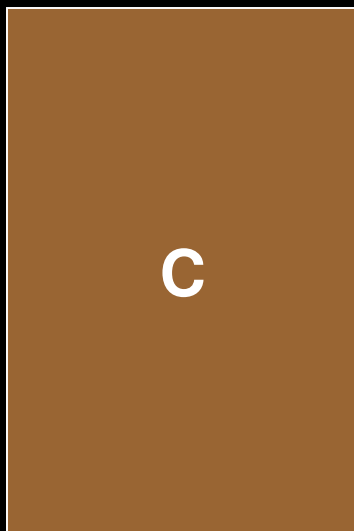
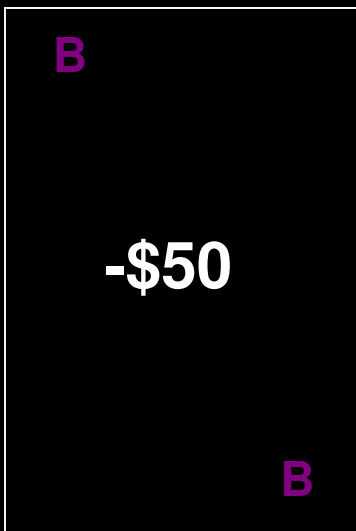
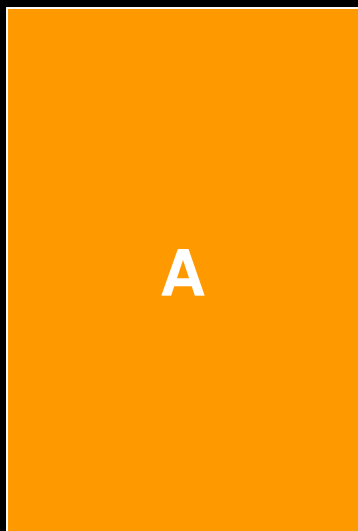


You win!!!
Your total is \$2100

Next trial



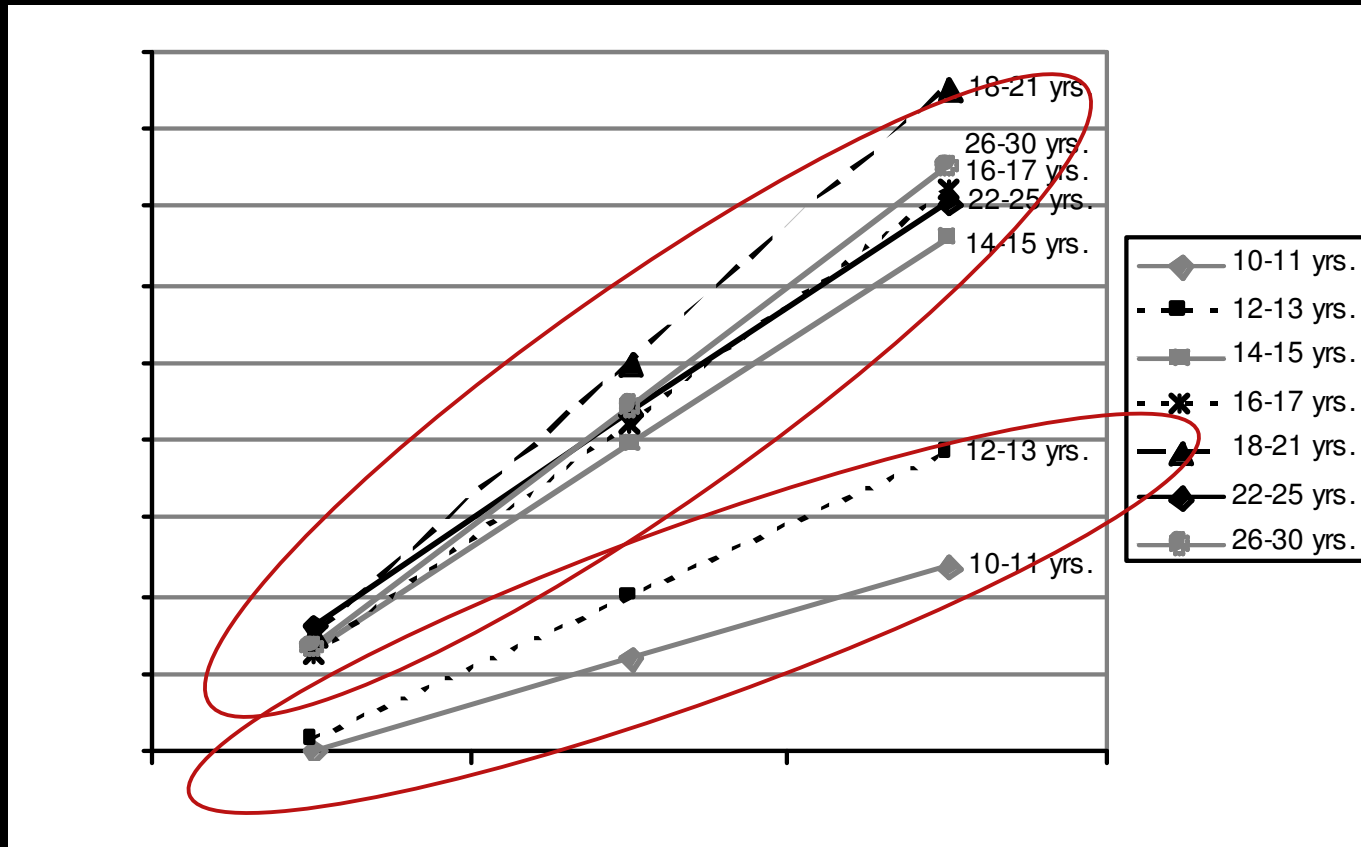
Play (1) or
Pass (2)



