Prenatal drug exposure alters adolescent neural responses in a probabilistic reward/punishment task

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AIM
To assess the impact of prenatal drug exposure on adolescent decision making in the face of variable uncertainty and reward.

INTRODUCTION
• Prenatal drug exposure has been associated with cognitive and affective deficits, including difficulties with emotional regulation (Ackerman et al 2010), likely related to processing of rewards and punishments.
• Animal models suggest prenatal drug exposure causes structural and molecular changes relevant to reward functioning as well as changes in behavioral expressions of reward functioning (Malanga et al 2003; Gendle et al 2003).
• The Wheel of Fortune task (Ernst et al 2004) involves choosing between two different monetary outcomes with different probabilities. The task probes willingness to take risks versus preference for safer choices as well as responses to differing levels of uncertainty.

METHODS
Subjects: 39 African-American adolescents
- Twenty-two exposed to drugs in utero (primarily cocaine but also some alcohol, cigarettes, opiates, and marijuana)
- 10 male, 12 female
- 14.23 ±/−1.06 years old
- 21/22 right-handed
- Seventeen non-exposed from same neighborhood and socioeconomic status
- 5 male, 12 female
- 13.59 ±/−1.27 years old
- 17/17 right-handed
- All were enrolled in an ongoing longitudinal follow up study at University of Maryland, Baltimore School of Medicine of infants exposed to drugs in utero.

Task: Wheel of Fortune
- Modified so that all choices had the same expected value and differed only in certainty of outcome (See Figure 1).
- Eight blocks of 20 trials each
- Alternated between ‘Win’ and ‘Loss’ blocks
- 40 80%/20% wheels, 20 100% wheels 20 50%/50% wheels presented in ‘Win’ blocks. Same breakdown for ‘Loss’ blocks.
- Participants were able to keep up to $50 of their final total

Behavior:
- All participants responded slower to ‘Loss’ wheels than to ‘Win’ wheels and used response 1 (sky under index finger) more frequently than response 2 (sky under middle finger).
- Exposed group used response 1 significantly more than non-exposed group.
- Exposed participants were slower when making any 20% choice (‘Win’ or ‘Loss’ wheels) and slower when choosing on an 80%/20% wheel in the ‘Loss’ blocks (regardless of choice made).
- Wide variety in choice on 80%/20% wheels but no difference by group (See Figure 2).

RESULTS
Subjects:
- Matched on gender, age and non-maternal care
- Differed on exposure to alcohol and cigarettes in utero

Behavior:
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- Exposed participants were slower when making any 20% choice (‘Win’ or ‘Loss’ wheels) and slower when choosing on an 80%/20% wheel in the ‘Loss’ blocks (regardless of choice made).
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Imaging:
- Task maps: All 8 choice types (Win100, Win50/50, Win80/20, Loss100, Win80/20, Loss80/20, and corresponding Loss choices) produced very similar maps with activation in medial frontal/anterior cingulate, striatal regions, fronto-parietal attention network, insula and visual cortex (See Figure 3).
- Contrast maps: Few contrasts yielded significant differences between activation related to the various choices. Figure 4 shows significant differences in Win100 vs Win80/20 (select 20% side) and Loss100 vs Loss80/20 (Select 20% side).

CONCLUSIONS
• Making a risky choice engages attention and reward areas in adolescents.
• Adolescents exposed to drugs in utero show increased activation in response to a probabilistic stimulus predictive of reward and punishment in numerous areas associated with attention and response to probabilistic reward valuation (Peters 2009). This increased activation during a variety of choices combined with slower reaction times may reflect less efficient processing as a consequence of prenatal drug exposure.
• Adolescents exposed to drugs in utero show reduced activation in frontal regions associated with executive control when required to make a choice based on chance alone in the context of an impending loss.

REFERENCES

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