RISKY DECISION MAKING IN TEENS

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## Disclosures of Potential Conflicts

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OUTLINE

- Decision Making Under Risk
- Modeling Risky Decision Making in the MRI Scanner
- Results
- Implications
- Future Directions
IMPACT OF SUBSTANCE USE DISORDERS

drugabuse.gov

$193 billion

Estimated cost of drug use to the U.S. society in lost productivity, health care and criminal justice costs in 2007
(Source: NDIC)

Every hour, 1 BABY is born suffering from opiate withdrawal.
COULD WE HAVE SEEN THIS COMING?
COSTS OF RISKY DECISIONS

- Risky Driving: $19,342/year/risky driver (Sommers 2011)
- Substance Use Disorders: $110 Billion/year
- Accidents: leading cause of death among adolescents
TREATMENTS FOR RISKY DECISION MAKING

- ZERO
- NADA
- Nothing
MODELING RISKY DECISION MAKING: BALLOON ANALOG RISK TASK (BART)
Fig. 1. Stages and associated processes involved with decision-making.
Neural activation during risky decision-making in youth at high risk for substance use disorders

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the balloon analog risk task (BART) showing successive balloon inflations (i.e., a D series of Choose Inflates) that either end up exploding (“You Lose!”).
Decision Period

Outcome Period

You Win!

You Lose!

Jittered Delay (0-6 sec)

START

Fixation

30 sec

Choose Inflated

Successful Inflation

Button Press

500 ms

Jittered Delay (1.5-2.5 sec)

Choose Win ("Cash Out")

Balloon Explosion

1000 ms

1000 ms

New Trial

Return to decision period

500 ms

1000 ms

Blank Screen

1000 ms

Jittered Delay (2-4 sec)
BART FINDINGS

- Behavioral:
  - Differentiates smokers and non-smokers (Lejuez, 2003)
  - Performance related to MDMA use (Hopko, 2006)
  - Associated with psychopathology and impulsivity (Hunt, 2005; Bornovalova, 2009)
  - Predicts real world adolescent risk taking (Lejuez, 2003)
  - Acute stress induces sex-differences (Lighthall, 2009)
**Neuroimaging:**

- Voluntary (mesolimbic frontal) vs. Involuntary Risk (DLPFC; Rao 2008)
- vmPFC involved in value calculation; escalating risk taking = increasing potential losses (Schonberg 2012)
- IFG/ACC = loss aversion at time of choice (Fukunaga 2012)
- Adolescents with TBI (Chui et al 2012)
- Predicting risky vs. safe choice (Helfinstein 2013)
ULTRA/FAMILIAL HIGH RISK PARTICIPANTS

- 10-14 yo male and female biological offspring of men with past or present SUDs + another 1st or 2nd degree family member with a SUD
- High risk “neurobehavioral disinhibition” estimated by a diagnoses of ADHD + CD/ODD/DBD NOS (KSADS).
- Used drugs, alcohol or nicotine NO MORE than five times in their lifetime
MID-RISK PARTICIPANTS

- 10-14 yo male and female biological youth from families without SUDs (<2 relatives)
- High risk “neurobehavioral disinhibition” estimated by a diagnoses of ADHD + CD/ODD/DBD NOS (KSADS).
- Used drugs, alcohol or nicotine NO MORE than five times in their lifetime
In addition to other exclusionary criteria, no ADHD, ODD/CD/DBD NOS

No current diagnosis or lifetime history of any DSM-5 psychiatric or SUD (exceptions: specific phobias, enuresis, learning disorders)

Exclude participants with a first degree relative with a history or current diagnosis of a SUD

Attempt to match controls on age, sex, IQ and socioeconomic status.
EXCLUSION CRITERIA

- Lifetime history of bipolar disorder, psychotic symptoms, pervasive developmental disorders or SUDs
- Current major depressive disorder
- Current psychopharmacologic treatment (none within 4 weeks) other than psychostimulants (held the days of assessment and scanning)
- History of neurological problems (e.g., epilepsy, traumatic brain injury, brain tumors, cerebrovascular disease)
- Estimated Full Scale IQ below 80
- Active or debilitating medical conditions
- Active maternal substance use disorder during pregnancy
- Left handedness
MRI ANALYSES