You lose!!!
Your total is \$2050



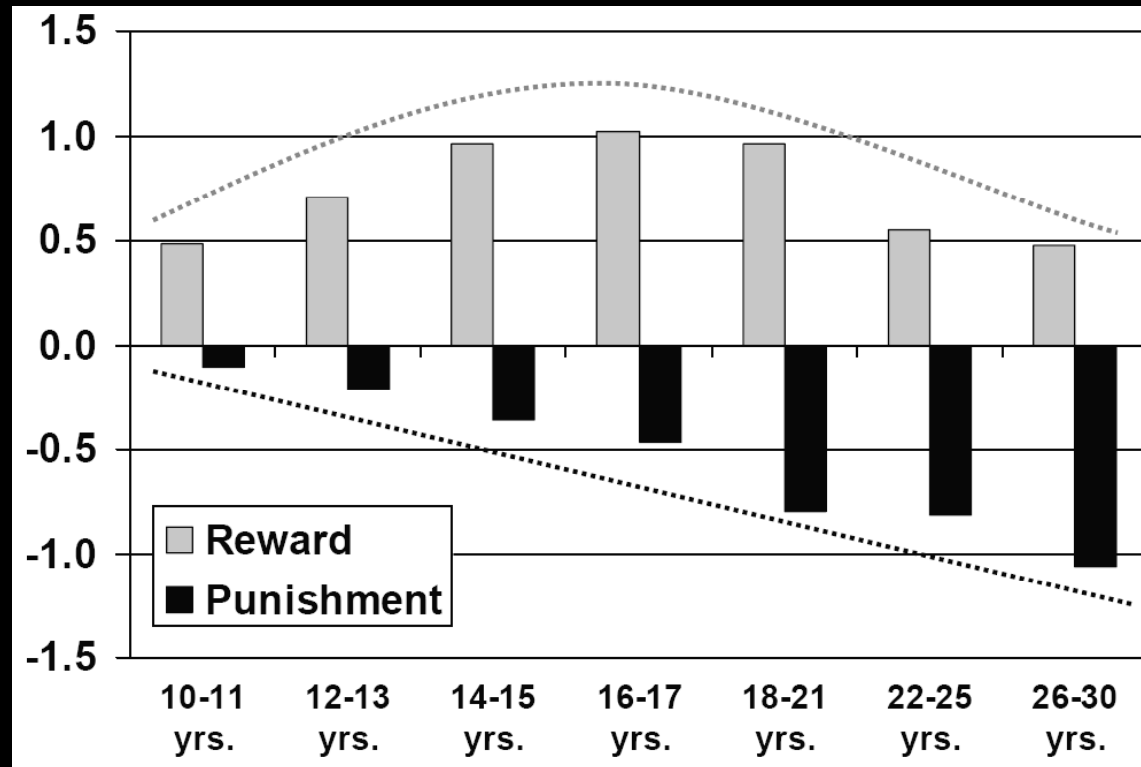
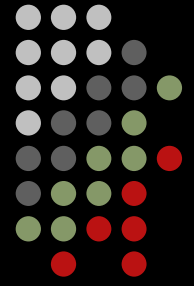
Learning about the decks



Older than 13 learn more quickly and better

Cauffman et al. (submitted)

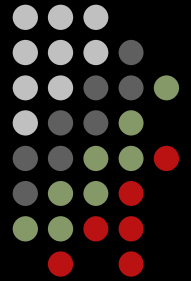
Reward vs. punishment



Reward: Curvilinear Relationship - peak around 16

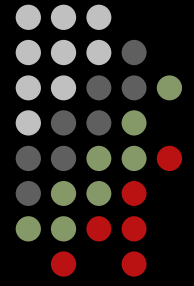
Punishment: Linear - increasing sensitivity with age

Risk processing when structure can be learned



- 1 Different pattern than BART
- 1 Peak sensitivity to reward at 16; increasing sensitivity to punishment
- 1 How does this relate to self-reports?
 - 1 Risk Preference (derived from Zuckerman Sensation Seeking)
 - 1 “It’s fun to drive 100 mph”
 - 1 Risk Perception (MacArthur Competence Study)
 - 1 “It’s not dangerous to drive 100 mph”

