Nucleus accumbens core lesions have little effect on temporal sensitivity in impulsive choice

Sydney Edmisten*, Melina S. Campa, Jennifer R. Peterson, & Kimberly Kirkpatrick
Kansas State University

Introduction

- Impulsive choice behavior involves choosing between a smaller reward after a shorter delay (smaller-sooner, SS) versus a larger reward after a longer delay (large-later, LL).
- The delay and/or amount of the rewards can be manipulated to determine general patterns of preference for the SS or LL options.
- A tendency to make impulsive choices (SS) has been linked with many problem behaviors such as: drug use, stereotypes, poor financial planning, gambling, drinking, and stealing.
- Impulsive choice behavior is also linked with ADHD1,2,3, and this may be due to an over-responsive Nucleus Accumbens core (NAC)4.
- NAC is believed to play a central role in determining the value of rewards that guides choice behavior.
- Our previous research5,6 with NAC lesions indicated deficits in adjusting to increases in reward magnitude, so that when reward magnitude increased, choice behavior in NAC-lesioned rats did not change significantly.
- Also, recent work from our lab7 showed that dynamic tasks may result in more random choices and increased impulsive behavior.
- Thus, the previous NAC lesion studies6, conducted with dynamic procedures may be showing non-specific deficits of the lesions when dealing with dynamic environments.
- When we tested NAC lesions in a systematic steady state procedure that maximized opportunities for learning the reward options, the NAC was necessary for the computation of reward value in an impulsive choice task with manipulations of reward magnitude.7

PURPOSE: Here, we tested whether NAC lesions affected impulsive choice behavior under changes in delay. We also tested timing accuracy/precision using a temporal bisection task, and delay tolerance using a progressive interval.

HYPOTHESIS: Rats with NAC lesions should not present deficits in assessing LL delays, in timing accuracy, or in delay tolerance in comparison to sham control rats.

Conclusions

- The lesion group responded to the changes in LL delay a similar manner to the sham group, but the lesion rats did have a shallower slope, meaning that their behavior did not change as much with the changes of the LL delay.
- The temporal bisection task also disclosed similar behavior between the lesion and sham rats, indicating that temporal processing was not affected by the lesion.
- In the progressive interval task, there was no difference in rewards earned between the groups, indicating that the NAC lesion did not affect delay tolerance.
- The results from the temporal bisection task and the PI task suggest that the difference in slope in the choice procedure is not due to specific deficits in timing processes.
- These outcomes support the original hypothesis that the lesion rats should not have a deficit in core processing of delays and timing accuracy/precision.
- This suggests a selectivity in NAC function to differences in magnitude in choice behavior rather than a general role in valuation processes related to impulsive choice.

Methods

- Animals: 24 male Sprague Dawley rats
- Pair-housed, food restricted (85% weight), 90 days old
- Apparatus: 24 operant chambers (Med-Associates, St. Albans, VT)

Procedure

1. Surgery. Rats received neurotoxic lesions of the NAC or sham lesions.

   Surgical procedure:
   - Anesthetized with isoflurane
   - Placed on a stereotaxic frame
   - 1.2 cm incision at top of the head
   - Skull exposed and bregma located
   - Holes made with precision drill
   - 30 gauge infusion needle injected bilaterally
   - 0.5 µl of 0.09 M Quinolinic acid in 0.1 M PBS into brain tissue: Neurotosis lesion of NAC (12 rats)
   - 0.5 µl of 0.1 M PBS into brain tissue: Sham lesion (12 rats)

2. Training and Testing.

   - Session = 82 trials ➔ each with a 60 s fixed ITI
   - S4 Free Choice + 14 SS Forced Choice + 14 LL Forced Choice
   - Free choice trials. Both levers presented = SS vs LL
   - Forced choice trials. Only one lever presented = SS or LL
   - Magnitude remained stable for across delays (SS = 1, LL = 2)
   - LL delay incremented systematically:
     - Temporal Bisection:
       - Training. Rats trained to distinguish short (4 s) and long (12 s) signal lights
         80 trials (40 short + 40 long) / Correct = 1 p (15 s ITI) ; Incorrect = 15 s (ITI)
       - Testing. 10 sessions = 2 x each cue duration ➔ 4, 5.26, 6.92, 9.12, 12 s
   - Progressive Interval (PI) Schedule:
     Adapted from Marshall, Smith and Kirkpatrick (2014) procedure
     - Delay incremented arithmetically by the PI duration for each subsequent trial
     - Only one lever = 1 pellet ➔ 5, 10, 30 s
     - Number of reinforcers earned at each delay

   Order of PI and Bisection training/testing counterbalanced across groups.

Results

- Figure 1: The lesion and sham rats both show decreasing LL choices with increases in LL delay. The sham rats had a steeper slope to their choice function, indicating that they changed their behavior more when the delay changed.

- Figure 2: The sham and lesion rats showed similar behavior across the signal delays in the temporal bisection task.

- Figure 3: The two groups of rats earned similar numbers of rewards across all three PI delays.

References


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*Email: sydney11@ksu.edu

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