- Mock scanner training
- Siemens 3T; 32-channel head coil
- AFNI
- Event Related Design
- Parametric Modulation
- Choose Win vs Choose Inflate
- Outcome Explode vs Outcome Inflate
- P<0.01 at voxel level; cluster size correction k=21 6 voxels
- p<0.05
- IQ/SES with and without covariates
RESULTS: BART BEHAVIORAL FINDINGS
<table>
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<tr>
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<th>Low Risk</th>
<th>High Risk</th>
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<tr>
<td>Total Winnings</td>
<td>$10.35 (± 0.48)</td>
<td>$11.51 (± 0.53)</td>
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<tr>
<td>Reaction Times &gt;5000 ms</td>
<td>0.70 (± 0.99)</td>
<td>0.04 (± 0.21)</td>
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<tr>
<td>Reaction Times of Inflates (ms)</td>
<td>835.91 (± 53.47)</td>
<td>710.09 (± 43.99)</td>
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<tr>
<td>Total Balloons Completed</td>
<td>20.40 (± 0.48)</td>
<td>20.39 (± 0.72)</td>
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<td>Balloon Outcomes</td>
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<tr>
<td>Won</td>
<td>15.37 (± 0.75)</td>
<td>15.26 (± 0.94)</td>
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<tr>
<td>Lost (Exploded)</td>
<td>4.81 (± 0.34)</td>
<td>5.13 (± 0.38)</td>
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<tr>
<td>Inflations per Balloon</td>
<td>5.35 (± 0.15)</td>
<td>5.57 (± 0.17)</td>
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<tr>
<td>Standard Deviation of Inflations</td>
<td>1.03 (± 0.08)</td>
<td>1.17 (± 0.10)</td>
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<tr>
<td>Minimum Number of Inflations</td>
<td>3.44 (± 0.23)</td>
<td>3.39 (± 0.27)</td>
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<tr>
<td>Maximum Number of Inflations</td>
<td>6.89 (± 0.20)</td>
<td>7.43 (± 0.22)</td>
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<tr>
<td>Reaction Times (ms)</td>
<td>770.69 (±66.23)*</td>
<td>554.82 (±38.31)*</td>
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<tr>
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<td>727.85 (± 61.35)</td>
<td>634.68 (± 69.69)</td>
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RESULTS: BART NEUROIMAGING FINDINGS
**Decision Period**

- **Fixation**
  - Start
  - 30 sec

- **Choose Inflated**
  - Button Press
  - Successful Inflation

- **Choose Win (“Cash Out”)**
  - You Win!
  - Jittered Delay (0-6 sec)
  - Jittered Delay (2-4 sec)
  - Blank Screen
  - New Trial

**Outcome Period**

- **You Lose!**
  - 1000 ms
  - 1000 ms

- **You Win!**
  - 500 ms
  - Jittered Delay (1.5-2.5 sec)

**Additional Notes**

- **Outcome Period**
  - Return to decision period
Fig. 2. Group differences (healthy comparisons (HC) vs. high risk (HR)) on the parametrically modulated outcome contrast. Group differences, driven by increasing activation intensities as explosion probability increases in the HR group, were found in a bilateral cluster in the ventromedial prefrontal cortex (vmPFC; Table 5). Bar graphs plot activation intensities (y-axis) from the cluster according to condition (Outcome Inflate or Outcome Explode) and group (HC or HR). Line graphs illustrate the relationship between probabilities of balloon explosion (x-axis) vs. activation intensities of the blood oxygen level dependent (BOLD) signal in the cluster (y-axis).
FAMILY HISTORY + VS -:
VENTROMEDIAL PFC
DECISION MAKING

- **vmPFC**: Decision making during uncertainty; deficits seen during tasks where individuals “fail to learn from their mistakes”

- **Ventral striatum**: Uncertain outcomes; forming expectancies for future
Fig. 1. Stages and associated processes involved with decision-making.
IMPLICATIONS

• In this age group, impulsive, disruptive behavior disordered youth show different activation patterns, as risk changes, than comparisons, but only on the OUTCOME of decision making.

• Proposed mechanism: Failure to close the “feedback loop” related to learning from high risk experiences?

• Regions implicated are particularly relevant to highly uncertain scenarios and formation of expectations for future decisions.
CURRENT STUDY

- R01: 222 kids, followed over 5 years
- Adding study of sexual risk behaviors
- Understanding cognitive mechanisms underlying these deficits (working memory? Executive control?)
- Comparing with other types of decision making tasks
- ULTIMATE GOAL: TRANSLATE TO NEW TREATMENT INTERVENTION FOR HIGH RISK KIDS
ACKNOWLEDGEMENTS

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- Violet Davies, BA

- NIDA
- Kids and their families!!
- Many students/interns
Compensation:
Free mental health evaluation
Participants can make up to $430

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