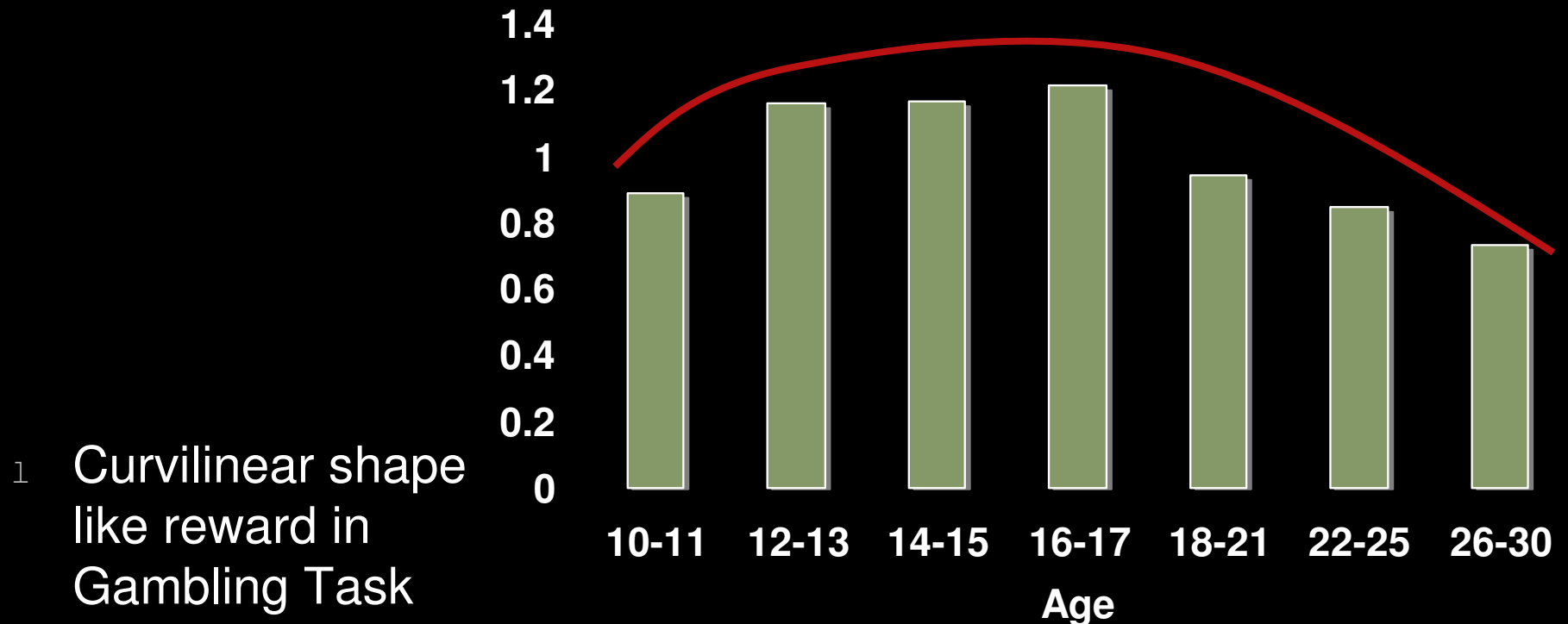
Risk Preference



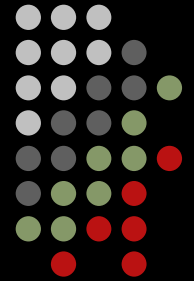
1 True or false judgments

1 “I like to have new and exciting experiences and sensations even if they are a little frightening.”

1 “I like doing things just for the thrill of it.”



Risk Perception



How much do the costs of doing this activity outweigh the possible benefits?

not at all

very much

Having sex

without protection 1 2 3 4 5 6 7

Drinking alcohol 1 2 3 4 5 6 7

Vandalizing property 1 2 3 4 5 6 7

Riding in a car

with a drunk driver 1 2 3 4 5 6 7

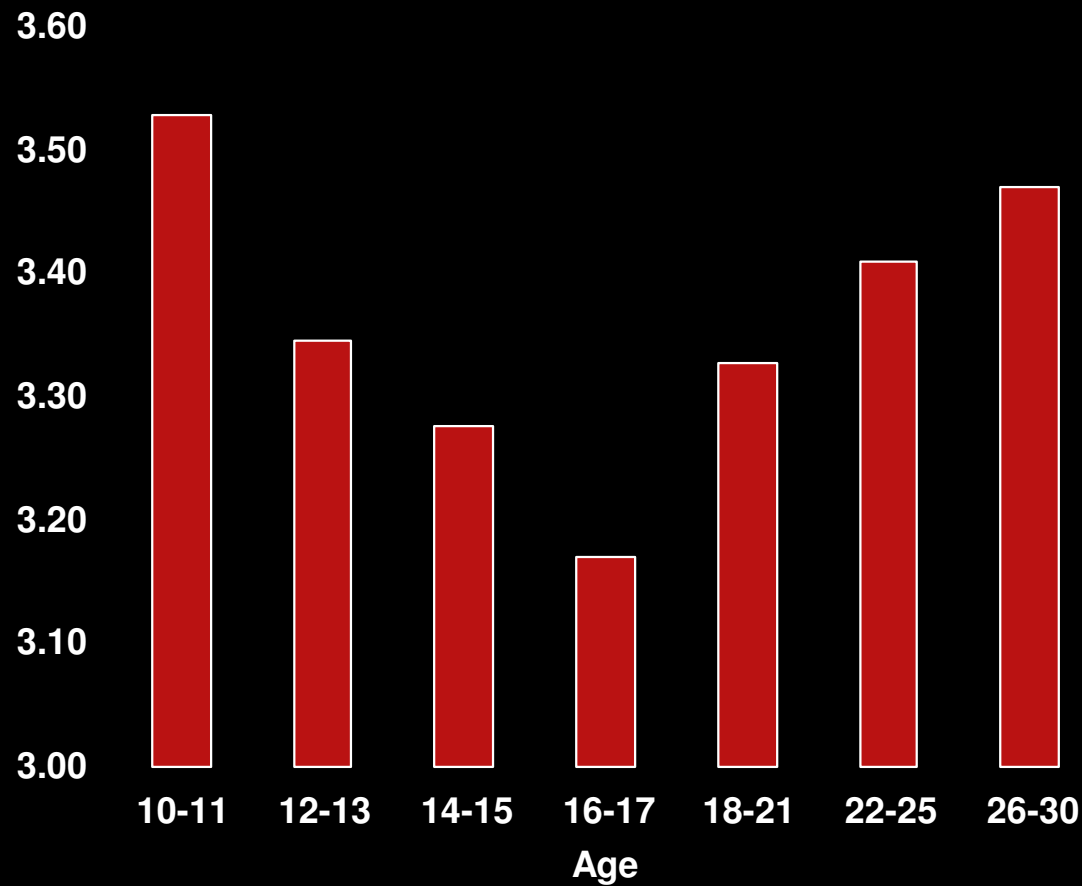
Smoking cigarettes 1 2 3 4 5 6 7

Stealing from a store 1 2 3 4 5 6 7

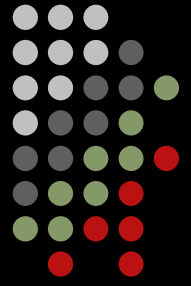
Fighting 1 2 3 4 5 6 7

Threatening someone 1 2 3 4 5 6 7

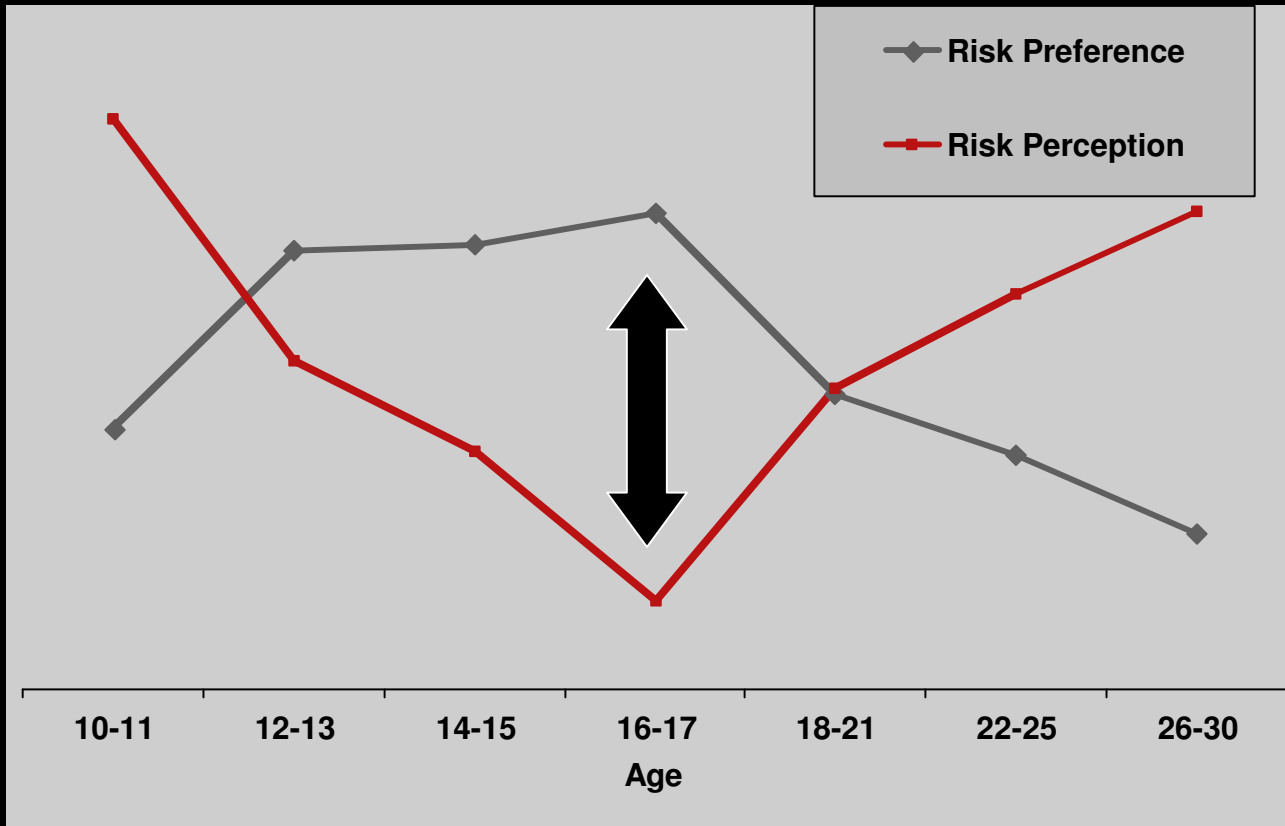
Risk Perception



- Inverted U-shape with minimum at 16

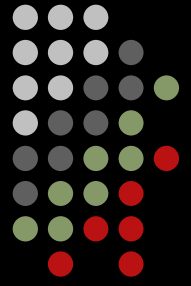


The risk “Gap”



- Age 16 appears to be a particularly vulnerable time period
 - Risk preference is high
 - Risk perception is low

Impulsivity



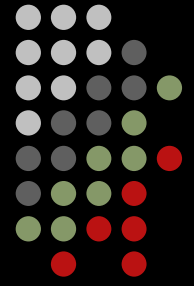
1 Delay discounting

1 Task used with animals, infants, young children

1 DECISION-MAKING:

1 Do I want the small reward now or can I wait for the larger reward later?

1 Typically considered to be linked to impulsivity



Delay Discounting Task

- 1 “Do you want \$600 right now or \$1000 in 3 months?”
- 1 Examine point of no preference - Indifference point (e.g. \$600 now = \$1000 in three months)

- 1 **Delay Function**

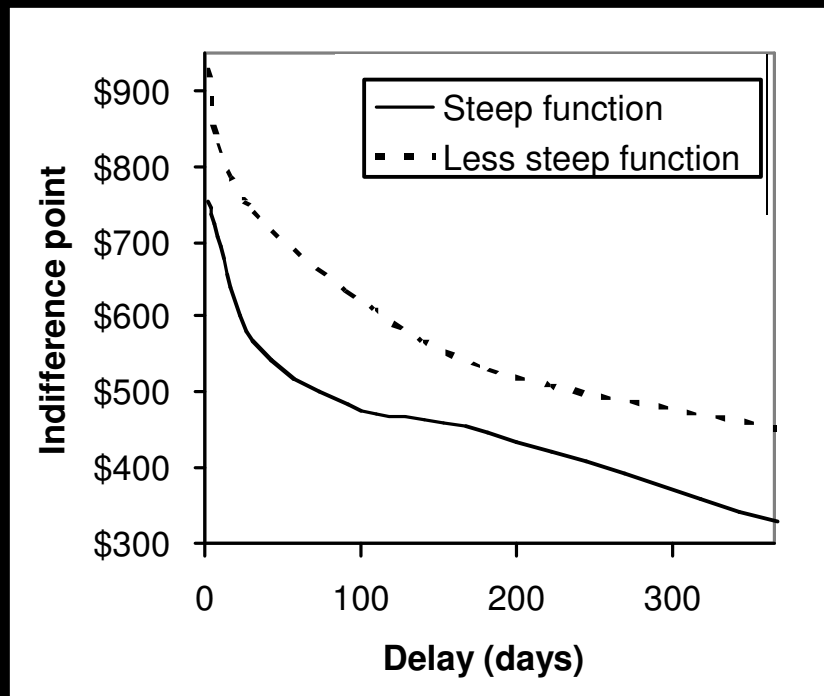
- 1 Steeper functions associated with impulsivity

- 1 **Measures**

- 1 Indifference point
 - 1 Area under the curve

- 1 **Associated with individual differences**

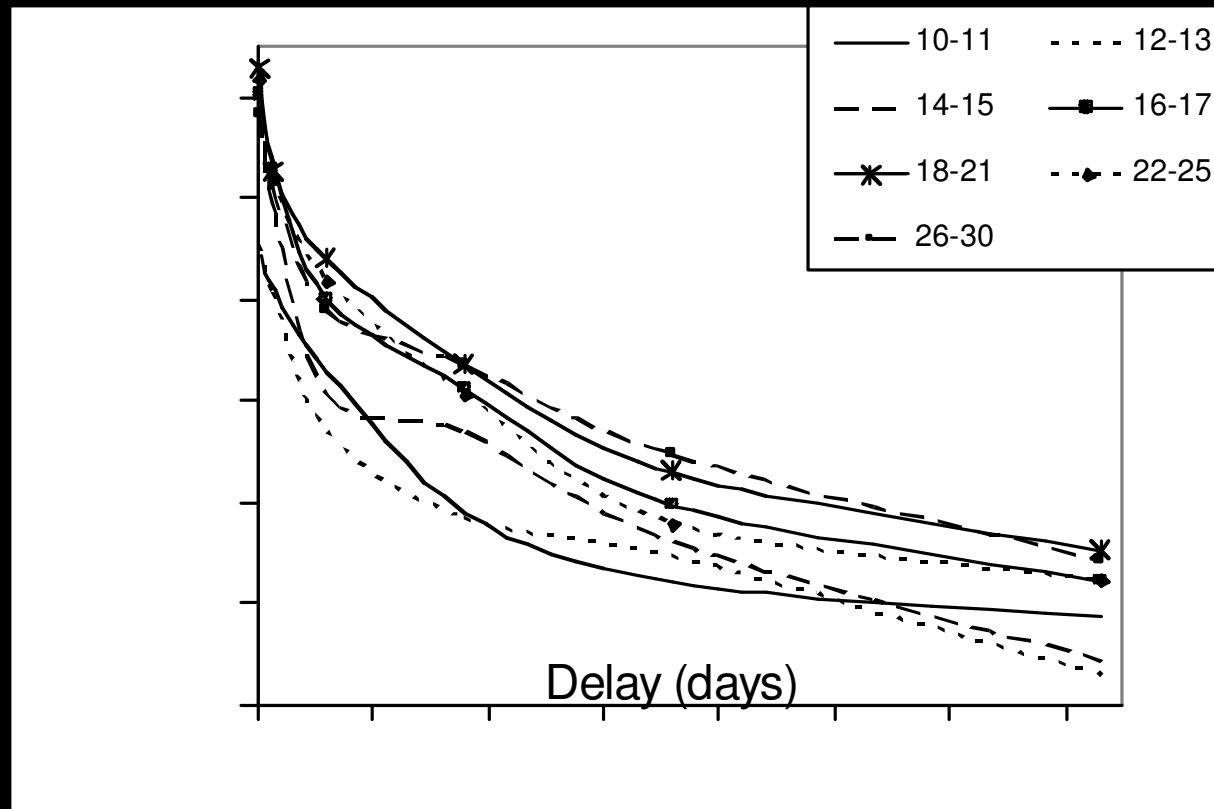
- 1 Steeper functions in individuals with substance abuse problems



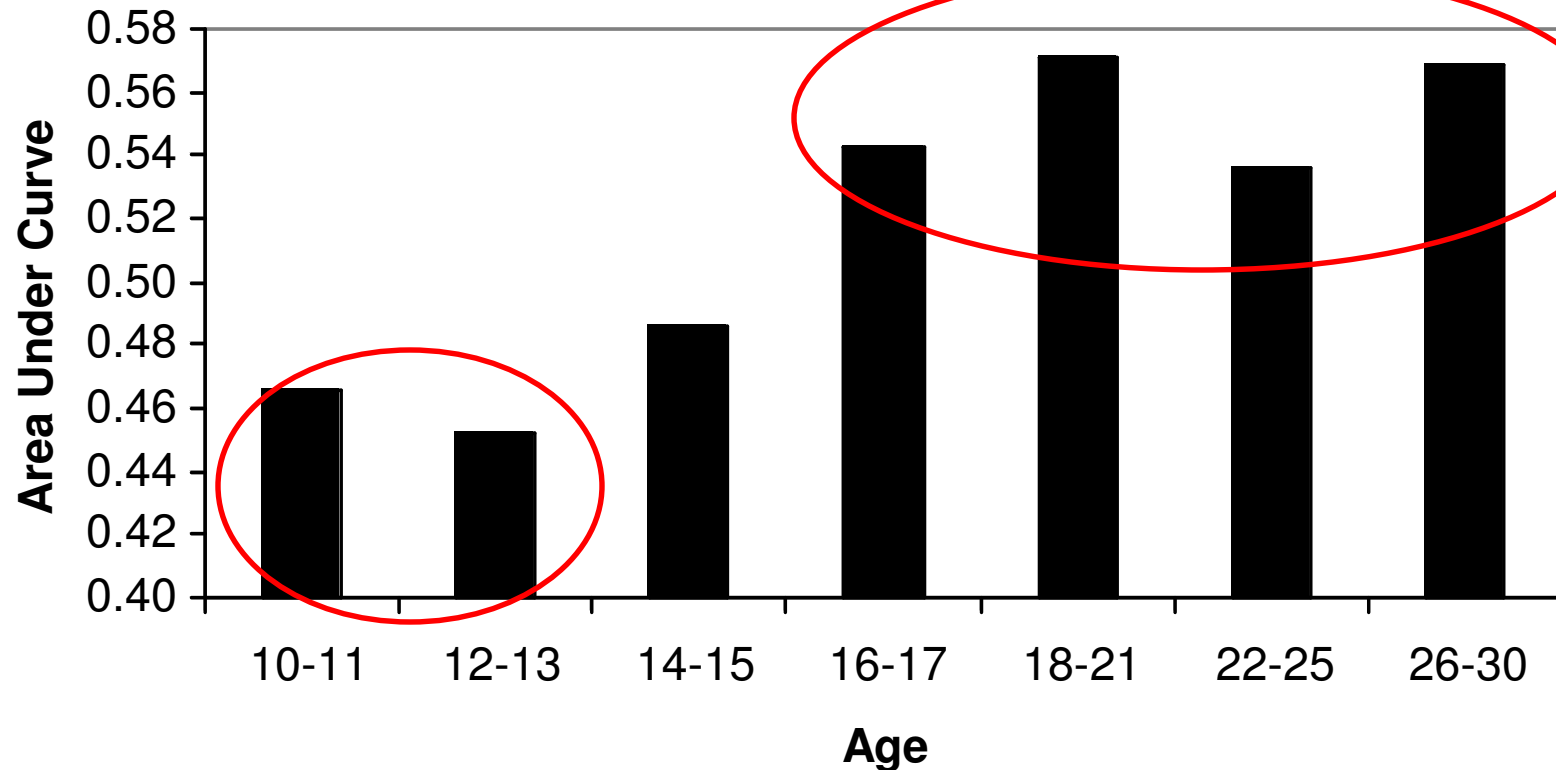


Delay Function by Age

- 1 Indifferent point measures at 6 time delays
- 1 1 day, 1 week, 1 month, 3 months, 6 months, 1 year

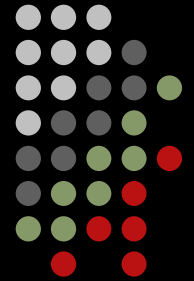


Average Delayed Reward Discount Function Across 7 Age Groups



1 Difference appears between 13 and 16

Link to individual differences



1 Two Questionnaires

1 Impulsivity (Barratt)

- 1 Motor impulsivity - acting without thinking
- 1 Attentional impulsivity - making quick cognitive decisions
- 1 Non-planning impulsivity - lack of concern about the future

1 Future Orientation (new measure)

- 1 Sequential Planning to reach a goal (If...then)
- 1 Time perspective on the future
- 1 Anticipation of consequences

1 Which statement better describes you?

- § “Some people usually think about the consequences before they do something” BUT
- § “Some people just act - they don’t waste time thinking about consequences”

Individual differences with Delay



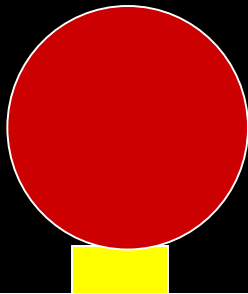
- 1 Correlates with Future Orientation
 - 1 In particular: Future consequences, time orientation
 - 1 Not: Planning ahead
- 1 DOES NOT correlate with impulsivity
- 1 Suggests a different interpretation for delay discount
- 1 Must consider other factors besides impulsivity and reward sensitivity in decision-making

Translation to Substance Abuse

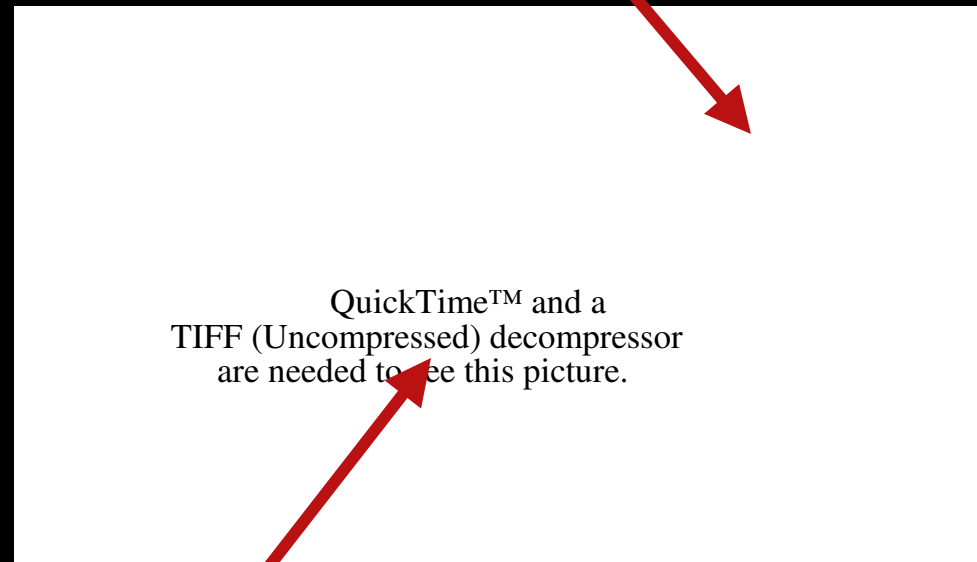


Adolescents with severe substance and conduct problems

1 BART



Click here to pump up the balloon



Controls

Replicates prior work - patients pump more

Crowley et al. (2006)

Risk-taking is not necessarily impulsivity



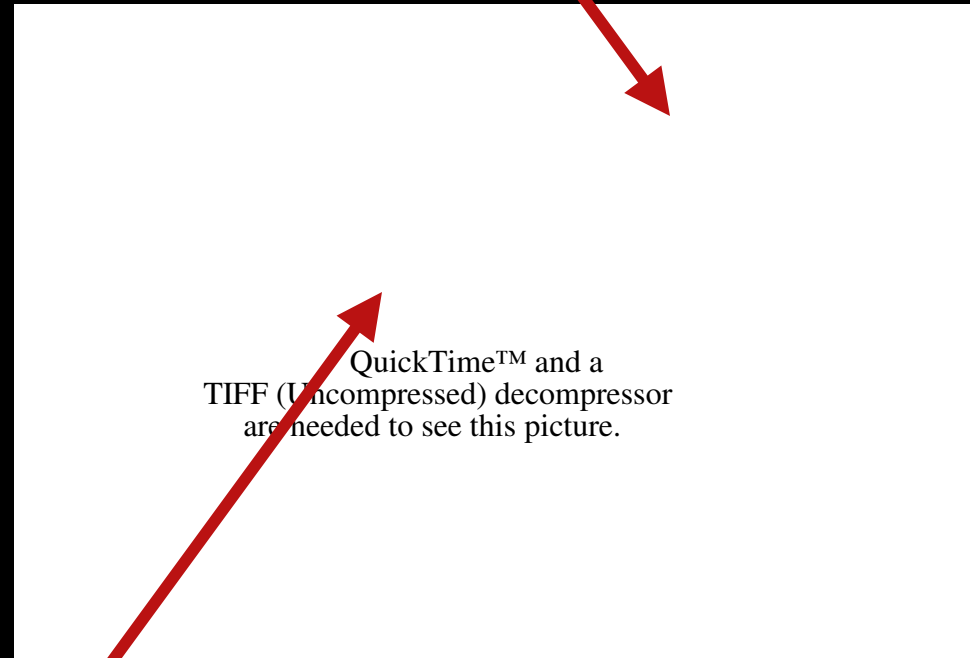
Adolescents with severe substance and conduct problems

1 Inter-pump interval

- 1 Are they pressing impulsively or actually “thinking” about it?

1 Patients take longer

- 1 Are they savoring the anticipation of potential reward?



Controls

Crowley et al. (2006)

Colorado Balloon Task

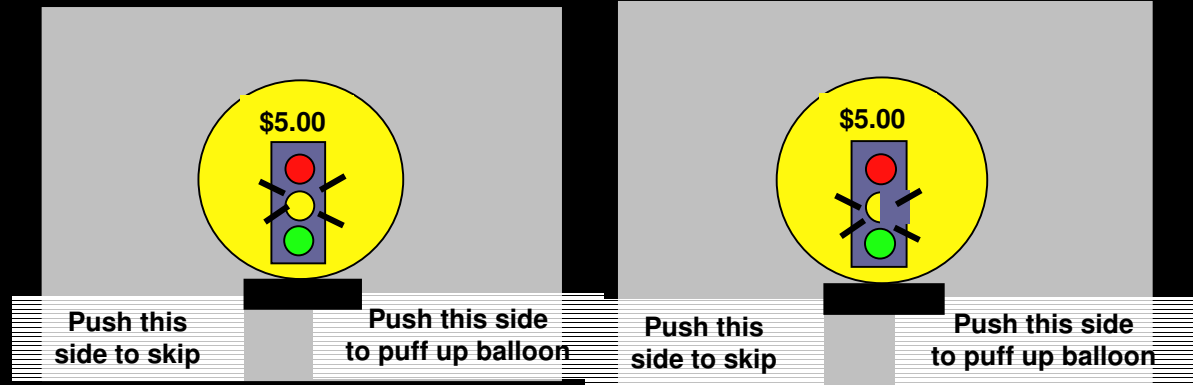


Active

Passive

- 1 Modified
 - 1 1 pump
 - 1 More likely to blow up over trials

Yellow:
4 Sec



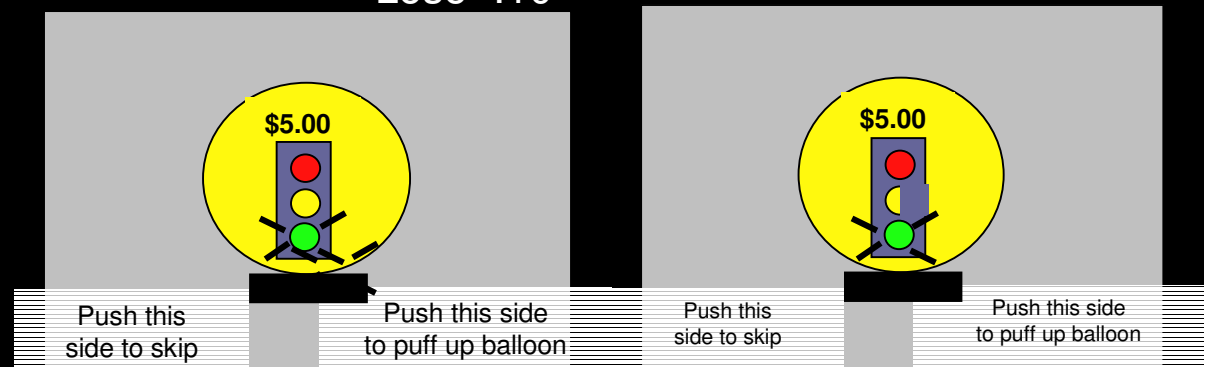
Add +.01 Win +.05
Lose -.10

Add +.02

- 1 Active vs. passive

- 1 Decision vs. reward

Green:
.5 Sec



Crowley et al.
(unpub.)

Red:
3.5 Sec

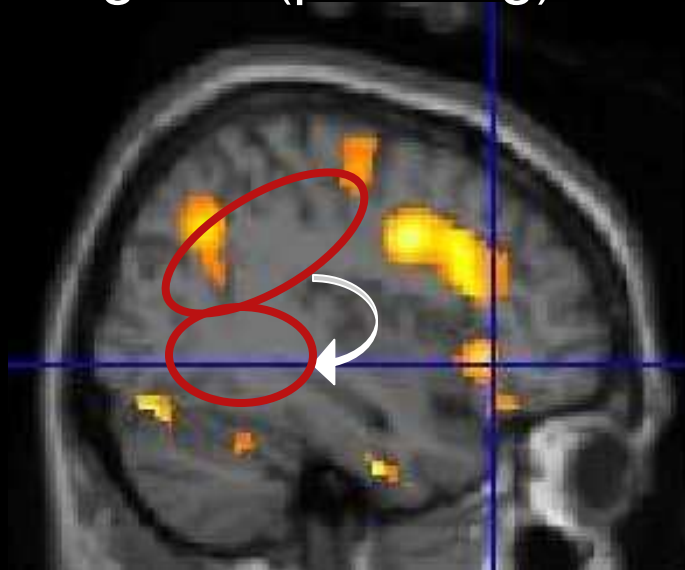
Observe Outcome

Controls > Patients

Decision Making (Active > Inactive)

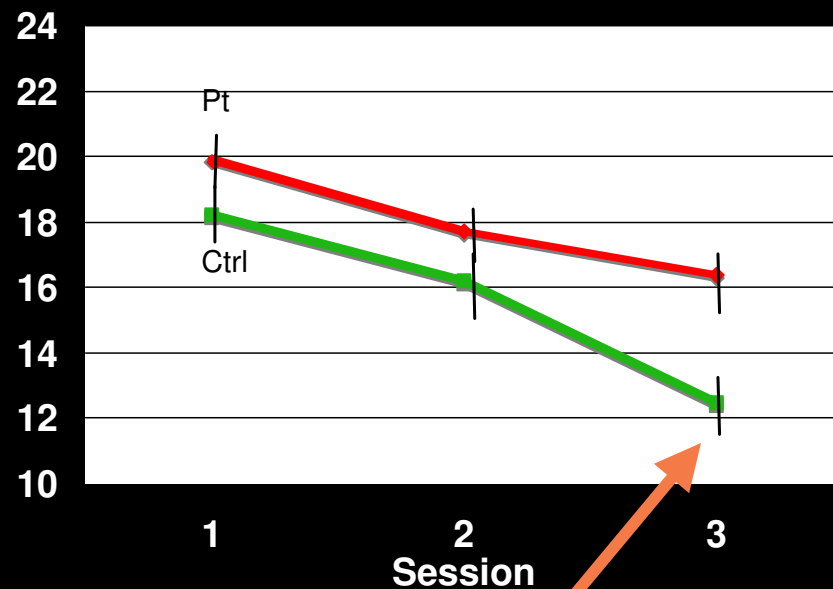


- Dorsolateral prefrontal regions (planning)



- Orbitofrontal regions (emotion)

Risky Right Presses



Controls stop taking risks
Patients don't

Outcome

Sample Patient

1 Patients more activity in subcortical regions

1

1 Caudate

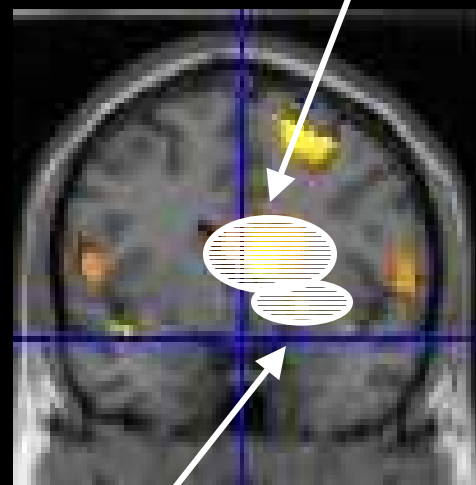
1 Amygdala

1 Learned associations with emotion

1 Fear

Reward

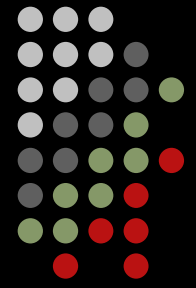
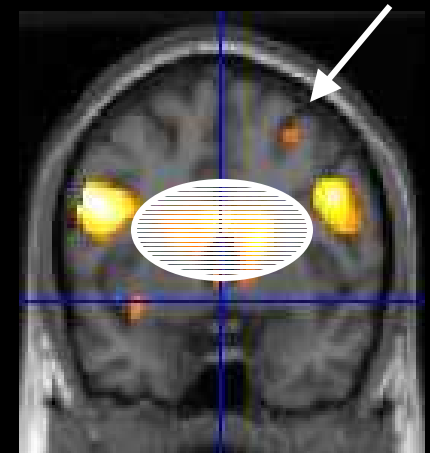
Left Caudate and Nacc



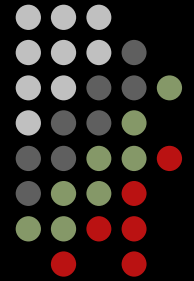
Amygdala

Loss

Right Left Caudate and left Nacc



Reward and Impulsivity



1 Reward

1 Age-related profile

1 Reward sensitivity (preference)

§ Age related differences - peaks at 16

1 Risk perception

§ Age related differences - least at age 16

1 The risk “gap” at 16

1 Patients seem to process reward information differently

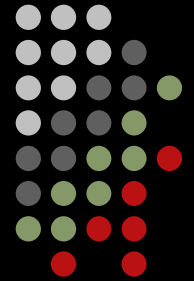
1 Impulsivity

1 Decreases with age

1 Individual differences

1 Not related to Delay Discounting within “normal” group

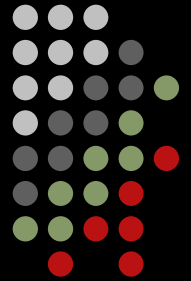
§ Related to Time to first move in a task that requiring planning



Other factors

- 1 Additional factors of importance
 - 1 Time Orientation/Planning
 - 1 Explains individual differences in delay discounting
 - 1 Attentional Selection and Control
 - 1 Differences in neural activation between adolescents with severe substance and conduct problems vs. controls
- 1 Suggests need to consider
 - 1 An interaction between emotional and cognitive factors
 - 1 An interaction between the neural systems involved in both

Relation to substance abuse



- 1 Need to consider that there can be a dissociation between two factors:
 - 1 Developmental Trajectories
 - 1 Individual Differences
- 1 Will need to understand how these two factors interrelate in producing vulnerability to substance abuse

Thanks



- 1 MacArthur Foundation Network on Adolescent Development and Juvenile Justice (www.adjj.org)
 - 1 Larry Steinberg, Temple Univ.
 - 1 Elizabeth Cauffman, Univ. of California, Irvine
 - 1 Sandra Graham, Univ. of California, Los Angeles
 - 1 Jennifer Woolard, Georgetown University

- 1 Thomas Crowley, M.D.
 - 1 Dept. of Psychiatry, Univ. of Colorado - Denver
 - 1 National Institute of Drug Abuse Grant # R01 DA009842